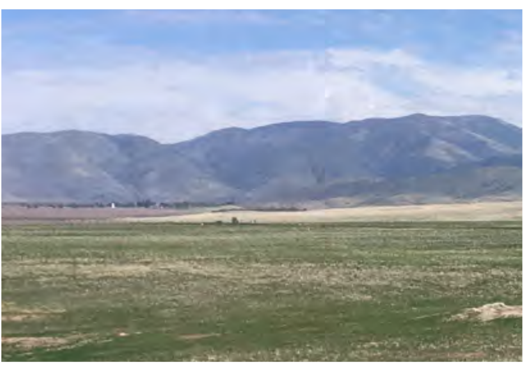
December 2021

Groundwater Sustainability Plan

for the White Wolf Subbasin






White Wolf Groundwater Sustainability Agency

eki environment & water

Groundwater Sustainability Plan

White Wolf Subbasin

Prepared by:

EKI Environment & Water, Inc.

for

White Wolf Groundwater Sustainability Agency

December 2021

www.ekiconsult.com
2001 Junipero Serra Blvd, Suite 300 • Daly City, CA 94014

Groundwater Sustainability Plan

For the White Wolf Subbasin

FINAL | December 2021

Prepared for:

White Wolf Groundwater Sustainability Agency
Angelica Martin, Plan Manager for the White Wolf Groundwater Sustainability Agency
4436 Lebec Road
Lebec, California 93243

Prepared by:

EKI Environment & Water, Inc.
2001 Junipero Serra Blvd., Suite 300
Daly City, California 94014
(650) 292-9100
www.ekiconsult.com
EKI B50001.05

PROFESSIONAL GEOLOGIST
ANONA L. DUTTON
No.7683
STATE OF CALIFORNIA

Anona Dutton, PG (#7683), CHg (#841)
Vice President

PROFESSIONAL GEOLOGIST
CHRISTOPHER S. HEPPNER
No. 9188
Exp. 11/2022
STATE OF CALIFORNIA

Christopher Heppner, PhD, PG (#9188)
Supervising Hydrogeologist

Christina Lucero, PG (#9262)
Hydrogeologist

PROFESSIONAL GEOLOGIST
CHRISTINA LUCERO
No. PG 9262
expires 7/2022
STATE OF CALIFORNIA

TABLE OF CONTENTS

List of Tables

LIST OF FIGURES

Groundwater Conditions

Monitoring Network

Projects and Management Actions

LIST OF APPENDICES

LIST OF ABBREVIATIONS

1,2,3-TCP	1,2,3-trichloropropane
AB	Assembly Bill
AEWSD	Arvin-Edison Water Storage District
AF	acre-feet
AFY	acre-feet per year
AL	Action Level
AN	above normal
APN	Assessor Parcel Number
AWMP	Agricultural Water Management Plan
BLM	Bureau of Land Management
BMP	Best Management Practices
BN	below normal
CA DPW	California Department of Public Works
CalEPA	State of California Environmental Protection Agency
CalGEM	California Geologic Energy Management Division
Caltrans	California Department of Transportation
CASGEM	California Statewide Groundwater Elevation Monitoring
CCR	California Code of Regulations
CDMG	California Division of Mines and Geology
CE	Categorical Exemption
CEDEN	California Environmental Data Exchange Network
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CG	coarse grid
CIMIS	California Irrigation Management Information System
COC	constituent of concern
CRC	California Resources Corporation
CT	central tendency
CVHM	Central Valley Hydrologic Model
CVP	Central Valley Project
CVRWQCB	Central Valley Regional Water Quality Control Board
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
CWC	California Water Code
DAC	Disadvantaged Communities
DEM	digital elevation model
DEW	Drier/Extreme Warming

DMS	Data Management System
DOGGR	Division of Oil, Gas, and Geothermal Resources
DTSC	Department of Toxic Substances Control
DTW	depth to water
DWR	California Department of Water Resources
EIR	Environmental Impact Report
ES	executive summary
ET	evapotranspiration
ETc	crop evapotranspiration
FEMA	Federal Emergency Management Agency
FG	fine-grid
ft	feet
ft bgs	feet below ground surface
ft msl	feet above mean sea level
ft/day	feet per day
ft/yr	feet per year
FWA	Friant Water Authority
GAMA	Groundwater Ambient Monitoring and Assessment
GDE	Groundwater Dependent Ecosystems
GIS	Geographic Information System
GPS	Global Positioning System
GSA	Groundwater Sustainability Agency
GSE	Ground Surface Elevation
GSP	Groundwater Sustainability Plan
GW	groundwater
GWC	groundwater conditions
GWE	groundwater elevation
GWL	groundwater level
GWMP	Groundwater Management Plan
HCM	Hydrogeologic Conceptual Model
HL	historical low
HUC8	Hydrologic Unit Code
I-5	Interstate 5
ILRP	Irrigated Lands Regulatory Program
IM	Interim Milestone
InSAR	Interferometric synthetic aperture radar
IRWMP	Irrigated Regional Water Management Plan

IS	Initial Study
ITRC	Irrigation Training and Research Center
IWFM	Integrated Water Flow Model
JPA	Joint Powers Agreement
JPL	Jet Propulsion Laboratory
KCWA	Kern County Water Agency
KGA	Kern Groundwater Authority
KRWCA	Kern River Watershed Coalition Authority
LUST	Leaking Underground Storage Tank
M&I	municipal and industrial
MA	Management Area
MAF	million acre-feet
MAWA	Maximum Applied Water Allowance
MCL	maximum contaminant level
MCLs	Maximum Contaminant Levels
meq/L	milliequivalents per liter
METRIC	Mapping EvapoTranspiration at high Resolution with Internalized Calibration
mg/L	milligrams per liter
MHI	median household income
MN	monitoring network
MND	Mitigated Negative Declaration
MO	Measurable Objective
MODFLOW	modular finite-difference flow model
MOs	Measurable Objectives
MPE	measuring point elevation
MPEs	measuring point elevations
MT	Minimum Threshold
MW	Monitoring Well
NA	not applicable
NAD83	North American Datum of 1983
NASA	National Aeronautics and Space Administration
NAVD88	North American Vertical Datum of 1988
NCCAG	Natural Communities Commonly Associated with Groundwater
ND	Negative Declaration
NDMI	Normalized Derived Moisture Index
NDVI	Normalized Derived Vegetation Index
NEPA	National Environmental Policy Act

NO3	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NRCS	Natural Resources Conservation Service
NSF	National Sanitation Foundation
O&M	operations & maintenance
OCAP	Operations, Criteria, and Plan
PA	plan area
PI	plan implementation
PLSS	Public Land Survey System
P/MA	Projects and/or Management Actions
POD	point of diversion
PRISM	Parameter-elevation Regressions on Independent Slopes Model
PWRPA	Power and Water Resources Pooling Authority
PWS	Public Water System
QA/QC	quality assistance and quality control
RMS	Representative Monitoring Site
RMW	Representative Monitoring Well
RMW-ISW	Representative Monitoring Well for Depletions of Interconnected Surface Water
RMW-WL	Representative Monitoring Well for Chronic Lowering of Groundwater Levels
RMW-WQ	Representative Monitoring Well for Degraded Water Quality
RP	Reference Point
RPE	reference point elevation
RWQCB	Regional Water Quality Control Board
SAGBI	Soil Agricultural Groundwater Banking Index
SB	Senate Bill
SCEP	Stakeholder Communication and Engagement Plan
SCS	Soil Conservation Service
SDAC	Severely Disadvantaged Communities
SDWA	Safe Drinking Water Act
SDWIS	Safe Drinking Water Information System
SGMA	Sustainable Groundwater Management Act
SIMETAW	Simulation of Evapotranspiration of Applied Water
SJVAPCD	San Joaquin Valley Air Pollution Control District
SMARA	Surface Mining and Reclamation Act
SMB	soil moisture budget accounting model
SMCs	Sustainable Management Criteria

SSURGO	Soil Survey Geographic Database
SVOCs	semi-volatile organic compounds
SWP	State Water Project
SWRCB	State Water Resources Control Board
TCCWD	Tehachapi-Cummings County Water District
TCF	trend continuation factor
TCWD	Tejon-Castac Water District
TDS	total dissolved solids
TNC	The Nature Conservancy
TRC	Tejon Ranch Company
TRCC	Tejon Ranch Commerce Center
ug/L	micrograms per liter
UNAVCO	University Navstar Consortium
UR	Undesirable Result
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
VCF	variability correction factor
VIC	variable infiltration capacity
VOCs	volatile organic compounds
WAPA	Western Area Power Administration
WB	water budget
WCRs	Well Completion Reports
WDRs	Waste Discharge Requirements
WMP	Water Management Plan
WMW	Wetter/Moderate Warming
WQO	Water Quality Objective
WRMWSD	Wheeler Ridge-Maricopa Water Storage District
WWF	White Wolf Fault
WWGFM	White Wolf Groundwater Flow Model
WY	Water Year

EXECUTIVE SUMMARY

§ 354.4. Each Plan shall include the following general information:
(a) An executive summary written in plain language that provides an overview of the Plan and description of groundwater conditions in the basin.

ES.1. Introduction

On 16 September 2014, the California legislature enacted the Sustainable Groundwater Management Act (SGMA) whose primary purpose is to achieve and/or maintain sustainability within the state's high and medium priority groundwater basins. Key tenets of SGMA are the concept of local control, use of best available data and science, and active engagement and consideration of all beneficial uses and users of groundwater. As such, SGMA empowers certain local agencies to form Groundwater Sustainability Agencies (GSAs) whose purpose is to manage basins sustainably through the development and implementation of Groundwater Sustainability Plans (GSPs). Under SGMA, GSPs are required to contain certain elements, the most significant of which include: a Sustainability Goal; a description of the area covered by the GSP ("Plan Area"); a description of the Basin Setting, including the hydrogeologic conceptual model, historical and current groundwater conditions, and a water budget; locally-defined sustainability criteria; networks and protocols for monitoring sustainability indicators; and a description of projects and/or management actions that will be implemented to achieve or maintain sustainability. SGMA also requires a significant element of stakeholder outreach to ensure that beneficial uses and users of groundwater are given the opportunity to provide input into the GSP development and implementation process.

This GSP has been prepared by the White Wolf GSA and covers the entirety of the San Joaquin Valley Groundwater Basin - White Wolf Subbasin (also referred to herein as "the Basin"), California Department of Water Resources (DWR) Basin No. 5-022.18 (see **Figure ES-1**). The Basin was officially recognized by DWR in 2016 and was subsequently classified as a medium priority basin (DWR, 2019). The Basin is not subject to critical conditions of overdraft. As such, the Basin is required to develop a GSP by 2022 and achieve sustainability by 2042.

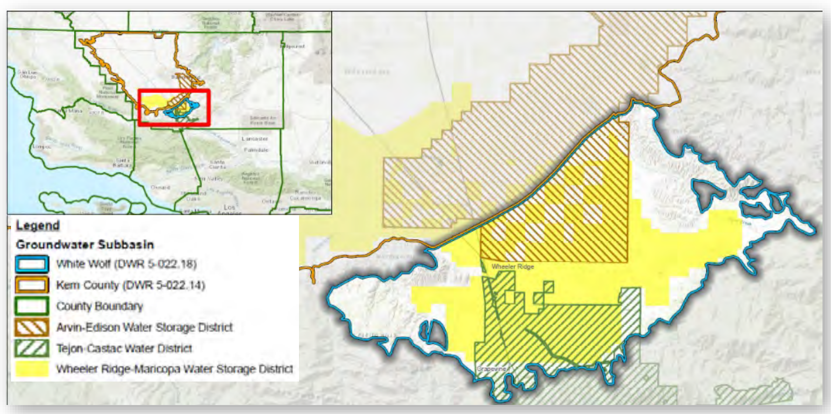


Figure ES-1. White Wolf Subbasin Location

The White Wolf GSA overseeing the Basin is the exclusive GSA for the Basin. The White Wolf GSA was formed in 2017 upon adoption of a Joint Powers Agreement (JPA) and is governed by a seven-member

Board of Directors which includes two (2) representatives of each member district: Arvin-Edison Water Storage District (AEWSD), Tejon-Castac Water District (TCWD), and Wheeler Ridge-Maricopa Water Storage District (WRMWSD). Kern County is represented as the seventh, non-voting, member of the Board.

This GSP has been developed to meet SGMA regulatory requirements[1] while reflecting local conditions and preserving local control over groundwater resources. This GSP provides a path to maintain and document sustainable groundwater management within 20 years following GSP adoption, thereby promoting the long-term sustainability of locally-managed groundwater resources.

ES.2. Sustainability Goal

The White Wolf GSA adopted the following Sustainability Goal for the Basin: *Cooperatively continue to maintain an economically-viable groundwater resource within the White Wolf Subbasin that supports the current and future beneficial uses and users of groundwater by utilizing the area's groundwater resources within the local sustainable yield and avoiding undesirable results*.

ES.3. Plan Area

The Basin encompasses 107,532 acres in the southernmost region of the San Joaquin Valley Groundwater Basin within Kern County, California. The Basin is bordered on the north by the Kern County Subbasin, with no adjacent basins located to the south, east, or west.

Irrigated agriculture is the primary developed land use and encompasses approximately 34,200 acres within the Basin (32% of the total Basin acreage). Irrigated lands are predominantly vineyards, deciduous fruits and nuts, and truck nursery and berry crops and are supplied by a mixture of groundwater and/or local and imported surface water (see **Figure ES-2**). Other developed areas include the Tejon Ranch Commerce Center (TRCC) and quarry, mining, and oil field lands which collectively cover approximately 2,000 acres (2% of the total Basin acreage). Finally, undeveloped lands which are either native lands, pasture lands, or conservation and preserve lands cover approximately 71,400 acres (66% of the total Basin acreage).

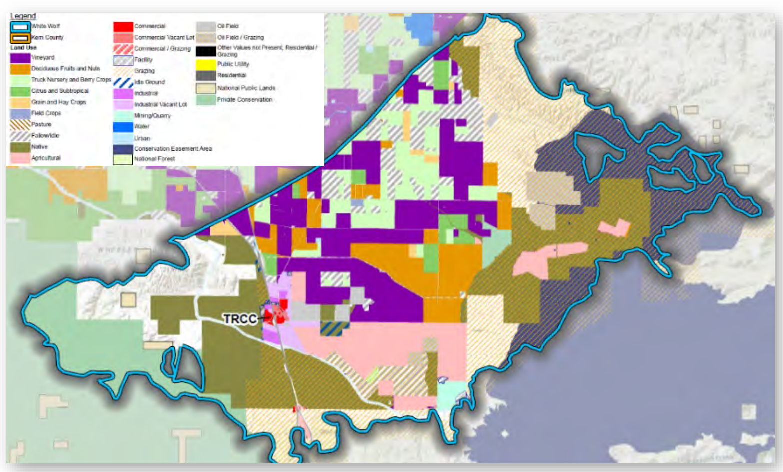


Figure ES-2. Current Land Use

Although there are no incorporated cities

[1] Regulations for Groundwater Sustainability Plan (GSP) development are contained within Title 23 of the California Code of Regulations (CCR) Division 2 Chapter 1.5 Subchapter 2. https://www.waterboards.ca.gov/laws_regulations/docs/wrregs.pdf

within the Basin, there are some small domestic well owners and three public water systems which provide potable water supply through surface water and/or groundwater sources. Public water system groundwater consumption is minimal, amounting to less than approximately 100 acre-feet per year (AFY).

There are two small regions within the Basin that qualify as Disadvantaged Communities (DAC) or Severely Disadvantaged Communities (SDAC). Both areas are lightly populated (i.e., it is estimated that approximately 390 people currently live within the Basin [DWR, 2019]).

ES.4. Stakeholder Outreach Efforts

The White Wolf GSA adopted a Stakeholder Communication and Engagement Plan (SCEP) in June 2018 to fulfill SGMA notice and communications requirements as well as to encourage and achieve active engagement and input of all beneficial users of groundwater within the Basin. The goal of the outreach efforts described in the SCEP is to encourage open and transparent engagement by diverse stakeholders, and public participation has been welcomed throughout the GSP development process. Venues for stakeholder engagement and input have included: Stakeholder Workshops, GSA Board meetings, and direct outreach such as distribution and collection of a Stakeholder Survey, various letters sent to the public water systems, and distribution of flyers inviting participation in Stakeholder Workshops. The White Wolf GSA's website (http://whitewolfgsa.org) also contains materials presented at meetings as well as a schedule for upcoming meetings and other workshops open to the public.

ES.5. Hydrogeologic Conceptual Model

Located at the southern end of California's Central Valley, the Basin is a structural trough filled with continental and shallow marine sedimentary deposits and bounded by three mountain ranges to the south, east, and west. The Basin is located in a tectonically active region and contains both high-angle and oblique-slip faults and surrounding thrust faults. The White Wolf Fault (WWF) system forms the northern Basin boundary. The WWF is a southward-dipping reverse fault whose displacement plane extends to the ground surface and restricts groundwater flowing northward out of the Basin. The Springs Fault creates an interior subdivision of the Basin by creating a partial hydraulic barrier to flow in the southeastern corner of the Basin, effectively separating the Principal Aquifer from the shallow aquifer system that supports groundwater dependent ecosystems (GDEs).

Structurally, pre-tertiary bedrock forms the bottom of the Basin. However, many of the geologic formations encountered between the land surface and bedrock have not been accessed for groundwater production based on depth, quality and/or hydraulic properties. The uppermost formations of the Basin include the: (1) shallow quaternary alluvium, (2) Kern River Formation, (3) Chanac Formation, and (4) Santa Margarita Formation. Depending upon the specific location within the Basin, the base of fresh water is located in either the undifferentiated Kern River/Chanac or Santa Margarita formations. Virtually all groundwater pumping in the Basin occurs in the formations above the Santa Margarita and therefore, the purposes of this GSP, the effective bottom of the Basin (i.e., the "Principal Aquifer") is defined as the deposits consisting of the Shallow Alluvium, Kern River Formation, and Chanac Formation (see **Figure ES-3**). A shallow water-bearing zone located within alluvium south of the Springs Fault is hydraulically isolated from the Principal Aquifer in the north and central portion of the Basin. There are no known regional aquitards present in the Principal Aquifer although a clay-rich transition zone occurs between the Chanac and Santa Margarita formations and may act as a confining layer to the Santa Margarita Formation.

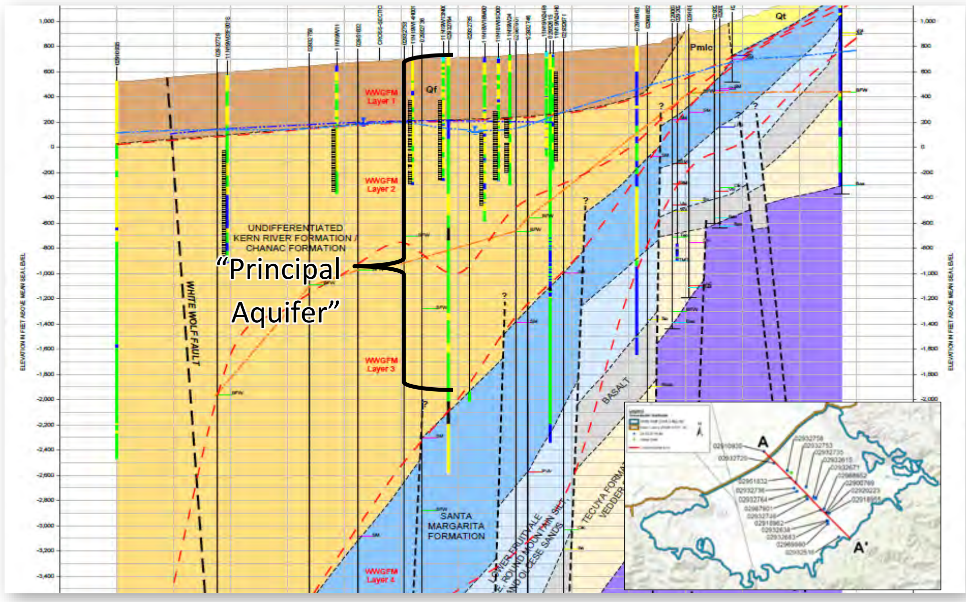


Figure ES-3. Cross Section A

The primary use of groundwater from the Principal Aquifer is to supply irrigated agriculture, and the density of wells is greatest in the central and northern parts of the Basin where agricultural development has occurred. Soils in the Basin are relatively coarse, with the highest infiltration/recharge potential located in the central part of the Basin. Sources of recharge include percolation of applied irrigation water (local, imported and groundwater), percolation of streamflow from surrounding watersheds, percolation of water conveyance and distribution system leakage, percolation of precipitation, and percolation of municipal and industrial (M&I) effluent. Sources of discharge include groundwater pumping for agricultural use, a small volume of groundwater pumping for domestic and M&I uses, groundwater flow across the WWF, and discharges to and/or shallow evaporation from springs and shallow groundwater located south of the Springs Fault.

Imported surface water is distributed primarily to agricultural lands within the Basin, with some supply meeting potable water demands of the TRCC. Collectively, AEWSD, TCWD, and WRMWSD import water from the State Water Project (SWP), Central Valley Project (CVP), Kern Water Bank, Kern River, and other sources. Additionally, at least one landowner in the Basin has developed local surface water sources to supply agricultural irrigation.

ES.6. Current Groundwater Conditions

Information on the Basin's current groundwater conditions with respect to the six "Sustainability Indicators" defined under SGMA are presented in this GSP and include the following:

- Chronic lowering of groundwater levels
- Reduction in groundwater storage
- Seawater intrusion
- Degraded water quality
- Land subsidence
- Depletion of interconnected surface water

Except where data are not available, "current conditions" refers to Basin conditions documented between water year (WY) 2015 (i.e., the effective date of SGMA) and 2019.

Water Levels: Groundwater levels are presented using contour maps depicting seasonal high (spring) and seasonal low (fall) conditions for 2015 and 2019, as well as hydrographs from wells located throughout the Basin that have extended historical records. Generally, the available data indicates that groundwater flows from the southeast to the northwest, across the WWF and into the adjacent Kern County Subbasin within the AEWSD and WRMWSD service areas. Long term trends in groundwater levels correlate with the amount of imported surface water delivered to the Basin. From the 1950s to 1970s, groundwater levels declined—in some cases more than 200 feet. Around 1975, groundwater levels began to recover (AEWSD began importing surface water into the Basin for irrigated agriculture in 1966 and WRMWSD in 1975). By 2007, most of the decline seen prior to the 1970s had been recovered. Recent hydrograph data exhibit relative water level increases throughout the 1990s, water level stability throughout the early 2000s, and water level declines starting around 2010 which have continued in most wells throughout 2019. Current depth to groundwater in the Principal Aquifer ranges from approximately 70 to 980 feet below ground surface (ft bgs), averaging around 500 ft bgs (see **Figure ES-4**). Although data are only available for 2021, depths to water of around 20 to 30 ft bgs were measured in newly-installed shallow wells located immediately south (upgradient) of

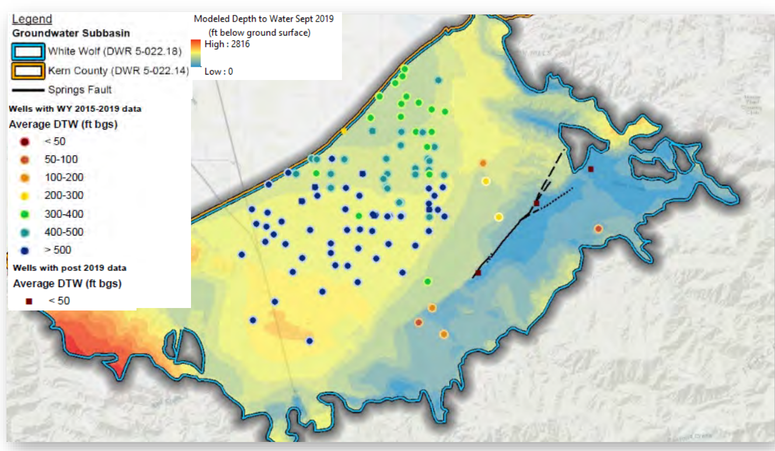


Figure ES-4. Current depth to groundwater

the Springs Fault suggesting the fault acts as a partial barrier to groundwater flow.

Groundwater Storage: Changes in groundwater storage over selected time periods were calculated by comparing groundwater levels between seasonal high periods. Between 1975 and 2017, groundwater levels increased in 90% of the irrigated portion of the Basin. Over the 20-year historical period (WY 1995-2014), groundwater levels also increased; however, over the current conditions period (WY 2015-2019), most of the Basin has seen a decline in groundwater levels. Furthermore, the calibrated White Wolf Groundwater Flow Model (WWGFM) estimates monthly changes in groundwater storage (discussed below in ***Section ES.7 Water Budget***), which range from -38,800 to -1,500 AFY between current condition seasonal highs (March 2015-February 2019).

Water Quality: Agricultural use is the dominant beneficial use within the Basin and the observed groundwater quality is generally suitable for agricultural uses. Potential constituents of concern have been identified based on a water quality exceedance of either the primary maximum contaminant level (MCL), secondary MCL, or water quality objective in more than 15% of the wells sampled between WY 2015-2019. These constituents include arsenic, nitrate, selenium, total dissolved solids (TDS), sulfate, iron, boron, and sodium, many of which are naturally-occurring. Additionally, 1,2,3-trichloropropane (1,2,3-TCP) has been identified as a potential emerging constituent of concern. Statistical analyses on the limited available water quality data suggest that there are very few wells exhibiting statistically significant water quality trends, with only nitrate, TDS, and sodium exhibiting an increasing trend.

Land Subsidence: Very little subsidence has occurred within the Basin over both historical (1949-2005) and recent (2015-2021) timeframes. Subsidence has the potential to affect critical infrastructure including water conveyance systems (i.e., California Aqueduct and 850 Canal). Due to the geologic nature of the Basin (e.g., no thick clay beds), so long as groundwater levels remain above levels observed in the 1970s (i.e., the historical low), significant and unreasonable additional land subsidence should not occur. Therefore, land subsidence remains an issue of relatively low concern in the Basin.

Seawater Intrusion: The Basin is located far from coastal areas, and therefore seawater intrusion is not considered to be a threat to groundwater resources.

Interconnected Surface Water: Although ten streams enter the Basin from surrounding watersheds, most are primarily ephemeral with infrequent streamflow caused by storm runoff. Due to the deep depth to groundwater in the Principal Aquifer, these stream reaches are considered disconnected from the Principal Aquifer.

The exception is an area near the Springs Fault, where groundwater appears to back up against the fault and rise to the surface. This area is upslope of the developed portion of the Basin and is primarily natural conservation land with very little pumping in the vicinity. Approximately 435 acres of GDEs have been identified through a field and desktop study in this area that appear to be supported by a shallow water-bearing zone upgradient of the Springs Fault (see **Figure ES-5**). Subsequent monitoring has indicated that the GDEs and interconnected surface waters in this area are likely disconnected from the Principal Aquifer due to hydraulic restrictions caused by the Springs Fault.

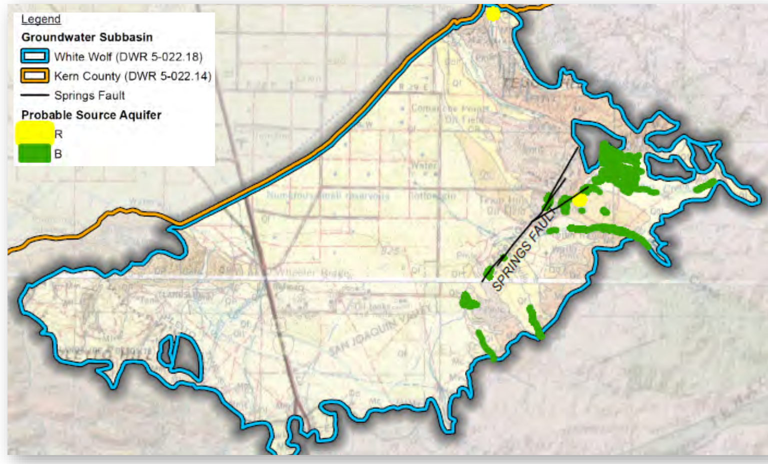


Figure ES-5. GDE Areas of Interest

ES.7. Water Budget

To generate a water budget accounting for the volume of groundwater entering and leaving the Basin for historical, current, and projected future conditions, a Basin-specific numerical groundwater flow model, the WWGFM, was developed. A historical water budget period (WY 1995-2014) represents 20 years of historical hydrology and was used for calibration; a current conditions water budget period representing average conditions for the recent 5-year period (WY 2015-2019) was used to support model validation against recent data; and a 53-year projected water budget period (WY 2020-2072) was used to support sustainability planning.

Imported surface water supplies averaged approximately 68,100 AFY over the historical water budget period, which decreased to approximately 48,500 AFY over the current water budget period. Approximately 85% of inflows to the groundwater system are attributed to the infiltration of applied water, precipitation, or leaking distribution and conveyance channels under both historical and current conditions. Approximately 77% of outflows from the groundwater system are attributed to groundwater pumping under historical conditions, which increased to approximately 84% under current conditions (see **Figure ES-6**).

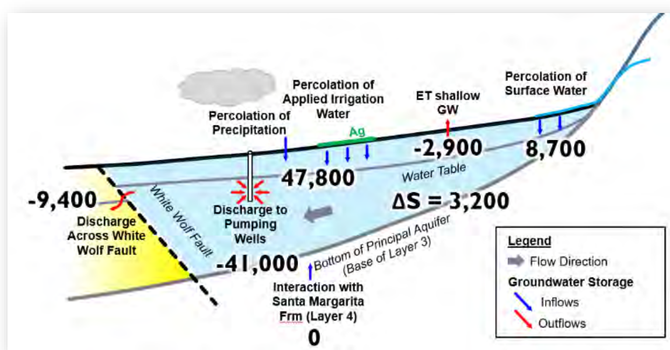


Figure ES-6. Water Budget

Over the historical period WY 1995-2014, there were more inflows to the groundwater system than outflows resulting in a net accretion of groundwater storage of approximately 3,200 AFY. However, over the current period WY 2015-2019, there were more outflows from the groundwater system than inflows resulting in a net decrease in groundwater storage of approximately 20,300 AFY.

The Basin's sustainable yield was conservatively estimated using model-calculated groundwater pumping and change in storage to quantify the volume of water that, if pumped over the water budget period of interest, would have resulted in zero change in storage due to pumping. The historical range in sustainable yield is 38,200 AFY to 47,200 AFY and is likely a reasonably conservative estimate for future planning purposes. Furthermore, model results confirmed that under the Projected 2030 Climate Change Scenario, no Undesirable Results for Chronic Lowering of Groundwater Levels are projected to occur.

Three projected water budget scenarios were developed using repeated historical hydrology, current (2019) land use, projected climate change factors, and projected imported surface water supplies: (1) a Baseline Scenario, (2) a 2030 Climate Change Scenario, and (3) a 2070 Central Tendency Climate Change Scenario. For the Baseline condition, the long-term average change in groundwater storage was approximately -4,600 AFY. The projected deficit under the 2030 Climate Change Scenario (-8,400 AFY) was used as the basis to develop Projects and/or Management Actions (P/MAs) for the Basin.

Limitations for the water budget can be attributed to uncertainty in simulated stresses (i.e., recharge and groundwater pumping), modeled water transmitting and storage properties, and data gaps. The WWGFM will be updated and recalibrated, as needed, throughout GSP implementation as additional data become available.

ES.8. Sustainable Management Criteria

Sustainable Management Criteria (SMCs) are the metrics by which groundwater sustainability is judged under SGMA. Key terms related to SMCs under SGMA include the following:

Undesirable Results: Undesirable Results (URs) are the significant and unreasonable effects, for any of the six Sustainability Indicators defined under SGMA, caused by groundwater conditions throughout the Basin.

Minimum Thresholds: Minimum Thresholds (MTs) are the numeric criteria for each Sustainability Indicator that, if exceeded in a locally-defined combination of representative monitoring sites, may constitute an Undesirable Results for that indicator. Where appropriate, and as allowed under the California Code of Regulations Title 23 (23 CCR), the MTs for certain Sustainability Indicators have been set using groundwater levels as a proxy.

Measurable Objectives: Measurable Objectives (MOs) are specific, quantifiable goals for the maintenance or improvement of groundwater conditions. MOs use the same units and metrics as the MTs and are thus directly comparable.

Interim Milestones: Interim Milestones are a set of target values representing measurable groundwater conditions in increments of five (5) years over the 20-year statutory deadline for achieving sustainability.

Chronic Lowering of Groundwater Levels is arguably the most fundamental Sustainability Indicator, as it can influence several other key Sustainability Indicators, including Reduction of Groundwater Storage, Land Subsidence, and possibly Depletions of Interconnected Surface Water and Degraded Water Quality. The SMCs for Chronic Lowering of Groundwater Levels were established at 14 Representative Monitoring Wells for Chronic Lowering of Groundwater Levels (RMW-WLs) based on spatial and temporal analysis of long-term groundwater level data at the RMW-WLs (many of which have long-term records). Development of the SMCs considered potential impacts to beneficial users, adjacent basin SMCs, projected future Basin conditions, and proximity to critical infrastructure. SMCs were evaluated against known well construction data to assess potential impacts on existing wells (i.e., potential dewatering).

Sustainability Indicator	Undesirable Results Definition	Undesirable Results Criteria	MT	MO
Chronic Lowering of Groundwater Levels	If and when a chronic decline in groundwater levels in the Principal Aquifer negatively affects the reasonable and beneficial use of, and access to, groundwater for beneficial users and uses within the Basin, including complete dewatering of more than 25% of existing wells.	Groundwater levels in the Principal Aquifer decline below the established MTs in 40% or more of the RMW-WLs over four consecutive seasonal measurements.	Consideration of groundwater level trend between WY 2010-2019 extended 10 years, historical low groundwater levels, and variability correction factor (25%).	Lower of either Fall 2015 or Fall 2019 groundwater level.

Significant Groundwater Storage exists within the Basin and is closely linked to groundwater levels. It is estimated that if Basin groundwater levels reached the MTs for Chronic Lowering of Groundwater Levels in all RMW-WLs, the usable storage in the Basin would be reduced by approximately 19%. As such, it was determined to be sufficiently protective to define the SMCs for Reduction of Groundwater Storage based on the use of SMCs for Chronic Lowering of Groundwater Levels as a proxy.

Sustainability Indicator	Undesirable Results Definition	Undesirable Results Criteria	MT	MO
Reduction of Groundwater Storage	If and when a reduction in storage in the Principal Aquifer negatively affects the long-term viable access to groundwater for the beneficial users and uses within the Basin, including a reduction in usable groundwater storage of more than 20% relative to the Fall 2015 groundwater storage volume.	MT exceedance for Chronic Lowering of Groundwater Levels used as a proxy.	Chronic Lowering of Groundwater Levels used as a proxy.	Chronic Lowering of Groundwater Levels used as a proxy.

The SMCs for Degraded Water Quality are defined at four Representative Monitoring Wells for Degraded Water Quality (RMW-WQ) for arsenic, nitrate, and selenium. The SMCs are tied to regulatory water quality standards in that the MT is set at the primary Maximum Contaminant Levels (MCLs) set by the United States Environmental Protection Agency (USEPA) and the State of California Environmental Protection

Agency (CalEPA) and the MO is set to 75% of the primary MCL. Due to lack of concurrent groundwater level and water quality data, a causal nexus between measured constituent concentrations and water levels and groundwater management actions within the Basin has not been established based on available data. On-going monitoring for all potential constituents of concern will continue, and if a nexus between these constituent concentrations and water levels and groundwater management actions is established, then the SMCs for Degraded Water Quality will be revisited.

Sustainability Indicator	Undesirable Results Definition	Undesirable Results Criteria	MT	MO
Degraded Water Quality	If and when water quality conditions of the Principal Aquifer are degraded as a result of SGMA-related groundwater management activities such that they negatively impact the long-term viability of the groundwater resource for beneficial users and uses, including a regional increase in concentrations of identified constituents of concern above state and federal regulatory thresholds.	MTs are exceeded for any of the identified constituents of concern in 25% or more of the RMW-WQs for two (2) consecutive years as a result of SGMA-related groundwater management activities.	Arsenic: 0.01 mg/L Nitrate as N: 10 mg/L Selenium: 0.05 mg/L	Arsenic: 0.0075 mg/L Nitrate as N: 7.5 mg/L Selenium: 0.0375 mg/L

Minimal Land Subsidence has been observed historically in the Basin. Any future subsidence would be a result of compaction of interbedded clay units due to decreasing water levels and would have the most impact to the Basin's critical infrastructure for water conveyance (i.e., the California Aqueduct and the 850 Canal). Therefore, subsidence is closely linked to groundwater levels and SMCs are based on the use of SMCs for Chronic Lowering of Groundwater Levels as a proxy. Specifically, the MT for Chronic Lowering of Groundwater Levels for all RMW-WLs within 1 mile of critical infrastructure was set to historic low groundwater levels. Unless groundwater levels decline below this point, no significant and unreasonable additional subsidence is anticipated to occur.

Sustainability Indicator	Undesirable Results Definition	Undesirable Results Criteria	MT	MO
Land Subsidence	If and when land subsidence due to groundwater level declines in the Principal Aquifer negatively affects the ability to use existing critical infrastructure within the Basin, including subsidence-related damage to critical water conveyance infrastructure (i.e., the California Aqueduct and the 850 Canal), resulting in a loss of functional capacity of the infrastructure that prevents conveyance of available volumes of water that could otherwise be conveyed if the subsidence had not occurred.	MT exceedance for Chronic Lowering of Groundwater Levels used as a proxy.	Historical low groundwater levels for RMW-WLs located within 1-mile of critical infrastructure.	Lower of either Fall 2015 or Fall 2019 groundwater level.

GDEs continue to be investigated, are located in natural areas south of the Spring Fault, and are grouped under the Interconnected Surface Water Sustainability Indicator. GDEs are reliant on shallow groundwater within rooting depths, and as such groundwater levels were used as a proxy to develop SMCs. Although very limited monitoring data is available to date, preliminary SMCs have been developed through temporal analysis of the limited groundwater level data from June 2021 at the three Representative Monitoring Wells for Depletions of Interconnected Surface Water (RMW-ISWs). Preliminary data suggests the Springs Fault acts a partial hydraulic barrier separating the shallow water-bearing zone upgradient of the fault from the Principal Aquifer. Ongoing monitoring will be crucial to further refine the conceptual understanding of the drivers of conditions in this shallow groundwater system, and future GSP updates will appropriately consider whether revisions to SMCs for this Sustainability Indicator are warranted.

Sustainability Indicator	Undesirable Results Definition	Undesirable Results Criteria	MT	MO
Depletions of Interconnected Surface Water	If and when the health of the GDEs is adversely impacted by lowering of groundwater levels as a result of SGMA-related groundwater management activities in the Principal Aquifer, rather than effects of natural or climactic processes and/or unfavorable hydrologic conditions, including a 30% reduction of, or visual impact to, the health of GDEs based on their conditions observed during 2018 through 2020 that can be directly attributed to Principal Aquifer pumping-related lowering of groundwater levels rather than the effects of natural or climatic processes.	Groundwater levels in one or more of the RMW-ISWs exceeds (falls below) their MTs over four consecutive seasonal measurements as a result of SGMA-related groundwater management activities.	Lower of June groundwater level trend extended to end of October or 30 ft below ground surface (typical deepest rooting depths).	June groundwater level trend extended to end of October.

Seawater Intrusion is not considered a threat to groundwater resources within the Basin due to its considerable isolation from any oceans, bays, or other saltwater bodies of water.

Sustainability Indicator	Undesirable Results Definition
Seawater Intrusion	No Undesirable Results definition. Not applicable to the Basin due to geographic distance from the ocean.

ES.9. Monitoring Network

The objectives of the Basin's SGMA Monitoring Network are to: (1) collect sufficient data for the assessment of the Sustainability Indicators relevant to the Basin, (2) evaluate potential impacts to the beneficial uses and users of groundwater, and (3) assess the effectiveness of the P/MAs implemented by the White Wolf GSA. The proposed SGMA Monitoring Network was developed to ensure sufficient spatial distribution and spatial density. The network consists of 14 RMW-WLs for monitoring groundwater levels and (by proxy) groundwater storage, four RMW-WQ for monitoring groundwater quality, five RMW-WLs for monitoring land subsidence by proxy, and three RMW-ISWs for monitoring GDEs and ISW by proxy (see **Figure ES-7**). Furthermore, planned monitoring for each Sustainability Indicator includes additional supplemental monitoring sites and/or data sources that will be used for ongoing data collection and analysis and to inform future sustainability planning (for example, the White Wolf GSA plans to establish land surface monitoring along the 850 Canal for protective measures). The SGMA Monitoring Network supplements other monitoring networks and programs in the Basin such as the former DWR California Statewide Groundwater Elevation Monitoring (CASGEM), AEWSD's and WRMWSD's semiannual groundwater monitoring program, public water system reporting to the Division of Drinking Water, monitoring conducted in support of the Irrigated Lands Regulatory Program (ILRP), DWR subsidence monitoring along the California Aqueduct, etc.

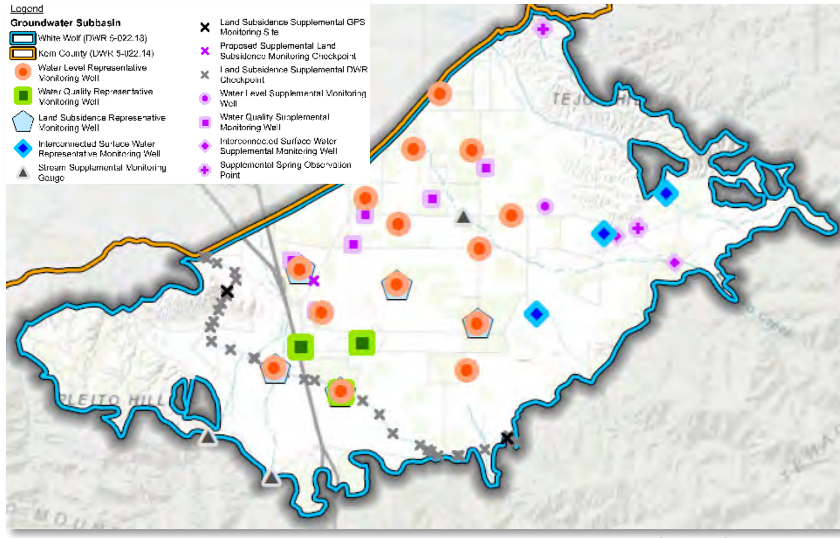


Figure ES-7. SGMA Monitoring Network and Supplemental Monitoring Sites

Data collected from the SGMA Monitoring Network (and the additional monitoring sites as applicable) will be stored and managed in the Basin's Data Management System (DMS). Data collected for the SGMA Monitoring Network will be reported to DWR in accordance with 23 CCR § 354.40. These data and that collected from other monitoring programs may be used to support compliance with the 23 CCR regarding Annual Reporting or as otherwise deemed necessary for subsequent GSP updates.

ES.10. Projects and Management Actions

Maintaining sustainability in the Basin will require implementation of a suite of P/MAs to address projected groundwater storage deficits and to avoid URs. As such, a portfolio of 24 P/MAs has been identified, each with specific expected benefits, implementation triggers, and costs. Each GSA member district has identified P/MAs, some combination of which will be implemented. At this time, the White Wolf GSA acknowledges that details pertaining to which P/MAs will ultimately be initiated, P/MA timing, projected benefits, payments and cost allocations, etc. will be negotiated as part of P/MA and GSP implementation.

A preliminary "glide path" (see **Figure ES-8**) has been developed which results in closing the estimated projected future groundwater storage deficit under 2030 Climate Change and approximately 64% of the

RMW-WLs meeting their MOs by Spring 2042. Accelerated implementation of P/MAs will be triggered if observed groundwater conditions deteriorate, as measured against defined SMCs at the RMW-WLs.

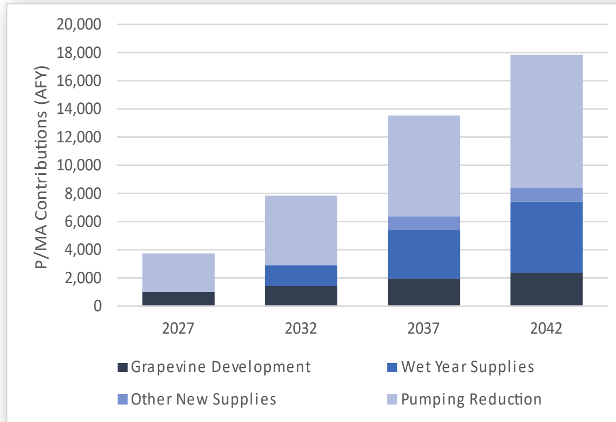


Figure ES-8. "Glide Path" for P/MA Implementation

Projects within the P/MA portfolio focus on supply augmentation and the primary expected benefit. These projects are grouped into the following categories (1) develop or obtain new and/or wet year supplies; (2) recapture cross-boundary flows; (3) expand in-lieu recharge; and (4) increase surface storage capacity and/or delivery flexibility. Management Actions within the portfolio focus on demand reduction as their primary expected benefit. Finally, "Other" P/MAs have been identified which have implications for other P/MAs or secondary benefits.

Results from the WWGFM Projected 2030 Climate Change scenario with P/MAs indicate that P/MA implementation along the preliminary "glide path" will successfully achieve sustainability and avoid Undesirable Results for Chronic Lowering of Groundwater Levels (and by proxy for most of the other applicable Sustainability Indicators). The glide path provides a general guide to how quickly these benefits are to be realized (see **Figure ES-9**). However, the exact schedule and order of implementation is not known, and further analysis will be conducted to prioritize the P/MAs in consideration of factors including permitting, engineering feasibility, cost effectiveness and other factors. Additional stakeholder outreach efforts will be conducted prior to and during P/MA implementation.

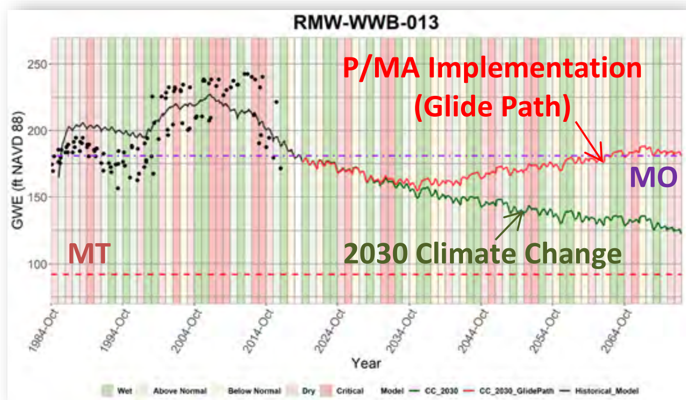


Figure ES-9. Projected Water Level Benefits as a Result of P/MA Implementation

ES.11. GSP Implementation

Key GSP implementation activities to be undertaken by the White Wolf GSA over the next five (5) years include:

- Monitoring and data collection for SGMA compliance;
- Data gap filling efforts;
- Continued outreach and engagement with stakeholders;

- Inter-basin and intra-basin coordination;
- Annual reporting;
- Response to DWR comments on this GSP;
- Evaluation of and updates to the GSP, as appropriate, as part of the required periodic evaluations (i.e., GSP "five-year updates");
- Enforcement and response actions, as necessary; and
- P/MA implementation and grant application(s).

ES.12. GSP Implementation Costs and Funding

Costs to implement this GSP can be divided into several groups, as follows:

1. Costs of monitoring, data collection, and data gap filling;
2. Costs associated with stakeholder outreach and coordination;
3. Costs associated with reporting;
4. Costs of enforcements and response actions; and
5. Costs to implement P/MAs, including capital/one-time costs and ongoing costs.

Costs associated with continued GSA activities (groups 1 through 4) are estimated to be approximately $295,000 per year (range of $201,000 to $443,000), not including White Wolf GSA and member district staff time. At this time, the White Wolf GSA acknowledges that details pertaining to projected cost allocations, etc. need to be negotiated as part of GSP and P/MA implementation. Furthermore, estimated annual costs for individual P/MAs (group 5) will primarily be determined in the future. The White Wolf GSA will likely meet the estimated costs through a combination of contributions from landowners, grant funding, if available, and through rate payers.

ES.13. Conclusion

The passage of SGMA in 2014 ushered in a new era of groundwater management in California. The law and regulations emphasize the use of best available science, local control and decision making, and active engagement of affected stakeholders. Because of the breadth and scope of the groundwater sustainability problem in California and the legislative and regulatory response to it, SGMA presents significant challenges both for local implementing agencies and groundwater users alike. Maintaining sustainability in the face of uncertain future water supply conditions while addressing and balancing the needs of all beneficial uses and users of groundwater will require significant effort, creative solutions, and unprecedented collaboration. The White Wolf GSA recognizes the importance of maintaining groundwater sustainability for the Basin. Therefore, as the implementing agency, the White Wolf GSA is committed to facing these challenges in a manner that upholds the interests of local landowners and constituents.

INTRODUCTION

1. PURPOSE OF THE GROUNDWATER SUSTAINABILITY PLAN

The purpose of this Groundwater Sustainability Plan (GSP or Plan) is to meet the regulatory requirements set forth in the three-bill legislative package consisting of Assembly Bill (AB) 1739 (Dickinson), Senate Bill (SB) 1168 (Pavley), and SB 1319 (Pavley), collectively known as the Sustainable Groundwater Management Act (SGMA)[2]. SGMA defines sustainable groundwater management as the "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results". Undesirable results are defined by SGMA as any of the following effects caused by groundwater conditions occurring throughout a basin:

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply;
- Significant and unreasonable reduction of groundwater storage;
- Significant and unreasonable seawater intrusion;
- Significant and unreasonable degraded water quality;
- Significant and unreasonable land subsidence; and/or
- Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

The White Wolf Subbasin has been identified by the California Department of Water Resources (DWR) as a medium priority basin. This GSP has been developed to meet SGMA regulatory requirements by the January 31, 2022 deadline for medium priority basins while reflecting local needs and preserving local control over water resources. This GSP provides a path to maintain and document sustainable groundwater management within 20 years following Plan adoption, and preserves the long-term sustainability of locally-managed groundwater resources.

[2] Nothing in this Groundwater Sustainability Plan (GSP) determines or alters surface water rights or groundwater rights under common law, any provision of law that determines or grants surface water rights, or otherwise (see California Water Code [CWC] § 10720.5(b)). This GSP shall be construed consistent with Section 2 of Article X of the California Constitution, and nothing provided in this GSP modifies rights or priorities to use or store groundwater except as expressly stated in CWC § 10720.5(a).

2. SUSTAINABILITY GOAL

The White Wolf Groundwater Sustainability Agency adopted the following Sustainability Goal for the White Wolf Subbasin:

Cooperatively continue to maintain an economically-viable groundwater resource within the White Wolf Subbasin that supports the current and future beneficial uses of groundwater by utilizing the area's groundwater resources within the local sustainable yield and avoiding undesirable results.

3. AGENCY INFORMATION

§ 354.6. When submitting an adopted Plan to the Department, the Agency shall include a copy of the information provided pursuant to Water Code Section 10723.8, with any updates, if necessary, along with the following information:
(a) The name and mailing address of the Agency.
(b) The organization and management structure of the Agency, identifying persons with management authority for implementation of the Plan.
(c) The name and contact information, including the phone number, mailing address and electronic mail address, of the plan manager.
(d) The legal authority of the Agency, with specific reference to citations setting forth the duties, powers, and responsibilities of the Agency, demonstrating that the Agency has the legal authority to implement the Plan.
(e) An estimate of the cost of implementing the Plan and a general description of how the Agency plans to meet those costs.

3.1. Name and Mailing Address of the Groundwater Sustainability Agency (GSA or Agency)

The White Wolf Groundwater Sustainability Agency (GSA) is the exclusive GSA for the White Wolf Subbasin of the San Joaquin Valley Groundwater Basin (Department of Water Resources [DWR] Basin No. 5-022.18, referred to herein as the "Basin").

The mailing address for the White Wolf GSA is:

4436 Lebec Road
Lebec, CA 93243

3.2. Organization and Management Structure of the GSA

As outlined in the Joint Powers Agreement (JPA) dated 9 May 2017 (***Appendix A***), the White Wolf GSA is governed by seven JPA Board Members. Arvin-Edison Water Storage District (AEWSD), Tejon-Castac Water District (TCWD), and Wheeler Ridge-Maricopa Water Storage District (WRMWSD) each have two votes on the JPA Board and are designated as "voting parties." Kern County is a non-voting Board member and is designated as an "Additional Entity." Information regarding current White Wolf GSA Board members and representatives can be found on the GSA's website at http://whitewolfgsa.org/gsa-board/. Current Board Members include:

- Tito Martinez – Chairman (AEWSD);
- Jeff Giumarra (AEWSD);
- Allen Lyda – Vice-Chair (TCWD);
- George Capello (TCWD);
- Jeff Mettler (WRMWSD);
- Jon Reiter (WRMWSD); and

- Alan Christensen (Kern County)

Each of the voting parties may appoint one or more alternate JPA Board members. As outlined on the White Wolf GSA website (http://whitewolfgsa.org/gsa-board/) AEWSD has appointed ten alternatives, TCWD has appointed one alternative, and WRMWSD has appointed one alternative.

3.3. Plan Manager

The Plan Manager is Angelica Martin, Secretary of the White Wolf GSA. Ms. Martin can be reached at:

Mailing Address:
Angelica Martin
4436 Lebec Road
Lebec, CA, 93243

Phone: (661) 663-4262

Email: amartin@tejonranch.com

3.4. Legal Authority of the GSA

The White Wolf GSA applied for and was granted exclusive GSA status under Sustainable Groundwater Management Act (SGMA) Section 10723(c).

3.5. GSP Implementation Cost Estimate

Direct costs for GSP implementation are estimated to range from $290,000 to $345,000 annually over the next five years, not including GSA and GSA member district personnel time. The White Wolf GSA will likely meet the estimated costs through a combination of contributions from landowners, grant funding, if available, and through rate payers. Detailed information on estimated costs to implement the GSP and the White Wolf GSA's plan to meet those costs is provided in ***Section 19.2 Plan Implementation Costs***.

4. GSP ORGANIZATION

This Groundwater Sustainability Plan (GSP) is organized as follows:

- Section ES provides an **Executive Summary**, or overview, of the GSP.
- Sections 1 through 3 comprise the **Introduction**, including the following sections:
    - Section 1. Purpose of the Groundwater Sustainability Plan
    - Section 2. Sustainability Goal
    - Section 3. Agency Information
    - Section 4. GSP Organization
- Section 5 provides a **Description of the Plan Area**.
- Sections 6 through 10 present the **Basin Setting**, including the following sections:
    - Section 6. Introduction to Basin Setting
    - Section 7. Hydrogeologic Conceptual Model
    - Section 8. Current and Historical Groundwater Conditions
    - Section 9. Water Budget Information
    - Section 10. Management Areas
- Sections 11 through 15 present the **Sustainable Management Criteria** including the following sections:
    - Section 11. Introduction to Sustainable Management Criteria
    - Section 12. Sustainability Goal
    - Section 13. Undesirable Results
    - Section 14. Minimum Thresholds
    - Section 15. Measurable Objectives and Interim Milestones
    - Section 16. Action Plan Related to Minimum Threshold Exceedances
- Section 17 presents the **Monitoring Network**.
- Section 18 presents the **Projects and Management Actions**.
- Section 19 presents **Plan Implementation**.
- **References and Technical Studies** are included at the end of this document.
- Supporting information is provided in **Appendices**.

PLAN AREA

5. DESCRIPTION OF THE PLAN AREA

This section presents a description of the Plan Area and a summary of the relevant jurisdictional boundaries and other key land use features potentially relevant to the sustainable management of groundwater in the White Wolf Subbasin (Basin). This section also describes the water monitoring programs, water management programs, and general plans relevant to the Basin and their influence on the development and execution of this Groundwater Sustainability Plan (GSP).

5.1. Summary of Jurisdictional Areas and Other Features

§ 354.8. Each Plan shall include a description of the geographic areas covered, including the following information:

(a) One or more maps of the basin that depict the following, as applicable:
- *(1) The area covered by the Plan, delineating areas managed by the Agency as an exclusive Agency and any areas for which the Agency is not an exclusive Agency, and the name and location of any adjacent basins.*
- *(2) Adjudicated areas, other Agencies within the basin, and areas covered by an Alternative.*
- *(3) Jurisdictional boundaries of federal or state land (including the identity of the agency with jurisdiction over that land), tribal land, cities, counties, agencies with water management responsibilities, and areas covered by relevant general plans.*
- *(4) Existing land use designations and the identification of water use sector and water source type.*
- *(5) The density of wells per square mile, by dasymetric or similar mapping techniques, showing the general distribution of agricultural, industrial, and domestic water supply wells in the basin, including de minimis extractors, and the location and extent of communities dependent upon groundwater, utilizing data provided by the Department, as specified in Section 353.2, or the best available information.*

(b) A written description of the Plan area, including a summary of the jurisdictional areas and other features depicted on the map.

5.1.1. Plan Area Setting

The Basin encompasses 107,532 acres at the southern end of the San Joaquin Valley Groundwater Basin (see **Figure PA-1**) within Kern County. The entire Basin is covered by the White Wolf Groundwater Sustainability Agency (GSA), which is the exclusive GSA for the Basin. To the north of the Basin lies the Kern County Subbasin of the San Joaquin Valley Groundwater Basin (California Department of Water Resources [DWR] No. 5-022.14); there are no other adjacent groundwater basins directly to the south, east, or west.

5.1.2. Adjudicated Areas, Other Agencies, and Alternative Areas

The Basin is not adjudicated and does not contain any areas covered by an Alternative Plan. Kern County Water Agency's (KCWA) governance areas includes all lands within Kern County, including the Basin.

Therefore, although KCWA is not a JPA member of the White Wolf GSA, it is an Agency located within the Basin.

5.1.3. Jurisdictional Boundaries

The following section describes the jurisdictional boundaries within the Basin. These boundaries include cities, counties, California protected areas, local, state, and federal lands, Native American Tribal communities and lands, disadvantaged communities, and entities with water management responsibilities within the Basin.

5.1.3.1. Cities and Counties

No incorporated cities lie within the Basin; however, the Basin does include the unincorporated communities of Wheeler Ridge and Grapevine (see **Figure PA-1**). The Basin falls entirely within Kern County.

The Basin is located within the Kern County General Plan area, which is discussed in more detail below in ***Section 5.3.1 General Plans and Other Land Use Plans.*** The Kern County General Plan further identifies several Specific Plan areas which cover portions of the Basin, including the Tejon Industrial Complex East, San Emidio New Town, Grapevine[3], Tunis Ridge, Tunis Creek, Tejon Hills, Tejon Creek No. 1, Tejon Creek No. 2, and Commanche. These Specific Plan areas are discussed in more detail below in ***Section 5.3.1 General Plans and Other Land Use Plans***.

5.1.3.2. California Protected Areas, Conservation Easement Areas, and Local, State, and Federal Lands

As shown on **Figure PA-1**, there are two small areas of federally owned lands totaling 330 acres managed by the Bureau of Land Management (BLM) located south of Wheeler Ridge within the foothills of the San Emigdio Mountains. There are no State-owned lands within the Basin.

The southwesterly portion of the Basin includes 10,198 acres of Wind Wolves Preserve which is private conservation land managed by The Wildlands Conservancy. The southeasterly portion of the Basin also contains 18,465 acres of conservation easement lands protected under the Tejon Ranch Conservation Land Use Agreement (TRC, 2008).

5.1.3.3. Native American Tribal Communities and Lands

According to the information made available by DWR[4] in support of GSP development, there are no tribal lands within or in the vicinity of the Basin.

---

[3] The Kern County Interactive GIS Online Mapping Tool calls this "Grapevine Commercial" and shows a different boundary than the Grapevine Specific Plan Boundary mapped in the Grapevine Final Specific and Community Plan (Tejon Ranchcorp, 2016).

[4] SGMA Data Viewer: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer

5.1.3.4. Disadvantaged Communities

DWR presents information regarding U.S. Census Blocks, Tracts and Places that are defined as disadvantaged communities (DAC) or severely disadvantaged communities (SDAC) based on the median household income (MHI) of an area compared to the statewide MHI.[5] DAC communities are those with a MHI that is no more than 40% of the statewide MHI, and SDAC communities are those with a MHI that is no more than 20% the statewide MHI (California Code, Public Resources Code § 75005(g)). **Figure PA-2** shows the DAC/SDAC designations within the Basin based on 2016 MHI from the 2013-2017 American Community Survey 5-Year Estimates. The area located to the west of Interstate-5 (I-5) is considered a SDAC based on the Census Block Group and a DAC based on the Census Tract characterizations. Additionally, a small portion of the unincorporated community of Stallion Springs, which is defined as a SDAC based on the Census Place characterization, is located in the southeastern portion of the Basin in the Tehachapi Mountains. Most of the DAC/SDAC areas within the Basin are lightly populated (i.e., it is estimated that approximately 390 people currently live within the Basin [DWR, 2019]).

5.1.3.5. Entities with Water Management Responsibilities

As shown on **Figure PA-1**, agencies with water management responsibilities within the Basin include Arvin-Edison Water Storage District (AEWSD), Wheeler Ridge-Maricopa Water Storage District (WRMWSD), Tejon-Castac Water District (TCWD), and KCWA[6]. The Tehachapi-Cummings County Water District (TCCWD) is located to the east of the Basin and overlies a very small portion of the Basin in the eastern, undeveloped uplands. During the basin boundary modification process in 2016, TCWD informed TCCWD of the apparent overlap. The TCCWD responded with a letter stating that it had no interest in management of the Basin under the Sustainable Groundwater Management Act (SGMA), and that the apparent overlap was likely a result of imperfect boundary delineation in Geographic Information System (GIS) data layers.[7]

5.1.4. Existing Land Use and Water Use

Table PA-1 and **Figure PA-3** summarize the current (Spring 2019) land use designations within the Basin, based on information provided by DWR and White Wolf GSA member districts. Developed lands defined as either irrigated agricultural areas or urban development areas comprise approximately 36,000 acres within the Basin. Of the developed lands, agriculture is currently the primary land use, with approximately 34,000 acres irrigated for agricultural purposes (**Table PA-1**). Of the irrigated area, 38% is used for cultivation of vineyards (12,974 acres), 26% is used for cultivation of deciduous fruits and nuts (8,738 acres), 11% is used for cultivation of truck nursery and berry crops (3,850 acres), 3% is used for cultivation of citrus trees (1,115 acres), 2% is used for cultivation of grain and hay (675 acres), and 20% is idle agricultural land (6,758 acres). All irrigated crop lands within the Basin are supplied by a mixture of groundwater and/or surface water.

---

[5] Ibid [4]

[6] KCWA governance area includes all lands within Kern County, including the Basin. Therefore, although KCWA is not a JPA member of the White Wolf GSA, it is an entity with water management responsibilities located within the Basin.

[7] TCCWD letter to TCWD, 4 April 2016.

The Tejon Ranch Commerce Center (TRCC), owned and operated by the Tejon Ranch Company (TRC) and served by TCWD, is a large non-agricultural development in the Basin (i.e., the area classified as "Commercial" and "Industrial" on **Figure PA-3**). The Grapevine commercial district located at the junction of I-5 and Grapevine Road is another non-agricultural development in the Basin. TCWD provides potable water service to the TRCC from imported water sources. The TRCC generates wastewater that is treated or reclaimed by TCWD. Treated wastewater either is sent to lined ponds or is used for landscape irrigation purposes.

Undeveloped lands defined as non-irrigated areas cover approximately 71,400 acres within the Basin. As discussed above, the southwesterly portion of the Basin includes 10,198 acres of Wind Wolves Preserve which is private conservation land managed by The Wildlands Conservancy. The southeasterly portion of the Basin also contains 18,465 acres of conservation easement lands protected under the Tejon Ranch Conservation Land Use Agreement (TRC, 2008). Another 330 acres are national public lands managed by BLM. Approximately 49,600 acres of native land in the uplands portion of the Basin are dedicated to grazing with some oil field and mining operations. Finally, a newly developed 700-acre aggregate facility is located near the north side of the Springs Fault.

Table PA-1. Current Land Use Designations

Land Use Category	Total Area (acres)	Percent of Irrigated Agriculture (%)	Percent of Basin Area (%)
	Irrigated Agriculture		
Vineyard	12,974	38%	12%
Deciduous Fruits and Nuts	8,738	26%	8%
Idle	6,758	20%	6%
Truck Nursery and Berry Crops	3,850	11%	4%
Citrus and Subtropical	1,115	3%	1%
Grain and Hay Crops	675	2%	0.6%
Field Crops	69	0.2%	0.06%
Subtotal	*34,177*	--	*32%*
	Developed		
Urban	209		0.2%
Quarry/Mining/Oil Field	1,771		2%
Subtotal	*1,980*		*2%*
	Undeveloped Lands		
Native	21,486		20%
Pasture	26,802		25%
Not classified (assumed native)	23,087		21%
Subtotal	*71,375*		*66%*
Basin Area	***107,532***		

The potable consumption of groundwater in the Basin includes use by domestic well owners and public water systems. Three public water systems were identified within the Basin:

- TCWD is a public water agency providing potable water service from both surface water and groundwater sources (CA1503341) to the TRCC. TCWD owns three wells within the Basin that provide potable groundwater supply[8]; wells are maintained as an emergency backup supply. Groundwater pumping between 2013 and 2019 has been minimal, occurring only during select years, and was approximately 40 AFY, when utilized.[9]
- Tut Brothers Farm #96 is a community water system (CA1500516) whose two active wells supply potable groundwater to approximately 30 residents year-round (Safe Drinking Water Information System [SDWIS], 2018). Groundwater pumping volumes between 2013 and 2019 were typically

[8] TCWD identifies the three wells as domestic wells, with the extractions from two of the wells used for public supply and the extractions from one well used for irrigation.
[9] https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/eardata.html

less than 1 AFY.[10]

- Cuyama Orchards is a water system (CA1503679) whose one active well supplies potable groundwater to approximately eight "non-transient" and 80 "transient" consumers (SDWIS, 2021). Groundwater pumping volumes between 2013 and 2019 were approximately 15 AFY.[11]

To develop a subset of information on private domestic wells, a stakeholder survey was sent out to landowners within the Basin. One stakeholder identified two domestic wells. As discussed in ***Section 5.1.5 Well Density per Square Mile***, there are 20 known wells categorized as domestic or mixed domestic use in the Basin.

5.1.5. Well Density per Square Mile

Figure PA-4 shows the density of wells per square mile within the Basin based on Well Completion Report records compiled by DWR.[12] According to these records, four domestic, 66 production[13], and one public supply well have been installed within the Public Land Survey System (PLSS) sections[14] that fall partially or entirely within the Basin. However, based on White Wolf Data Management System (DMS), 20 domestic or mixed domestic use (i.e., irrigation/domestic or domestic/municipal and industrial [M&I]), 275 production[15], and two public supply wells have been installed within the Basin. Of these wells, eight are identified as abandoned and 25 are identified as inactive. **Figure PA-5** shows the density of wells per square mile within the Basin based on the DMS. A comparison between **Figure PA-4** and **Figure PA-5** shows that the DMS contains much greater well counts, especially for production wells within the Basin.

5.2. Water Resources Monitoring and Management Programs

§ 354.8. Each Plan shall include a description of the geographic areas covered, including the following information:

(c) Identification of existing water resource monitoring and management programs, and description of any such programs the Agency plans to incorporate in its monitoring network or in development of its Plan. The Agency may coordinate with existing water resource monitoring and management programs to incorporate and adopt that program as part of the Plan.

(d) A description of how existing water resource monitoring or management programs may limit operational flexibility in the basin, and how the Plan has been developed to adapt to those limits.

(e) A description of conjunctive use programs in the basin.

[10] Ibid [9]
[11] Ibid [9]
[12] DWR Well Completion Report Map Application website: https://dwr.maps.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37, accessed 10/23/2018.
[13] Production well counts include public supply wells.
[14] Each PLSS represents approximately 1 square mile of area (i.e., 640 acres).
[15] Wells designated with a site use type of industrial, irrigation, stock, or unknown in the White Wolf DMS were assigned to the production category.

5.2.1. Existing Monitoring Programs

Existing groundwater monitoring in the Basin includes:

- The California Statewide Groundwater Elevation Monitoring (CASGEM) Program was established to track long-term groundwater elevation trends in groundwater basins throughout California. The CASGEM program's mission is to establish a permanent, locally-managed program of regular and systematic monitoring in all of California's alluvial groundwater basins. In the Basin, WRMWSD and AEWSD are the CASGEM Monitoring entities. Upon GSP submittal, DWR will transition any CASGEM Monitoring entity within the basin out of CASGEM and into the SGMA monitoring program.
- The Groundwater Ambient Monitoring and Assessment Program (GAMA) monitors groundwater quality trends throughout California.
- The State Water Resources Control Board (SWRCB)'s Division of Drinking Water monitors groundwater quality from public water system wells. There are two small public water system located within the Basin (Tut Brothers Farm #96 and Cuyama Orchards). Additionally, TCWD maintains two wells as emergency backup public water supply.
- WRMWSD and AEWSD each conduct periodic monitoring for groundwater quality in selected wells in their respective areas of the Basin.
- Water quality sampling from three wells within the AEWSD service area for the Irrigated Lands Regulatory Program (ILRP) is overseen by Kern River Watershed Coalition Authority (KRWCA).

CASGEM groundwater elevations (and groundwater elevations from all wells in the WRMWSD and AEWSD monitoring networks) have been used to characterize groundwater level conditions (see ***Section 8.2 Groundwater Elevations and Flow Direction***). Water quality data have been used to identify groundwater quality concerns (see ***Section 8.5 Groundwater Quality Concerns***).

Existing land subsidence monitoring and data in the Basin is available through the following sources:

- University Navstar[16] Consortium (UNAVCO) Plate Boundary Observatory's continuous and conventional Global Positioning System (GPS) subsidence monitoring network. Two GPS sites are located in the Basin.
- Remote sensing studies by the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL).
- DWR's San Luis Field Division and the San Joaquin Field Division conducted a land subsidence study along the California Aqueduct to understand the magnitude, location, and effects of past and present land subsidence (DWR, 2017a). For this study, data from 940 survey benchmarks along the California Aqueduct that have been monitored at 1-year and 7-year intervals by the San Luis Field Division, and 1,009 benchmarks that have been monitored at 3-year and 7-year intervals by the

[16] Navstar is a network of U.S. satellites that provide GPS services.

San Joaquin Field Division were used. Within the Basin, DWR monitors 34 sites along the California Aqueduct.[17] These sites have been surveyed intermittently since 1969, including the most recent surveys completed in 2019. Measurements are ongoing, with DWR continuing to maintain ground-based subsidence monitoring stations along the California Aqueduct and procuring interferometric synthetic aperture radar (InSAR) based subsidence data.

Existing surface water monitoring in the Basin includes:

- Stream monitoring along El Paso Creek under the ILRP overseen by KRWCA from 2015 through current;
- Stream gauging along Salt and Tecuya Creeks installed in 2018 and overseen by WRMWSD from January 2018 through current;
- Stream gauging at points of diversion along El Paso, Grapevine, Tejon, Tunis, Tecuya, Liveoak, and Pastoria creeks collected by TRC from 2008 through current;
- Seasonal peak streamflow measurements collected by Kern County on Grapevine Creek from 2005 to 2015; and
- Peak streamflow measurements performed by the United States Geological Survey (USGS) on Pastoria Creek, El Paso Creek, and Tejon Creek in the late 1970s.

As discussed in ***Section 8.7 Interconnected Surface Water Systems***, to date the stream gauging sites have recorded very limited flows both in magnitude and temporally. Even so, the available streamflow data can be used to supports estimates of the amount of inflow into the Basin from surrounding watersheds and can be used as a comparison with the estimated water budget inflows. A new stream gauging site on El Paso Creek at the Basin boundary and above the point of diversion is planned to be installed by the White Wolf GSA to better quantify flows into the Basin from surrounding watersheds.

Data from the above networks and datasets have been used to characterize the conditions of the Basin and are being incorporated into future monitoring to assess and manage towards sustainability. For example, select wells from the CASGEM monitoring network have been incorporated into the representative monitoring network for the chronic lowering of groundwater levels (RMW-WLs) and as a proxy for the land subsidence and groundwater storage sustainability indicators (see ***Section 17.1.1 Monitoring Network for Chronic Lowering of Groundwater Levels***). Additionally, the two existing UNAVCO GPS stations will be used to monitor land subsidence. The representative monitoring wells for degraded water quality (RMW-WQ) include four public water system wells in the Basin. Finally, data from operating stream gauges will be compiled as part of the monitoring network for depletions of interconnected surface waters.

[17] Only mile markers are included. Duplicates at the same location are removed.

5.2.2. Existing Management Programs

5.2.2.1. Integrated Regional Water Management Plans

The Basin falls within the Tulare Lake Basin portion of the Kern County Integrated Regional Water Management Region (Kern Region) and is therefore included in the March 2020 Kern Integrated Regional Water Management Plan (Kern IRWMP; Provost & Pritchard, 2020). The Kern Region covers approximately 5,690 square miles of Kern County and a small portion of southern Kings County. The Kern Region is separated into nine subregions based on variation in geography, agency boundaries, and water management strategies. These subregions are: (1) Greater Bakersfield, (2) Kern Fan, (3) Mountains/Foothills, (4) Kern River Valley, (5) North County, (6) South County, (7) West Side, (8) KCWA and (9) the County of Kern. The Basin is identified as part of both the South County and Mountains/Foothills subregions (Provost & Pritchard, 2020).

The key issues, needs, challenges, and priorities for the South County subregion, according to the Kern IRWMP (2020), include the following:

- Decreased imported water supply;
- Water quality/groundwater contamination;
- Urban growth encroachment on key recharge areas; and
- Water rights.

The key issues, needs, challenges, and priorities for the Mountains/Foothills subregion, according to the Kern IRWMP (2020), include the following:

- Groundwater overdraft;
- Watershed protection;
- Aging and/or duplicative infrastructure;
- Urban growth and water demand (South Mountains);
- Climate change; and
- Water quality/groundwater contamination.

5.2.2.2. Groundwater Management Plans

Both AEWSD and WRMWSD have existing Groundwater Management Plans (GWMPs). Although this GSP extends and supersedes the groundwater management efforts outlined in the GWMPs, brief summaries of both GWMPs are included below for completeness.

The AEWSD GWMP was developed in 2003 and aimed to implement groundwater management strategies that would maintain high quality and dependable water resources while minimizing negative impacts within the AEWSD service area. Specifically, the AEWSD GWMP (2003) set forth the following groundwater management objectives to guide future water management activities, programs, and projects:

- Water supply reliability;
- Water supply affordability;
- Groundwater overdraft;
- Groundwater quality;
- Compliance with contracts, agreements, laws, and cooperation with other agencies;
- Inelastic land surface subsidence; and
- Groundwater monitoring.

The WRMWSD GWMP was developed in 2007 and aimed to increase reliability and sustainability of water supply by conjunctively integrating groundwater with imported surface water supply. Specifically, the WRMWSD GWMP (2007) set forth the following groundwater management objectives to guide future water management actions:

- Prevent a return to historical overdraft conditions;
- Maintain groundwater quality;
- Monitor water levels, water quality, and groundwater storage; and
- Estimate groundwater use and future groundwater demands on the basin.

5.2.2.3. Irrigated Lands Regulatory Program

The ILRP, initiated in 2003 and last modified in 2013 to include groundwater provisions, is a program whose objective is to protect both groundwater and surface water from irrigated agricultural waste dischargers throughout the Central Valley. The ILRP is implemented through Central Valley Regional Water Quality Control Board (CVRWQCB) Orders, also called Waste Discharge Requirements (WDRs). Order R5-2013-0120 (Order) regulates discharges in the Tulare Lake Basin. Under the Order, third parties are responsible for fulfilling regional requirements and conditions (e.g., surface and groundwater monitoring). AEWSD and WRMWSD are members of the KRWCA, which is a third-party coalition that formed in 2014 to respond to the Order. Key elements of the ILRP include a Surface Water/Groundwater Quality Monitoring Plan, a Sediment and Erosion Control Plan, and a Nitrogen Management Plan and Mitigation Monitoring. The overall goals of the ILRP for the Tulare Lake Basin are as follows:

- Restore and/or maintain the highest reasonable quality of State waters;
- Minimize waste discharge from irrigated agricultural lands that could degrade State water quality;
- Maintain the economic viability of agriculture in California's Central Valley; and
- Ensure that irrigated agricultural discharges do not impair access by Central Valley communities and residents to safe and reliable drinking water.

In accordance with these goals, the objectives of the ILRP for the Tulare Lake Basin are the following:

- Restore and/or maintain appropriate beneficial uses established in CVRWQCB plans by ensuring that all state waters meet applicable water quality objectives; and
- Encourage implementation of management practices that improve water quality in keeping with the first objective, without jeopardizing the economic viability for all sizes of irrigated agricultural operations.

5.2.2.4. Water Management Plans

WRMWSD prepared an Agricultural Water Management Plan (AWMP) in accordance with the requirements of Senate Bill (SB) X7-7 and Governor's Executive Order B-29-15, and it was last modified in July 2021. The purpose of this AWMP was to describe and document WRMWSD's existing and proposed agricultural water management programs and activities aimed to provide reliable agricultural water supply for its landowners. The document provides a description and quantification of water supply sources for agricultural users (surface and groundwater), water rates, a water reliability assessment, resiliency planning, water quality analysis and summarizes the status of implementation of Efficient Water Management Practices at the District. An update has also been provided on the Analysis of the Effects of Climate Change in accordance with the 2020 DWR Guidebook to discuss the climatic impacts and vulnerability assessment (WRMWSD, 2021).

AEWSD's United States Bureau of Reclamation (USBR) Water Management Plan (WMP) was first developed in 1996 (then referred to as a USBR "Water Conservation Plan"), was revised in 2013 to comply with new requirements of Senate Bill (SB) x7 of 2009, and was last updated in October 2018 pursuant to the Central Valley Project Improvement Act of 1992 and Section 210(b) of the Reclamation Reform Act of 1982. This WMP describes water use within AEWSD, provides an inventory of water resources, contains a Drought Management Plan, and establishes Best Management Practices (BMPs) for agricultural contractors to improve water use efficiency. Examples of these practices include metering delivered water, supporting the local Resource Conservation District's Mobile Lab Program's program of conducting on-farm evaluations, and supporting more precise irrigation and delivery scheduling.

5.2.2.5. Groundwater Sustainability Plans

AEWSD, WRMWSD, and TCWD adopted Management Area Plans which were incorporated into the greater Kern County Subbasin GSP (GEI Consultants, 2020). These Management Area Plans cover management of lands and groundwater located immediately north of the Basin. As required, these Management Area Plans established sustainable management criteria at Representative Monitoring Wells located within District lands overlying Kern County Subbasin. Furthermore, these Management Area Plans identified Projects/Management Actions (P/MAs) to improve the groundwater conditions beneath District lands overlying the Kern County Subbasin.

5.2.3. Operational Flexibility Limitations

The water resource monitoring programs are not expected to limit operational flexibility in the Basin. In fact, the CASGEM monitoring network will be integral to the on-going monitoring and reporting that will be conducted pursuant to this GSP (see ***Section 17 Monitoring Network***).

The IRWMP and GSP development are complementary management processes. To the extent that the issues identified for the greater IRWMP region affect the Basin, these issues will be discussed in the following sections of this GSP. Implementation of this GSP will contribute to the sustainable use of water supplies within the IRWMP region and the IRWMP is not expected to limit operational flexibility in the Basin.

Most of the groundwater management objectives identified in both GWMPs are consistent with the issues and objectives identified in the following sections of this GSP. Implementation of this GSP will contribute to the sustainable groundwater use within the AEWSD and WRMWSD portions of the Basin. Therefore, this GSP complements and supersedes the GWMPs.

Many of the assumptions regarding sustainability planning utilized in the Kern County Subbasin Management Area Plans were considered and, when applicable, were maintained to be consistent throughout development of this GSP. Therefore, this GSP complements and considers sustainability planning in the adjacent subbasin. However, due to the two-year adoption lag between the Kern County Subbasin GSP and this GSP, some District-wide management considerations may need to be re-assessed during each respective five-year GSP update.

5.2.4. Conjunctive Use Programs

For the last several decades AEWSD and WRMWSD have supported the conjunctive use of surface water (local surface water, Kern River, State Water Project [SWP] and Central Valley Project [CVP]) and groundwater resources within the Basin, which has been the primary cause of the recovery and stability of groundwater levels. There is an additional conjunctive use program within the Basin, the WRMWSD Mettler Groundwater Recharge Project, which was constructed in 2019. This project includes a 60-acre recharge basin facility which recharges surface water imported from unused allocations of CVP and SWP waters, and potentially high flow Kern River supplies, if available (Provost & Pritchard, 2018a). Once the project comes online, it is expected to be able to recharge up to 36,000 acre-feet per year (AFY) into the Basin aquifer during winter months, that can be recovered using existing wells during the high demand irrigation season (Provost & Pritchard, 2018a).

5.3. Land Use Elements or Topic Categories of Applicable General Plans

§ 354.8. Each Plan shall include a description of the geographic areas covered, including the following information:

(f) A plain language description of the land use elements or topic categories of applicable general plans that includes the following:

(1) A summary of general plans and other land use plans governing the basin.

(2) A general description of how implementation of existing land use plans may change water demands within the basin or affect the ability of the Agency to achieve sustainable groundwater management over the planning and implementation horizon, and how the Plan addresses those potential effects.

(3) A general description of how implementation of the Plan may affect the water supply assumptions of relevant land use plans over the planning and implementation horizon.

(4) A summary of the process for permitting new or replacement wells in the basin, including adopted standards in local well ordinances, zoning codes, and policies contained in adopted land use plans.

(5) To the extent known, the Agency may include information regarding the implementation of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management.

5.3.1. General Plans and Other Land Use Plans

5.3.1.1. Kern County General Plan

The Basin is located within the Kern County General Plan (Kern County, 2009) area. The Kern County General Plan was first adopted in 2004 and has undergone several amendments, the most recent of which was approved in 2009 (i.e., the "2009 General Plan"). The County is currently working to update its General Plan through 2040 (i.e., the "2040 General Plan"). This section identifies relevant policies in the current 2009 General Plan that could: (1) affect water demands in the Basin (e.g., due to population growth and development of the built environment), (2) influence the GSP's ability to achieve sustainable groundwater use, and (3) affect implementation of the 2009 General Plan land use policies.

Figure PA-6 shows the 2009 General Plan land use designations within the Basin. The land use designations identified within the 2009 General Plan primarily include extensive agriculture (43%), intensive agriculture (30%), and mineral and petroleum (9%). These designations are generally consistent with the predominantly agricultural land use within the Basin (see **Figure PA-3**).

The Land Use, Open Space, and Conservation Element (Chapter 1) of the General Plan includes the following goals, policies, and implementation measures that are related to groundwater or land use management, and that could potentially influence the implementation of this GSP:[18]

[18] The 2009 General Plan goals, policies, and implementation measures were in effect at the time that components of this GSP were under development (i.e., 2019). To the extent that these goals, policies, and implementation measures are updated as part of the 2040 General Plan, those will be incorporated and considered in future five-year GSP updates (i.e., in 2027).

Physical and Environmental Constraints

- **Implementation Measure C.** Cooperate with the KCWA to classify lands in the County overlying groundwater according to groundwater quantity and quality limitations.

Public Facilities and Services

- **Goal 5.** Ensure that adequate supplies of quality (appropriate for intended use) water are available to residential, industrial, and agricultural users within Kern County.
- **Goal 7.** Facilitate the provision of reliable and cost-effective utility services to residents of Kern County.
- **Policy 2.** The efficient and cost-effective delivery of public services and facilities will be promoted by designating areas for urban development which occur within or adjacent to areas with adequate public service and facility capacity.
- **Policy 2.a.** Ensure that water quality standards are met for existing users and future development.

Residential

- **Goal 6.** Promote the conservation of water quantity and quality in Kern County.
- **Goal 7.** Minimize land use conflicts between residential and resource, commercial, or industrial land uses.

Industrial

- **Goal 2.** Promote the future economic strength and well-being of Kern County and its residents without detriment to its environmental quality.

Resource

- **Policy 7.** Areas designated for agricultural use—which include Class I and II, and other enhanced agricultural soils with surface delivery water systems—should be protected from incompatible residential, commercial, and industrial subdivision and development activities.
- **Policy 10.** To encourage effective groundwater resource management for the long-term economic benefit of the County, the following shall be considered:
    - **Policy 10.a.** Promote groundwater recharge activities in various zone districts.
    - **Policy 10.c.** Support the development of groundwater management plans.
    - **Policy 10.d.** Support the development of future sources of additional surface water and groundwater, including conjunctive use, recycled water, conservation, additional storage of surface water and groundwater and desalination.

General Provisions

- **Goal 1.** Ensure that the County can accommodate anticipated future growth and development while maintaining a safe and healthful environment and a prosperous economy by preserving valuable natural resources, guiding development away from hazardous areas, and assuring the provision of adequate public services.

- **Policy 40.** Encourage utilization of community water systems rather than the reliance on individual wells.
- **Policy 41.** Review development proposals to ensure adequate water is available to accommodate projected growth.
- **Policy 45.** New high consumptive water uses such as lakes and golf courses should require evidence of additional verified sources of water other than local groundwater. Other sources may include recycled stormwater or wastewater.
- **Implementation Measure U.** The Kern County Environmental Health Services Department will develop guidelines for the protection of groundwater quality which will include comprehensive well construction standards and the promotion of groundwater protection for identified degraded watersheds.

5.3.1.2. Specific and Community Plans (Specific Plans)

The 2009 General Plan identifies several Specific Plan areas, including the Tejon Industrial Complex East, San Emidio New Town, Grapevine[19], Tunis Ridge, Tunis Creek, Tejon Hills, Tejon Creek No. 1, Tejon Creek No. 2, and Commanche which cover portions of the Basin (see **Figure PA-7**). The Tejon Industrial Complex East Specific Plan area has already been developed, the San Emidio New Town Specific Plan area remains undeveloped although it has an accepted Specific Plan document dated 1992, and the other Specific Plan areas are proposed developments and do not currently have Specific Plans. As such, only the Grapevine Specific Plan, which was approved by the Board of Supervisors of the County of Kern on 10 December 2019,[20] is described further below.

The Grapevine Specific Plan area is located adjacent to I-5 at the southern boundary of the Basin. The Grapevine development, as envisioned, will consist of 4,643 acres and will include 12,000 residential units, 5.1 million square feet of commercial and industrial space, and 3,367 acres designated as grazing and open spaces (Tejon Ranchcorp, 2016).

One of the Grapevine Specific Plan's sustainability commitments outlined in its Appendix C: Sustainability Principles is "conserving resources including water reduction, pollution prevention, and protecting the quality and availability of the water supply by setting standards for water and wastewater, landscaping, and water fixtures" (Tejon Ranchcorp, 2016). The Grapevine Specific Plan further includes the following goals, policies, and implementation measures outlined in the Land Use Conservation, Open Space, and Recreation Chapter (Chapter 2) that are related to groundwater or land use management, and that could

[19] The Kern County Interactive GIS Online Mapping Tool calls this "Grapevine Commercial" and shows a different boundary than the Grapevine Specific Plan Boundary mapped in the Grapevine Final Specific and Community Plan (Tejon Ranchcorp, 2016).
[20] https://psbweb.co.kern.ca.us/planning/pdfs/eirs/grapevine_sreir/grapevine_2019_nod.pdf

potentially influence the implementation of this GSP:

- **Policy 13.** Ensure adequate water supply is available prior to development.
- **Implementation Measure M.** Require that development incorporates the energy-efficient design features specified in the Grapevine Special Plan development standards, the Grapevine Design Principles and the Grapevine Sustainability Principles document outlining energy and water conservation techniques for site planning and building design.
- **Implementation Measure O.** Require development to implement the Grapevine Sustainability Principles document, which includes feasible measures that serve to reduce water and energy use (e.g., for interior fixtures, require tank-less water heaters and low-flow plumbing) and establishes the need for a Maximum Applied Water Allowance (MAWA) budget for each land use.
- **Goal E.** A community that minimizes impacts to the natural environment.
- **Goal H.** A community that minimizes the use of energy and natural resources.
- **Implementation Measure S.** Require conservation of important natural features such as Grapevine Creek, Cattle Creek, and natural landforms to the extent feasible.
- **Implementation Measure V.** Require a restricted landscape palette for all development in order to conserve water and promote the use of native and other drought-resistant or drought-tolerant plants and plant species that are reflective of agricultural heritage native to the San Joaquin Valley.
- **Implementation Measure W.** Landscape and irrigation shall comply with the Water-Efficient Landscape requirements set forth in the Grapevine Special Plan development standards and the Grapevine Sustainability Principles document.
- **Implementation Measure AA.** Restrict uses within the Open Area district to grazing, oil and gas production, unfenced drainage sumps and water detention basins, flood control facilities and debris basins, managed wetlands, water recharge facilities, underground utilities, scientific study sites, and trails.

5.3.1.3. Tejon Ranch Conservation & Land Use Agreement

As shown on **Figure PA-3**, 18,465 acres within the Basin are protected under the Tejon Ranch Conservation & Land Use Agreement (“Agreement”; TRC, 2008). The Agreement states in Exhibit M Paragraph 1(b)(3): “In managing Owner’s future native groundwater extraction activities within the Conservation Easement Area, Owner will avoid changes to or expansion of groundwater extraction practices as of the Effective Date that would cause significant groundwater related adverse impacts to the surface Conservation Values existing as of the Effective Date. In addition, Owner shall not make any alterations or improvements to the surface of the Conservation Easement Area in connection with water storage, including storage of water in underground aquifers, except as permitted by Paragraph 1(b)(1)(G).”

5.3.2. Implementation of Existing Land Use Plans

The above goals, policies, and implementation measures established by the 2009 General Plan are complementary to sustainable groundwater management of the Basin relative to future land use development and conservation (i.e., the plan encourages development of the County's groundwater supply to ensure that existing users have access to high quality water and states that future growth should be accommodated only while ensuring that adequate high-quality water supplies are available to existing and future users). Given that the 2009 General Plan is being updated concurrently with the development of this GSP, and that the County is engaged in the process of GSP development through its participation in the White Wolf GSA, it is anticipated that the 2040 General Plan would consider this GSP and utilize consistent water supply assumptions over the 2040 planning horizon. Although the County is not a voting entity of the White Wolf GSA, a County representative attends GSA Board meetings and is kept apprise of the findings and decisions made throughout the GSP development process.

The above goals, policies, and implementation measures established by the Grapevine Specific Plan are complementary to sustainable groundwater management of the Basin relative to future land use development and conservation (i.e., the plan encourages protecting the natural environment and water conservation). The Grapevine Specific Plan outlines a major change in land use in which 4,643 acres of agricultural and grazing land will be developed into residential, commercial, and industrial spaces (see **Figure PA-8** zoning "Mixed Use District," "Village Mixed Use District," and "Industrial District"). As outlined in the Grapevine Specific Plan, if and when Grapevine is developed, all potable water demands will be met by surface water imported from the California Aqueduct and non-potable water demands (i.e., landscape irrigation) will be met with treated recycled water to the maximum extent possible to reduce overall water demands. The Grapevine Specific Plan also identifies that, as required for future use, additional water sources such as transfers, recycled water, and potential local groundwater will be secured over time. Therefore, the Grapevine development is anticipated to act as a net benefit to groundwater recharge within the Basin. Implementation of Grapevine Specific Plan policies is not expected to negatively affect the Basin's ability to achieve groundwater sustainability.

Because the Agreement places limitations on groundwater extraction in order to prevent certain adverse consequences, it is complementary to sustainable groundwater management under the SGMA framework and is not expected to limit the ability to achieve groundwater sustainability in the Basin.

5.3.3. Implementation of the GSP

Successful implementation of this GSP will contribute to sustainable management of the Basin groundwater supply. Therefore, implementation of this GSP is not anticipated to significantly affect the County's current water supply assumptions or land use plans. However, implementation of this GSP may limit the availability of potential local groundwater sources to be used for future demands exceeding current rates of groundwater extraction. Given that the 2009 General Plan is being updated concurrently with the development of this GSP, and as the County is engaged in the process of GSP development through its participation in the White Wolf GSA, it is anticipated that the 2040 General Plan would consider this GSP and utilize consistent water supply assumptions over the 2040 planning horizon.

Although the Grapevine development will result in a shift in land use and water supply assumptions, implementation of this GSP should not affect the water supply assumptions of the Grapevine Specific Plan, as all water demands expect to be met by surface water imported from the Kern River or local recycled water.

5.3.4. Well Permitting Process

Well permits with the Basin are issued by the Kern County Public Health Services Department Water Well Program (Water Well Program). The Water Well Program issues permits to construct, reconstruct, and destroy water wells. All wells must be constructed in accordance with Kern County Ordinance Code Section 14.08, and DWR's Bulletin 74-81 and Bulletin 74-90, except as modified by subsequent revisions. The mandates require, among other provisions, that domestic and agricultural wells be installed a minimum distance from potential pollution and contaminant sources, that water quality be tested for new and reconstructed wells, that an NSF 61 Approved flowmeter be installed, and that the final well construction be inspected by County staff. Current well permit applications submitted to the Water Well Program must identify if the well is located within an adjudicated district or an overdrafted basin[21] and must submit an overdrafted basin supplemental well application[22], if applicable. Although this information would not be transmitted directly to the White Wolf GSA, as the Basin is not adjudicated nor overdrafted, it is expected that as part of GSP implementation the Water Well Program may be more closely coordinated with White Wolf GSA activities to support long-term sustainability within the Basin.

5.3.5. Implementation of Land Use Plans Outside the Basin

The Basin shares its northern boundary with the Kern County Subbasin, which prepared an Umbrella GSP that was adopted in January 2020 by the Kern Groundwater Authority (KGA; GEI Consultants, 2020). According to the KGA GSP, land use in the southern portion of the Kern County Subbasin, immediately adjacent to the northern border of the Basin, is largely agricultural and undeveloped land. The KGA GSP did not consider or model projected changes in land use. For consistency, this GSP assumes that no land use changes will occur in the southern portion of the Kern County Subbasin. Therefore, this GSP has not made unique land use assumptions for areas outside of the Basin.

5.4. Additional GSP Elements

§ 354.8. Each Plan shall include a description of the geographic areas covered, including the following information:
(g) A description of any of the additional Plan elements included in Water Code Section 10727.4 that the Agency determines to be appropriate.

5.4.1. Other Elements

5.4.1.1. Control of saline water intrusion

Because the Basin is located far from coastal areas, seawater intrusion is not considered to be an issue; therefore, no control measures for saline water intrusion have been established.

[21] https://kernpublichealth.com/wp-content/uploads/WATER-WELL-PERMIT-APPLICATION_8142019.pdf
[22] https://kernpublichealth.com/wp-content/uploads/2021/01/Overdrafted-Basin-supplement-app.pdf

5.4.1.2. Wellhead protection

The Water Well Program issues permits to construct, reconstruct, and destroy water wells (see ***Section 5.3.4 Well Permitting Process***).

5.4.1.3. Migration of contaminated groundwater

The mitigation, remediation, and management of groundwater contamination plumes is regulated by the Regional Water Quality Control Board (RWQCB), Department of Toxic Substances Control (DTSC), and the County of Kern. As discussed in ***Section 8.5.4 Point-Source Contamination Sites***, all known groundwater contamination sites are closed.

5.4.1.4. Well abandonment and well destruction program

The Water Well Program issues permits to construct, reconstruct, and destroy water wells (see ***Section 5.3.4 Well Permitting Process***).

5.4.1.5. Replenishment of groundwater extractions

The groundwater system underlying the Basin is recharged from multiple natural and anthropogenic sources, including percolation of applied irrigation water from imported sources, percolation of surface water inflow from surrounding watersheds and streams within the Basin, percolation of canal leakage, percolation of precipitation, and percolation of municipal and industrial (M&I) effluent (see ***Section 7.3.4 Groundwater Recharge and Discharge Areas***).

5.4.1.6. Conjunctive use and underground storage

AEWSD, TCWD, and WRMWSD have supported the operation of conjunctive use projects within the Basin, including the WRMWSD Mettler Groundwater Recharge Project, which was built in 2019. These projects have contributed to the recovery and stabilization of groundwater levels (see ***Section 5.2.4 Conjunctive Use Programs***).

5.4.1.7. Well construction policies

The Kern County Water Well Program issues permits to construct, reconstruct, and destroy water wells (see ***Section 5.3.4 Well Permitting Process***). The GSA will continue to support the County's Program.

5.4.1.8. Groundwater contamination cleanup, recharge, diversions to storage, conservation, water recycling, conveyance, and extraction projects

There are no active groundwater contamination cleanup sites within the Basin (see ***Section 8.5.4 Point-Source Contamination Sites***).

Reclaimed water is used to meet some of TRCC's landscape irrigation demand (see ***Section 7.3.4***

Groundwater Recharge and Discharge Areas).[23]

The California Aqueduct crosses the Basin, and the 850 Canal is an important irrigation water supply facility within the Basin (see ***Section 7.3.5 Surface Water Bodies***).

There are currently no major urban water suppliers (i.e., more than 3,000 connections or supplying more than 3,000 acre-feet (AF) of water annually) within the Basin. Therefore, urban water conservation is not mandated.

5.4.1.9. Efficient water management practices

Groundwater within the Basin is primarily used for agricultural irrigation supply. The White Wolf GSA will encourage implementation of efficient irrigation and water management techniques, as described in the WRMWSD AWMP (WRMWSD, 2021) and AEWSD's USBR WMP (AEWSD, 2018). These plans are summarized in ***Section 5.2.1 Existing Monitoring Programs***.

5.4.1.10. Relationships with State and federal regulatory agencies

The White Wolf GSA is a CASGEM reporting agency and therefore reports measured groundwater levels collected from CASGEM network wells to DWR.

AEWSD maintains a perpetual federal water supply contract with the USBR for its Friant Division surface water supply and Westside CVP supplies (e.g., Cross-Valley Canal, Section 215). AEWSD also has multiple agreements in place with DWR relating to its system of connections to the California Aqueduct. Finally, AEWSD's contract with the Western Area Power Administration (WAPA) through the Power and Water Resources Pooling Authority (PWRPA) allows AEWSD to manage both power assets and water exchanges.

TCWD has a direct relationship with DWR related to the Beartrap turnout off of the SWP system and via the purchase, use, and transfer of SWP water.

WRMWSD's water supply contract with DWR for its SWP surface water supply originally remained in effect until 2035. On 17 July 2019, Amendment No. 40 was executed between DWR and KCWA extending the previous water supply contract for its SWP surface water supply through 2085.[24]

5.4.1.11. Land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity

Applicable land use planning documents and processes are discussed in ***Section 5.3 Land Use Elements or Topic Categories of Applicable General Plans***.

5.4.1.12. Impacts on Groundwater Dependent Ecosystems (GDE)

GDEs have been identified within the Basin, as discussed in further detail below in ***Section 8.8***

[23] California Regional Water Quality Control Board Central Valley Region Waste Discharge Requirements Order No. R5-2011-0066 for Tejon-Castac Water District Tejon Ranch Commerce Center New East Wastewater Treatment Facility Kern County.
[24] https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/State-Water-Project/Management/Water-Supply-Contract-Extension/Files/Kern_County_Water_Agency_WSC_Extension_Amendment_1_111620.pdf

Groundwater Dependent Ecosystems.

5.5. Notice and Communication

§ 354.10. Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:

(a) A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.

(b) A list of public meetings at which the Plan was discussed or considered by the Agency.

(c) Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.

(d) A communication section of the Plan that includes the following:

(1) An explanation of the Agency's decision-making process.

(2) Identification of opportunities for public engagement and a discussion of how public input and response will be used.

(3) A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.

(4) The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.

The GSA adopted its Stakeholder Communication and Engagement Plan (SCEP) in June 2018 to fulfill community notice and communication requirements. The SCEP is available on the GSA's website (http://whitewolfgsa.org) and is included herein as ***Appendix B***.

5.5.1. Beneficial Uses and Users of Groundwater

As part of the SCEP, beneficial uses and users of groundwater in the Basin were identified (see SCEP Section 3). Additionally, a Stakeholder Constituency "Lay of the Land" exercise was developed which identified Basin stakeholders, key interests and issues, and the level of engagement expected with each stakeholder (see SCEP Table 1). This exercise will be updated during select phases of GSP development and/or implementation.

5.5.2. Public Meetings Summary

The list below identifies public meetings, workshops, and direct outreach specific to GSP development. Detailed meeting minutes and materials are available on the GSA's website (http://whitewolfgsa.org).

GSA Board Meetings

- 22 August 2017
- 19 September 2017
- 20 March 2018
- 11 April 2018

- 5 June 2018
- 4 September 2018
- 5 March 2019
- 4 June 2019
- 1 October 2019
- 3 March 2020
- 1 September 2020
- 1 December 2020
- 2 March 2021
- 1 June 2021
- 12 August 2021
- 7 September 2021
- 6 December 2021
- 25 January 2022

The list above will be updated throughout GSP development and/or implementation.

Stakeholder Workshops

- 4 June 2019
- 8 October 2020
- 26 July 2021

This list will be populated throughout GSP development and/or implementation.

Direct Outreach

- Website for the White Wolf GSA (http://whitewolfgsa.org/) maintenance (2015 to ongoing)
- Stakeholder Survey distribution and respondence (July 2018-November 2018)
- Stakeholder data request distribution and respondence (October 2018-November 2018)
- Public water system data request (June 2018-September 2018 and May 2021)
- Inquiry with specific landowners regarding access to wells for inclusion in the SGMA monitoring network (February 2020 to ongoing)

The list above will be updated throughout GSP development and/or implementation.

5.5.3. Public Comments on the GSP

Table PA-2 below summarizes the public comments received and the White Wolf GSA response. Public comments received on the draft GSP will be listed in ***Appendix C*** along with the White Wolf GSA's responses.

Table PA-2. Public Comments on the GSP and White Wolf GSA Responses

Public Comment	White Wolf GSA Response
8/22/2017 White Wolf GSA Board Meeting: Mr. Mark Hall from Grapevine Vineyards, expressed his appreciation for putting this together and benefitting everyone in the basin. He also thanked the county for participating.	The White Wolf GSA acknowledged comment.
Landon Peppel of Wind Wolves Preserve emailed the White Wolf GSA regarding potential groundwater dependent ecosystems (GDEs), potential endangered species, and the potential for installing monitoring wells on lands within the Basin in an email on 30 March 2018 *"Testing Wells White Wolf GSA"*.	The White Wolf GSA acknowledged receipt and invited Wind Wolves Preserve to participate in White Wolf GSA Board meetings to share data, concerns, and to enhance coordination.
Landon Peppel of Wind Wolves Preserve emailed the White Wolf GSA regarding the accuracy of groundwater level hydrograph depiction on their lands and inquiring on the benefits of accessing preserve lands for additional data collection in an email on 26 July 2018 *"Water Modeling Methods for White Wolf GSA"*.	The White Wolf GSA acknowledged receipt and invited Wind Wolves Preserve to provide data through the Stakeholder Survey and data collection process.
The Nature Conservancy (TNC) provided information regarding the environmental users of surface water in an email to the White Wolf GSA on 25 September 2018 "*Potential Environmental Beneficial Users of Surface Water in Your GSA*".	The White Wolf GSA acknowledged receipt and incorporated information into ***Section 8.8 Groundwater Dependent Ecosystems (GDEs)*** and ***Appendix J***.
Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, TNC, and Union of Concerned Scientists provided a comment letter on the public draft GSP on 6 November 2021.	The White Wolf GSA provided references and made edits to the GSP accordingly. See ***Appendix C*** for details.

Table PA-2 will be updated as more comments are received during GSP development and/or implementation.

5.5.4. Communication

The SCEP outlines the GSA's communication goals.

5.5.4.1. Decision-Making Process

The SCEP Section 2.2 outlines the White Wolf GSA's decision-making process. Key GSP development and implementation decisions are made by the White Wolf GSA's Board of Directors.

5.5.4.2. Public Engagement Opportunities

The SCEP Section 6 discusses public engagement opportunities and SCEP Sections 5 and 6 describe how public input and responses will be handled. These opportunities include White Wolf GSA Board meetings, stakeholder workshops, the planned public hearing at which the draft GSP will be available for public comments, and other direct outreach as identified in ***Section 5.5.2 Public Meetings Summary*** above.

5.5.4.3. Stakeholder Involvement

The SCEP Section 5 outlines the GSA's goals, including open and transparent engagement with diverse stakeholders. Additionally, SCEP Section 4 outlines the Stakeholder Survey, which the GSA used to acquire additional, relevant information about Basin stakeholders. Specifically, results from 21 Stakeholder Survey responses received indicate that:

- Approximately 60% of stakeholders within the Basin are both agricultural groundwater and surface water users; approximately 15% of stakeholders are agricultural groundwater, surface water, and domestic groundwater users; and the remaining 25% of stakeholders are either surface water users, agricultural groundwater users, public water system, or domestic well, commercial/industrial groundwater, and surface water users.
- All but two stakeholders indicated familiarity with the SGMA regulations. AEWSD and WRMWSD followed up with these two entities immediately upon receipt of this feedback.
- Twelve stakeholders (60%) are currently engaged in groundwater management activities or discussions; four stakeholders (20%) are occasionally engaged in groundwater management activities or discussions; and four stakeholders (20%) are not actively engaged in groundwater management activities or discussions.
- Ten stakeholders have concerns about groundwater management, and topics of particular concern include the following:
    - Protecting economic investments of land and permanent crops;
    - Ensuring adequate water supply (both groundwater pumping and surface water allocations);
    - Preserving current and future rights to water; and
    - The ability to continue farming.

In addition to the responses to the Stakeholder Survey identified above, six Basin stakeholders provided specific data on their wells to the White Wolf GSA for consideration and inclusion in the GSP. Data included well locations, well construction information, depth-to-water measurements, estimated pumping rates, lithologic and geophysical logs, water quality data, and pump tests. These data were added to the White

Wolf DMS and considered during assessment of groundwater conditions (***Section 8 Current and Historical Groundwater Conditions***).

5.5.4.4. Public Notification

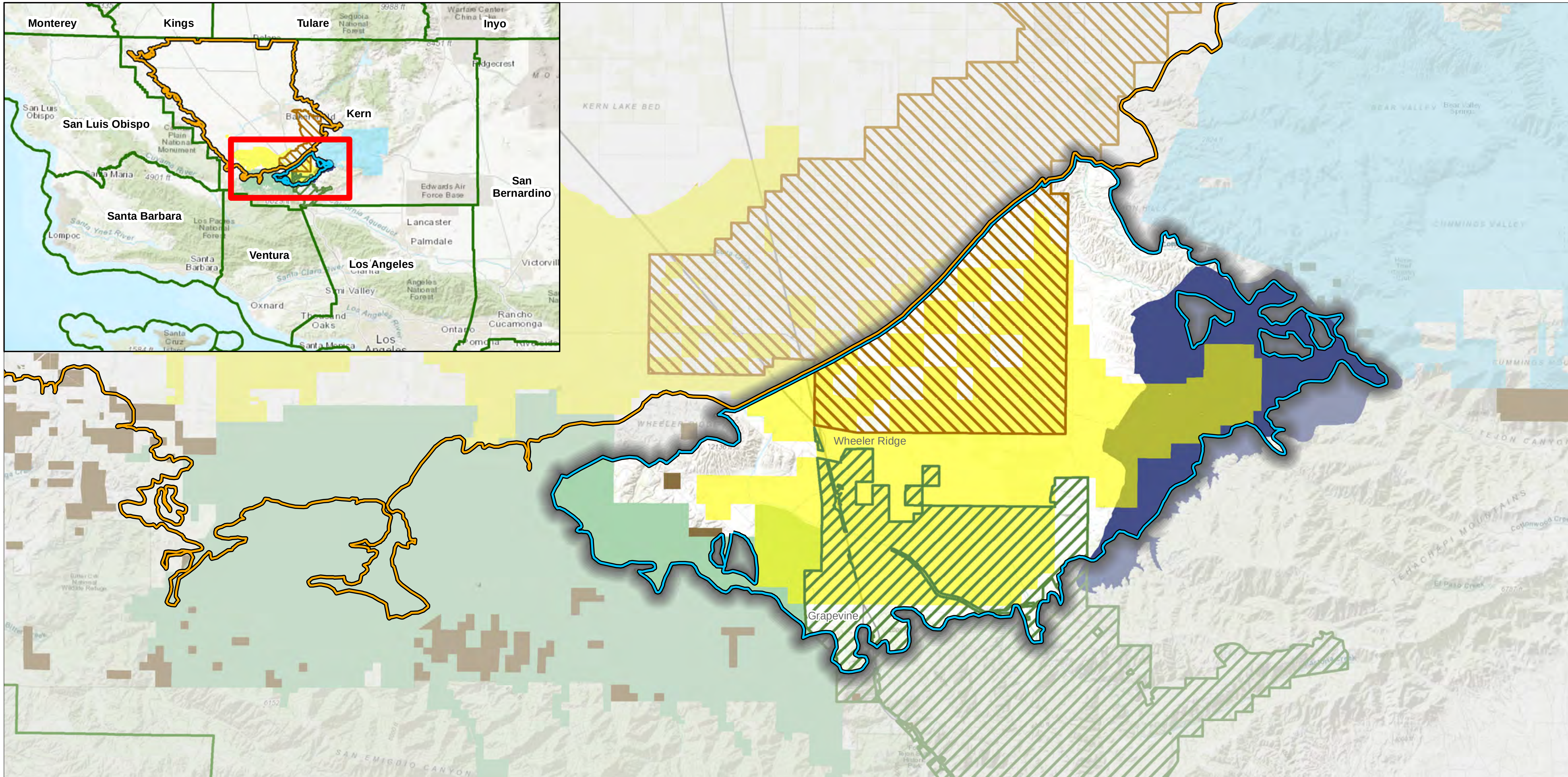
The SCEP Section 5 and 6 details the methodology that is being followed to inform the public on GSP updates, status, and actions. This includes making key GSP development decisions in an open and transparent fashion during public GSA Board meetings, holding periodic stakeholder workshops to communicate progress on GSP technical components to stakeholders, and receiving input on upcoming decisions and work efforts. The GSA will publicize all Board meetings and stakeholder workshops on its website (http://whitewolfgsa.org) as well as provide email notice to the GSA list of interested parties.

5.5.4.5. Public Comment

Public comments are welcome at the White Wolf GSA Board of Directors meetings during the appropriate meeting agenda item. Additional public comments received on the draft GSP will be listed in ***Appendix C*** along with the White Wolf GSA's responses.

5.5.5. Interbasin Coordination

The GSA has actively participated in interbasin coordinating with the neighboring Kern County Subbasin (DWR 5-022.14) throughout the GSP development process. Coordination topics have included delineation of the White Wolf Fault, cross-boundary flows between subbasins, and C2VSimFG-Kern model development to support initial water budget accounting.



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- County Boundary
- Arvin-Edison Water Storage District
- Tejon-Castac Water District
- Wheeler Ridge-Maricopa Water Storage District
- Tehachapi - Cummings County Water District
- Federal Lands
- Conservation Easement Area
- Private Conservation

Abbreviations

CCED = California Conservation Easement Database
CPAD = California Protected Areas Database
DWR = California Department of Water Resources
GSA = Groundwater Sustainability Agency

Notes

1. All locations are approximate.
2. The enitre displayed area within Kern County is covered by the Kern County General Plan
3. The White Wolf GSA covers the entire White Wolf Subbasin and is the exclusive GSA for the Subbasin.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 20 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. District boundaries acquired from respective District staff.
4. Federal Lands from CPAD 2017 - www.calands.org.
5. Private Conservation Lands from CPAD 2018 - www.calands.org.
6. Conservation Easement Area Lands from CCED -www.calands.org/CCED.
7. Kern County General Plan information obtained on 16 August 2018 from http://esps.kerndsa.com/gis/gis-download-data.

N

0 3 6

(Scale in Miles)

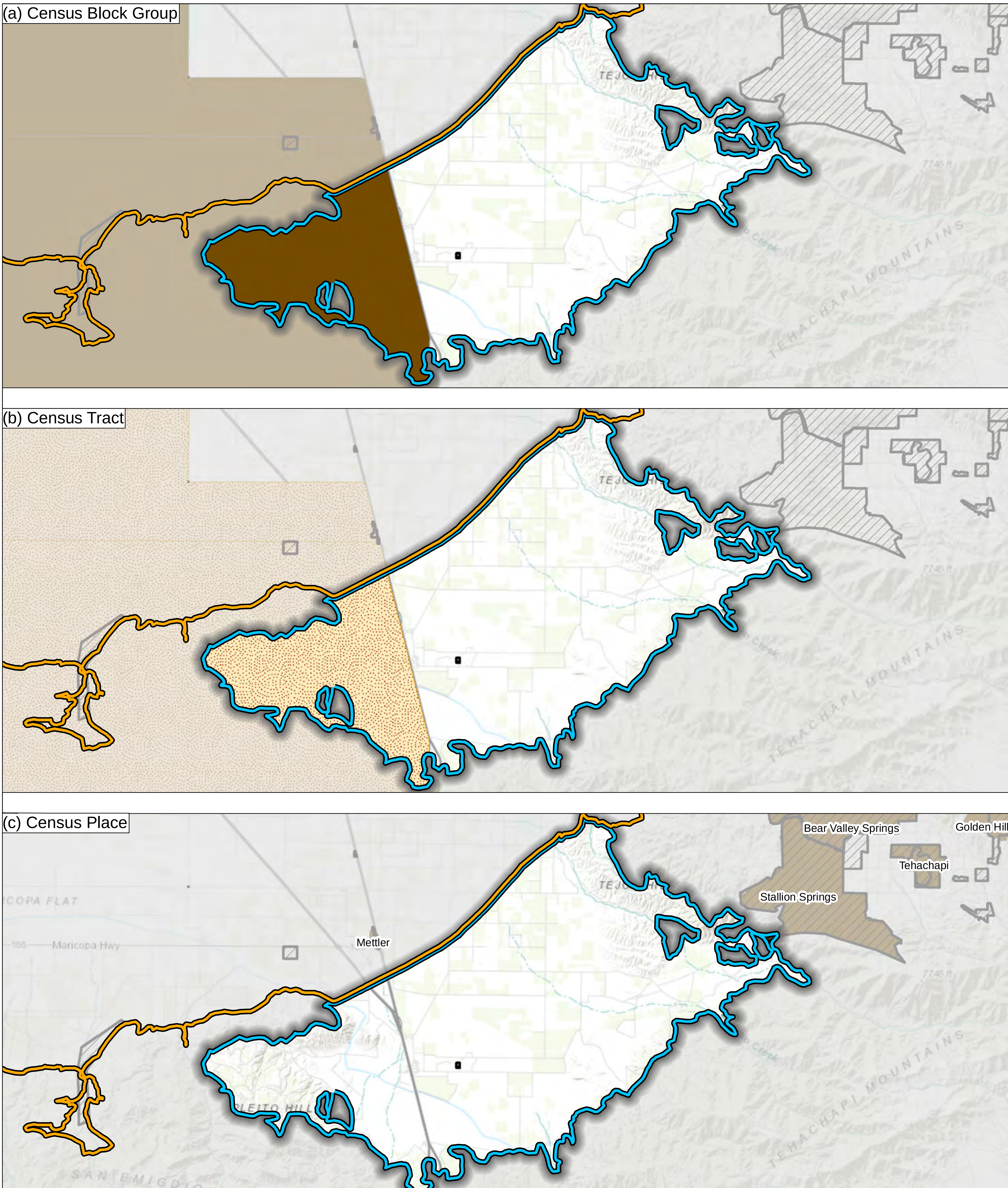
White Wolf Subbasin Plan Area and Relevant Boundaries

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure PA-1

Path: X:\B50001.05\Maps\GSP\2022\01\FigPA-1_PlanArea.mxd



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

Public Water System Service Area

Disadvantaged Communities

Severely Disadvantaged Communities

Disadvantaged Communities

Abbreviations

DWR = California Department of Water Resources

SGMA = Sustainable Groundwater Management Act

Notes

1. All locations are approximate.
2. Not all public water system service areas are mapped.
3. Disadvantaged communities defined based on 2016 median household income.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Disadvantaged Communities information downloaded on 4 October 2018 from the SGMA Data Viewer: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer. Last updated 2016.
4. Public Water System Service area boundaries are from the California Department of Public Health Drinking Water Systems Geographic Reporting Tool. (https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/water_supplier.shtml)

N

0 4 8

(Scale in Miles)

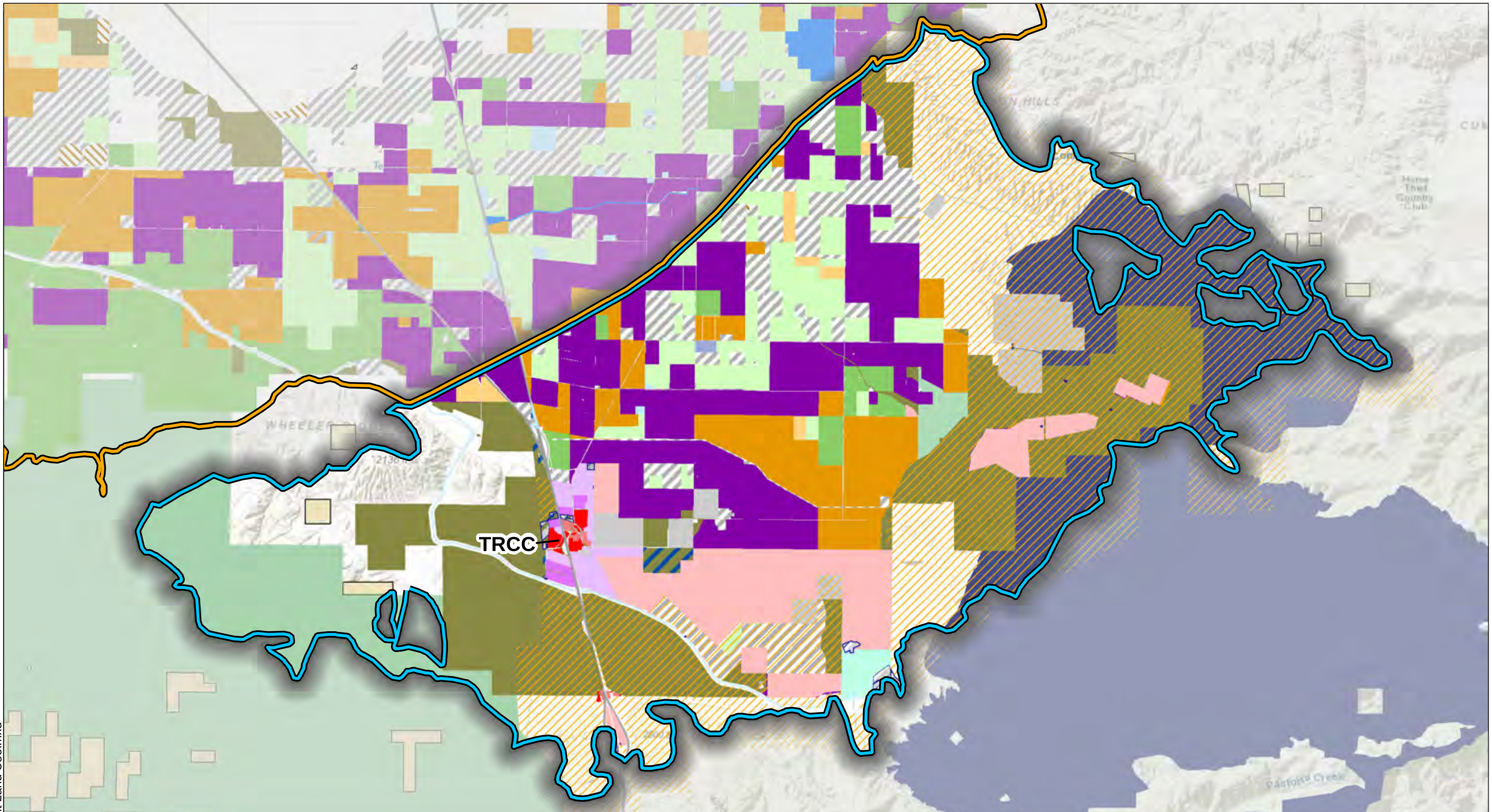
Disadvantaged and Severely Disadvantaged Communities

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure PA-2

Path: X:\B50001.05\Maps\GSP\2022\01\FigPA-2_DACs.mxd



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)

Land Use

- Vineyard
- Deciduous Fruits and Nuts
- Truck Nursery and Berry Crops
- Citrus and Subtropical
- Grain and Hay Crops
- Field Crops
- Pasture
- Fallow/Idle
- Native
- Agricultural
- Commercial
- Commercial Vacant Lot
- Commercial / Grazing
- Facility
- Grazing
- Idle Ground
- Industrial
- Water
- Urban
- Private Conservation
- Industrial Vacant Lot
- Mining/Quarry
- Oil Field
- Oil Field / Grazing
- Other Values not Present; Residential / Grazing
- Public Utility
- Residential
- Conservation Easement
- National Forest
- National Public Lands

Abbreviations

AEWSD = Arvin-Edison Water Storage District
CCED = California Conservation Easement Database
CPAD = California Protected Areas Database
DWR = California Department of Water Resources
TCWD = Tejon-Castac Water District
TRCC = Tejon Ranch Commerce Center
WRMWSD = Wheeler Ridge-Maricopa Water Storage District

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. 2017 parcel land use data provided by WRMWSD; 2019 parcel land use data provided by AEWSD; and 2018 parcel land use data provided by TCWD.
4. Federal and State Lands from CPAD 2017 - ww.calands.org
5. Conservation Easement Area Lands from CCED 2018 - www.calands.org/CCED.
6. National Forest, National Public Lands, and Private Conservation Lands from CPAD 2018 - www.calands.org

N

0 3 6

(Scale in Miles)

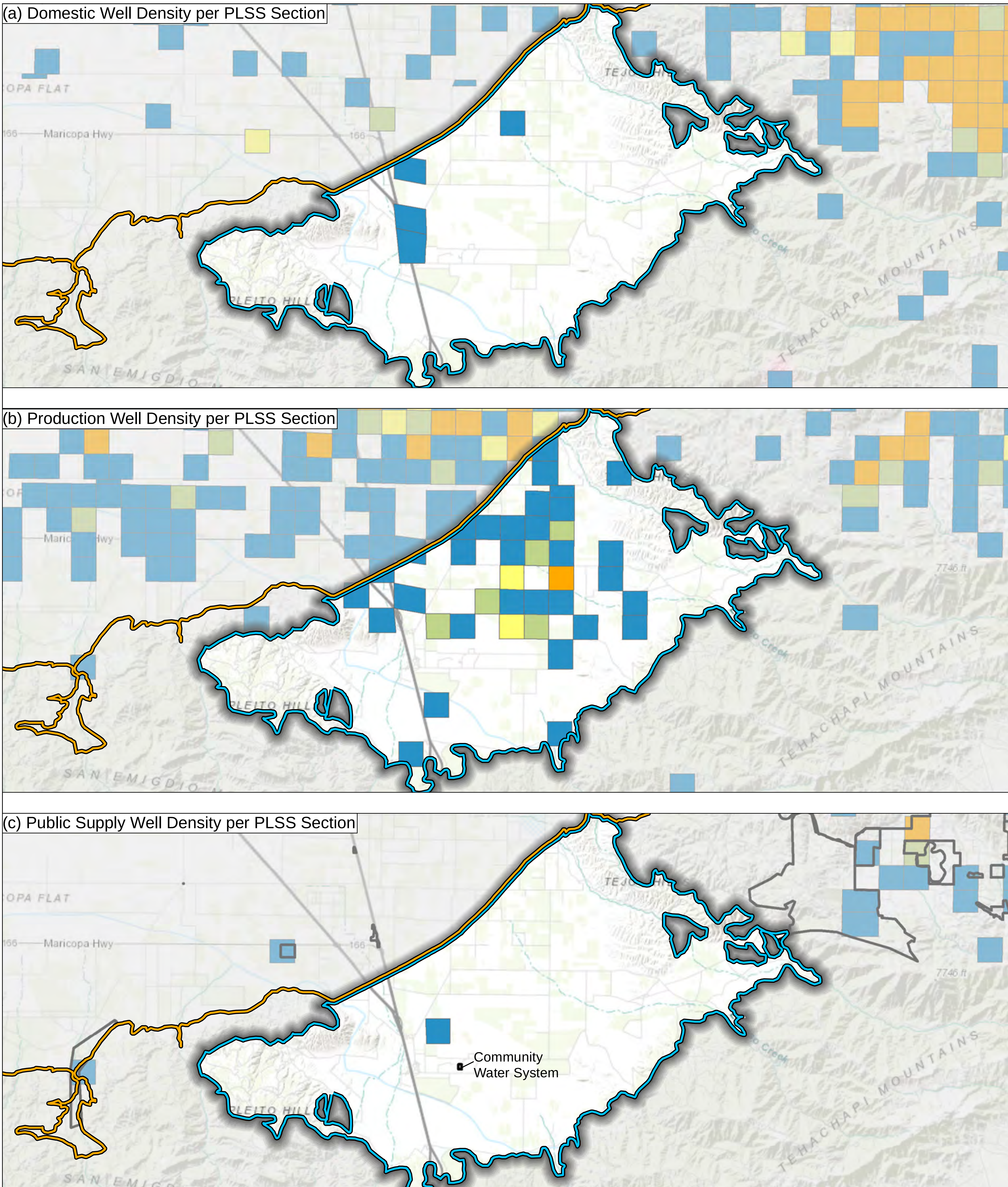
Current Land Use

eki environment & water

White Wolf GSA
Kern County, California
December 2021
B50001.05

Figure PA-3

Path: X:\B50001.05\Maps\GSP\2022\01\FigPA-3 Current Land Use.mxd



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

Well Density per PLSS Section

1 - 2

2 - 3

3 - 4

> 4

Abbreviations

DWR = California Department of Water Resources

PLSS = Public Land Survey System

Notes

1. All locations are approximate.
2. Production well counts include public supply wells.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Well count per square mile (PLSS section) from Well Completion Report Map Application, obtained on 23 October 2018 (https://dwr.maps.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37).

N

0 4 8

(Scale in Miles)

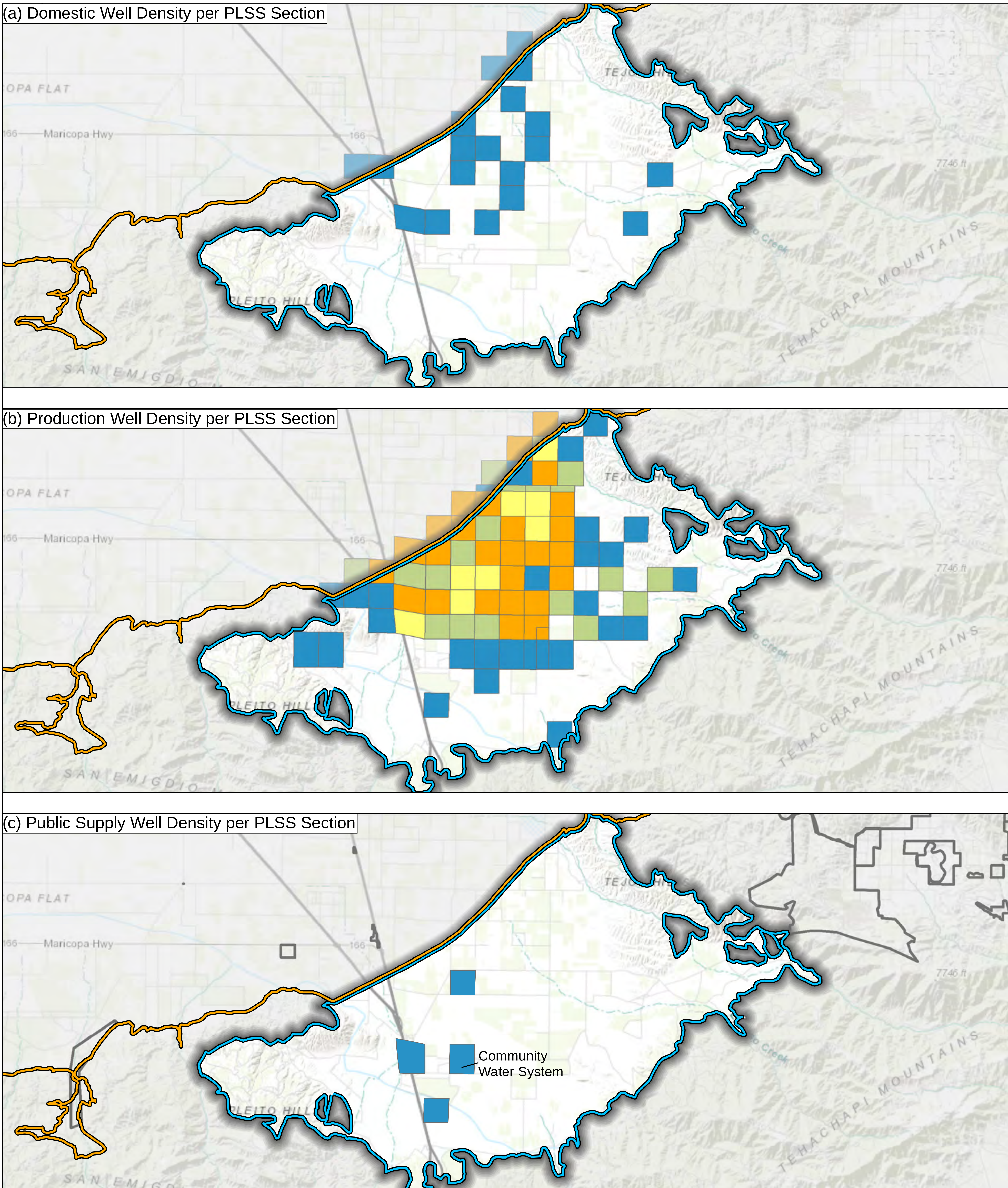
Well Density from DWR Well Completion Reports

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure PA-4

Path: X:\B50001.05\Maps\GSP\2022\01\FigPA-4_WellDensity_DWR.mxd



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)

Well Density per PLSS Section

- 1 - 2
- 2 - 3
- 3 - 4
- > 4

Abbreviations

DMS = Data Management System
DWR = California Department of Water Resources
PLSS = Public Land Survey System

Notes

1. All locations are approximate.
2. Production wells include "unknown" well use as specified in the White Wolf DMS.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Well count per square mile (PLSS section) from White Wolf DMS.

N

0 4 8

(Scale in Miles)

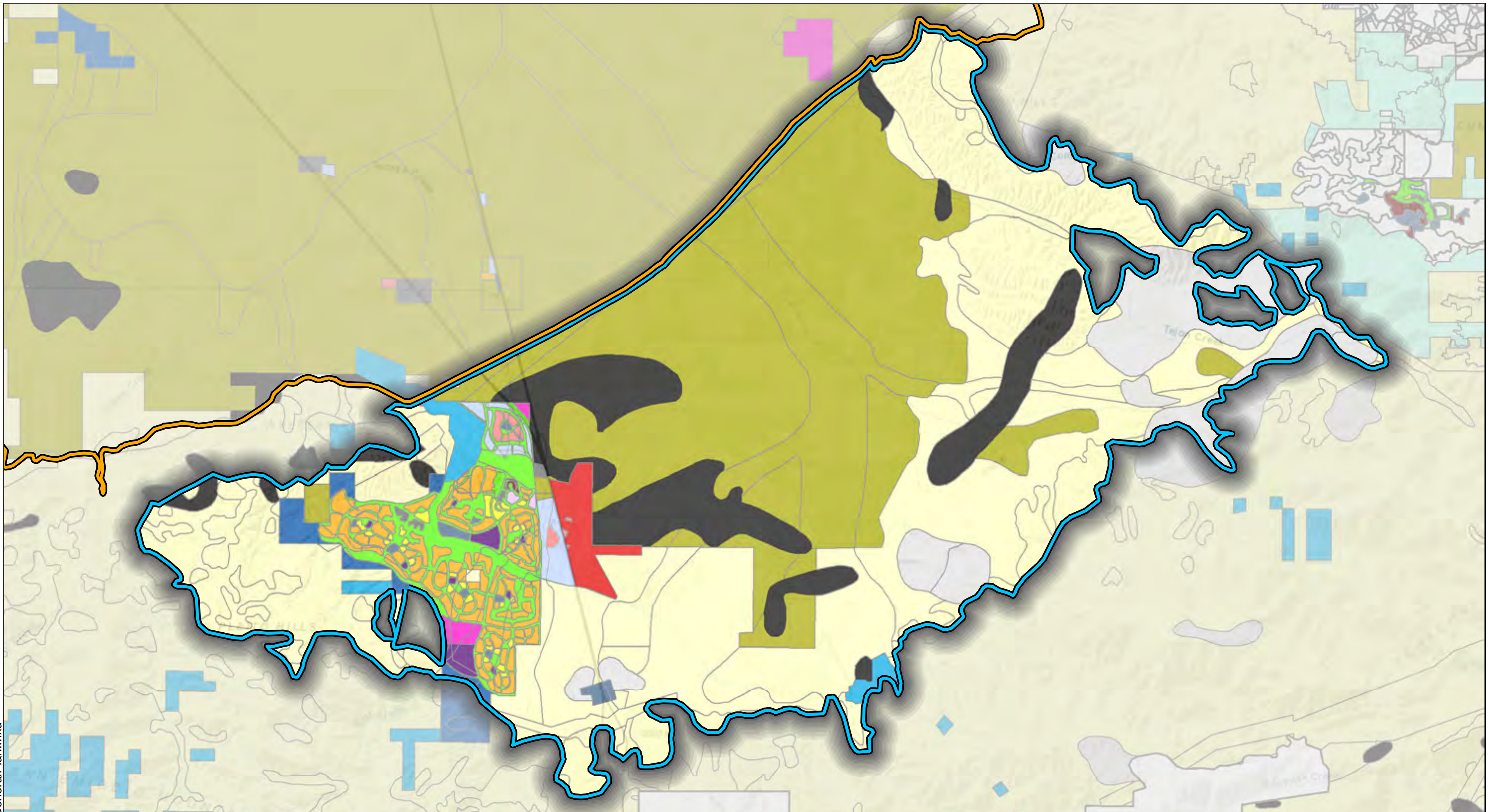
Well Density from White Wolf DMS

White Wolf GSA
Kern County, California
December 2021
B50001.05

Figure PA-5

eki environment & water

Path: X:\B50001.05\Maps\GSP\2022\01\FigPA-5_WellDensity_DMS.mxd



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)

Kern County General Plan Land Use Designation

- Light Industrial
- General Industrial
- Service Industrial
- General Commercial
- Major Commercial
- Educational Facilities
- Other Facilities
- Highway Commercial
- Maximum 10 Units/Net
- Maximum 16 Units/Net
- Maximum 29 Units/Net
- Mineral and Petroleum (Min. 5 Acre Parcel Size)
- Public or Private Recreation
- Resource Management (Min. 20 Acre Parcel Size)
- Resource Reserve (Min. 20 Acre Parcel Size)
- State or Federal Land
- Extensive Agriculture (Min. 20 Acre Parcel Size)
- Intensive Agriculture (Min. 20 Acre Parcel Size)
- Specific Plan Required
- Other designations, not in White Wolf

Abbreviations

DWR = California Department of Water Resources
Min. = Minimum

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Kern County General Plan information obtained on 16 August 2018 from http://esps.kerndsa.com/gis/gis-download-data

N

0 3 6

(Scale in Miles)

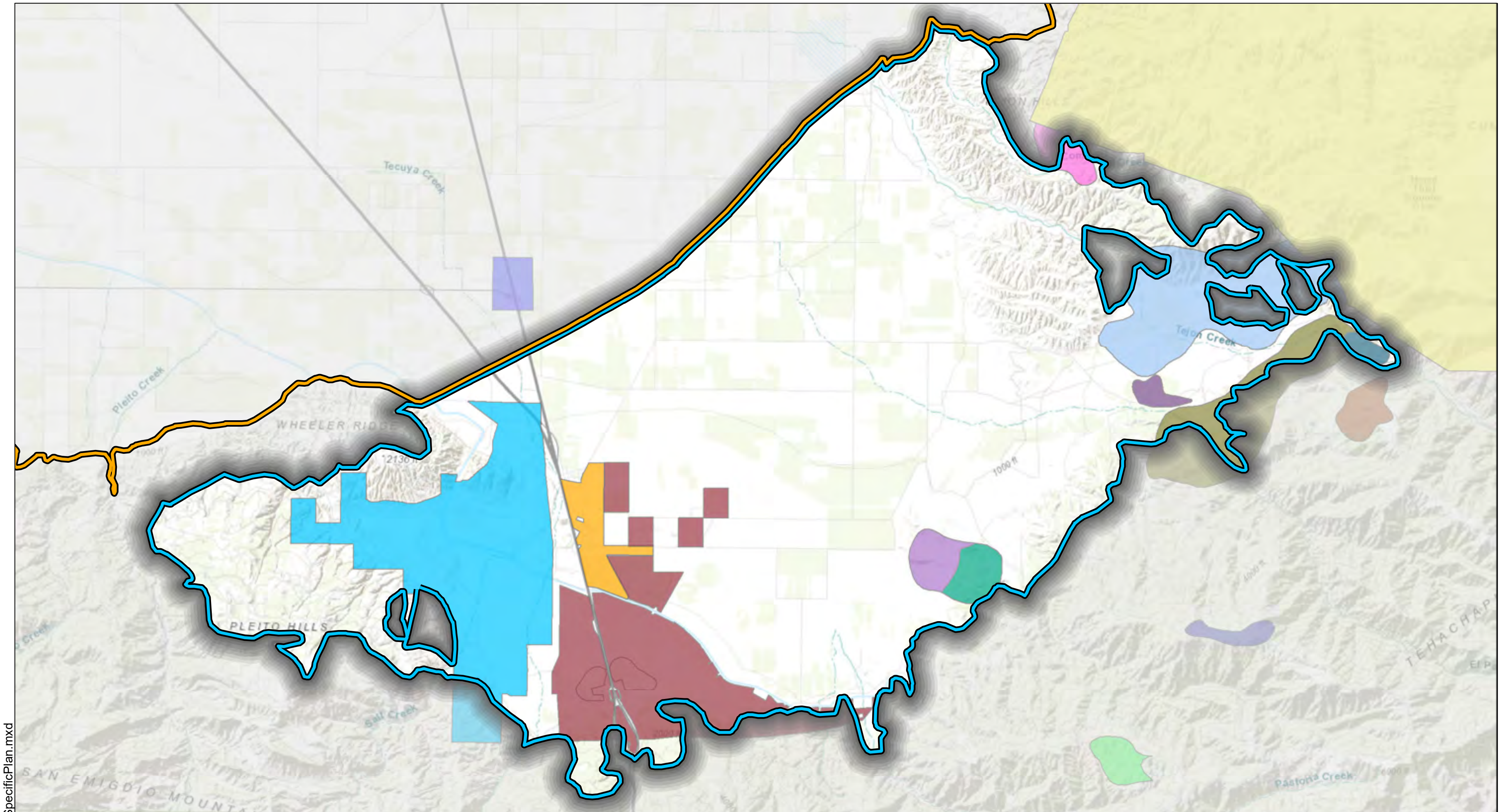
Kern County General Plan Land Use Designation

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure PA-6

Path: X:\B50001.05\Maps\GSP\2022\01\FigPA-6_KC_GeneralPlan.mxd



Legend

Groundwater Subbasin
- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)

Specific Plan Area
- Bear Trap
- Commanche
- Grapevine
- Greater Tehachapi Area
- Mettler
- San Emidio
- Tejon Canyon North
- Tejon Canyon Resort
- Tejon Canyon South
- Tejon Creek No. 1
- Tejon Creek No. 2
- Tejon Hills
- Tejon Industrial Complex East
- Tunis Creek
- Tunis Ridge
- Winters Ridge

Abbreviations

DWR = California Department of Water Resources

Notes

1. All locations are approximate.
2. The Grapevine Specific Plan area is a different boundary than shown on the Kern County Interactive GIS Online Mapping Tool (called "Grapevine Commercial").

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Specific Plan areas from Kern County General Plan obtained on 16 August 2018 from http://esps.kerndsa.com/gis/gis-download-data
4. Grapevine Specific Plan area provided by Tejon Ranch Company on 3 December 2018.

N 0 3 6 (Scale in Miles)

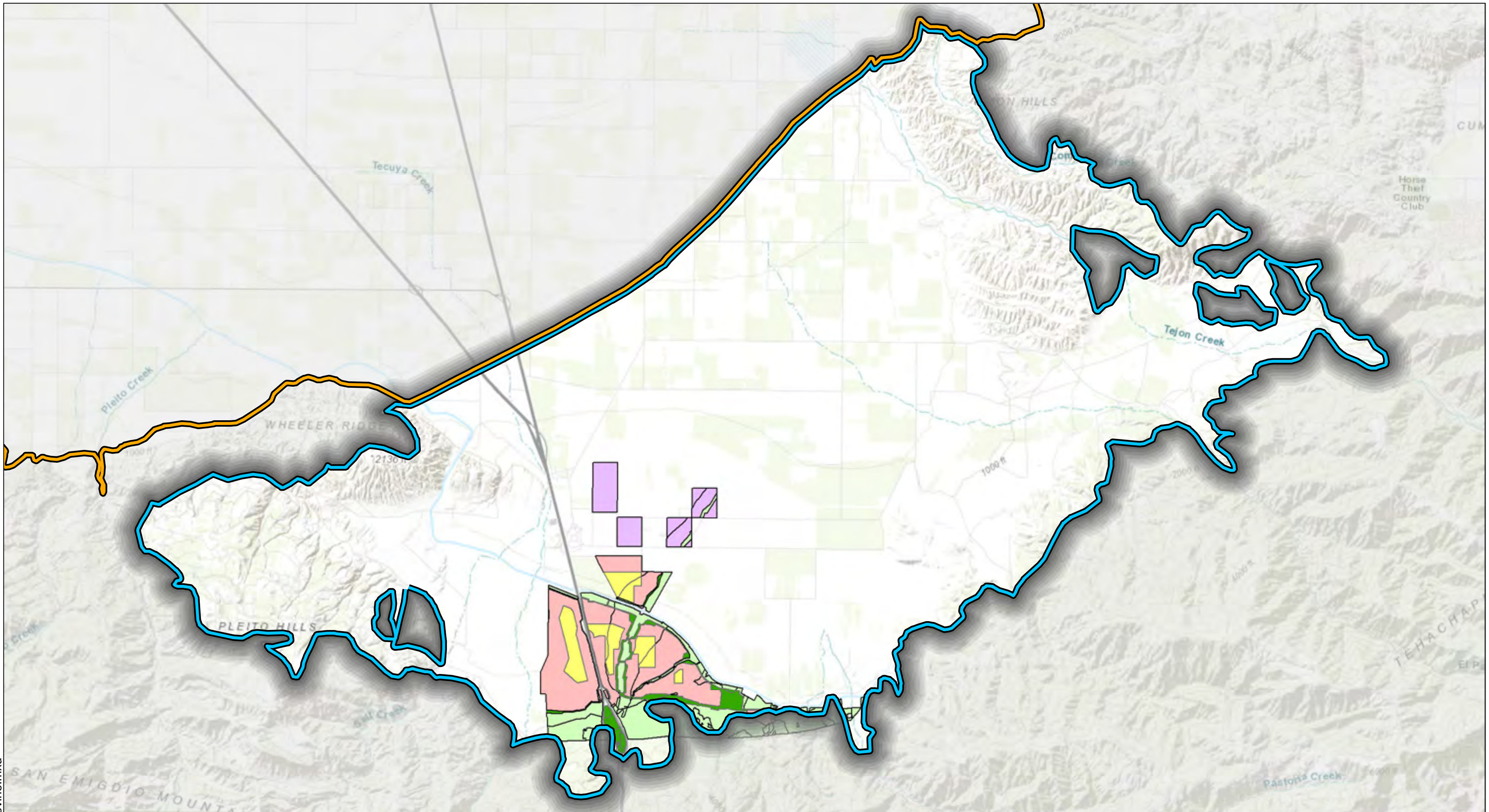
Specific Plan Areas

eki environment & water

White Wolf GSA
Kern County, California
December 2021
B50001.05

Figure PA-7

Path: X:\B50001.05\Maps\GSP\2022\01\FigPA-7_KC_SpecificPlan.mxd



Path: X:\B50001.05\Maps\GSP\2022\01\FigPA-8_Grapevine.mxd

Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)

Grapevine Development Zoning

- Exclusive Agriculture
- Industrial District
- Mixed Use District
- Open Area
- Village Mixed Use District

Abbreviations

DWR = California Department of Water Resources

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Grapevine zoning provided by Tejon Ranch Company on 3 December 2018.

N

0 3 6

(Scale in Miles)

Grapevine Specific Plan Projected Land Use

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure PA-8

BASIN SETTING

6. INTRODUCTION TO BASIN SETTING

§ 354.12. Introduction to Basin Setting
This Subarticle describes the information about the physical setting and characteristics of the basin and current conditions of the basin that shall be part of each Plan, including the identification of data gaps and levels of uncertainty, which comprise the basin setting that serves as the basis for defining and assessing reasonable sustainable management criteria and projects and management actions. Information provided pursuant to this Subarticle shall be prepared by or under the direction of a professional geologist or professional engineer.

This section presents the Basin Setting information for the White Wolf Subbasin (Basin) (**Figure HCM-1**). In some cases, Basin Setting information for areas proximal to, but outside of, the Basin is provided for context. Basin Setting information includes the Hydrogeologic Conceptual Model (HCM), Groundwater Conditions, and Water Budget.

7. HYDROGEOLOGIC CONCEPTUAL MODEL

§ 354.14. Hydrogeologic Conceptual Model
(d) Each Plan shall include a descriptive hydrogeologic conceptual model of the basin based on technical studies and qualified maps that characterizes the physical components and interaction of the surface water and groundwater systems in the basin.

This section presents the Hydrogeologic Conceptual Model (HCM) for the White Wolf Subbasin (Basin). As described in the HCM Best Management Practices (BMP) document (California Department of Water Resources [DWR], 2016a), a HCM provides, through descriptive and graphical means, an understanding of the physical characteristics of an area that affect the occurrence and movement of groundwater, including geology, hydrology, land use, aquifers and aquitards, and water quality. This HCM serves as a foundation for subsequent Basin Setting analysis including water budgets (***Section 9***) and the development of sustainable management criteria (***Section 11*** through ***15***).

7.1. General Description

§ 354.14. Hydrogeologic Conceptual Model
(b) The hydrogeologic conceptual model shall be summarized in a written description that includes the following:
(1) The regional geologic and structural setting of the basin including the immediate surrounding area, as necessary for geologic consistency.
(2) Lateral basin boundaries, including major geologic features that significantly affect groundwater flow.
(3) The definable bottom of the basin.
(4) Principal aquifers and aquitards, including the following information:
(A) Formation names, if defined.
(B) Physical properties of aquifers and aquitards, including the vertical and lateral extent, hydraulic conductivity, and storativity, which may be based on existing technical studies or other best available information.
(C) Structural properties of the basin that restrict groundwater flow within the principal aquifers, including information regarding stratigraphic changes, truncation of units, or other features.
(D) General water quality of the principal aquifers, which may be based on information derived from existing technical studies or regulatory programs.
(E) Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply.
(5) Identification of data gaps and uncertainty within the hydrogeologic conceptual model

7.1.1. Geological and Structural Setting

The Basin is located at the southern end of the San Joaquin Valley Groundwater Basin which is the portion of California's Central Valley that is south of the San Joaquin/Sacramento River Delta (**Figure HCM-1**). The San Joaquin Valley is a structural trough filled with tens of thousands of feet of Cenozoic continental and shallow marine sedimentary deposits transported from the surrounding mountains which include the Sierra Nevada Mountains to the east, the Coast Range Mountains to the west, and the San Emigdio and

Tehachapi Mountains to the south (Davis et al., 1959). The Basin is bounded on the north by the White Wolf Fault (WWF) system, on the east and south by a crystalline basement complex of the Tehachapi Mountains, and on the west by Tertiary-age sedimentary rocks of the San Emigdio Mountains. The Basin is a sedimentary trough filled with Tertiary-age sandstone, siltstone, shale, conglomerates, and minor volcanics and Quaternary-age alluvial deposits. Underlying the Basin is the U-shaped Tejon embayment, which consists of Eocene-age marine facies and rests unconformably on a basement complex (Nilsen, 1987). In the center of the Basin lies a graben created by high-angle normal faulting of the Tejon embayment (Goodman et al., 1989).

The Basin is located in a tectonically active region in which stresses are created by the convergence of the Pacific and North American Plates. The San Andreas Fault, which forms the tectonic boundary between these two plates, experiences a significant deviation in trend where it intersects with the Garlock Fault, less than 20 miles to the west of the Basin (e.g., area known as "The Big Bend;" Goodman and Malin, 1992). The geologic structure of the Basin and the underlying Tejon embayment includes the WWF defining the northern boundary; high-angle and oblique-slip faults and a central graben in the center of the Basin; surrounding thrust faults; and the prominent Wheeler Ridge and Comanche Point anticlines (Goodman and Malin, 1992). The WWF is a recently active southward-dipping high-angle reverse fault that has resulted in significant displacement of stratigraphic units on either site (California Division of Mines, 1955). The Springs Fault is another southeastern-dipping high angle fault with evidence of oblique movement that displaces impermeable strata, resulting in an interior subdivision of the Basin by creating a partial hydraulic barrier to flow in the southeastern corner of the Basin (Bookman-Edmonston, 1995; Goodman and Malin, 1992) and effectively separating the Principal Aquifer from the shallow water-bearing zone that supports groundwater dependent ecosystems (GDEs). At the surface, the Springs Fault has a visible escarpment and clusters of springs on the south side of the mapped fault zone (Goodman and Malin, 1992).

7.1.2. Lateral Basin Boundaries

The Basin is bounded on the east, south, and west by the extent of late Tertiary and Quaternary continental deposits, as drawn in geologic maps produced by the California Division of Mines and Geology (CDMG) (CDMG, 1964; CDMG, 1969). See ***Section 7.3 Physical Characteristics*** below for additional discussion.

The WWF forms the northern boundary of the Basin, separating it from the Kern County Subbasin. As discussed above, the WWF is a southward-dipping reverse fault, with the northern block down-dropped relative to the southern block. There is also a component of left-lateral slip on the fault (California Division of Mines, 1955). The total vertical displacement is estimated to be over 10,000 feet (ft) and is greatest at the southwestern end, lessening to the northeast (California Division of Mines, 1955). As evidenced by surface rupture during the major earthquake of 21 July 1952, the WWF is active and its displacement plane extends to the ground surface, affecting the youngest sedimentary deposits. As discussed in more detail in ***Section 7.1.4*** below, the bulk of available evidence demonstrates that the WWF acts as a significant impediment to groundwater flow (Erler & Kalinowski, Inc. [EKI], 2016). These lines of evidence include substantial groundwater elevation differences across the fault (based on analysis of available water level data and reports prepared by others) and groundwater modeling studies. This fact led DWR to delineate the Basin in 2016 as a separate basin from the Kern County Subbasin, with the WWF bounding the Basin on the north.

7.1.3. Bottom of the Basin

The southern San Joaquin Valley is a deep structural trough filled with a thick sequence of Tertiary sediments including sandstone, siltstone, shale, and conglomerate. Multiple sources of information can be relied on to define the "bottom of the basin" for purposes of Sustainable Groundwater Management Act (SGMA), including elevation maps of the basement bedrock surface; information on the base of fresh water; the presence, location and depth of oil and gas fields; "exempted" aquifers under the Safe Drinking Water Act (SDWA); and depth of groundwater extraction. Each of these is discussed below, with depth information presented as feet below ground surface (ft bgs) or feet above mean sea level (ft msl), based on the original source information. A summary comparison, including a unit normalization, is included in **Table HCM-1**.

7.1.3.1. Depth to Basement Bedrock

The depth of pre-Tertiary basement rocks which form the impermeable floor of the San Joaquin Valley groundwater basin generally increases from east to west within the southern end of the San Joaquin Valley. Within the Basin, the elevation of the top of the basement rock surface ranges from about -6,000 ft msl in the east to about -20,000 ft msl in the west (Scheirer, 2013). Given the land surface elevations, discussed in further detail in ***Section 7.3 Physical Characteristics***, the depth to bedrock ranges from over 8,000 ft bgs in the eastern portion of the Basin to over 24,000 ft bgs in the western portion.

7.1.3.2. Base of Fresh Water

Despite the substantial thickness of sedimentary strata overlying the impermeable basement bedrock within the basin, it is often more appropriate to consider geochemical properties (i.e. water quality) in determining the definable bottom of the Central Valley basins (DWR, 2016a). Documentation of DWR's California Central Valley Surface Water-Groundwater Simulation model (C2VSim) states that "although the Central Valley sedimentary basins are very thick, the freshwater aquifer in each basin is very thin" (Brush et al., 2016).

For over a century, oil and gas exploration and development has occurred throughout Kern County, tapping various Tertiary sedimentary deposits. Such activity continues to this day and has resulted in the accumulation of a substantial body of knowledge concerning the regional geology, including stratigraphy, structural features, hydrocarbon occurrence, and the geochemical character of the groundwater. Active oil fields in the Basin and contours of the depth to base of fresh water are shown on **Figure HCM-2**. The base of fresh water is defined by the California Geologic Energy Management Division (CalGEM, formerly California Division of Oil, Gas, and Geothermal Resources [DOGGR]) to be the depth where groundwater exceeds 3,000 milligrams per liter (mg/L) of total dissolved solids (TDS).[25] The CalGEM base of freshwater determination is based primarily on salinity derived from borehole electric log ("e-log") data but in some cases is based on boron concentrations.

The vertical extent of fresh water in the Basin is deepest in the center of the valley trough and in the northern portion of the Basin; the base of fresh water indicated on the field data sheets for these oil fields ranges from 750 ft bgs at Comanche Point to 2,200 ft bgs at Tejon Flats (DOGGR, 1998). Investigations of the Basin in the 1970s determined that fresh water occurs in water-bearing strata to depths of nearly 2,500 ft bgs (Bookman-Edmonston, 1975; Anderson et al., 1979). The depth to the base of freshwater declines towards the margins of the Basin, where alluvial layers thin and eventually meet bedrock at the Basin boundary. North of the WWF, in the Kern County Subbasin, the depth to base of fresh water is generally greater than in the Basin, with values ranging from 2,500 to 5,500 ft bgs.

Groundwater with TDS concentrations less than 10,000 mg/L could theoretically be used as a source of drinking water (Metzger and Landon, 2018). Recent tabulation of data from wells located within the Wheeler Ridge and Tejon oil fields suggests that groundwater with TDS concentrations exceeding 3,000 mg/L is found at approximately 1,200 and 1,800 ft bgs, respectively and that groundwater with TDS concentrations exceeding 10,000 mg/L is found at approximately 1,200 and 3,100 ft bgs, respectively (Metzger and Landon, 2018).

7.1.3.3. Exempted Aquifers

Under the SDWA, the United States Environmental Protection Agency (USEPA, and through a primacy agreement, the State Water Resources Control Board [SWRCB]) regulates injections into underground sources of drinking water. One such type of injection, known as Class II injections, involves either enhanced oil recovery or disposal of fluids associated with oil and gas production. Class II injections are prohibited under the SDWA, except in "exempted aquifers." The CalGEM and SWRCB consider proposals for aquifer exemptions on a case-by-case basis.

Within the Basin, an aquifer exemption for the Upper Miocene marine shelf sandstone Transition Zone within the western area of the Tejon oil field was approved by the SWRCB on 8 February 2017[26]. Based on the CalGEM field data sheet for the Tejon oil field, this formation generally occurs at an approximate depth of 2,600 ft bgs (DOGGR, 1998).

[25] The United States Environmental Protection Agency (USEPA) defines water with a TDS concentration of less than 3,000 mg/L to be suitable for livestock consumption or crop irrigation. Water between 3,000 mg/L and 10,000 mg/L is defined as "usable quality water" and water exceeding 10,000 mg/L is defined as "brine." The USGS commonly refers to water with a TDS concentration of less than 1,000 mg/L as freshwater. A recent USGS report (Osborn et al., 2013) completed as part of the Brackish Groundwater Assessment defined saline groundwater as follows: "slightly saline" groundwater containing a TDS concentration between 1,000 and 3,000 mg/L; "moderately saline" groundwater containing a TDS concentration between 3,000 and 10,000 mg/L; "very saline" groundwater containing a TDS concentration between 10,000 and 35,000 mg/L; and "brine" containing a TDS concentration exceeding 35,000 mg/L. For the purposes of this Study, the CalGEM definition of 3,000 mg/L was utilized to describe the base to fresh water.

[26] https://epa.maps.arcgis.com/apps/MapSeries/index.html?appid=426ef9d346f9487e96ee5899ab67a2e4

7.1.3.4. Deepest Groundwater Extractions

The HCM BMP (DWR, 2016a) states that "the definable bottom of the basin should be at least as deep as the deepest groundwater extractions." Based on well construction information from 130 wells within the Basin[27], all wells have depths of 2,200 ft bgs or less and 90% of the wells have depths of 1,522 ft bgs or less.

Another representation of the "bottom" of the Basin is included in applicable groundwater flow models, specifically DWR's C2VSim model which has been developed over many years and iterations (Brush et al., 2016; DWR, 2020a) and the White Wolf Groundwater Flow Model (WWGFM) developed specifically for the Basin. A new fine-grid (FG) version of C2VSim was released by DWR in April 2021. Compared to previous versions of this model, the updated version of C2VSim (C2VSimFG V1.01)[28] has a finer grid/mesh, revised thicknesses for Layers 1 through 3, and an additional deeper Layer 4. Groundwater pumping in the C2VSimFG V1.01 model is simulated to occur only within the top two layers in the domain covering the Basin. The combined thickness of these two upper layers for the 115 C2VSimFG V1.01 model nodes within the Basin ranges from 838 ft to 4,010 ft, averaging 1,833 ft. In the Basin, the average depth of the bottom of Layer 2 of C2VSimFG V1.01 appears to capture the large majority of well depths with the exception of about 5% of wells with depths greater than 1,833 ft bgs. The depth of these wells is below the bottom of Layer 2. However, it is likely that their screened intervals extend upwards into the depth zone captured by Layer 2 of C2VSimFG V1.01 (i.e., they are not likely to be screened entirely below the bottom of Layer 2).

As discussed in ***Section 9.2 Water Budget Methods*** below, the WWGFM is a numerical groundwater flow model developed for the Basin. The WWGFM has four model layers representing the four primary formations in the Basin: (1) shallow quaternary alluvium, (2) Kern River Formation, (3) Chanac Formation, and (4) Santa Margarita Formation. While 96 percent of the pumping in the WWGFM occurs in Layer 2 (Kern River Formation), a small amount of pumping occurs in Layer 3 (Chanac Formation) and virtually all pumping in the WWGFM occurs in the upper three layers. The combined thickness of these three layers ranges from 25 to 7,815 ft; in the central part of the Basin the average combined thickness of these three layers is approximately 2,700 ft (see **Figure HCM-3**).

Given the above information, the controlling factor for the definable "bottom of the basin" is determined to be the depth of the deepest groundwater extractions. Furthermore, as SGMA is focused on the extraction of usable, drinkable groundwater, this hydrogeologic definition also aligns with the intent of the legislation itself. Therefore, for the purposes of this Groundwater Sustainability Plan (GSP), the bottom of the Basin is defined to be the bottom of the Chanac Formation which averages 2,700 ft bgs in the central part of the Basin where all production wells exist. In places this is deeper than the reported depth to the base of fresh water.

[27] Wells with screen, completed well depth, and/or borehole depth information.
[28] https://data.cnra.ca.gov/dataset/c2vsimfg-version-1-01

Table HCM-1. Information Relevant to Definition of the Bottom of the Basin

Type of Information	Source(s)	Elevation Range[a] (ft msl)	Depth Range[a] (ft bgs)
Depth to Bedrock Basement	Scheirer, 2013	Western Area: -18,000 to -20,000 Eastern Area: -6,000 to -8,000	Western Area: 22,000 to 24,000 Eastern Area: 9,000 to 11,000
Oil Field Base of Fresh Water Information	DOGGR, 1998	Comanche Point: 50 Tejon Flats: -1,400	Comanche Point: 750 Tejon Flats: 2,200
Base of Fresh Water	Bookman-Edmonston, 1975; Anderson et al., 1979	Northern Area: -2,000	Northern Area: 2,500
	Metzger and Landon, 2018	Tejon: -700 Wheeler Ridge: 50	Tejon: 1,800 Wheeler Ridge: 1,200
Exempted Aquifers	SWRCB; CalGEM	Tejon oil field area: -1,500	2,600
Principal Aquifer	WWGFM Layers 1-3	Entire Basin: -6,981 to 2330 Central Basin: -9,306 to 679 (avg -2,300)	Entire Basin: 25 to 7,518 Central Basin: 223 to 7,518
Deepest Groundwater Extractions from Well Construction Information	White Wolf Subbasin DMS	90% of wells bottom < -918 100% of wells bottom < -1,308	90% of wells < 1,522 feet deep 100% of wells < 2,200 feet deep
Deepest Groundwater Extractions from Regional Groundwater Model	DWR, 2020a	C2VSim-FG V1.01: -1,022 to 836[b]	C2VSim-FG V1.01: 838 to 4,010[b]
Deepest Groundwater Extractions from Basin Groundwater Model	WWGFM	WWGFM -4,189 to 628[b]	WWGFM 495 to 4,707[b]

Abbreviations:

C2VSim-FG V1.01 = California Central Valley Surface Water-Groundwater Simulation model fine-grid version 1.01
CalGEM = California Geologic Energy Management Division
DMS = Data Management System
DOGGR = California Division of Oil, Gas, and Geothermal Resources
DWR = California Department of Water Resources
ft bgs = feet below ground surface
ft msl = feet above mean sea level
SWRCB = State Water Resources Control Board
WWGFM = White Wolf Groundwater Flow Model

Notes:

(a) Shaded cells indicate estimated values based on approximate ground surface elevation.
(b) Elevations and depths reported here are for the bottom of the model layer with the deepest groundwater extractions. Perforated intervals in the pumping wells are likely above the layer bottoms.

7.1.4. Principal Aquifers and Aquitards

Principal aquifers are defined in 23 California Code of Regulations (CCR) §351 as "aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems" (23 CCR §351(aa)). As shown on **Figure HCM-4**, well construction information from 130 wells within the Basin indicates that all wells have depths less than 2,200 ft bgs. Therefore, for the purposes of this GSP and consistent with the definition for the bottom of the Basin, the Principal Aquifer is defined as consisting of the deposits of Shallow Alluvium, Kern River Formation, and Chanac Formation. Within this depth zone, the Basin is underlain by four potentially water-bearing units: (1) Quaternary/Recent fan, terrace, and alluvial deposits (referred to herein as the Shallow Alluvium), (2) the Kern River Formation, (3) the Chanac Formation, and (4) the Santa Margarita Formation (Wood and Dale, 1964; Arvin-Edison Water Storage District [AEWSD], 2003; Wheeler Ridge-Maricopa Water Storage District [WRMWSD], 2007). **Table HCM-2** illustrates the relationship between the various stratigraphy and nomenclature for aquifer units, formation names, corresponding WWGFM and C2VSimFG V1.01 model layers, and geologic units throughout the Basin.

The Basin contains productive, water-bearing strata with a total estimated storage capacity of 4.0 million acre-feet (AF) (Anderson et al., 1979). The degree to which formations in the Basin are confined or unconfined is not well known, but groundwater is generally expected to be unconfined to semi-confined to depths of 1,000 ft or more (WRMWSD, 2007). Confinement in the Basin increases with depth and is likely related to sections of poorly sorted, fine-grained deposits, rather than, for example, a single thick layer of lacustrine clay. The lenticular geometry, heterogeneity of deposits, and similarity of depositional environments makes it difficult to distinguish separate aquifer units in most areas of the Basin. Therefore, for the purposes of this GSP, the Principal Aquifer is defined as consisting of the deposits of Shallow Alluvium, Kern River Formation, and Chanac Formation. Consistent with the definition of the bottom of the Basin, the thickness of the Principal Aquifer ranges from 25 to 7,518 ft (average of 2,200 ft) over the entire Basin.

Table HCM-2. Stratigraphic Nomenclature and Associations

Aquifer	Formation Name	WWGFM Layer	C2VSim-FG V1.01 Layer	Symbol on Surficial Geologic Map (Figure HCM-13)	Symbol / Label on Hydrogeologic Cross-Sections (Figure HCM-11 and Figure HCM-12)
Principal	Shallow Alluvium[a]	Layer 1	Layer 1	Qf, Qt, Qal	Qf, Qt, Qal
	Kern River	Layer 2 & Layer 3	Layers 2-4[b]	Qc	Undifferentiated Kern River/Chanac
	Chanac			Pmlc	
Unpumped	Santa Margarita	Layer 4		Mc	Santa Margarita

Abbreviations:
C2VSim-FG V1.01 = California Central Valley Surface Water-Groundwater Simulation model fine-grid version 1.01
WWGFM = White Wolf Groundwater Flow Model

Notes:
(a) The shallow water-bearing zone located south of the Springs Fault is hydraulically isolated from the Principal Aquifer in the north and central portion of the Basin.
(b) Depending on location, model layer may include one or more of these formations.

7.1.4.1. Formation Names and Occurrence

The Shallow Alluvium is comprised of Quaternary/Recent fan, terrace, and alluvial deposits, including discontinuous beds of sand, silt, clay, and gravel alluvial deposits. Thickness of the Shallow Alluvium varies throughout the Basin. As described in ***Section 7.1.2*** and illustrated on **Figure HCM-1**, the western, southern, and eastern Basin boundaries are defined by the outcrop of late Tertiary and Quaternary continental deposits, and therefore alluvial deposits are not believed to exist outside these boundaries. These alluvial deposits are generally thinner near the eastern, southern, and western Basin margins and thicken towards the center of the Basin. Anderson et al. (1979) reported alluvial thickness increasing from the eastern margins to the northwest portion of the Basin.

The Kern River Formation consists of coarse- to fine-grained sand and sandy clays interbedded with poorly-sorted sands, gravels, and boulders. This formation is considered to be moderately to highly permeable and able to yield moderate to large volumes of water (Bookman-Edmonston, 1995). The depth and thickness of the Kern River Formation varies throughout the Basin. Overall, the formation thickens and deepens with distance from the southern and eastern margins of the Basin. The formation pinches out approximately two miles from the southern boundary, in between Interstate-5 (I-5) and the A.D. Edmonston Pumping Plant (WZI, 2013). To the north and west, the Kern River Formation thickens to over

1,000 ft, and the depth to the top of the formation increases from 400 ft bgs to nearly 900 ft bgs. A significant regional aquitard, the “E”-Clay or “Corcoran Clay,” is one of several flood-basin, lacustrine and marsh deposits that exist within the southern San Joaquin Valley and is often referred to as “blue clay” in well driller logs (Croft, 1972). Another similar regional aquitard unit, the “A”-Clay, exists at shallower depth. Neither the “E”-Clay nor the “A”-Clay are present within the Basin (Croft, 1972).

The Chanac Formation underlies the Kern River Formation in most of the Basin and contains several semi-confined and confined water-bearing units. This formation consists of loosely consolidated fanglomerate with sand and clay lenses (Bookman-Edmonston, 1995). In the central portion of the Basin, the top of the formation occurs at average depths of approximately 2,700 ft bgs (below the depths of water wells in the Basin). A clay-rich transition zone spans about 50 to 100 ft between the Chanac Formation and the underlying Santa Margarita Formation and may act as a confining layer to the Santa Margarita Formation aquifer.

The Santa Margarita Formation consists of well-sorted gray sandstone, gravel, and shale (Croft, 1972). The thickness of this formation in the Basin is 100 to 1,000 ft in the Tejon Hills and 700 to 900 ft near Pastoria Creek in the southern portion of the Basin (Hoots, 1930; Bookman-Edmonston, 2007).

7.1.4.2. Physical Properties of Aquifers and Aquitards

Specific yields were reported by Davis et al (1959) for alluvium in the San Joaquin Valley. For those township-range areas overlying the Basin, specific yields for the top 200 ft of alluvium were reported to range between 16% and 18%. Although this portion of alluvium is currently unsaturated in most of the Basin, these specific yields are likely to be generally consistent with deeper alluvium given the similar depositional nature and composition of the sediments. Since confinement and consolidation increases with depth, however, specific yields are likely somewhat lower at greater depths. Anderson et al. (1979) estimated that the weighted average of specific yields for all depth zones throughout the entire Basin was between 13.3% and 14.3%.

Wood and Dale (1964) developed a map of “yield factors” for the Edison-Maricopa area, which includes the central part of the Basin. The yield factor is defined as the specific capacity (gallons per minute per foot of drawdown) per 100 ft of aquifer screened by a well (i.e., units of gpm/100ft^2). The Wood and Dale (1964) map (**Figure HCM-5**) shows the central portion of the Basin has yield factors between 11 and 50 gpm/100ft^2, whereas areas near the margins of the Basin have lower yield factors between six and 10 gpm/100ft^2. While the yield factors of Wood and Dale (1964) provide insight into the relative productivity of wells, they do not directly translate into aquifer hydraulic properties.

Bookman-Edmonston (2007) evaluated the potential for groundwater storage and recovery in the southern portion of the Basin near Pastoria Creek. As part of this investigation, hydraulic properties were estimated in the center of the Basin through production well testing (two wells) and long-term aquifer testing (four wells). Production well testing consisted of 12-hour step-drawdown and 24-hour constant rate pumping tests, and the resulting data were analyzed using the Neuman method of analysis for anisotropic, unconfined aquifers. Long-term aquifer testing included three constant rate pumping tests conducted over a period of six weeks. Since Bookman-Edmonston (2007) experienced difficulty in distinguishing the Shallow Alluvium from the Kern River Formation, the two formations were reported in aggregate as "alluvium" (WRMWSD, email correspondence, 18 February 2016), which correspond to the upper formations comprising the Principal Aquifer. Formations within the Basin are considered to be productive relative to elsewhere in the region, as evidenced by the high transmissivity values reported (WRMWSD, 2007). Based on the production well testing, hydraulic conductivity estimates range from 52 to 217 ft/day with an average of 135 ft/day, specific yield estimates range from 10 to 21% with an average of 16%, and transmissivity estimates range from 251,000 to 1,050,000 gallons per day per foot (gpd/ft) with an average of 650,000 gpd/ft. Based on the long-term aquifer testing, hydraulic conductivity estimates range from 48 to 213 ft/day with an average of 92 ft/day, specific yield estimates range from 2.2 to 11% with an average of 6.5%, and transmissivity estimates range from 232,000 to 1,030,000 gpd/ft with an average of 685,000 gpd/ft. These parameters reported by Bookman-Edmonston (2007) are subject to uncertainty given the limited nature of the dataset.

Other estimates of transmissivity values for the Principal Aquifer include a range of 60,000 to 187,500 gpd/ft based on a yield factor analysis in which transmissivity is calculated as a function of the specific capacity of the well and the thickness of the water-bearing materials (Bookman-Edmonston, 1995). Transmissivity was also estimated from a step-drawdown pumping test adjacent to the WWF (EKI, 2016). Using a commonly-applied empirical formula to estimate transmissivity from specific capacity (Driscoll, 1986), a transmissivity of 65,000 gpd/ft was estimated for the Principal Aquifer. Finally, specific capacity calculated from information found on DWR Well Completion Reports can be used to estimate transmissivity and hydraulic conductivity when either the length of well screen or well depth is known. Based on available specific capacity data, transmissivity values range from 300 to 182,800 gpd/ft and average 59,600 gpd/ft. Using a specific capacity scaling factor of 1,500 representative of unconfined coarse-grained materials (Driscoll, 1986), hydraulic conductivity estimates range from 0.2 to 68 ft/d, and average 14 ft/d. **Figure HCM-6** shows the distribution of hydraulic conductivity estimates for the Basin based on pumping tests and specific capacity data.

In the central portion of the Basin, the Chanac Formation has a porosity of about 30% (DOGGR, 1998). Hydraulic conductivities for the formation have been reported up to 8.5 ft/day (DOGGR, 1998) with averages around 4 ft/d (WZI, 2013). Bookman-Edmonston (2007) conducted a series of pumping tests in this aquifer and calculated transmissivity in the range of 109 to 329 gpd/ft.

The porosity of the Santa Margarita Formation in the Basin ranges from 29% to 36%, with higher porosities occurring on the eastern portion of the Basin (DOGGR, 1998). Hydraulic conductivities range from 1.7 ft/day in the center of the Basin to 8.5 ft/day in the eastern portion of the Basin (WZI, 2013). Reliable transmissivity values for the Santa Margarita Formation aquifer are unavailable,[29] but use of the Santa

[29] Based on data from a pumping test, a transmissivity of 79 gpd/ft was calculated for the aquifer (Bookman-Edmonston, 2007). However, this estimated transmissivity does not appear to be representative of the Santa Margarita Formation aquifer (AEWSD, email correspondence, 26 January 2016). The low transmissivity value reported by Bookman-Edmonston (2007) may be explained by partial penetration that occurred as a result of short screened intervals in the pumping well (WRMWSD, email correspondence, 18 February 2016).

Margarita Formation for water supply purposes is not known within the Basin (AEWSD, email correspondence, 26 January 2016).

Numerical groundwater models can also provide information on the representation of the water-bearing properties of these materials (i.e., hydraulic conductivity, specific yield, and storativity). Models with extents that cover the Basin include DWR's C2VSim-FG, the U.S. Geological Survey (USGS)'s Central Valley Hydrologic Model (CVHM), and the WWGFM. **Table HCM-3** shows a summary of hydraulic property information from the three groundwater models.

C2VSim-FG has four model layers: Layer 1 generally corresponds to the Shallow Alluvium and layers 2-4 correspond to the Kern River, Chanac, Santa Margarita, and deeper formations, depending on location.

The CVHM is based on the USGS modular finite-difference flow model (MODFLOW) software package that simulates integrated subsurface and surface water flow processes for the period from October 1961 through September 2003. CVHM model layers 6, 7, 8, and 9 represent the saturated part of the Principal Aquifer to an approximate depth of the base of freshwater.

The WWGFM is the Basin-specific numerical groundwater flow model (MODFLOW-NWT) with four model layers representing the four primary formations in the Basin: layer 1 corresponds to the shallow alluvium, layers 2 and 3 correspond to the undifferentiated Kern River and Chanac Formations, and layer 4 corresponds to the Santa Margarita Formation. As such, layers 1 through 3 represent the Principal Aquifer.

Hydraulic conductivity values specified in the WWGFM are informed by texture maps whereby hydraulic conductivity varies depending on the percentage of coarse- and fine-grained materials. Aquifer storage and transmitting properties were calibrated against observed water level measurements in wells throughout the Basin.

Table HCM-3. Hydraulic Properties for the Basin Extracted from Numerical Groundwater Flow Models

Model	**Layer**	**Horizontal Hydraulic Conductivity (ft/day)** Average (Min to Max)	**Vertical Hydraulic Conductivity (ft/day)** Average (Min to Max)	**Specific Yield (-)** Average (Min to Max)	**Specific Storage (-)** Average (Min to Max)
C2VSim-FG V1.01	1	42 (11 to 110)	0.80 (0.22 to 1.6)	0.15 (0.11 to 0.17)	$1.1x10^{-5}$ ($1.0x10^{-5}$ to $2.7x10^{-6}$)
	2	16 (0.00010 to 32)	0.23 (0.11 to 0.48)	0.13 (0.09 to 0.17)	$1.8x10^{-5}$ ($2.0x10^{-5}$ to $4.7x10^{-5}$)
CVHM	6	222 (40 to 410)	0.092 (0.026 to 0.17)	N/A[a]	$2.0x10^{-6}$ ($1.0x10^{-6}$ to $2.0x10^{-6}$)
	7	142 (0.26 to 410)	0.045 (0.00033 to 0.070)	N/A[a]	$2.0x10^{-6}$ ($1.0x10^{-6}$ to $2.0x10^{-6}$)
	8	118 (0.26 to 420)	0.034 (0.00033 to 0.049)	N/A[a]	$2.0x10^{-6}$ ($1.0x10^{-6}$ to $2.0x10^{-6}$)
	9	101 (0.26 to 340)	0.023 (0.00033 to 0.029)	N/A[a]	$2.0x10^{-6}$
WWGFM	1	16 (0.062 to 50)	0.19 (0.0032 to 0.98)	0.12	$1.6x10^{-3}$ ($3.0x10^{-4}$ to $3.0x10^{-3}$)
	2	8.4 (0.0010 to 40)	0.07 (0.0002 to 0.24)	0.12	$8.7x10^{-4}$ ($2.0x10^{-6}$ to $2.0x10^{-3}$)
	3	0.22 (0.0050 to 0.68)	0.02 (0.0005 to 0.068)	0.12[a]	$8.7x10^{-4}$ ($2.0x10^{-6}$ to $2.0x10^{-3}$)
	4	0.95 (0.020 to 2.0)	0.0013 (0.00003 to 0.003)	0.12[a]	$5.6x10^{-4}$ ($2.0x10^{-6}$ to $1.5x10^{-3}$)

Abbreviations:

C2VSim-FG V1.01 = California Central Valley Surface Water-Groundwater Simulation model fine-grid version 1.01
CVHM = Central Valley Hydrologic Model
ft/day = feet per day
N/A = not applicable
WWGFM = White Wolf Groundwater Flow Model

Notes:

(a) Model layer is confined and therefore does not utilize specific yield in solving the groundwater flow equation.

7.1.4.3. Structural Properties of the Basin that Restrict Groundwater Flow Within the Principal Aquifers

The bulk of available evidence demonstrates that the WWF acts as a significant impediment to groundwater flow (EKI, 2016). This fact has been recognized by scientific studies (California Department of Public Works [CA DPW], 1952; Dibblee and Oakeshott, 1953; Dibblee, 1955; Hagan, 2001), DWR (Swanson, 1977; Anderson et al. 1979) and USGS (Davis et al., 1959; Wood and Dale, 1964) reports, and groundwater models (Faunt et al., 2009; Brush et al., 2013), and has led to local water agencies treating the Basin as a hydrologically separate unit (Jaspar, 1974; Jaspar et al., 1977; Tejon Ranch Company [TRC], 1984; Bookman-Edmonston, 1995; WRMWSD, 2007). On the basis of this scientific evidence, in 2016 DWR delineated the Basin as a separate subbasin from the Kern County Subbasin, with the northern boundary of the Basin represented by the WWF.

In addition to the WWF, which forms the northern boundary, there are numerous other faults within and near the Basin. The primary faults within the Basin are the northeast-trending Badger and Springs faults. The Badger Fault is located in the center of the Basin and dips 60° to 70° northwest (Goodman and Malin, 1992). The Springs Fault lies subparallel to the WWF in the southeastern portion of the Basin and, as described further in ***Appendix D***, forms a distinct partial barrier to groundwater flow, effectively isolating a shallow water-bearing zone from the Principal Aquifer. In addition to these two faults, there are many unnamed normal faults in the Basin that generally trend northwest and northeast (Goodman and Malin, 1992, see **Figure HCM-13**). The northwest-striking faults dip at approximately 45° and are locally truncated by the steeper-angle, northeast-striking faults, which dip at about 70° at shallow depths (Goodman et al., 1989). Finally, there are several thrust faults surrounding the rim of the Basin, including the Wheeler Ridge fault to the west, the Pleito thrust system to the southwest, and the Comanche thrusts to the northeast. These thrust systems lie between zones of normal faults, which they have locally exhumed and truncated (Goodman and Malin, 1992).

7.1.4.4. General Water Quality of the Principal Aquifer

General groundwater quality within the central part of the Basin is categorized by Wood and Dale (1964) as "transition" waters (see **Figure HCM-7**). In the east portion of the Basin there is an area categorized as "waters of the older rocks" and in the west there is an area categorized as "west-side waters." These categories reflect differences in the chemical characteristics of the streams that recharge the groundwater and the rock types through which the groundwater moves. The "waters of the older rocks" are of a sodium or sodium-calcium-bicarbonate type and the "west-side waters" have sulfate as the predominant anion with an intermediate cation composition. The "transition" waters represent the transition from water emanating from the east ("waters of older rocks") and water emanating from the west ("west-side waters"). The "transition" waters have bicarbonate as the predominant anion and an intermediate cation composition.

General water quality types can be inferred from the ionic composition of water samples, plotted on either a Piper Diagram (trilinear diagram) or Stiff Diagram. Both diagrams display the relative proportions of cations and anions in water samples. The ionic composition is typically derived from soluble and partially soluble minerals that the groundwater contacts during its flow downgradient.

In a Piper Diagram, the proportions of anions (chloride, sulfate, bicarbonate and carbonate) and cations (calcium, magnesium, potassium, and sodium) are plotted as points in lower triangles and the data points are projected into the central diamond plotting field along parallel lines. The Stiff Diagram plotting technique uses parallel horizontal axes extending on each side of a vertical zero axis. Concentrations of cations (sodium, calcium, and magnesium, in milliequivalents per liter [meq/L]), are plotted sequentially on each axis to the left of zero. Similarly, anion concentrations (chloride, bicarbonate, and sulfate) are plotted sequentially on each axis to the right of zero. The resulting points are connected to give an irregular polygonal shape or pattern, which can provide a distinctive method of showing water composition differences and similarities. The width of the pattern is proportional to the sample's total ionic content.

The Piper Diagram in **Figure HCM-8** represents the general water quality variability across the White Wolf Basin. There is no predominant cation in the samples, but most samples are dominated by bicarbonate. The Stiff Diagrams in **Figure HCM-9** represent a subset of the water quality samples and their shapes generally consistent with the characteristics represented by the Piper Plot. When placed on a map, the Stiff Diagrams provide additional insight into the spatial variability in water quality characteristics. The diagrams show that the composition of water samples from wells within central portions of the Basin are generally similar in ionic composition and content, with most comprised primarily of calcium and bicarbonate. Exceptions occur near the Basin boundaries and surface drainage features. For example, in the southwest and near Tecuya Creek the water samples are relatively rich in sulfate ion concentrations. Similarly, in the south and near LiveOak Cattle Creek, and in the northeast near Comanche Creek, the well water samples are relatively rich in sodium and chloride ion concentrations. These results suggest that the water quality in these wells is influenced by the dissolution of naturally occurring evaporite minerals that exist in the watersheds that feed these creeks, and introduced to the underlying groundwater with recharge as leakage, and is consistent with past conclusions of increased salinity and TDS concentrations on the western side of the Basin being attributed to recharge from Salt and Tecuya Creeks sourced from upland marine sediments (Anderson et al. 1979).

Groundwater quality in the Basin is generally suitable for agriculture, with TDS generally less than 500 mg/L (WRMWSD, 2007). Water quality data in the Basin are collected by several entities, including WRMWSD, AEWSD, DWR, and the USGS. Data collection and analysis mainly focuses on inorganic water quality constituents, as organic constituents generally do not appear to be a concern for water quality in the Basin (WRMWSD, 2007). Further discussion of specific constituents of particular relevance to the beneficial uses within the Basin, including maps of the distribution of these constituents, is provided in ***Section 8.5 Groundwater Quality Concerns***.

7.1.4.5. Primary Uses of the Principal Aquifer

The primary use of groundwater from the Principal Aquifer is to supply irrigated agriculture, predominantly lands planted with vineyards, deciduous fruits and nuts, and truck nursery and berry crops. This includes groundwater pumped by individual landowners for use on their crops, as well as groundwater pumped by WRMWSD and subsequently distributed to their customers. There are several domestic wells in the Basin, and the Tejon-Castac Water District (TCWD) maintains public supply wells for emergency backup for commercial and industrial use to the Tejon Ranch Commerce Center (TRCC). Finally, there are two other public water systems who provide water from a total of three wells. **Figure HCM-10** shows the distribution of wells within the Basin by well type (agriculture, domestic, industrial, monitoring, and unknown). The density of wells is greatest in the central and northern parts of the Basin where agricultural development has occurred.

7.1.5. Data Gaps

Key data gaps and uncertainties identified during development of this HCM for the Basin include:

- Uncertainty in distinguishing hydraulic properties (hydraulic conductivity, specific yield, and specific storage) between the Shallow Alluvium, Kern River Formation, and Chanac Formation.
- Uncertainty in hydraulic properties, hydraulic gradient, and groundwater flow across the WWF.
- Uncertainty in hydraulic properties, hydraulic gradient, and groundwater flow across the Springs Fault, with implications for management (or not) of shallow groundwater.
- Uncertainty about well construction details (i.e., many available well logs are old and illegible, and some well logs cannot be matched with certainty to the correct well and location).
- Uncertainty about well use and status (i.e., whether or not wells are active).
- Unknown well locations for the Tut Brothers public water system wells.
- Well density and spacing.

Additional data gaps related to the definition of groundwater conditions and water budget estimations are discussed in their relevant sections below.

7.2. Cross Sections

§ 354.14. Hydrogeologic Conceptual Model
(c) The hydrogeologic conceptual model shall be represented graphically by at least two scaled cross-sections that display the information required by this section and are sufficient to depict major stratigraphic and structural features in the basin.

Two geologic cross-sections (A-A’ and B-B’) were developed in support of this HCM (see **Figure HCM-11** and **Figure HCM-12**, respectively). The locations of the cross-sections with respect to the surficial geology are shown on **Figure HCM-13**. The two cross-sections were drawn orthogonal to each other, with cross-section A-A’ generally aligned northwest to southeast and cross-section B-B’ generally aligned southwest to northeast. The cross-sections extend laterally slightly beyond the boundaries of the Basin and extend vertically down to an elevation of -4,000 ft msl. As such, the cross-sections include the entire thickness of aquifer materials that comprise the Principal Aquifer (i.e., down through the Pliocene and younger continental/alluvial deposits of the Kern River Formation, ending at the base of the Mio-Pliocene Chanac Formation, or down through at least 2,200 ft bgs as discussed above) and includes the entire zone above the CalGEM base of freshwater surface. The cross-sections include the following:

- Land surface elevation extracted from the USGS 10-meter digital elevation model (DEM);
- Surficial geologic units after California Division of Mines and Geology (CDMG, 1964; CDMG, 1969), discussed further below;
- Water supply wells proximal to the cross-section lines[30], showing the perforated/screened interval and generalized lithologic information (i.e., fine, medium, or coarse intervals) derived from inspection of wells logs. The locations of water supply wells included on the cross-sections are shown on inset maps in the cross-section figures.
- CalGEM oil wells proximal to the cross-section lines from which the elevation of various stratigraphic markers and generalized lithologic information, where available, were extracted from well records.
- Subsurface geologic units, informed by Bartow (1984), Goodman and Malin (1992), EKI (2016), and CalGEM oil well information;
- Subsurface faults, informed by Goodman and Malin (1992);
- Groundwater levels from Fall 2015 and Fall 2019;
- Approximate depths of WWGFM layers; and
- Base of fresh groundwater or freshwater sands as identified from CalGEM oil wells.

As shown on the cross-sections and discussed previously, all groundwater supply wells with known construction information are less than 2,200 ft in total depth, whereas the Chanac Formation extends significantly deeper in the main irrigated portion of the Basin. Along the cross-section lines, the base of fresh water is deeper than groundwater supply wells in the Basin. Wells are typically not drilled deeper than needed to obtain the desired quantity and quality of water.

7.2.1. Cross-Section A-A’

Cross-section A-A’ (**Figure HCM-11**) extends for approximately 10.5 miles in a northwest-southeast direction through the center of Basin and is perpendicular to the WWF, Badger Fault, Springs Fault, and other unnamed, high-angle normal faults. The cross-section starts north of the WWF within the Kern County Subbasin (outside of the Basin), crosses into the Basin shortly thereafter, and extends through the entire Basin extent. The cross-section passes through the center of the Basin in which the surficial geologic unit is Quaternary fan deposits (“Qf”). Further south, where the land surface begins to rise near the foothills of the Tehachapi Mountains, the surficial geologic unit is Middle and/or Lower Pliocene non-marine (“Pmlc”) which transitions to Quaternary non-marine terrace deposits (“Qt”).

The subsurface geologic units include the Shallow Alluvium, underlain by the undifferentiated Kern River Formation and Chanac Formation, underlain by the Santa Margarita Formation. As discussed above, for the purposes of this GSP, the Principal Aquifer is defined as consisting of the deposits of Shallow Alluvium,

[30] Data were included from wells within 0.5 miles of the section line for cross-sections A-A’ and B-B’.

Kern River Formation, and Chanac Formation. Towards the foothills to the southeast, deeper formations including the Lower Fruitvale Shale, Round Mountain Silts and Olcese Sands are found beneath the Santa Margarita, which are further underlain by a basalt volcanic layer, the Tecuya Formation, Vedder Sands, and finally the granite basement. The formations beneath the Principal Aquifer are high-producing oil formations (Goodman and Malin, 1992).

In the central part of the Basin where most of the agricultural production wells are located, the base of fresh water delineated in the CalGEM logs falls within the undifferentiated Kern River Formation and Chanac Formation at elevations of approximately -700 to -1,200 ft msl, except for the most southeasterly area of the cross-section line where the Shallow Alluvium and Kern River Formation pinch out and the deeper Chanac and Santa Margarita Formations are closer to land surface. The base of fresh water deepens moving from southeast to northwest. The Fall 2015 and Fall 2019 groundwater elevation surfaces are shown only for the portion of the cross-section where water level measurements are available. Groundwater levels are around 200 ft msl in the center of the Basin and gradually decline to around 100 ft msl moving northward toward the WWF.

7.2.2. Cross-Section B-B’

Cross-section B-B’ (**Figure HCM-12**) extends for approximately 16 miles in a southwest-northeast direction through the center of Basin, is orthogonal to cross-section A-A’, is parallel with the Badger Fault, and is perpendicular to the Comanche thrust fault. The cross-section starts within the San Emigdio Mountains, crosses through the Pleito Thrust fault into the basin, and extends through the entire Basin extent. The surficial geology at the start of the line outside the Basin is Lower Miocene marine deposits (“Ml”), which transitions into Quaternary fan deposits (“Qf”) at the Basin boundary and remains throughout the main Basin floor area. In the northeast section of the line towards Comanche Point oil field, the cross section intersects a small outcrop of Pleistocene non-marine deposits (“Qc”) which then transitions through Quaternary non-marine terrace deposits (“Qt”). Moving northeasterly into the Tehachapi Mountains, the cross-section line intersects recent alluvium deposits (“Qal”) associated with Tejon Creek and Comanche Creek, interspersed between outcrops of Middle and/or Lower Pliocene non-marine (“Pmlc”) and undivided Miocene non-marine (“Mc”).

The subsurface geologic units include the Shallow Alluvium, underlain by the undifferentiated Kern River Formation and Chanac Formation, underlain by the Santa Margarita Formation. To the northeast towards the Tehachapi Mountains, the cross-section intersects the Comanche thrust faults which uplifted the formations to the east compared to the Basin center. Deeper formations in this area include the Upper and Lower Fruitvale Shale and Olcese Sands, underlain by a basalt volcanic layer and the granite basement. These formations are intercepted by a series of high-angle normal faults which formed the central graben located in the middle of the Basin (Goodman and Malin, 1992). On the southwest side of the Comanche thrust faults, oil reserve sands associated with the Comanche Point oil field are found around -2,000 ft msl and deeper.

In the central part of the Basin where most of the agricultural production wells are located, the base of fresh water delineated in the CalGEM logs falls within the Shallow Alluvium and undifferentiated Kern

River Formation and Chanac Formation at elevations of approximately -400 to -1,200 ft msl. The base of fresh water generally decreases moving southwest to northeast and generally agrees with the base of the C2VSim-FG Beta layer 2. The Fall 2015 groundwater elevation surface is shown for the areas in which water level measurements from the Principal Aquifer are available. Groundwater levels are around 250 ft msl in the center of the Basin; near the Comanche thrust fault, groundwater elevations rise to values of approximately 300 ft msl.

7.3. Physical Characteristics

§ 354.14. Hydrogeologic Conceptual Model

(d) Physical characteristics of the basin shall be represented on one or more maps that depict the following:

(1) Topographic information derived from the U.S. Geological Survey or another reliable source.

(2) Surficial geology derived from a qualified map including the locations of cross- sections required by this Section.

(3) Soil characteristics as described by the appropriate Natural Resources Conservation Service soil survey or other applicable studies.

(4) Delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas, including significant active springs, seeps, and wetlands within or adjacent to the basin.

(5) Surface water bodies that are significant to the management of the basin.

(6) The source and point of delivery for imported water supplies.

7.3.1. Topographic Information

Figure HCM-14 shows the topography within the Basin. Ground surface elevations in the Basin range from approximately 500 ft msl in the vicinity of the WWF to about 4,100 ft msl in the far western portion of the Basin. The main Basin floor area, where most of the irrigated agricultural lands are located, has ground surface elevations ranging from approximately 500 ft msl to 1,000 ft msl. The Basin is bordered on the east, south, and west by mountain ranges.

To the east and north of the Basin lies the Sierra Nevada, a north-south trending, westward-tilting, fault block. Summit elevations in this portion of the mountain range are typically between 5,000 ft msl and 7,000 ft msl, with some local peaks exceeding 8,000 ft msl. The southern terminus of the 370-mile Sierra Nevada occurs just to the east of the Basin, at the junction with the Tehachapi Mountains.

The Tehachapi Mountains are located to the south and east of the Basin and form the southern border of the San Joaquin Valley. Although topographically continuous with the Sierra Nevada, the two ranges bear little structural or genetic resemblance. Rather, the Tehachapi Mountains, which consist of a complex horst lifted principally by faulting, possess more similarities to the Transverse Ranges to the south and Central Coast Ranges to the west (Buwalda, 1954). The Tehachapi Mountains extend approximately 50 miles southwest from the junction with the Sierra Nevada to Grapevine Creek. Elevations in the Tehachapi Mountains range up to 8,000 ft msl in the watersheds surrounding the Basin.

To the west of the Basin, the San Emigdio Mountains extend from the intersection with the Tehachapi Mountains at Grapevine Creek to Cienaga Canyon, where they meet the Temblor Ranges. Elevations in the San Emigdio Mountains are typically between 5,000 ft msl and 6,500 ft msl.

7.3.2. Surficial Geology

Figure HCM-13 shows the surficial geology within the Basin based on the Geologic Map of California, Bakersfield Sheet (CDMG, 1964) and Los Angeles Sheet (CDMG, 1969), and associated map explanation. The predominant surficial geologic unit in the Basin is “Qf” (i.e., Recent alluvial fan deposits in the Great Valley). This material was deposited by streams entering the San Joaquin Valley from the uplands to the south and west. In the eastern part of the Basin, “Qal” (Recent alluvium), “Qt” (Quaternary) non-marine terrace deposits, “Qc” (Pleistocene) non-marine deposits, “Pmlc” (lower Pliocene) non-marine deposits, and “Mc” (Miocene) non-marine deposits are prevalent. In the west part of the Basin “Mm” and Ml” (Miocene) marine deposits underlie large areas of landslide deposits. Areas of “QP” (Plio-Pleistocene) non-marine deposits also exist in the west. As shown on cross-sections A-A’ and B-B’, the Pliocene-Pleistocene non-marine deposits include the Kern River Formation and Chanac Formation deposits which underlie the Shallow Alluvium throughout the Basin area. In general, the shallow alluvium consists of gravels and sands with boulders and cobbles whereas the Kern River Formation consists of siltstones interbedded with very coarse-grained sands (WZI, 2013).

7.3.3. Soil Characteristics

Soils within the Basin are shown on **Figure HCM-15**, based on U.S. Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) Soil Survey Geographic Database (SSURGO) for the southwestern and southeastern parts of Kern County. Soils are relatively coarse in texture with the predominant type being sandy loam (47%) with lesser areas of sandy clay loam (19%), clay loam (15%), loamy sand (11%), and others. The saturated hydraulic conductivity of the soils is generally in the range of two to four inches per hour (four to eight ft/d) with the highest areas being in the central part of the Basin and the lowest areas being in the eastern part of the Basin.

Hydrologic Soil Group identification provides an indication of the relative runoff and infiltration potential of the soils with Hydrologic Soil Group A having the lowest runoff potential and highest infiltration potential and Hydrologic Soil Group D having the highest runoff potential and the lowest infiltration potential. Soils are predominantly in the A Hydrologic Soil Group in the central part of the Basin, with the B Hydrologic Soil Group being predominant in the west and the Hydrologic Soil Group C being predominant in the east. Very small areas of Hydrologic Soil Group D exist in the south and east part of the Basin.

7.3.4. Groundwater Recharge and Discharge Areas

Figure HCM-16 shows existing and potential groundwater recharge and discharge areas within the Basin.

7.3.4.1. Recharge Areas and Sources

Groundwater inflows to the Basin include percolation of applied irrigation water, percolation of streamflow from surrounding watersheds, percolation of water conveyance and distribution system leakage, percolation of precipitation, and percolation of municipal and industrial (M&I) effluent; inflow from the adjacent Kern County subbasin is negligible.

Irrigated agriculture currently occupies approximately 34,200 (32%) acres of the Basin area. Excess soil moisture that remains after the crop water demand has been met is assumed to percolate and become recharge to the groundwater aquifer.

As shown on **Figure HCM-16**, a total of ten named streams flow from the surrounding highlands into the Basin. From the northeast and progressing clockwise around the perimeter of the Basin, these streams are Comanche Creek, Chanac Creek, Tejon Creek, El Paso Creek, Tunis Creek, Pastoria Creek, LiveOak Creek, Grapevine Creek, Tecuya Creek, and Salt Creek. The total watershed area for these streams is approximately 363 square miles (232,500 acres).

Percolation of precipitation occurs on non-agricultural (i.e., non-irrigated) lands, which comprise approximately 72,400 (66%) of the Basin area. A small quantity of M&I wastewater effluent is discharged to percolation ponds and use areas in the TRCC, contributing a negligible volume of groundwater recharge within the Basin.

As discussed in ***Section 8.2 Groundwater Elevations and Flow Direction,*** maps of groundwater elevation indicate that groundwater in the Basin flows in a convergent fashion from the eastern, southern, and western margins northwards towards center of the Basin and then generally northwards across the WWF into the Kern County Subbasin. No other groundwater basins have a direct subsurface connection to the Basin. Groundwater inflow from the surrounding crystalline basement bedrock is seemingly insignificant. Therefore, groundwater inflows as a whole from outside the Basin are assumed to be negligible.

7.3.4.2. SAGBI Soil Recharge Potential

Figure HCM-17 shows groundwater recharge suitability on agricultural lands within the Basin based on the University of California at Davis California Soil Resource Lab's Soil Agricultural Groundwater Banking Index (SAGBI) dataset. This dataset ranks agricultural lands for groundwater recharge suitability based on soil types and five key factors: deep percolation potential, root zone residence time, topography, chemical limitations, and soil surface conditions. The SAGBI dataset ranks a majority of lands within the Basin as having "Excellent" to "Good" suitability for groundwater recharge, including nearly all the central and northwest (i.e., irrigated) portions of the Basin. Soils ranked as having "Moderately Poor" or "Poor" groundwater recharge suitability are located primarily in the eastern portion of the Basin; the westernmost areas of the Basin are not ranked. WRMWSD has developed the Mettler Recharge Project in the western portion of the Basin, which is ranked as having "Good" suitability for groundwater recharge (see **Figure HCM-17**). Any additional future groundwater recharge facilities proposed within the Basin will be screened against the SAGBI dataset along with other local sources of information to determine their potential suitability for groundwater recharge operations.

7.3.4.3. Discharge Areas and Sources

Groundwater outflows from the Basin include groundwater pumping for agricultural use, a small volume of groundwater pumping for domestic and M&I uses, groundwater flow across the WWF, and discharges to springs and/or evaporation from shallow groundwater.

Groundwater is used to supplement imported surface water delivered by WRMWSD and AEWSD for irrigation water supply in their respective service areas in the Basin. Outside of the Districts' service areas, agricultural demands are met exclusively with groundwater with small fields receiving surface water diverted from streams.

Groundwater levels and gradient directions indicate that some groundwater flows northwards across the WWF into the Kern County Subbasin. As it passes through the WWF zone the groundwater gradients steepen significantly, indicating that the fault zone has a reduced permeability compared to the aquifer further upgradient (EKI, 2016).

In the vicinity of the Springs Fault, which is located in the southeastern corner of the Basin, evidence of spring flow includes a strip of natural well-watered vegetation in an otherwise dry land cover. Spring flow appears to be caused by groundwater backing up and rising to the ground surface on the south side of the Springs Fault due to the fault acting as a partial barrier to groundwater flow (i.e., separating this upgradient area from the Principal Aquifer). Flow from these springs are assumed to either evaporate or percolate back into the Basin; no spring flow discharge leaves the Basin.

The three wells located at the TRCC were historically used by TCWD to help meet peak demands and now serve only as an emergency public water supply source. Given that the total TRCC demand has been small, and that groundwater has always only supplied a small fraction of that demand, the total groundwater pumping for M&I use is assumed to be negligible. There are only three other public supply wells and a few domestic wells within the Basin; pumping from these wells is also assumed to be negligible. For instance, typical groundwater use from the other two public water systems are less than 20 AFY (see ***Section 5.1.4 Existing Land Use and Water Use***).

7.3.5. Surface Water Bodies

Surface water bodies significant to the management of the Basin include both natural surface water features as well as man-made features. **Figure HCM-18** shows the surface water features in the vicinity of the Basin.

As mentioned above, the Basin is surrounded by approximately 363 square miles (232,500 acres) of upland watershed areas on the west, south, and east that drain into the Basin, providing occasional inflows and likely some subsurface inflow. The primary streams in the Basin are Comanche Creek, Chanac Creek, Tejon Creek, El Paso Creek, Tunis Creek, Pastoria Creek, LiveOak Creek, Grapevine Creek, Tecuya Creek, and Salt Creek. Due to the intermittent nature of flows in these streams, flow measurement data from these streams are limited. Under most conditions, water in these streams percolates into the alluvial sediments and minimal surface water leaves the Basin (AEWSD, 2003; WRMWSD, 2007). The mountain watersheds that drain into the Basin receive substantially greater precipitation than the Basin itself and therefore streamflow from these watersheds is likely a source of recharge.

Man-made surface water features include the California Aqueduct, the 850 Canal, two reservoirs, and a network of smaller irrigation canals and ditches. The California Aqueduct, operated by DWR as the backbone of the State Water Project (SWP), runs southeast from the northwest corner of the Basin to the southern boundary, where the A.D. Edmonston Pumping Plant lifts water up and over the Tehachapi Mountains. Distribution of water supplied by AEWSD and WRMWSD to irrigated agricultural lands within the Basin occurs through a network of distribution pipelines. The only major irrigation canal in the Basin is the 850 Canal, a seven-mile, concrete-lined canal operated by WRMWSD. Private landowners utilize irrigation ditches and holding ponds to convey and store water within and between their properties. Finally, Tejon Ranch operates two reservoirs (Reservoir I and Reservoir II) which store water diverted from streams (Grapevine, El Paso, Tejon, Pastoria, and Tunis creeks) for agricultural irrigation use.

7.3.6. Source and Point of Delivery for Imported Water Supplies

Figure HCM-19 shows facilities and infrastructure within the WRMWSD, AEWSD, and TCWD service areas in the Basin. The figure shows the locations of canals, pipelines, pump stations, and turnouts used to convey and distribute imported surface water to agricultural lands within the Basin.

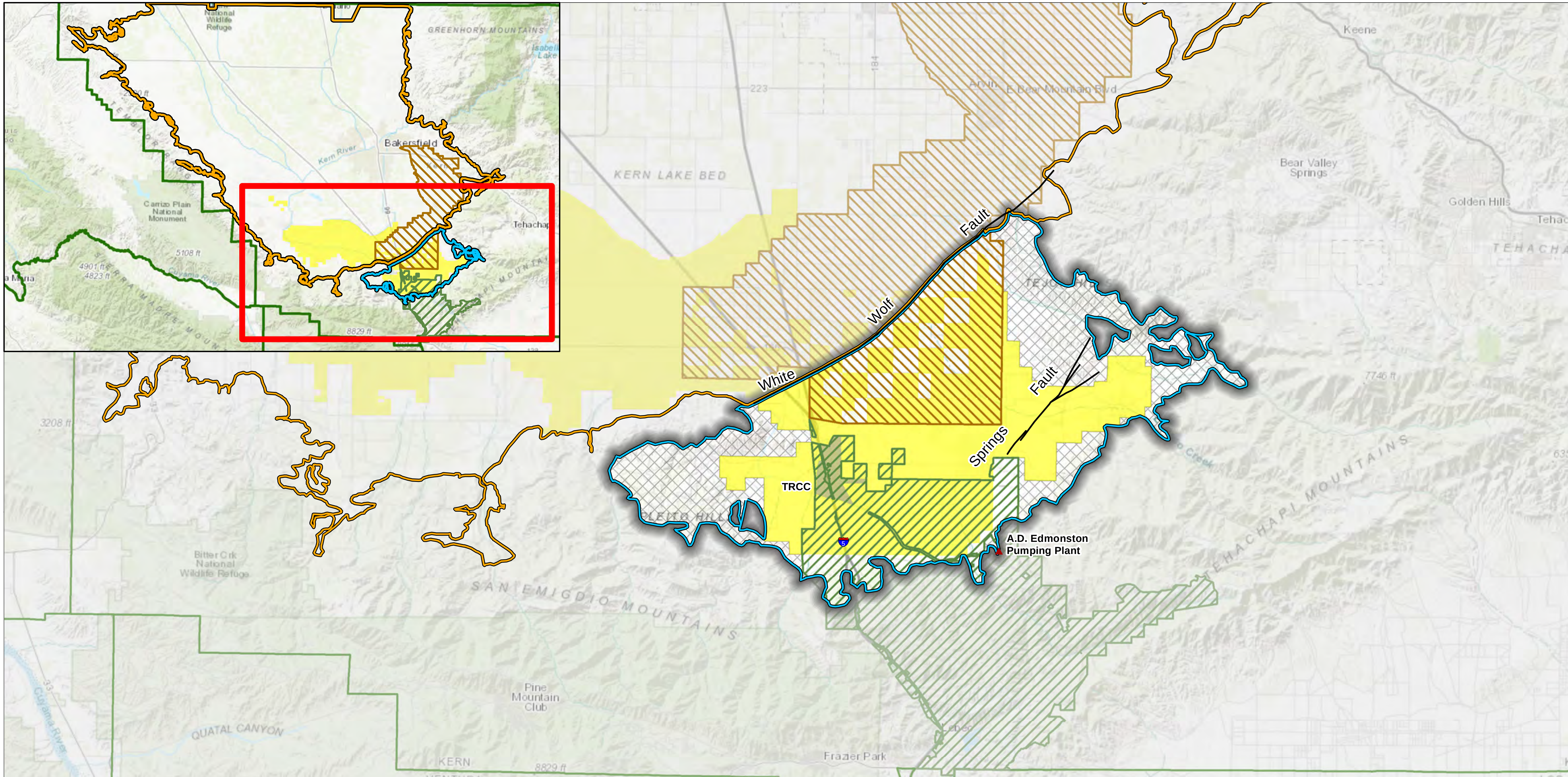
The Basin contains 57,600 (38%) of the total 150,000 acres of service area covered by WRMWSD. The WRMWSD imports SWP water pursuant to its contractual agreement with the Kern County Water Agency (KCWA) for 197,088 acre-feet per year (AFY) of Table A Allocation (WRMWSD, 2021). During wet years, the WRMWSD also receives “Article 21” wet period, surplus water from the SWP. Pursuant to transfer agreements with partner agencies (e.g., Buena Vista Water Storage District, Tehachapi-Cummings Community Water District, etc.) the WRMWSD has also obtained additional imported water from the SWP, the Central Valley Project (CVP), and other sources. Additionally, the WRMWSD banks water with the Kern Water Bank, Pioneer Project, and Berrenda Mesa in wet years and recovers banked water in dry years.[31] The WRMWSD has approximately twenty pump stations along the California Aqueduct (nine within the Basin) that feed the SWP water into the WRMWSD pipelines, distributing water to the WRMWSD Surface Water Service Area.

The Basin contains 23,400 (17%) of the total 132,000 acres of service area covered by AEWSD. The AEWSD contracts with the United States Bureau of Reclamation (USBR) for water service from the CVP. AEWSD’s USBR contract provides for 40,000 AFY of Class 1 water and up to 311,675 AFY of Class 2 water from the Friant Division of the CVP. The AEWSD also participates in exchange agreements with other public agencies that provide for the substitution of Friant-Kern water for Shasta CVP water, delivered through the California Aqueduct and Cross Valley Canal. The AEWSD also operates its own water banking program in the Kern County Subbasin and is actively engaged in banking agreements with Metropolitan Water District of Southern California and Rosedale-Rio Bravo Water Storage District, among others, to increase the reliability and flexibility of its surface water supplies. The AEWSD’s imported water supply is blended from the various sources prior to entering the Basin via pipelines. The AEWSD also has a connection at its

[31] Table 4-2 of the WRMWSD Agricultural Water Management Plan (WRMWSD, 2021) provides a complete listing of water transfer and exchange partners.

southern end to the California Aqueduct through which it can either draw or return water.

The TCWD provides water and wastewater service to the TRCC, the only significant commercial development in the Basin. In addition to the commercial and industrial demand at TRCC, TCWD contributes approximately 100 AFY of water for various regional and system-wide purposes. In the past, TCWD has occasionally conducted temporary transfers of surplus water supplies to other water users for uses such as agricultural irrigation. The TCWD has rights to receive up to 5,278 AFY of SWP surface water supplies (62% designated for agricultural uses and 38% designated for M&I uses) under contracts with KCWA. Additional imported water supplies include exchanges with other contractor(s), water rights to high flows in the Lower Kern River, and water banking with the Kern Water Bank and Pioneer Project.



Path: X:\B50001.05\Maps\GSP\2022\01\FigHCM-1_WWGSA.mxd

Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- Arvin-Edison Water Storage District
- Tejon-Castac Water District
- Wheeler Ridge-Maricopa Water Storage District
- Kern County (outside of other GSA parties' jurisdictions)
- County Boundary
- TRCC
- Fault

Abbreviations

AEWSD = Arvin-Edison Water Storage District
DWR = California Department of Water Resources
GSA = Groundwater Sustainability Agency
TCWD = Tejon-Castac Water District
TRCC = Tejon Ranch Commerce Center
WRMWSD = Wheeler Ridge-Maricopa Water Storage District

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. District boundaries acquired from respective District staff.
4. White Wolf Fault location is from Wood P.R. and R. H. Dale, Geology and Ground-Water Features of the Edison-Maricopa Area, Kern County, California, USGS Water Supply Paper 1656, 1964.
5. Springs Fault trace from Bartow, 1984, Geologic Map and Cross Sections of the Southeastern Margin of the San Joaquin Valley, California: U .S. Geological Survey Map I-149.

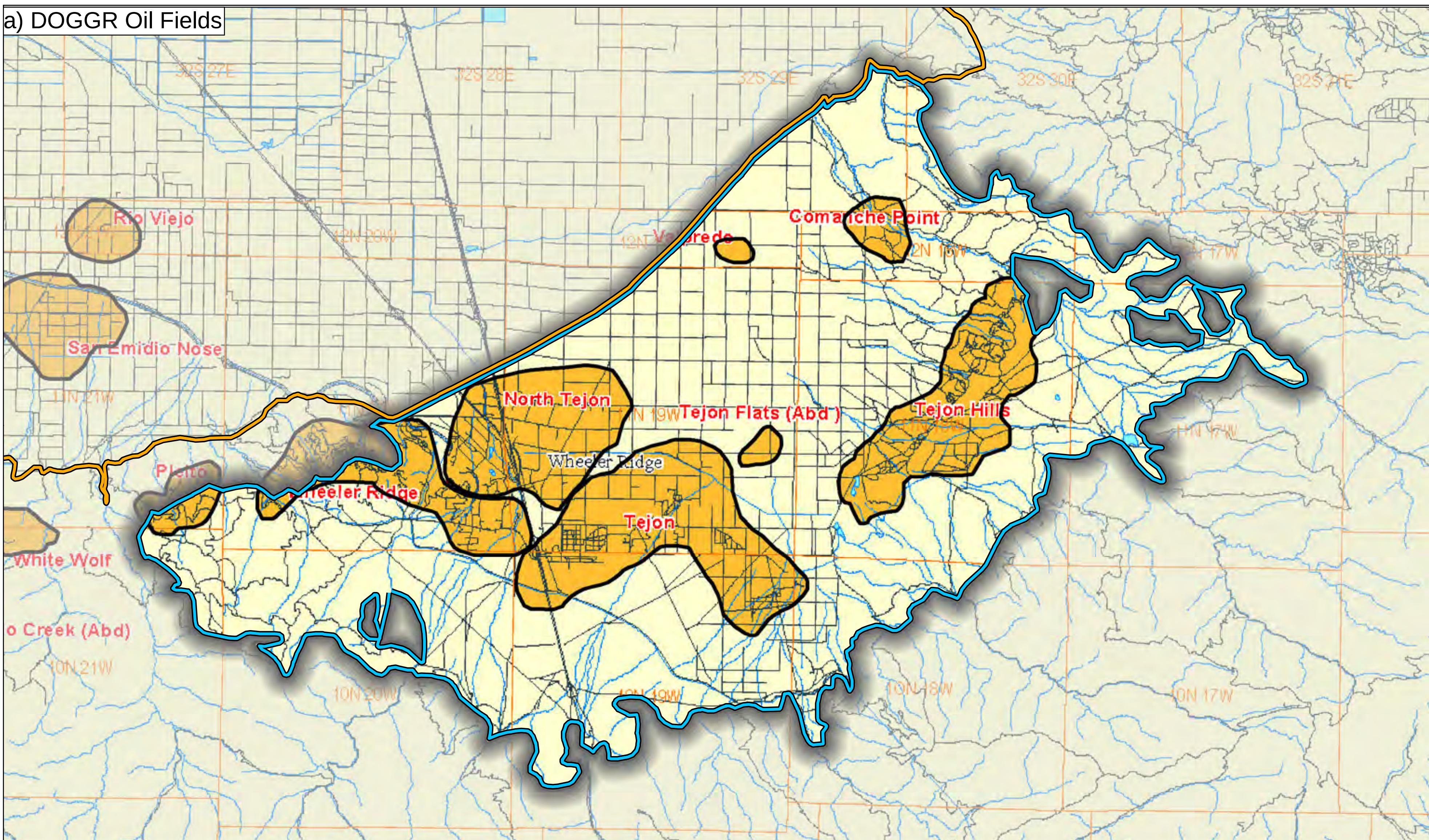
N
0 4 8
(Scale in Miles)

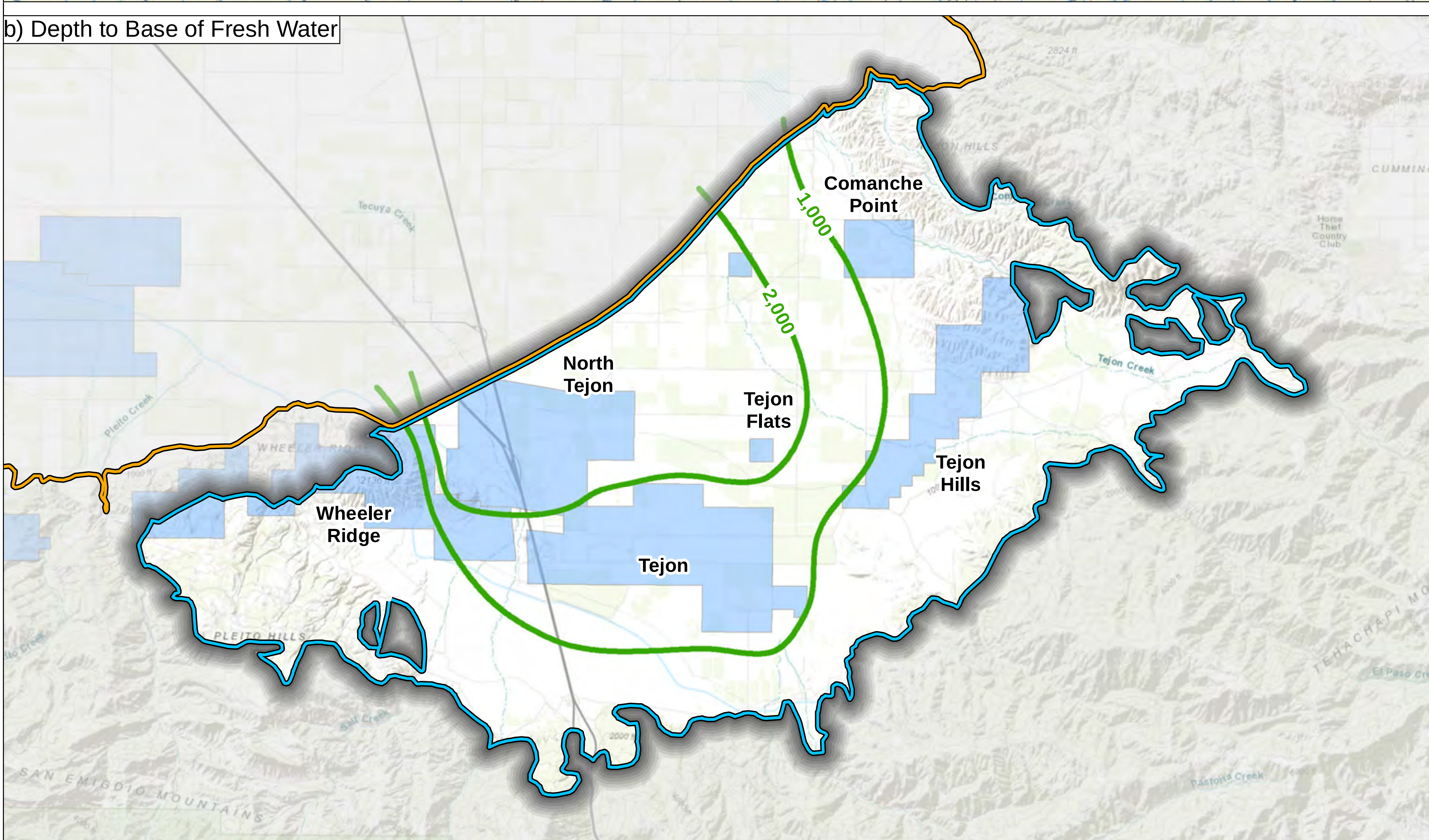
White Wolf Subbasin and Groundwater Sustainability Agency

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure HCM-1





Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- Oil Field Administrative Boundaries
- Contours of Approximate Depth to Base of Fresh Water (ft bgs)

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 20 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Oil field data from DOGGR, 1998, California Oil and Gas Fields, Volume I - Central California and DOGGR, 1989, The Effects of Oil Field Operations on Underground Sources of Drinking Water in Kern County.
4. Oil fields map obtained from CalGEM website (ftp://ftp.consrv.ca.gov/pub/oil/maps/dist4/Dist4_fields.pdf)

Abbreviations

CalGEM	= California Geologic Energy Management Division
DOGGR	= Division of Oil, Gas and Geothermal Resources
DWR	= California Department of Water Resources
ft bgs	= feet below ground surface
mg/L	= milligrams per liter
TDS	= Total Dissolved Solids

Notes

1. All locations are approximate.
2. Values posted on panel (b) are approximate depths to base of fresh water, in ft bgs, as defined by CalGEM to be 3,000 mg/L TDS.
3. Panel (b) presents boundaries of areas of oil fields digitized from Source 2.

N

0 3 6

(Scale in Miles)

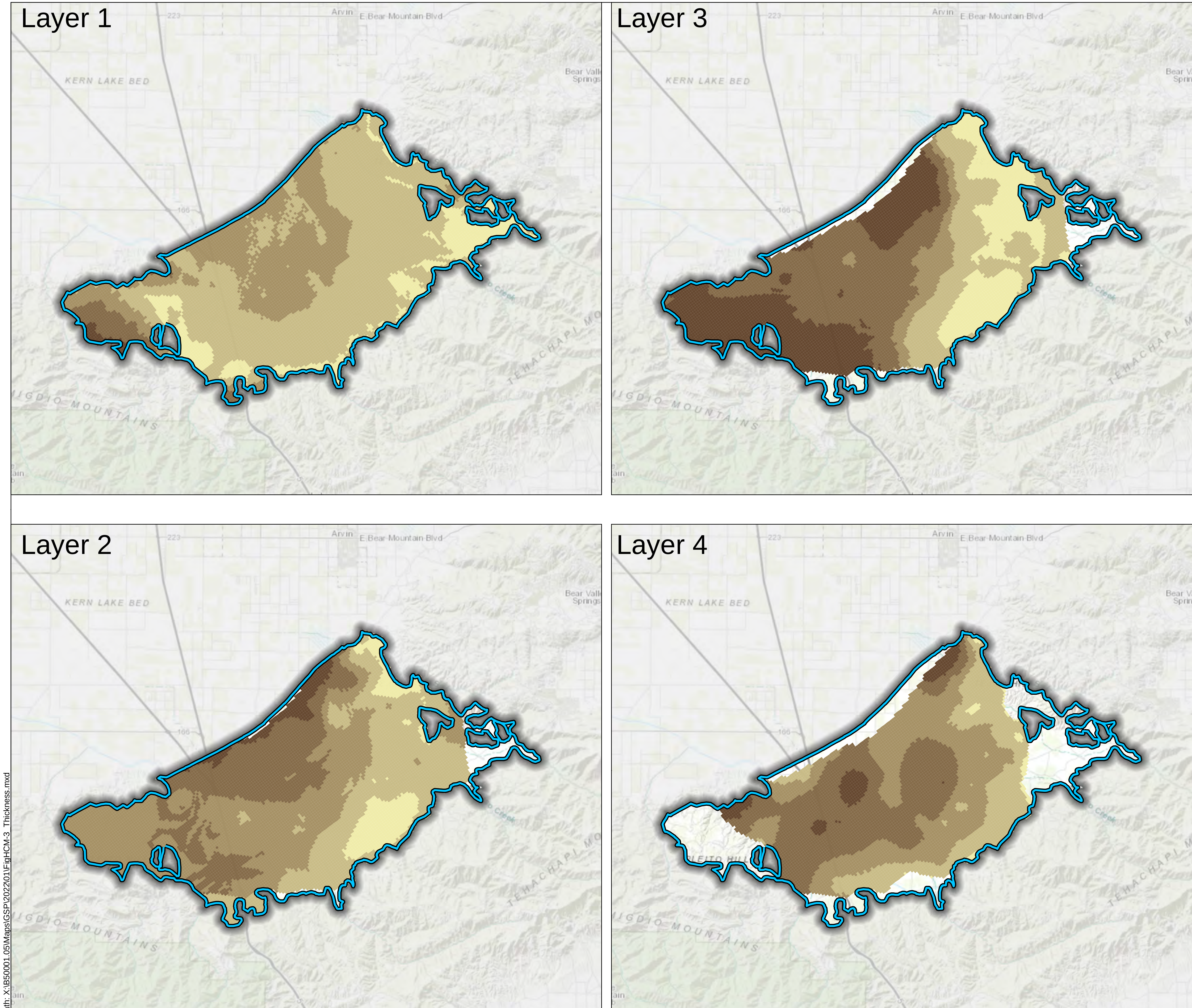
Kern County Oil Fields and Depth to Base of Fresh Groundwater

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure HCM-2

Path: X:\B50001.05\Maps\GSP\2022\01\FigHCM-2_Oil_Fields_base_freshwater.mxd



Legend

White Wolf Subbasin (DWR 5-022.18)

Layer Thickness (ft)

- < 100
- 101 - 500
- 501 - 1,000
- 1,001 - 2,000
- > 2,000

Abbreviations

DWR = California Department of Water Resources

ft = feet

Notes

1. All locations are approximate.
2. Layers 1, 2, and 3 represent the Principal Aquifer, while Layer 4 represents the unpumped aquifer.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.

N

0 5 10

(Scale in Miles)

White Wolf Groundwater Flow Model Layer Thickness

eki environment & water

White Wolf GSA

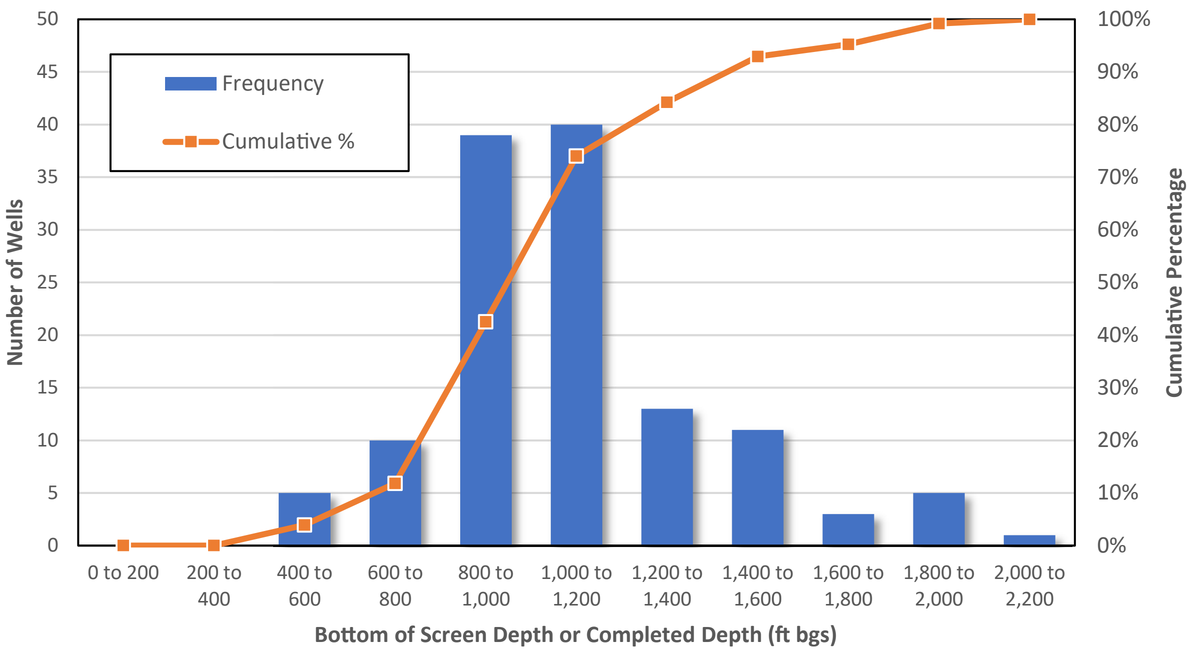
Kern County, CA

December 2021

EKI B50001.05

Figure HCM-3

Path: X:\B50001.05\Maps\GSP\2022\01\FigHCM-3_Thickness.mxd



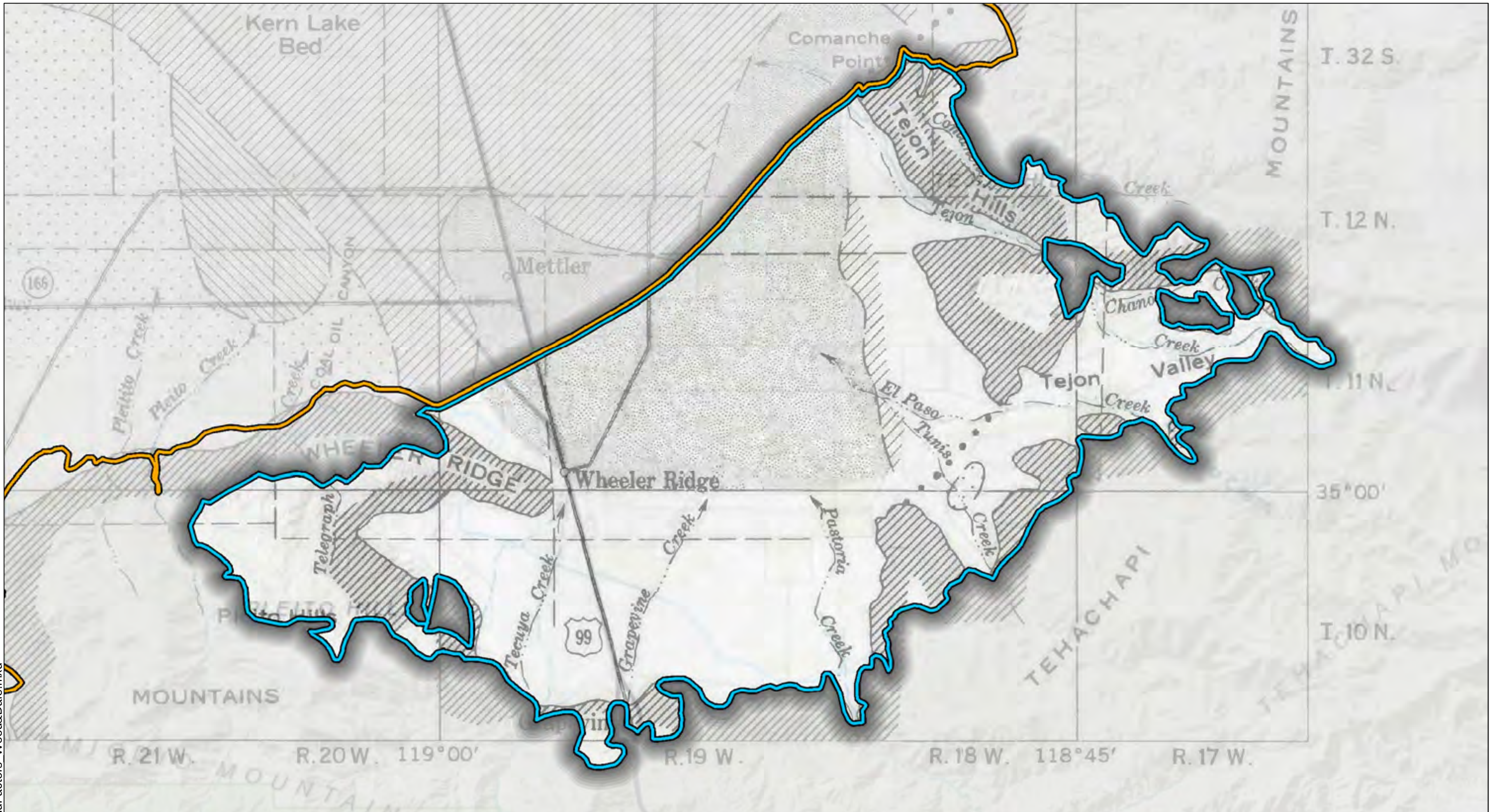
<u>Abbreviations</u>
BOS = bottom of screen
ft bgs = feet below ground surface

<u>Notes</u>
1. Well depth data is based on digitized well records of 127 wells in the White Wolf Subbasin.
2. Completed depth used when BOS depth was not available.

eki environment & water

Summary of Well Depth Data

White Wolf GSA Kern County, California
December 2021
EKI B50001.05
Figure HCM-4



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

Yield Factor (gpm/ft per 100 feet of aquifer)

< 1

1 - 5

6 - 10

11 - 50

> 50

Abbreviations

DWR = California Department of Water Resources

gpm/ft = gallons per minute per foot

Notes

1. All locations are approximate.
2. Yield factor is in gallons per minute per foot of drawdown per 100 feet of saturated materials penetrated by irrigation wells.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. P. R. Wood and R. H. Dale, 1964, Geology and Ground-Water Features of the Edison-Maricopa Area, Geological Survey Water-Supply Paper 1656.

N

0 4 8

(Scale in Miles)

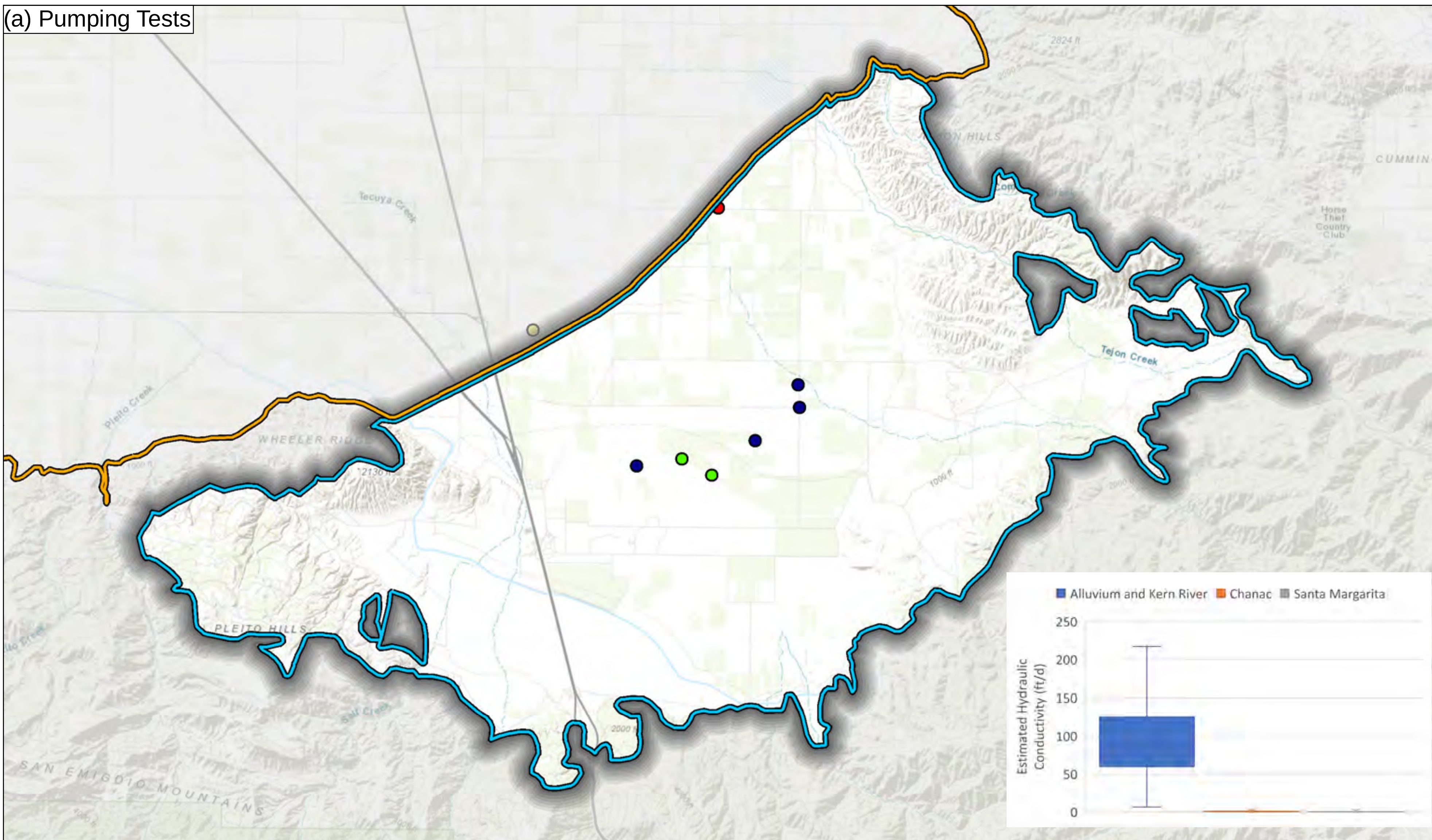
Yield Factors Based on Wood & Dale, 1964 (USGS)

White Wolf GSA
Kern County, California
December 2021
B50001.05

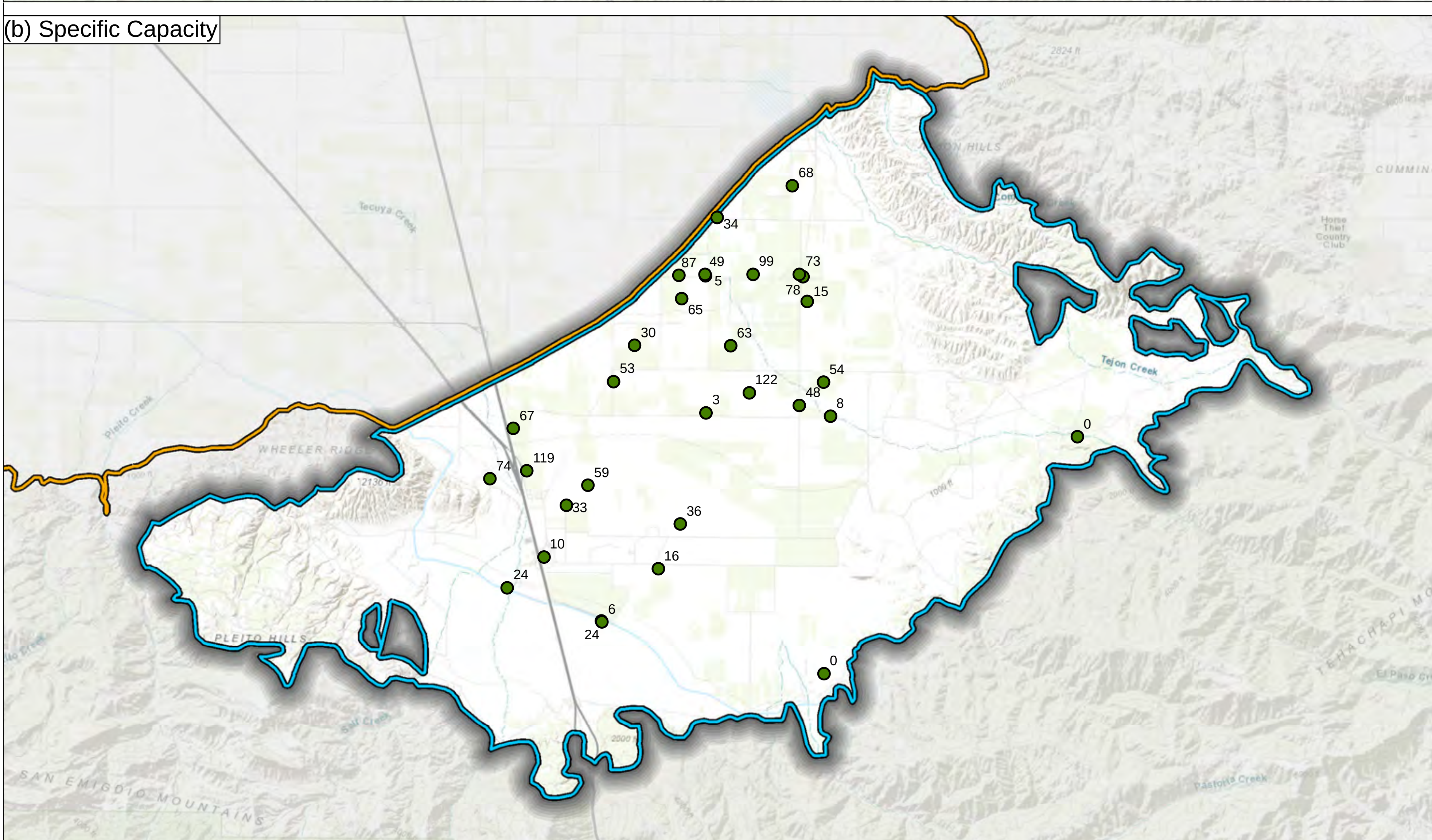
eki environment & water

Figure HCM-5

(a) Pumping Tests



(b) Specific Capacity



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

Hagan 2001 Pumping Test

EKI 2016 Pumping Test Well

B-E 2007 Short Pumping Test Well

B-E 2007 Long-Term Pumping Test Well

Specific Capacity (gpm/ft)

Abbreviations

B-E	= Bookman-Edmonston
DWR	= California Department of Water Resources
EKI	= EKI Environment and Water, Inc.
ft/d	= feet per day
gpm/ft	= gallon per minute per foot of drawdown

Notes
1. All locations are approximate.
2. Specific capacity data extracted from DWR well completion reports. Hydraulic conductivity estimated by scaling specific capacity to transmissivity using a scaling factor of 1,500, applied over the length of screened interval.

N

0 3 6

(Scale in Miles)

Hydraulic Conductivity Estimates from Pumping Tests and Specific Capacity Data

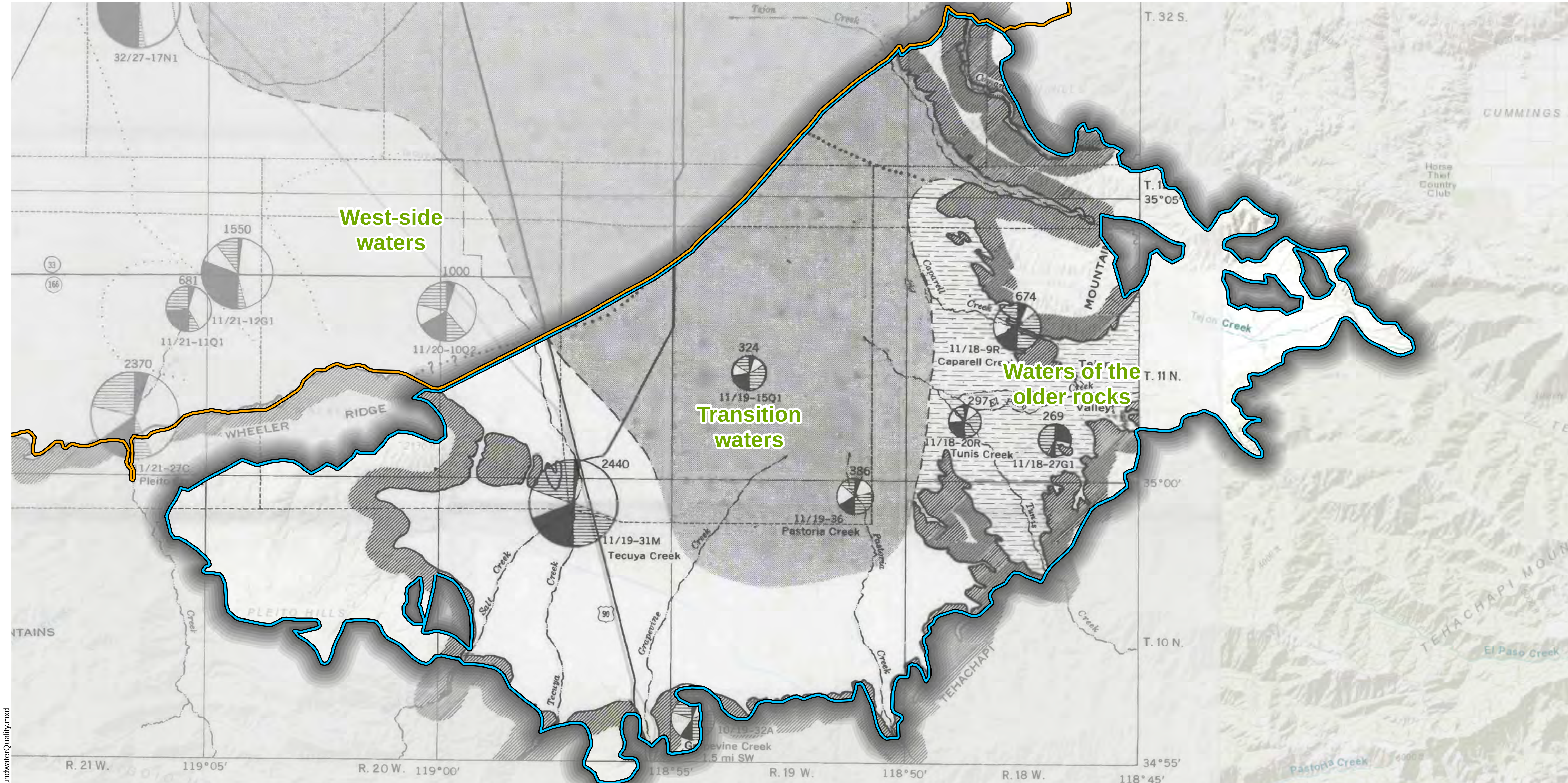
Sources
1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 20 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Bookman-Edmonston, 2007. Bookman-Edmonston, Groundwater Storage and Recovery Pilot Project in White Wolf Basin, Final Project Report, prepared for Wheeler Ridge-Maricopa Water Storage District, revised 26 January 2007.
4. EKI, 2016, Erler and Kalinowski, Inc., White Wolf Subbasin Technical Report, prepared for: Wheeler Ridge-Maricopa Water Storage District, Arvin-Edison Water Storage District, Tejon-Castac Water District, 68 pp.

White Wolf GSA
Kern County, CA
December 2021
B50001.05

eki environment & water

Figure HCM-6

Path: X:\B50001.05\Maps\GSP\2022\01\FigHCM-6_Aq Props.mxd



Legend

Groundwater Subbasin

Kern County (DWR 5-022.14)

White Wolf (DWR 5-022.18)

General Water Quality

Probable boundary between groundwater subtypes

Consolidated rocks bordering the valley

Groundwater barrier (querried where uncertain)

Na+K, Cl+NO$_3$+F, Mg, SO$_4$, HCO$_3$ + CO$_3$, 31/16-36A1 Well No

Area of circle indicates mineral concentration (excluding silica), in parts per million

SCALE OF RADII

Abbreviations

- $Cl + NO_3 + F$ = Chloride + Nitrate + Fluoride
- DWR = California Department of Water Resources
- $HCO_3 + CO_3$ = Bicarbonate + Carbonate
- Mg = Magnesium
- Na + K = Sodium + Potassium
- SO_4 = Sulfate

Notes

1. All locations are approximate.
2. Map shows areas of different water quality (shading, hatching, and stippling), as shown by labels, and chemical composition of major ions (pie charts) the sizes of which are scaled by the total mineral concentration (excluding silica).

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Wood P.R. and R. H. Dale, 1964, Geology and Ground-Water Features of the Edison-Maricopa Area, Kern County, California. USGS Water Supply Paper 1656.

N

0 2 4

(Scale in Miles)

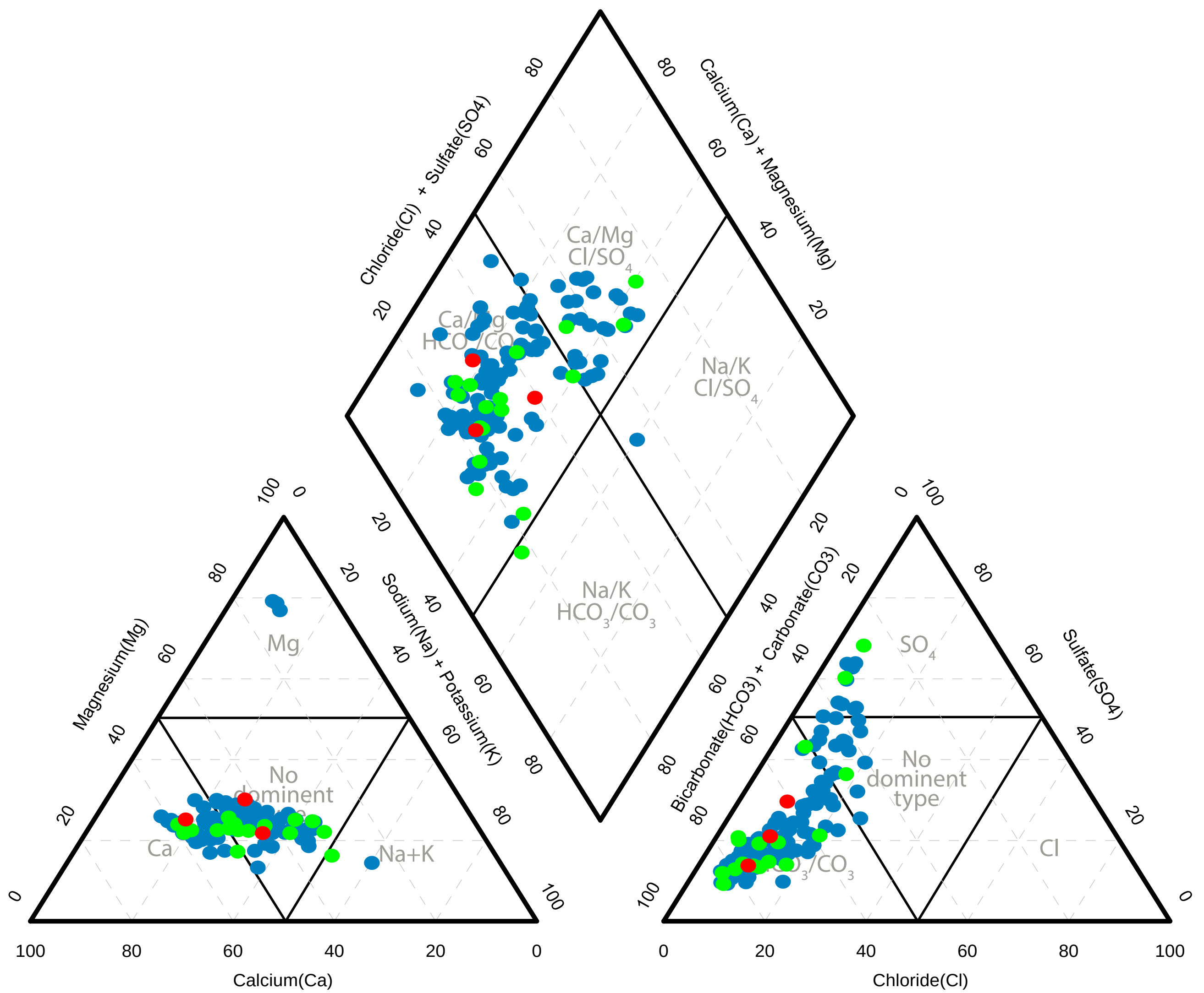
General Groundwater Quality

eki environment & water

White Wolf GSA
Kern County, CA
December 2021
B50001.05

Figure HCM-7

Path: X:\B50001.05\Maps\GSP\2022\01\FigHCM-7_GeneralGroundwaterQuality.mxd



Legend

- = RMW-ISW
- = Well in Stiff Diagram (Figure HCM-9)
- = Other Basin Well

Abbreviations

RMW-ISW = Representative Monitoring Well for Depletions of Interconnected Surface Water

Notes

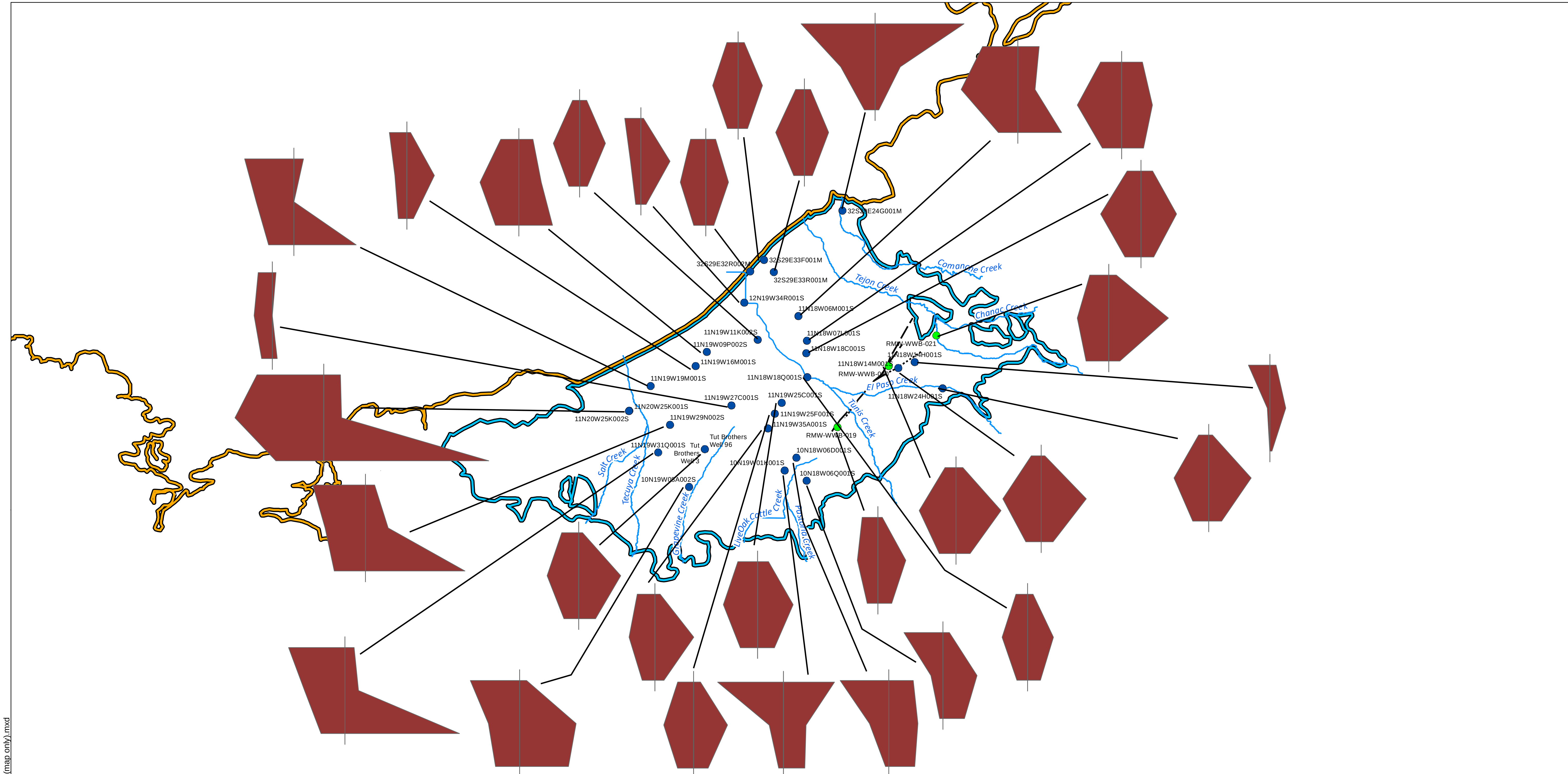
1. Water quality samples collected in Basin wells between Water Years 2015 and Water Year 2019.
2. Water quality samples collected in RMW-ISWs in March 2021.

Piper Diagram

eki environment & water

White Wolf GSA
Kern County, California
December 2021
B50001.05

Figure HCM-8



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

Springs Fault

Certain

Approximately Located

Concealed

Stream

RMW-ISW

Well

Na Ca Mg — Cl HCO_3 SO_4

Abbreviations

Ca	= Calcium	Cl	= Chloride
DWR	= California Department of Water Resources	HCO_3	= Bicarbonate
Mg	= Magnesium	Na	= Sodium
RMW-ISW	= Representative Monitoring Well for Depletions of Interconnected Surface Water	SO_4	= Sulfate

Notes

1. All locations are approximate.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019
2. Springs Fault trace from Bartow (1984).

N

0 4 8

(Scale in Miles)

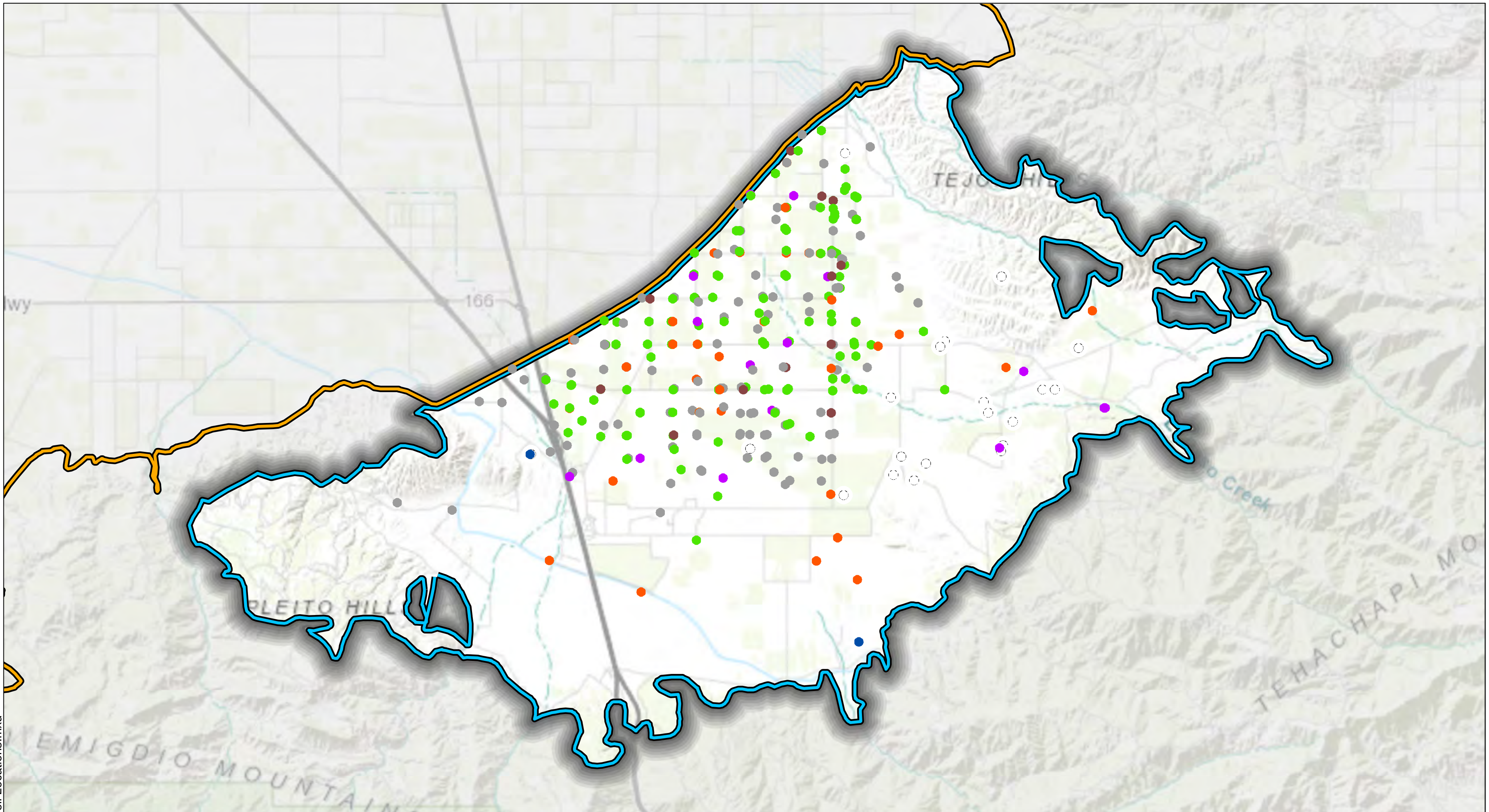
Stiff Diagrams

eki environment & water

White Wolf GSA
Kern County, CA
December 2021
B50001.05

Figure HCM-9

Path: X:\B50001.05\Maps\GSP\2022\01\FigHCM-9_Stiff Diagrams (map only).mxd



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)

Well Use/Status

- Agriculture,
- Domestic,
- Industrial,
- Monitoring
- Inactive
- Abandoned
- Unknown

Abbreviations

DWR = California Department of Water Resources

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 20 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.

N

0 4 8

(Scale in Miles)

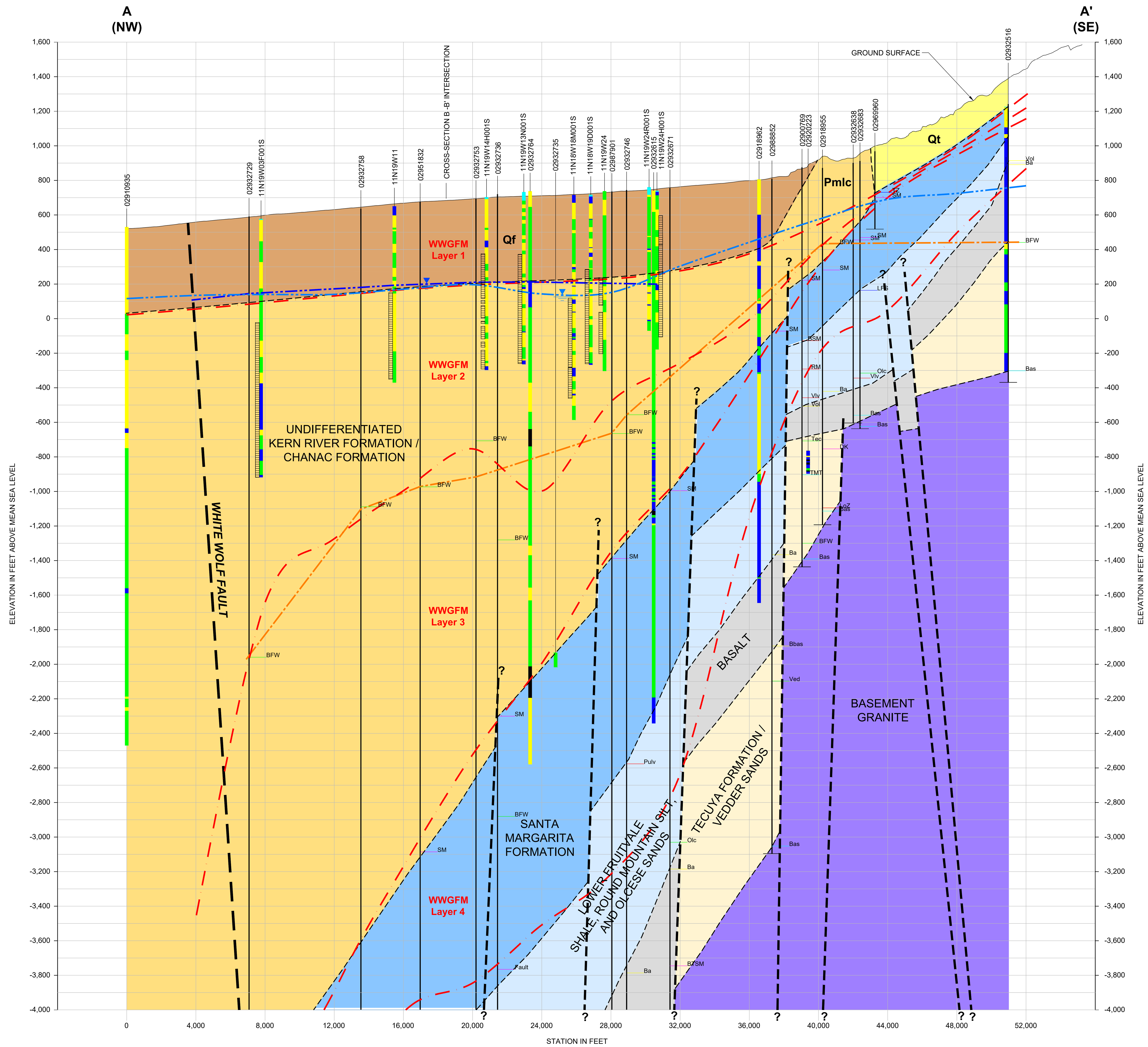
Well Locations, Use, and Status

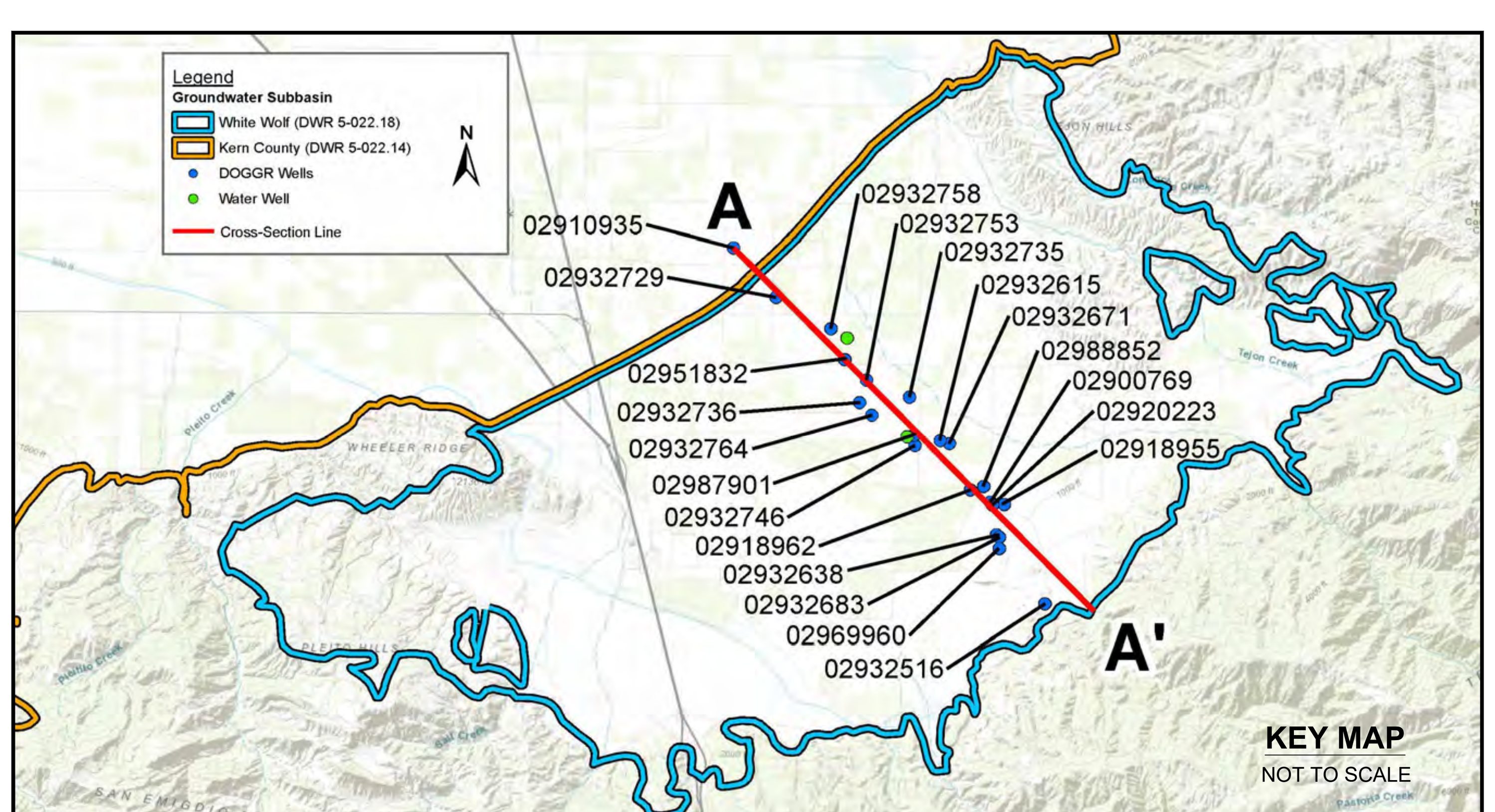
eki environment & water

White Wolf GSA
Kern County, California
December 2021
B50001.05

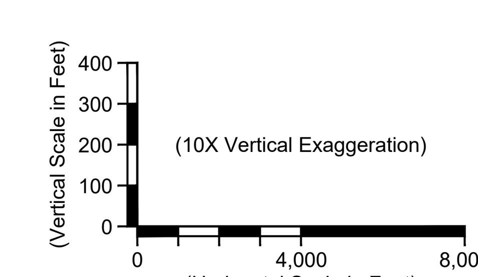
Figure HCM-10

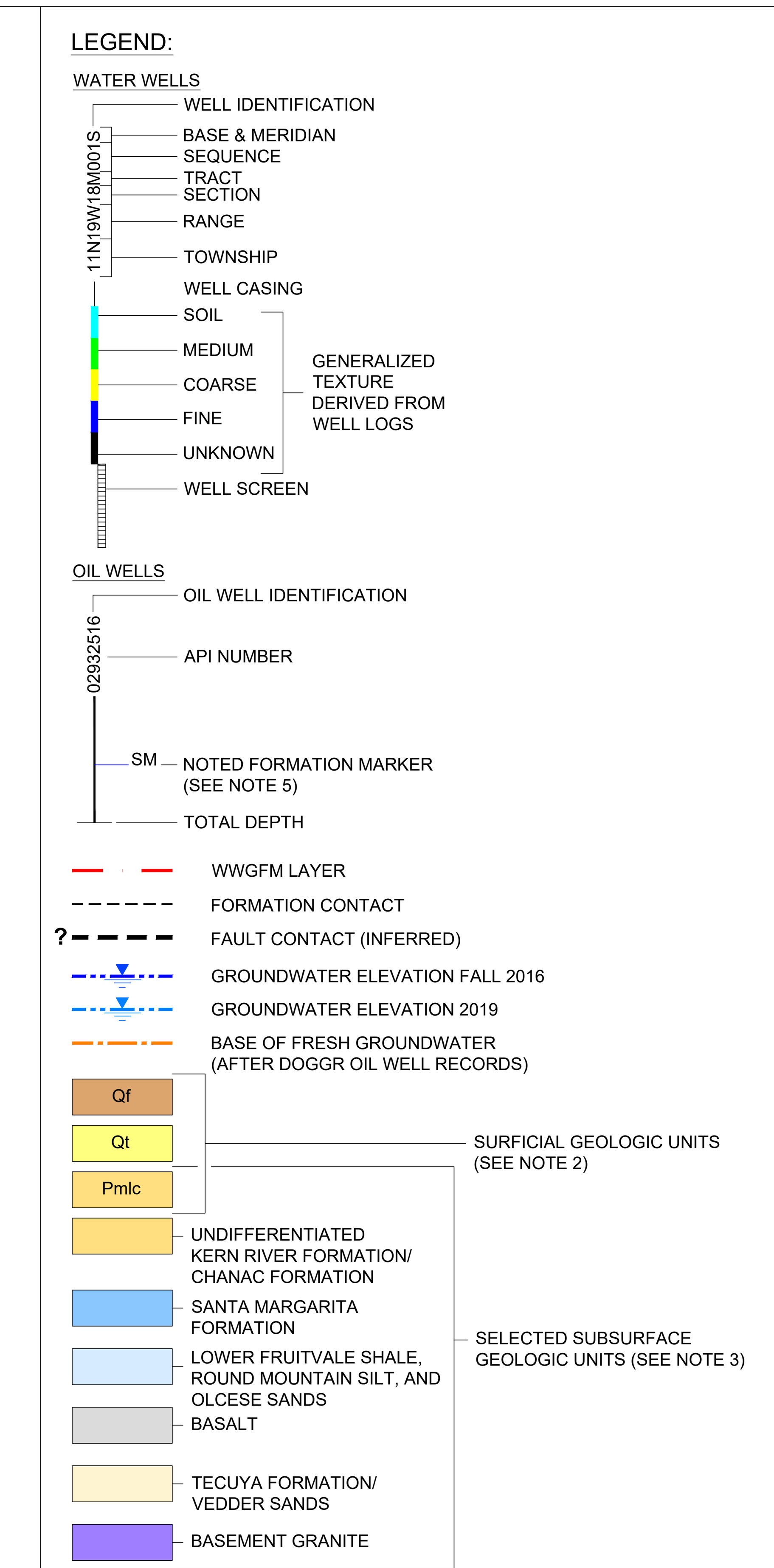
Path: X:\B50001.05\Maps\GSP\2022\01\FigHCM-10_Well Locations.mxd





GEOLOGIC CROSS-SECTION A - A'





ABBREVIATIONS:

API = AMERICAN PETROLEUM INSTITUTE

WWGFM= WHITE WOLF GROUNDWATER FLOW MODEL

CDMG= CALIFORNIA DIVISION OF MINES AND GEOLOGY

DOGGR= DIVISION OF OIL, GAS & GEOTHERMAL RESOURCES

SOURCES:

1. CDMG, 1964, CALIFORNIA DIVISION OF MINES AND GEOLOGY, GEOLOGIC MAP, OLAF P. JENKINS EDITION, BAKERSFIELD SHEET.
2. CDMG, 1969, CALIFORNIA DIVISION OF MINES AND GEOLOGY, GEOLOGIC MAP, OLAF P. JENKINS EDITION, LOS ANGELES SHEET.
3. GOODMAN, E.D., AND P.E. MALIN, 1992, EVOLUTION OF THE SOUTHERN SAN JOAQUIN BASIN AND MID-TERTIARY "TRANSITIONAL" TECTONICS, CENTRAL CALIFORNIA, *TECTONICS,* VOL. 11, NO. 3, PAGES 478-498.
4. BARTOW, 1984. BARTOW, J.A. TERTIARY STRATIGRAPHY OF THE SOUTHEASTERN SAN JOAQUIN VALLEY, CALIFORNIA, USGS BULLETIN 1529-J, 1984.
5. DOGGR OIL WELL RECORDS (https://maps.conservation.ca.gov/doggr/wellfinder/#close).
6. USGS 10-METER DIGITAL ELEVATION MODEL (https://viewer.nationalmap.gov/basic/).

NOTES:

1. WELL IDENTIFICATION BASED ON PUBLIC LAND SURVEY SYSTEM.
2. SURFICIAL GEOLOGY AS SHOWN ON CDMG (1964). SURFICIAL GEOLOGY MAP UNIT SYMBOLS ARE:
   - Qf - RECENT FAN DEPOSITS
   - Qt - QUARTERNARY NON-MARINE TERRACE DEPOSITS
   - Pmlc - MIDDLE AND/OR LOWER PLIOCENE NON-MARINE
3. SUBSURFACE GEOLOGIC UNITS AND FAULT LOCATIONS BASED ON BARTOW (1984) WITH GOODMAN AND MALIN (1992) AND DOGGR OIL WELL RECORDS.
4. SEE FIGURE HCM-12 FOR CROSS-SECTION LOCATION. WELLS SHOWN ON CROSS-SECTION ARE LOCATED WITHIN 1/2 MILE OF CROSS-SECTION LINE.
5. MAJOR FORMATION MARKERS FROM DOGGR OIL WELL RECORDS INCLUDE:BFW (BASE OF FRESH WATER), SM (SANTA MARGARITA), TZ (TRANSITION ZONE), LFS (LOWER FRUITVALE SHALE), RM (ROUND MOUNTAIN SILTS), Olc (OLCESE SANDS), Bas (BASEMENT GRANITE).

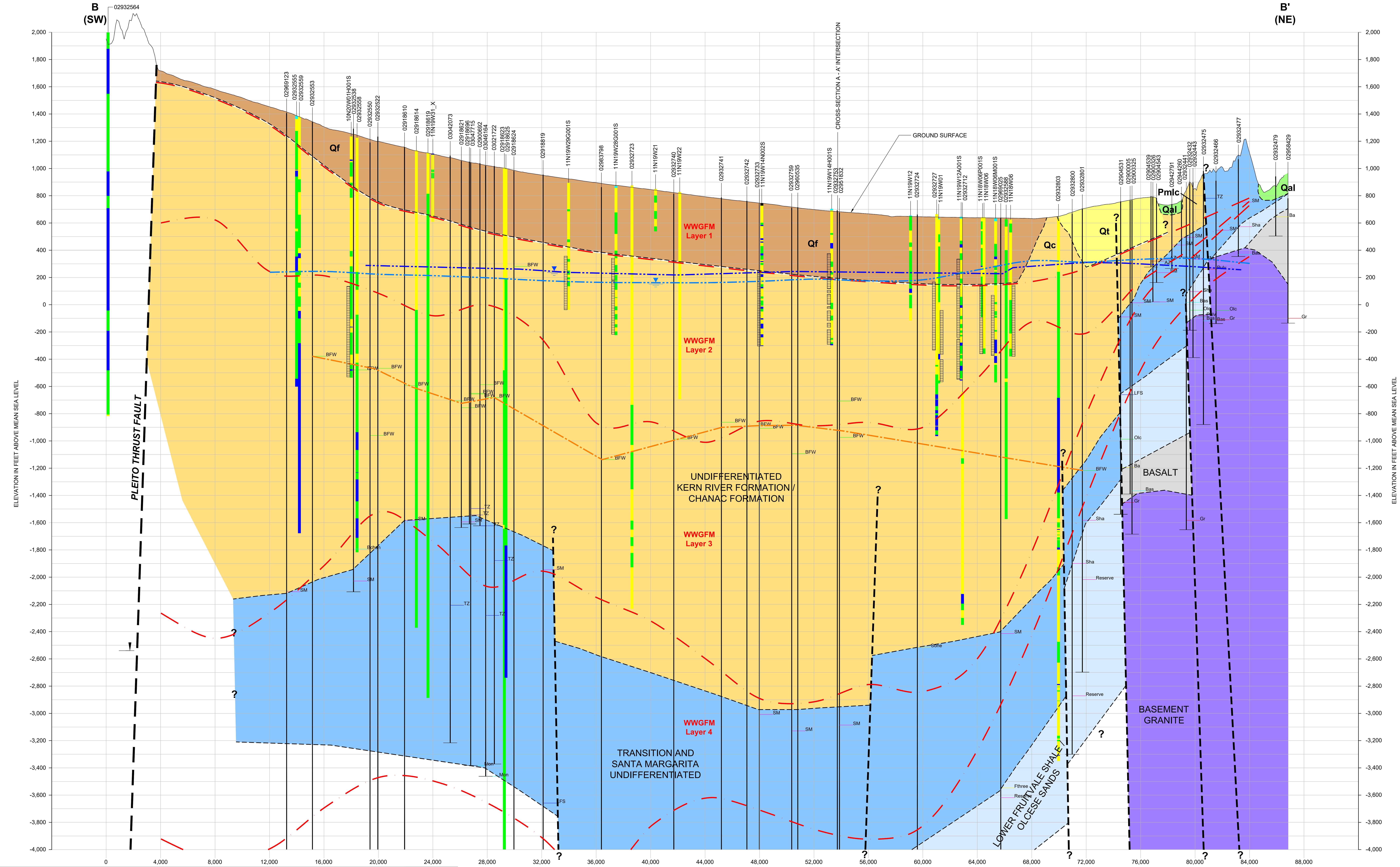
GEOLOGIC CROSS-SECTION A - A'

eki environment & water

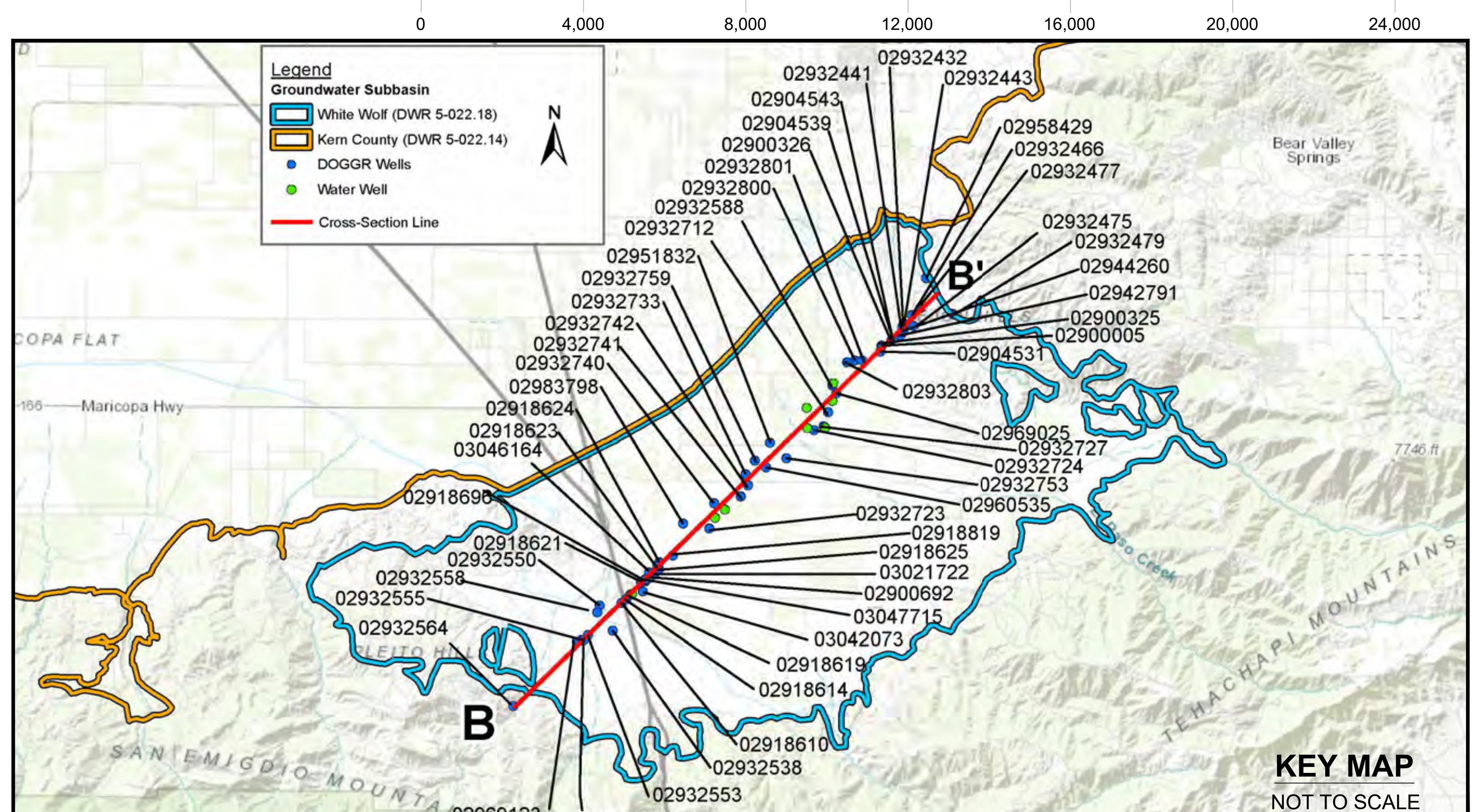
White Wolf GSA
Kern County, CA
December 2021
EKI B50001.05

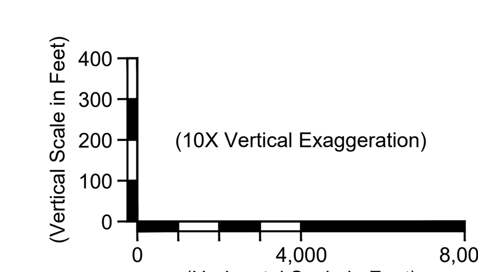
Figure HCM-11

G:\B50001.05\2021-08\Cross Section Section A and B.dwg 8-10-21



GEOLOGIC CROSS-SECTION B - B'





LEGEND:

WATER WELLS

- WELL IDENTIFICATION
- BASE & MERIDIAN
- SEQUENCE
- TRACT
- SECTION
- RANGE
- TOWNSHIP
- WELL CASING
- SOIL
- MEDIUM
- COARSE
- FINE
- WELL SCREEN

GENERALIZED TEXTURE DERIVED FROM WELL LOGS

11N19W18M001S

OIL WELLS

- OIL WELL IDENTIFICATION
- API NUMBER
- SM — NOTED FORMATION MARKER (SEE NOTE 5)
- TOTAL DEPTH

02932516

- WWGFM LAYER
- FORMATION CONTACT
- ? FAULT CONTACT (INFERRED)
- GROUNDWATER ELEVATION FALL 2015
- GROUNDWATER ELEVATION 2019
- BASE OF FRESH GROUNDWATER (AFTER DOGGR OIL WELL RECORDS)

SURFICIAL GEOLOGIC UNITS (SEE NOTE 2)

- Qal
- Qf
- Qt
- Qc
- Pmlc

SELECTED SUBSURFACE GEOLOGIC UNITS (SEE NOTE 3)

- UNDIFFERENTIATED KERN RIVER FORMATION/ CHANAC FORMATION
- TRANSITION AND SANTA MARGARITA UNDIFFERENTIATED
- LOWER FRUITVALE SHALE / OLCESE SANDS
- BASALT
- BASEMENT GRANITE

ABBREVIATIONS:

API = AMERICAN PETROLEUM INSTITUTE

WWGFM= WHITE WOLF GROUNDWATER FLOW MODEL

CDMG= CALIFORNIA DIVISION OF MINES AND GEOLOGY

DOGGR= DIVISION OF OIL, GAS & GEOTHERMAL RESOURCES

SOURCES:

1. CDMG, 1964, CALIFORNIA DIVISION OF MINES AND GEOLOGY, GEOLOGIC MAP, OLAF P. JENKINS EDITION, BAKERSFIELD SHEET.
2. CDMG, 1969, CALIFORNIA DIVISION OF MINES AND GEOLOGY, GEOLOGIC MAP, OLAF P. JENKINS EDITION, LOS ANGELES SHEET.
3. GOODMAN, E.D., AND P.E. MALIN, 1992, EVOLUTION OF THE SOUTHERN SAN JOAQUIN BASIN AND MID-TERTIARY "TRANSITIONAL" TECTONICS, CENTRAL CALIFORNIA, *TECTONICS,* VOL. 11, NO. 3, PAGES 478-498.
4. BARTOW, 1984. BARTOW, J.A. TERTIARY STRATIGRAPHY OF THE SOUTHEASTERN SAN JOAQUIN VALLEY, CALIFORNIA, USGS BULLETIN 1529-J, 1984.
5. DOGGR OIL WELL RECORDS (https://maps.conservation.ca.gov/doggr/wellfinder/#close).
6. USGS 10-METER DIGITAL ELEVATION MODEL (https://viewer.nationalmap.gov/basic/).

NOTES:

1. WELL IDENTIFICATION BASED ON PUBLIC LAND SURVEY SYSTEM.
2. SURFICIAL GEOLOGY AS SHOWN ON CDMG (1964). SURFICIAL GEOLOGY MAP UNIT SYMBOLS ARE:
   - Qal - RECENT ALLUVIUM
   - Qc - PLEISTOCENE NON-MARINE
   - Qf - RECENT FAN DEPOSITS
   - Qt - QUARTERNARY NON-MARINE TERRACE DEPOSITS
   - Pmlc - MIDDLE AND/OR LOWER PLIOCENE NON-MARINE
3. SUBSURFACE GEOLOGIC UNITS AND FAULT LOCATIONS BASED ON BARTOW (1984) & GOODMAN AND MALIN (1992) AND DOGGR OIL WELL RECORDS.
4. SEE FIGURE HCM-12 FOR CROSS-SECTION LOCATION. WELLS SHOWN ON CROSS-SECTION ARE LOCATED WITHIN 1/2 MILE OF CROSS-SECTION LINE.
5. MAJOR FORMATION MARKERS FROM DOGGR OIL WELL RECORDS INCLUDE:BFW (BASE OF FRESH WATER), SM (SANTA MARGARITA), TZ (TRANSITION ZONE), LFS (LOWER FRUITVALE SHALE), Olc (OLCESE SANDS), Bas (BASEMENT GRANITE), Sha (SHALE), AND Fs (FRUITVALE SHALE) ARE THE SAME AS LSF (LOWER FRUITVALE SHALE).

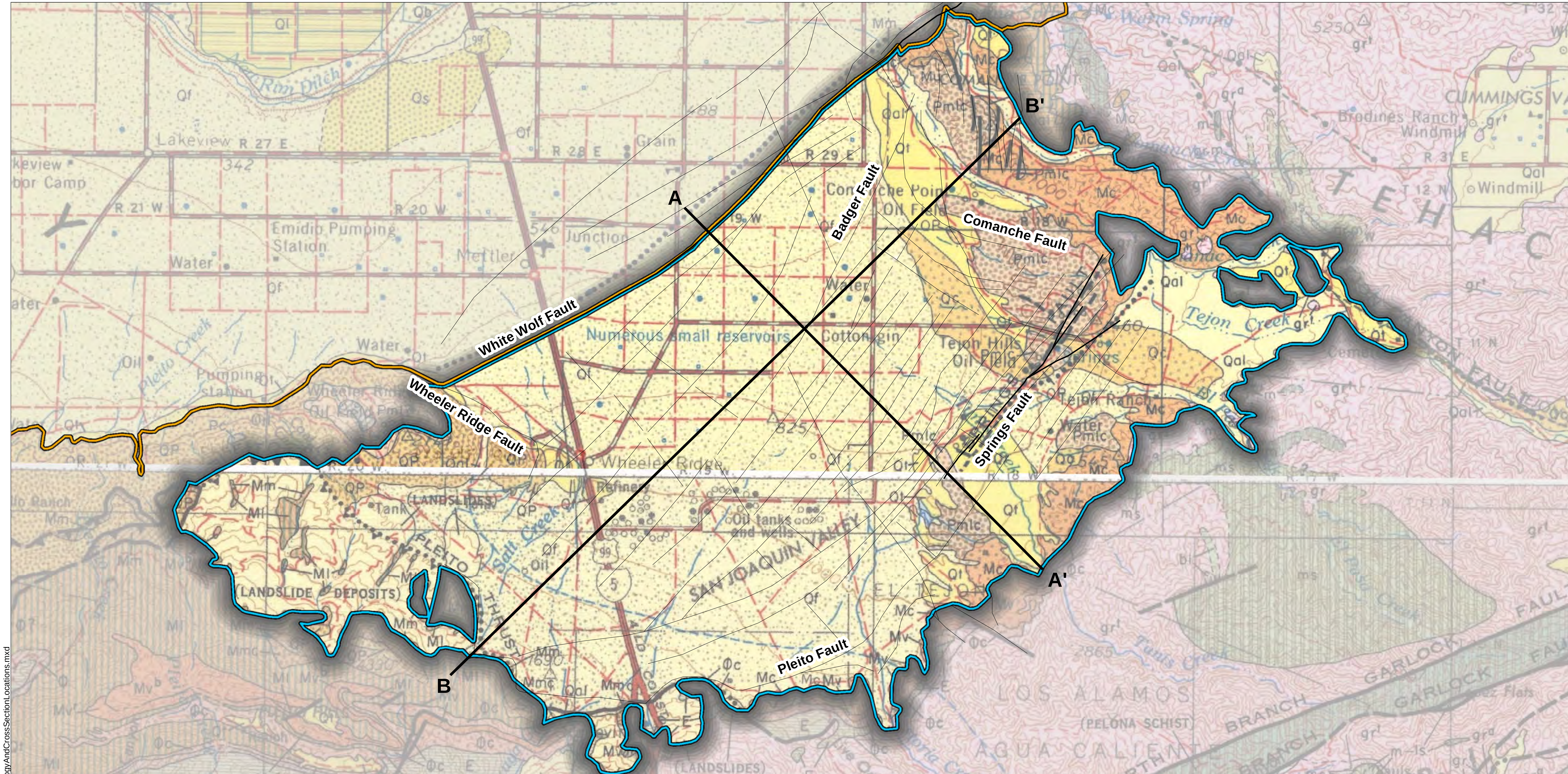
GEOLOGIC CROSS-SECTION B - B'

White Wolf GSA
Kern County, CA
December 2021
EKI B50001.05

eki environment & water

Figure HCM-12

G:\B50001.05\2021-08\Cross Section A and B.dwg 8-10-21



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- Cross Section Line
- Fault

Geologic Units

- Dune sand
- Quaternary fan deposits
- Quaternary nonmarine terrace deposits
- Undivided Pliocene nonmarine
- Undivided Miocene nonmarine
- Middle Miocene marine
- Oligocene marine
- Tertiary nonmarine
- Pre-Cretaceous metamorphic rocks
- Recent alluvium
- Quaternary basin deposits
- Pleistocene nonmarine
- Middle and/or lower Pliocene nonmarine
- Upper Miocene marine
- Lower Miocene marine
- Eocene marine
- Mesozoic basic intrusive rocks
- Pre-Cretaceous metasedimentary rocks
- Quaternary Stream channel deposits
- Quaternary lake deposits
- Plio-Pleistocene nonmarine
- Middle and/or lower Pliocene marine
- Miocene volcanic
- Oligocene nonmarine
- Paleocene marine
- Upper Cretaceous marine
- Mesozoic granitic rocks

Abbreviations

DWR = California Department of Water Resources

Notes

1. All locations are approximate.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
2. Surface geology from California Division of Mines and Geology, Geologic Map of California, Olaf P. Jenkins Edition, Bakersfield Sheet (1964) and Los Angeles Sheet (1969).
3. Fault locations from Goodman, E.D., and P.E. Malin, 1992, Evolution of the Southern San Joaquin Basin and Mid-Tertiary "Transitional" Tectonics, Central California, Tectonics, Vol. 11, No. 3, pages 478-498.

N

0 2 4

(Scale in Miles)

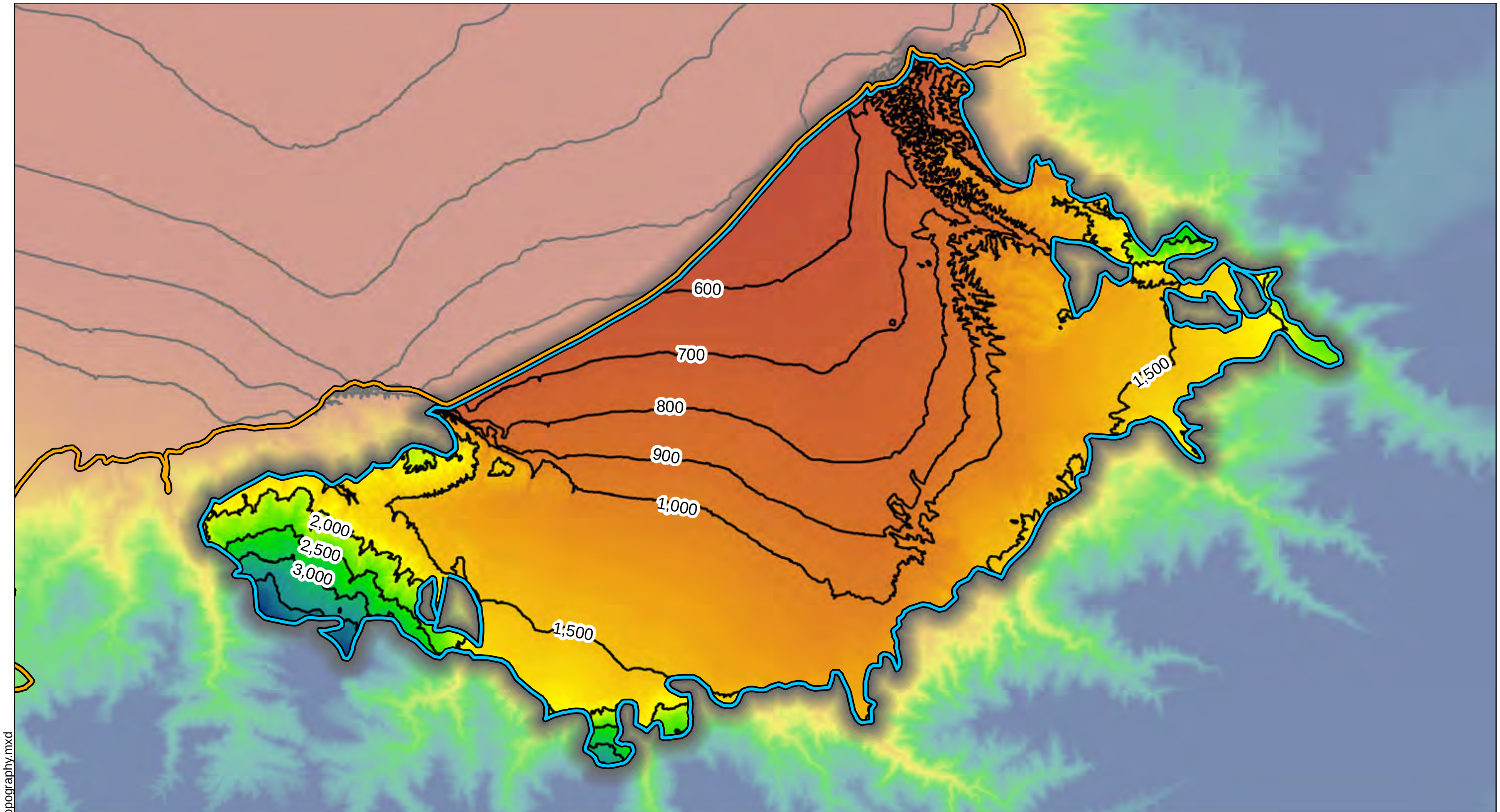
Surficial Geology and Cross Section Locations

eki environment & water

White Wolf GSA
Kern County, CA
December 2021
B50001.05

Figure HCM-13

Path: X:\B50001.05\Maps\GSP\2022\01\FigHCM-13_SurficialGeologyAndCrossSectionLocations.mxd



Path: X:\B50001.05\Maps\GSP\2022\01\FigHCM-14_Topography.mxd

Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

Elevation Contour (interval variable)

Land Surface Elevation (ft msl)

High : 4,100

Low : 500

Abbreviations

DWR = California Department of Water Resources
ft msl = feet above mean sea level
NED = National Elevation Dataset
USGS = United States Geological Survey

Notes

1. All locations are approximate.
2. Color scale is based on minimum and maximum elevations within the White Wolf Subbasin.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Land surface elevation data obtained from USGS NED (https://viewer.nationalmap.gov/basic/).

N

0 4 8

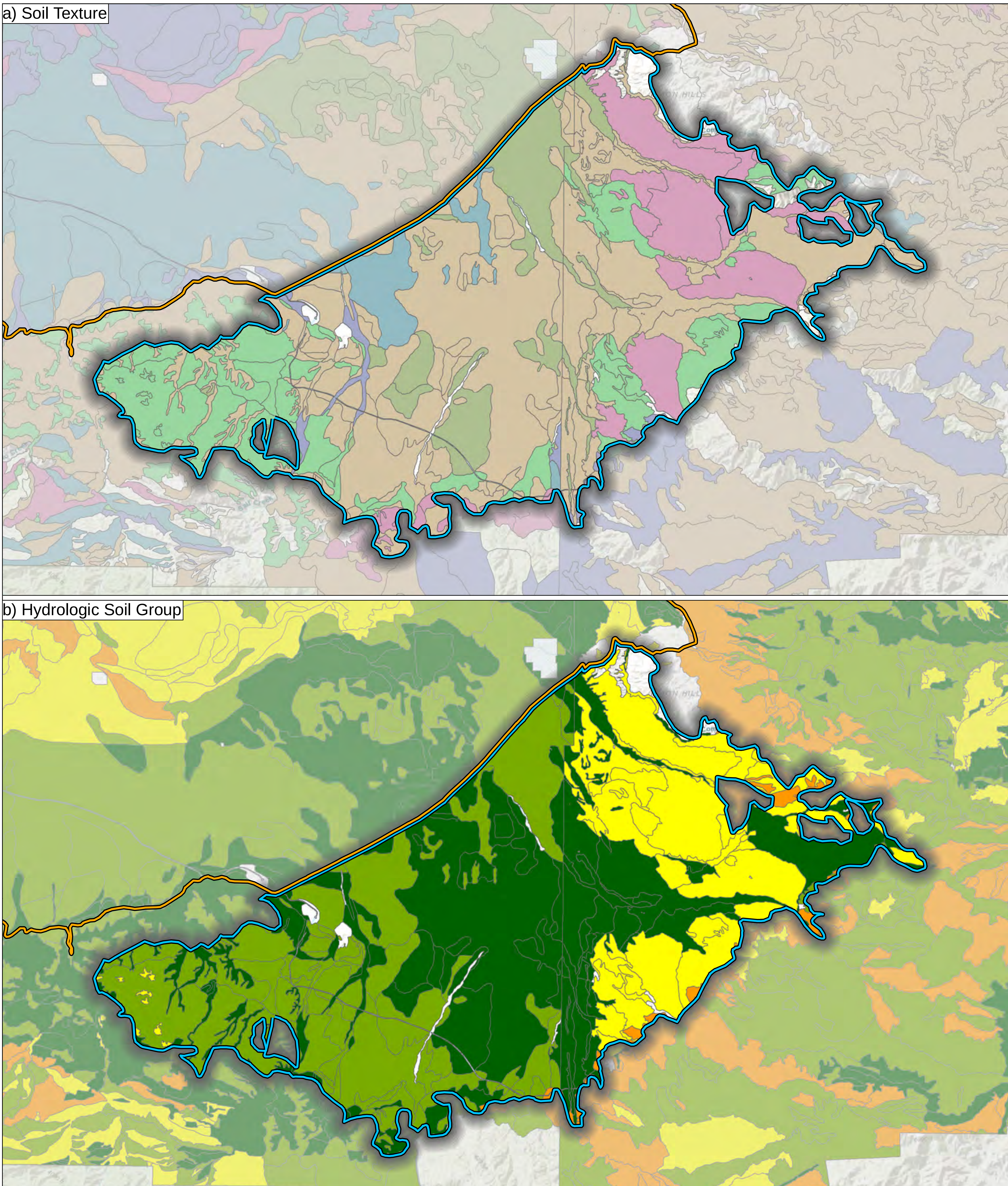
(Scale in Miles)

Topography

eki environment & water

White Wolf GSA
Kern County, California
December 2021
B50001.05

Figure HCM-14



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.14)
- Kern County (DWR 5-022.18)

Soil Texture

- Sandy Loam
- Sandy Clay Loam
- Clay Loam
- Loamy Sand
- Loam
- Other
- Not Identified

Hydrologic Soil Groups

- A
- B
- C
- D
- Not Identified

N

0 3 6
(Scale in Miles)

Abbreviations
DWR = California Department of Water Resources
SSURGO = Soil Survey Geographic Database

Notes
1. All locations are approximate.
2. Map units extracted from SSURGO data.
3. Only soil units of greatest extent are labeled.

Sources
1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Soil data from SSURGO (https://gdg.sc.egov.usda.gov/GDGOrder.aspx#).

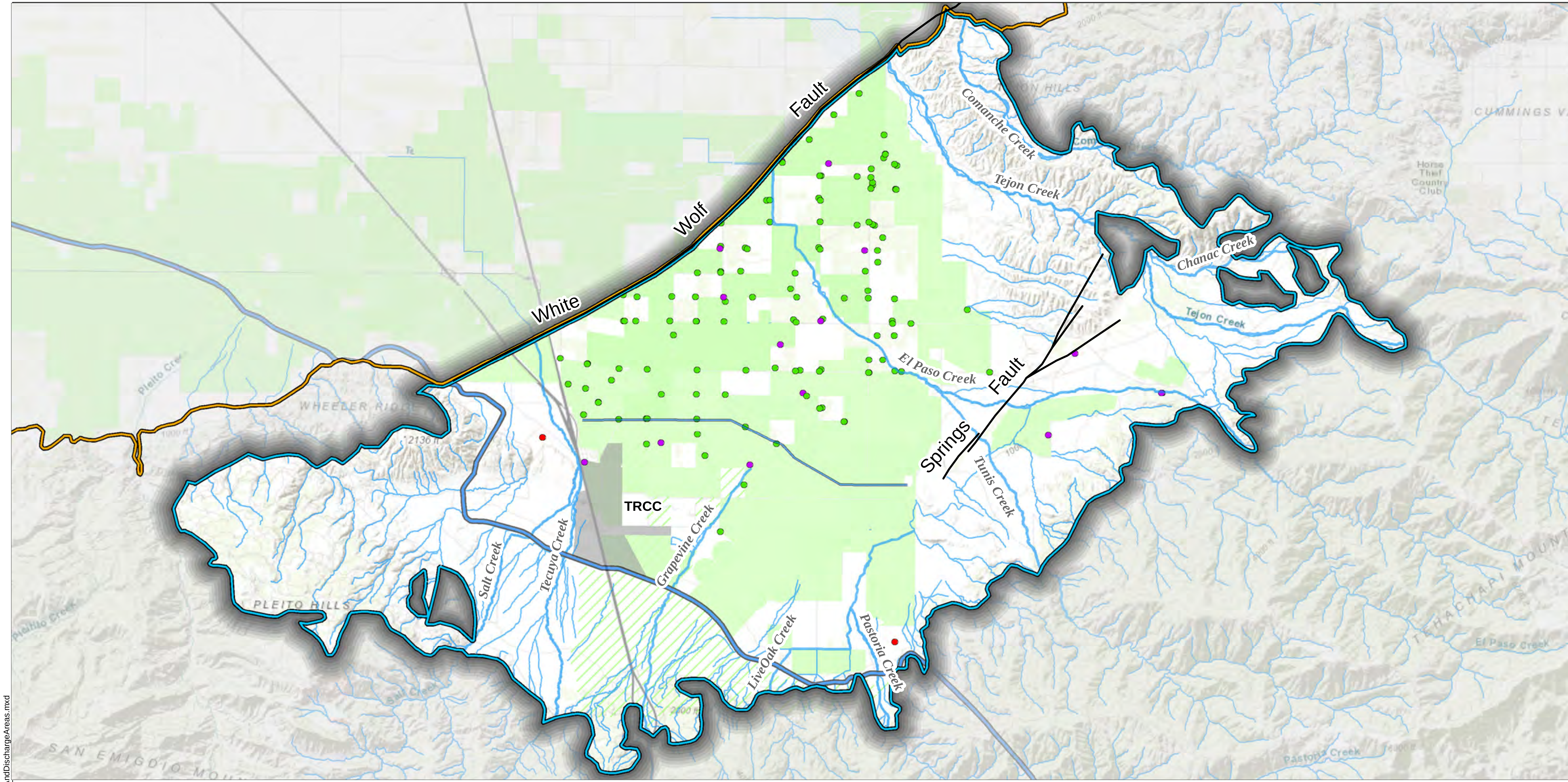
Soil Texture and Hydrologic Soil Group

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure HCM-15

Path: X:\B50001.05\Maps\GSP\2022\01\FigHCM-15_Soils.mxd



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

Fault

Discharge Areas

Well Use/Status

Agriculture, Active

Domestic, Active

Industrial, Active

Recharge Areas

California Aqueduct

850 Canal

Stream

Surface Water Service Area

Future Surface Water Service Area

TRCC

Abbreviations

AEWSD = Arvin-Edison Water Storage District
DWR = California Department of Water Resources
NHD = National Hydrography Dataset
TRCC = Tejon Ranch Commerce Center
WRMWSD = Wheeler Ridge-Maricopa Water Storage District

Notes

1. All locations are approximate.
2. Recharge from precipitation occurs over the entire White Wolf Subbasin.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 20 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Surface water features and California Aqueduct location from NHD (https://viewer.nationalmap.gov/basic/).
4. Surface Water Service Area and well type and status data provided by AEWSD and WRMWSD.

N 0 2 4 (Scale in Miles)

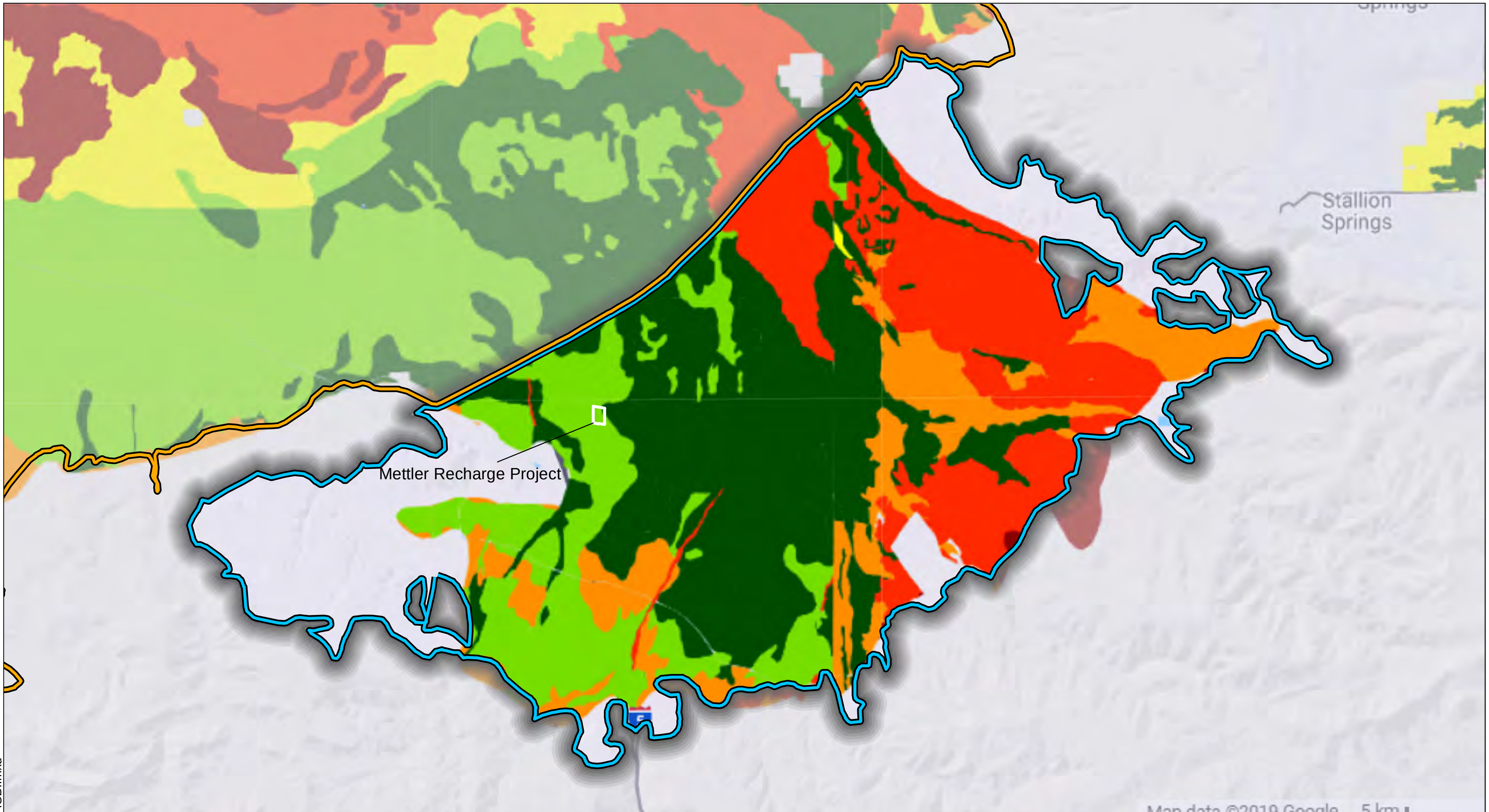
Groundwater Recharge and Discharge Areas

White Wolf GSA
Kern County, CA
December 2021
B50001.05

Figure HCM-16

eki environment & water

Path: X:\B50001.05\Maps\GSP\2022\01\FigHCM-16_RechargeAndDischargeAreas.mxd



Path: X:\B50001.05\Maps\GSP\2022\01\FigHCM-17_SAGBI.mxd

Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

SAGBI Rating

Excellent

Good

Moderately Good

Moderately Poor

Poor

Very Poor

Abbreviations

DWR = California Department of Water Resources

SAGBI = Soil Agricultural Groundwater Banking Index

Notes

1. All locations are approximate.
2. The SAGBI dataset is a spatial mapping of a suitability index for groundwater recharge on agricultural land, based on five key factors: deep percolation, root zone residence time, topography, chemical limitations, and soil surface condition.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
2. SAGBI data from https://casoilresource.lawr.ucdavis.edu/sagbi/.
4. Mettler Recharge Project recharge area from Provost and Pritchard Consulting Group, 2018, "Wheeler Ridge-Maricopa Water Storage District Mettler Groundwater Recharge Project Initial Study/Mitigated Negative Declaration", dated July 2018.

N

0 4 8

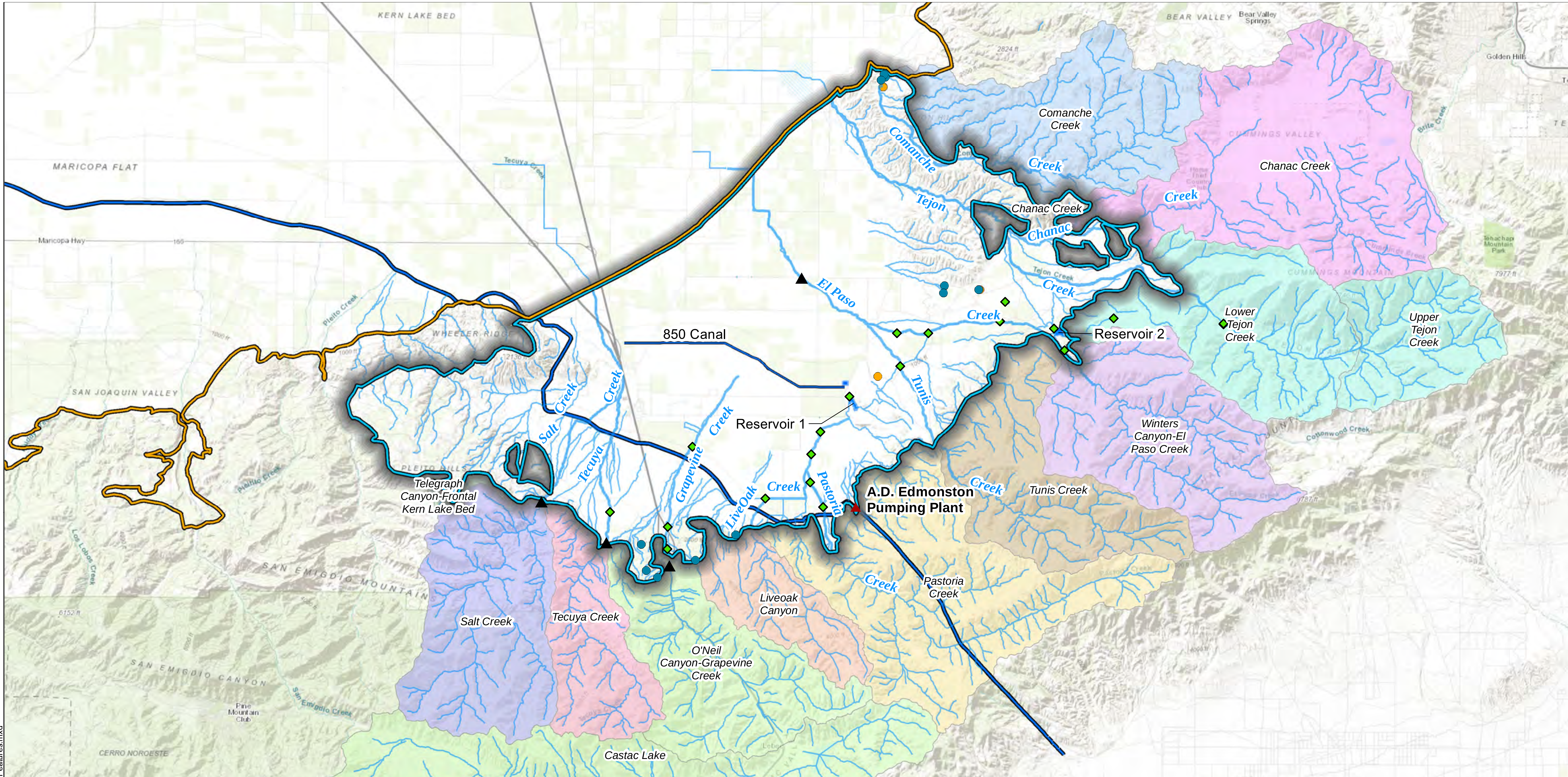
(Scale in Miles)

Soil Recharge Potential Based on SAGBI Dataset

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure HCM-17



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- Artesian Well/Spring
- Spring
- Surface Water Monitoring Location
- Permitted Points of Diversion
- California Aqueduct
- Stream into White Wolf Subbasin
- 850 Canal
- Reservoirs

Abbreviations

CEDEN = California Environmental Data Exchange Network
DWR = California Department of Water Resources
NHD = National Hydrography Dataset
WRMWSD = Wheeler Ridge-Maricopa Water Storage District

Notes

1. All locations are approximate.
2. Pastel filled areas are watersheds draining into the White Wolf Subbasin.
3. Other points of diversion exisit in the White Wolf Subbasin, but were inactive during the histroical and current conditions.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Surface water features, watersheds, and springs from NHD (https://viewer.nationalmap.gov/basic/).
4. Artesian Well/Spring from White Wolf Data Management System.
5. Surface water monitoring locations from CEDEN (https://ceden.waterboards.ca.gov), WRMWSD, 2018 Memorandum: Gaging Stations - Southern Stream Group – Project Update, and Kern County personal communication 7 January 2019.

N
0 3 6
(Scale in Miles)

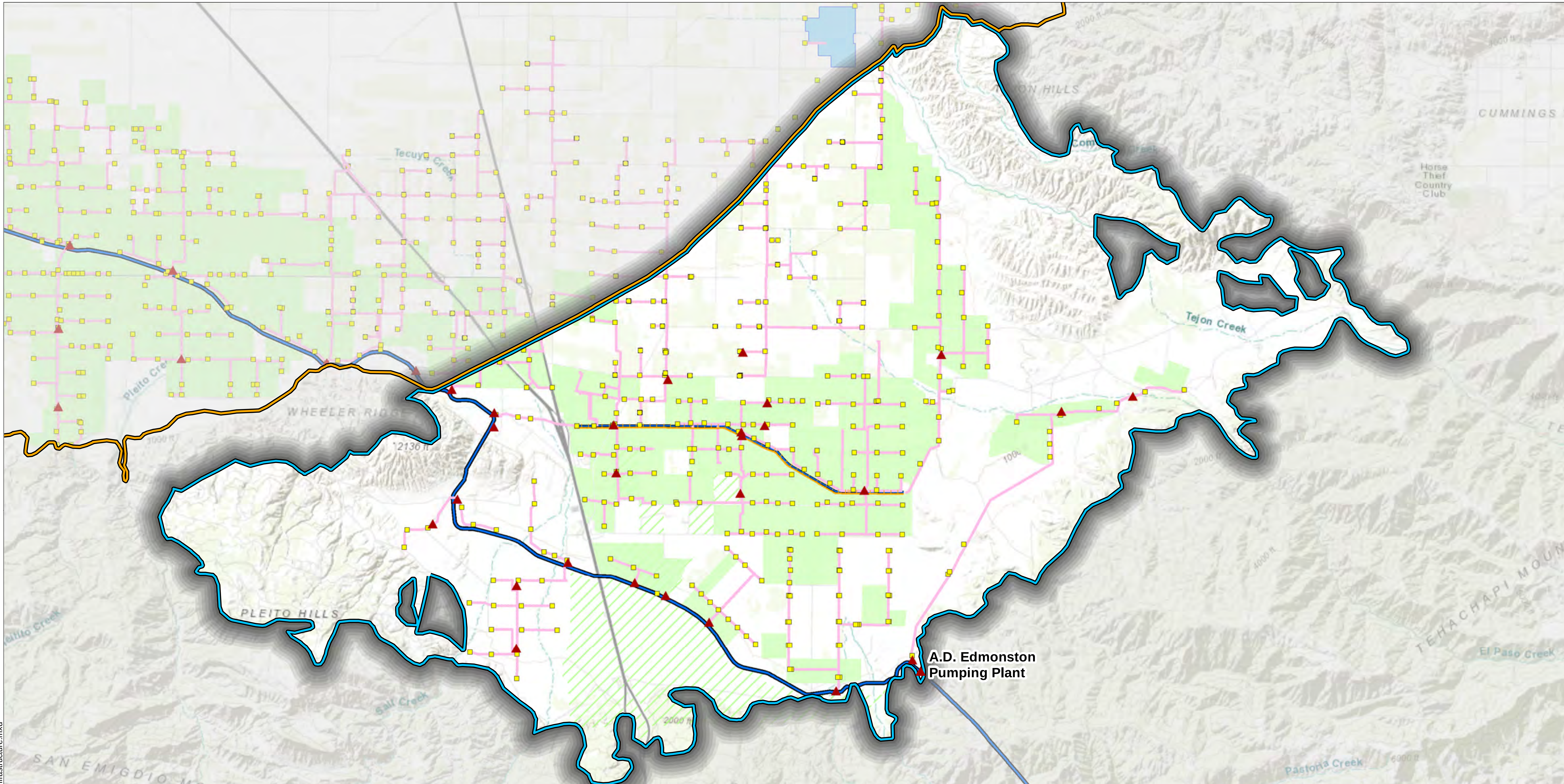
Surface Water Features

eki environment & water

White Wolf GSA
Kern County, CA
December 2021
B50001.05

Figure HCM-18

Path: X:\B50001.05\Maps\GSP\2022\01\FigHCM-18_SurfaceWaterFeatures.mxd



Legend

Groundwater Subbasin

- Kern County (DWR 5-022.14)
- White Wolf (DWR 5-022.18)
- Surface Water Service Area
- Future Surface Water Service Area
- Pumping Plant
- Turnout
- Pipeline
- California Aqueduct
- 850 Canal

Abbreviations

AEWSD = Arvin-Edison Water Storage District
DWR = California Department of Water Resources
WRMWSD = Wheeler Ridge-Maricopa Water Storage District

Notes

1. All locations are approximate.
2. Future surface water service area includes the proposed Grapevine Development area.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. AEWSD units and facility locations provided by AEWSD on 21 July 2021.
4. WRMWSD facility locations provided by WRMWSD on 21 November 2017.
5. California Aqueduct and 850 Canal locations are from the National Hydrography Dataset.

N

0 2 4

(Scale in Miles)

Facilities and Infrastructure

eki environment & water

White Wolf GSA
Kern County, CA
December 2021
B50001.05

Figure HCM-19

Path: X:\B50001.05\Maps\GSP\2022\01\FigHCM-19_Facilities&Infrastructure.mxd

8. CURRENT AND HISTORICAL GROUNDWATER CONDITIONS

> *§ 354.16. Groundwater Conditions*
> *Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:*

This section presents information on historical and current groundwater conditions within the Basin based on available data. Sources of data used to inform this assessment include data contained within the White Wolf Basin Data Management System (DMS) compiled from Arvin-Edison Water Storage District (AEWSD), Wheeler Ridge-Mariposa Water Storage District (WRMWSD) and Tejon-Castac Water District (TCWD) records, various state and federal databases (e.g., the California Department of Water Resources [DWR] California Statewide Groundwater Elevation Monitoring [CASGEM] database), other reports, and provided by stakeholders.

For the purpose of this assessment, except where data are not available, "current conditions" refers to Basin conditions documented between calendar year 2015 (i.e., the effective date of the Sustainable Groundwater Management Act [SGMA]) and 2019. This 2015-2019 period is consistent with the period used to calculate the current water budget (see ***Section 9.3 Historical and Current Water Budget***) and to establish baseline conditions for purposes of developing Sustainable Management Criteria (see ***Section 14.1 Minimum Threshold for Chronic Lowering of Groundwater Levels***).

For historical conditions, two periods are relevant. The first is DWR Water Years (WY) 1995 through 2014 (i.e., October 1994 through September 2014) which is the period being used for historical water budget development. As discussed further below, this period is climatically close to normal/average, but includes a significantly dry (drought) period between 2012 and 2014, as well as other drier and wetter than normal years. The second historical period discussed herein is the period from 1975 through 2019 which corresponds to the period when AEWSD, WRMWSD, and TCWD have been importing surface water (from the Central Valley Project [CVP] and the State Water Project [SWP], Kern River, and other sources) to their service areas in the Basin. The initiation of surface water imports by WRMWSD in 1975 represents the last major changed water supply condition in the Basin (AEWSD imports began in 1966). Consideration of this longer period allows for assessment of the long-term effects of GSA member District operations and various Sustainability Indicators (i.e., groundwater levels, storage, and water quality). In some cases, certain other historical periods are also discussed in this section when either (a) the discussion is constrained by the time periods of available datasets (e.g., for land subsidence), or (b) the groundwater conditions characterization is improved by incorporation of data from other time periods.

8.1. Data Management System

Per the California Code of Regulations Title 23 (23 CCR) § 352.6, each Groundwater Sustainability Agency (GSA) "shall develop and maintain a data management system that is capable of storing and reporting information relevant to the development or implementation of the Plan and monitoring of the basin." In support of Groundwater Sustainability Plan (GSP) development (i.e., the Hydrogeologic Conceptual Model [HCM] development, analysis of groundwater conditions, water budget development, and Plan Area definition), a substantial number of data sources were compiled, organized, processed, and stored within the White Wolf Basin DMS. The DMS consists of a Microsoft Access database file linked with a GIS "geodatabase," a composite file structure (.gdb) which packages attribute data with associated geospatial information in a user-defined coordinate system. Data within the DMS include well location, well construction, water level, and water quality data. The DMS will continue to be updated as additional data are received through GSA-led stakeholder outreach and data collection efforts.

During DMS preparation and population, quality assurance/quality control (QA/QC) checks were conducted prior to analysis of groundwater conditions. These QA/QC efforts included:

- Removing duplicate wells and combining records for wells with multiple names and multiple entries, renaming data associated with previous well names to the standardized well name, and reconciling location, use, status, and data inventory information for each well;
- Comparing Ground Surface Elevation (GSE) for a given well to the USGS Digital Elevation Model (DEM) data to validate the GSE and measuring point elevation (MPE);
- Formatting water quality data to ensure flags such as non-detected concentrations were accurately represented, and standardizing the analyte names;
- Converting depth-to-water data to water level elevations based on the MPEs; and
- Identification and removal of potentially erroneous data points where the rate of water level change between measurements seemed unreasonable through examination of hydrographs and recorded information on the quality of the measurement.

The resulting dataset used to inform the analysis and discussion of groundwater conditions herein consists of the following Basin-specific data:

- 6,609 groundwater elevation data points from 232 wells over the period from November 1919 to July 2021; and
- Groundwater quality data from 238 wells over the period from May 1966 to July 2021 which include 587 sample dates.

8.2. Groundwater Elevations and Flow Direction

§ 354.16. Groundwater Conditions

(a) Groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:

(1) Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin.

(2) Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.

For the purposes of this analysis, the periods of Spring and Fall 2015 and Spring and Fall 2019 are used to represent seasonal high and low conditions under current land and water use.[32]

8.2.1. Groundwater Elevation Contour Maps

Groundwater elevation contours of the Principal Aquifer for "current conditions" – Spring 2015/Fall 2015 and Spring 2019/Fall 2019 – are presented on **Figure GWC-1** and **Figure GWC-2**, respectively. The following general conclusions can be inferred from groundwater elevation data compiled for wells within the Basin:

- Groundwater level data are generally limited to the north-central portion of the Basin where most of the agricultural activity occurs.
- Groundwater levels are highest in the south in areas of higher topography and generally decrease to the north.
- There is a localized groundwater level low near the intersection of I-5 and State Highway 99 (more apparent in the Spring 2015 groundwater elevation contour map), as well as a relative groundwater level high between El Paso and Tejon creeks in the east central portion of the Basin.
- Assuming groundwater flow is perpendicular to groundwater elevation contours, flow directions are generally to the northwest.
- Average lateral groundwater gradients within the Basin were extracted using the difference between groundwater contour elevations divided by the lateral distance between contours as measured in GIS. The estimated lateral gradients within the central part of the Basin averaged 0.006 ft/ft in both Spring 2015 and Spring 2019, 0.008 ft/ft in Fall 2015, and 0.004 ft/ft in Fall 2019.

The relative highs and lows within the Basin appear to be controlled, at least in part, by natural surface water recharge, groundwater pumping, and irrigation return flows (see **Figure HCM-19**). The specific rates of groundwater pumping at different locations are not known and therefore, the localized effects of groundwater pumping on the distribution of the contours cannot be determined. The "barrier" effects of the WWF also tend to cause higher groundwater elevations on the upgradient side of the fault in the Basin. While not shown here due to lack of historical data, the Springs Fault also appears to impede groundwater flow, effectively separating the Principal Aquifer from a shallow water-bearing zone that is supporting groundwater dependent ecosystems (GDEs) in a small area of the Basin (see ***Section 8.8 Groundwater Dependent Ecosystems (GDEs)***).

8.2.1.1. Vertical Gradients

Vertical gradients between different depths (i.e., the Chanac Formation versus the Santa Margarita Formation) may develop due to the variability in aquifer properties, the proximity to recharge sources, and the location and intensity of pumping. Vertical gradients may also vary in time as the "stresses"

[32] For the purposes of the GSP, Spring is characterized as the period between January 15th and April 15th and Fall is characterized as the period between August 15th and November 15th.

affecting water levels are also temporally variable.

Evaluation of vertical gradients can be accomplished by examination of water levels in well pairs where one well is representative of the upper aquifer zone and the other well is representative of the lower aquifer zone. This approach requires water level information from wells that: (a) have known well construction information, (b) are screened in different depth zones, (c) have contemporaneous measurements (i.e., water levels measured at least in the same year and season), and (d) are in close spatial proximity to each other (i.e., to minimize the influence of lateral gradients effects).

Limited data exist throughout the Basin to characterize vertical gradients. However, two multi-depth monitoring well sites located in the southern portion of the Basin have been identified that meet the above criteria. Site locations and hydrographs for these wells, which are reportedly screened in the Chanac and Santa Margarita formations, are provided in **Figure GWC-3**. Vertical gradients in these wells represent the vertical gradients in this area between the Principal Aquifer where most groundwater pumping occurs and the underlying Santa Margarita Formation which is largely unpumped. Vertical gradients are calculated for each site as the difference in groundwater elevation between the shallow and deep well divided by the distance between the midpoints of the screened intervals. A negative vertical gradient signifies upward flow between aquifer zones whereas a positive vertical gradient signifies downward flow between aquifer zones.

- Site 1: Wells 10N18W06D001S (screened 720-820 feet below ground surface [ft bgs]) and 10N18W06D002S (screened 1,060-1,140 ft bgs) represent wells screened in the Chanac and Santa Margarita formations, respectively. Contemporaneous water level measurements are available from 2003 through 2019.
- Site 2: Wells 10N19W01K001S (screened 420-440 ft bgs) and 10N19W01K002S (screened 900-990 ft bgs) represent wells screened in the Chanac and Santa Margarita formations, respectively. Contemporaneous water level measurements are available from 2003 through 2019.

The Site 1 hydrographs show that between 2003 and 2019 vertical gradients between the Chanac and Santa Margarita formations are upward and relatively stable. "Current" gradients represented by the average gradient over the time period Spring 2015 through Fall 2019 is upwards with a value of -0.087 ft/ft (**Table GWC-1**).

The Site 2 hydrographs show that between 2003 and 2019 vertical gradients between the Chanac and Santa Margarita formations are upward and more variable than at Site 1. "Current" gradients represented by the average gradient over the time period Spring 2015 through Fall 2019 is upwards with a value of -0.104 ft/ft (**Table GWC-1**).

Vertical gradients at these sites were compared to vertical gradients simulated by the WWGFM. At Site 1 the simulated vertical gradient was upward, but the magnitude of the simulated upward gradient was approximately 25% of the magnitude of the measured upward gradient. At Site 2 the simulated vertical gradient is downward, which is opposite of the measured gradient.

Table GWC-1. Average Vertical Gradients under Current Conditions

Site	Well	Screen Interval (ft bgs)		Formation	Average Groundwater Elevation (ft msl)	Average Gradient (ft/ft)[(a)]
		Top	Bottom			
1	10N18W06D001S	720	820	Chanac	719.4	-0.087
	10N18W06D002S	1,060	1,140	Santa Margarita	748.2	
2	10N19W01K001S	420	440	Chanac	799.4	-0.104
	10N19W01K002S	900	990	Santa Margarita	853.1	

Abbreviations:
ft bgs = feet below ground surface
ft msl = feet above mean sea level

Notes:
(a) A negative vertical gradient signifies upward flow between aquifer zones whereas a positive vertical gradient signifies downward flow between aquifer zones.

8.2.1.2. Depth to Groundwater

As shown on **Figure GWC-4**, depth to groundwater for "current conditions" (i.e., average from Fall 2014 through Fall 2019) ranges from 69 to 982 ft bgs and averages about 500 ft bgs.

The greatest depth to water, 982 ft bgs, was measured in a well in the southwest part of the Basin adjacent to the California Aqueduct where the depth to water is influenced by the higher land surface elevation. Most of the Basin has depths to water of between 330 and 760 ft bgs, with relatively shallower water levels in the northern part of the Basin and deeper water levels in the central part of the Basin.

The shallowest depths to water, less than 200 ft bgs, were measured in wells in the southern portion of the Basin upgradient to the Springs Fault. Wells clustered near the southwestern end of the fault are reportedly screened in the Chanac and Santa Margarita formations where upward gradients exist. A shallow measurement (i.e., average of 69 ft bgs) from a domestic well located adjacent to El Paso Creek is suspected to be screened in shallow alluvium. Finally, although measured in 2021, depth to water of less than 20 ft bgs were measured in shallow wells immediately adjacent to the Springs Fault and of around 30 ft bgs were measured in the northern-most shallow well located adjacent to Tejon Creek. Although limited, these data suggest as water flows to the north, the Springs Fault acts as a partial barrier to flow in which water backs up immediately on the southern side of the fault.

8.2.2. Long-Term Groundwater Elevation Trends

Long-term trends in groundwater elevations were evaluated based on examination of hydrographs for 16 wells in the Basin for the time period 1955 through 2019 (**Figure GWC-5**)[33], and the more recent period

[33] **Figure GWC-5** shows data from 1955 through 2019. For the purposes of the water level trend calculation, only the data from 1975 through 2019 (i.e., the period between SWP water importation and most recently available data) were used.

from 1994 through 2019 (**Figure GWC-6**)[34]. Wells were selected for hydrograph analysis based on their length of record, their distribution through the Basin, and their representativeness of conditions in their area. Prior to 1966, groundwater was the only source of water for irrigation in the Basin. In 1966, AEWSD began to import surface water into the Basin and in 1975 WRMWSD began to import surface water into the Basin. From the 1950s through the 1970s, water levels in the region declined more than 200 ft in some wells. Beginning around 1975, when both AEWSD and WRMWSD were importing water into the Basin, water levels began to recover. By 2007, water levels appeared to have recovered much of the decline, and the recovery continued beyond 2007 in some wells.

Linear regression of the water level data was used to evaluate long-term groundwater elevation trends. This method can be slightly biased by the data's temporal frequency and distribution. Based on the hydrographs for 16 wells, over the period from 1975 (the start of SWP water importation by WRMWSD and the last major changed water supply condition in the Basin) through Fall 2019, all wells show an increasing long-term groundwater elevation trend at rates between 0.6 feet per year (ft/yr) to 2.8 ft/yr over this time period. Over the historical water budget time period of Water Year (WY) 1995-2014, groundwater elevation trends increased from 0.3 ft/yr to 2.6 ft/yr in all but one well (12N19W33R001S) which exhibited a decrease of 0.9 ft/yr. Over the current conditions water budget time period of WY 2015-2019, groundwater elevation trends increased from 0.5 to 26.9 ft/yr in six wells and decreased from 2.6 to 17.8 ft/yr in eight wells,[35] and two wells had insufficient water level measurements with which to extrapolate a trend.

Table GWC-2 below shows the DWR WY type (DWR, 2021)[36]. For the 25 WYs from 1995-2019, there were six "critical" (dry) years, four dry years, three below normal years, four above normal years, and eight wet years. The first third of this period was a mix of wet and dry, the middle third was extremely dry, and the last third of the period was moderately dry. This climatic factor is reflected in the hydrographs which tend to exhibit water level increases in the 1990s, relative stability in the early 2000s, and then water level decreases starting around WY 2010. Under current conditions, water level trends vary between increasing and decreasing, suggesting areas of the Basin did not exhibit water level recovery following the critically dry years of 2013 and 2014.

[34] **Figure GWC-6** shows data from 1994 through 2019. For the purposes of the water level trend calculations, data from 1994 through 2014 (i.e., the historical water budget period) and from 2015 through 2019 (i.e., the current conditions water budget period) were used.
[35] In some instances, Fall 2019 measurements were obtained in early October 2019. These measurements were used as part of the trend calculation although technically outside the trend calculation period.
[36] DWR defines a Water Year (WY) as extending from October 1 of the previous year to September 30 of the year in question. For example, WY 2015 extends from October 1, 2014 through September 30, 2015.

Table GWC-2. Summary of DWR Water Year Types, 1995-2019

WY	WY Type	WY	WY Type	WY	WY Type
1995	Wet	2004	Dry	2013	Critical
1996	Above Normal	2005	Wet	2014	Critical
1997	Dry	2006	Wet	2015	Dry
1998	Wet	2007	Critical	2016	Above Normal
1999	Wet	2008	Critical	2017	Wet
2000	Dry	2009	Critical	2018	Below Normal
2001	Below Normal	2010	Above Normal	2019	Wet[(a)]
2002	Critical	2011	Wet		
2003	Below Normal	2012	Above Normal		

Abbreviations:
WY = Water Year

Notes:
(a) WY type for 2019 was unavailable, and was estimated using same methodology presented in DWR, 2021.

Sources:
(1) WY types are based on classifications for HUC8 18030003 Middle Kern-Upper Tehachapi-Grapevine (DWR, 2021).

8.3. Change in Groundwater Storage

> *§ 354.16. Groundwater Conditions*
> *(b) A graph depicting estimates of the change in groundwater in storage, based on data, demonstrating the annual and cumulative change in the volume of groundwater in storage between seasonal high groundwater conditions, including the annual groundwater use and water year type.*

Change in groundwater storage was estimated based on data for selected periods of interest. Storage change was calculated by using water level data collected at the start and end of each period, spatially-variable specific yield information, and the following relationship over a specified gridded area:

$$Change\ in\ storage = [Ending\ Water\ Level - Starting\ Water\ Level] * Specific\ Yield * Area$$

Specifically, this approach was implemented by:

(1) interpolating groundwater elevations for both years onto a 100-ft grid of pixels using the geostatistical spatial interpolation method known as kriging;

(2) using a specific yield value (0.12) that is consistent with the calibrated value utilized in the White Wolf Groundwater Flow Model (WWGFM);

(3) calculating the water level difference at each pixel;

(4) multiplying the result from (4) by the area of each pixel (i.e., 100 ft x 100 ft = 10,000 ft^2); and

(5) summing all calculated values over the area of storage change analysis.[37]

Figure GWC-7 shows the distribution of groundwater elevation change for the developed agricultural area of the Basin for the periods from Spring 1975 through Spring 2017, Spring 1994 through Spring 2015, Spring 2014 through Spring 2015, and Spring 2015 through Spring 2019 (groundwater elevation change is directly related to storage change). During the period from Spring 1975 through Spring 2017 groundwater elevation increased throughout 90% of the analysis area. The largest increase occurred in the northeast part of the analysis area and the largest decrease occurred to the west of this area near the WWF. The area with the greatest decrease in groundwater elevation is based on only one well pair and is near the area with the greatest increase in groundwater elevation. Therefore, the large groundwater elevation decrease at this location may be an outlier. Over the historical water budget period from Spring 1994 through Spring 2015 groundwater elevation increased in 95% of the analysis area. The largest groundwater elevation increase was in the eastern part of the analysis area and the largest groundwater elevation decrease was in the west-central part of the analysis area near the WWF. Over the period from Spring 2014 to Spring 2015, which was a dry period, groundwater elevation decreased in 70% of the analysis area. Groundwater elevation declines were greatest in the central part of the analysis area and along the WWF. Finally, during the current conditions water budget period (i.e., Spring 2015 through Spring 2019), groundwater elevation decreased in 77% of the analysis area. Groundwater elevation declines were greatest in the central part of the analysis area and along the WWF, although paired-well data in this area was limited. **Table GWC-3** summarizes the change in groundwater storage estimation based on water level change calculations for selected time periods.

[37] Due to the lack of available water level data outside of the main irrigated agricultural area of the Basin, the storage change analysis included only the area where reasonable estimates of groundwater elevations could be interpolated, totaling approximately 35,000 acres. Storage change in areas of the Basin outside of the irrigated areas is assumed to be negligible over the long term. To avoid errors caused by comparison of interpolated data that are based on different well points, a paired-well approach was used, wherein wells were selected for inclusion only if they were present in both datasets or if they were in close proximity (less than 1 mile) to a well in both datasets.

Table GWC-3. Water Level Change-Calculated Change in Storage for Selected Time Periods

Period	Relevance of Time Period	Total Change in Storage (AF)	Annual Rate of Change in Storage (AFY)
Spring 1994 – Spring 2015	Historical water budget period	95,500	4,500
Spring 2003 – Spring 2015	Longer normal/dry period	-119,600	-10,000
Spring 1994 – Spring 2003	Longer normal/wet period	180,500	20,100
Spring 2014 – Spring 2015	Short dry period	-39,300	-39,300
Spring 2009 – Spring 2011	Short wet period	-9,100	-4,600
Spring 2015 – Spring 2019	Current water budget period	-76,200	-19,100

Abbreviations:
AF = acre-feet
AFY = acre-feet per year

Notes:
(a) Water level change methodology only considers the area with reasonable estimates of groundwater elevations, encompassing approximately 35,000 acres.

Determination of the change in storage on a yearly basis using the method described above is more difficult due to a lack of consistent water level monitoring data and insufficient spatial coverage. To fully quantify storage changes across the entire Basin, annual change in storage estimates were extracted from the calibrated WWGFM, described further in **Section *9 Water Budget Information*** below.

A graph of estimated annual change in storage between seasonal water level highs (i.e., from March of each year to March of the following year), is presented on **Figure GWC-8**. Also shown on **Figure GWC-8** is the WY type[38]. As shown on **Figure GWC-8**, annual change in storage within the Basin ranged from an increase of 55,300 AF for the period from March 1998 – February 1999 to a decrease of 45,600 AF for the period between March 2013 and February 2014. In general, change in storage tends to be more negative during dry WYs and more positive during wet WYs. Change in groundwater storage is discussed further below in ***Section 9.3.4 Change in Groundwater Storage***.

8.4. Seawater Intrusion

> *§ 354.16. Groundwater Conditions*
> *(c) Seawater intrusion conditions in the basin, including maps and cross-sections of the seawater intrusion front for each principal aquifer.*

The Basin is located far from coastal areas and seawater intrusion is not considered to be a threat to

[38] The seasonal high groundwater condition occurs typically in late winter or spring and for the purposes of **Figure GWC-8** is assumed to occur in March. March groundwater levels are affected by both the amount of pumping during the prior summer (i.e., previous DWR Water Year) as well as the amount of precipitation during the winter months of the current DWR Water Year. In **Figure GWC-8** the color of each bar is based on the Water Year type for the year the begins in the October between the March and February represented by the bar.

groundwater resources.

8.5. Groundwater Quality Concerns

> *§ 354.16. Groundwater Conditions*
> *(d) Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes.*

Groundwater quality concerns occur when dissolved constituent concentrations in water exceed a prescribed limitation. Groundwater quality constituents that may affect the supply and beneficial uses of groundwater in the Basin were identified by comparing the highest measured concentrations detected from WY 2015 through 2019 (i.e., October 2014–September 2019) at individual wells to applicable screening levels for the various beneficial uses (i.e., Maximum Contaminant Levels [MCLs] for M&I uses and Water Quality Objectives [WQO] for irrigated agricultural use):

- Primary MCLs are drinking water standards set by the United States Environmental Protection Agency (USEPA) and California Environmental Protection Agency (CalEPA) based on human health considerations.
- Secondary MCLs are non-health related standards set by the State Water Resources Control Board (SWRCB) based on aesthetic characteristics of drinking water such as taste, odor, and color. For four common constituents (i.e., total dissolved solids [TDS], specific conductance, chloride, and sulfate), the SWRCB sets three levels of Secondary MCLs for consumer acceptance, referred to from lowest to highest concentration as "recommended," "upper," and "short term."
- Action Levels (ALs) set by the USEPA for public water systems (PWS).
- Health Advisory limits set by the USEPA for non-cancer health effects.

All constituents that have a Primary MCL, Secondary MCL, AL, or WQO were screened against well-water samples contained within the Basin's DMS. **Table GWC-4** summarizes the screening levels associated with key inorganic constituents and other constituents in which well water samples within the Basin DMS exceeded their applicable screening levels between WY 2015-2019.

Table GWC-4. Screening Levels and Exceedances for Key Water Quality Constituents

Constituent	Limitation (mg/L)	Limit Type and Source	Wells Sampled[a]	Wells Exceeding Limitation
Inorganics				
Arsenic	**0.01**	**Primary MCL (Title 22)**	**109**	**13 (12%)**
Fluoride	2.0	Primary MCL (Title 22)	141	0 (0%)
Nitrate as nitrogen (N)	**10**	**Primary MCL (Title 22)**	**301**	**133 (44%)**
Selenium	**0.05**	**Primary MCL (Title 22)**	**31**	**6 (19%)**
TDS	**500**	**Secondary MCL-Recommended (Title 22)**	**171**	**76 (44%)**
Chloride	250	Secondary MCL-Recommended (Title 22)	143	0 (0%)
Sulfate	**250**	**Secondary MCL-Recommended (Title 22)**	**137**	**22 (16%)**
Iron	**0.3**	**Secondary MCL (Title 22)**	**136**	**24 (18%)**
Manganese	0.05	Secondary MCL (Title 22)	136	18 (13%)
Lead	0.015	WQO (USEPA AL Title 22)	24	0 (0%)
Boron	**0.5**	**WQO (USEPA Health Advisory)**	**134**	**13 (10%)**
Sodium	**20**	**WQO (USEPA Health Advisory)**	**142**	**139 (98%)**
Radionuclides				
Alpha Radiation	15	Primary MCL (Title 22)	22	0 (0%)
Uranium	0.03	Primary MCL (Title 22)	39	0 (0%)
Non-Volatile Synthetic Organic Chemicals[c]				
1,2,3-Trichloropropane	0.000005	Primary MCL (Title 22)	16	0 (0%)
1,2-Dibromo-3-Chloropropane	0.0002	Primary MCL (Title 22)	26	2 (8%)

Abbreviations:

AL = action level
COC = constituent of concern
DMS = Data Management System
MCL = maximum contaminant limit
USEPA = United States Environmental Protection Agency
WQO = Water quality objective

Notes:

(a) Wells sampled in WY 2015-2019 by TCWD, AEWSD, WRMWSD, Public Water System, Department of Drinking Water, ILRP, and other private parties. Counts include both total and dissolved constituents for arsenic, selenium, boron, and sodium.
(b) Bold text identifies potential COCs based on a water quality exceedance of MCLs or WQOs in more than 15% of wells sampled. Arsenic is included herein due to its potential impact on beneficial users of groundwater.
(c) Only non-volatile synthetic organic chemicals that were detected in wells within the Basin DMS between WY 2015-2019 or are a known "constituent of special interest" are shown in **Table GWC-4**.

Wells that have been sampled exist primarily in the central part of the Basin. ***Appendix E*** includes a list and description of potential water quality datasets that have been preliminarily evaluated to further assess groundwater quality conditions in the Basin including, for example, the CalEPA Regulated Site Portal, Cortese List, Drinking Water Watch, GAMA-Priority Basin Project, California Pesticide Information Portal, USEPA National Priorities List, and California Geologic Energy Management Division (CalGEM) CalStim'D and WellFinder datasets. The available water quality data for wells within the Basin from these sources has been compiled and has been added to the DMS as appropriate.

8.5.1. Constituents with Primary MCLs

Constituents in Basin well water samples were screened against the Primary MCLs as those are associated with potential health risks. When the concentrations exceeded the Primary MCL, that constituent is considered herein as a "Water Quality Exceedance." For the purpose of this analysis, if more than 15% of the wells have samples with a Water Quality Exceedance for a constituent, then that constituent is identified as being a potential constituent of concern (COC) in Basin groundwater, and trends associated with concentrations over time in relation to groundwater levels over time were conducted, as detailed in ***Section 8.5.3 Water Quality Trends***.

Maps were prepared to characterize the nature and extent of water quality impacts related to these COCs for current conditions (based on data collected between WY 2015-2019). The resultant maps (**Figure GWC-9** through **Figure GWC-12**) explore the geographic distribution of water quality concerns across the Basin.

- **Arsenic** is a naturally occurring constituent that is associated with geologic formations that comprise the aquifers within the Basin (Agency for Toxic Substances and Disease Registry, 2011). Ingestion has been associated with an increased risk of cancer and other chronic health effects, and concentrations that exceed the MCL in drinking water sources are a significant human health concern (Title 22 CCR Article 18 § 64465). Arsenic was detected above the Primary MCL of 0.01 milligrams per liter (mg/L) in 13 of 109 wells (12%) sampled from WY 2015-2019. The highest arsenic concentrations are detected in wells in the central and northern part of the Basin (**Figure GWC-9**). While data are not conclusive as to whether arsenic concentrations have been, or could in the future be, impacted by GSA actions (see ***Section 8.5.3 Water Quality Trends***), and although less than 15% of the wells have arsenic water quality exceedances, elevated arsenic concentrations can impact beneficial drinking water users and therefore has been conservatively considered a potential COC.
- **Nitrate** concentrations in drinking water are a significant health concern for pregnant women and infants, and concentrations that exceed the MCL can cause methemoglobinemia ("blue baby syndrome") (Title 22 CCR Article 18 § 64465). Nitrate was detected above the Primary MCL of 10 mg/L (as N) or 45 mg/L (as NO_3) in 133 of the 301 wells (44%) sampled from WY 2015-2019. As shown on **Figure GWC-9**, the highest nitrate concentrations were measured in wells located in the northern part of the Basin near the WWF and along the eastern margin of the sampled area. The lowest nitrate concentrations were measured in wells generally located in the central part of the Basin. Although nitrate is separately regulated under the Irrigated Lands Regulatory Program (ILRP)

and/or Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS), and the data are not conclusive as to whether nitrate concentrations have been, or could in the future be, impacted by GSA actions, because nitrate exceeded the Primary MCL in more than 15% of well water samples, it is considered a potential COC.

- **Selenium** is a naturally occurring constituent that is associated with geologic formations that comprise the aquifers within the Basin (Agency for Toxic Substances and Disease Registry, 2011). Concentrations in drinking water can be a significant health concern causing circulation system problems (Title 22 CCR Article 18 § 64465). Selenium was detected above the Primary MCL of 0.05 mg/L in 6 of the 31 wells (19%) sampled from WY 2015-2019. High concentrations are detected along the eastern margin of the sampled area and in the northwestern part of the Basin (**Figure GWC-10**). Although the data are not conclusive as to whether selenium concentrations have been, or could in the future be, impacted by GSA actions, because selenium exceeded the Primary MCL in more than 15% of well water samples, it is considered a potential COC.
- Analysis of recent samples collected within the Basin by WRMWSD, TCWD, and public water systems has included inorganic constituents such as major ions and metals, as well as volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs). VOCs and SVOCs are typically not a concern for agricultural beneficial uses, but some are harmful to humans if consumed at high enough concentrations (often at parts per million or parts per billion concentrations) and are thus regulated by the USEPA and CalEPA (specifically the SWRCB) in drinking water sources. Some of these compounds currently are or have historically been used in agriculture as pesticides, herbicides, or fungicides and can be transported to groundwater by deep percolation of excess applied water. One compound in particular, 1,2,3-trichloropropane (1,2,3-TCP), which is an industrial solvent that was also a component of a soil fumigant, was recognized in 2006 as a "constituent of special interest" in Kern County (Shelton et al., 2008), and was recently assigned a Primary MCL of 0.000005 mg/L (five parts per trillion) by the CalEPA, effective 17 December 2017. Limited data (44 samples from 17 wells sampled between 2000-2019) showed that 1,2,3-TCP was not detected in wells within the Basin except for one well-water sample in January 2006. Additionally, limited data from the USGS Groundwater Ambient Monitoring and Assessment Program (GAMA) program showed that 1,2,3-TCP was not detected in wells within the Basin (Shelton et al., 2008). More recent monitoring from outside of the "current conditions" period of record (i.e., post-2019) indicates the presence of 1,2,3-TCP in some wells. Since data are limited, 1,2,3-TCP is an emerging water quality constituent of concern that the GSA plans to monitor in the Basin.

8.5.2. Constituents with Secondary MCLs and WQOs

Constituents for which samples exceeded the Secondary (i.e., aesthetically-based) MCLs include TDS, sulfate, and iron. Constituents for which samples exceeded the WQOs include boron and sodium. As described below, these constituents are either only detected on a limited basis or not likely to significantly affect beneficial uses of groundwater in the Basin and therefore are not considered a potential water quality COC. However, as part of increasing Basin characterization and understanding, the GSA intends to continue to monitor the following constituents:

- **TDS** was detected above the "recommended" Secondary MCL of 500 mg/L in 76 of the 171 wells (44%) sampled from WY 2015-2019. These wells are located throughout the central part of the Basin, with most being located on the west and east margins of the sampled area (**Figure GWC-11**). TDS exceeded the "upper" Secondary MCL of 1,000 mg/L in 12 (7%) of the wells sampled; These wells are located exclusively in the western part of the sampled area. Historical water quality sampling from the 1960s shows a similar distribution of TDS concentrations as is observed from the WY 2015-2019 data. The distribution of TDS concentrations has not changed substantially over time. Although TDS is not considered a primary pollutant effecting human health, it is an indication of aesthetic characteristics of drinking water and can include an aggregated broad array of potential chemical contaminants (Hem, 1970). Therefore, TDS is a water quality constituent that the GSA plans to continue to monitor in the Basin.

- **Sulfate** occurs widely in soil and water (Hem, 1970). Sulfate was detected above the "recommended" Secondary MCL of 250 mg/L in 22 of the 137 wells (16%) sampled from WY 2015-2019. Sulfate exceeded the "upper" Secondary MCL of 500 mg/L in 9 (7%) of the wells sampled. The wells having the highest sulfate concentrations are all located in the western and central part of the sampled area (**Figure GWC-10**). Although sulfate is not considered a primary pollutant effecting human health, it is an indication of aesthetic characteristics of drinking water. Therefore, sulfate is a water quality constituent that the GSA plans to continue to monitor in the Basin.

- **Iron** is an essential (and naturally occurring) element in the metabolism of animals and plants, however excessively high concentrations can cause staining; therefore, iron is considered an objectionable impurity (Hem, 1970). Iron exceeded its Secondary MCL (0.3 mg/L) in 24 of 136 wells (18%) sampled. Although Iron is not considered a primary pollutant effecting human health, it is an indication of aesthetic characteristics of drinking water. Therefore, iron is a water quality constituent that the GSA plans to continue to monitor in the Basin.

- **Boron** is a naturally occurring element that does not have a Primary or Secondary MCL, but levels exceeding 0.50 mg/L can be detrimental to certain sensitive crops (including oranges and grapes) and thus may discourage farmers from growing those sensitive crops if boron concentrations are too high (Ayers and Westcot, 1985). Boron was detected at levels that may restrict a water's use for irrigation for crops (e.g., above 0.50 mg/L; Ayers and Westcot, 1985) in 13 of the 134 wells (10%) sampled from WY 2015-2019. Boron was detected throughout the central part of the Basin, with the higher concentrations occurring in the western part (**Figure GWC-12**). Because of its potential impacts to agricultural beneficial users the GSA plans to continue to monitor boron in the Basin.

- **Sodium** does not have a Primary or Secondary MCL, but elevated sodium levels can affect soil structure, cause plant toxicity (Ayers and Westcot, 1985), and have poor aesthetic effects on drinking water (i.e., taste) when it exceeds the WQO of 20 mg/L. Elevated sodium levels were observed in almost all wells sampled from WY 2015-2019. Sodium was detected throughout the Basin, with the higher concentrations occurring in the western part (**Figure GWC-12**). Because of its potential impacts to agricultural beneficial users the GSA plans to continue to monitor Sodium in the Basin.

8.5.3. Water Quality Trends

Available concentration data for potential COCs and some additional constituents (e.g., TDS and sodium) were evaluated with respect to changes over time, and in relation to groundwater levels. Available chemographs (plots of concentration versus time) and hydrographs are presented in ***Appendix F.*** A Mann-Kendall trend analysis was performed on wells with at least four water quality measurements between 1995 and 2018 to determine whether concentrations exhibited a statistically significant trend. For the purpose of this analysis, a trend identified from the Mann-Kendall test with p-value less than or equal to 0.05 is considered to be significant. Most wells had very limited well water sample data and in general, those that had at least four samples did not exhibit significant concentration trends. **Table GWC-5** below summarizes the number of wells exhibiting statistically significant trends for each COC.

Table GWC-5. Wells with Significant Water Quality Trends, 1995-2018

Constituent of Concern	Total Number of Wells[(a)]	Number of Wells with Decreasing Trend	Number of Wells with Increasing Trend
Arsenic	17	2	0
Nitrate as N	56	4	8
Selenium	16	0	0
TDS	46	1	5
Sulfate	34	0	4
Iron	20	1	1
Manganese	15	0	0
Boron	30	0	0
Sodium	38	0	0
Chromium	10	0	0
Total	282	8	18

Notes:
(a) Wells with at least four water quality measurements between 1995 and 2018.

Well-water sample results and concurrent water level data are limited. In the DMS, only 16 Basin wells have four or more concurrent annual water quality and water level data points as part of their record. Twelve of these 16 wells are irrigation wells, three are monitoring wells, and one is an unknown use type. Most of these wells are part of the California Statewide Groundwater Elevation Monitoring (CASGEM) monitoring and reporting program, including five wells classified as CASGEM wells and ten wells classified as voluntary wells. Thus, these 15 wells have been sampled more frequently and have sufficient concurrent groundwater levels and water quality data for statistical cross-correlation analyses. The correlation results are summarized in ***Appendix G***. Only three of the 16 wells (all irrigation wells) show statistically significant relationships between concentration and groundwater elevation for at least one constituent:

- Samples from one well show a positive relationship between TDS concentrations and groundwater levels, whereby TDS concentrations increase as water levels increase (approximately 2.14 mg/L increase per foot of water level increase).
- Samples from one well show positive relationships between sodium and TDS concentrations and groundwater levels, whereby sodium and TDS concentrations increase as water levels increase (approximately 1.29 and 12.2 mg/L increase per foot of water level increase, respectively).
- Samples from one well show inverse relationships between sodium, nitrate as nitrogen and TDS concentrations and groundwater levels, whereby sodium, nitrate as nitrogen and TDS concentrations decrease as water levels increase (approximately 0.378, 0.451 and 5.92 mg/L decrease per foot of water level increase).

The limited spatial extent and temporal frequency of concurrent water level and water quality data limit the applicability of these statistical results to Basin-wide conditions and the potential nexus between water quality, a GSA's groundwater management actions, and possible future changes owing to GSP implementation (for example, changes in well extractions, groundwater elevations, and storage). As discussed in ***Section 17 Monitoring Network***, future monitoring efforts will include routine collection of water level and quality data, and such data and any associated trends will be evaluated in future reporting and GSP updates. As discussed in ***Section 16 Action Plan Related to Minimum Threshold Exceedances***, if the groundwater quality worsens during GSP implementation, the GSA intends to increase monitoring frequency and re-evaluate statistically significant trends in an effort to determine possible causative links between water quality degradation and GSA groundwater management activities.

8.5.4. Point-Source Contamination Sites

In addition to the relatively widespread non-point source groundwater quality constituents of concern, there are a small number of point-source contamination sites within the Basin, as identified on the SWRCB GeoTracker website[39]. These sites, shown on **Figure GWC-13**, are typically associated with certain industrial or commercial land uses (e.g., gas stations). There are eight closed and inactive Leaking Underground Storage Tank (LUST) sites within the Basin. The identified contaminants of concern at all sites were petroleum hydrocarbons, and soil was the media of concern, as identified on GeoTracker. Given the lack of open sites and the fact that the depth to groundwater is generally hundreds of feet below the land surface, the threat to groundwater from these sites is likely negligible.

8.5.5. Oil Field Injection Wells and Produced Water Ponds

As described in ***Section 7.1.3 Bottom of the Basin***, there are eight oil fields within the Basin – Comanche Point, Tejon Hills, Tejon Flats (Abd), Tejon, North Tejon, Wheeler Ridge, Pleito, and Valpredo. **Figure GWC-14** shows the locations of active underground injection wells and produced water ponds used for oil field operations in these areas. In total there are 31 active injection wells and no currently active produced

[39] http://geotracker.waterboards.ca.gov

water ponds within the Basin, although there is one "open" pond within the Tejon Oil Field.

Underground injection wells used to dispose of wastewater from oil and gas development are regulated in California by USEPA, CalGEM, and SWRCB (see California Health and Safety Code § 25159.10 et seq.) As described in ***Section 7.1.3 Bottom of the Basin***, injection wells within the Tejon Oil Field inject wastewater into the Upper Miocene marine shelf sandstone Transition Zone, which is classified as an "Exempted Aquifer," per SWRCB approval on 8 February 2017.

Produced water discharges to ponds are under the purview of SWRCB and the Central Valley Regional Water Quality Control Board (CVRWQCB) regulatory oversight and are subject to regulation under individual and general Waste Discharge Requirements (WDRs) amongst other requirements to ensure adequate protection against impacts to underlying groundwater resources. Pursuant to Senate Bill 4 (2013), the SWRCB established a Regional Groundwater Monitoring Program[40] to assess the potential effects on groundwater resources of well stimulation activities in oil and gas producing areas.

8.6. Land Subsidence

> *§ 354.16. Groundwater Conditions*
> *(e) The extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the Department, as specified in Section 353.2, or the best available information.*

To the north of the Basin, the Kern County Subbasin has a documented history of subsidence, including historical and recent subsidence in the southern portion of the subbasin, south of the Kern River (Lofgren, 1975; DWR, 2014). Subsidence in this area is caused primarily due to withdrawal of groundwater, with some areas also affected by hydrocompaction (Lofgren, 1975). By contrast, the Basin has experienced only minor land subsidence. **Figure GWC-15** depicts maps of historical (1949-2005) and recent (2015-2016) subsidence, both of which are discussed below.

8.6.1. Historical Subsidence

Widespread land subsidence was first recognized in the region directly north of the WWF (in the Kern County Subbasin) in 1953, following the 1952 Arvin-Tehachapi earthquake. The Basin was upwarped as a result of the earthquake, but land subsidence in the valley alluvium north of the WWF was attributed principally to the extensive decline in groundwater levels, rather than tectonic activity (Lofgren, 1963). Substantial land subsidence occurred over an area of nearly 500,000 acres north of the WWF, with maximum subsidence of nine ft (Lofgren, 1975). Subsidence was generally moderate until water levels declined more than 100 ft. Although some land subsidence has occurred in the northern portion of the Basin, it has been modest relative to subsidence experienced north of the WWF. Over the period 1959 to 1962, water-level decline contributed to up to 1.5 ft of subsidence north of the WWF, whereas subsidence south of the WWF was less than 0.15 ft (Lofgren, 1975).

[40] https://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/regional_monitoring/

The DWR's assessment of subsidence in California similarly recognized that little subsidence occurred in the Basin between 1949 and 2005 (DWR, 2014)[41]. The stabilization and steady recovery in water levels over the past forty years has reduced the immediate threat of subsidence in the Basin. Provided that water levels remain higher than levels observed in the 1970s, subsidence-related problems within the Basin are not a concern (WRMWSD, 2007).

8.6.2. Recent Subsidence

A small degree of subsidence due to water level decline has occurred in recent times of groundwater level decline associated with dry climatic conditions; between May 2015 and September 2016 a region in the northwest portion of the Basin along the WWF, experienced between one and four inches of subsidence (see **Figure GWC-15**; based on California Institute of Technology, 2016). The occurrence of recent subsidence during a time when groundwater levels are not necessarily below their historic minima demonstrates that subsidence can continue to occur even after water levels are partially recovered. This recent subsidence may be elastic or inelastic subsidence resulting from the temporally-lagged, continued slow depressurization of compactable fine-grained materials (Lofgren, 1975). The amount of recent subsidence observed with the Basin is also within the range of possible error in subsidence measurement methods using remote sensing (i.e., on the order of 0.25 to 4 inches [California Institute of Technology, 2016; personal communication, Michelle Sneed, USGS, 2018]). The most recent interferometric synthetic aperture radar (InSAR) map covering periods through October 2020 shows less than 0.1 inches of subsidence throughout the Basin (TRE Altamira, 2021)

There are two continuous subsidence monitoring sites located along the California Aqueduct at the margins of the Basin (see **Figure GWC-15**). Site WGPP is in the western part of the Basin near where the California Aqueduct enters the Basin. At this site about 1.4 inches of subsidence was measured between 1999 and mid-2021. Site EDPP is in the southern part of the Basin near the A.D. Edmonston Pumping Plant and about 1.6 inches of uplift was measured between 2000 and mid-2021. Neither of these sites are located in the central part of the Basin where groundwater pumping occurs.

DWR has also documented subsidence of the California Aqueduct by milepost with a baseline ground surface elevation in the 1960s to 1970s[42] (DWR, 2017a). Approximately 14 miles of the California Aqueduct runs through the Basin. Along this section of the Aqueduct, DWR monitors 34 sites, from approximately Milepost 278.93 to Milepost 293.39. Measured values for these survey benchmark locations show an average of approximately 2.8 inches of subsidence from the baseline through 2019 with the maximum subsidence that was observed was approximately 1 foot at Milepost 282.00. In recent annual surveys (2016 through 2019), the measured annual subsidence rates average approximately 0.2 inches per year[43].

[41] Areas of significant subsidence at the margins of the Basin shown on **Figure GWC-15** (b) are likely the result of erroneous data/noise at the edges of the map produced by DWR.
[42] Most of the sites were initially surveyed in the 1960s to 1970s. Within the Basin, there are three sites with more recent initial surveys in 1981, 1993, and 2000.
[43] Data received from DWR in response to Public Records Request, 22 July 2019.

8.7. Interconnected Surface Water Systems

> *§ 354.16. Groundwater Conditions*
> *(f) Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from the Department, as specified in Section 353.2, or the best available information.*

Interconnected surface water is defined in 23-CCR §354(o) as "*surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted.*" Measured groundwater levels and streamflow are fundamental data required to characterize the nature and occurrence of interconnected surface water. Specifically, maps showing depth to groundwater can identify areas where saturated and unsaturated conditions might exist beneath a surface water body, and streamflow gains (seepage from groundwater) or losses (leakage to groundwater) can be identified from measured changes in flow between two points along a stream or river. As discussed above, groundwater levels in the Principal Aquifer are far below the land surface within most of the Basin (**Figure GWC-4**), and therefore there is no interconnected surface water throughout most of the Basin.

Furthermore, the definition of interconnected surface water requires that the surface water feature not be completely depleted (i.e., not dry). As shown on **Figure GWC-16**, a total of ten named streams flow from the surrounding highlands into the Basin. From the northeast and progressing clockwise around the perimeter of the Basin, these streams are Comanche Creek, Tejon Creek, Chanac Creek, El Paso Creek, Tunis Creek, Pastoria Creek, LiveOak Creek, Grapevine Creek, Tecuya Creek, and Salt Creek. El Paso Creek, Tecuya Creek, and Tejon Creek extend from the foothills through the main Basin valley floor. While infrequent large storm events in the Basin can occur and cause localized short-duration flooding (e.g., in 2017), for the most part the creeks flow only intermittently.

With the exception of upstream reaches, El Paso Creek is ephemeral and mostly dry with infrequent stream flows caused by storm or irrigation runoff (Provost & Pritchard, 2015). The El Paso Creek monitoring site associated with the Irrigated Lands Regulatory Program (ILRP) (**Figure GWC-16**) has been primarily dry from 2010 through 2017, with only two measured flow events, one measuring less than 5 cubic feet per second (cfs) during March 2011 (California Environmental Data Exchange Network [CEDEN], 2018) and the other measuring 1.3 cfs during January 2017 (Provost & Pritchard, 2016, 2017, & 2018b). Other streams within the Basin are similarly primarily ephemeral and behave similarly to El Paso Creek (Provost & Pritchard, 2015). WRMWSD installed gauging stations on Salt Creek and Tecuya Creek in 2018 (**Figure GWC-16**) (WRMWSD, 2018), although no flow records are currently available.

Notably, the Nature Conservancy (TNC) has a web mapping application that categorizes rivers and streams in the Central Valley on the likelihood that they are interconnected surface water.[44] The streams in the portion of the Basin shown on this map are all designated as "likely disconnected". Therefore, due to the deep groundwater levels and the typically dry nature of the existing streams, depletion of interconnected

[44] https://icons.codefornature.org/

surface water is not considered to be an issue in the Basin. One potential exception is an area near the Springs Fault as discussed above in ***Section 7.3 Physical Characteristics.*** There is evidence in this area of spring flow that appears to be caused by groundwater backing up and rising to the ground surface on the south side of the Springs Fault. This area is upslope of the developed part of the Basin and there is little groundwater pumping on the upgradient side of the fault (see **Figure GWC-16**). Furthermore, based on the available data (see ***Appendix D***), water level data installed in co-located shallow monitoring wells show no impact from groundwater production from the Principal Aquifer. This suggests that this area is hydraulically disconnected from, and at a minimum should be managed separately from, the Principal Aquifer.

As discussed in ***Section 16 Action Plan Related to Minimum Threshold Exceedances,*** if water levels significantly decline during GSP implementation leading to a reduction in GDE health, the GSA intends to re-evaluate statistically significant trends in an effort to determine possible causative links between decreasing water levels in the Principal Aquifer and water levels in the RMW-ISWs as a result of SGMA-related groundwater management activities.

8.8. Groundwater Dependent Ecosystems (GDEs)

> *§ 354.16. Groundwater Conditions*
> *(g) Identification of groundwater dependent ecosystems within the basin, utilizing data available from the Department, as specified in Section 353.2, or the best available information.*

GDEs are defined in the 23-CCR §351(m) as "*ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface.*" DWR and The Nature Conservancy (TNC) have developed a map of "Natural Communities Commonly Associated with Groundwater" (NCCAG) for use by GSAs in identifying potential GDEs. The NCCAG dataset was used in conjunction with depth to water information, both contours and point measurements at wells, to identify potential GDEs in the Basin. Then, a more detailed study and filed investigation was conducted to confirm the nature and presence of any GDEs.

8.8.1. Initial GDE Screening Process

Figure GWC-17a shows the potential GDEs in the Basin identified in the NCCAG shapefiles produced by TNC and DWR. These areas are primarily riparian communities (i.e., located along the channels of existing streams).

In recognition of TNC's guidance document entitled "*Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act Guidance for Preparing Groundwater Sustainability Plans*", and as described in detail in ***Appendix H***, the White Wolf GSA has determined that natural communities located where the depth to water (i.e., inferred from available water level data or contours) is greater than 30 ft bgs and within 3.1 miles of a well with a depth to water measurement greater than 30 ft bgs are considered disconnected from the Principal Aquifer (TNC, 2018a). As shown on **Figure GWC-17**, groundwater levels in the Principal Aquifer and in areas where these vegetation, wetlands, and streams have been identified are greater than 200 ft bgs with the exception of one area in the southern central portion of the Basin, where groundwater levels are between about 50 and 200 ft bgs. However, these relatively shallow water levels are measured in deep-screened wells and likely do not represent the depth to the water table (i.e., they rather reflect the potentiometric head surface). Additionally, as described above, the stability of groundwater levels in the Basin suggests that groundwater conditions have not negatively impacted vegetation, wetlands, and streams.

Table GWC-6 below summarizes the potential GDEs mapped in **Figure GWC-17** and reports their maximum plant rooting depths, as compiled by TNC.[45] Reported maximum rooting depths in the Basin range from 0.4 to 24 ft. Given their relatively shallow rooting depth, these vegetation communities (i.e., mostly areas of cottonwood, tamarisk, and valley oak) are likely not dependent on groundwater from the Principal Aquifer system, but rather may derive necessary moisture from perched groundwater and/or relatively shallow, wet, water-retentive soils disconnected from and far above the Principal Aquifer.

Table GWC-6. Maximum Plant Rooting Depths for Potential GDEs (TNC, 2018b)

Potential GDE		**Maximum Rooting Depth (ft)**[(a)]
Scientific Name/NCCAG Category	**Common Name**	
Anemopsis californica	Yerba Mansa	0.4
Atriplex lentiformis	Quailbush	--
Baccharis salicifolia	Mule fat	2
California Warm Temperate Marsh/Seep	Not applicable	--
Fremont Cottonwood	Fremont Cottonwood	1 to 7
Isocoma acradenia	Alkali Goldenbush	--
Lepidospartum squamatum	Scalebroom	--
Platanus racemosa	California Sycamore	9[(b)]
Populus fremontii	Fremont Cottonwood	1 to 7
Quercus lobata	Valley Oak	24[(c)]
Riparian Introduced Scrub	Not applicable	--
Riparian Mixed Hardwood	Not applicable	--
Salix gooddingii	Goodding's Willow	7
Salix laevigata	Red Willow	--
Sambucus nigra	Common Elderberry	--
Sporobolus airoides	Alkali Sacaton	--
Tamarix spp.	Tamarisk	16
Vitis californica - provisional	California Grape	--
Willow	Willow	3
Willow (Shrub)	Willow	3

[45] https://groundwaterresourcehub.org/sgma-tools/gde-rooting-depths-database-for-gdes

Notes:
(a) Maximum rooting depth was not available for all potential GDEs, signified by a “--".
(b) Rooting depth based on similar species.
(c) Rooting depths for Valley Oak can be up to 80 feet in fractured rock environments (TNC, 2021), however the soil texture observed near Valley Oak in the Basin was cobbly alluvium. Moreover, the presence of Valley Oak is predominantly near surface water features. The shallower rooting depth tabulated by TNC (2018) is therefore conservatively used compared to the deeper rooting depth tabulated by TNC (2021).

Sources:
1. TNC, 2018, https://groundwaterresourcehub.org/sgma-tools/gde-rooting-depths-database-for-gdes [database], dated 19 April 2018.
2. TNC, 2021, https://groundwaterresourcehub.org/sgma-tools/gde-rooting-depths-database-for-gdes [database], dated 25 May 2021.

For the purposes of this GSP, based on the above and TNC’s *Best Practices for using the NC Dataset* (TNC, 2019), potential GDEs identified in the NCCAG dataset were removed where depth to groundwater measurements are deeper than 50 ft bgs measured in wells located within 3 miles of the potential GDEs (see **Figure GWC-17b**). Plant communities located in areas where depth to groundwater is at or deeper than 50 ft bgs (i.e., double the maximum rooting depths for Basin GDEs) are considered to not be dependent upon groundwater from the Principal Aquifer. The remaining 1,000 acres of potential GDEs are located south of the Springs Fault and within the upland areas of the Basin.

8.8.2. GDE Field Investigation and Confirmation Process

Following the screening effort, a field and desktop study of the potential GDEs in the Basin was then undertaken in which over 1,000 acres of potential GDEs were assessed (722 acres were formally assessed in the field). As discussed in ***Appendix H***, the Basin currently supports a diversity of healthy GDEs, particularly in locations upgradient of the Spring Fault.

The Basin contains approximately 880 acres of GDEs, most of which (~91%) are identified in the NCCAG dataset, with an additional 9% added per field observations and image interpretation. Mapped GDEs include open water, riparian forests and shrublands, wet meadows, and marshes. Common woody riparian species dominating the GDEs are Fremont cottonwood, valley oak, Goodding’s willow, red willow, elderberry, nettle, saltcedar, and seep willow. A total of 33 plant species were mapped during the field assessment (see ***Appendix H*** Table 8 for detailed vegetation types and acreages). Surface water presence and persistence varies by GDE location; however, the TNC maximum rooting depth database indicates that the species mapped in the Basin have rooting depths of 25 feet or less and therefore may be supported either by surface water or shallow groundwater. Only one of the species identified during the field study (i.e., saltcedar) has a rooting depth greater than 25 feet (i.e., 71 feet).

The desktop study entailed using the field assessment to classify and group GDEs. Specifically, each potential GDE was designated with an index associated with moisture class, probable source aquifer, and man-made modifier. Approximately 175 acres of NCCAG potential GDEs were classified as not dominated by phreatophytic/hydrophilic plants and had no visual evidence of surface water or groundwater. Because these areas were determined to not be a GDE they were subsequently removed from the potential GDE dataset.

A total of 881 acres of remaining GDE areas were assessed and classified. ***Appendix H*** Table 3, Table 4, and Table 5 summarize the GDE classification by wetness index class, probable source aquifer, and man-made modifier, respectively and ***Appendix H*** Figure 6 summarizes the full GDE classification schema as reported in Table 2. In general, the majority of the Basin's GDEs are naturally occurring, dominated by phreatophytic trees and shrubs located in areas with no visual evidence of surface water or groundwater or where surface water is suspected to be ephemeral or intermittent. Additionally, approximately half of the Basin's GDEs appear to be associated with a shallow water-bearing zone located upgradient of the Springs Fault. The subsurface structures and conditions that give rise to these shallow groundwater conditions are not well understood, however. The White Wolf GSA is attempting to fill this data gap through installation (in 2021) and monitoring of three new shallow monitoring wells (RMW-ISWs) as further described in ***Section 17.1.6 Monitoring Network for Depletions of Interconnected Surface Water***.

Figure GWC-18 shows the 435 acres of GDEs of interest for the purposes of this GSP, which are those characterized as "*site appears to be supported by a shallow water-bearing zone upgradient of the Springs Fault*" (classification "B") or "*site appears to be supported by the regional aquifer*[46]" (classification "R"). Subsequent monitoring has indicated that the GDEs area are likely disconnected from the Principal Aquifer due to hydraulic restrictions caused by the Springs Fault (see ***Section 7.1.4.3 Structural Properties of the Basin that Restrict Groundwater Flow Within the Principal Aquifers*** and ***Appendix D***).

8.8.3. GDE Health Trend Analysis

The GDE Pulse Interactive Map[47] developed by The Nature Conservancy (TNC), which uses remote sensing data from satellites to monitor the health of vegetation, can be used to assess long-term temporal trends of vegetation metrics in the Basin. The vegetation metrics include Normalized Derived Vegetation Index (NDVI) which estimates vegetation greenness and Normalized Derived Moisture Index (NDMI) which estimates vegetation moisture. Both NDVI and NDMI are used to indicate vegetation health for GDEs through their relationship to photosynthetic chlorophyll and moisture, respectively.

As discussed in ***Appendix H***, an overall average Basin-wide assessment of NDVI and NDMI suggests that vegetative greenness (i.e., NDVI) has slightly increased over the past 30 years, while vegetative moisture content (i.e., NDMI) has interannual variability but is generally stable over the past 30 years. Since almost 50% of the Basin's GDEs are supported by a shallow water-bearing zone upgradient of the Springs Fault, this suggests that <u>pumping from the Principal Aquifer has not affected the relative health of the Basin's GDEs</u>.

To explore this relationship in more detail, ***Appendix I*** examines the NDVI and NDMI trends for selected GDE areas of interest upgradient of the Springs Fault compared against the long-term precipitation trends and available depth to groundwater data from the Principal Aquifer. As discussed in ***Appendix I***, over the

[46] For the purposes of this section, regional aquifer is synonymous with Principal Aquifer.
[47] https://gde.codefornature.org/#/map, accessed on 12 October 2020.

past 30 years, NDVI and NDMI trends have generally been mostly stable, with local or short-term declines and increases, and trends generally visually aligning with long-term trends in precipitation. Future depth to water data collected from the newly installed shallow monitoring wells and the supplemental interconnected surface waters monitoring network (see ***Section 17.1.6 Monitoring Network for Depletions of Interconnected Surface Water***) will improve future correlation analyses between depth to groundwater and vegetative metrics.

8.8.4. Other Environmental Users of Groundwater

In addition to vegetation and wetland communities, other environmental users of groundwater include species reliant on interconnected surface water. TNC compiled a list of freshwater species located within each groundwater basin for use by GSAs to evaluate species reliant on surface water.[48] ***Appendix J*** contains the TNC freshwater species list for the Basin. The list includes 138 unique species grouped into three taxonomic groups: birds, herps (i.e., reptiles), and plants. The species on this list, including the special status species listed below, may be present within the Basin as of April 2015. However, additional work supported by wildlife surveys would be needed to confirm their presence.

Species on the Federal Endangered Species list that may be present within the Basin include the following:

- Bird of Conservation Concern: bald eagle and tricolored blackbird
- Threatened: California red-legged frog
- Under review in the candidate or petition process: western spadefoot

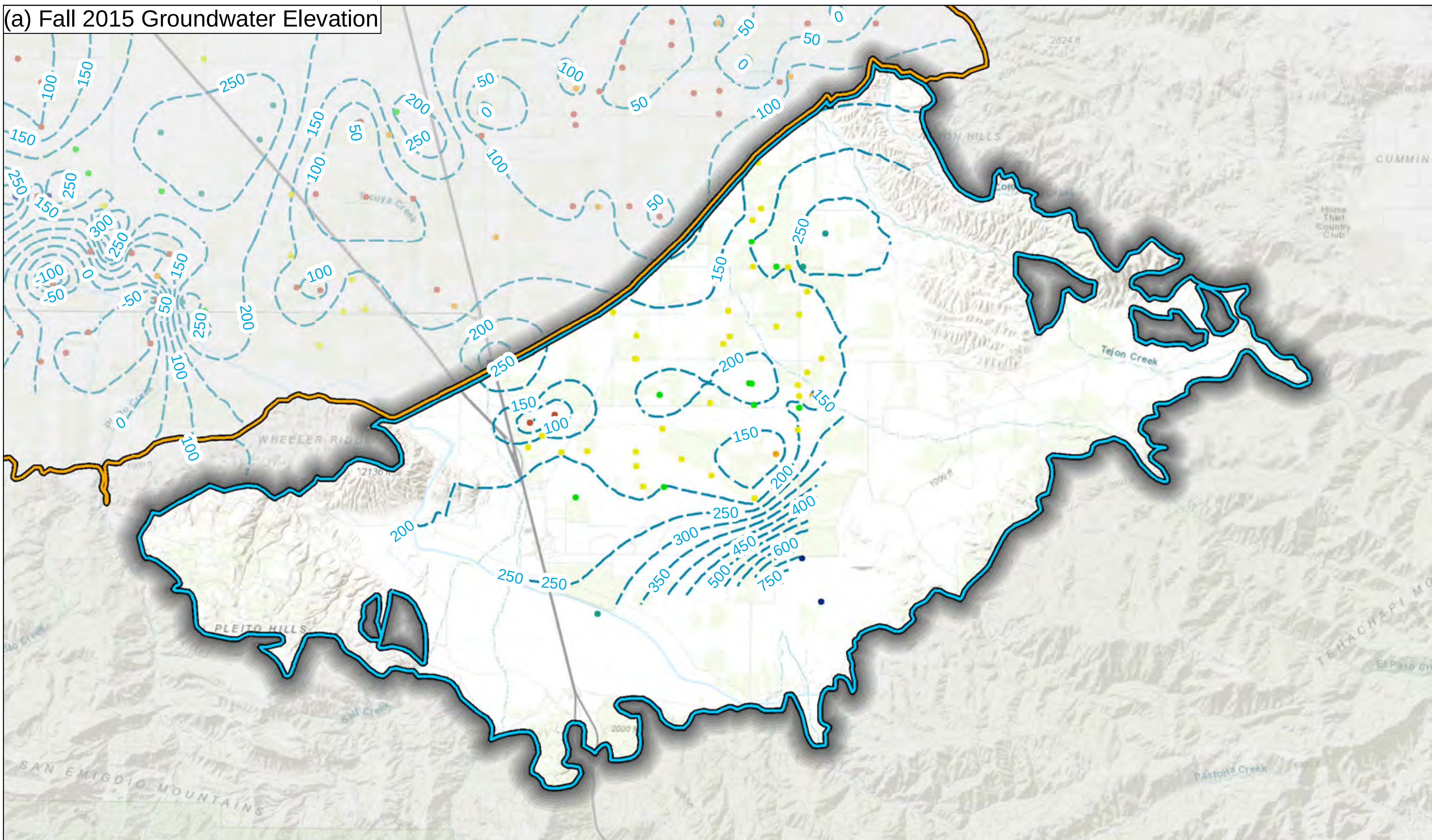
Species on the California Endangered Species or Sensitive Species lists that may be present within the Basin include the following:

- Endangered: bald eagle
- Special Concern: canvasback, redhead, tricolored blackbird, western pond turtle, California red-legged frog, western spadefoot, Mexican mosquito fern, slender sedge, slough thistle, spiny rush, ferris' goldfields, parish's yampah, pringle's yampah, and Rocky Mountain checker-mallow
- Watch List: white-faced ibis

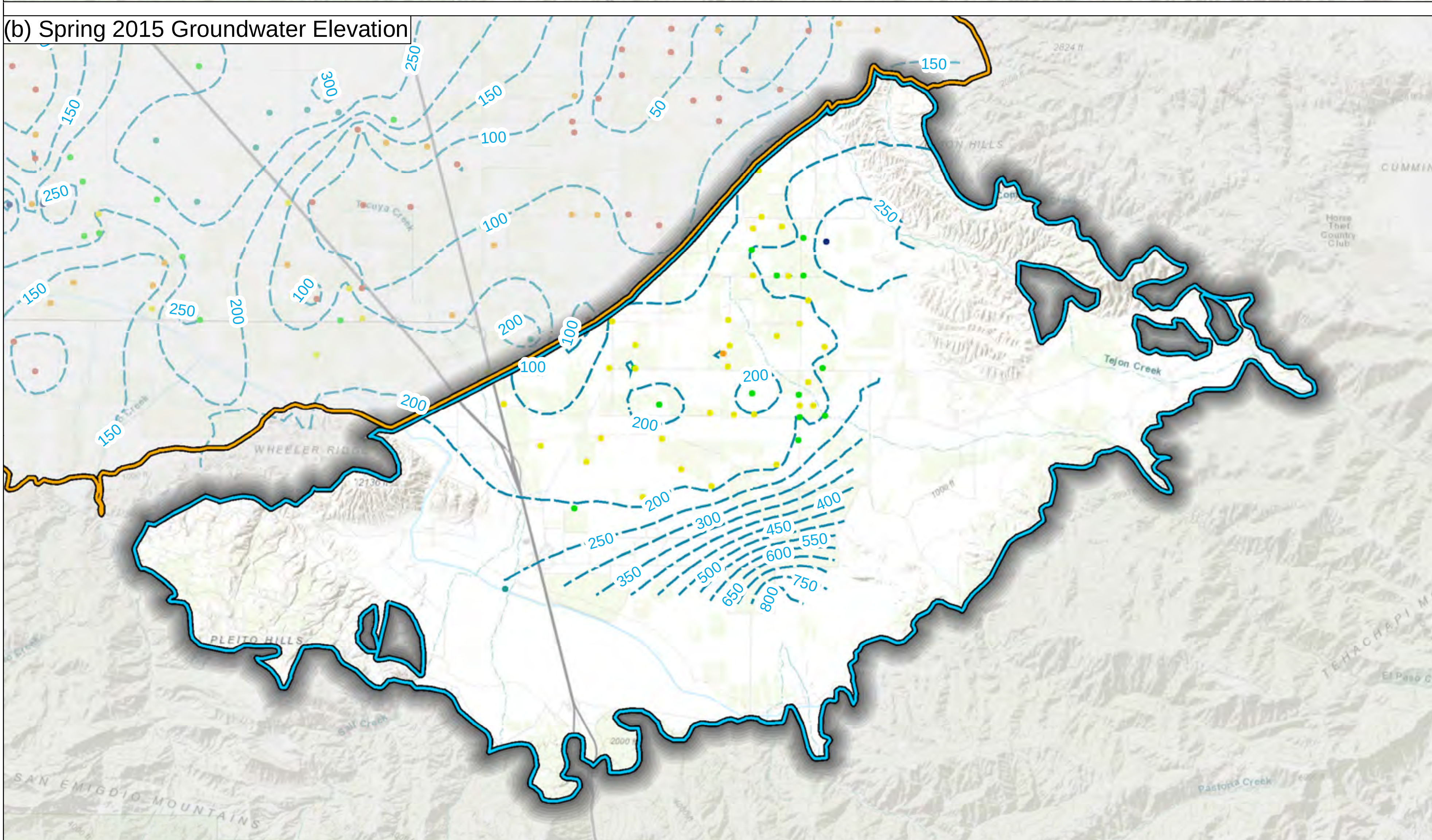
Per TNC data, the above species have the potential to exist within the Basin. However, the presence of these species has not been verified. During the GDE field study, a tricolored blackbird was encountered within the Wind Wolves Preserve (see ***Appendix H***). Although the GDE area in which this bird was observed has been classified as "*a site supported by bedrock springs or shallow alluvium over low permeability sediments or rocks*," and therefore not connected to the Principal Aquifer, it confirms that at least one species of concern is present within the Basin.

[48] https://groundwaterresourcehub.org/sgma-tools/environmental-surface-water-beneficiaries/

(a) Fall 2015 Groundwater Elevation



(b) Spring 2015 Groundwater Elevation



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- 2015 Groundwater Elevation (50 ft interval) (ft msl)

2015 Groundwater Elevation (ft msl)

- < 100
- 100 - 150
- 150 - 200
- 200 - 250
- 250 - 300
- > 300

Abbreviations

DWR = California Department of Water Resources
ft = feet
ft msl = feet above mean sea level

Notes

1. All locations are approximate.
2. Groundwater elevation contours are based on kriged data and are less certain in areas with sparse data.
3. Spring is classified as January 15th to April 15th, while fall is classified as August 15th to November 15th.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 18 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.

N 0 3 6 (Scale in Miles)

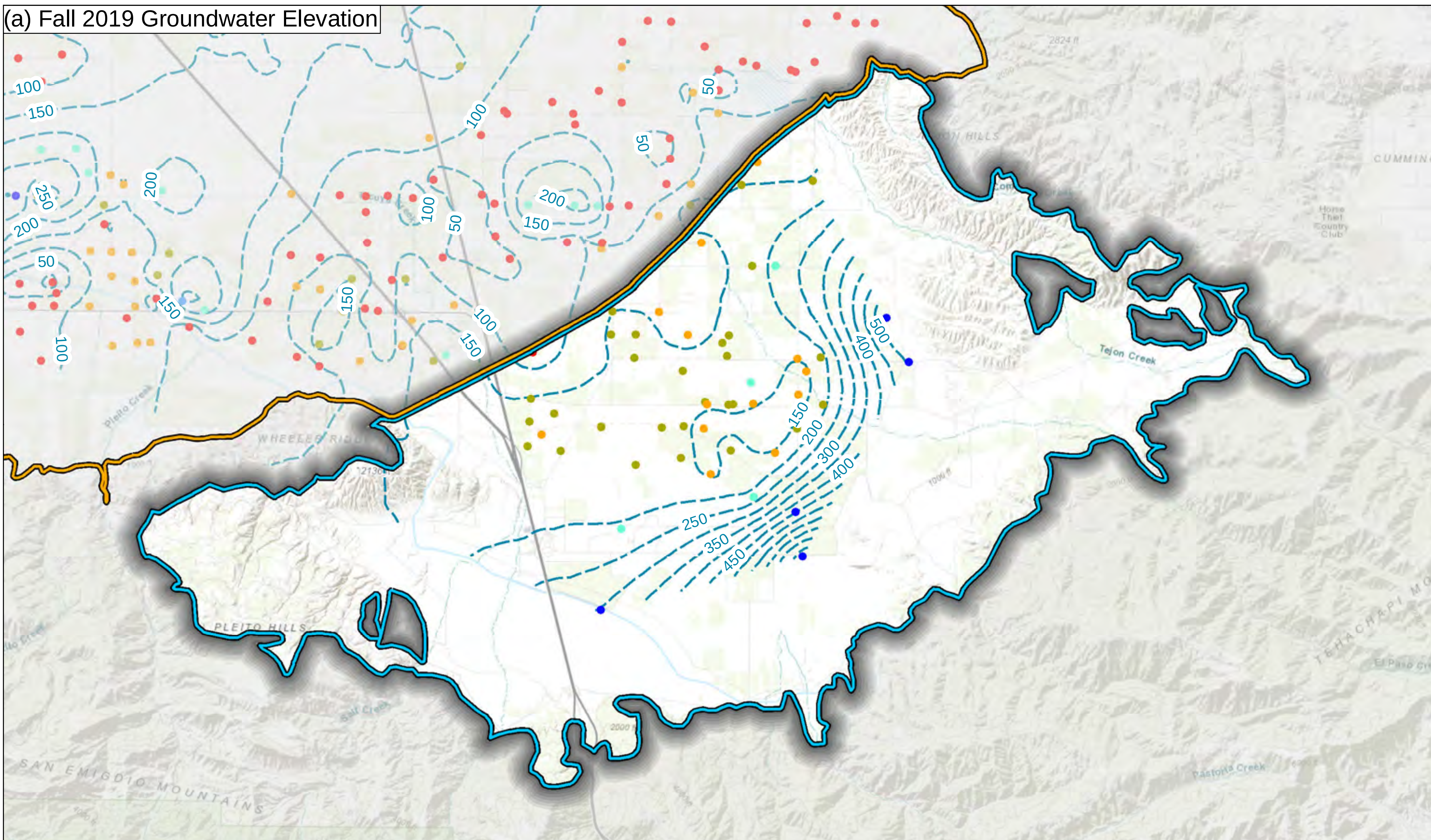
Groundwater Elevations - Fall and Spring 2015

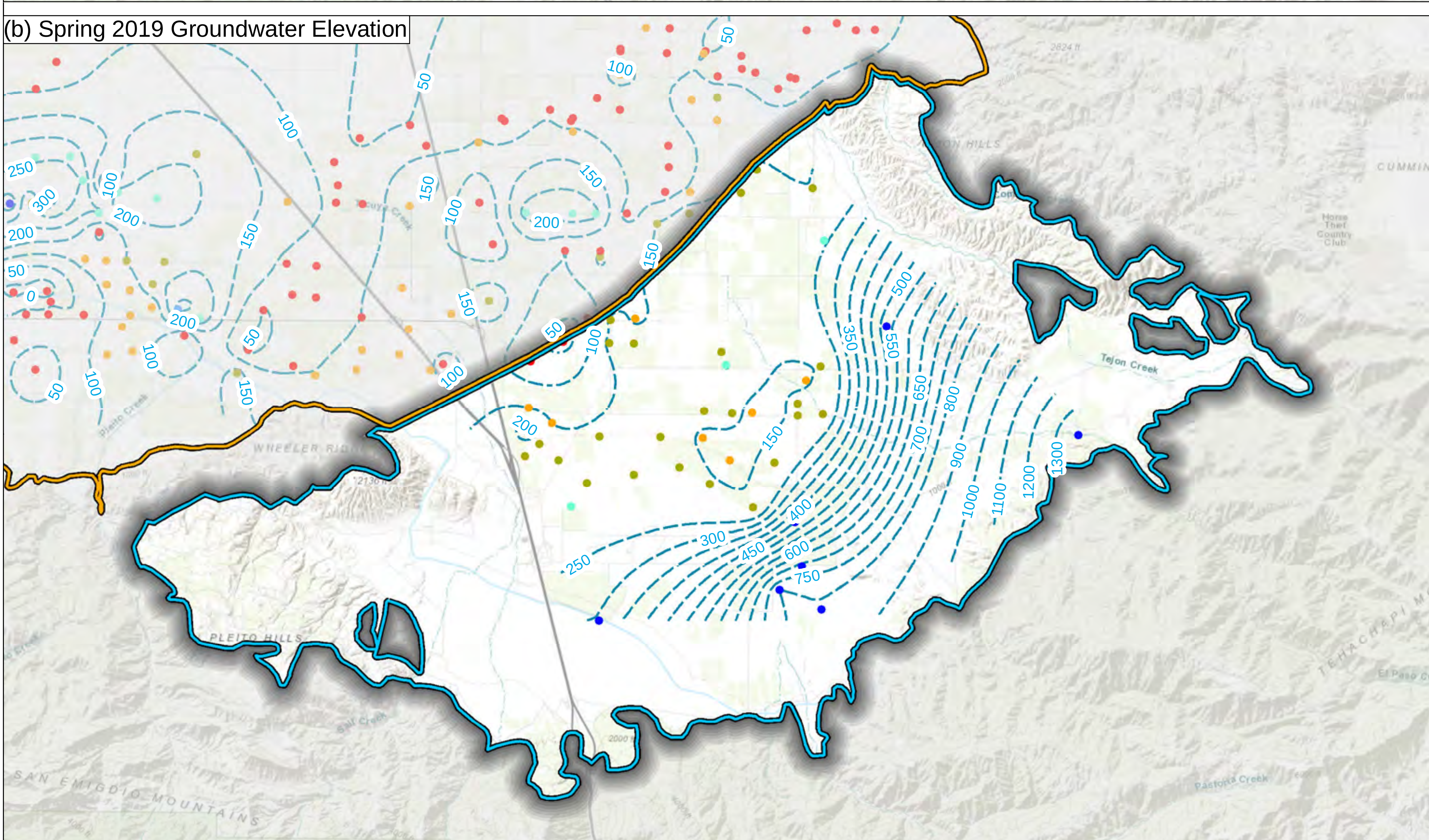
White Wolf GSA
Kern County, CA
December 2021
B50001.05

eki environment & water

Figure GWC-1

Path: X:\B50001.05\Maps\GSP\2022\01\FigGWC-1_GWE 2015.mxd





Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- 2019 Groundwater Elevation (50 ft interval) (ft msl)

2019 Groundwater Elevation (ft msl)

- < 100
- 100 - 150
- 150 - 200
- 200 - 50
- 250 - 300
- > 300

Abbreviations

DWR = California Department of Water Resources
ft = feet
ft msl = feet above mean sea level

Notes

1. All locations are approximate.
2. Groundwater elevation contours are based on kriged data and are less certain in areas with sparse data.
3. Spring is classified as January 15th to April 15th, while fall is classified as August 15th to November 15th.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 18 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.

N

0 3 6
(Scale in Miles)

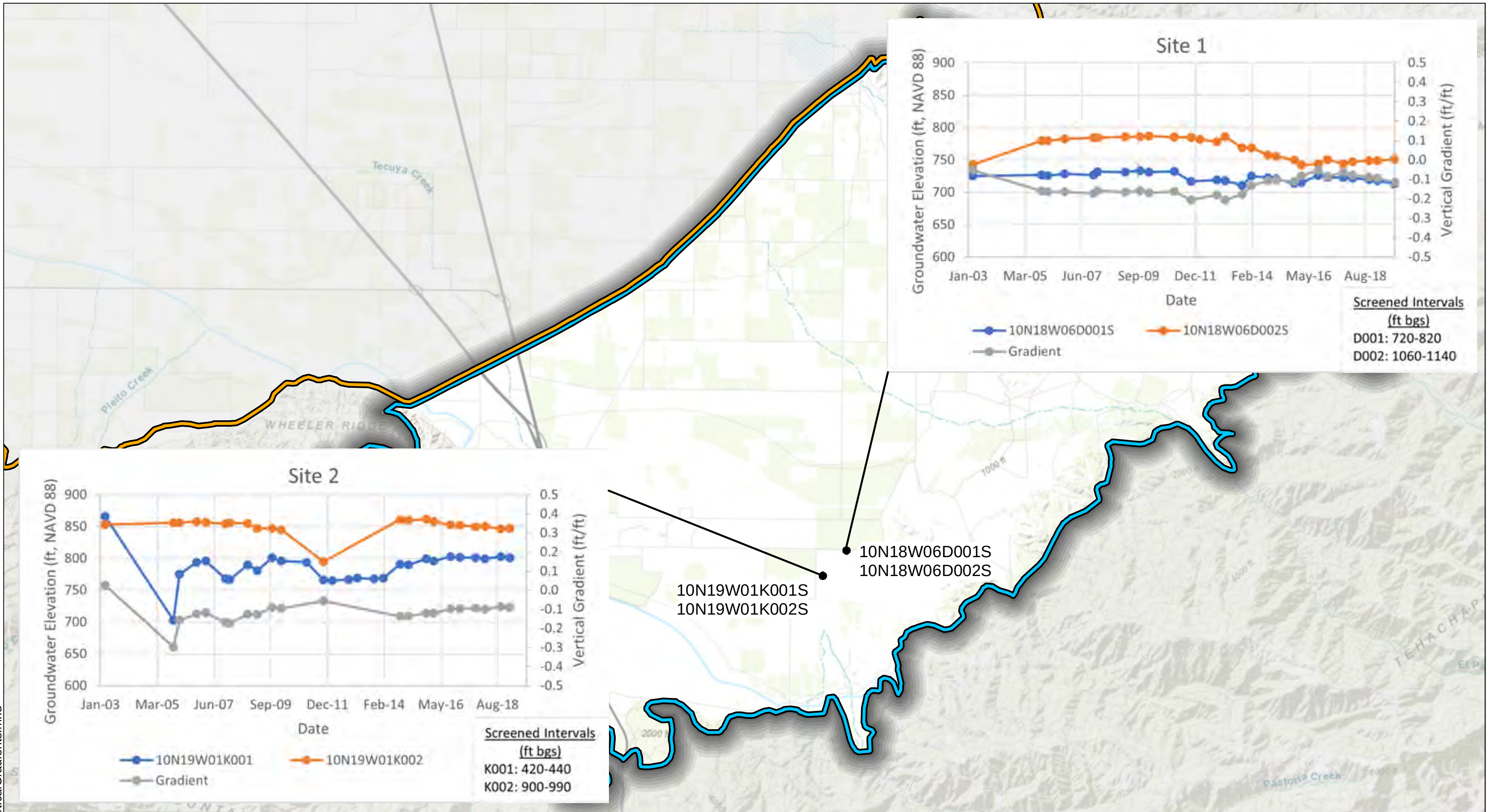
Groundwater Elevations - Fall and Spring 2019

White Wolf GSA
Kern County, CA
December 2021
B50001.05

eki environment & water

Figure GWC-2

Path: X:\B50001.05\Maps\GSP\2022\01\FigGWC-2_GWE 2019.mxd



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

● Multi-Depth Monitoring Well Cluster

Abbreviations

DWR = California Department of Water Resources

ft = feet

ft bgs = feet below ground surface

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 20 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwate Bulletin 118 - Final Prioritization, dated February 2019.

N

0 3 6

(Scale in Miles)

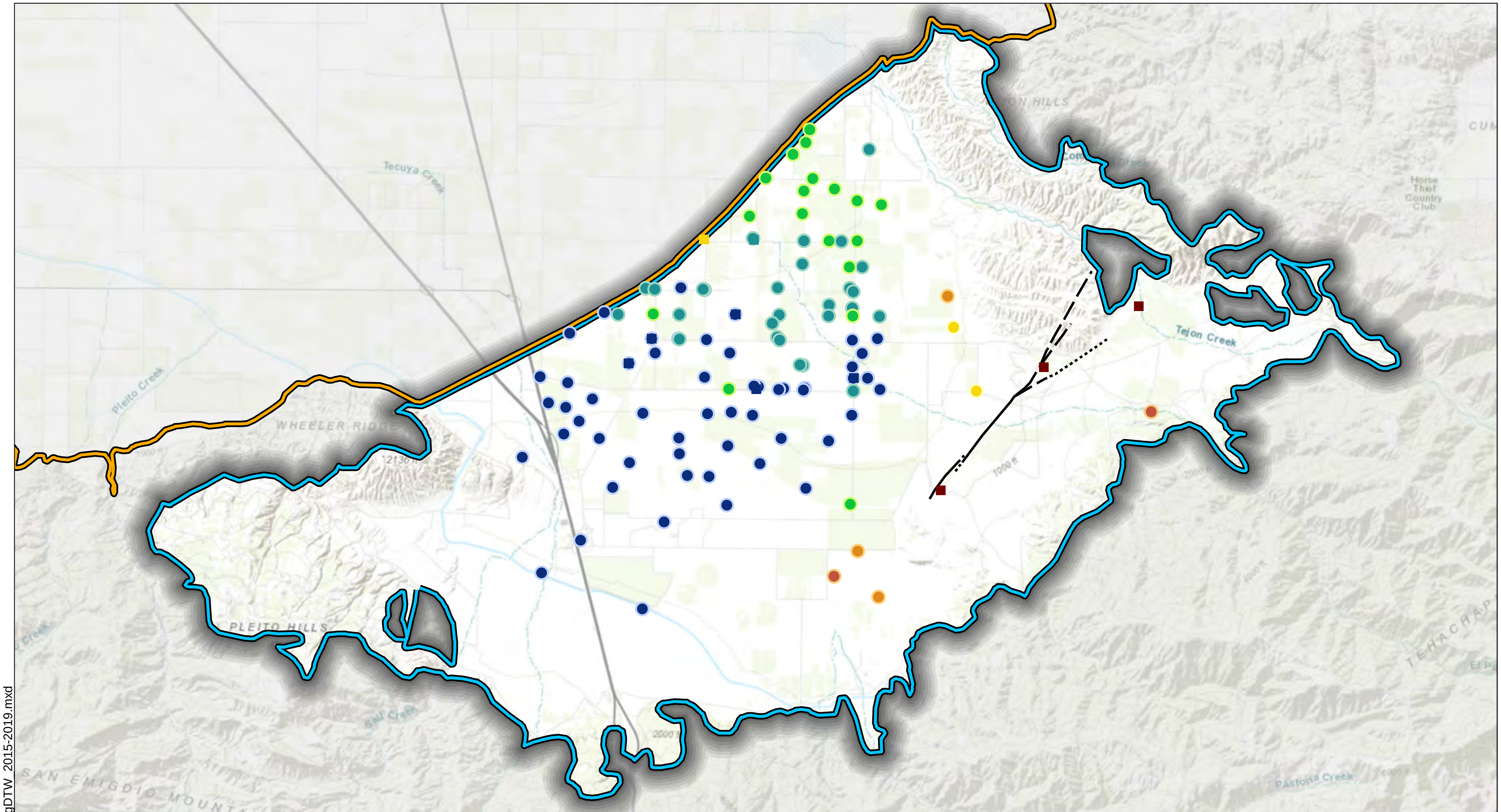
Vertical Gradient Hydrographs

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure GWC-3

Path: X:\B50001.05\Maps\GSP\2022\01\FigGWC-3_VerticalGradients.mxd



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- Springs Fault

Wells with WY 2015-2019 data Average DTW (ft bgs)	Wells with post 2019 data Average DTW (ft bgs)
< 50	< 50
50-100	50-100
100-200	100-200
200-300	200-300
300-400	300-400
400-500	400-500
> 500	> 500

Abbreviations

DTW = Depth to groundwater
DWR = California Department of Water Resources
GDE = Groundwater Dependent Ecosystem
ft bgs = feet below ground surface

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 18 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Springs Fault trace from Bartow, 1984, Geologic Map and Cross Sections of the San Joaquin Valley, California: US Geological Survey Map I-49

N 0 3 6 (Scale in Miles)

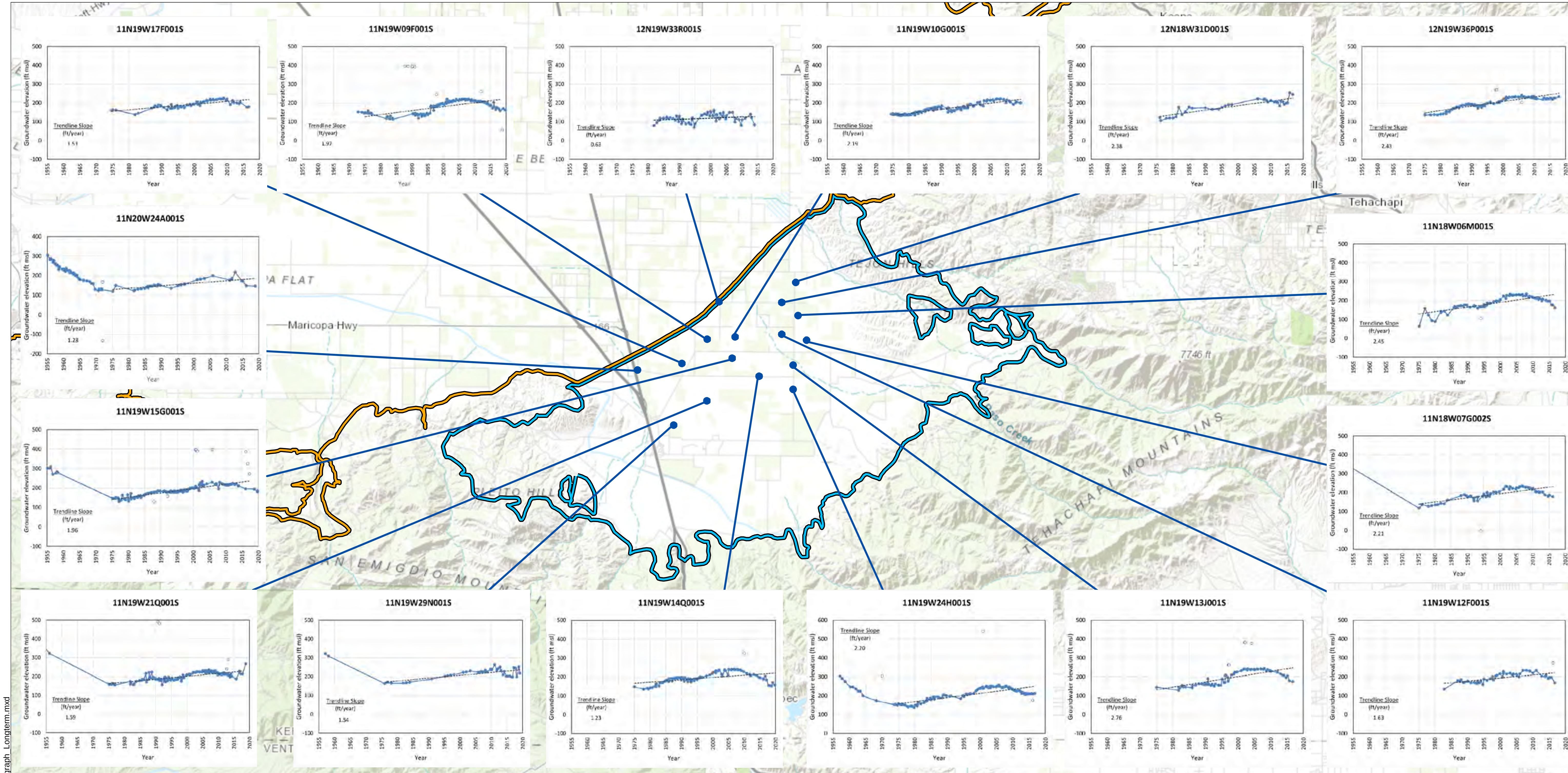
Average Depth to Groundwater - WY 2015-2019

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure GWC-4

Path: X:\B50001.05\Maps\GSP\2022\01\FigGWC-4_AvgDTW_2015-2019.mxd



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

Groundwater Monitoring Well

Groundwater Elevation Measurement

Groundwater Elevation Measurement, Apparent Outlier

Abbreviations

DWR = California Department of Water Resources

ft msl = feet above mean sea level

Notes

1. All locations are approximate.
2. The water level trend was calculating using linear regression on all non-outlier data between 1 January 1975 and 1 August 2018.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 18 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Groundwater elevation data from the White Wolf Data Management System.

N

0 4 8

(Scale in Miles)

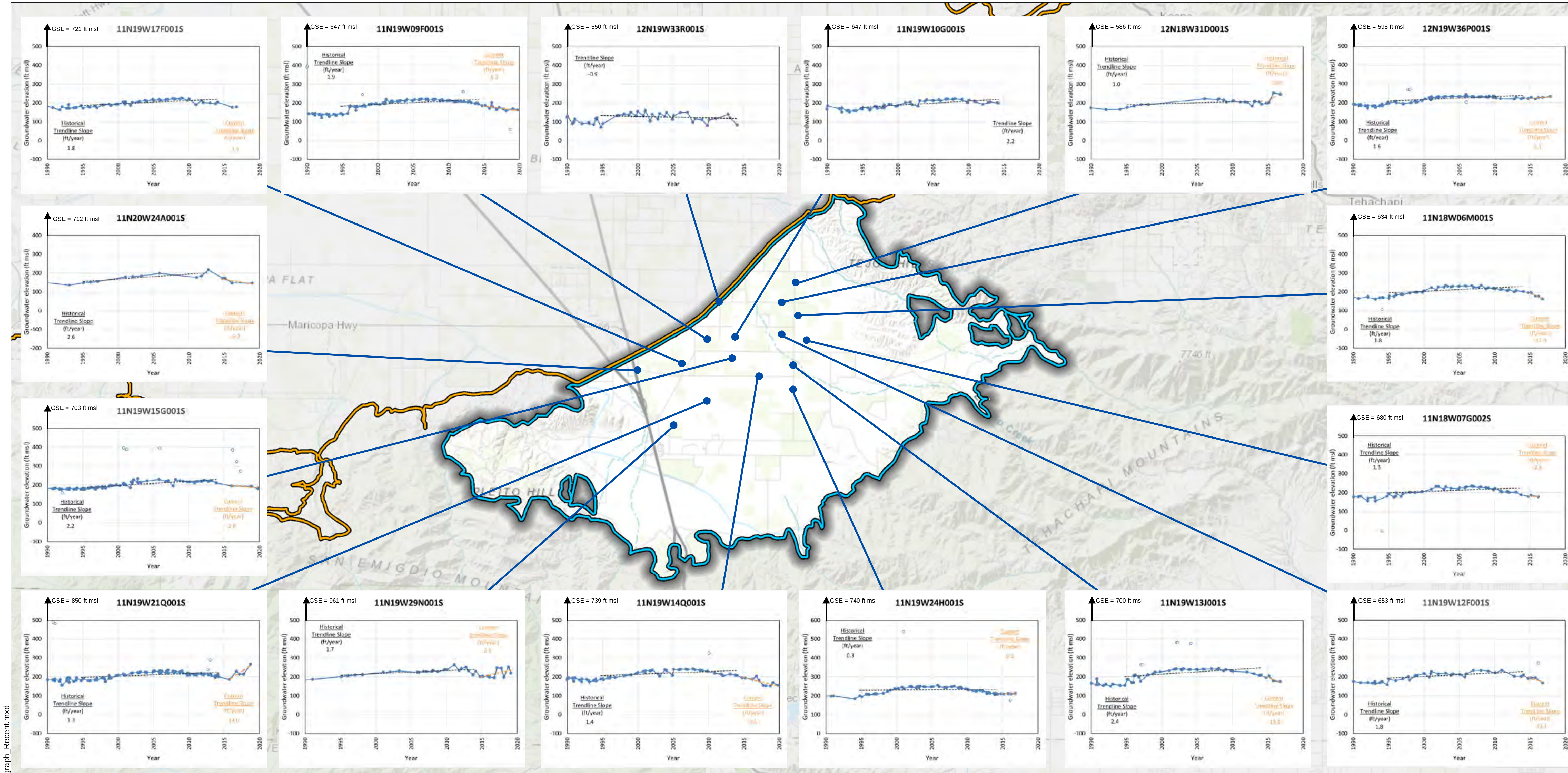
Historical (1955-2019) Groundwater Elevation Hydrographs

eki environment & water

White Wolf GSA
Kern County, CA
December 2021
B50001.05

Figure GWC-5

Path: X:\B50001.05\Maps\GSP\2022\01\FigGWC-5_GWEL_Hydrograph_Longterm.mxd



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

Groundwater Monitoring Well

Groundwater Elevation Measurement

Groundwater Elevation Measurement, Apparent Outlier

Abbreviations

DWR = California Department of Water Resources

ft msl = feet above mean sea level

GSE = ground surface elevation

Notes

1. All locations are approximate.
2. The water level trend was calculating using linear regression on all non-outlier data between 1 October 1994 and 30 September 2015.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 21 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Groundwater elevation data from the White Wolf Data Management System.

N

0 4 8

(Scale in Miles)

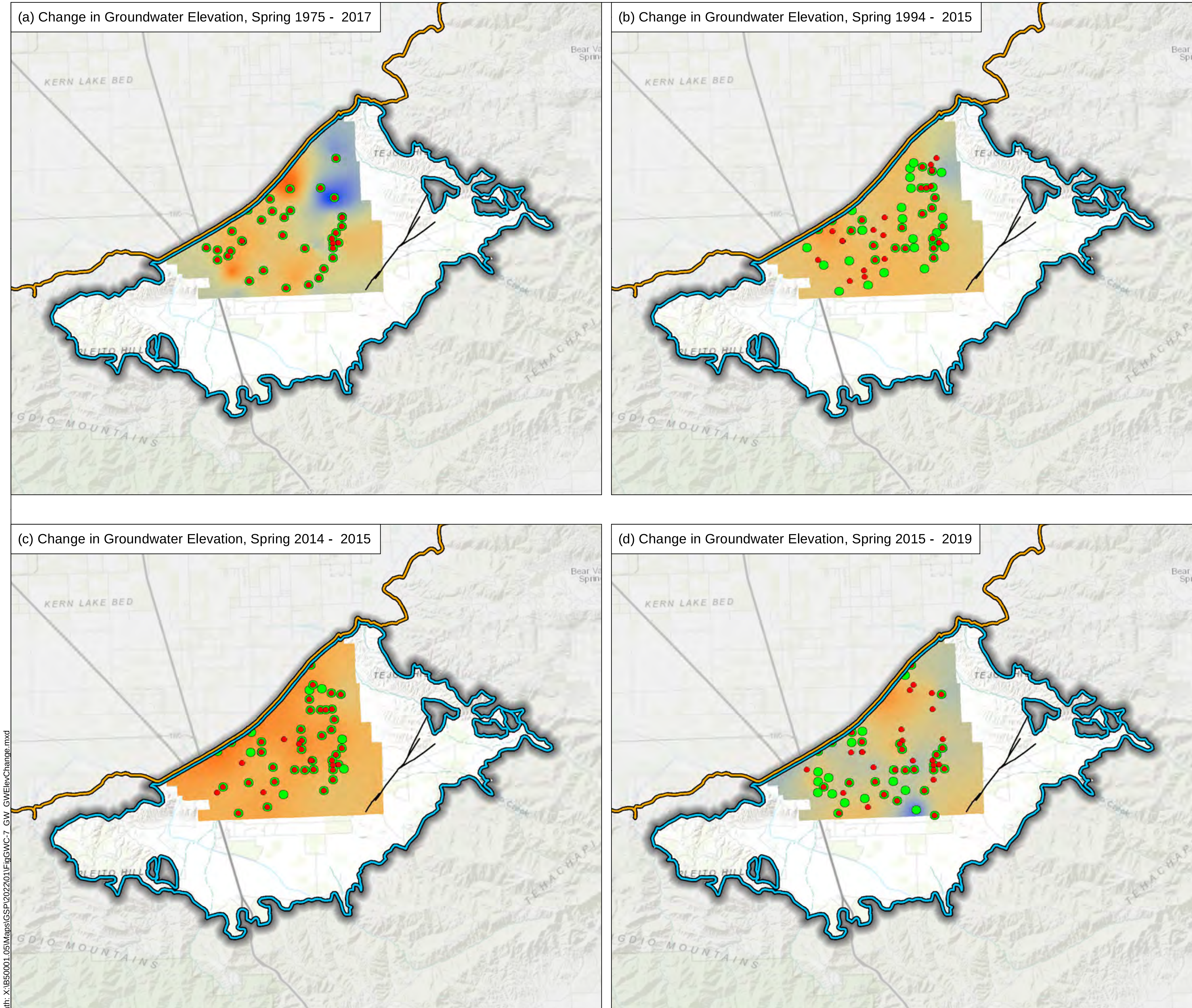
Recent (1994-2019) Groundwater Elevation Hydrographs

eki environment & water

White Wolf GSA
Kern County, CA
December 2021
B50001.05

Figure GWC-6

Path: X:\B50001.05\Maps\GSP\2022\01\FigGWC-6_GWEL_Hydrograph_Recent.mxd



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- Starting Groundwater Elevation Point
- Ending Groundwater Elevation Point
- Springs Fault

Groundwater Elevation Change (ft)

High : 235
200
150
100
50
0
-50
-100
Low : -120

Abbreviations

AEWSD = Arvin-Edison Water Storage District
DWR = California Department of Water Resources
WRMWSD = Wheeler Ridge-Maricopa Water Storage District

Notes

1. All locations are approximate.
2. Groundwater elevation change shown as feet change in each 100 ft by 100 ft cell. Groundwater elevation data were interpolated using kriging for each year, and the difference was calculated using GIS tools.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 20 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Groundwater elevation data provided by AEWSD and WRMWSD.

N

0 5 10
(Scale in Miles)

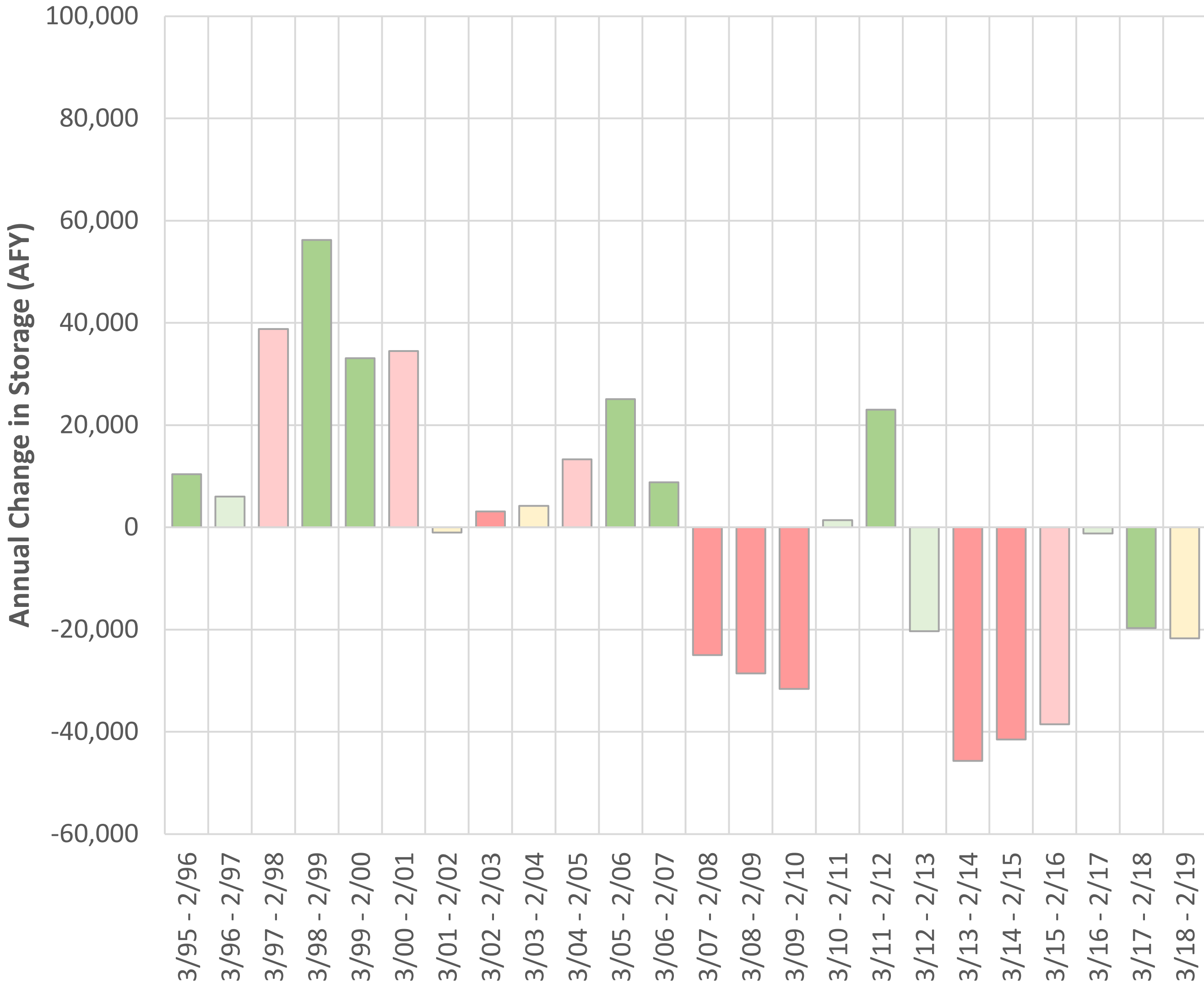
Groundwater Elevation Change 1975-2017, 1994-2015, 2014-2015, and 2015-2019

White Wolf GSA
Kern County, CA
December 2021
B50001.05

eki environment & water

Figure GWC-7

Path: X:\B50001.05\Maps\GSP\2022\01\FigGWC-7_GW_GWElevChange.mxd



Legend

DWR Water Year Type

- Wet
- Above Normal
- Below Normal
- Dry
- Critical

Abbreviations

AFY = acre-feet per year
DWR = California Department of Water Resources

Notes

1. "Seasonal high" condition is defined as March - February of the following year.
2. The color of each bar is based on the DWR Water Year type which year falls within the period.

Sources

1. DWR Water Year type from (DWR, 2021).
2. Change in storage estimated by the White Wolf Groundwater Flow Model.

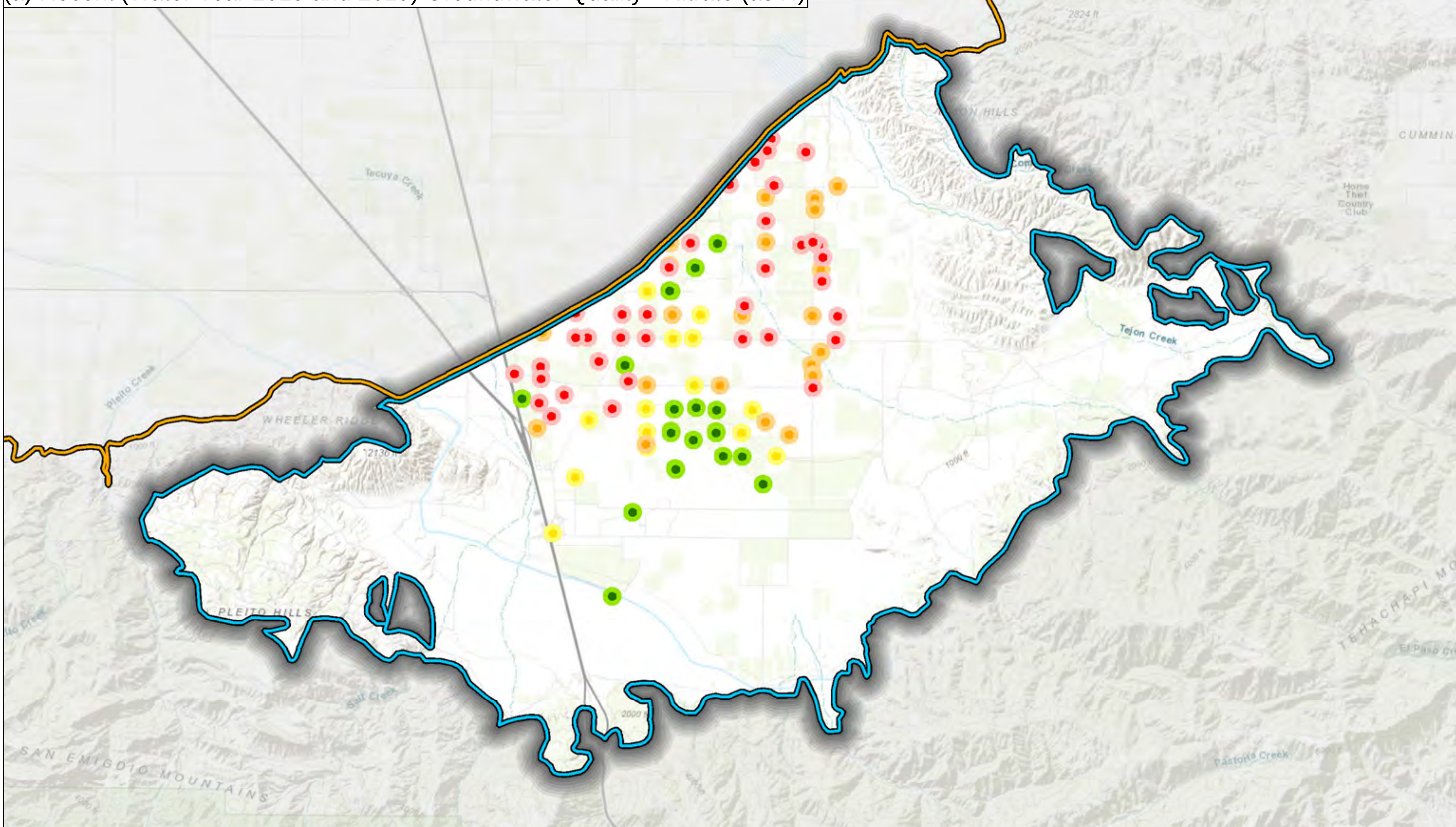
Annual Change in Storage Between Seasonal Highs vs. DWR Water Year Type

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

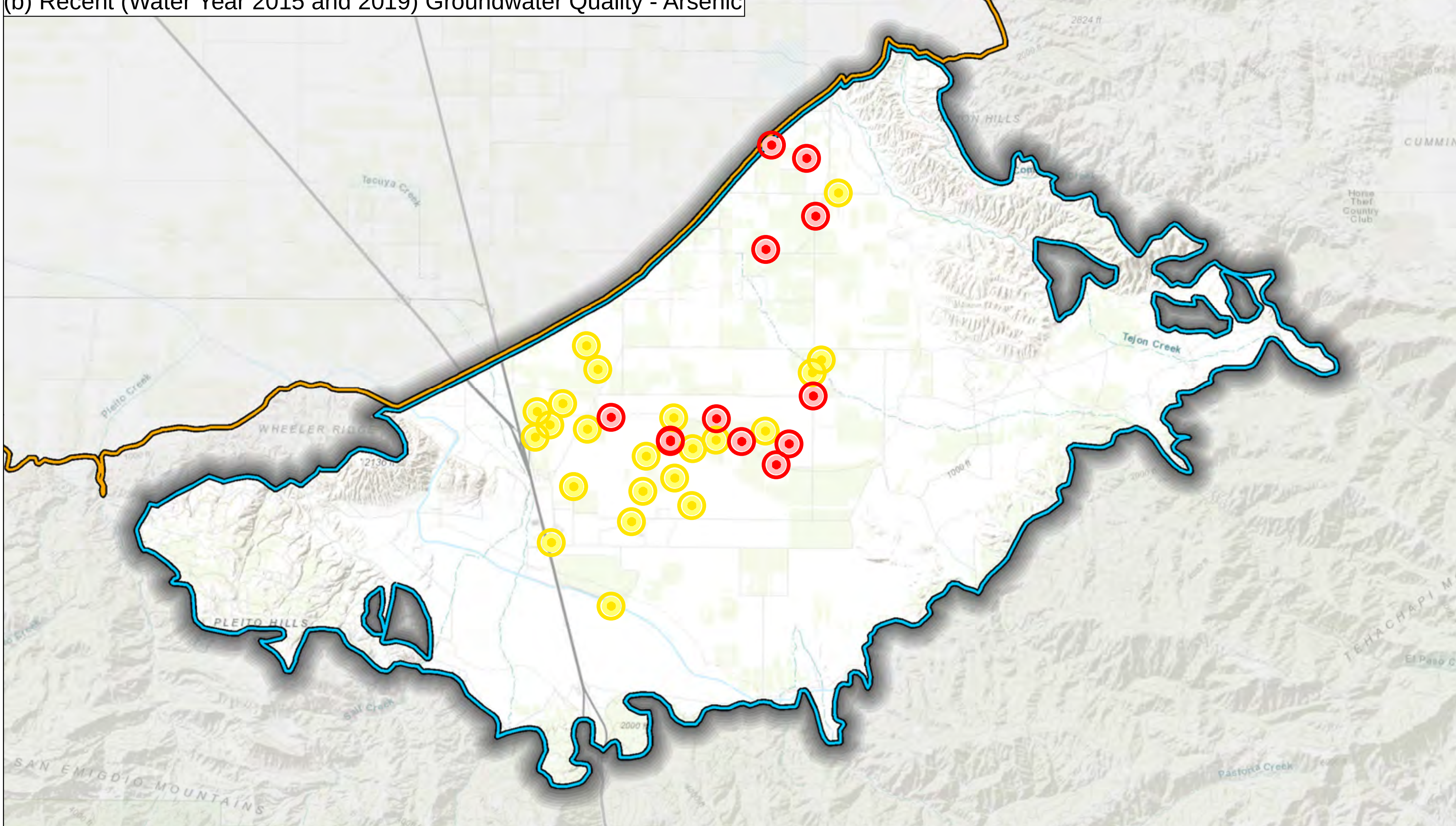
eki environment & water

Figure GWC-8

(a) Recent (Water Year 2015 and 2019) Groundwater Quality - Nitrate (as N)



(b) Recent (Water Year 2015 and 2019) Groundwater Quality - Arsenic



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)

Total Arsenic Concentration (ug/L)

- ND (< 2.0)
- 2.0 - 10
- > 10

Dissolved Arsenic Concentration (ug/L)

- ND (< 2.0)
- 2.0 - 10
- > 10

Nitrate Concentration (mg/L NO_3 as N)

- ND
- 0 - 2.5
- 2.5 - 5
- 5 - 10
- >10

Abbreviations

AEWSD	= Arvin-Edison Water Storage District
CCR	= California Code of Regulations
DDW	= Department of Drinking Water
DWR	= California Department of Water Resources
ILRP	= Irrigated Lands Regulatory Program
MCL	= Maximum Concentration Level
mg/L	= milligrams per liter
N	= nitrogen
ND	= non-detect
NO_3	= nitrate
TCWD	= Tejon-Castac Water District
ug/L	= micrograms per liter
WRMWSD	= Wheeler Ridge-Maricopa Water Storage District

N

0 3 6

(Scale in Miles)

Notes

1. All locations are approximate.
2. Constituent concentration is the maximum observed for each well between Water Year 2015 and 2019.
3. CCR 22-4 Table 64431-A lists primary MCL for NO_3 as N at 10 mg/L.
4. CCR 22-4 Table 64431-A lists Primary MCL for Arsenic at 10 ug/L.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 20 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Wells sampled in Water Year 2015-2019 by TCWD, AEWSD, WRMWSD, Public Water System, DDW, ILRP, and other private parties.

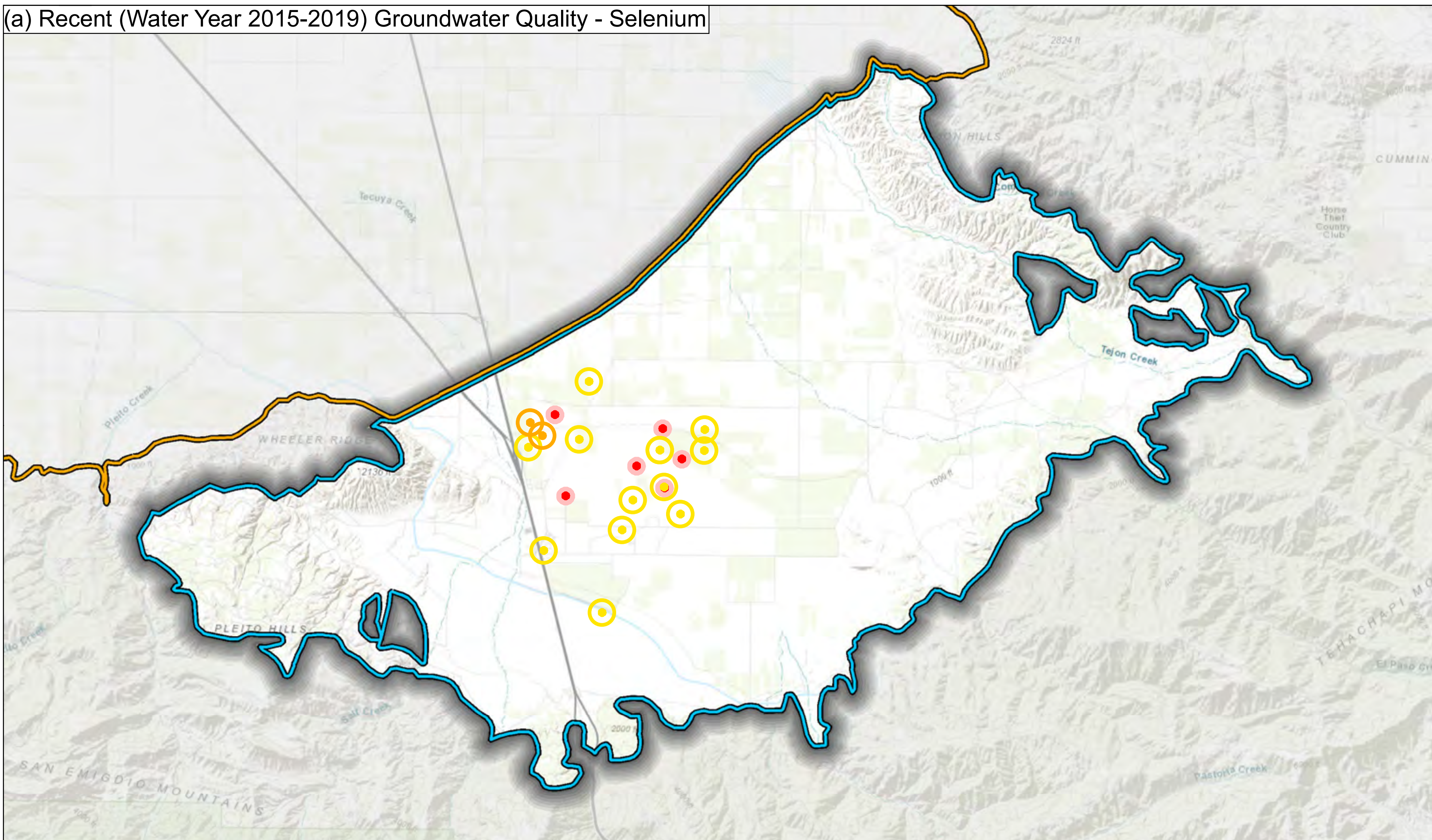
Path: X:\B50001.05\Maps\GSP\2022\01\FigGWC-9_NitrateArsenicConcentrations(2015-2019).mxd

Groundwater Quality – Nitrate and Arsenic Concentrations (Water Year 2015-2019)

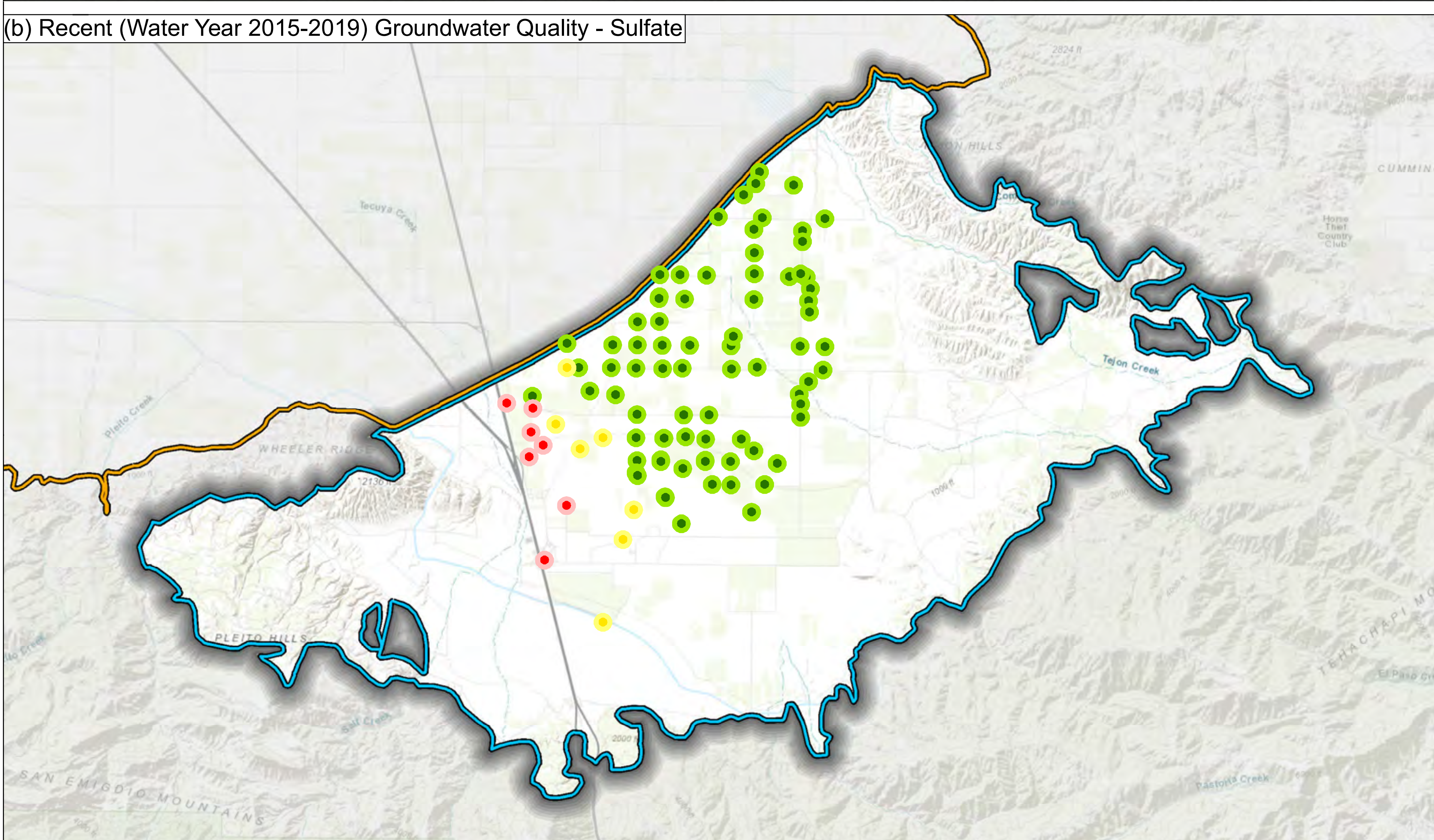
White Wolf GSA
Kern County, CA
December 2021
B50001.05

eki environment & water

Figure GWC-9



(a) Recent (Water Year 2015-2019) Groundwater Quality - Selenium



(b) Recent (Water Year 2015-2019) Groundwater Quality - Sulfate

Legend

Groundwater Subbasin
- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)

Sulfate Concentration (mg/L)
- < 250
- 250 - 500
- > 500

Total Selenium Concentration (mg/L)
- ND
- 0-0.025
- 0.025 - 0.05

Dissolved Selenium Concentration (mg/L)
- ND (<0.05)
- > 0.05

Abbreviations

AEWSD	= Arvin-Edison Water Storage District
CCR	= California Code of Regulations
DDW	= Department of Drinking Water
DWR	= California Department of Water Resources
ILRP	= Irrigated Lands Regulatory Program
MCL	= Maximum Concentration Level
mg/L	= milligrams per liter
ND	= non-detect
TCWD	= Tejon-Castac Water District
ug/L	= miligram per liter
WRMWSD	= Wheeler Ridge-Maricopa Water Storage District

Notes
1. All locations are approximate.
2. Constituent concentration is the maximum observed for each well between Water Year 2015-2019.
3. CCR 22-4 Table 64431-A lists Primary MCL for Selenium at 50 ug/L, or 0.05 mg/L.
4. CCR 22-4 Table 64449-B lists “upper” Secondary MCL for Sulfate at 500 mg/L.

Sources
1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 20 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Wells sampled in Water Year 2015-2019 by TCWD, AEWSD, WRMWSD, Public Water System, DDW, ILRP, and other private parties.

N

0 3 6

(Scale in Miles)

Groundwater Quality – Selenium and Sulfate Concentrations (Water Year 2015-2019)

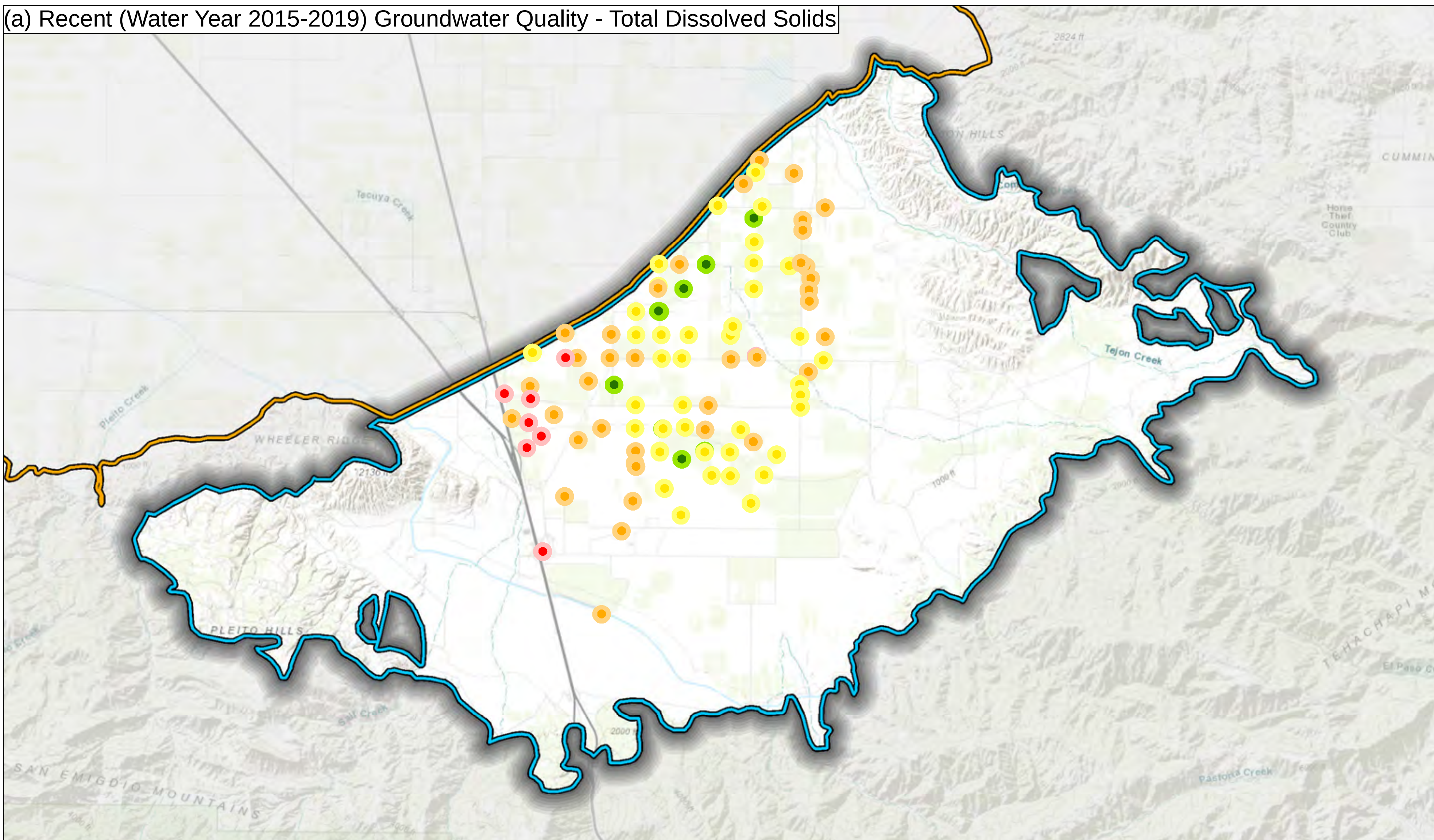
White Wolf GSA
Kern County, CA
December 2021
B50001.05

eki environment & water

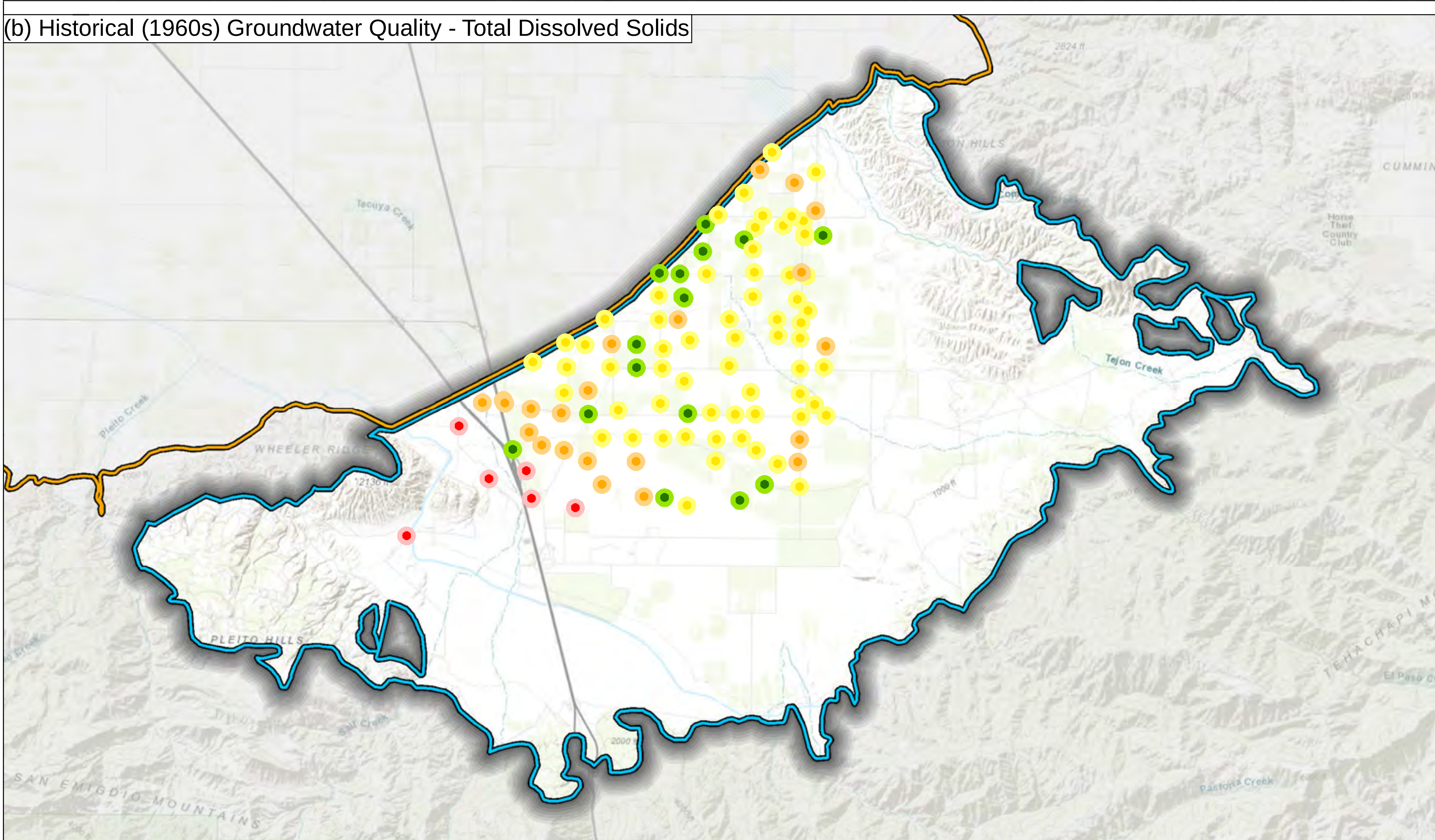
Figure GWC-10

Path: X:\B50001.05\Maps\GSP\2022\01\FigGWC-10_SeleniumSulfateConcentrations(2015-2019).mxd

(a) Recent (Water Year 2015-2019) Groundwater Quality - Total Dissolved Solids



(b) Historical (1960s) Groundwater Quality - Total Dissolved Solids



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

Total Dissolved Solids Concentration (mg/L)

< 300

300 - 500

500 - 1,000

> 1,000

Abbreviations

AEWSD = Arvin-Edison Water Storage District
CCR = California Code of Regulations
DDW = Department of Drinking Water
DWR = California Department of Water Resources
ILRP = Irrigated Lands Regulatory Program
MCL = Maximum Contaminant Level
mg/L = milligrams per liter
TCWD = Tejon-Castac Water District
TDS = Total Dissolved Solids
WRMWSD = Wheeler Ridge-Maricopa Water Storage District

Notes

1. All locations are approximate.
2. Constituent concentration is the maximum observed for each well between Water Year 2015 and 2019 (Figure GWC-11(a)) and between 1960 and 1969 (Figure GWC-11(b)).
3. CCR 22-4 Table 64449-B lists "upper" Secondary MCL for TDS at 1,000 mg/L and "lower" Secondary MCL for TDS at 500 mg/L.

N

0 3 6

(Scale in Miles)

Groundwater Quality – Recent (Water Year 2015-2019) and Historical (1960s) TDS Concentrations

Sources

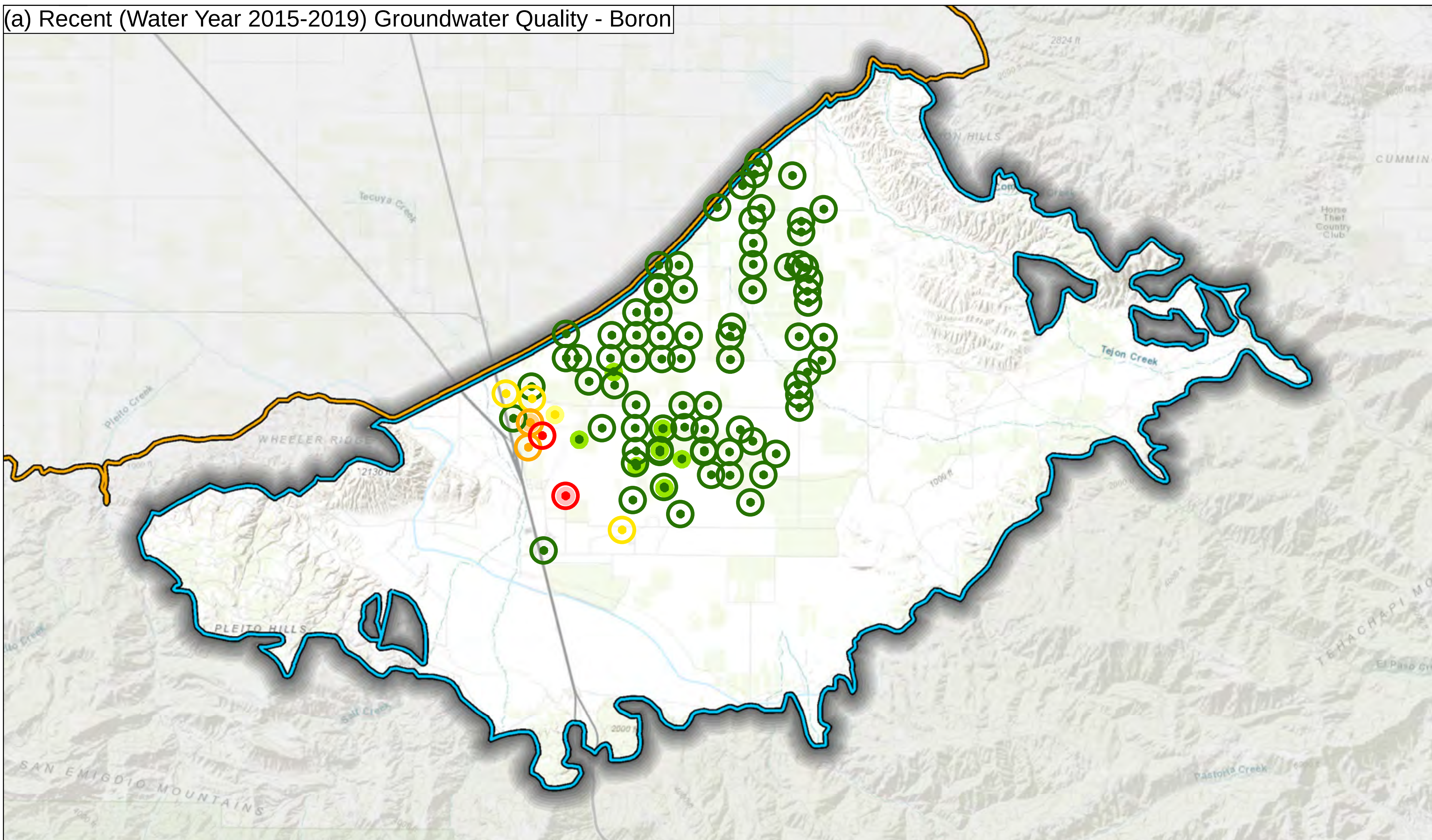
1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 18 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Wells sampled in Water Year 2015-2019 by TCWD, AEWSD, WRMWSD, Public Water System, DDW, ILRP, and other private parties.

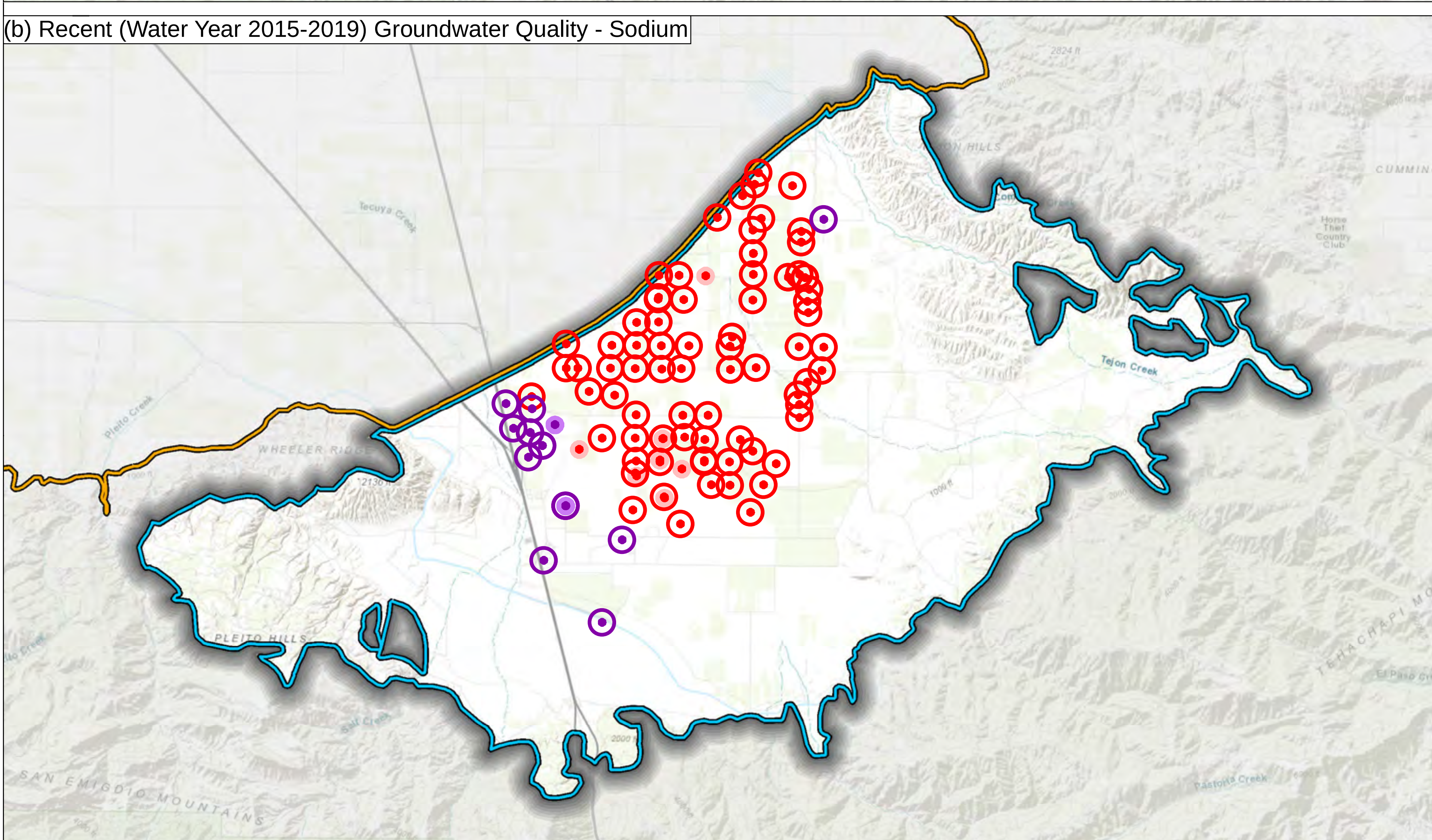
eki environment & water

White Wolf GSA
Kern County, CA
December 2021
B50001.05

Figure GWC-11

Path: X:\B50001.05\Maps\GSP\2022\01\Fig\GWC-11_RecentHistoricTDSconcentration.mxd





Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

Total Sodium Concentration (mg/L)

- < 20
- 20 - 100
- > 100

Dissolved Sodium Concentration (mg/L)

- 20 - 100
- > 100

Total Boron Concentration (mg/L)

- < 0.50
- 0.50 - 0.75
- 0.75 - 1.0
- > 1.0

Dissolved Boron Concentration (mg/L)

- < 0.50
- 0.50 - 0.75
- 0.75 - 1.0
- > 1.0

Abbreviations

AEWSD	= Arvin-Edison Water Storage District
CCR	= California Code of Regulations
DDW	= Department of Drinking Water
DWR	= California Department of Water Resources
ILRP	= Irrigated Lands Regulatory Program
MCL	= Maximum Concentration Level
mg/L	= milligrams per liter
TCWD	= Tejon-Castac Water District
WRMWSD	= Wheeler Ridge-Maricopa Water Storage District

N 0 3 6 (Scale in Miles)

Notes
1. All locations are approximate.
2. Constituent concentration is the maximum observed for each well between Water Year 2015-2019.
3. Boron levels >0.5 mg/L can exhibit slight to moderate restrictions on agricultural productivity, depending on crop type.
4. The Water Quality Objective of Sodium is 20 mg/L.

Sources
1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 18 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Wells sampled in Water Year 2015-2019 by TCWD, AEWSD, WRMWSD, Public Water System, DDW, ILRP, and other private parties.

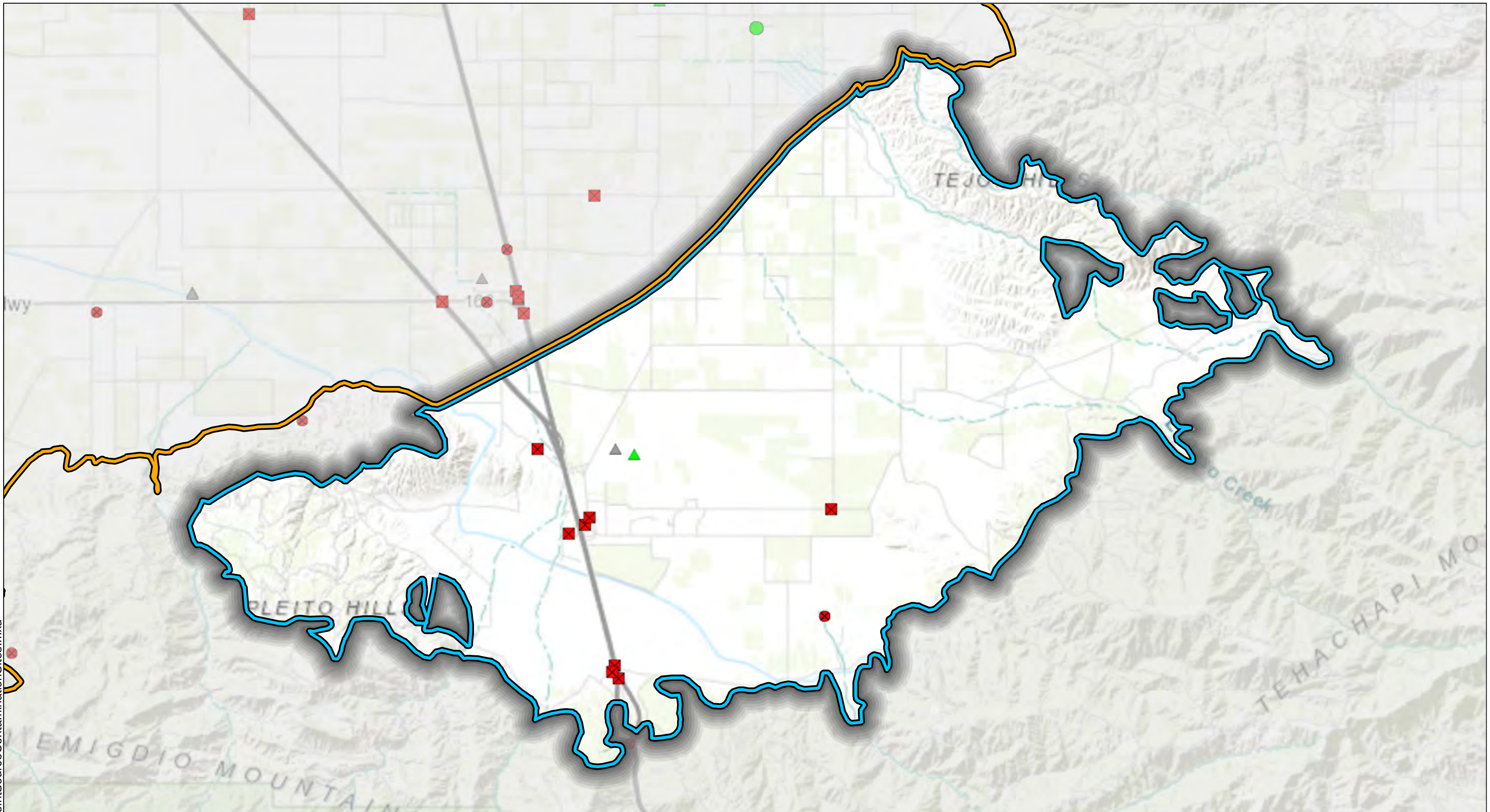
Groundwater Quality – Boron and Sodium Concentrations (Water Year 2015-2019)

White Wolf GSA
Kern County, CA
December 2021
B50001.05

eki environment & water

Figure GWC-12

Path: X:\B50001.05\Maps\GSP\2022\01\FigGWC-12_BoronSodiumConcentrations(2015-2019).mxd



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

GeoTracker Sites

Cleanup Program Site, Open

Cleanup Program Site, Closed

LUST Cleanup Site, Closed

DTSC Cleanup Site, Voluntary Cleanup

DTSC Cleanup Site, Inactive

Abbreviations

DTSC = Department of Toxic Substance Control
DWR = California Department of Water Resources
LUST = Leaking Underground Storage Tank
SWRCB = State Water Resources Control Board

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 20 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Locations of contamination sites from SWRCB GeoTracker website (http://geotracker.waterboards.ca.gov/datadownload), accessed 2 December 2019.

N 0 4 8 (Scale in Miles)

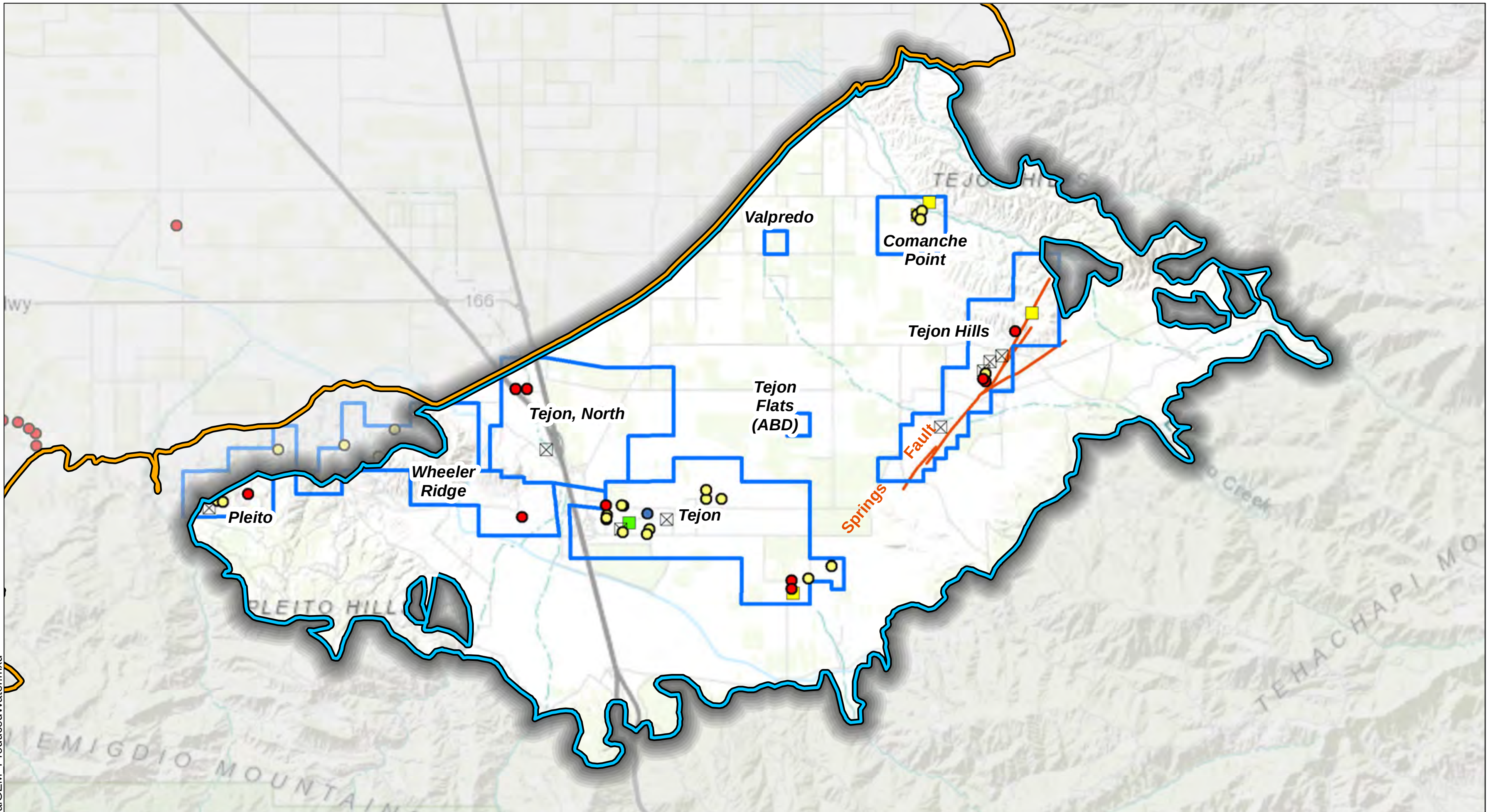
Point Source Contamination Sites

eki environment & water

White Wolf GSA
Kern County, California
December 2021
B50001.05

Figure GWC-13

Path: X:\B50001.05\Maps\GSP\2022\01\FigGWC-13_PointSourceContaminationSites.mxd



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

CalGEM Oil & Gas Fields

Fault

Injection Well Type (see Note 2)

INJ

Multi

WD

Produced Water Ponds

Closed

Inactive

Open

Abbreviations

CalGEM = California Geologic Energy Management Division

DWR = California Department of Water Resources

Notes

1. All locations are approximate.
2. Wells shown are listed as "Active" and include injection (INJ), Multi (injection and production), and water disposal (WD).

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 18 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. CalGEM well data obtained 4 June 2019.
4. Produced water ponds data obtained 4 June 2019.

N 0 4 8 (Scale in Miles)

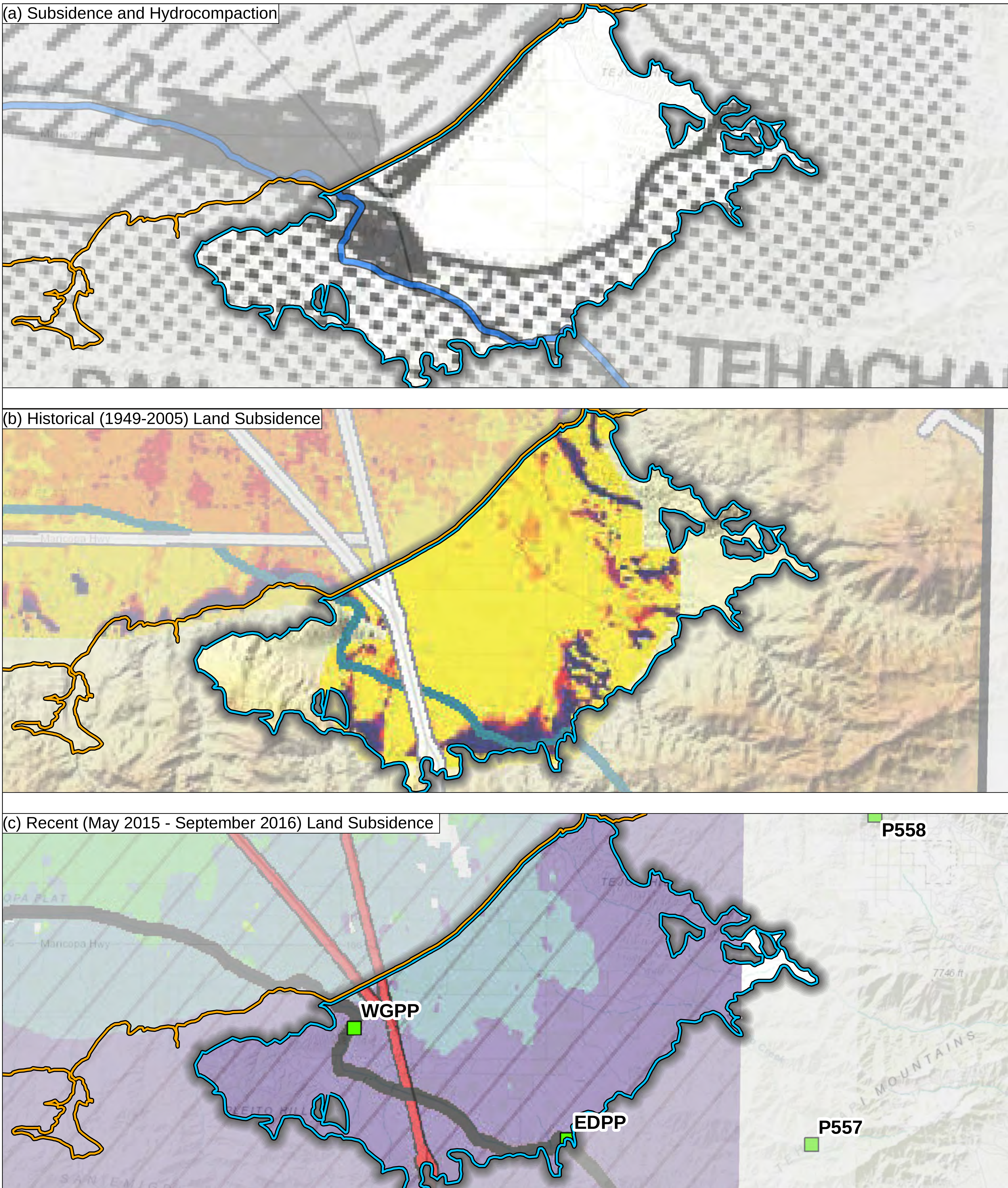
Locations of Oil Fields, Active Injection Wells, and Produced Water Ponds

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure GWC-14

Path: X:\B50001.05\Maps\GSP\2022\01\FigGWC-14_CalGEM_ProducedWater.mxd



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)

Subsidence Type (after Ireland et al., 1984)

- Area of subsidence due to hydrocompaction
- Area with subsidence due to water level decline of >1 foot
- Outline of valley
- Subsidence Monitoring Station

Subsidence (1949 - 2005)

- -30 to -25 feet
- -25 to -20 feet
- -20 to -15 feet
- -15 to -10 feet
- -10 to -5 feet
- -5 to 0 feet
- Highway
- California Aqueduct

Subsidence (May 2015 - Sept. 2016)

- No data
- -12 to -8 inches
- -8 to -4 inches
- -4 to -1 inches
- -1 to 1 inches
- California Aqueduct
- Highway

Abbreviations

DWR = California Department of Water Resources
UNAVCO = University Navstar Consortium
USGS = United States Geological Survey

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 20 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Ireland et al., 1984. Land Subsidence in the San Joaquin Valley, California, as of 1980. USGS Professional Paper 437-1.
4. California Aqueduct location is from the National Hydrography Dataset.
5. Subsidence monitoring locations are from UNAVCO's Plate Boundary Observatory database.
6. Historical subsidence data is from DWR's Estimated Subsidence in the San Joaquin Valley between 1949-2005.
7. Recent subsidence data is from the California Institute of Technology Jet Propulsion Laboratory Progress Report: Subsidence in California, March 2015 - September 2016.

N

0 4 8

(Scale in Miles)

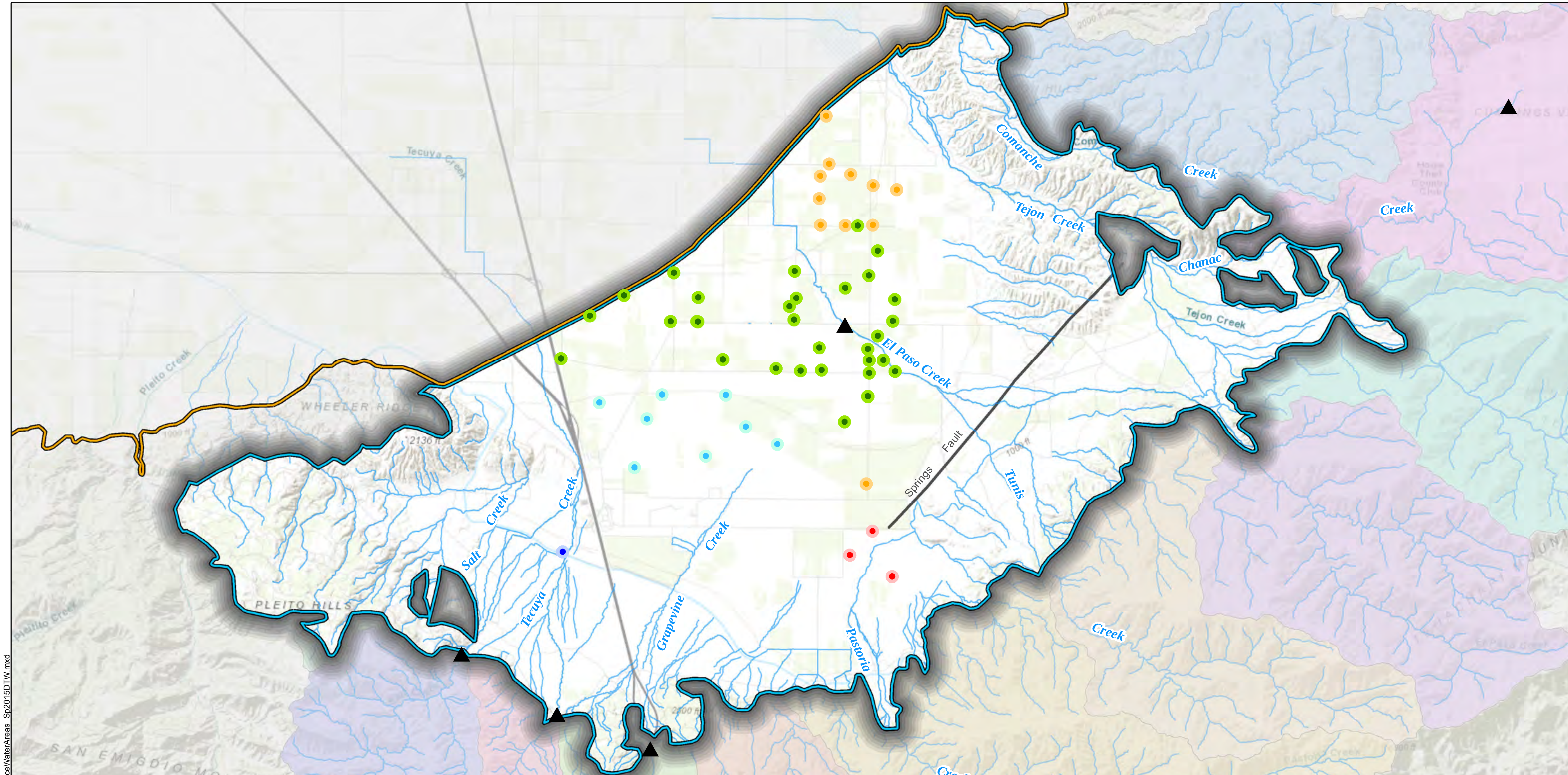
Historical (1949-2005) and Recent (2015-2016) Land Subsidence, and Hydrocompaction

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure GWC-15

Path: X:\B50001.05\Maps\GSP\2022\01\FigGWC-15_HistoricRecentSubsidence.mxd



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- Stream into White Wolf Subbasin
- Surface Water Monitoring Locations
- Fault

Spring 2015 Depth to Groundwater (ft bgs)

- < 200
- 200 - 400
- 400 - 600
- 600 - 800
- > 800

Abbreviations

CEDEN	= California Environmental Data Exchange Network	NHD	= National Hydrography Dataset
DWR	= California Department of Water Resources	WRMWSD	= Wheeler Ridge Maricopa Water Storage District
ft bgs	= feet below ground surface		

Notes

1. All locations are approximate.
2. Pastel filled areas are watersheds draining into the White Wolf Subbasin.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 20 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Surface water features and watersheds from NHD (https://viewer.nationalmap.gov/basic/).
4. Surface water monitoring locations from CEDEN (https://ceden.waterboards.ca.gov/AdvancedQueryTool) and WRMWSD, 2018 Memorandum: Gaging Stations - Southern Stream Group – Project Update.
5. Springs Fault from Goodman, E.D., and P.E. Malin, 1992, Evolution of the Southern San Joaquin Basin and Mid-Tertiary "Transitional" Tectonics, Central California, Tectonics, Vol. 11, No. 3, pages 478-498.

N

0 2 4

(Scale in Miles)

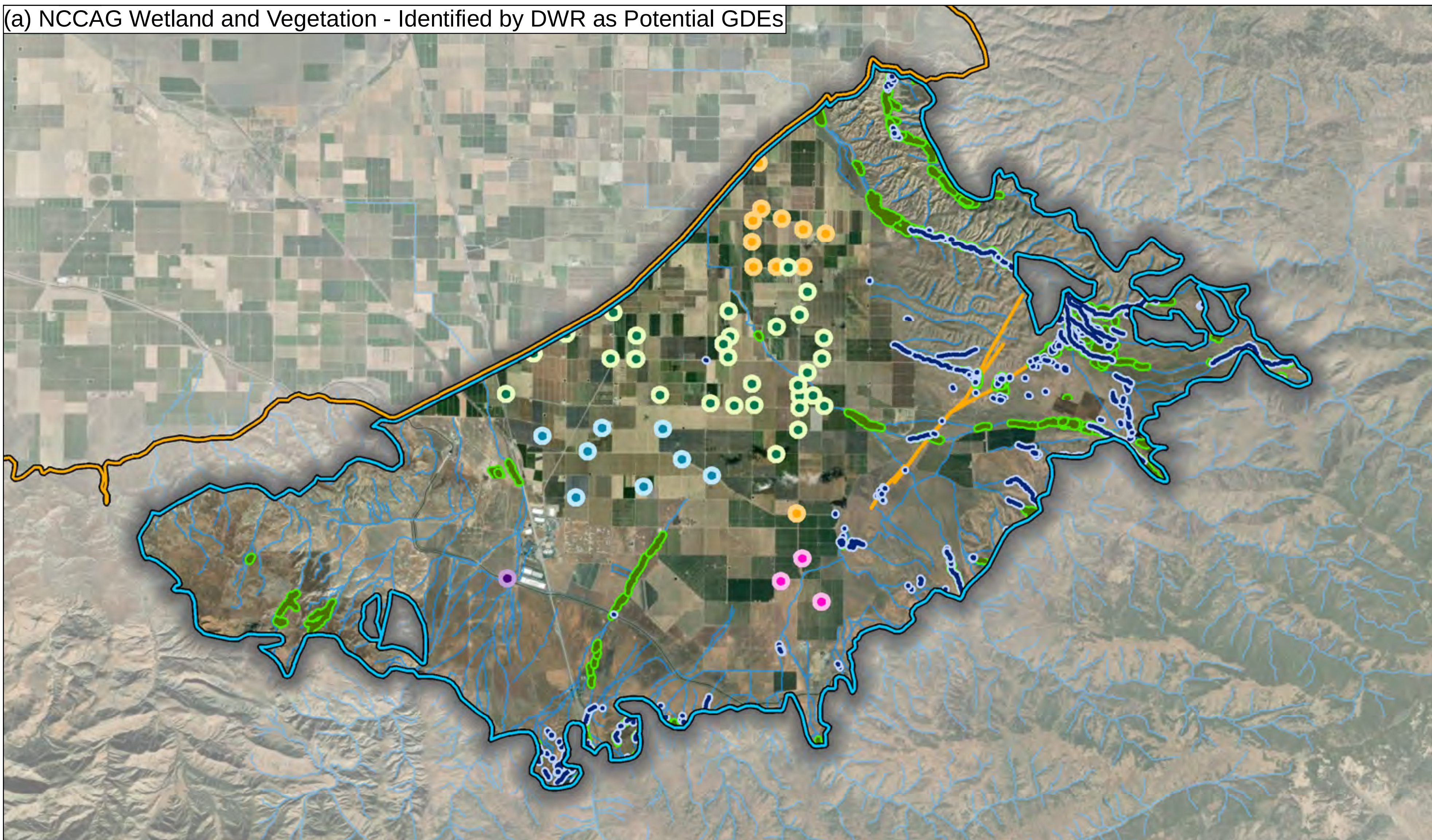
Natural Surface Water Features with Spring 2015 Depth to Groundwater

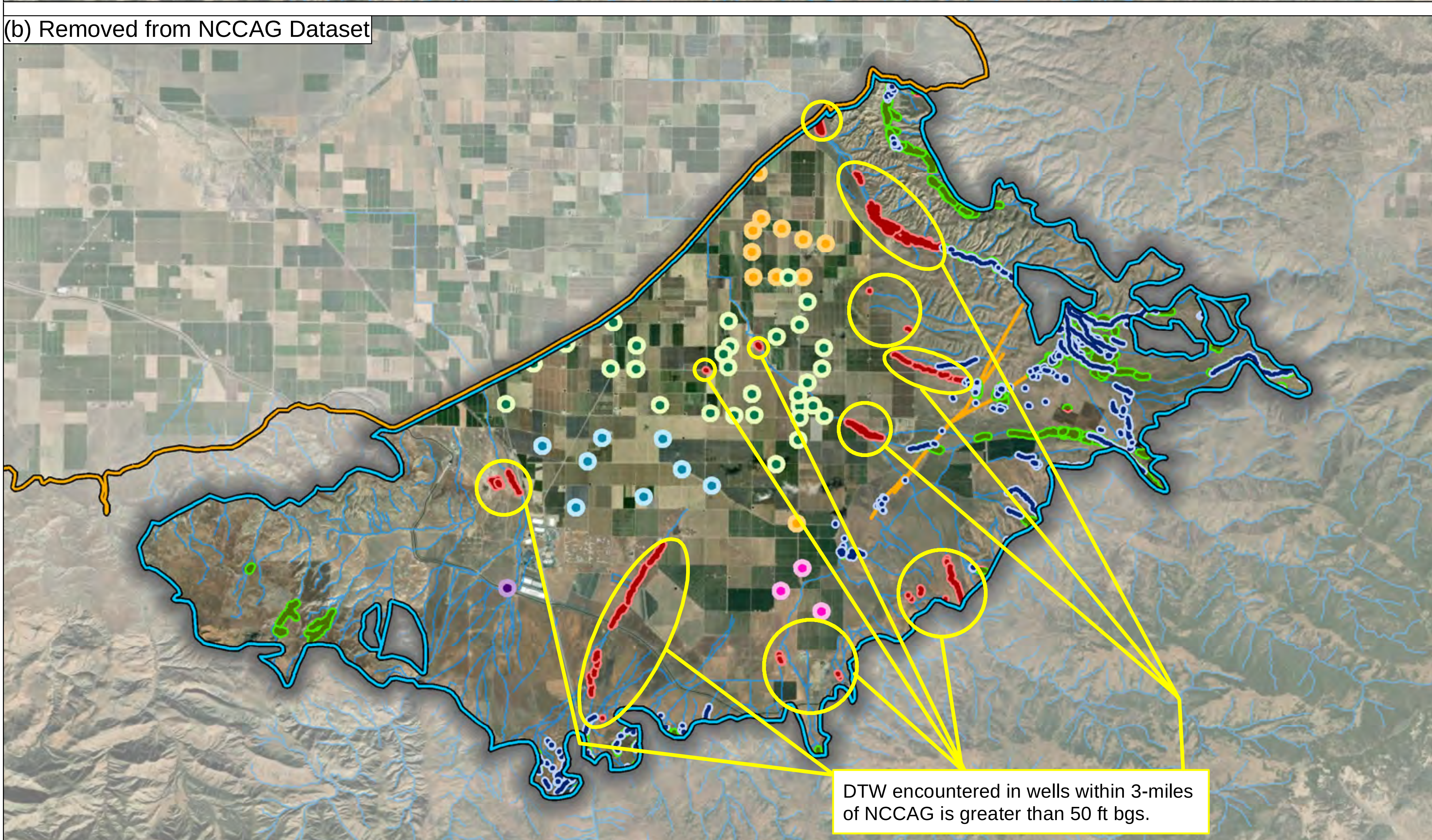
White Wolf GSA
Kern County, CA
December 2021
B50001.05

eki environment & water

Figure GWC-16

Path: X:\B50001.05\Maps\GSP\2022\01\FigGWC-16_NaturalSurfaceWaterAreas_Sp2015DTW.mxd





Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)

NCCAG

- Wetland
- Vegetation
- Removed from NCCAG
- Springs Fault
- Stream into White Wolf Subbasin

Spring 2015 Depth to Groundwater (ft bgs)

- < 200
- 200 - 400
- 400 - 600
- 600 - 800
- > 800

Abbreviations

DTW	= depth to groundwater
DWR	= California Department of Water Resources
ft bgs	= feet below ground surface
NCCAG	= Natural Communities Commonly Associated with Groundwater
NHD	= National Hydrography Dataset

N

0 3 6

(Scale in Miles)

Notes
1. All locations are approximate.
2. Potenital GDEs from the NCCAG dataset were removed where depth to groundwater measurements are deeper than 50 ft bgs measured in wells located within 3 miles of the potential GDEs.

Sources
1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 18 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. DWR NCCAG dataset was obtained from NC Dataset Viewer (https://gis.water.ca.gov/app/NCDatasetViewer/)
4. Surface water features and watersheds from NHD (https://viewer.nationalmap.gov/basic/).

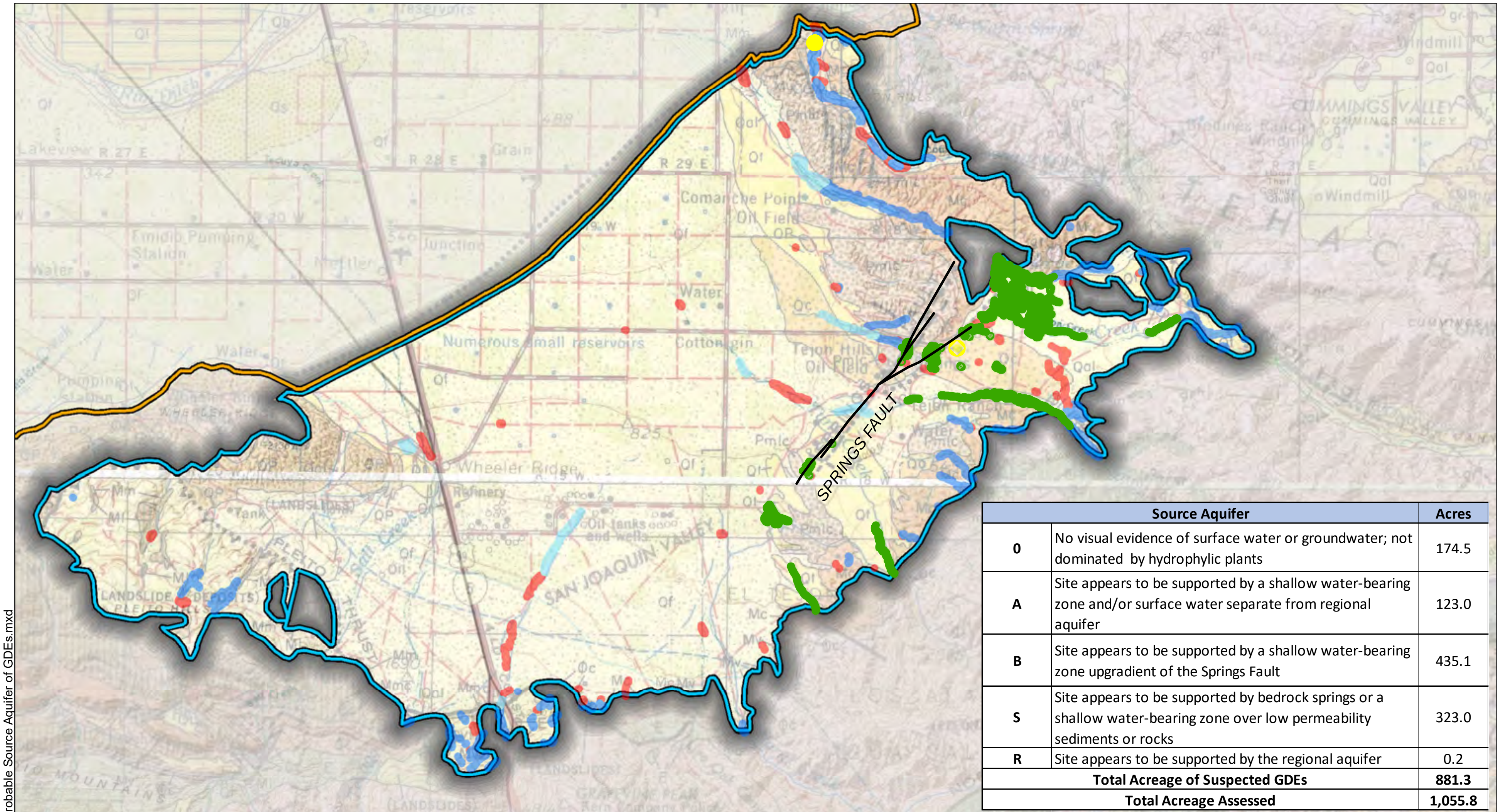
Path: X:\B50001.05\Maps\GSP\2022\01\Fig\GWC-17_NCCAG.mxd

Natural Communities Commonly Associated with Groundwater and Spring 2015 Depth to Groundwater

White Wolf GSA
Kern County, CA
December 2021
B50001.05

eki environment & water

Figure GWC-17



	Source Aquifer	Acres
0	No visual evidence of surface water or groundwater; not dominated by hydrophylic plants	174.5
A	Site appears to be supported by a shallow water-bearing zone and/or surface water separate from regional aquifer	123.0
B	Site appears to be supported by a shallow water-bearing zone upgradient of the Springs Fault	435.1
S	Site appears to be supported by bedrock springs or a shallow water-bearing zone over low permeability sediments or rocks	323.0
R	Site appears to be supported by the regional aquifer	0.2
Total Acreage of Suspected GDEs		881.3
Total Acreage Assessed		1,055.8

Legend

Probable Source Aquifer

- 0
- A
- B
- S
- R

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- Springs Fault

Abbreviations

DWR= California Department of Water Resources
GDE= Groundwater Dependant Ecosystem

Notes

1. All locations are approximate.
2. GDEs of interest for the purpose of the White Wolf Groundwater Sustainability Plan are those categorized as sites appearing to be supported by the shallow water-bearing zone upgradient of the Springs Fault ("B") or the Regional Aquifer ("R").

Sources

1. Basemap is surface geology from California Division of Mines and Geology, Geologic Map of California, Olaf P. Jenkins Edition, Bakersfield Sheet (1964) and Los Angeles Sheet (1969).
2. Bartow, 1984, Geological Map and Cross Sections of the Southeastern Margin of the San Joaquin Valley, California: U.S. Geological Survey Map I-1496.
3. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
4. Map and table are modified from GeoSystems Analysis, Inc. GDE Evaluation Report Figure 4 and Table 4 respectively.

N

0 3 6

(Scale in Miles)

Probable Source Aquifer of Groundwater Dependant Ecosystems

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure GWC-18

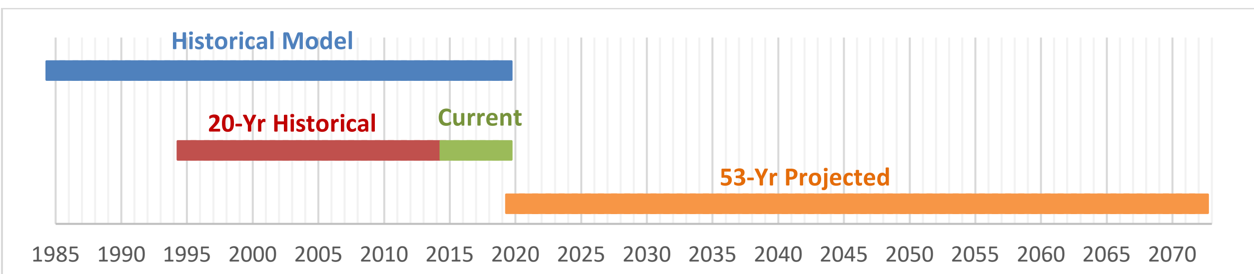
Path: X:\B50001.05\Maps\GSP\2022\01\FigGWC-18_Probable Source Aquifer of GDEs.mxd

9. WATER BUDGET INFORMATION

> *§ 354.18. Water Budget*
> *(a) Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.*

This section presents information on the water budget for the Basin. Consistent with the 23 California Code of Regulations (CCR) Division 2 Chapter 1.5 Subchapter 2 and DWR's Water Budget Best Management Practices (BMP) (DWR, 2016b), this water budget provides an accounting of the total annual volume of water entering and leaving the Basin for historical, current, and projected future conditions. Three water budget time periods are presented herein:

- A historical water budget period representing 20 years of historical hydrology for the period Water Year[49] (WY) 1995-2014 and calibrated to historical data;
- A current conditions water budget period representing average conditions for the recent 5-year period (WY 2015-2019), validated against recent data; and
- A 53-year projected water budget period (WY 2020-2072), with results presented as averages for comparison to historical and current conditions.



As discussed in ***Section 9.2 Water Budget Methods*** below, detailed historical and current water budgets are presented for both the land surface system and groundwater system. To facilitate planning for future sustainability, this Groundwater Sustainability Plan (GSP) focuses on future impacts to groundwater storage.

As shown in **Table WB-1**, under the historical water budget periods, inflow to the groundwater system was greater than outflows, resulting in storage accretion. However, under current and projected water budget conditions, outflows exceed inflows resulting in a reduction in groundwater storage. Information regarding the inputs and assumptions for the water budget analysis are presented below, and detailed breakdowns of groundwater system components can be found in **Table WB-5**. The historical range in

[49] Water Year run from October of the previous year to September of the current year (e.g. Water Year 2015 is October 2014 – September 2015.

sustainable yield is 38,200 AFY to 47,200 AFY and is likely a reasonably conservative estimate for future planning purposes. The White Wolf Groundwater Sustainability Agency (GSA) has elected to utilize the Projected 2030 Climate Change as a baseline for designing Projects and/or Management Actions (P/MAs) to ensure the Basin meets the Sustainability Goal.

Table WB-1. Summary of Groundwater System Water Budgets

Scenario	Average Volumetric Flux (AFY)		
	GW Inflows	GW Outflows	Change in GW Storage
Historical and Current Water Budget Periods			
Historical Water Budget Period (WY 1995-2014)	56,500	53,300	3,200
Current Conditions Water Budget Period (WY 2015-2019)	49,500	69,800	-20,300
Projected Water Budget Period (WY 2020-2072)			
Projected Baseline	52,100	56,700	-4,600
Projected 2030 Climate Change	51,000	59,400	-8,400
Projected 2070 CT Climate Change	48,100	63,600	-15,500
Projected 2030 Climate Change with Grapevine P/MA	51,600	58,800	-7,200
Projected 2030 Climate Change with Combined P/MAs	51,400	52,100	-700

Abbreviations:

AFY = acre-feet per year
CT = Central Tendency
GW = groundwater
P/MA = Project and/or Management Action
WY = Water year

Notes:

(a) Values rounded to the nearest hundred acre-feet.

9.1. Water Budget Data Sources

§ 354.18. Water Budget

(d) The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:

(1) Historical water budget information for mean annual temperature, mean annual precipitation, water year type, and land use.

(2) Current water budget information for temperature, water year type, evapotranspiration, and land use.

(3) Projected water budget information for population, population growth, climate change, and sea level rise.

(e) Each Plan shall rely on the best available information and best available science to quantify the water budget for the basin in order to provide an understanding of historical and projected hydrology, water demand, water supply, land use, population, climate change, sea level rise, groundwater and surface water interaction, and subsurface groundwater flow. If a numerical groundwater and surface water model is not used to quantify and evaluate the projected water budget conditions and the potential impacts to beneficial uses and users of groundwater, the Plan shall identify and describe an equally effective method, tool, or analytical model to evaluate projected water budget conditions.

(f) The Department shall provide the California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) and the Integrated Water Flow Model (IWFM) for use by Agencies in developing the water budget. Each Agency may choose to use a different groundwater and surface water model, pursuant to Section 352.4.

9.1.1. Data Sources

Per 23-CCR §354.18(e), the best-available data were used to evaluate the water budget for the Basin and include the following:

- Precipitation Records including:
  - Two climate stations ("PA-2 Pumping Plant" and "Spillway Basin") operated by Wheeler Ridge-Maricopa Water Storage District (WRMWSD), *Monthly, January 1978 – December 2017*
  - Two additional climate stations ("Tejon Rancho" and "Lebec") maintained by the National Oceanic and Atmospheric Administration (NOAA), *Monthly (period of data availability varies by station)*
  - Parameter-elevation Regressions on Independent Slopes Model (PRISM)[50] data, *Daily, October 1994 – September 2019*
- Satellite Evapotranspiration (ET) Data from the Cal Poly Irrigation Training and Research Center's "Mapping Evapotranspiration at High Resolution with Internalized Calibration" (ITRC-METRIC)

[50] https://prism.oregonstate.edu/recent/

Study, funded by the Kern Groundwater Authority (KGA)[51] and White Wolf GSA[52]; *Monthly, January 1993 – December 2019*[53]

- Reference ET Data from California Irrigation Management Information System (CIMIS) Arvin-Edison station #125; *Daily, October 1994 – September 2019*.[54]
- Pan Evaporation Records including:
  - One climate station ("PA-2 Pumping Plant") operated by WRMWSD, *Monthly, January 1978 – October 2017*
  - One climate station ("Maricopa.T") from the University of California Integrated Pest Management Program, *Daily, January 1982 – May 1987*[55]
  - NOAA climate station 325 in Arvin-Edison Water Storage District (AEWSD), *mean monthly, March 1967 – December 1977* (NOAA, 1982)
  - "Shafter" climate station (Snyder et al., 2005), *mean monthly*
- Land Use Surveys including:
  - AEWSD surveys from the District's internal land use records; *Seasonal, Spring 1994 – Fall 2019 (data availability varies by season)*
  - WRMWSD surveys from the District's internal land use records; *Seasonal, Spring 2001 – Spring 2017 (data availability varies by season)*
  - Tejon-Castac Water District (TCWD) survey by Assessor Parcel Number (APN); *Year 2018*; and
  - DWR historical Kern County land use surveys; *1990 and 1998.*[56]
  - CalVeg[57]
- Surface Water Imports/Delivery Records including:

[51] Howes, D. 2017. 1993-2015 ITRC-METRIC ETc for Kern County. prepared for the Kern Groundwater Authority. Irrigation Training & Research Center California Polytechnic State University; Howes, D., 2020. 1993-2019 ITRC METRIC ETc for Kern County. Prepared for Kern Groundwater Authority. Irrigation Training & Research Center California Polytechnic State University.
[52] Howes, D. 2021. 2017-2020 ITRC-METRIC ETc for White Wolf Subbasin Draft v2. Prepared for the White Wolf GSA. Irrigation Training & Research Center California Polytechnic State University.
[53] There is no ITRC satellite evapotranspiration (ET) data for calendar year 2012, as the LANDSAT satellite system employed in the ITRC-METRIC analysis was non-operational during this period. See ***Appendix K*** for further details.
[54] Data between 1 October 1994 and 21 March 1995 were unavailable at the Arvin-Edison station and were estimated based on linear correlation with the nearby Cuyama station.
[55] Available online at http://ipm.ucanr.edu/calludt.cgi/WXDESCRIPTION?STN=MARICOPA.T#003
[56] Available online at https://gis.water.ca.gov/app/CADWRLandUseViewer/
[57] Available online at https://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192

- AEWSD surface water imports records from the District's internal operations records; *Monthly, January 1966 – December 2019*
- WRMWSD surface water delivery records from the District's internal operations records; *Monthly, January 1999 – December 2019*
- TCWD potable and recycled water usage from the District's internal operations records; *Monthly, July 2015 – December 2019*.

- Pumping Records including:
  - WRMWSD "pump in" records of privately pumped groundwater that has been added to the WRMWSD water distribution system from the District's internal operations records; *Annual, 1990 – 2019*.
  - WRMWSD pumping volumes from District-owned wells from the District's internal operations records; *Monthly, 2001 – 2019.*
  - Public Water System pumping[58]; *Monthly, 2013-2019 (not all months have available records).*
  - Private agricultural pumping was calculated by the soil moisture budget accounting model (SMB). Data inputs to the SMB include:
    - Soil properties (i.e., hydrologic group, wilting point, field capacity, soil porosity, saturated hydraulic conductivity, and depth) from the United States Department of Agriculture (USDA) Soil Survey Geographic Database (SSURGO),
    - Curve numbers for runoff for agriculture, urban, and native vegetation classifications including conifer forest/woodland, hardwood forest/woodland, mixed conifer and hardwood forest/woodland, shrub, herbaceous, and barren from USDA, 1989, and

- Stream diversions at points of diversion (PODs) on El Paso, Grapevine, Tunis, Tejon, and Pastoria Creeks and Reservoirs 1 and 2 from Tejon Ranch Conservancy (TRC) internal records and as uploaded to the Electronic Water Rights Information Management System (eWRIMs); *Monthly, 2007 – 2019 (data availability varies by diversion).*
- Historical Groundwater Level Records from selected wells within the Basin; *Seasonal, Fall 1919 – Spring 2019 (data availability varies by well)*
- Historical Stream Gauge Records from selected point locations along El Paso, Tunis, and Tejon Creeks; *weekly, January 2002 – October 2016 (data availability varies by station)*

[58] Available online at: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/eardata.html

9.2. Water Budget Methods

Two complementary approaches were used to quantify the Basin's water budget:

(1) A **spreadsheet model** that quantifies each flow component and enforces mass balance principles for each "subdomain" that collectively comprise the water budget domain (the Basin). The spreadsheet model approach was developed for the Basin to serve as a preliminary water budget and an independent check on the estimates of the historical and current water budget derived from the numerical model approach. The spreadsheet model approach uses a variety of data and analytical methods to quantify each water budget flow component, and is similar to the analytical water budget approach used by AEWSD and WRMWSD as part of their Kern County Subbasin Management Area Plans. Processes and groups of processes are grouped into "subdomains" and "flow components". These water budget flow components are quantified on a monthly timestep for the period from October 1994 through December 2015. Details of the methods, data, approach, and results of the spreadsheet model are provided in ***Appendix K***.

(2) A **numerical groundwater flow model**, the White Wolf Groundwater Flow Model (WWGFM), which uses the United States Geological Survey (USGS) Newton formulation of the Modular Three-Dimensional Groundwater Modeling platform (MODFLOW-NWT), from which water budget components are extracted for the Basin. Due to the model's spatial discretization and physic-based quantitative flow calculations, the WWGFM is considered the best tool to develop the water budget. Therefore, all water budget results presented herein are based on the WWGFM.

The numerical model approach is based on the application of the WWGFM, which is a numerical groundwater flow model developed for the Basin. The WWGFM uses the USGS MODFLOW-NWT platform to solve the governing groundwater flow equations. The WWGFM divides the spatial model domain of the Basin into a gridded network of cells, applies data-driven assumptions of groundwater system properties at those cells, applies stresses such as recharge and pumping, and calculates groundwater levels in the cells and groundwater fluxes between cells by solving a system of equations based on groundwater flow principles. **Figure WB-1** shows the active extent of the WWGFM grid.

Details on the WWGFM development are provided in ***Appendix L***. Key aspects of the WWGFM include:

- Grid whose active extent covers the entire extent of the Basin, as defined by DWR;
- Four model layers representing the four primary formations in the Basin (i.e., shallow Quaternary alluvium, Kern River, Chanac, and Santa Margarita formations), consistent with the Basin's Hydrogeological Conceptual Model (HCM);
- White Wolf Fault (WWF) represented as a partial barrier to groundwater flow between the Basin and the adjacent Kern County Subbasin;[59]

[59] The WWF representation in the WWGFM falls along the Basin boundary in model layer 1, with deeper layers adjusted to the southeast to account for fault dip.

- Internal faults (i.e., the Springs Fault and Wheeler Ridge Fault) represented as partial barriers to groundwater flow;
- Ten major ephemeral streams flowing into the Basin from upslope watersheds;
- Spatially variable groundwater recharge based on the SMB;
- Evaporation from shallow groundwater that may support groundwater dependent ecosystems (GDEs); and
- Groundwater pumping from agricultural wells, estimated by the SMB, and from WRMWSD-owned wells based on pumping records.

As discussed in ***Appendix L***, the WWGFM adequately represents the historical conditions of the Basin and the calibration has been verified against recent water level measurements. Therefore, it is appropriate to use for water budget purposes. Water budget information is extracted from simulated model results for the spatial and temporal domain of interest. The land surface processes (e.g., precipitation, applied water, and plant ET) are simulated by the SMB. The SMB calculates deep percolation on a grid cell basis, which is then specified as recharge in the WWGFM. Similarly, the SMB calculates the demand that is unmet by District water deliveries and precipitation, which is specified as private irrigation well pumping in the WWGFM. Therefore, the land surface processes are integrated into the groundwater system processes. To quantify all required water budget components as specified in the 23 CCR § 354.18(b), this GSP presents results from both the SMB for the land surface system and the WWGFM for the groundwater system.

9.2.1. Land Surface System Water Budget Components

The SMB accounts for most processes relevant to the land surface system budget quantification, including the following:

Precipitation within the Basin is measured at two stations operated by the WRMWSD and one station maintained by the NOAA and is also available as a gridded dataset from PRISM. Precipitation falling on Basin lands serves to wet the near surface soil and then either evaporates, contributes to crop or natural vegetation water demand, or when intense enough, percolates through the root zone to eventually recharge groundwater. The SMB uses daily precipitation rates estimated by PRISM. The SMB uses PRISM data as input rather than the data from the individual stations because the PRISM data provides a better representation of the spatial distribution of precipitation over the entire extent of the Basin.[60]

Applied Water is a combination of the following:

- **Imported surface water** has been delivered by AEWSD, WRMWSD, and TCWD to Basin lands since 1966, 1975, and 1965, respectively.[61] Imported surface water is delivered to primarily agricultural

[60] PRISM data was compared to measured data at the stations within the Basin. Four years of PRISM data was scaled due to exceedingly high estimates compared to measured data.
[61] Discrepancies between contract dates and delivery dates reflects the period between contracting, infrastructure development, and delivering water to the Basin.

users to meet crop water demand. A small portion of imported surface water is also delivered to M&I users to meet urban demands at the Tejon Ranch Commerce Center (TRCC) or to support industrial applications, such as power generation and mining. Imported surface water is delivered to lands based on each District's surface water service area and land use. The SMB uses monthly imported surface water to attempt to meet agricultural and urban demands before calculating private pumping required to meet the remaining demand.[62]

- **Applied diversion water** is the amount of surface water diverted from streams used to meet agricultural irrigation demands. Permitted diversions from Grapevine Creek meet landscape irrigation demand for fields surrounding the TRCC and permitted diversions from El Paso, Tejon, Pastoria, and Tunis Creeks (and Reservoirs 1 and 2) meet irrigation demand for other fields located on TRC lands and/or covered by the WRMWSD service area. Applied diversions are based on monthly reported stream and reservoir diversion data.
- **Applied groundwater** is a combination of groundwater pumped from (1) WRMWSD-owned wells into their distribution system, (2) private irrigation wells which "pump in" to the WRMWSD distribution system, and (3) private irrigation wells which provide groundwater directly to crops. WRMWSD keeps records of pumping into their distribution system. Pumping from private wells directly to irrigate crops is the largest component of pumping in the Basin and is unknown. The SMB calculates this private irrigation pumping as the amount of water required to meet crop demand that cannot be met by the imported surface water, diversion water, and groundwater that has been added to the WRMWSD distribution system.

ET for developed areas (i.e., agricultural and urban lands) is estimated by monthly ITRC-METRIC remote sensing data.[63] Since the ITRC-METRIC data does not cover the entire Basin and the method is not designed for non-irrigated land uses, ET for native vegetation and fallow lands is instead estimated using a crop coefficient method that incorporates an ET stress function that reduces ET when soil moisture is low (i.e., at the wilting point). The SMB calculates an actual ET rate based on the potential ET and with consideration of the available soil moisture. See ***Appendix L*** for details.

Runoff is calculated as the amount of precipitation and applied water that does not infiltrate the soil, but rather drains off the land. The SMB calculates rainfall excess runoff based on the U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS) curve number method, with curve numbers a function of land use type, soil hydrologic group, and antecedent moisture. The SMB also calculates saturation excess runoff based on soil depth and porosity, although the occurrence of this type of runoff is very rare (i.e., only occurs on thin, low permeability soils during times of high deliveries of applied water).

[62] Imported surface water delivered by WRMWSD to M&I users are not included in the SMB. Historically, 99% of the M&I water was delivered to Pastoria Energy Facility. It is assumed that these M&I deliveries contributions to the groundwater system are negligible.

[63] The ITRC-METRIC remote sensing data was scaled on a monthly basis to account for (1) additional evaporation of ineffective precipitation during winter months that is generally not captured by remote sensing data due to the intermittent and episodic nature of rainfall events and (2) greater crop ET during summer months, as calculated by comparison to Cal-SIMETAW crop ET rates, possibly due to the ITRC-METRIC method not capturing high ET rates after irrigation events.

Root zone storage is calculated on a running basis throughout each SMB daily time step. It is increased by precipitation and applied water and decreased by ET and recharge. Soil moisture also feeds back into the calculation of curve number runoff and the ET for non-irrigated lands, as described above.

Recharge to the groundwater system is calculated by the SMB to occur when soil moisture exceeds the field capacity of the soil, after infiltration of the precipitation remaining after curve number runoff and after ET. Recharge is limited to a fraction of the saturated hydraulic conductivity of soil, and when the soil is unable to recharge the entire amount of soil moisture in excess of field capacity, the soil moisture can exceed field capacity, eventually building up to reach soil porosity and causing saturation excess runoff, although such occurrence is very rare, as mentioned above.

The WWGFM simulates stream processes relevant to the land surface system budget quantification, including the following:

Stream inflows from surrounding watersheds are specified for the ten major ephemeral streams flowing into the Basin from the east, south, and west, including Salt Creek, Tecuya Creek, Grapevine Creek, LiveOak Creek, Pastoria Creek, Tunis Creek, El Paso Creek, Tejon Creek, Chanac Creek, and Comanche Creek. Flow measurement data from these creeks are limited. Data from gauges on streams in the general vicinity but outside of the Basin indicate a highly seasonal pattern of streamflow with substantial annual variability. It is expected that most creeks flowing into the Basin exhibit similar behavior. Therefore, stream inflow is estimated as an assumed percentage of precipitation runoff from surrounding watershed areas. See ***Appendix L*** for details.

Stream diversions are specified in the WWGFM based on reported diversion data. A total of four PODs are specified – one each on Grapevine Creek, El Paso Creek, Pastoria Creek, and Tunis Creek, and the WWGFM will only divert water when adequate streamflow is available. The diversions on Grapevine Creek and El Paso Creek, located approximately where the creeks enter the Basin boundary, were extracted from the specified stream inflows prior to specification into the WWGFM.

Stream outflow is calculated by the WWGFM, after diversions and stream-groundwater interactions have occurred. Of the ten major streams entering the Basin, only four streams (Tecuya, El Paso, Tejon, and Comanche) have channels that flow out of the Basin, and into either AEWSD or WRMWSD service areas.

Stream-groundwater interactions is calculated by the WWGFM based on stream stage, assumed streambed properties and the surrounding model-calculated groundwater levels. More information is provided under the groundwater system below.

9.2.2. Groundwater System Water Budget Components

The WWGFM accounts for all water flow processes relevant to groundwater system budget quantification. Some values originate from the SMB, whereas others are direct inputs to or outputs from the WWGFM.

Recharge from excess precipitation and applied water is calculated by the SMB, as described above.

Additionally, leakage from the surface water distribution systems contributes to groundwater recharge. Leakage is estimated as 4% of the total delivered water by AEWSD, WRMWSD, and TCWD (including imported surface water, applied groundwater, and diversions).

Groundwater pumping from private irrigation wells is calculated by the SMB.[64] The SMB distributes private irrigation well pumping based on the closest well to the unmet demand. For groundwater pumping from WRMWSD-owned wells and private irrigation wells which "pump in" to the WRMWSD distribution system, reported pumping (either monthly or annual data, depending on source) was used.

Stream-groundwater interactions are calculated by the WWGFM based on stream stage, assumed streambed properties, and the surrounding model-calculated groundwater levels. Stream stage is calculated by the WWGFM based on specified stream channel properties. Flows within streams can leak to the underlying groundwater system (i.e., a losing stream condition). Alternatively, groundwater can seep into the stream (i.e., a gaining stream condition). [65] Therefore, leakage signifies a loss of streamflow to groundwater and seepage signifies a gain of streamflow from groundwater. Most of the streams entering the Basin are ephemeral and the net exchange is a leakage from surface water to groundwater.

Evaporation from shallow groundwater is evaporation that occurs directly from the groundwater system in areas of shallow groundwater conditions. This primarily occurs in areas that support GDEs. The WWGFM simulates evaporation from the water table based on an assumed evaporation extinction depth of 7 ft[66] and a monthly pan evaporation rate based on historical data from nearby stations. The maximum evaporation rate occurs when the water table is at land surface and the rate decreases linearly as water table depth increases until the rate becomes zero when the water table reaches the extinction depth.

Subsurface flow with the adjacent Kern County Subbasin is calculated by the WWGFM using a general head boundary condition. Therefore, the WWGFM calculates subsurface flow based on an assumed groundwater elevation at points in the Kern County Subbasin, distance from those points to the WWF, and fault conductance. Because the Basin is surrounded on the east, south, and west by mostly granitic and metamorphic bedrock formations, they are treated as no-flow boundaries and therefore it is assumed that the Basin does not receive subsurface inflows from these areas.

Subsurface flow with the Santa Margarita Formation (unpumped aquifer) is calculated by the WWGFM

[64] Approximately 3% (1,400 AFY) of the SMB-calculated private irrigation well pumping is not represented in the model due to either the proximity of the well locations to the White Wolf Fault and fault geometry or to assumptions on screened interval placement within model layers which may go dry during the model simulation period. In cases where the well to which SMB-calculated pumping is assigned is adjacent to the White Wolf Fault and the dip of the fault is such that the well head is located in the Basin, but the perforations are north of the fault, the pumping is assumed to occur in the Kern County Subbasin and outside the WWGFM domain.

[65] Very few modeled stream cells simulate gaining conditions. These cells are primarily located near the edges of the active model extent or near the Springs Fault. Gaining cells are most likely a function of assumptions with initial heads and/or boundary conditions.

[66] This extinction depth is consistent with the extinction depth used by Belitz et al. (1993) in their groundwater-flow model of the western San Joaquin Valley.

based on aquifer properties and specified fluxes. As described in *Section 7.1.4 Principal Aquifers and Aquitards*, the one Principal Aquifer for the Basin is defined as the combination of shallow alluvium, Kern River, and Chanac formations, which are represented as WWGFM layers 1, 2, and 3, respectively. These layers interact with layer 4 (i.e., the Santa Margarita Formation or the "unpumped aquifer") based on the vertical conductance and specified initial conditions and fluxes (i.e., pumping).

Change in groundwater storage is calculated by the WWGFM by solving the groundwater flow equation. The groundwater storage inflows and outflows extracted from the WWGFM are referenced in regard to groundwater storage instead of the groundwater system domain. For the purposes of this GSP, change in groundwater storage is calculated as the groundwater system inflows minus the groundwater system outflows. Therefore, a positive change in storage indicates an increase in groundwater storage and a negative change in storage indicates a decrease in groundwater storage.

Water budget information for the historical and current water budget periods is presented in ***Section 9.3 Historical and Current Water Budget*** below and water budget information for the projected future scenarios is presented in ***Section 9.4 Projected Water Budget*** below.

9.2.3. Temporal Coverage

23-CCR §354.18(c)(2) requires quantification of historical water budget components for at least the past 10 years. Additionally, per DWR's Water Budget BMP, the water budget should represent average hydrology, with both wet and dry years (DWR, 2016b). As shown on **Figure WB-2**, the long-term average precipitation reported at the three climate stations within the Basin ranges between 8.6 and 11.2 inches per year (in/yr). Using the historical rainfall records at these climate stations, a 34-year model period representing WY 1986-2019 was identified, containing the following time periods:

- WY 1986-1994: A nine-year preconditioning period to allow the model to stabilize from initial conditions;
- WY 1995-2014: A 20-year model calibration period and defined as the historical water budget period, representing 20 years prior to the adoption of the Sustainable Groundwater Management Act (SGMA). The average precipitation at each station over the historical water budget period (WY 1994-2014) ranges between 7.6 and 11.1 in/yr and is similar to the long-term averages. The average precipitation falling on Basin lands represented in the WWGFM between WY 1999-2014 is 9.1 in/yr (**Table WB-2**). This historical water budget time period contains a variety of water year types and therefore adequately represent average hydrologic conditions for purposes of quantifying the Basin water budget.
- WY 2015-2019: A 5-year model post-audit validation period, over which average conditions are defined for the current conditions water budget. The average precipitation falling on Basin lands represented in the WWGFM between WY 2015-2019 is 9.4 in/yr (**Table WB-2**). The current conditions time period contains a variety of water year types whereby the first half of this period represents a critically dry period and the latter half represents a more normal pattern of wetter and drier years.

Table WB-2. Annual Precipitation, WY 1995-2019

WY	Spillway Basin [in/yr]	PA-2 Pumping Plant [in/yr]	Tejon Rancho [in/yr]	WWGFM [in/yr]	DWR WY Type[b]
1995	8.5	8.8	22.8	13.4	W
1996	9.3	8.1	7.6	7.0	AN
1997	6.0	6.7	9.1	7.9	D
1998	20.6	18.8	24.4	21.5	W
1999	10.3	8.4	12.5	9.8	W
2000	4.9	5.3	9.3	8.0	D
2001	7.8	6.7	10.5	9.5	BN
2002	5.5	6.3	6.2	5.0	C
2003	9.4	9.0	13.8	12.3	BN
2004	6.4	5.8	8.0	7.6	D
2005	11.2	11.3	12.3	15.8	W
2006	7.2	7.4	8.9	8.9	W
2007	6.2	5.5	10.3	5.6	C
2008	4.5	4.6	6.0	4.2	C
2009	5.9	5.2	7.6	6.3	C
2010	9.7	8.5	13.2	10.0	AN
2011	12.2	11.4	14.8	13.1	W
2012	7.4	5.7	9.4	7.7	AN
2013	7.2	5.1	9.9	4.4	C
2014	2.9	2.6	4.7	3.1	C
2015	5.4	7.1	7.0	7.9	D
2016	6.7	6.4	11.4	6.5	AN
2017	13.1	13.9	15.0	13.7	W
2018	NA	NA	9.2	6.0	BN
2019	NA	NA	13.7	12.9	W[c]
Historical Average (WY 1995-2014)	*8.1*	*7.6*	*11.1*	*9.1*	--
Current Average (WY 2015-2019)	*8.4*	*9.1*	*11.3*	*9.4*	--

Abbreviations:

DWR = California Department of Water Resources
in/yr = inches per year
NA = not available
WWGFM = White Wolf Groundwater Flow Model
WY = Water year

Notes:

(b) See Figure WB-2 for climate station locations.
(c) DWR WY types are based on classifications for HUC8 18030003 Middle Kern-Upper Tehachapi-Grapevine (DWR, 2021), and are as follows: W = wet, AN = above normal, BN = below normal, D = dry, C = critical.
(d) DWR WY type for 2019 was unavailable, and was estimated using same methodology presented in DWR, 2021.

9.3. Historical and Current Water Budget

§ 354.18. Water Budget

(a) Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.

(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:

(1) Total surface water entering and leaving a basin by water source type.

(2) Inflow to the groundwater system by water source type, including subsurface groundwater inflow and infiltration of precipitation, applied water, and surface water systems, such as lakes, streams, rivers, canals, springs and conveyance systems.

(3) Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow.

(4) The change in the annual volume of groundwater in storage between seasonal high conditions.

(5) If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.

(6) The water year type associated with the annual supply, demand, and change in groundwater stored.

(7) An estimate of sustainable yield for the basin.

This section presents water budget results from the calibrated WWGFM and associated SMB. Results are presented below in terms of both annual values and averages during the historical water budget period (WY 1995–2014) and the current water budget period (WY 2015-2019).

9.3.1. Surface Water Inflows and Outflows

23 CCR §354.18(b)(1) requires quantification of total surface water entering and leaving the Basin by water source type. 23 CCR §351(ak) defines water source type as "the source from which water is derived to meet the applied beneficial uses, including *[…]* surface water sources identified as Central Valley Project *[(CVP)]*, the State Water Project *[(SWP)]*, *[…]* local supplies, and local imported supplies". Based on this definition, Basin surface water inflows include (1) imported surface water and (2) natural streamflow into the area from surrounding watersheds and surface water outflows include (1) natural streamflow leaving the Basin, and (2) diversions from streams. Under historical and current conditions, there are no surface water exports from the Basin. **Table WB-3** presents an annual summary of the total surface water inflows to and outflows from the Basin between WY 1995-2019. **Figure WB-3** shows the annual surface water inflows by source and, in general, surface water inflows have varied widely from year to year. Historical (WY 1995-2014) surface water inflows to the Basin averaged approximately 79,500 acre-feet per year (AFY), however current (WY 2015-2019), surface water inflows to the Basin are much less, averaging approximately 58,300 AFY. Approximately 86% of surface water historical inflows are from imported water supplies and 14% are from streamflow from surrounding watersheds.

TABLE WB-3. Annual Surface Water Inflows and Outflows by Source Type

Water Year (Oct-Sept)	INFLOWS [AFY]										OUTFLOWS [AFY]					
	Surface Water Imports (b)							*Stream Inflows*		**TOTAL SURFACE WATER INFLOWS**	*Surface Water Exports*		*Stream Outflows*			**TOTAL SURFACE WATER OUTFLOWS**
	AEWSD Imports	TCWD Imports	WRMWSD Imports		*Total Imported Surface Water*			Streamflow into Basin	*Total Stream Inflows*		Exports to MWD	*Total Surface Water Exports*	Streamflow Out of Basin	Diversions from Streams (d)	*Total Stream Outflows*	
	Agricultural	M&I	Agricultural	M&I (c)	*Agricultural*	*M&I*	*Total*									
Historical Water Budget (WY1994-2014)																
1995	22,800	100	41,200	0	*64,000*	*100*	*64,100*	21,500	*21,500*	**85,600**	0	0	2,300	300	2,600	**2,600**
1996	27,200	100	50,000	0	*77,200*	*100*	*77,300*	6,400	*6,400*	**83,700**	0	0	0	200	200	**200**
1997	24,100	100	52,700	0	*76,800*	*100*	*76,900*	8,800	*8,800*	**85,700**	0	0	0	200	200	**200**
1998	19,400	100	47,200	0	*66,600*	*100*	*66,700*	28,000	*28,000*	**94,700**	0	0	2,500	300	2,800	**2,800**
1999	22,600	100	47,100	0	*69,700*	*100*	*69,800*	9,900	*9,900*	**79,700**	0	0	0	300	300	**300**
2000	26,400	100	56,200	200	*82,600*	*300*	*82,900*	8,000	*8,000*	**90,900**	0	0	0	200	200	**200**
2001	23,800	100	41,100	200	*64,900*	*300*	*65,200*	10,500	*10,500*	**75,700**	0	0	0	200	200	**200**
2002	25,600	100	48,100	100	*73,700*	*200*	*73,900*	4,800	*4,800*	**78,700**	0	0	0	200	200	**200**
2003	24,600	100	42,500	100	*67,100*	*200*	*67,300*	13,700	*13,700*	**81,000**	0	0	0	300	300	**300**
2004	26,600	100	50,300	100	*76,900*	*200*	*77,100*	7,200	*7,200*	**84,300**	0	0	0	200	200	**200**
2005	22,000	100	43,200	1,600	*65,200*	*1,700*	*66,900*	22,800	*22,800*	**89,700**	0	0	1,300	300	1,600	**1,600**
2006	22,400	100	53,800	3,100	*76,200*	*3,200*	*79,400*	10,600	*10,600*	**90,000**	0	0	0	200	200	**200**
2007	24,600	100	52,600	3,400	*77,200*	*3,500*	*80,700*	6,600	*6,600*	**87,300**	0	0	0	300	300	**300**
2008	25,500	100	41,400	3,400	*66,900*	*3,500*	*70,400*	6,900	*6,900*	**77,300**	0	0	100	200	300	**300**
2009	23,900	100	31,300	3,400	*55,200*	*3,500*	*58,700*	7,900	*7,900*	**66,600**	0	0	0	800	800	**800**
2010	22,600	100	23,900	2,900	*46,500*	*3,000*	*49,500*	12,300	*12,300*	**61,800**	0	0	0	600	600	**600**
2011	22,300	100	45,900	2,300	*68,200*	*2,400*	*70,600*	23,000	*23,000*	**93,600**	0	0	900	3,300	4,200	**4,200**
2012	24,700	200	36,900	2,900	*61,600*	*3,100*	*64,700*	9,000	*9,000*	**73,700**	0	0	0	1,200	1,200	**1,200**
2013	26,500	200	30,300	3,500	*56,800*	*3,700*	*60,500*	4,700	*4,700*	**65,200**	0	0	0	600	600	**600**
2014	24,100	200	11,200	3,600	*35,300*	*3,800*	*39,100*	6,200	*6,200*	**45,300**	0	0	0	0	0	**0**
AVERAGE	*24,100*	*100*	*42,300*	*1,500*	*66,400*	*1,700*	*68,100*	*11,400*	*11,400*	***79,500***	*0*	*0*	*400*	*500*	*900*	***900***
%	*30%*	*0%*	*53%*	*2%*	*84%*	*2%*	*86%*	*14%*	*14%*	-	*0%*	*0%*	*44%*	*56%*	--	-
Current Water Budget (WY 2015-2019)																
2015	16,600	200	9,500	3,300	*26,100*	*3,500*	*29,600*	8,000	*8,000*	**37,600**	0	0	0	200	200	**200**
2016	17,000	300	15,900	3,400	*32,900*	*3,700*	*36,600*	8,500	*8,500*	**45,100**	0	0	0	1,300	1,300	**1,300**
2017	18,700	300	46,700	2,600	*65,400*	*2,900*	*68,300*	12,600	*12,600*	**80,900**	0	0	300	1,200	1,500	**1,500**
2018	20,500	400	26,900	3,000	*47,400*	*3,400*	*50,800*	5,500	*5,500*	**56,300**	0	0	0	100	100	**100**
2019	18,200	400	35,900	2,800	*54,100*	*3,200*	*57,300*	14,100	*14,100*	**71,400**	0	0	0	600	600	**600**
AVERAGE	*18,200*	*300*	*27,000*	*3,000*	*45,200*	*3,300*	*48,500*	*9,700*	*9,700*	***58,300***	*0*	*0*	*100*	*700*	*700*	***700***
%	*31%*	*1%*	*46%*	*5%*	*78%*	*6%*	*83%*	*17%*	*17%*	-	*0%*	*0%*	*14%*	*100%*	--	-

Abbreviations

AEWSD = Arvin-Edison Water Storage District
AFY = acre-feet per year
M&I = municipal and industrial
MWD = Metropolitan Water District
TCWD = Tejon-Castac Water District
WRMWSD = Wheeler Ridge-Maricopa Water Storage District
WWGFM = White Wolf Groundwater Flow Model
WY = Water Year

Notes

(a) All values rounded to the nearest hundred acre-feet.
(b) Surface water imports are based on surface water deliveries to customers. Actual imports may be greater due to conveyance system losses.
(c) Imported surface water delivered by WRMWSD to M&I users are not included in the Soil Moisture Budget model. Historically, 99% of the M&I water was delivered to Pastoria Energy Facility. It is assumed that these M&I deliveries contributions to the groundwater system are negligible.
(d) WWGFM-calculated value. Recorded diversions from the four PODs modeled within the Basin averaged approximately 1,200 AFY between 2008 and 2019. Discrepancies between modeled and actual diversions is attributed to data gaps associated with specified stream inflows based on simple watershed runoff calculations. Ongoing efforts to collect streamflow data during Groundwater Sustainability Plan implementation aim to reconcile discrepancies.

9.3.1.1. Imported Surface Water Supplies

Figure WB-4 presents an annual summary of surface water imports by District for WY 1995-2019. Imported surface water supplies vary greatly by volume and source depending on WY. Over WY 1995-2014, average total surface water imports into the Basin were approximately 68,100 AFY, with approximately 35% originating from AEWSD, 64% originating from WRMWSD, and less than 1% originating from TCWD. Over WY 2015-2019, average total surface water imports into the Basin were less at approximately 48,500 AFY.

AEWSD's primary source of imported water is the Friant Division of the CVP. AEWSD has a contract for 40,000 AFY of Class 1 CVP water and 311,675 AFY of Class 2 CVP water.[67] In addition to its CVP contract, AEWSD actively and regularly pursues additional water supplies through transfers, purchases, exchanges, and banking programs. Over the past 21 years, AEWSD has obtained roughly 1.49 million AF of additional water supplies through agreements with multiple entities. Furthermore, AEWSD has invested in surface water infrastructure that gives it great flexibility to move water into and out of its service area to facilitate water exchanges (see **Figure HCM-19**). AEWSD categorizes its imported surface water by source type according to the specific conveyance facility through which the water passes, as follows:

- Friant-Kern Canal (i.e., Class 1 and Class 2 Friant Division water);
- Cross Valley Canal (SWP, Kern River, and previously banked water);
- California Aqueduct (through its Intertie Pipeline, SWP and CVP water);
- Kern River;
- Deliveries from WRMWSD (originating from the California Aqueduct) to WRMWSD lands that overlap AEWSD lands; and
- "Other" infrequent supply sources, including wheeled surface water and groundwater from the adjacent Kern Delta Water District.

WRMWSD's primary source of imported water is the SWP, delivered via the California Aqueduct. WRMWSD has a contract with Kern County Water Agency (KCWA) for 197,088 AFY of Table A water from the SWP. In addition to its Table A water allocation, WRMWSD has access to Article 21 water when it is available (primarily during wet years). Pursuant to transfer agreements with partner agencies (e.g., Buena Vista Water Storage District, Tehachapi-Cummings County Water District, and others), WRMWSD has also obtained additional imported water from the SWP, the CVP, and other sources. When surplus supplies are available, WRMWSD banks water in several out-of-District (and out-of-Basin) water banks. Recovery of banked water during dry years is used to supplement SWP allocations. WRMWSD also actively and regularly pursues additional water supplies through banking programs, water transfers, and purchases. WRMWSD delivers water to both agricultural and M&I users, with agricultural users utilizing approximately 94% and M&I users utilizing 6% of total WRMWSD delivered water in recent years (i.e., WY

[67] https://www.usbr.gov/mp/cvp-water/docs/latest-water-contractors.pdf

2015-2019).[68]

Finally, TCWD imports a small amount of SWP water delivered via the California Aqueduct to supply the TRCC. TCWD has a contract with KCWA for 5,278 AFY of Table A water from the SWP (62% designated for agricultural uses and 38% designated for M&I uses) and 6,693 AFY of Kern River water. Additional imported water supplies include exchanges with other contractor(s), water rights to high flows in the Lower Kern River through the KCWA, and water banking with the Kern Water Bank and Pioneer Project.

Historical Surface Water Availability and Reliability

As described above, AEWSD's only contracted source of surface water supply is its Class 1 and Class 2 contract for CVP (Friant Division) water, at 40,000 AFY and 311,675 AFY, respectively. AEWSD has received its full Friant Class 1 allocation a total of 38 times in the 54 years since deliveries began in 1966, and in 16 out of 20 years over the historical water budget period (WY 1995-2014). The average annual volume of Class 1 Friant water delivered to the AEWSD over WY 1995-2014 is 35,700 AFY, and the total average volume of Friant water (including Class 1, Class 2 and other supplies) is 98,000 AFY.

The only contracted source of surface water supply for WRMWSD is its SWP supply contract with KCWA for 197,088 AFY of Table A water. Over the historical water budget period (WY 1995-2014), WRMWSD received an average allocation (entitlement) of approximately 64% (126,000 AFY) of this contractual amount.

Historically, TCWD has utilized only a fraction of its SWP supply contract with KCWA for 5,278 AFY of Table A water for distribution to the TRCC. Under current conditions (WY 2015-2019), the average annual volume of SWP water delivered to the TRCC by TCWD was approximately 320 AFY, or 6% of its contractual amount. Due to TCWD's water banking operations with the Kern Water Bank and Pioneer Project, TCWD's imported surface water is considered reliable even in drought years.

Figure WB-5 presents an annual breakdown of total imported water by AEWSD, TCWD, and WRMWSD relative to existing contract volumes. The large inter-annual variability in supply indicates that, while imported CVP and SWP water remains the primary and most important source to the Basin, its reliability is not assured and has been impacted significantly in recent years due to natural drought, federal court rulings and other regulatory measures, and subsidence, which has impacted conveyance capacity of the Friant-Kern Canal. For this reason, the AEWSD and WRMWSD actively and regularly pursue additional water supplies through transfers, purchases, exchanges, and banking programs, as well as supporting efforts to increase the conveyance capacity and yields from the Friant Division.

Figure WB-6 presents the combined cumulative total imported surface water into the Basin since 1966.

---

[68] Imported surface water delivered by WRMWSD to M&I users are not included in the SMB. Historically, 99% of the M&I water was delivered to Pastoria Energy Facility. It is assumed that these M&I deliveries contributions to the groundwater system are negligible.

9.3.1.2. Natural Streamflow

Historical (WY 1995-2014) streamflow into the Basin from adjacent watersheds was estimated to average approximately 11,400 AFY. This is similar to the volume estimated using results from the USGS Basin Characterization Model (Flint et al., 2013) for the period 1981-2010 (9,700 AFY) which suggests that estimated streamflow from adjacent watersheds is reasonable.

Within the Basin, streamflow is diverted for irrigation purposes at PODs along streams. Based on results from the WWGFM, diversions from the four PODs within the modeled domain were estimated to average approximately 500 AFY, with large variability due to WY type and the associated availability of streamflow. Modeled diversions are less than recorded diversions due to uncertainties with specified stream inflows.[69]

Almost all of the streamflow entering the Basin either percolates to the groundwater system, is diverted for agricultural use, or evaporates to the atmosphere. There is anecdotal evidence that during some storm events El Paso Creek has occasionally flowed out of the Basin and caused some flooding in the Kern County Subbasin. However, the frequency of occurrence and quantity of El Paso Creek flows into the Kern County Subbasin are unknown. Based on visual accounts, there was some surface water outflow in 1998, 2003, 2005, and 2017 during major storm events where runoff flowed north out of the Basin.[70] Based on results from the WWGFM, as shown in **Table WB-3**, there are minimal surface water outflows from the Basin represented in the water budget. These outflow events typically coincide with winter months of wetter years.

9.3.2. Land Surface System Inflows and Outflows

As mentioned above, most of the land surface system processes are simulated by the SMB. **Figure WB-7** provides an annual summary of inflows to and outflows from the SMB land surface system by water source type for WY 1995-2019.

Figure WB-8 provides a summary of the historical (WY 1995-2014) long-term annual average inflows to and outflows from the land surface system. As shown in **Table WB-4**, total historical (WY 1995-2014) inflows to the land surface system averaged approximately 191,000 AFY. Approximately 43% of total inflows to the land surface system were from precipitation and 57% were from applied water (including imported surface water, diverted water from streams, and groundwater). Total outflows from the land surface system averaged almost 192,000 AFY for the same 20-year period. Approximately 74% of total outflows from the land surface system were from ET, 2% to runoff, and 23% to deep percolation to the groundwater system. Within the land use categories, ET of agricultural areas is approximately 61% of the Basin outflows, ET of native areas is approximately 13% of the Basin outflows, and ET of urban areas is

---

[69] Recorded diversions from the four PODs modeled within the Basin averaged approximately 1,000 AFY between 2008 and 2019. Discrepancies between modeled and actual diversions is attributed to data gaps associated with specified stream inflows based on simple watershed runoff calculations (see ***Section 9.5.3 Data Gaps***). Ongoing efforts to collect streamflow data during GSP implementation aim to reconcile discrepancies.

[70] Personal communication, Tom Suggs, WRMWSD.

less than 1% of the Basin outflows. The small difference between average inflows to, and outflows from the land surface system (-700 AFY) is attributed to a change in root zone storage.

TABLE WB-4. Annual Land Surface System Imflows and Outflows

Water Year (Oct-Sept)	INFLOWS (AFY)			OUTFLOWS (AFY)						Change in Root Zone Storage (AFY)(c)
	Precipitation	Applied Water(b)	TOTAL INFLOWS	Actual Evapotranspiration			Runoff	Recharge to Groundwater System	TOTAL OUTFLOWS	
				Agricultural	Urban	Native				
Historical Water Budget (WY 1995-2014)										
1995	120,000	95,900	**215,900**	134,600	1,200	48,900	7,900	35,700	**228,300**	-12,400
1996	63,200	118,000	**181,200**	115,700	700	21,600	2,000	42,300	**182,300**	-1,100
1997	70,700	113,700	**184,400**	107,400	800	24,800	2,400	46,400	**181,800**	2,600
1998	192,800	90,400	**283,200**	126,200	1,000	30,100	15,600	92,300	**265,200**	18,000
1999	88,200	95,900	**184,100**	123,000	700	17,400	5,800	58,700	**205,600**	-21,500
2000	71,700	111,500	**183,200**	103,500	600	10,900	4,000	65,600	**184,600**	-1,400
2001	85,100	100,400	**185,500**	112,200	800	21,500	6,200	42,300	**183,000**	2,500
2002	44,900	114,100	**159,000**	105,400	800	15,300	1,400	36,800	**159,700**	-700
2003	110,400	99,600	**210,000**	120,700	1,200	37,200	8,100	39,100	**206,300**	3,700
2004	68,600	116,900	**185,500**	124,400	1,000	23,100	4,500	35,800	**188,800**	-3,300
2005	142,100	87,600	**229,700**	116,300	1,500	45,100	9,000	52,100	**224,000**	5,700
2006	80,000	106,000	**186,000**	101,800	900	29,200	5,800	52,300	**190,000**	-4,000
2007	50,400	132,500	**182,900**	132,800	1,100	17,600	1,500	30,500	**183,500**	-600
2008	37,600	130,700	**168,300**	120,300	800	14,800	600	32,600	**169,100**	-800
2009	56,700	122,600	**179,300**	121,800	700	20,800	900	35,500	**179,700**	-400
2010	90,000	105,400	**195,400**	119,700	700	32,000	2,400	38,900	**193,700**	1,700
2011	118,100	100,800	**218,900**	112,300	600	38,500	11,100	56,000	**218,500**	400
2012	69,600	114,500	**184,100**	114,700	500	24,100	4,300	41,500	**185,100**	-1,000
2013	39,500	127,800	**167,300**	120,700	500	14,100	500	32,100	**167,900**	-600
2014	28,100	111,000	**139,100**	101,500	400	9,900	600	27,000	**139,400**	-300
AVERAGE	81,400	109,800	**191,200**	116,800	800	24,800	4,700	44,700	**191,800**	-700
%	43%	57%	--	61%	0%	13%	2%	23%	--	
Current Water Budget (WY 2015-2019)										
2015	71,200	90,900	**162,100**	103,600	900	22,600	2,300	27,200	**156,600**	5,500
2016	58,100	98,700	**156,800**	107,200	600	20,900	800	32,100	**161,600**	-4,800
2017	123,100	113,800	**236,900**	132,000	800	33,900	8,100	61,600	**236,400**	500
2018	54,000	121,800	**175,800**	123,800	600	18,000	2,600	31,700	**176,700**	-900
2019	116,000	111,100	**227,100**	141,700	900	38,700	4,300	41,500	**227,100**	0
AVERAGE	84,500	107,300	**191,700**	121,700	800	26,800	3,600	38,800	**191,700**	100
%	44%	56%	--	63%	0%	14%	2%	20%	--	--

Abbreviations

AFY = acre-feet per year
WY = Water Year

Notes

(a) All values rounded to the nearest hundred acre-feet.
(b) Applied water includes imported surface water, diverted water from streams, and groundwater.
(c) Change in root zone storage calculated as the difference between inflows and outflows.

9.3.3. Groundwater System Inflows and Outflows

Per 23 CCR §354.18(b)(2) and (b)(3), **Table WB-5** and **Figure WB-9** provide an annual summary of inflows to and outflows from the groundwater system by water source type for WY 1995-2019. As evident from these two exhibits (as well as the groundwater hydrographs shown in **Figure GWC-5** and **Figure GWC-6**), the groundwater system is highly sensitive to climatic conditions and AEWSD and WRMWSD operations. As such, annual inflows and outflows vary widely depending on availability of surface water supplies to meet irrigation demands.

Figure WB-10 provides a summary of historical long-term annual average inflows to and outflows from the groundwater system. The total inflows to the groundwater system averaged 56,500 AFY over WY 1995-2014. During this period, approximately 85% of total inflows to the groundwater system were from infiltration of applied water, precipitation, or infiltration from leaking distribution and conveyance channels; 15% was from net leakage from streams; and 0% was from net subsurface groundwater flow from the unpumped aquifer. Total outflows from the groundwater system averaged 53,300 AFY over WY 1995-2014. Approximately 77% of total outflows from the groundwater system was from pumping; 5% was from evaporation of shallow groundwater in the vicinity of GDEs; and 18% was net subsurface outflow to the Kern County Subbasin across the WWF. Therefore, over the historical period WY 1995-2014, there were more inflows to the groundwater system than outflows from the groundwater system resulting in a net accretion of groundwater storage of approximately 3,200 AFY.

Figure WB-11 provides a summary of current annual average inflows to and outflows from the groundwater system. The total inflows to the groundwater system averaged 49,500 AFY over WY 2015-2019. During this period, approximately 84% of total inflows to the groundwater system were from infiltration of applied water, precipitation, or infiltration from leaking distribution and conveyance channels; 16% was from net leakage from streams; and less than 1% was from net subsurface groundwater flow from the unpumped aquifer. Total outflows from the groundwater system averaged 69,800 AFY over WY 2015-2019. Approximately 84% of total outflows from the groundwater system was from pumping; 3% was from evaporation of shallow groundwater in the vicinity of GDEs; and 13% was net subsurface outflow to the Kern County Subbasin along the WWF. Therefore, over the current period WY 2015-2019, there were more outflows from the groundwater system than inflows to the groundwater system resulting in a net decrease in groundwater storage of approximately 20,300 AFY.

TABLE WB-5. Annual Groundwater System Inflows and Outflows

Water Year (Oct-Sept)	INFLOWS (AFY)						OUTFLOWS (AFY)					CHANGE IN STORAGE	
	Infiltration[b]			Net Streamflow Leakage to Groundwater	Net Subsurface Groundwater Flow from Unpumped Aquifer	TOTAL INFLOWS	Groundwater Extractions		Evaporation of Shallow Groundwater/ GDEs	Net Subsurface Groundwater Flow to Kern County Subbasin	TOTAL OUTFLOWS	Change in Groundwater Storage (AFY) [d]	*Cumulative Change in Groundwater Storage Since WY 1995 (AF)*
	Agricultural	Urban	Native				Agricultural Wells[c]	M&I Wells					
Historical Water Budget (WY1994-2014)													
1995	34,400	900	3,200	14,000	-200	**52,300**	29,400	0	3,100	10,000	**42,500**	**9,800**	*9,800*
1996	42,000	1,200	2,300	5,400	0	**50,900**	38,100	0	2,800	9,100	**50,000**	**900**	*10,700*
1997	45,800	1,200	2,600	7,600	100	**57,300**	34,300	0	2,700	8,200	**45,200**	**12,100**	*22,800*
1998	68,400	1,100	25,600	18,900	-300	**113,700**	21,700	0	3,300	7,800	**32,800**	**80,900**	*103,700*
1999	58,900	200	2,600	8,300	-100	**69,900**	24,200	0	3,600	8,300	**36,100**	**33,800**	*137,500*
2000	66,300	200	2,600	6,500	-100	**75,500**	26,700	0	4,000	8,600	**39,300**	**36,200**	*173,700*
2001	42,500	600	2,100	8,400	-100	**53,500**	33,800	0	3,600	8,800	**46,200**	**7,300**	*181,000*
2002	37,600	600	1,700	4,200	100	**44,200**	38,300	0	3,200	9,200	**50,700**	**-6,500**	*174,500*
2003	39,200	600	2,100	11,100	-100	**52,900**	30,600	0	3,100	9,300	**43,000**	**9,900**	*184,400*
2004	36,600	600	1,800	6,000	0	**45,000**	38,000	0	2,900	9,200	**50,100**	**-5,100**	*179,300*
2005	44,100	700	10,000	15,600	-300	**70,100**	20,800	0	2,900	9,600	**33,300**	**36,800**	*216,100*
2006	52,000	1,300	2,200	8,800	-200	**64,100**	28,000	0	2,900	9,600	**40,500**	**23,600**	*239,700*
2007	31,500	700	1,600	5,700	100	**39,600**	52,900	0	2,600	10,200	**65,700**	**-26,100**	*213,600*
2008	33,300	700	2,000	5,400	100	**41,500**	60,800	0	2,500	10,100	**73,400**	**-31,900**	*181,700*
2009	35,200	600	2,800	6,200	200	**45,000**	64,400	0	2,600	10,200	**77,200**	**-32,200**	*149,500*
2010	38,100	700	3,100	10,100	100	**52,100**	56,900	0	2,500	9,700	**69,100**	**-17,000**	*132,500*
2011	53,500	900	4,800	15,300	-100	**74,400**	30,100	0	2,600	9,400	**42,100**	**32,300**	*164,800*
2012	41,500	400	2,800	7,000	100	**51,800**	50,600	0	2,500	9,600	**62,700**	**-10,900**	*153,900*
2013	32,300	200	2,800	3,600	400	**39,300**	67,800	0	2,300	9,800	**79,900**	**-40,600**	*113,300*
2014	27,900	100	1,500	5,500	500	**35,500**	72,200	0	2,100	10,300	**84,600**	**-49,100**	*64,200*
AVERAGE	*43,100*	*700*	*4,000*	*8,700*	*0*	***56,500***	*41,000*	*0*	*2,900*	*9,400*	***53,300***	**3,200**	--
%	*76%*	*1%*	*7%*	*15%*	*0%*	--	*77%*	*0%*	*5%*	*18%*	**--**	--	--
Current Water Budget (WY 2015-2019)													
2015	27,400	100	1,800	7,000	600	**36,900**	62,300	0	2,100	10,400	**74,800**	**-37,900**	*26,300*
2016	32,000	200	2,400	6,600	500	**41,700**	63,200	0	2,000	10,700	**75,900**	**-34,200**	*-7,900*
2017	52,600	500	11,500	9,300	100	**74,000**	44,700	0	2,000	9,600	**56,300**	**17,700**	*9,800*
2018	31,900	200	2,400	4,500	500	**39,500**	69,900	200	1,900	8,300	**80,300**	**-40,800**	*-31,000*
2019	39,200	400	4,600	11,200	400	**55,800**	51,900	100	1,900	7,600	**61,500**	**-5,700**	*-36,700*
AVERAGE	*36,600*	*300*	*4,500*	*7,700*	*400*	***49,500***	*58,400*	*100*	*2,000*	*9,300*	***69,800***	**-20,300**	--
%	*74%*	*1%*	*9%*	*16%*	*1%*	--	*84%*	*0%*	*3%*	*13%*	**--**	--	--

Abbreviations

AF	= acre-feet
AFY	= acre-feet per year
GDEs	= Groundwater Dependent Ecosystems
M&I	= municipal and industrial
WRMWSD	= Wheeler Ridge-Maricopa Water Storage District
WY	= Water Year

Notes

(a) All values rounded to the nearest hundred acre-feet.
(b) Infiltration represents recharge to the groundwater system originating from precipitation, applied water, or leakage from distribution and conveyance systems.
(c) Agricultural wells includes both private irrigation wells and WRMWSD wells.
(d) Change in groundwater storage calculated as the difference between inflows and outflows.

9.3.4. Change in Groundwater Storage

Per 23 CCR §354.18(b)(4), **Figure WB-12** and **Table WB-6** present the annual and cumulative change in groundwater storage between seasonal high conditions, which are defined in this GSP to be March through February of the following year. Note that this time window is distinct from DWR's definition of the "Water Year"; thus the values presented in **Table WB-6** are slightly different than the annual and cumulative change in storage estimates provided for DWR WY 1995-2019 in **Figure WB-13**, **Figure WB-14**, and **Table WB-7**.

Annual change in groundwater storage in the Basin averaged approximately -1,200 AFY between seasonal high conditions for the historical and current period of record (March 1995 – February 2019), with a cumulative change in storage of approximately -27,700 AF over the same period of record. However, as seen in **Figure WB-12**, change in storage varied widely between years with much of the storage accretion occurring before 2007 and much of the storage depletion occurring thereafter.

Per 23 CCR §354.18(b)(5), **Figure WB-13**, **Figure WB-14**, and **Table WB-7** compare the DWR WY type to the annual groundwater supply (i.e., inflows), demand (i.e., outflows), change in storage, and cumulative change in storage in the Basin for WY 1995–2019. These exhibits depict a clear relationship between change in groundwater storage to WY type, whereby change in storage becomes more positive with increasing "wet" conditions and more negative with increasing "dry" conditions. The net benefit of a "wet" period on groundwater conditions is especially evident in WY 1995-2000 (average storage change of +29,000 AFY), whereas the impact of a severe multi-year drought is evident in WY 2013-2015 (average storage change of -42,500 AFY). Furthermore, available supply was much more prevalent pre-2008 resulting in a large increase in groundwater storage. As surface water reliability and drought conditions have significantly reduced available supply, groundwater storage has decreased under current conditions. As discussed above in *Section 9.3.3 Groundwater System Inflows and Outflows*, change in groundwater storage over the historical (WY 1995-2014) period averaged 3,200 AFY whereas change in groundwater storage over the current (WY 2015-2019) period averaged -23,200 AFY. **Figure WB-13** shows that over the WY 1995-2019 period, supplies to the groundwater system (inflows) have remained stable to decreasing (average decrease of approximately 900 AFY) but demands on the groundwater system (outflows) continue to increase, especially since WY 2006 (average increase of approximately 1,600 AFY).

Section 8.3 Change in Groundwater Storage reports values for change in storage based on interpolated groundwater levels and the WWGFM-calibrated specific yield value (0.12). **Figure WB-15** shows a comparison of the WWGFM-based transient change in storage against the water level-based change in storage values. The water level-based storage change values were determined for the irrigated part of the Basin (approximately 35,000 acres). Storage change in areas of the Basin outside of the irrigated areas is assumed to be negligible over the long term. As shown on **Figure WB-15**, the WWGFM matches the water level-based change in storage estimates.

Table WB-6. Annual and Cumulative Change in Groundwater Storage between Seasonal Highs (March–February)

Period of Reference [m/yy]	Annual Change in Groundwater Storage [AFY]	Cumulative Change in Groundwater Storage [AF]
3/95 - 2/96	9,900	9,900
3/96 - 2/97	5,400	15,300
3/97 - 2/98	38,400	53,700
3/98 - 2/99	56,100	109,800
3/99 - 2/00	32,900	142,700
3/00 - 2/01	34,200	176,900
3/01 - 2/02	-1,500	175,400
3/02 - 2/03	2,500	177,900
3/03 - 2/04	3,700	181,600
3/04 - 2/05	12,800	194,400
3/05 - 2/06	24,700	219,100
3/06 - 2/07	8,400	227,500
3/07 - 2/08	-25,800	201,700
3/08 - 2/09	-29,400	172,300
3/09 - 2/10	-32,400	139,900
3/10 - 2/11	800	140,700
3/11 - 2/12	22,600	163,300
3/12 - 2/13	-20,800	142,500
3/13 - 2/14	-46,300	96,200
3/14 - 2/15	-42,100	54,100
3/15 - 2/16	-38,800	15,300
3/16 - 2/17	-1,500	13,800
3/17 - 2/18	-19,800	-6,000
3/18 - 2/19	-21,700	-27,700
TOTAL	-27,700	-27,700
AVERAGE	-1,200	-

Abbreviations:
AF = acre-feet
AFY = acre-feet per year
m = month
yy = year

Notes:
(a) Values rounded to the nearest hundred acre-feet.

Table WB-7. Annual Groundwater System Supplies, Demands, and Change in Groundwater Storage vs. DWR Water Year Type

Water Year (Oct-Sept)	DWR Water Year Type[(a)]	Supply [AFY]	Demand [AFY]	Annual Change in Groundwater Storage [AFY]	Cumulative Change in Groundwater Storage [AF]
Historical Water Budget (WY 1995-2014)					
1995	W	52,300	42,500	9,800	9,800
1996	AN	50,900	50,000	900	10,700
1997	D	57,300	45,200	12,100	22,800
1998	W	113,700	32,800	80,900	103,700
1999	W	69,900	36,100	33,800	137,500
2000	D	75,500	39,300	36,200	173,700
2001	BN	53,500	46,200	7,300	181,000
2002	C	44,200	50,700	-6,500	174,500
2003	BN	52,900	43,000	9,900	184,400
2004	D	45,000	50,100	-5,100	179,300
2005	W	70,100	33,300	36,800	216,100
2006	W	64,100	40,500	23,600	239,700
2007	C	39,600	65,700	-26,100	213,600
2008	C	41,500	73,400	-31,900	181,700
2009	C	45,000	77,200	-32,200	149,500
2010	AN	52,100	69,100	-17,000	132,500
2011	W	74,400	42,100	32,300	164,800
2012	AN	51,800	62,700	-10,900	153,900
2013	C	39,300	79,900	-40,600	113,300
2014	C	35,500	84,600	-49,100	64,200
Current Water Budget (WY 2015-2019)					
2015	D	36,900	74,800	-37,900	26,300
2016	AN	41,700	75,900	-34,200	-7,900
2017	W	74,000	56,300	17,700	9,800
2018	BN	39,500	80,300	-40,800	-31,000
2019	W	55,800	61,500	-5,700	-36,700

Abbreviations:
AFY = acre-feet per year
DWR = California Department of Water Resources

Notes:
(a) DWR Water Year Types are as follows: W = wet, AN = above normal, BN = below normal, D = dry, C = critical. Colors indicate Water Year Type where green is wet and red is dry and are consistent with those plotted on **Figure WB-14**.
(b) Values rounded to the nearest hundred acre-feet.

Sources:
(1) DWR Water Year Type is from DWR (2021).

9.3.5. Total Basin Inflows and Outflows

Per 23-CCR §354.18(c)(1), **Table WB-8** and **Figure WB-16** summarizes total inflows and outflows in the Basin for WY 1995-2019, which includes the current water budget period of WY 2015-2019.

Quantitative Assessment of Historical Water Budget

The 20-year historical water budget period (WY 1995-2014) included six "critical" (dry) years, three dry years, two below normal years, three above normal years, and six wet years (DWR, 2021). The first third of this period was relatively wet, the middle third was a mix of wet and dry years, and the last third of the period was extremely dry. This climatic pattern is clearly reflected in the water budget for the Basin, whereby the groundwater system shows consistent increases in storage with “wetter” conditions and decreases in storage under “drier” conditions (see **Figure WB-13, Figure WB-14** and **Table WB-7**).

Figure WB-17 provides a summary of average historical total Basin inflows and outflows. Under historical conditions, total inflows to the Basin were comprised of 51% precipitation, 41% surface water imports, 7% of natural streamflow, 1% of applied groundwater from wells screened within Kern County Subbasin, and less than 1% of subsurface groundwater inflow and root zone storage change. Total outflows from the Basin were comprised of 87% ET (consumptive use by vegetation), 2% evaporation of shallow groundwater near GDEs, 3% runoff, 6% net subsurface outflow to the Kern County Subbasin, less than 1% of streamflow, and 2% change in groundwater storage.

Quantitative Assessment of Current Water Budget

The 5-year current water budget period (WY 2015-2019) included one dry year, one below normal year, one above normal year, and two wet years (DWR, 2021) and is representative of a period in time following perhaps the worst drought condition in recent history within the region. Per 23 CCR §354.18(d)(1), **Table WB-8** and **Figure WB-16** provide a tabular and graphical breakdown of total Basin inflows and outflows for WY 1995-2019, which includes the current water budget period (WY 2015-2019). **Figure WB-18** provides a summary of average current annual total Basin inflows and outflows.

Under current conditions, total inflows to the Basin were comprised of 52% precipitation, 29% surface water imports, 1% of applied groundwater from wells screened within Kern County Subbasin, 6% of natural streamflow, less than 1% of subsurface groundwater inflow, and 12% change in groundwater storage. Total outflows from the Basin were comprised of 91% ET (consumptive use by vegetation), 2% evaporation of shallow groundwater near GDEs, 2% runoff, 6% net subsurface outflow to the Kern County Subbasin, and less than 1% of streamflow and change in root zone storage. Compared to the historical water budget period, surface water imports decreased and ET increased.

As evident from these water budget values, the Basin (like nearly all areas in San Joaquin Valley as a whole) was impacted significantly by the extreme drought conditions of WY 2013-2016, resulting in a net loss of approximately 162,000 AF of groundwater storage during this timeframe. Although subsequent WYs 2017-2019 have varied between wet and below normal, water levels and groundwater storage have not yet exhibited a recovery.

TABLE WB-8. Annual Inflows to and Outflows from the Basin, and Change in Storage

Water Year (Oct-Sept)	INFLOWS [AFY]						OUTFLOWS [AFY]							CHANGE IN STORAGE [AFY][b]	
	Subsurface Groudwater Flow	Precipitation	Surface Water Imports	Applied GW from Kern County Subbasin Wells[c]	Streamflow	**TOTAL INFLOWS**	Evapo-transpiration	Evaporation of Shallow Groundwater/GDEs	Surface Water Exports	Streamflow	Runoff	Subsurface Groundwater Flow	**TOTAL OUTFLOWS**	**Groundwater Storage Change**	**Root Zone Storage Change**
Historical Water Budget (WY 1995-2014)															
1995	-100	120,000	64,100	1,200	21,500	**206,700**	184,700	3,100	0	2,300	7,900	9,500	**207,500**	**10,400**	*-12,400*
1996	100	63,200	77,300	1,600	6,400	**148,600**	138,000	2,800	0	0	2,000	8,700	**151,500**	**1,400**	*-1,100*
1997	200	70,700	76,900	1,400	8,800	**158,000**	133,000	2,700	0	0	2,400	7,900	**146,000**	**12,500**	*2,600*
1998	-200	192,800	66,700	1,000	28,000	**288,300**	157,300	3,300	0	2,500	15,600	7,700	**186,400**	**81,100**	*18,000*
1999	-100	88,200	69,800	1,000	9,900	**168,800**	141,100	3,600	0	0	5,800	8,200	**158,700**	**33,900**	*-21,500*
2000	0	71,700	82,700	1,300	8,000	**163,700**	115,000	4,000	0	0	4,000	8,300	**131,300**	**36,600**	*-1,400*
2001	0	85,100	65,000	900	10,500	**161,500**	134,500	3,600	0	0	6,200	8,400	**152,700**	**7,800**	*2,500*
2002	200	44,900	73,800	1,100	4,800	**124,800**	121,500	3,200	0	0	1,400	8,600	**134,700**	**-5,900**	*-700*
2003	0	110,400	67,200	1,000	13,700	**192,300**	159,100	3,100	0	0	8,100	8,700	**179,000**	**10,500**	*3,700*
2004	100	68,600	77,000	1,000	7,200	**153,900**	148,500	2,900	0	0	4,500	8,600	**164,500**	**-4,500**	*-3,300*
2005	-200	142,100	65,300	800	22,800	**230,800**	162,900	2,900	0	1,300	9,000	9,200	**185,300**	**37,300**	*5,700*
2006	-100	80,000	76,300	800	10,600	**167,600**	131,900	2,900	0	0	5,800	9,200	**149,800**	**24,100**	*-4,000*
2007	200	50,400	77,300	1,100	6,600	**135,600**	151,500	2,600	0	0	1,500	9,500	**165,100**	**-25,300**	*-600*
2008	200	37,600	67,000	1,400	6,900	**113,100**	135,900	2,500	0	100	600	9,400	**148,500**	**-31,200**	*-800*
2009	300	56,700	55,300	1,200	7,900	**121,400**	143,300	2,600	0	0	900	9,400	**156,200**	**-31,300**	*-400*
2010	200	90,000	46,600	800	12,300	**149,900**	152,400	2,500	0	0	2,400	9,000	**166,300**	**-16,300**	*1,700*
2011	0	118,100	68,300	600	23,000	**210,000**	151,400	2,600	0	900	11,100	8,900	**174,900**	**32,900**	*400*
2012	200	69,600	61,800	1,000	9,000	**141,600**	139,300	2,500	0	0	4,300	9,100	**155,200**	**-10,400**	*-1,000*
2013	500	39,500	57,000	1,400	4,700	**103,100**	135,300	2,300	0	0	500	9,200	**147,300**	**-40,000**	*-600*
2014	600	28,100	35,500	1,700	6,200	**72,100**	111,800	2,100	0	0	600	9,600	**124,100**	**-48,500**	*-300*
AVERAGE	**100**	**81,400**	**66,500**	**1,100**	**11,400**	**160,600**	**142,400**	**2,900**	**0**	**400**	**4,700**	**8,900**	**159,300**	**3,800**	-700
%	*0%*	*51%*	*41%*	*1%*	*7%*	-	*89%*	*2%*	*0%*	*0%*	*3%*	*6%*	-	-	-
Current Water Budget (WY 2015-2019)															
2015	700	71,200	26,000	1,300	8,000	**107,200**	127,100	2,100	0	0	2,300	9,900	**141,400**	**-37,400**	*5,500*
2016	500	58,100	35,100	1,000	8,500	**103,200**	128,700	2,000	0	0	800	10,400	**141,900**	**-34,000**	*-4,800*
2017	100	123,100	68,300	1,400	12,600	**205,500**	166,700	2,000	0	300	8,100	9,500	**186,600**	**17,700**	*500*
2018	600	54,000	50,800	2,000	5,500	**112,900**	142,400	1,900	0	0	2,600	8,200	**155,100**	**-40,800**	*-900*
2019	500	116,000	54,000	1,500	14,100	**186,100**	181,300	1,900	0	0	4,300	7,600	**195,100**	**-5,900**	*0*
AVERAGE	**500**	**84,500**	**46,800**	**1,400**	**9,700**	**143,000**	**149,200**	**2,000**	**0**	**100**	**3,600**	**9,100**	**164,000**	**-20,200**	*100*
%	*0%*	*59%*	*33%*	*1%*	*7%*	-	*91%*	*1%*	*0%*	*0%*	*2%*	*6%*	-	-	-

Abbreviations

AF = acre-feet
AFY = acre-feet per year
GW = groundwater
M&I = municipal & industrial
SMB = Soil moisture budget accounting model
WWGFM = White Wolf Groundwater Flow Model
WY = Water Year

WWGFM output
SMB output

Notes

(a) All values rounded to the nearest hundred acre-feet.
(b) Differences between Basin inflows, outflows, and storage change are on average 1% and can be attributed to rounding errors and minor inconsistencies of water budget component representations between the SMB and WWGFM.
(c) In cases where the well to which SMB-calculated pumping is assigned is adjacent to the White Wolf Fault and the dip of the fault is such that the well head is located in the Basin, but the perforations are north of the fault, the pumping is assumed to occur in the Kern County Subbasin and outside the WWGFM domain.

9.3.6. Overdraft Conditions

The Basin is a medium-priority basin and is not designated as being in a condition of critical overdraft by DWR in its latest version of *Bulletin 118 – California's Groundwater* (DWR, 2016c). In fact, the Basin was one point away from being prioritized as a "Low Priority" basin during DWR's 2019 basin prioritization. With respect to overdraft conditions and basins subject to those conditions, DWR has made the following statements:

- "A basin is subject to critical conditions of overdraft when continuation of present water management practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts." (DWR, 1980)
- Groundwater overdraft is "... the condition of a groundwater basin or subbasin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years, during which the water supply conditions approximate average conditions. Overdraft can be characterized by groundwater levels that decline over a period of years and never fully recover, even in wet years. If overdraft continues for a number of years, significant adverse impacts may occur, including increased extraction costs, costs of well deepening or replacement, land subsidence, water quality degradation, and environmental impacts." (DWR, 2003)
- "Overdraft occurs where the average annual amount of groundwater extraction exceeds the long-term average annual supply of water to the basin. Effects of overdraft result can include seawater intrusion, land subsidence, groundwater depletion, and/or chronic lowering of groundwater levels".[71]

In evaluating basins for critical overdraft conditions in its most recent Bulletin 118 update, DWR considered the time period from WY 1989-2009. This period excludes the recent drought which began in 2012, includes both wet and dry periods, is at least 10 years in length, and includes precipitation close to the long-term average; these were all criteria used in selecting the time period.

The historical water budget information discussed herein covers the period from WY 1995-2014[72] (i.e., it does not cover the entire period used in DWR's evaluation). Over the historical water budget period, the average annual change in storage was 3,200 AFY. However, within the period covered by the historical water budget, the timeframe between WY 1997-2009 (October 1996 through September 2009) meets all of the same criteria. During this 13-year period, the cumulative departure in statewide average precipitation increased by approximately 9% (DWR, 2016c Figure 1), indicating that, on average, each year was less than 1% wetter than the long-term average. Over this time period, the cumulative change in storage within the Basin increased by approximately 139,000 AF, averaging 10,700 AFY. Therefore, by this metric, and DWR's description of overdraft on their website (see footnote 71), the Basin as a whole is <u>not</u>

[71] https://water.ca.gov/Programs/Groundwater-Management/Bulletin-118/Critically-Overdrafted-Basins, accessed 1 July 2018.

[72] This timeframe is consistent with the water budgeting timeframes incorporated into basin-level modeling efforts for the Kern County Subbasin.

in a condition of critical overdraft[73].

9.3.7. Sustainable Yield

SGMA defines sustainable yield as "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result" (CWC, §10721(w)). DWR's Water Budget BMP (DWR, 2016b) further states that "Water budget accounting information should directly support the estimate of sustainable yield for the basin and include an explanation of how the estimate of sustainable yield will allow the basin to be operated to avoid locally defined undesirable results." Inherent to the codified definition and the BMP statement is the avoidance of Undesirable Results, which include significant and unreasonable effects for any of the six SGMA sustainability indicators. Therefore, determination of the sustainable yield for the Basin depends upon how the Undesirable Results are defined.

While no exact method for defining the sustainable yield is required by SGMA or promoted by DWR in its Water Budget BMP, the BMP does emphasize that water budget accounting information should be used. It follows that an estimate of the sustainable yield of the groundwater system in the Basin can be made by adding the average annual change in storage to the average annual groundwater extraction. This simplified approach provides a sustainable yield estimate corresponding to the volume of water that, if pumped over the water budget period of interest, would have resulted in zero change in storage due to pumping – a reasonably conservative approach for quantifying sustainability.

Based on the average annual change in groundwater storage over the historical water budget period from WY 1995-2014 (i.e., 3,200 AFY) and the average annual groundwater extraction (i.e., 41,000 AFY), the sustainable yield is estimated at approximately 44,200 AFY under historical supply and demand conditions.

To incorporate the avoidance of Undesirable Results in the estimate of sustainable yield, the WWGFM was used to project a variety of pumping rates under projected conditions. Model-calculated water levels in Representative Monitoring Wells for Chronic Lowering of Groundwater Levels (RMW-WLs) were screened against the Minimum Thresholds (MTs). As defined in ***Section 13.1 Undesirable Results for Chronic Lowering of Groundwater Levels***, an Undesirable Result for Chronic Lowering of Groundwater Levels would be identified if MTs are exceeded in 40% or more of the RMW-WLs (i.e., six out of 14 RMW-WLs) over four consecutive seasonal measurements (i.e., measurements spanning a total of two years, including two seasonal high groundwater level periods and two seasonal low groundwater level periods). Under the Projected 2030 Climate Change Scenario, model-calculated water levels from only two RMW-WLs exceed their MTs under the aforementioned definition (i.e., four consecutive seasonal measurements). Therefore, under the Projected 2030 Climate Change Scenario, without any P/MAs

[73] It should be noted that groundwater conditions vary spatially through the Basin, and broad generalizations over large areas can lead to mischaracterization of conditions on a local scale. For this reason, its imperative (and SGMA requires) that conditions be evaluated locally on a management area or representative monitoring location basis.

implementation, no Undesirable Results are projected to occur.

Table WB-9 below provides a summary of the range of potential sustainable yield estimates for different selected time periods. Under historical conditions (WY 1995-2014), the sustainable yield estimate is 44,200 AFY, whereas under current supply and demand conditions (WY 2015-2019) the sustainable yield estimate is less at 38,200 AFY. For the WY 1997-2009 overdraft evaluation period, the sustainable yield estimate is 47,200 AFY. These historical evaluations produce a range in sustainable yield estimates for the Basin from about 38,200 AFY to 47,200 AFY. Model calculations discussed below in ***Section 9.4.4 Projected Water Budget Results*** indicate that under Projected Baseline conditions, the average annual change in groundwater storage is -4,500 AFY and there are no projected Undesirable Results. These conditions are associated with a sustainable yield estimate that is slightly greater than historical conditions (46,800 AFY). Should future climatic conditions be drier, such as under the 2030 central tendency climate change scenario, the sustainable yield estimate is 47,100 AFY. The historical range in sustainable yield of 38,200 AFY to 47,200 AFY is therefore likely a reasonably conservative estimate for future planning purposes.

Table WB-9. Estimated Sustainable Yield for Selected Time Periods

Time Period	Relevance of Time Period	Annual Change in Groundwater Storage [AFY]	Average Annual Groundwater Extraction [AFY]	Sustainable Yield [AFY]
WY 1995-2014	Historical Water Budget Period	3,200	41,000	44,200
WY 2015-2019	Current Water Budget Period	-20,300	58,500	38,200
WY 1997-2009	Overdraft Evaluation Period (See ***Section 9.3.6***)	10,700	36,500	47,200
WY 2020-2072 (Baseline)	Projected Water Budget Period	-4,500	51,300	46,800
WY 2020-2072 (2030 Climate Change)	Projected Water Budget Period under 2030 Climate Change	-8,400	55,500	47,100

Abbreviations:
AFY = acre-feet per year
WY = Water year

Notes:
(a) Values rounded to the nearest hundred acre-feet.
(b) Sustainable Yield is calculated as average annual change in groundwater storage minus average annual groundwater extraction.

9.3.7.1. Operation within Sustainable Yield

Average annual change in groundwater storage in the Basin amounted to 3,200 AFY between WY 1995-2014, resulting in a cumulative change (increase) in groundwater storage of 64,200 AF within this period. This cumulative storage change over a 20-year historical record, that includes part of the recent severe drought, indicates that the historical groundwater system was in a state of relative balance, and not a state of overdraft. Although the overall net change during this period is positive, the calculated transient change in storage and groundwater levels measured in wells within the Basin (see **Figure GWC-5,** and **Figure GWC-6**) demonstrate that the groundwater system is sensitive to climatic variability and AEWSD and WRMWSD operations, with decreases in storage during drought followed by increases in storage during wet periods where imported surface water is more readily available and the groundwater pumping demand decreases.

As discussed previously and shown on **Figure WB-6**, over 3.3 million AF of water has been imported into the Basin since surface water imports began by AEWSD (1966) and WRMWSD (1975). During the historical water budget period, over 1.6 million AF (average of 68,100 AFY) of water has been imported into the Basin, the groundwater system experienced an estimated long-term increase in storage of over 64,000 AF through 2014 and groundwater elevations increased in areas where imported surface water is delivered (see **Figure GWC-5**). Clearly AEWSD and WRMWSD historical imports have resulted in a net benefit to the groundwater supply in the Basin, demonstrating successful groundwater management.

Under current conditions (WY 2015-2019), the severe drought significantly reduced the availability of imported surface water, whereby average imports reduced by 29% (approximately 20,000 AFY) compared to historical conditions, resulting in an increase in groundwater pumping to meet the remaining irrigation demand. The combination of reduced imported surface water deliveries and increased groundwater pumping resulted in a groundwater storage deficit of approximately 20,000 AFY under current conditions, and the lowest sustainable yield estimate (38,200 AFY) over the time periods examined (see **Table WB-9**). Average pumping under current conditions (WY 2015-2019) was approximately 58,500 AFY, which is greater than the estimated sustainable yield rage reported in **Table WB-9** (38,200 to 47,200 AFY). As future climatic conditions are difficult to predict, it is expected that reliance on groundwater pumping will remain similar to current conditions without any P/MAs implementation. Therefore, P/MAs that reduce groundwater consumption (demand reduction) and increase Basin recharge will support long-term groundwater sustainability.

9.4. Projected Water Budget

§ 354.18. Water Budget
(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:
(3) Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:
(A) Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology. The projected hydrology information shall also be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise.
(B) Projected water demand shall utilize the most recent land use, evapotranspiration, and crop coefficient information as the baseline condition for estimating future water demand. The projected water demand information shall also be applied as the baseline condition used to evaluate future scenarios of water demand uncertainty associated with projected changes in local land use planning, population growth, and climate.
(C) Projected surface water supply shall utilize the most recent water supply information as the baseline condition for estimating future surface water supply. The projected surface water supply shall also be applied as the baseline condition used to evaluate future scenarios of surface water supply availability and reliability as a function of the historical surface water supply identified in Section 354.18(c)(2)(A), and the projected changes in local land use planning, population growth, and climate.

Per 23-CCR §354.18(c)(2), projected water budgets are required to estimate future conditions of water supply and demand within a basin, as well as the aquifer response to GSP implementation over the planning and implementation horizon. To develop a projected water budget for the Basin, the WWGFM was used, with updated inputs for climate variables (e.g., precipitation and ET), land use changes, and Project and Management Action (P/MA) implementation.

Three projected scenarios were used for this water budget analysis per the DWR's guidance (DWR, 2018)[74]:

- Projected Baseline (Historical Analog) Scenario,
- Projected "Near future" 2030 Climate Change Scenario, and
- Projected "Late future" 2070 central tendency Climate Change Scenario.

[74] The "late future extreme" 2070 drier with extreme warming and wetter with moderate warming climate change scenarios were considered during the White Wolf GSA June 2021 Board of Directors meeting. Due to the uncertainty surrounding projected climate change conditions, only the central tendencies are presented herein.

In addition, two future land-use scenarios were considered for the water budget analysis, including:

- Current (2019) Land-Use Scenario, and
- Projected land use based on the Grapevine Development P/MA Scenario.

Finally, proposed P/MAs were considered for the water budget analysis, whereby several P/MAs were generically incorporated into the Projected 2030 Climate Change Scenario consistent with the "Glide Path" presented in ***Section 18.7 Status and Implementation Timetable***. All scenarios are used to project the water budget for the Basin through 2072 through use of the WWGFM.

9.4.1. Projected Analog Period

Per 23-CCR §354.18(c)(3)(A), the projected water budgets must use 50 years of historical precipitation, ET, and streamflow information as the basis for evaluating future conditions under baseline and climate-modified scenarios. To develop the required 50 years of projected hydrologic input information, an "analog period" was created by repeating select sequences of the historical hydrologic record in a way that maintains long-term historical average hydrologic conditions, as detailed below. To allow for comparison of projected subsurface flows with the adjacent Kern County Subbasin, the 53-year analog period used to develop projected water budgets is informed by and generally consistent with the methodology employed in the Kern County Subbasin numerical groundwater flow model used for GSP development purposes (TODD Groundwater, 2020). However, one additional year at the beginning and two additional years at the end were added to allow the projected simulation to run from 2020 through the GSP implementation phase of 2072. This approach allows for the simulation of a continuous 53-year period of future hydrologic data to inform the projected water budget analysis, even when certain component datasets are not available for that length of time. The sequence of actual years that were combined to create the 53-year analog period is as follows:

- Analog Year 1: Based on actual year 2003
- Analog Years 2 to 13: Based on actual years 2003-2014
- Analog Years 14 to 33: Based on actual years 1995-2014
- Analog Years 34 to 51: Based on actual years 1995-2012
- Analog Years 52 to 53: Based on actual year 2012, repeated twice

The above mapping of actual years to analog years within the 53-year projected water budget period applies to input datasets, including precipitation, reference ET, stream inflows, stream diversions, surface water deliveries, and general head boundary heads. The satellite ET data, however, would be affected not only by hydrology but also land use. To simulate a similar hydrologic condition while maintaining consistency with the projected land use (2019 data), ET is projected based on 2019 values, varied by annual scaling factors calculated from the projected reference ET of analog years.

9.4.2. Projected Scenarios Data Sources

Per 23-CCR §354.18(c)(3), the projected water budgets must use "50 years of historical precipitation, evapotranspiration, and streamflow" for estimating future hydrology, "the most recent land use, evapotranspiration, and crop coefficient information" for estimating future water demand, and "the most recent water supply information" for estimating future surface water supply. Per 23-CCR §354.18(e), the best-available data were used to develop the projected water budget for the Basin and include the following:

- Monthly precipitation, ET, stream inflows, stream diversions, pumping, and surface water deliveries from the historical simulation period. See ***Section 9.1.1 Data Sources*** for details on the historical data sources.
- Current (2019) land use (**Figure PA-3**) and proposed Grapevine Development (**Figure WB-19**).
- C2VSimFG-Kern projected monthly simulated groundwater elevations for elements located in the Kern County Subbasin to the north of the WWF. Simulated groundwater elevations were extracted for the projected baseline, 2030, and 2070 simulations. Due to the misalignment of fault locations between C2VSimFG-Kern and the actual Basin boundary, simulated heads located approximately 2,000 feet north of the C2VSimFG-Kern WWF were vertically adjusted to better agree with observed heads located approximately 2,000 feet north of the WWF trace.[75] Model results from C2VSimFG-Kern are available for WY 2020 through 2070.
- Monthly climate change factors for precipitation, ET, and streamflow for the 2030 and 2070 Central Tendency scenarios (DWR, 2020b). Precipitation and ET climate change factors are spatially variable and mapped to a variable infiltration capacity (VIC) grid. Climate change factors for the VIC grid cells which intersect the Basin were used to vary historical precipitation and ET estimates. The streamflow climate change factors are available by Hydrologic Unit Code 8 (HUC8) watershed. The streamflow climate change factors for HUC8 watershed 18030003 representing the watershed area contributing to Basin streamflow were used to vary historical streamflow estimates. Climate change factors are available for the projected months represented by January 1915 through December 2011. For projected months represented by the period January 2012 through September 2014, analog years were assigned based on years with similar hydrology in which 2012, 2013, and 2014 were assigned the climate change factors associated with years 1959, 1960, and 1961, respectively.
- Monthly projected SWP supplies delineated as maximum Table A contract amounts and Article 21 water supplies for the entire Kern County Water Authority (KCWA) (DWR, 2020b). DWR utilized the CalSim II water resources planning model and projected climate conditions to develop

[75] To simulate the groundwater heads immediately north of the WWF, model-calculated groundwater elevations from the historical C2VSimFG-Kern were extracted at 15 points located 2,000 feet north of the WWF elemental representation in C2VSimFG-Kern. Model-calculated groundwater elevations were compared to observed groundwater elevations from wells located approximately 2,000 feet north of the Basin boundary (WWF trace used in the WWGFM). When warranted, the simulated groundwater elevations were vertically adjusted to better match observed water levels. Vertical adjustments were held constant throughout all projected time series and consistently applied to all model layers.

projected SWP supplies for the 1995, 2030,[76] 2070, 2070 Drier/Extreme Warming (DEW), and 2070 Wetter/Moderate Warming (WMW) scenarios. Projections are available for projected months represented by October 1921 through September 2003. For projected months represented by the period of October 2003 through September 2014, actual historical deliveries with modifications were used, as described below in more detail.

- Monthly projected CVP supplies delineated as Class 1, Class 2/Other, Paragraph 16(b), and San Joaquin River Restoration Program Delta recapture water supplies for AEWSD (Friant Water Authority [FWA], 2018). FWA utilized the CalSim II water resources planning model and projected climate conditions to develop projected CVP supplies for the 2015, 2030, 2070, 2070 DEW, and 2070 WMW scenarios. The FWA projected CVP supplies fully incorporates projected recapture and recirculation as a result of the San Joaquin River Restoration Settlement and San Joaquin River Restoration Program implementation, which DWR did not fully take into account; therefore, the FWA projected CVP supplies are considered to be a better projection for future reliability. Projections are available for projected months represented by October 1921 through September 2003. For projected months represented by the period October 2003 through September 2014, analog months October 1950 through September 1961 were assigned based on years with similar hydrology.
- Monthly projected Kern River at First Point flows, as projected by GEI (2018). Kern River at First Point flows above historical flows under 2030 and 2070 projected climate conditions were proportionally added to selected recharge deliveries (TODD, 2020). Projections are available for January 1956 through December 2010. For January 2011 through September 2014, analog calendar years 1986, 1991, 1990 and 1961 were assigned based on years with similar historical flows.

9.4.3. Projected Scenarios Development

9.4.3.1. Projected Baseline Scenario

Per 23-CCR §354.18(e)(2)(C), the projected water budgets must use "the most recent water supply information as the baseline condition for estimating future surface water supply." The Baseline Scenario is for comparison purposes and does not include any expected effects of climate change. As described below, the Baseline Scenario represents the projected land use and water demands through the GSP implementation period (i.e., between 2022 and 2042):

[76] In 2019, DWR updated "existing" and "near future" 2035 projected SWP supplies to incorporate CalSim II inputs associated with operating assumptions (DWR, 2020c). Over WYs considered for the projected scenarios development covered by both DWR datasets (i.e., WYs 1959-1961, 1995 to 2003), the average updated 2035 (DWR, 2020c) projected KCWA SWP supplies are approximately 11% less than those projected for 2030 (DWR, 2020b). For consistency with the assumptions used by the contractors in Kern County Subbasin, the DWR (2020a) 2030 SWP reliability factors were used. These SWP reliability factors will be re-assessed and updated, if warranted, in a subsequent GSP update. To incorporate the most reliable SWP supply estimates, an uncertainty analysis on the Projected 2030 Climate Change Scenario was conducted in which SWP reliability was by reduced 11%. See ***Section 9.5.1 Simulated Stresses*** for details.

- Current (2019) land use.
- Precipitation, reference ET, stream inflows, and stream diversions from the historical simulation period were repeated in the sequence of analog years.
- 2019 ITRC-METRIC ET varied by annual scaling factors calculated from the projected reference ET of analog years.
- General head boundary heads were specified as the vertically adjusted simulated groundwater elevations from C2VSimFG-Kern projected baseline simulation (see Footnote 75 for details).
- Groundwater extractions for WRMWSD-owned wells and private irrigation wells were estimated by the SMB.
- TCWD M&I SWP deliveries to the TRCC from the historical simulation period were repeated in the sequence of analog years.
- Other water deliveries were estimated using the same approach and methodology employed by contractors in the Kern County Subbasin. Specifically, projected CVP and SWP deliveries were allocated to individual districts using the assumptions outlined below. However, in addition to the projected availability of CVP and SWP supplies, each district participates in complex water trading and water banking operations in the Kern County Subbasin as a means of increasing supply reliability during extended periods of drought and/or regulatory restrictions. To account for additional projected availability due to these operations, a monthly ratio was calculated by calculating a percentage of total scenario inflows to total historical inflows, where inflows include CVP, SWP, and Kern River at First Point Flows (TODD, 2020).
    - WRMWSD SWP supplies. As discussed above, DWR projections did not fully incorporate reduced reliability as a result of the 2008 U.S. Fish and Wildlife Service (USFWS) Biological Opinions in the Operations, Criteria, and Plan (OCAP).[77] Therefore, consistent with the methodology employed by the contractors in the Kern County Subbasin, SWP reliability under the baseline scenario were simulated as follows, repeated in the sequence of analog years:
        - WY 1995-2003 deliveries are based on 2030 DWR reliability (DWR, 2020b) increased by 3.03%.
        - WY 2004-2007 deliveries are based on historical deliveries adjusted for the 2008 OCAP Biological Opinions. This effectively reduces reliability of 2004 by 20%, 2005 by 15%, 2006 by 5%, and no reduction in 2007.
        - WY 2008-2014 are based on historical deliveries.
    - AEWSD water supplies include:

[77] See https://www.fws.gov/sfbaydelta/Documents/SWP-CVP_OPs_BO_12-15_final_OCR.pdf and https://www.fisheries.noaa.gov/resource/document/biological-opinion-and-conference-opinion-long-term-operations-central-valley.

    - CVP supplies from the FWA "2015.c" dataset,
    - SWP supplies with the same reliability assumptions as stated above,
    - Kern River flows repeated in the sequence of analog years,
    - "Pump in" from District and private wells repeated in the sequence of analog years, and
    - "Other" infrequent supply sources, including wheeled surface water and groundwater from the adjacent districts, repeated in the sequence of analog years.
    - In addition, given the considerable uncertainty surrounding the future availability of non-CVP water supplies to AEWSD, the Baseline Scenario conservatively applies a 50% reduction to the initial estimates of SWP supplies and Kern River imports.
  - The above water supplies were assumed to have monthly leakage rates similar to those observed historically.

9.4.3.2. Projected 2030 Climate Change Scenario

To estimate the potential effects of climate change on the projected water budget during the GSP implementation period (i.e., between 2022 and 2042), a water budget scenario based on "near future" 2030 climate change was developed. The following items were modified from the Baseline Scenario:

- Historical precipitation, reference ET, stream inflows, and the scaled 2019 satellite ET were varied by the DWR 2030 climate change factors. This resulted in an average 2% increase in precipitation, an average 2% increase in ET, and an average 1% increase in stream inflows.
- General head boundary heads were specified as the vertically adjusted simulated groundwater elevations from C2VSimFG-Kern projected 2030 simulation (see Footnote 75 for details)
- Other water deliveries were estimated using the same approach and methodology employed by contractors in the Kern County Subbasin and that described above for the Projected Baseline Scenario. Specific assumptions are outlined below:
  - WRMWSD SWP supplies reliability were simulated as follows, repeated in the sequence of analog years:
    - WY 1995-2003 deliveries are based on 2030 DWR reliability (DWR, 2020b),
    - Baseline Scenario WY 2004-2007 deliveries are reduced by 3.03%, and
    - Historical WY 2008-2014 are reduced by 3.03%.
  - AEWSD water supplies include:
    - CVP supplies from the FWA "2030.c" dataset,
    - SWP supplies with the same reliability assumptions as stated above, reduced by 50%,

- Kern River 2030 flows from GEI (2018) and TODD (2020) reduced by 50%,
- "Pump in" from District and private wells repeated in the sequence of analog years, and
- "Other" infrequent supply sources, including wheeled surface water and groundwater from the adjacent districts, repeated in the sequence of analog years.

9.4.3.3. Projected 2070 Climate Change Scenario

To estimate the potential effects of climate change on the projected water budget during the GSP implementation period (i.e., between 2022 and 2042), a water budget scenario based on "late future" 2070 central tendency climate change was developed. The following items were modified from the Baseline Scenario:

- Historical precipitation, reference ET, stream inflows, and the scaled 2019 satellite ET were varied by the DWR 2070 climate change factors. This resulted in an average 2% decrease in precipitation, an average 4% increase in ET, and an average 6% decrease in stream inflows.
- General head boundary heads were specified as the vertically adjusted simulated groundwater elevations from C2VSimFG-Kern projected 2070 simulation (see Footnote 75 for details).
- Other water deliveries were estimated using the same approach and methodology employed by contractors in the Kern County Subbasin and that described above for the Projected Baseline Scenario. Specifically, projected CVP and SWP deliveries were allocated to individual districts using the assumptions outlined below:
    - o WRMWSD SWP supplies reliability were simulated as follows, repeated in the sequence of analog years:
        - WY 1995-2003 deliveries are based on 2070 DWR reliability (DWR, 2020b),
        - Baseline Scenario WY 2004-2007 deliveries are reduced by 8.09%, and
        - Historical WY 2008-2014 are reduced by 8.09%.
    - o AEWSD water supplies include:
        - CVP supplies from the FWA "2070.c" dataset,
        - SWP supplies with the same reliability assumptions as stated above, reduced by 50%,
        - Kern River 2070 flows from GEI (2018) and TODD (2020) reduced by 50%,
        - "Pump in" from District and private wells repeated in the sequence of analog years, and
        - "Other" infrequent supply sources, including wheeled surface water and groundwater from the adjacent districts, repeated in the sequence of analog years.

9.4.3.4. Projected 2030 Climate Change with Grapevine Development P/MA Scenario

The Baseline Scenario and Climate Change Scenarios described above assume land use remains constant, and therefore does not include completion of the Grapevine Development. The Grapevine Development Scenario includes the full Grapevine Development buildout whereby current land use was adjusted to urban to reflect the planned Grapevine Development (see **Figure WB-19**). The Grapevine Development is anticipated to be constructed in six phases over 19 years with an anticipated break-ground date of 2026 to 2027. Scaled ITRC-METRIC ET from nearby similar land use categories were specified once the development phase activated (e.g., scaled ITRC-METRIC ET from the TRCC was used for commercial and/or industrial lands).

Estimated available water supplies were simulated as shown in **Table WB-10**. The SMB only simulates outdoor processes. Supplies including recycled water and supplemental potable water for outdoor uses were proportioned to each month based on monthly reference ET. System losses were distributed equally to all months following the phase sequencing and were specified as direct recharge to the groundwater system (i.e., leakage). All other assumptions on water supply and reliability remain the same as the Baseline Scenario.

Table WB-10. Projected Water Supply for the Grapevine Development

Phase	Planning Area	Build Out Water Year	Water Supply for Outdoor Use (AFY)		System Losses (AFY)[a]
			Recycled Water[a]	Potable Water[b]	
1	2 & 6a	2027	796	17	219
2	1	2031	244	18	70
3	3	2035	455	9	113
4	4	2039	345	9	131
5	5	2043	292	5	96
6	6b - 6e	2046	1	9	2

Abbreviations:
AFY = acre-feet per year

Sources:
(a) EKI, 2015. Evaluation of Potable, Non-Potable and Recycled Water Demands Grapevine Project, prepared for Tejon Ranchcorp, dated November 2015.
(b) Estimated by the SMB.

9.4.3.5. Projected 2030 Climate Change with Combined P/MAs Scenario

To quantify the potential effects of proposed P/MAs on the projected water budget during the GSP implementation period (i.e., between 2022 and 2042), a water budget scenario under Projected 2030 Climate Change was developed which simulates the combined effect of the Grapevine Development, increased surface water supplies, and demand reductions, consistent with the "Glide Path" presented in ***Section 18.7 Status and Implementation Timetable***. The WWGFM input files for the Projected 2030

Climate Change were modified to simulate the combined net effect of the P/MAs above, consistent with the general descriptions provided below:

- The Grapevine Development land use adjustments, scaled ITRC-METRIC ET modifications, outdoor applied water, and system losses were integrated, as discussed in ***Section 9.4.3.4 Projected 2030 Climate Change with Grapevine Development P/MA Scenario*** above.
- Surface water supplies were increased by 1,500 AFY starting in WY 2032, by 3,500 starting in WY 2037, and by 5,000 AFY starting in WY 2042. The increased surface water supply was distributed approximately 60% to WRMWSD and 40% to AEWSD.
- Year-round WRMWSD surface water supplies were increased by 1,000 AFY starting in WY 2037.
- Overall groundwater pumping was reduced by 2,700 AFY starting in WY 2027, by 5,000 AFY starting in WY 2032, by 7,200 AFY by WY 2037, and by 9,500 AFY starting in WY 2042.

9.4.4. Projected Water Budget Results

Results of the projected water budget analyses are summarized in **Table WB-11** and **Figure WB-20**. Since projected conditions are representative of long-term averages, the WWGFM reaches an asymptotic semi-steady-state over the 53-year projected water budget period. Therefore, as shown in **Table WB-11**, water budget components simulated by the WWGFM are presented as averages over the 53-year projected water budget period, and water budget components are grouped into inflows and outflows. Also shown in **Table WB-11** is the estimated average annual change in groundwater storage and estimated sustainable yield based on each scenario.

There is approximately 3,000 acres more planted irrigated acreage under current land use (2019) compared to 2000. As such, in the Projected Baseline Scenario, the water budget components differ from the historical water budget primarily due to increases in irrigated vegetative demand (i.e., actual ET), reduced surface water reliability, and thereby increased pumping to make up the difference in unmet demand. Furthermore, lower Basin water levels result in a less steep gradient across the WWF, resulting in a reduction of flow. These land use and water demand projections result in a storage decrease of 4,600 AFY. The sustainable yield represented by the Projected Conditions Baseline Scenario is 46,600 AFY, which is on the upper end of the historical evaluation results (38,200 AFY to 47,200 AFY).

In the Projected 2030 Climate Change Scenario, recharge decreases and actual ET and pumping increase compared to the Projected Baseline Scenario, resulting in greater storage decrease (i.e., 8,400 AFY compared to 4,600 AFY). Under the Projected 2030 Climate Change Scenario, the estimated sustainable yield is 46,800 AFY.

In the Projected 2070 Climate Change Scenario, recharge decreases and actual ET and pumping increases compared to the Projected Baseline Scenario, resulting in an estimated storage decrease of 15,500 AFY. Under the Projected 2070 Climate Change Scenario, the estimated sustainable yield is 45,600 AFY. Due to the uncertainty surrounding the projections for 2070 climate change, the White Wolf GSA has elected to include the Projected 2070 Climate Change Scenario results as perspective but will be utilizing the

Projected 2030 Climate Change Scenario for sustainability planning.

For the Projected 2030 Climate Change with Grapevine Development P/MA Scenario, recharge increases due to new imported surface water and water distribution systems below the Grapevine Development. Under the Projected 2030 Climate Change with Grapevine Development P/MA Scenario, there is a 1,200 AFY increase in groundwater storage compared to the Projected 2030 Climate Change Scenario and the estimated sustainable yield of 47,500 AFY slightly exceeds the upper range of the historical estimates (38,200 AFY to 47,200 AFY).

In general, the combined P/MAs bring imported surface water or introduce new water sources into the Basin and reduce groundwater pumping. Therefore, the Projected 2030 Climate Change with Combined P/MAs Scenario results in a small increase in deep percolation, a moderate decrease in pumping, and an overall increase in groundwater storage. Under the Projected Combined P/MAs Scenario, the sustainable yield is estimated at approximately 45,100 AFY which is within the range of historical estimates (38,200 AFY to 47,200 AFY).

TABLE WB-11. Summary of Projected Water Budget Estimates

Scenario	Climate Period	Land Use	INFLOWS (AFY)						OUTFLOWS (AFY)					Change in Groundwater Storage (AFY)(d)	Sustainable Yield (AFY)(e)
			Infiltration(b)			Net Streamflow Leakage to Groundwater	Net Subsurface Groundwater Flow from Unpumped Aquifer	TOTAL INFLOWS	Groundwater Extractions		Evaporation of Shallow Groundwater/ GDEs	Net Subsurface Groundwater Flow to Kern County Subbasin	TOTAL OUTFLOWS		
			Agricultural	Urban	Native				Agricultural Wells(c)	M&I Wells					
Historical	WY 1995-2014	Historical	43,100	700	4,000	8,700	100	**56,600**	41,000	0	2,900	8,900	**52,800**	3,800	44,800
Current	WY 2015-2019	Current	36,600	300	4,500	7,700	500	**49,600**	58,600	100	2,000	9,100	**69,800**	-20,200	38,500
Projected Baseline	WY 1995-2014 Analog	Current	37,900	300	3,700	8,700	1,500	**52,100**	51,300	0	2,000	3,300	**56,600**	-4,500	46,800
Projected 2030 Climate Change	WY 1995-2014 Analog with DWR 2030 climate change	Current	36,300	300	3,900	8,700	1,900	**51,100**	55,500	0	2,000	2,000	**59,500**	-8,400	47,100
Projected 2070 CT Climate Change	WY 1995-2014 Analog with DWR 2070 CT Climate Change	Current	33,800	300	3,400	8,200	2,400	**48,100**	61,300	0	1,900	400	**63,600**	-15,500	45,800
Projected Grapevine P/MA 2030 Climate Change	WY 1995-2014 Analog with DWR 2030 climate change	Projected	35,900	1,400	3,800	8,700	1,800	**51,600**	54,700	0	2,000	2,100	**58,800**	-7,200	47,500
Projected 2030 Climate Change with Combined P/MAs	WY 1995-2014 Analog with DWR 2030 climate change	Projected	36,200	1,400	3,700	8,700	1,400	**51,400**	45,800	0	2,000	4,100	**51,900**	-500	45,300

Abbreviations

AFY = acre-feet per year
CT = Central Tendency
DWR = California Department of Water Resources
GDEs = Groundwater dependent ecosystems
P/MA = Project and/or Management Action
WY = Water Year

Notes

(a) All values rounded to the nearest hundred acre-feet.
(b) Infiltration represents recharge to the groundwater system originating from precipitation, applied water, or leakage from distribution and conveyance systems.
(c) Agricultural wells includes both private irrigation wells and WRMWSD wells.
(d) Change in groundwater storage calculated as the difference between inflows and outflows.
(e) Sustainable Yield is calculated as average annual change in groundwater storage minus average annual groundwater extraction.

9.5. Water Budget Uncertainty and Limitations

In this analysis, "uncertainty" refers to the incomplete understanding of the physical setting, characteristics, and current conditions that significantly affect calculation of the water budgets presented above. Each of the values in the annual water budget is an estimate subject to some uncertainty and this uncertainty can influence the calculation of groundwater storage changes the reliability of the estimated sustainable yield. Limitations are due primarily to data gaps and data uncertainty. Data gaps refer to limitations in the spatial coverage of measured data, or periods of time when no data are available. These occur when the locations and timing of data points are insufficient to adequately characterize conditions in model areas of interest. Data gaps require that assumptions be made regarding trends in the available data, and these assumed trends then are extrapolated into areas or time periods where data are lacking. Data uncertainty refers to errors or inaccuracies in the actual data used to populate the model. For example, groundwater recharge is estimated from assumptions regarding soil and crop properties and irrigation efficiencies. As these values cannot be measured, they must be inferred and are uncertain.

Limitations for the water budget presented herein can be grouped into three categories: (1) those affecting simulated stresses (i.e., recharge and groundwater pumping), (2) modeled water transmitting and storage properties, and (3) data gaps. An overall uncertainty and therefore potential range for each category was developed based on a sensitivity analysis of simulated stresses, the variability of values in aquifer properties, and professional judgement. A more detailed description of model sensitivity and uncertainty analyses can be found in ***Appendix L***.

9.5.1. Simulated Stresses

The primary simulated stresses in the WWGFM are recharge and pumping. Uncertainty in the WWGFM can be introduced by uncertainty in the input datasets used to calculate the stresses. Potential sources of uncertainty which factor into calculating recharge and agricultural pumping include:

- The reliability of ITRC-METRIC ET estimates. In order to compensate for additional evaporation of ineffective precipitation during winter months that is generally not captured by remote sensing data due to the intermittent and episodic nature of rainfall events and (2) greater crop ET during summer months, as calculated by comparison to Cal-SIMETAW crop ET rates, possibly due to the ITRC-METRIC method not capturing high ET rates after irrigation events, monthly scaling factors were developed and applied to the ITRC-METRIC ET estimates based on effective precipitation calculations and Cal-SIMETAW crop ET data. If ITRC-METRIC ET estimates differ from actual ET, the resulting calculated recharge and groundwater pumping will therefore differ from actual groundwater pumping. Sensitivity testing of the SMB suggests that recharge and groundwater pumping are sensitive to potential ET, whereby a 10% change to potential ET causes an approximately 7% change to recharge and an approximately 11% change to pumping. In addition, it should be noted that other ET estimation methodologies exist (e.g., those compiled under the OpenET program; https://openetdata.org/), and that these different methodologies often produce variable ET estimates for a given area and time period, further indicating that ET inputs to the SMB and WWGFM are a source of uncertainty.

- The reliability of PRISM precipitation estimates. A comparison of PRISM precipitation estimates to measured precipitation at the three climate stations within the Basin show that, in general, PRISM adequately estimates historical monthly precipitation. However, PRISM significantly over-estimated precipitation in four years (i.e., WYs 1995, 2011, 2014, and 2016) during the historical and current water budget periods. PRISM data for these years were therefore scaled to better reflect measured conditions in the Basin.[78] Sensitivity testing of the SMB suggests that recharge is sensitive to precipitation rates, whereby a 10% change in overall precipitation would cause an approximately 7% change to recharge.

- Distribution of applied surface water. The SMB applies each District's surface water uniformly to all applicable land use types within that district's surface water service area. To the extent that this distribution results in too much water being applied to certain irrigated lands and not enough water to other irrigated lands, this could result in both greater recharge and greater pumping estimates. Efforts to scale deliveries proportional to ET demands were attempted and found to cause unintended and unrealistic focused deliveries in certain times, and thus a uniform distribution was deemed a more appropriate approach.

- Calculated groundwater pumping and recharge are less sensitive to other parameters and assumptions in the SMB such as soil depth, depression storage, and the ET stress function multiplier (which controls how quickly crop coefficient-based ET rates decline from their maximum crop-dependent value as a function of soil moisture). Depression storage is a fixed value that adds to the interception of precipitation, allowing evaporation to occur prior to vegetative water demand. For example, a 10% change to soil depth would cause an approximate 1% change to recharge and the minimum and maximum spectrum of the ET stress function multiplier would cause anywhere from an approximate -3% to a +5% change in recharge.

The projected water budget is based on repeating historical climate patterns and current land use conditions. Therefore, the long-term projected water budget is a representation of the long-term average conditions. Under these conditions, the simulated groundwater system approaches a condition of equilibrium with these average stresses. Present-day evaluation of the future sustainability of the Basin using these long-term average conditions therefore does not consider potential variability in these stresses that may occur in the future.

In 2019, DWR updated "existing" and "near future" 2035 projected SWP supplies to incorporate CalSim II inputs associated with operating assumptions (DWR, 2020c). Over the WYs considered for the projected scenarios development covered by both DWR datasets (i.e., WYs 1959-1961, 1995 to 2003), the average updated 2035 (DWR, 2020c) projected KCWA SWP supplies are approximately 11% less than those projected for 2030 (DWR, 2020b) and therefore 11% less than those utilized in the Projected 2030 Climate

[78] Average annual PRISM estimated precipitation for Water Years 1995, 2011, 2014, and 2016 exceeded the average annual precipitation measured at the three stations within the Basin by more than 2.5 inches. Daily PRISM precipitation was scaled by 25%, 30%, 52%, and 29%, respectively, to better represent measured conditions in the Basin.

Change Scenario. An uncertainty analysis on the Projected 2030 Climate Change Scenario in which SWP reliability was reduced by 11% results in a 7% reduction of total applied surface water and a 4.5% increase of calculated groundwater pumping. These SWP reliability factors will be re-assessed and updated, if warranted, in a subsequent GSP update.

9.5.2. Modeled Water Transmitting and Storage Properties

Very limited estimates of hydraulic conductivity are available from pumping tests within the Basin. Specific capacity, calculated based on drawdown during pumping and as reported on DWR Well Completion Reports (WCRs), can be used to estimate hydraulic conductivity. Estimates of hydraulic conductivity calculated from specific capacity range from 0.2 feet per day (ft/d) to 68 ft/d (median of 13.7 ft/d). However, hydraulic conductivity estimates from pumping tests were higher, ranging from 6.3 ft/d to 217 ft/d (median of 86 ft/d). Although sensitivity tests show that model results are less sensitive to hydraulic conductivity than other aquifer properties, hydraulic conductivity values in the WWGFM generally fall within the range of pumping test and specific capacity estimates.

Model-calculated water levels over the calibration period are most sensitive to specific storage. There is high uncertainty in specific storage values and the only other estimates are from large scale models (i.e., C2VSimFG-Kern). The specific storage in the WWGFM is low compared to C2VSimFG-Kern and values in the main Basin are typically representative of dense sandy gravel and rock. However, an increase in specific storage results in an increase in Basin-wide water levels and therefore a worse calibration. Future multi-well aquifer testing at different locations within the Basin, ideally with one test in each the different physiographic parameter zone, could help constrain the specific storage values.

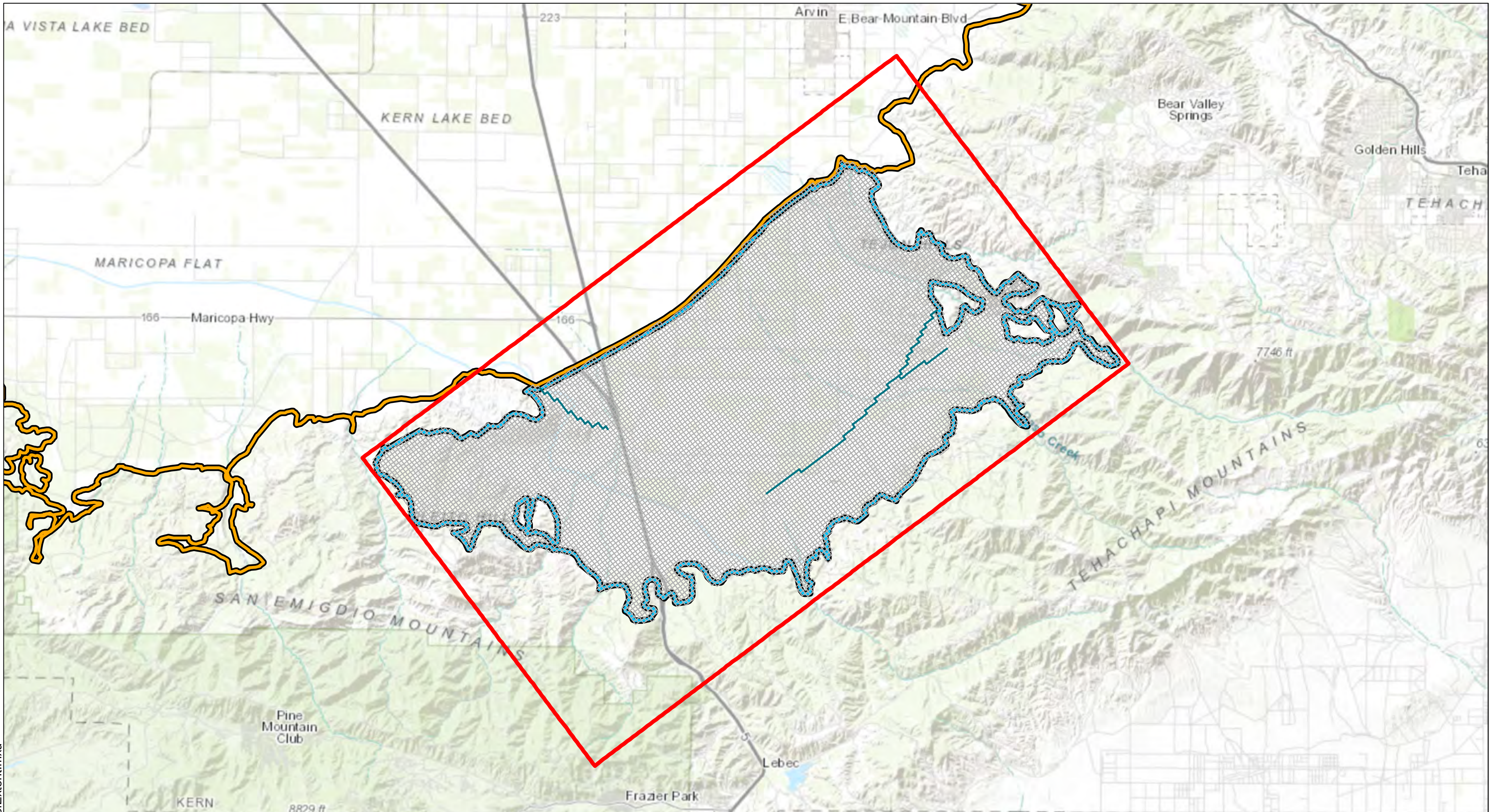
Model-calculated water levels were also sensitive to internal fault (Springs Fault and Wheeler Ridge Fault) hydraulic characteristic values. Very limited historical water level data exist in the vicinity of these faults, and fault hydraulic characteristic values were adjusted during model calibration to (1) maintain shallow groundwater levels south of the Springs Fault while minimizing flooding (model-calculated water levels above land surface) and (2) reduce water levels in wells located in the main Basin to the west of the Wheeler Ridge Fault.

Aquifer properties and fault hydraulic characteristic values were adjusted during model calibration; these parameters generally fall within reasonable ranges but may require further adjustments. The WWGFM will be recalibrated, as needed, throughout GSP implementation as additional data become available.

9.5.3. Data Gaps

Stream inflow to the Basin is not currently measured. Therefore, stream inflows from surrounding watersheds were quantified by an assumed 95% consumptive use of precipitation falling on the surrounding watershed. Although stream inflow comprises only 6% of the total estimated inflows to the Basin, it remains a source of uncertainty. Furthermore, due to lack of available streamflow and/or timing of stream inflows based on the watershed runoff calculations, modeled diversions are approximately 80% of recorded diversions. It is recommended that at least one stream gauge be installed at a location where a stream discharges into the Basin to better quantify stream inflows and compare to estimates used in model development. For instance, a stream flow data logger is proposed for installation where El Paso Creek enters the Basin, slightly upgradient of the POD.

The WWGFM simulates artesian conditions in some areas south of the Springs Fault. However, very limited water level data are available during both the calibration and validation periods to validate the calibration of aquifer properties and Springs Fault hydraulic characteristic values. Ongoing data collection from the three shallow monitoring wells installed during Spring 2021 will be critical for future WWGFM updates and potential recalibration.



Path: X:\B50001.05\Maps\GSP\2022\01\FigWB-1_ModelExtent.mxd

Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- Model Extent
- Active Model Cells
- Fault

Abbreviations

DWR = California Department of Water Resources

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.

N

0 5 10

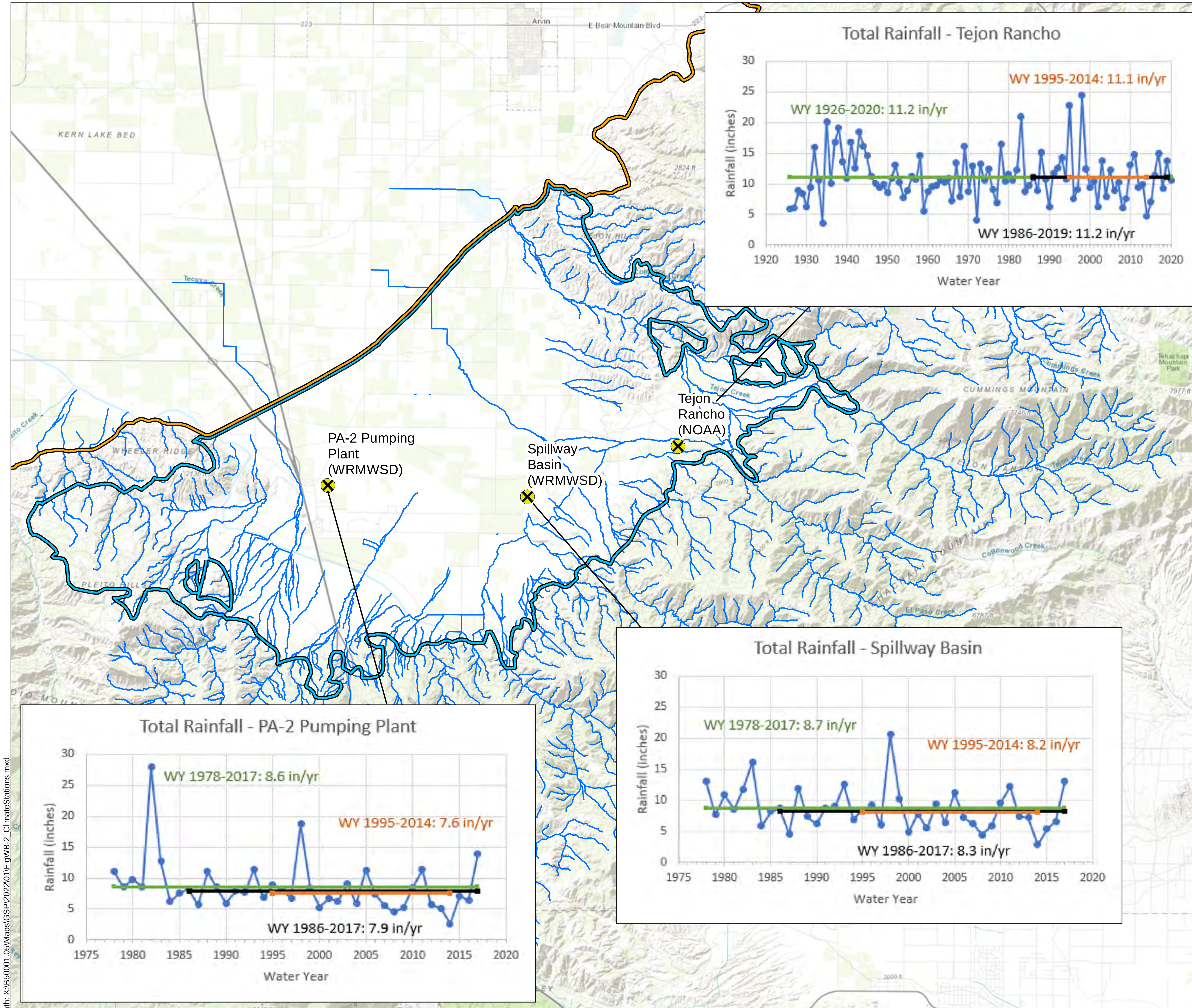
(Scale in Miles)

White Wolf Groundwater Flow Model Active Extent and Grid

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure WB-1



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- Climate Station
- Annual Precipitation
- Long-Term Average Rainfall
- Average Rainfall, Model Period (WY 1986-2019)
- Average Rainfall, Historical Water Budget Period (WY 1995-2014)

Abbreviations

CIMIS = California Irrigation Management Information System
DWR = California Department of Water Resources
in/yr = inches per year
NHD = National Hydrography Dataset
NOAA = National Centers for Environmental Information
WRMWSD = Wheeler Ridge-Maricopa Water Storage District
WY = Water Year

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Surface water features and watersheds from NHD website: (https://viewer.nationalmap.gov/basic/).
4. WRMWSD Climate Station information provided by WRMWSD.
5. NOAA climate stations information from NOAA website: (https://www.ncdc.noaa.gov/cdo-web/).

N

0 3 6

(Scale in Miles)

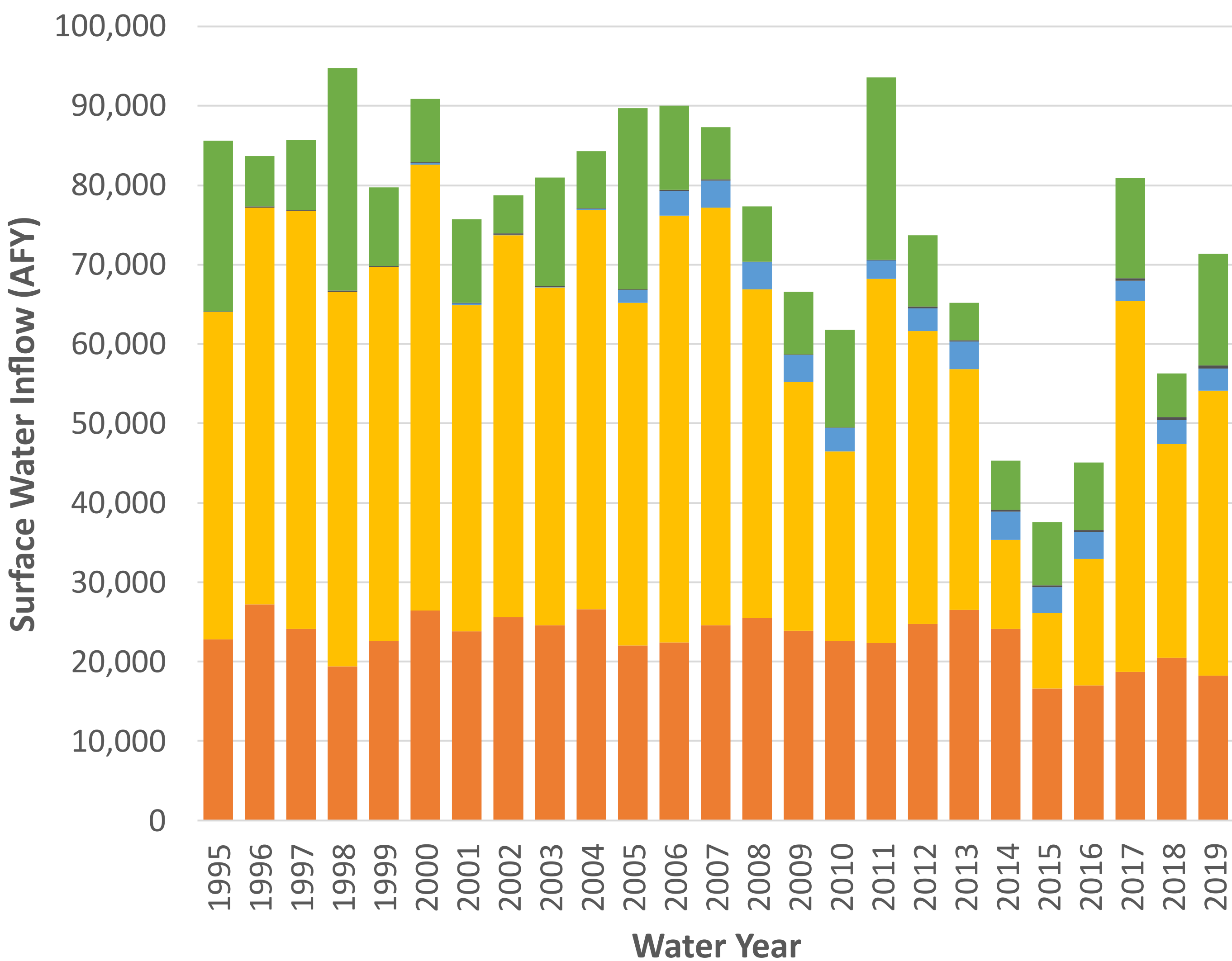
Climate Stations with Long-Term Precipitation Records, White Wolf Subbasin

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure WB-2

Path: X:\B50001.05\Maps\GSP\2022\01\FigWB-2_ClimateStations.mxd



Legend

- AEWSD Imports (Agricultural)
- WRMWSD Imports (Agricultural)
- WRMWSD Imports (M&I) TCWD
- Imports (M&I) Streamflow into
- Basin

Abbreviations

AEWSD = Arvin-Edison Water Storage District
AFY = acre-feet per year
M&I = municipal and industrial
TCWD = Tejon-Castac Water District
WRMWSD = Wheeler Ridge-Maricopa Water Storage District

Notes

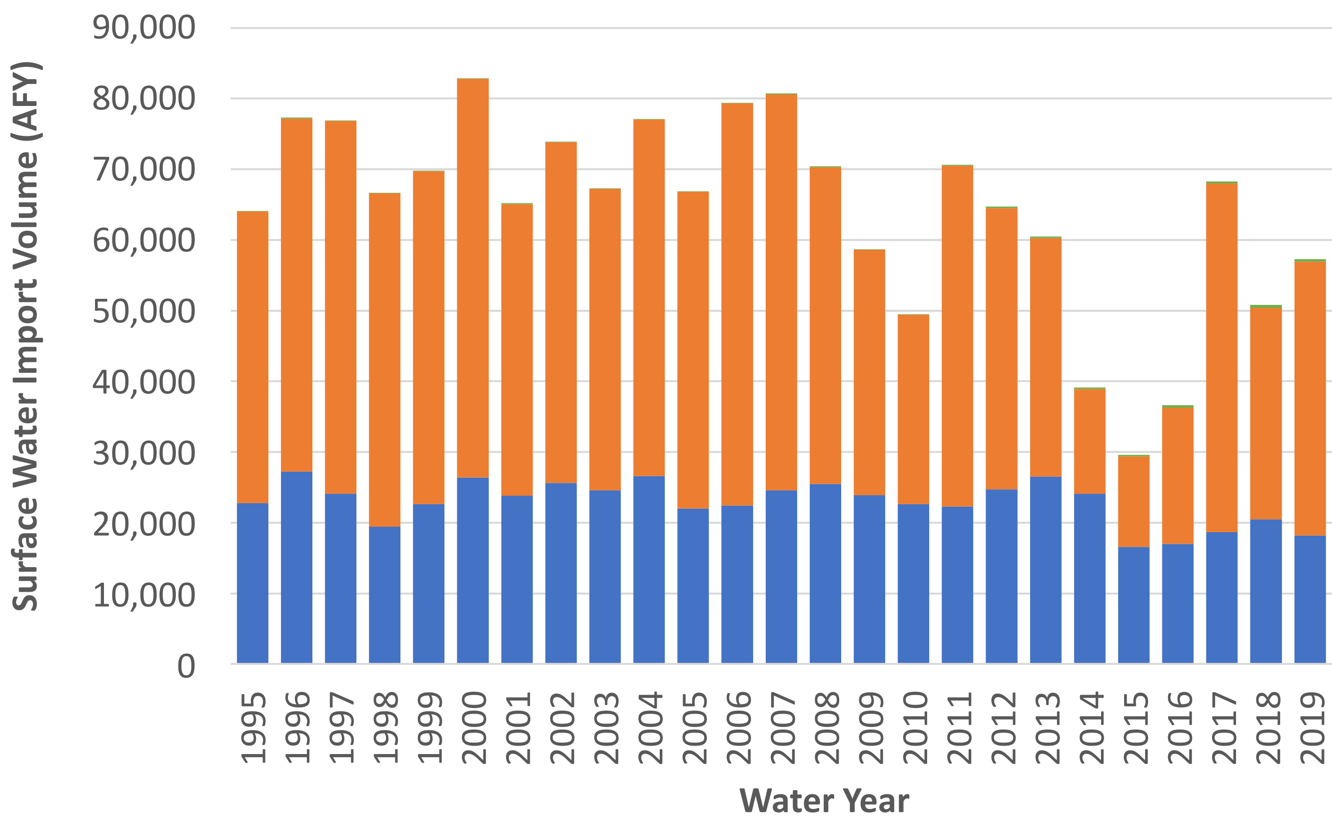
1. Water Year is defined as the October of the previous year through September of the current year.

Annual Surface Water Inflows by Source

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

eki environment & water

Figure WB-3



Legend

- AEWSD Imports
- WRMWSD Imports
- TCWD Imports

Abbreviations

AEWSD = Arvin-Edison Water Storage District
AFY = acre-feet per year
TCWD = Tejon-Castac Water District
WRMWSD = Wheeler Ridge-Maricopa Water Storage District

Notes

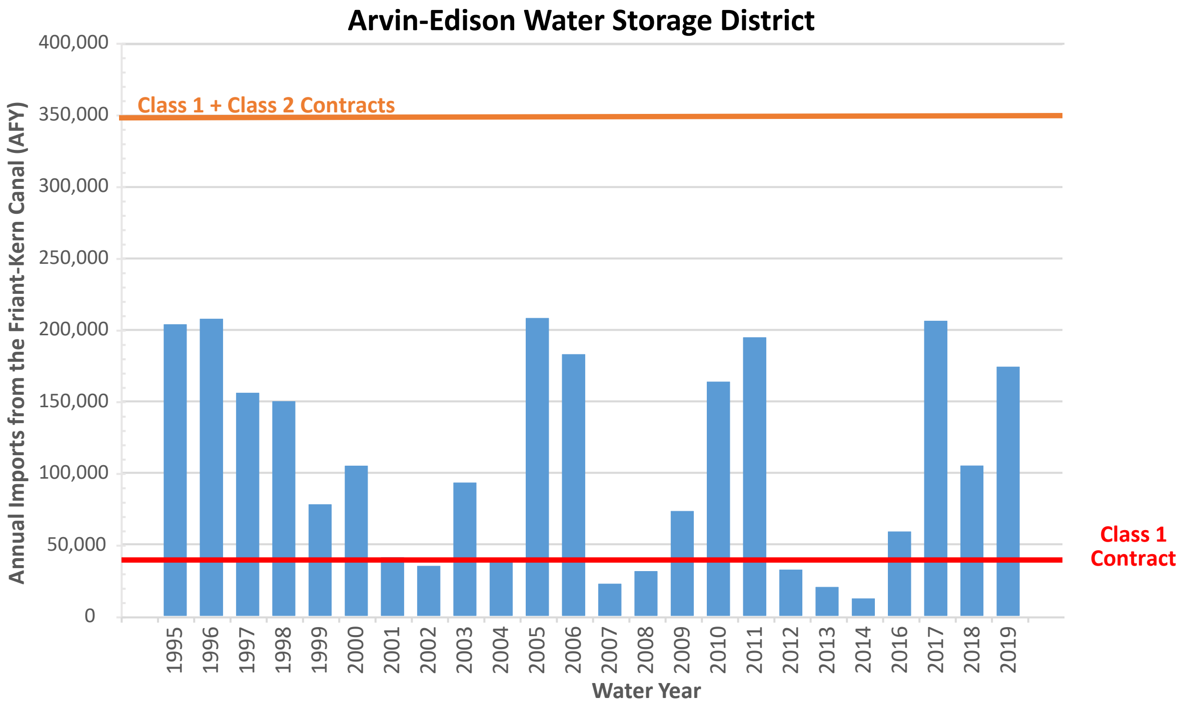
1. Water Year is defined as the October of the previous year through September of the current year.

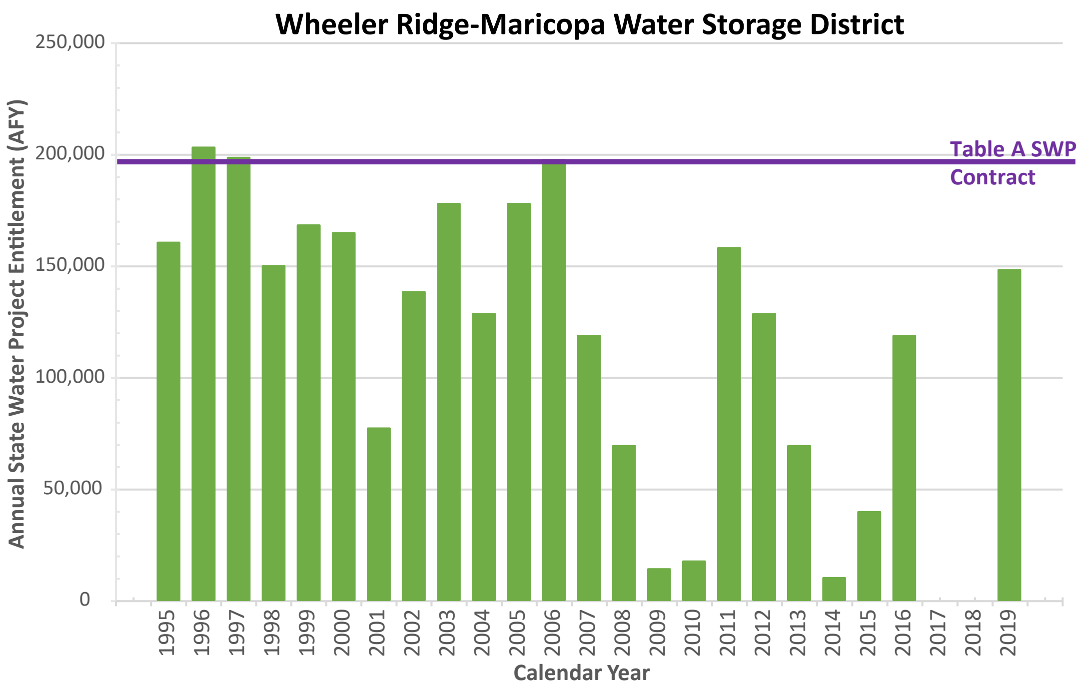
Annual Surface Water Imports by District

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

eki environment & water

Figure WB-4





Legend

- Friant-Kern Annual Imports
- SWP Annual Allotment
- Class 1 Contract
- Class 1 + Class 2 Contract
- SWP Table A Contract

Abbreviations

AEWSD = Arvin-Edison Water Storage District
AFY = acre-feet per year
SWP = State Water Project
WRMWSD = Wheeler Ridge-Maricopa Water Storage District

Notes

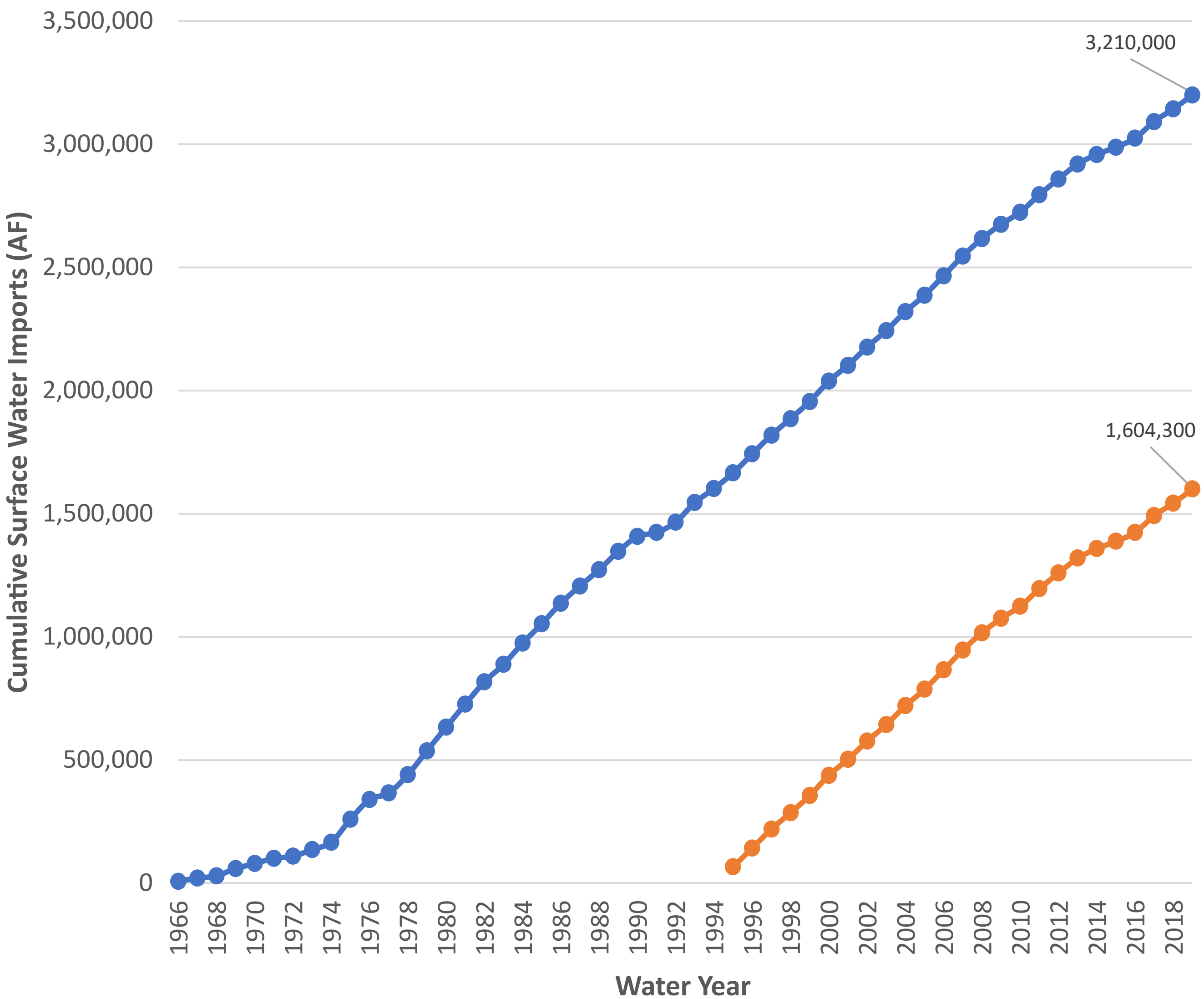
1. AEWSD's Class 1 Contract is 40,000 AFY and Class 2 Contract is 311,675 AFY.
2. WRMWSD's Table A SWP Contract is 197,088 AFY.
3. Values reported here are for the entire service area of each District, a portion of which is delivered to the White Wolf Subbasin.
4. Water Year is defined as the October of the previous year through September of the current year.
5. WRMWSD's 2018 SWP entitlement was not available.

Annual Imports vs. Contracted Supplies

eki environment & water

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

Figure WB-5



Legend

- Cumulative Imports 1966-2019
- Cumulative Imports 1995-2019

Abbreviations

AEWSD = Arvin-Edison Water Storage District
AF = acre-feet
TCWD = Tejon-Castac Water District
WRMWSD = Wheeler Ridge-Maricopa Water Storage District

Notes

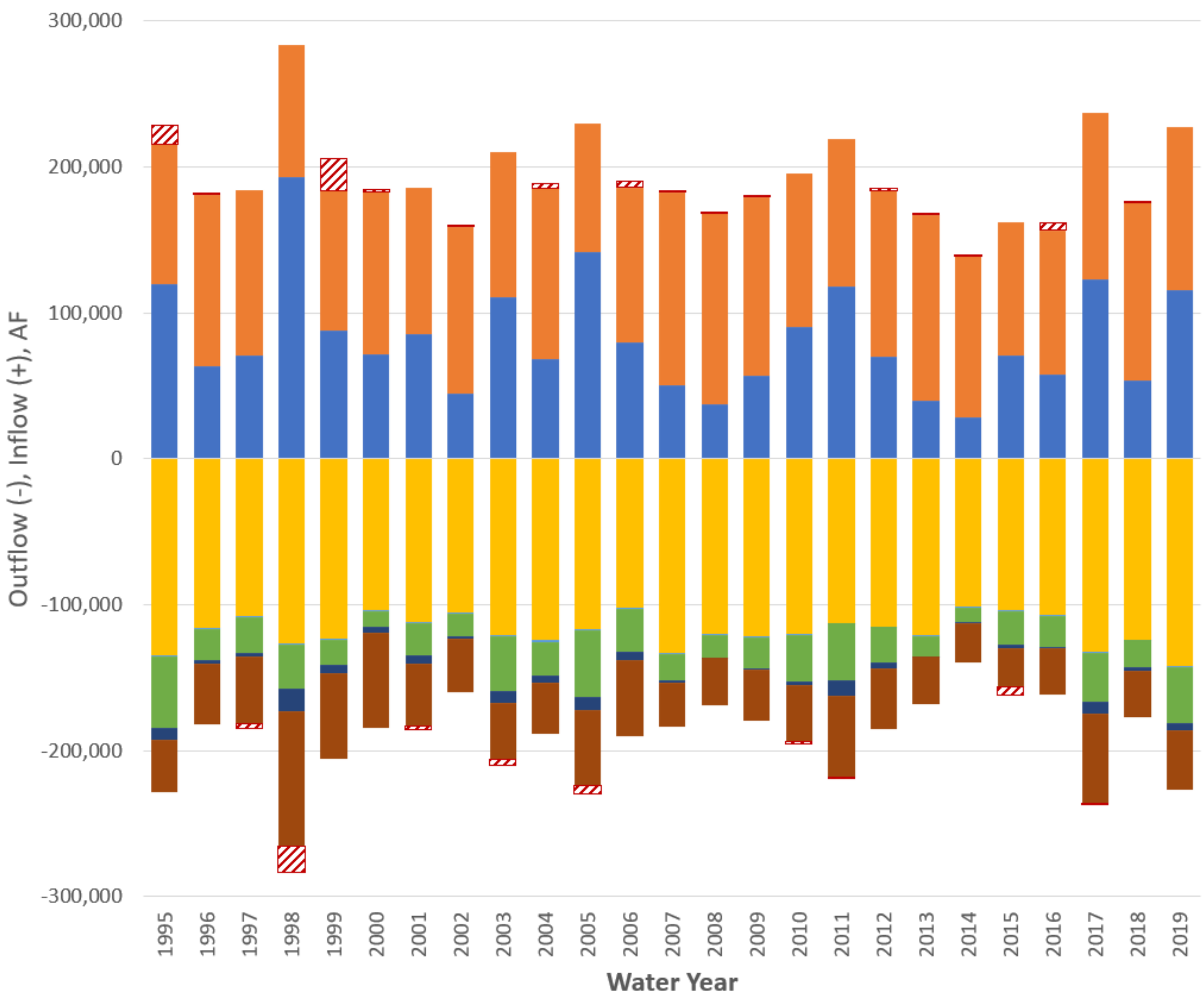
1. Annual volumes reported by AEWSD, TCWD, and WRMWSD are for different annual time periods (e.g., calendar year, water year, etc) and are reported as water year here for consistency with the water budget tables.
2. Water Year is defined as the October of the previous year through September of the current year.
3. Cumulative import values rounded to the nearest 100 AF.

Cumulative Surface Water Imports to the White Wolf Subbasin, 1966-2019

eki environment & water

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

Figure WB-6



Legend

Inflows

- Precipitation
- Applied water

Outflows

- ET (Agricultural)
- ET (Urban)
- ET (Native)
- Runoff
- Recharge to groundwater system

Change in Root Zone Storage

- Change in root zone storage

Abbreviations

AF = acre-feet
ET = evapotranspiration

Notes

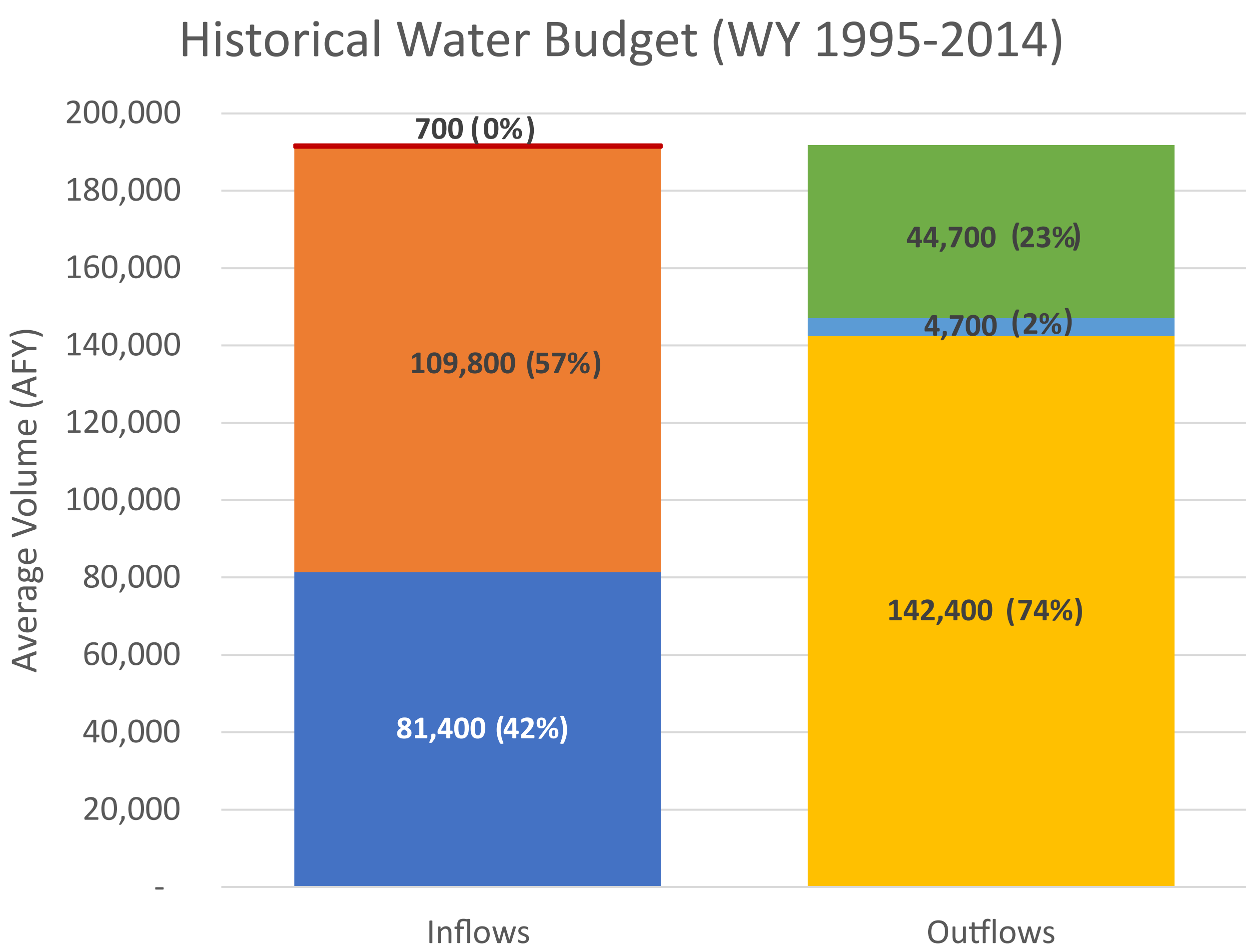
1. Water Year is defined as the October of the previous year through September of the current year.
2. A positive volume corresponds to a root zone system inflow and a negative volume corresponds to a root zone system outflow.

Annual Land Surface System Inflows and Outflows

eki environment & water

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

Figure WB-7



Legend

Inflows

Precipitation

Applied Water

Outflows

Actual ET

Runoff

Recharge to GW

Change in Root Zone Storage

Root Zone Storage Chnage

Abbreviations

AFY = acre-feet per year
ET = evapotranspiration
GW = groundwater
WY = Water Year

Notes

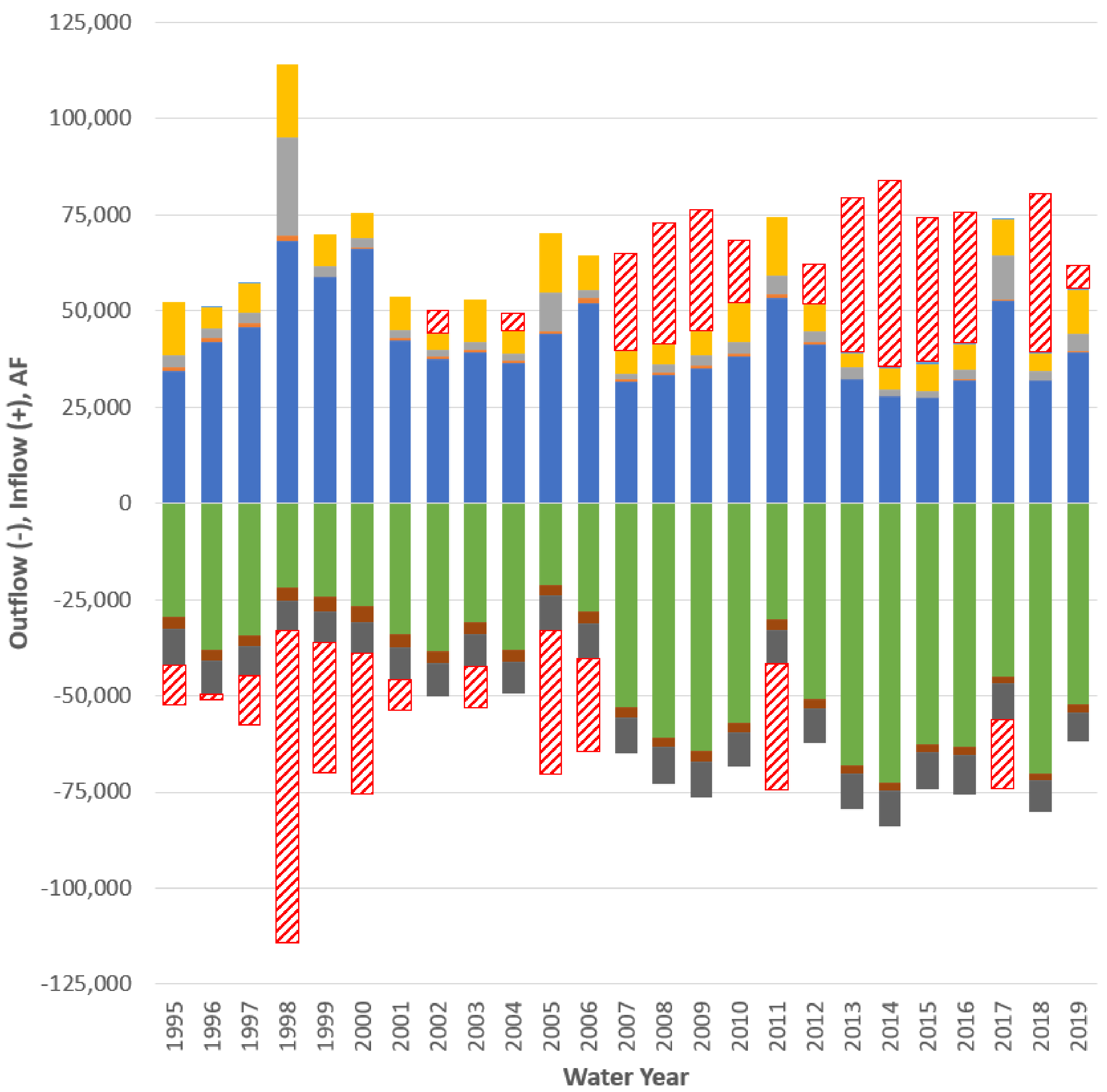
1. Water Year is defined as the October of the previous year through September of the current year.
2. A positive volume corresponds to a root zone system inflow and a negative volume corresponds to a root zone system outflow.
3. Percentages rounded to the nearest percent.

Historical Average (WY 1995-2014) Land Surface System Inflows and Outflows

eki environment & water

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

Figure WB-8



Legend

Inflows

- Infiltration (agricultural)
- Infiltration (urban)
- Infiltration (native)
- Net streamflow leakage to groundwater Net
- Subsurface flow from unpumped aquifer

Outflows

- Groundwater extractions (agricultural)
- Evaporation of shallow groundwater/GDEs Net
- subsurface flow to Kern County Subbasin

Change in Groundwater Storage

- Change in groundwater storage

Abbreviations

AF = acre-feet
GDEs = Groundwater Dependent Ecosystems

Notes

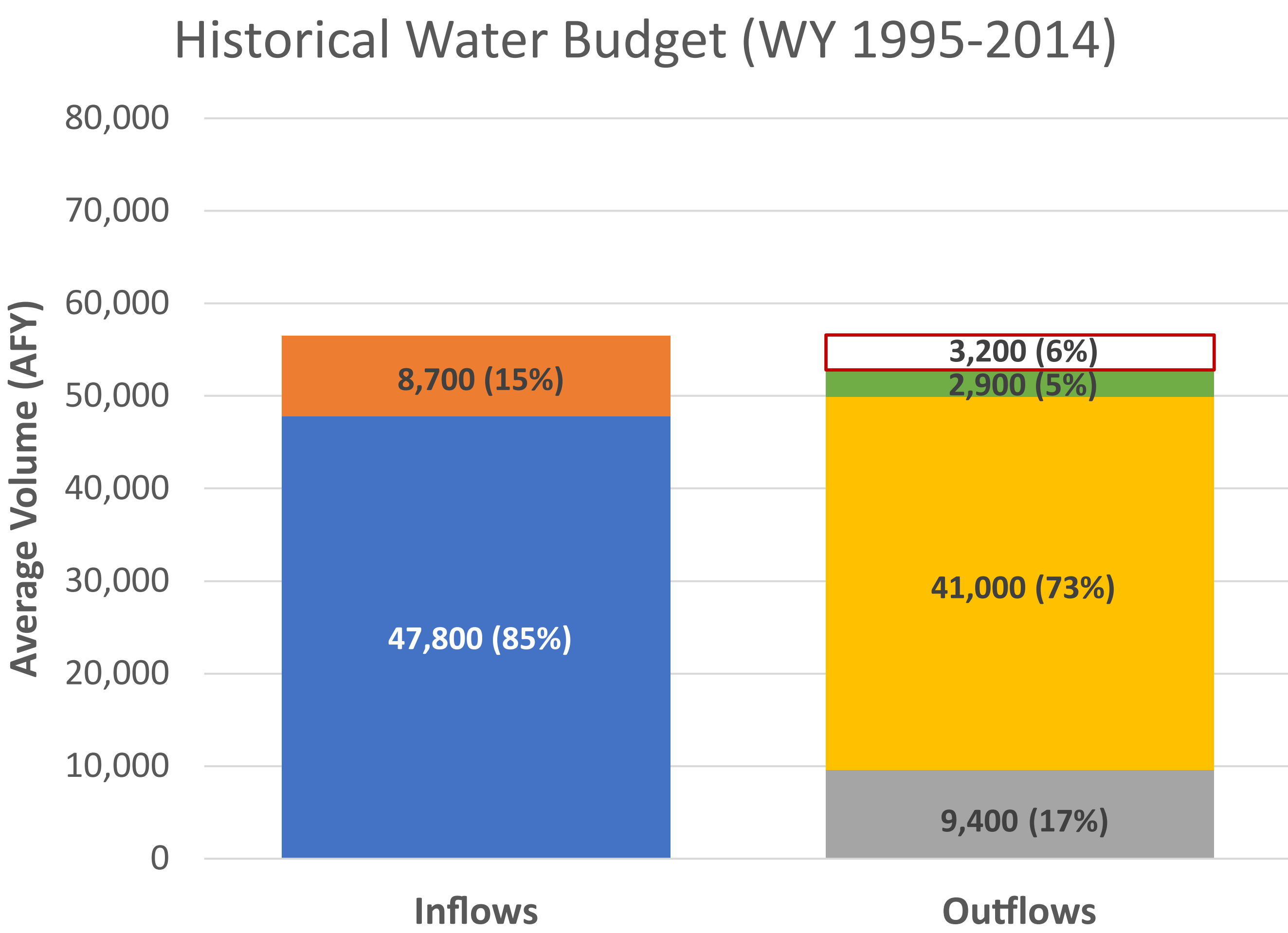
1. Water Year is defined as the October of the previous year through September of the current year.
2. A positive volume corresponds to a groundwater system inflow and a negative volume corresponds to a groundwater system outflow.

Annual Groundwater System Inflows and Outflows

eki environment & water

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

Figure WB-9



Legend

Inflows

Infiltration

Net Streamflow Leakage to Groundwater

Outflows

Groundwater Extractions

Evaporation ot Shallow Groundwater/GDEs

Net subsurface flow to Kern County Subbasin

Change in Groundwater Storage

Change in Groundwater Storage

Abbreviations

AFY = acre-feet per year
GDEs = Groundwater Dependent Ecosystems
WY = Water Year

Notes

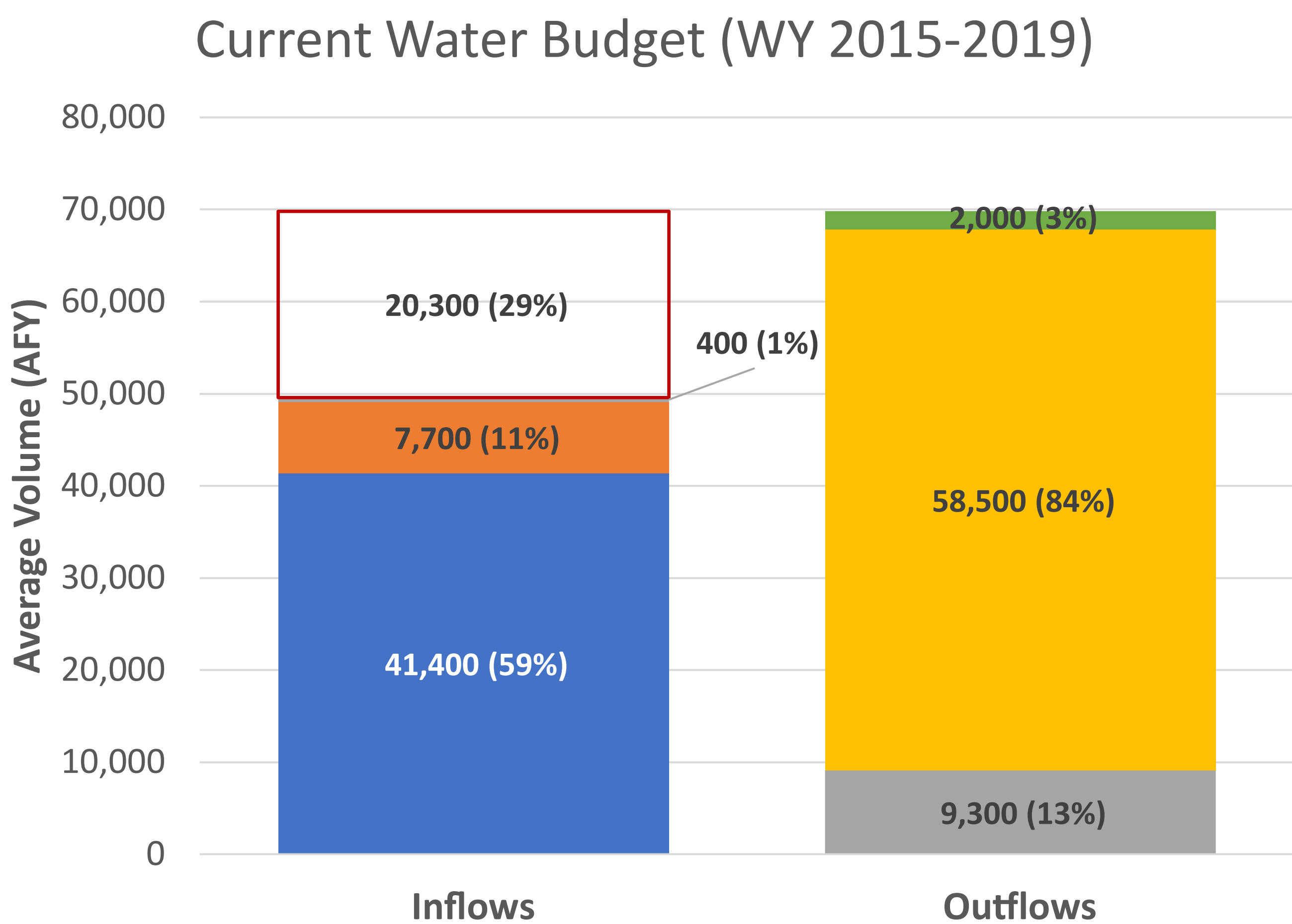
1. Water Year is defined as the October of the previous year through September of the current year.
2. A positive volume corresponds to a groundwater system inflow and a negative volume corresponds to a groundwater system outflow.

Historical Average (WY 1995-2014) Groundwater System Inflows and Outflows

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

eki environment & water

Figure WB-10



Legend

Inflows

- Infiltration
- Net Streamflow Leakage to Groundwater Net
- Subsurface Flow from Unpumped Aquifer

Outflows

- Groundwater Extractions
- Evaporation of Shallow Groundwater/GDEs
- Net Subsurface Groundwater Flow to Kern County Subbasin

Change in Groundwater Storage

- Change in groundwater storage

Abbreviations

AFY = acre-feet per year
GDEs = Groundwater Dependent Ecosystems
WY = Water Year

Notes

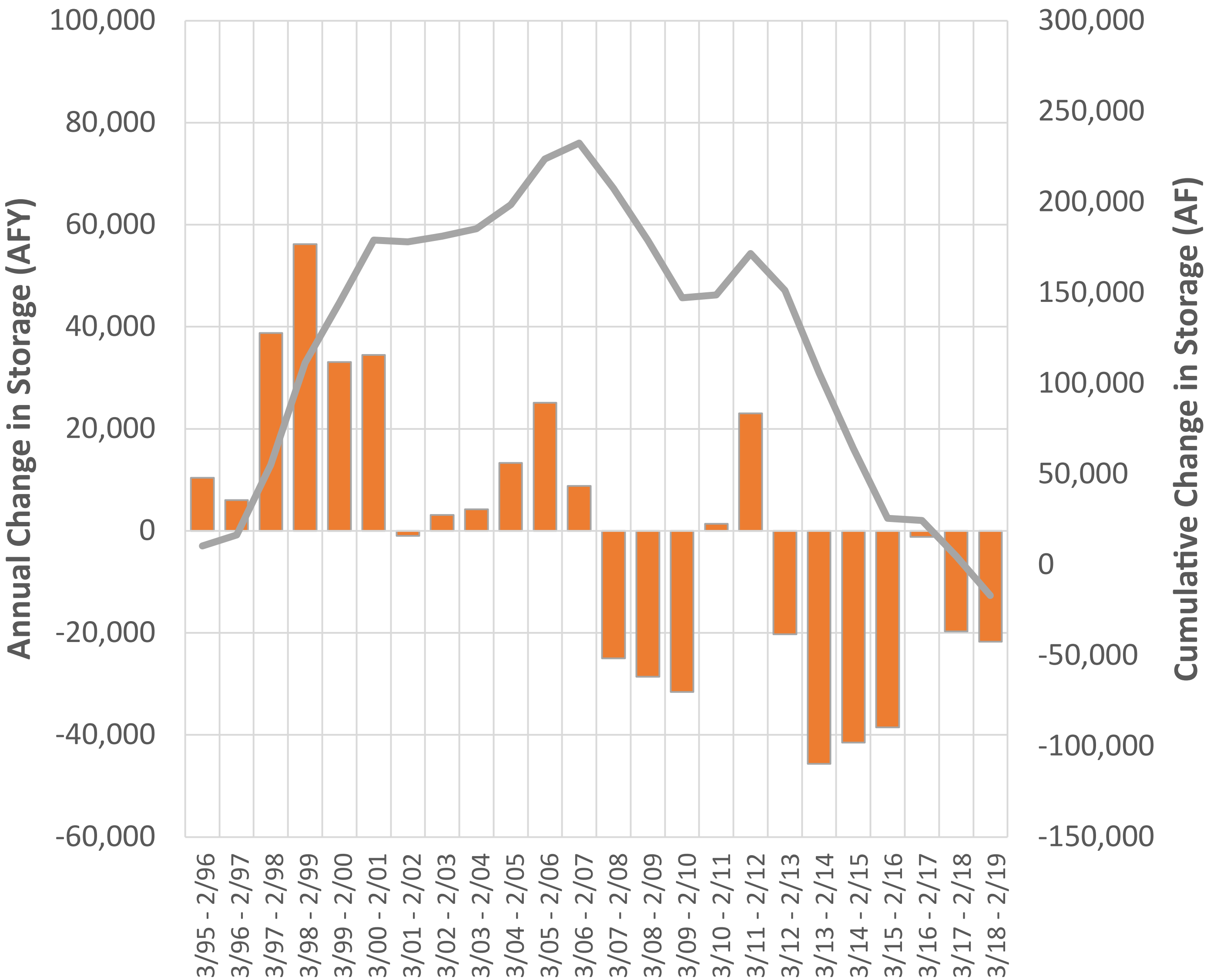
1. Water Year is defined as the October of the previous year through September of the current year.
2. A positive volume corresponds to a groundwater system inflow and a negative volume corresponds to a groundwater system outflow.

Current Average (WY 2015-2019) Groundwater System Inflows and Outflows

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

eki environment & water

Figure WB-11



Legend

Annual change in storage between seasonal highs

Cumulative change in storage since March 1995

Abbreviations

AF = acre-feet
AFY = acre-feet per year

Notes

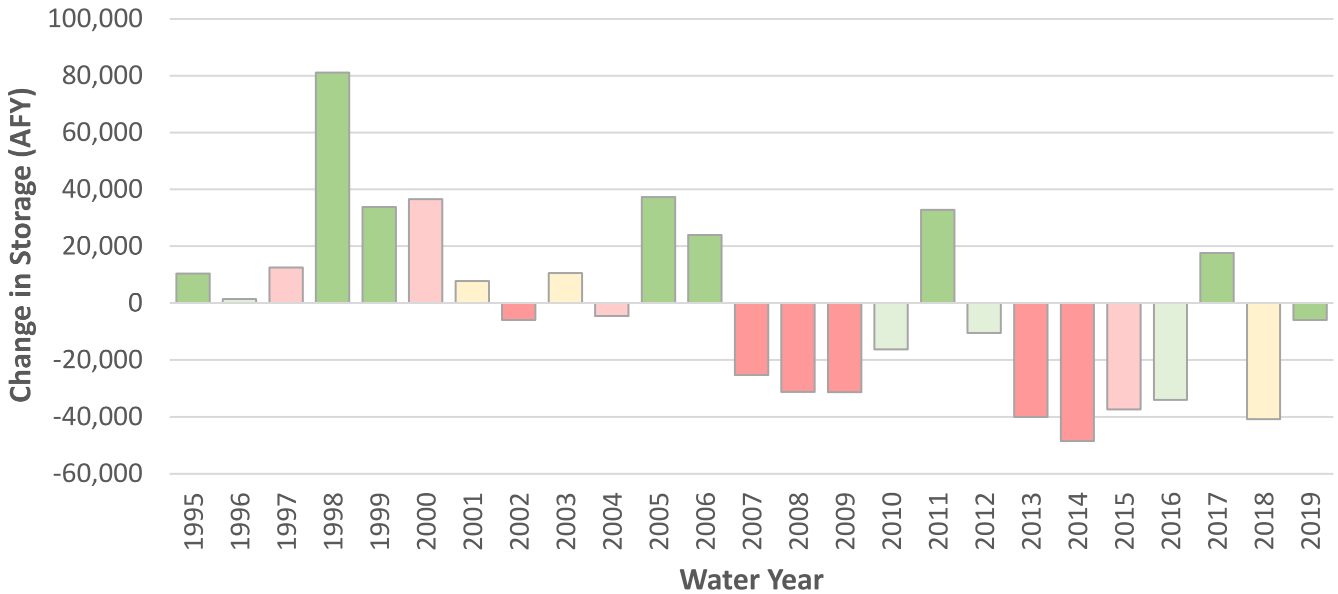
1. "Seasonal high" condition is defined as March - February of the following year.

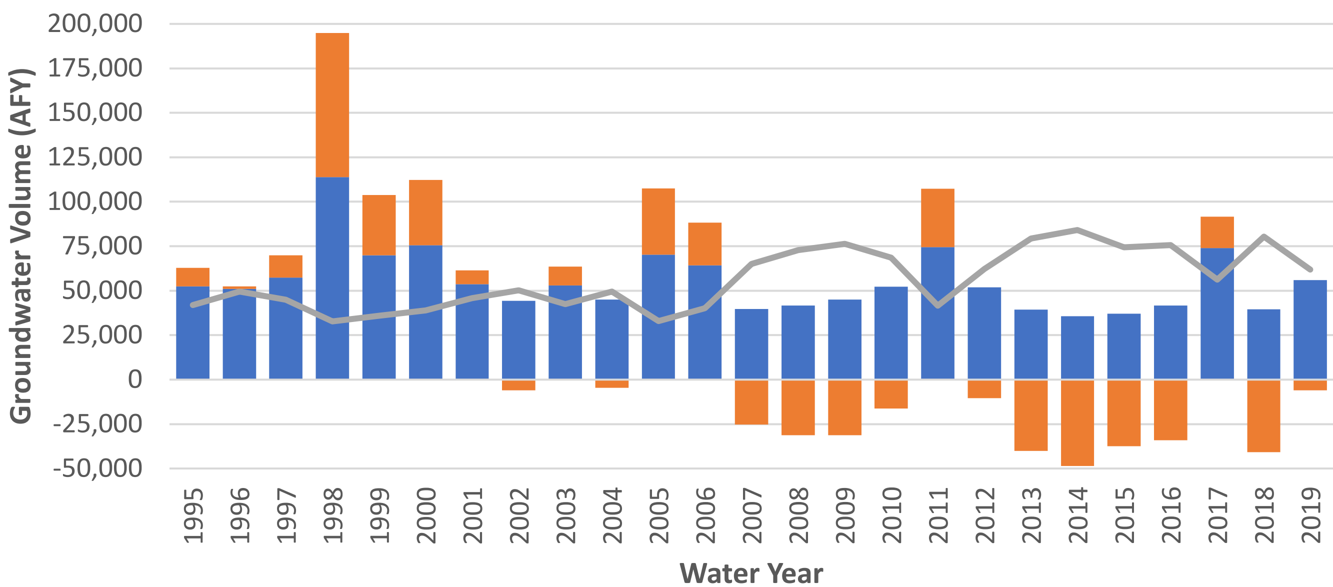
Annual and Cumulative Change in Storage Between Seasonal Highs, March 1995-February 2019

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

eki environment & water

Figure WB-12





Legend

DWR Water Year Type

- Wet
- Above Normal
- Below Normal
- Dry
- Critical
- Groundwater Inflows (i.e. supply)
- Groundwater Storage Change Groundwater
- Outflows (i.e., demand)

Abbreviations

AFY = acre-feet per year
DWR = California Department of Water Resources

Notes

1. Water Year is defined as the October of the previous year through September of the current year.

Sources

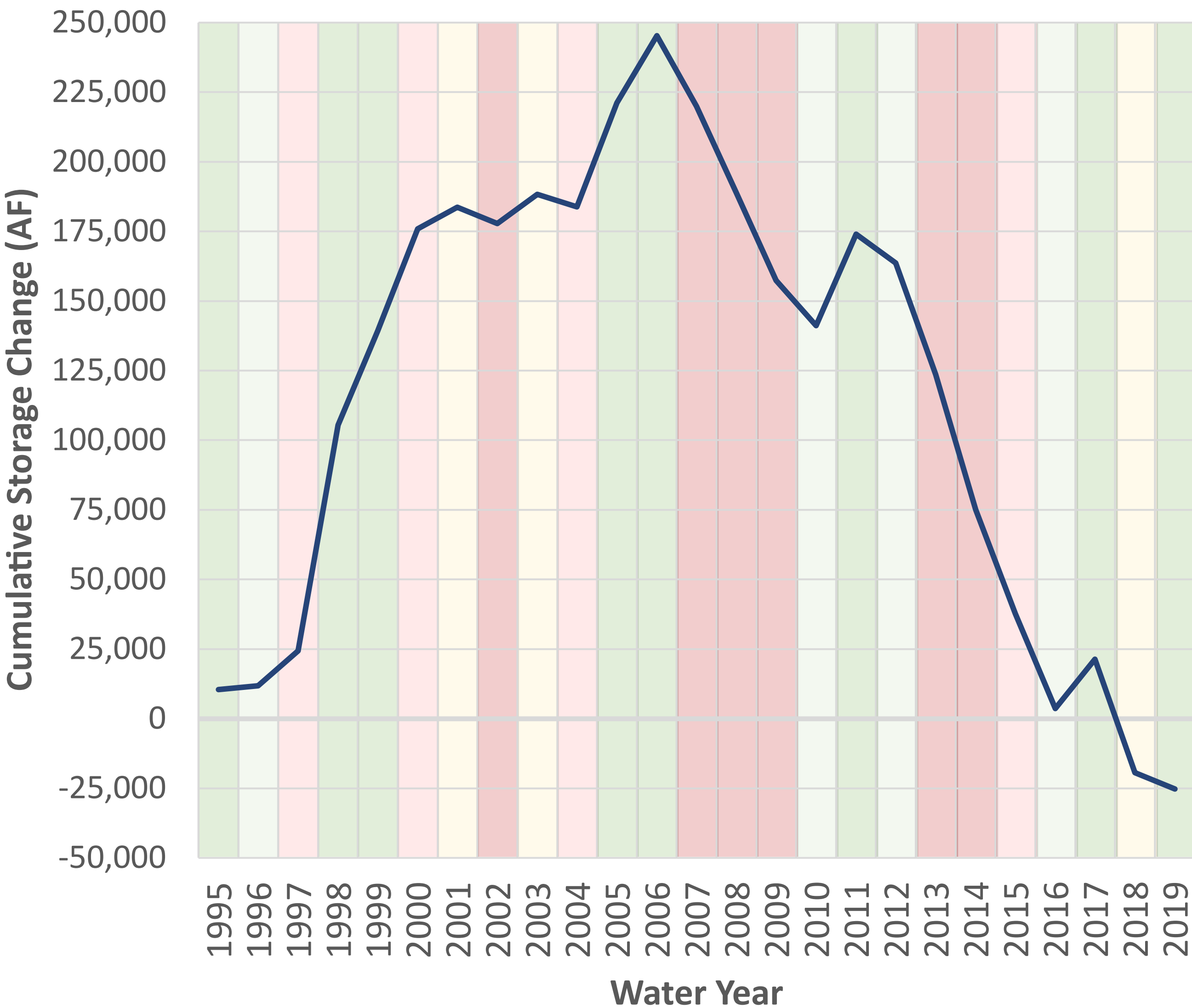
1. DWR Water Year type from (DWR, 2021).

Annual Groundwater Inflows, Outflows, and Change in Storage vs. DWR Water Year Type

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

eki environment & water

Figure WB-13



Legend

DWR Water Year Type

- Wet
- Above Normal
- Below Normal
- Dry
- Critical

Cumulative storage change since WY 1995

Abbreviations

AF = acre-feet
DWR = California Department of Water Resources
WY = Water Year

Notes

1. Water Year is defined as the October of the previous year through September of the current year.

Sources

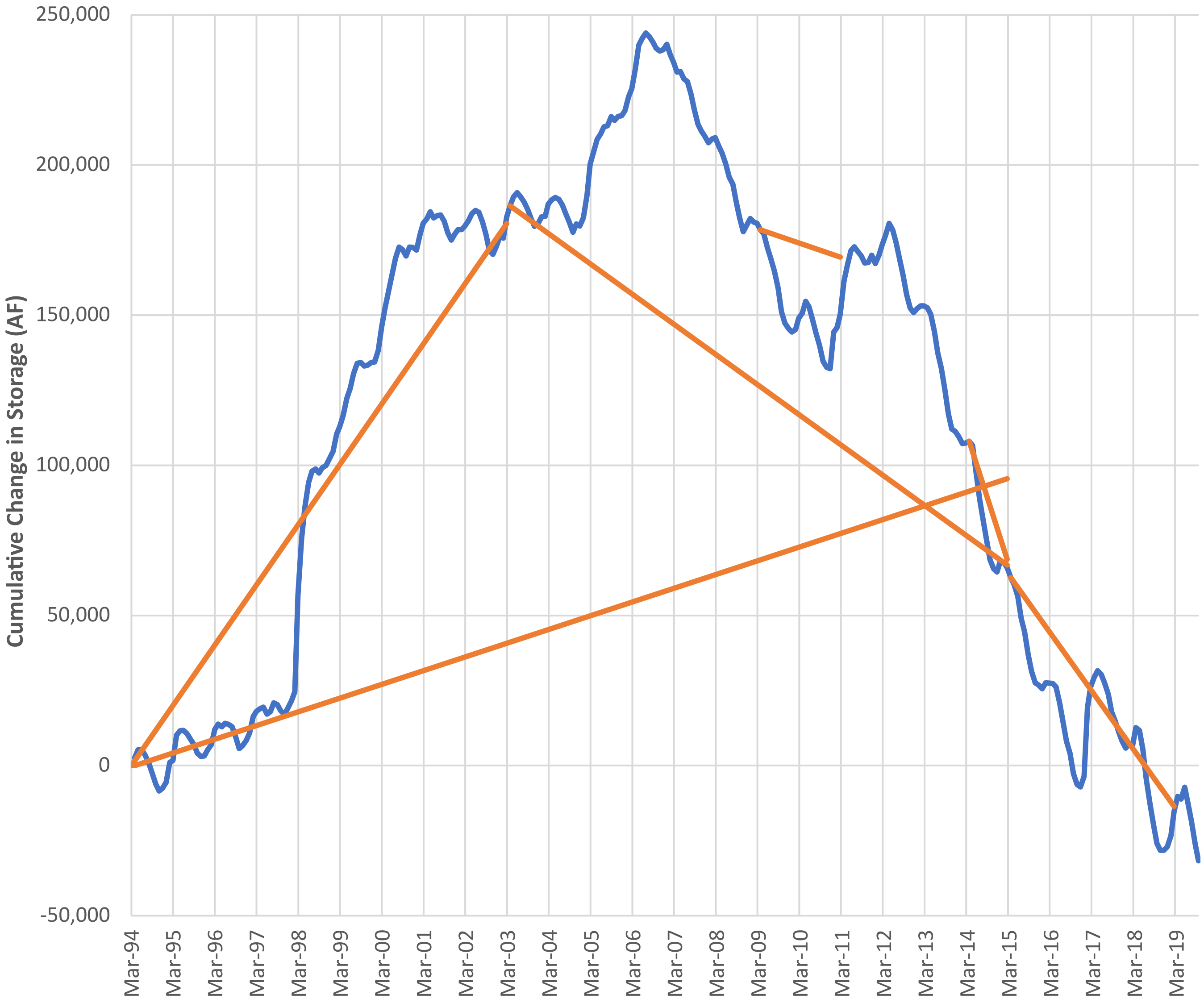
1. DWR Water Year type from (DWR, 2021).

Cumulative Change in Storage vs. DWR Water Year Type

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

eki environment & water

Figure WB-14



Legend

WWGFM calculated cumulative storage change since March 1994

Water level-based estimated storage change

Abbreviations

AF = acre-feet
WWGFM = White Wolf Groundwater Flow Model

Notes

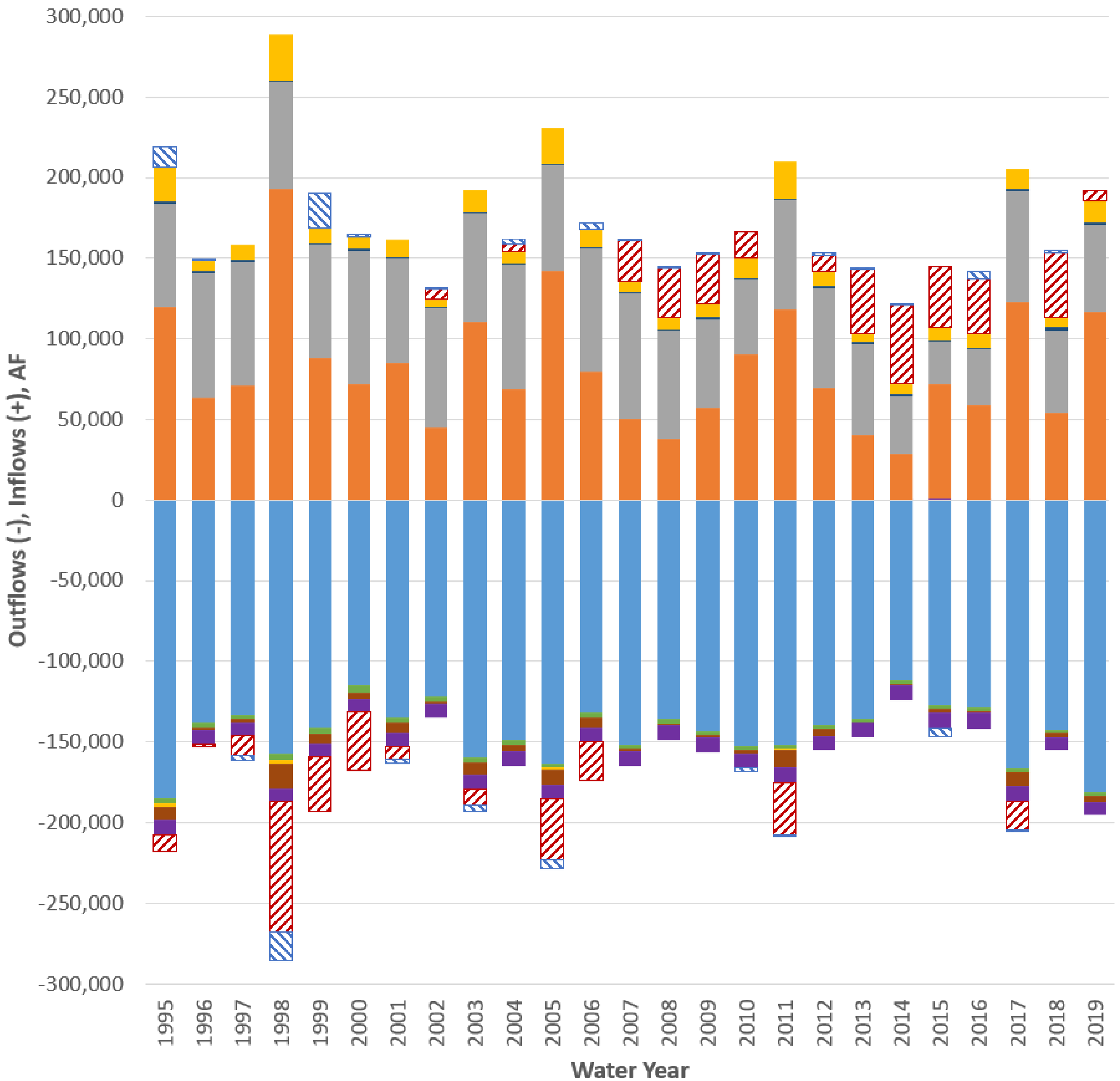
1. Water-level based estimated change in storage is for an area of approximately 35,000 acres.
2. Water level-based storage change calculations correspond to periods in Table GWC-3.

Comparison of Modeled & Water Level-Based Estimated Change in Storage

eki environment & water

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

Figure WB-15



Legend

Inflows

- Subsurface groundwater flow
- Precipitation
- Surface Water Imports
- Streamflow
- Applied Groundwater from Kern County Subbasin Wells

Outflows

- Evapotranspiration
- Evaporation of Shallow Groundwater/GDEs
- Streamflow
- Subsurface Groundwater Flow
- Runoff

Change in Storage

- Groundwater Storage Change
- Root Zone Storage Change

Abbreviations

AF = acre-feet
GDE = Groundwater Dependant Ecosystems

Notes

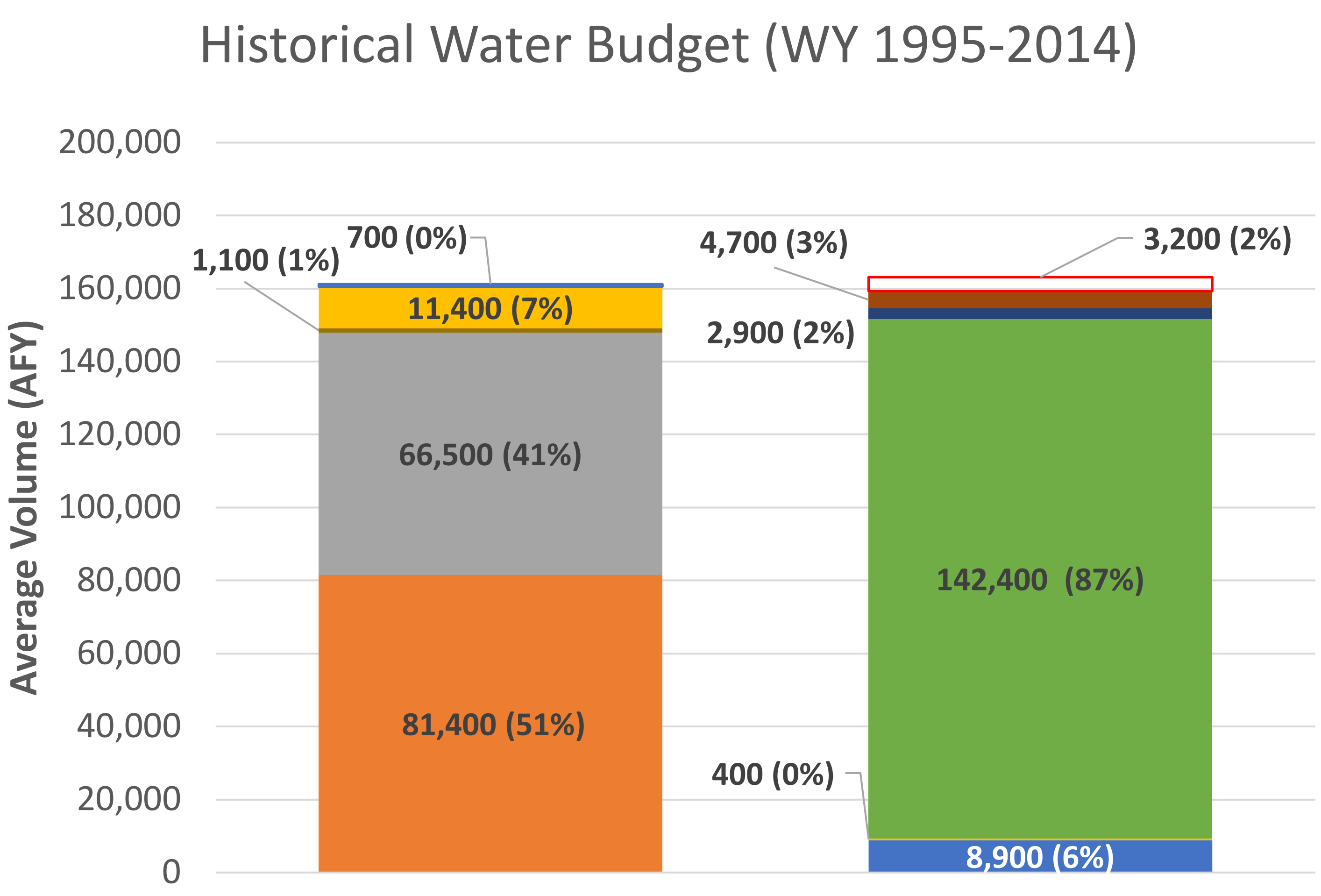
1. Water Year is defined as the October of the previous year through September of the current year.
2. A positive volume corresponds to a Basin inflow and a negative volume corresponds to a Basin outflow.

Annual Total Basin Inflows and Outflows

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

eki environment & water

Figure WB-16



Legend

Inflows
- Precipitation
- Streamflow
- Surface Water Imports
- Applied Groundwater from Kern County Subbasin Wells

Outflows
- Evapotranspiration
- Subsurface Groundwater Flow
- Runoff
- Streamflow
- Evaporation of Shallow Groundwater/ GDEs

Change in Groundwater Storage
- Groundwater Storage Change
- Root Zone Storage Change

Abbreviations

AFY = acre-feet per year
GDE = Groundwater Dependant Ecosystem
WY = Water Year

Notes

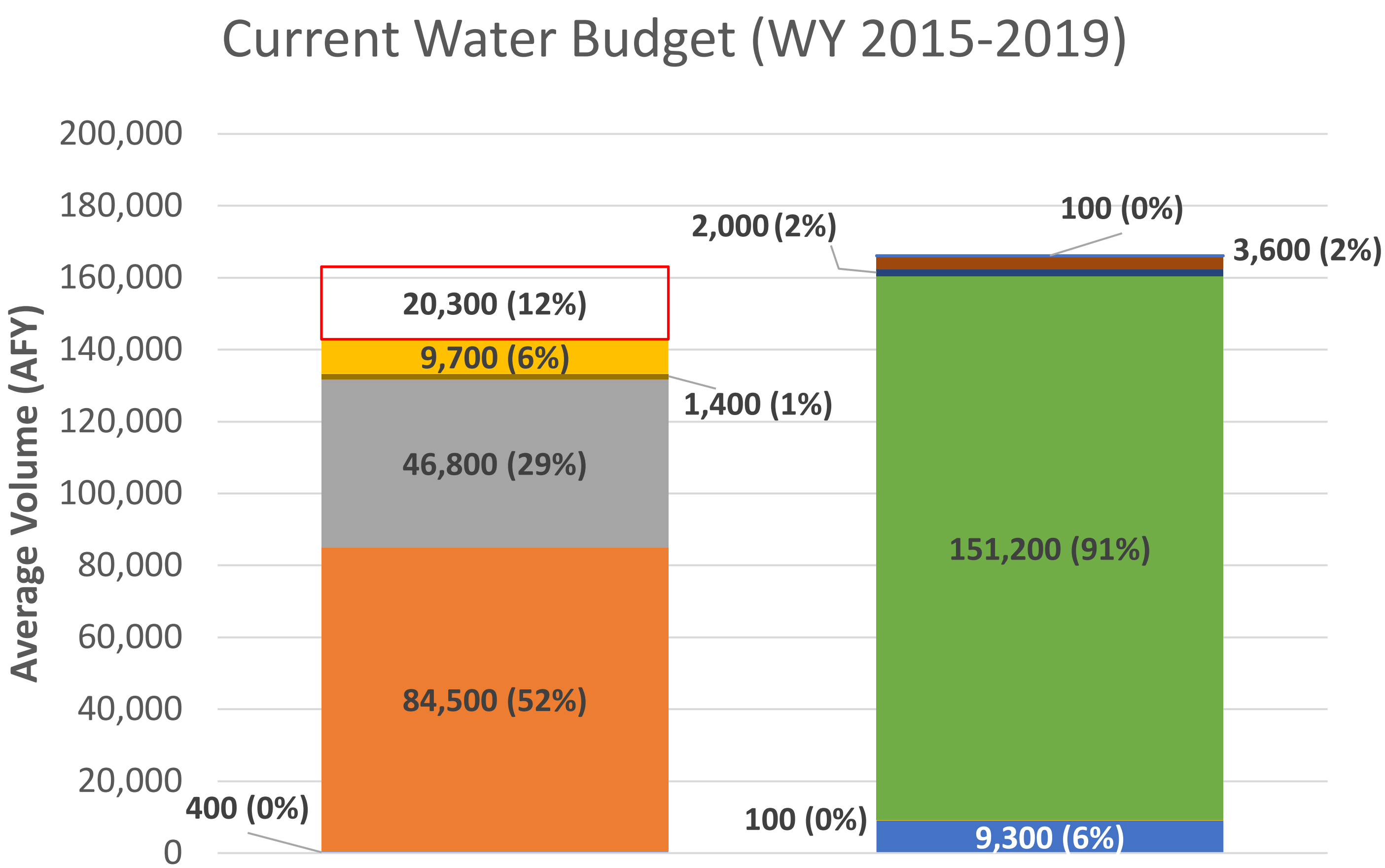
1. Water Year is defined as the October of the previous year through September of the current year.
2. A positive volume corresponds to a Basin inflow and a negative volume corresponds to a Basin outflow.
3. Percentages rounded to the nearest percent.

Historical Average (WY 1995-2014) Total Basin Inflows and Outflows

eki environment & water

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

Figure WB-17



Legend

Inflows

- Subsurface Groundwater Flow
- Precipitation
- Surface Water Imports
- Streamflow
- Applied Groundwater from Kern County Subbasin Wells

Outflows

- Evapotranspiration
- Subsurface groundwater flow
- Runoff
- Streamflow
- Evaporation of Shallow Groudnwater/GDEs

Change in Groundwater Storage

- Groundwater Storage Change
- Root Zone Storage Change

Abbreviations

AFY = acre-feet per year
GDE = Groundwater Dependant Ecosystem
WY = Water Year

Notes

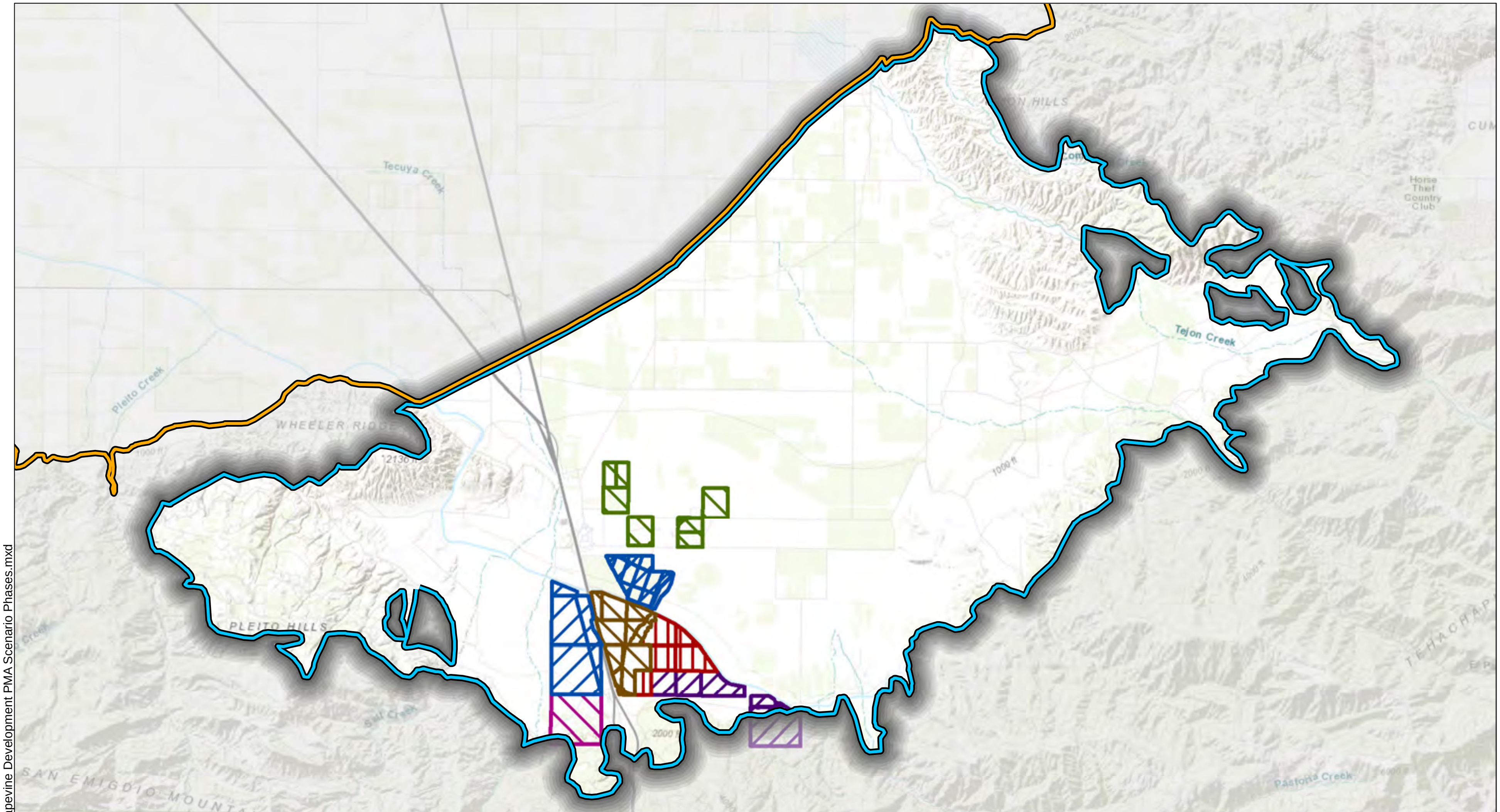
1. Water Year is defined as the October of the previous year through September of the current year.
2. A positive volume corresponds to a Basin inflow and a negative volume corresponds to a Basin outflow.
3. Percentages rounded to the nearest percent.

Current Average (WY 2015-2019)
Total Basin Inflows and Outflows

eki environment & water

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

Figure WB-18



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- Projected Grapevine Build-Out in 2027
- Projected Grapevine Build-Out in 2031
- Projected Grapevine Build-Out in 2035
- Projected Grapevine Build-Out in 2039
- Projected Grapevine Build-Out in 2043
- Projected Grapevine Build-Out in 2046

Abbreviations

DWR = California Department of Water Resources

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. EKI, 2015. Evaluation of Potable, Non-Potable and Recycled Water Demands Grapevine Project, prepared for Tejon Ranchcorp, dated November 2015.

N 0 3 6 (Scale in Miles)

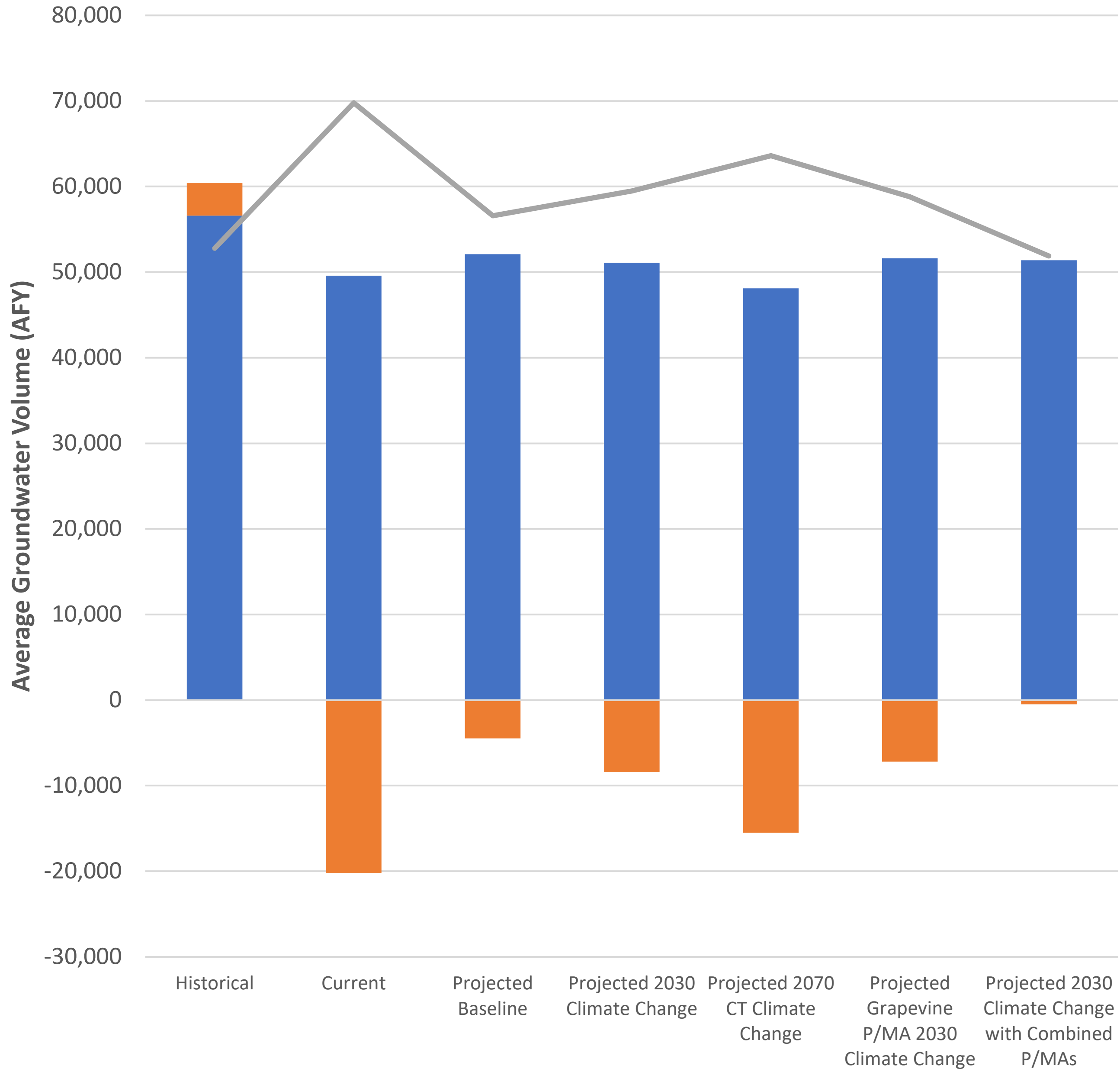
Grapevine Development P/MA Scenario Phases

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure WB-19

Path: X:\B50001.05\Maps\GSP\2022\01\FigWB-19_Grapevine Development PMA Scenario Phases.mxd



Legend

Groundwater Supply (i.e., inflows)
Groundwater Storage Change
Groundwater Demand (i.e., outflows)

Abbreviations

AFY = acre-feet per year
CT = Central Tendency
P/MA = Project and/or Management Action
WY = Water Year

Notes

1. Historical average over WY 1995-2014, current average over WY 2015-2019, projected average over WY 2020-2072.

Projected Groundwater System Supplies and Demands

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

eki environment & water

Figure WB-20

10. MANAGEMENT AREAS

The White Wolf Groundwater Sustainability Agency has elected to not utilize management areas at this time.

SUSTAINABLE MANAGEMENT CRITERIA

11. INTRODUCTION TO SUSTAINABLE MANAGEMENT CRITERIA

> *§ 354.22. Introduction to Sustainable Management Criteria*
> *This Subarticle describes criteria by which an Agency defines conditions in its Plan that constitute sustainable groundwater management for the basin, including the process by which the Agency shall characterize undesirable results, and establish minimum thresholds and measurable objectives for each applicable sustainability indicator.*

The Sustainable Groundwater Management Act (SGMA) legislation defines a "Sustainability Goal" as "the existence and implementation of one or more groundwater sustainability plans that achieve sustainable groundwater management by identifying and causing the implementation of measures targeted to ensure that the applicable basin is operated within its sustainable yield" (California Water Code [CWC] § 10721(u)). SGMA requires Groundwater Sustainability Agencies (GSAs) to develop and implement Groundwater Sustainability Plans (GSPs) to meet the Sustainability Goal (CWC § 10727(a)). The SGMA legislation and California Code of Regulations Title 23 (23 CCR) Division 2 Chapter 1.5 Subchapter 2 define terms related to achievement of the Sustainability Goal, including:

- Undesirable Result (UR) – "one or more of the following effects caused by groundwater conditions occurring throughout the basin:
    (1) Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.
    (2) Significant and unreasonable reduction of groundwater storage.
    (3) Significant and unreasonable seawater intrusion.
    (4) Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.
    (5) Significant and unreasonable land subsidence that substantially interferes with surface land uses.
    (6) Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water." (CWC § 10721(x));
- Minimum Threshold (MT) – "a numeric value for each sustainability indicator used to define undesirable results" (23 CCR § 351(t)).

- Measurable Objective (MO) – "specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin" (23 CCR § 351(s)); and
- Interim Milestone (IM) – "a target value representing measurable groundwater conditions, in increments of five years, set by an Agency as part of a Plan" (23 CCR § 351(q))

Collectively, the Sustainability Goal, URs, MTs, MOs, and IMs are referred to herein as Sustainable Management Criteria (SMCs).

Each of the following are referred to as "Sustainability Indicators", which, as stated above, can constitute URs if they are "significant and unreasonable": (1) Chronic Lowering of Groundwater Levels, (2) Reduction of Groundwater Storage, (3) Seawater Intrusion, (4) Degraded Water Quality, (5) Land Subsidence, and (6) Depletions of Interconnected Surface Waters[79] (CWC § 10721(x)). The 23 CCR also specify how GSAs must establish SMCs for each applicable Sustainability Indicator. ***Sections 12, 13, 14, and 15*** of this GSP describe the Sustainability Goal, URs, MTs, and MOs, respectively, that have been developed as part of this GSP.

[79] Groundwater Dependent Ecosystems (GDEs) are considered under Depletions of Interconnected Surface Waters Sustainability Indicator.

12. SUSTAINABILITY GOAL

> *§ 354.24 Sustainability Goal*
> *Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.*

The Sustainable Groundwater Management Act (SGMA) requires that a Sustainability Goal be defined for each medium- or high-priority basin (California Water Code [CWC] § 10727(a)). The California Code of Regulations Title 23 (23 CCR) Division 2 Chapter 1.5 Subchapter 2 further clarify that the Sustainability Goal should culminate "in the absence of undesirable results within 20 years of the applicable statutory deadline" (23 CCR § 354.24).

The White Wolf Groundwater Sustainability Agency has adopted the following Sustainability Goal for the White Wolf Subbasin:

Cooperatively continue to maintain an economically viable groundwater resource within the White Wolf Subbasin that supports the current and future beneficial uses of groundwater by utilizing the area's groundwater resources within the local sustainable yield and avoiding undesirable results.

13. UNDESIRABLE RESULTS

§ 354.26. Undesirable Results

(a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

(b) The description of undesirable results shall include the following:

(1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

(2) The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.

(3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.

(c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.

(d) An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.

This section describes the Undesirable Results (URs) for the White Wolf Subbasin (Basin) for each applicable Sustainability Indicator. The URs are defined in the Sustainable Groundwater Management Act (SGMA) as occurring "when significant and unreasonable effects for any of the Sustainability Indicators are caused by groundwater conditions occurring throughout the basin." As discussed below for each Sustainability Indicator, the quantitative criteria for determining URs refer to exceedances of the Minimum Thresholds (MTs) established within the Basin (see ***Section 14 Minimum Thresholds***). **Table SMC-1** summarizes the Undesirable Results definitions and justifications for each applicable Sustainability Indicator.

Table SMC-1. Summary of Undesirable Results and Minimum Threshold Definitions, Criteria, and Justification

Sustainability Indicator	Undesirable Result (UR) Causes	Potential Effects on Beneficial Users	UR Definition	Minimum Threshold (MT) Definition	MT Justification	UR Criteria	UR Justification
Chronic Lowering of Groundwater Levels	**Increased pumping** due to - increase in water use per acre on irrigated land - new land put into agricultural production - additional urban demand met by groundwater. **Reduced recharge** due to - increased agricultural irrigation efficiency - climate change resulting in decreased precipitation - decreased surface water inflows from contributing watersheds - reduced cross-boundary inflows and/or increased cross-boundary outflows - increased ET.	**Groundwater well dewatering** and associated effects (e.g., increased maintenance costs, possible well deepening/replacement, and reduced well lifespan). **Increased pumping lift** and associated effects (i.e., greater energy use, higher pumping costs, increased wear and tear on well pump motors, reduced well efficiency, and lower well yield). **Effects on correlated sustainability indicators** (i.e., groundwater storage, subsidence, and depletion of interconnected surface waters).	Undesirable Results would be experienced if and when a chronic decline in groundwater levels in the Principal Aquifer negatively affects the reasonable and beneficial use of, and access to, groundwater for beneficial users and uses within the Basin. **Significant and Unreasonable effects** associated with Undesirable Results occur would include: - complete dewatering of more than 25% of existing wells over the 20-year implementation period.	**MTs are set at the 14 designated RMW-WLs,** taking into consideration: - **Historical water level data**. - **Proximity to critical infrastructure** to take into consideration land subsidence impacts. For the six RMW-WL locations within one mile of the California Aqueduct or the 850 Canal, the **MTs for Chronic Lowering of Groundwater Levels are set to their historical low groundwater levels**. - Variability in groundwater levels is accounted for by calculating a **Variability Correction Factor**. A 25% conservative allowance has been set for water level fluctuations within wells. - To account for **the recent trends in groundwater levels** and to extend them for a period of time (Trend Extension Period), a **Trend Continuation Factor** has been determined.	MTs are set at levels indicating a depletion of supply that may lead to Undesirable Results, based on the most prevalent beneficial users (irrigation wells) and most sensitive beneficial users (domestic/public supply wells). MTs consider historical groundwater level trends. Using a **10-year Trend Extension Period** (1) allows the GSAs sufficient time for implementation of P/MAs needed to reverse declining trends and (2) this period is half the duration of the SGMA implementation period, the Basin should be on a trajectory towards achieving the Sustainability Goal. **Historical low groundwater levels** are not known to have caused significant and unreasonable impacts to beneficial uses and users of groundwater, based on the best available information. **Well Impact analysis** shows that proposed MTs are not expected to result in complete dewatering of any of the wells analyzed, and only 20% of irrigation wells (4 out of 20) would be partially dewatered at MT levels. As such, the extent of potential impacts is not considered to be significant and unreasonable. **The MTs have been developed in consideration of and in coordination with the neighboring Kern County Subbasin.** The MT methods are generally consistent with the adjoining basins. **The Basin's MTs are higher than those in the adjacent subbasin which ensures that the horizontal gradient of groundwater flow will remain similar to historical conditions** if water levels were to reach MTs.	Undesirable Results are defined to occur **if and when groundwater levels in the Principal Aquifer decline below the established MTs in 40% or more of the RMW-WLs (6 or more out of 14) over four consecutive seasonal measurements** (i.e., measurements spanning a total of two years, including two seasonal high groundwater level periods and two seasonal low groundwater level periods).	URs occur when MT exceedances occur in 40% or more of the RMW-WLs. Using the findings from the well impact analysis, the proposed MTs are not expected to result in complete dewatering of any of the wells analyzed. The percentage of wells that would likely require replacement due to age alone is estimated at 78% (i.e., 78% of wells in the Basin are 50 years old or more). Therefore, it is conservative to base the UR definition on a maximum allowable percentage of wells that could be completed dewatered at MT levels of 25%. If groundwater levels within the Basin and adjacent subbasin fall to the MTs, it would not impact sustainable groundwater management in the adjacent subbasin as the gradient direction would be maintained. Furthermore, the Basin will rely on at least one demand reduction P/MA to achieve the sustainability goal. There is an economic trade-off for agricultural users between increased pumping and increased fallowing.

Sustainability Indicator	Undesirable Result (UR) Causes	Potential Effects on Beneficial Users	UR Definition	Minimum Threshold (MT) Definition	MT Justification	UR Criteria	UR Justification
Reduction of Groundwater Storage	**Same causes as the Chronic Lowering of Groundwater Levels sustainability indicator Levels** (i.e., increased groundwater pumping and reduced recharge; see above).	**Reduced groundwater supply reliability** due to reduced quantity of water available.	Undesirable Results would be experienced if and when a reduction in storage in the Principal Aquifer negatively affects the long-term viable access to groundwater for the beneficial users and uses within the Basin. **Significant and unreasonable effects** associated with Undesirable Results would include: - Reduction in usable groundwater storage of more than 20% relative to the Fall 2015 usable groundwater storage volume.	**MTs for Chronic Lowering of Groundwater Levels are used as a proxy**. See above for definitions of those MTs.	MTs for Reduction in Groundwater Storage may be set by using MTs for Chronic Decline in Groundwater Levels as a proxy if it is demonstrated that a correlation exists between the two metrics. The following calculation demonstrates this correlation: The volume of "usable storage" theoretically accessible to existing wells was conservatively estimated using the WWGFM model as the storage between Fall 2015 groundwater levels and the median depth of production wells (1,050 ft). The usable storage volume is about 2.39 million acre-feet (MAF). The volume of groundwater above the Chronic Lowering of Groundwater Levels MTs and the Fall 2015 groundwater elevations is estimated at 455,000 AF, which is approximately 19% of the estimated volume of usable storage. **Because estimated usable storage is much greater than the volume of water above the MTs, the MTs for Chronic Lowering of Groundwater Levels are considered protective for the Reduction of Groundwater Storage Sustainability Indicator**.	Undesirable Results are defined to occur **if and when groundwater storage in the Principal Aquifer was to be reduced by an amount that would cause the groundwater levels in at least 40% of the RMW-WLs (6 or more out of 14) to exceed their MTs for Chronic Lowering of Groundwater Levels over two (2) consecutive years**.	The use of MTs for the Chronic Lowering of Groundwater Levels as a proxy for Reduction of Groundwater Storage has been demonstrated to be appropriate and protective. The amount by which groundwater storage would be reduced if all RMW-WLs declined to their respective MTs represents 19% of total usable groundwater storage. Given that the Undesirable Results definition is based on only 40% of RMW-WLs exceeding their MTs, the definition avoids significant and unreasonable effects for the Reduction of Groundwater Storage sustainability indicator.
Seawater Intrusion	Groundwater conditions in the Basin show that Seawater Intrusion is not present within the Basin, and is not anticipated to be present in the future, and therefore the Sustainability Indicator is **not applicable to the Basin**.						

Sustainability Indicator	Undesirable Result (UR) Causes	Potential Effects on Beneficial Users	UR Definition	Minimum Threshold (MT) Definition	MT Justification	UR Criteria	UR Justification
Degraded Water Quality	Causes related to **hydraulic conditions potentially influenced by groundwater level management**: - **Lateral migration from adjacent areas** with poorer quality groundwater - **Leaching from internal sources** such as fine-grained, clay-rich interbeds. - **Upwards vertical flow** from deeper zones below the bottom of the Basin. - **Recharge from managed recharge projects**.	**Increased costs to treat groundwater** to drinking water standards if it is to be used as a potable supply source. **Increased costs to blend** relatively poor-quality groundwater with higher quality sources for drinking water users. **Potential reduction in "usable storage" volume of groundwater** in the Basin if large areas are impaired to the point that they cannot be used to support beneficial uses and users.	Undesirable Results for Degraded Water Quality would be experienced in the Basin if and when water quality conditions of the Principal Aquifer are degraded as a result of SGMA-related groundwater management activities such that they negatively impact the long-term viability of the groundwater resource for beneficial users and uses. **Significant and unreasonable effects** associated with Undesirable Results would include: - Increase, on a regional basis, in concentrations of identified constituents of concern above state and federal regulatory thresholds, as a result of SGMA-related groundwater management activities.	**MTs are set at the four designated RMW-WQs**—all public supply wells. MTs are set for the following three identified constituents of concern **based on regulatory thresholds for drinking water beneficial use set by USEPA and State of CA**, as follows: Arsenic: 0.01 mg/L (Primary Maximum Contaminant Level [MCL]) Nitrate: 10 mg/L (Primary MCL) Selenium: 0.05 mg/L (Primary MCL)	**MTs were set for arsenic, nitrate, and selenium because these constituents were (a) detected in greater than 15% of samples, (b) have significant health concerns at elevated levels, and/or (c) have State of CA and USEPA Primary MCLs**, and therefore pose health risks to drinking water beneficial users at elevated concentrations. MTs were set at their respective MCLs because **MCLs are the water quality standards for the most sensitive beneficial use** (i.e., drinking water). It should be noted that other State, federal, and local entities have greater authority to enforce water quality standards, especially for anthropogenic-derived pollutant constituents, and regulation of those constituents is not under the purview of GSA.	Undesirable Results are defined to occur **if and when MTs are exceeded for any of the three identified constituents of concern in 25% or more of the RMW-WQ (1 out of 4) for at least two consecutive years** as a result of SGMA-related groundwater management activities.	Groundwater management decisions can influence local well water quality while having little to no influence on overall basin water quality conditions and sustainability. The criteria of 25% or more of RMW-WQs exceeding their MTs is justified because it addresses the potential cumulative effects from management decisions on basin-scale water quality conditions, while conservatively **identifying a potential basin-scale rather than well-specific water quality issue**.

Sustainability Indicator	Undesirable Result (UR) Causes	Potential Effects on Beneficial Users	UR Definition	Minimum Threshold (MT) Definition	MT Justification	UR Criteria	UR Justification
Land Subsidence	**Depressurization of aquifers and aquitards due to lowering of groundwater levels**, which can lead to compaction of compressible strata and lowering of the ground surface. Therefore, the causes of Undesirable Results due to Land Subsidence are the same as the potential causes listed above for Undesirable Results due to Chronic Lowering of Groundwater Levels.	**Damage to critical infrastructure**, including gravity-driven water conveyance infrastructure (e.g., the California Aqueduct and the 850 Canal), municipal water lines, canals, etc. that results in a loss of function or capacity of the infrastructure. **Damage to non-critical infrastructure** such as individual groundwater well heads, discharge lines, and casings.	Undesirable Results would be experienced if and when land subsidence due to groundwater level declines in the Principal Aquifer negatively affects the ability to use existing critical infrastructure within the Basin. **Significant and unreasonable effects** associated with Undesirable Results would include: - Subsidence-related damage to critical water conveyance infrastructure (i.e., the California Aqueduct and the 850 Canal) resulting in a loss of functional capacity of the infrastructure that prevents conveyance of available volumes of water that could otherwise be conveyed if the subsidence had not occurred.	**Groundwater levels at five RMW-WLs are used as a proxy** for monitoring URs from land subsidence. **No specific MTs are established for Land Subsidence**. Rather, the MTs established for Chronic Lowering of Groundwater Levels are deemed to be protective against Undesirable Results for Land Subsidence, because: - For the five RMW-WL locations within one mile of the California Aqueduct or the 850 Canal, the **MTs for Chronic Lowering of Groundwater Levels are set to their historical low groundwater levels**.	The MTs for Chronic Lowering of Groundwater Levels (discussed above) are set with consideration of beneficial uses and users, historical low groundwater levels, and an adequate timeframe for implementation of necessary P/MAs to halt downward trends, if any. The MTs for Chronic Lowering of Groundwater Levels (discussed above) are considered protective against Undesirable Results for Land Subsidence because (a) **historical data indicates just over half an inch of subsidence in 10 years** (1.2 inches (1999-2018) and 1.2 inches (2000-2018)) and (b) **the MTs for RMW-WL locations within one mile of the California Aqueduct and Canal are set to their historic lows**, and (c) the **infrastructure was designed and constructed with considerable freeboard** which acts as a margin of safety.	**No specific Undesirable Results criteria are set for Land Subsidence**. Rather, the criteria established for Chronic Lowering of Groundwater Levels are deemed to be protective against Undesirable Results for Land Subsidence.	**Inelastic subsidence** is not anticipated to occur since the MTs are set to the historic low levels observed. **Ongoing monitoring** of groundwater levels in the RMW-WL monitoring network and along the 850 Canal, supplemented by available regional-scale subsidence monitoring data (i.e., DWR's InSAR datasets, and additional land surface elevation checkpoints along the California Aqueduct), will allow the GSA to monitor for and track potential subsidence, and to modify SMCs in the future, as necessary.

Sustainability Indicator	Undesirable Result (UR) Causes	Potential Effects on Beneficial Users	UR Definition	Minimum Threshold (MT) Definition	MT Justification	UR Criteria	UR Justification
Depletions of Interconnected Surface Water	In interconnected systems, causes include **the same causes that contribute to Undesirable Results due to Chronic Lowering of Groundwater Levels** (i.e., increased groundwater pumping and reduced recharge; see above). **Additional causes directly related to surface water bodies** include: - hydrology (e.g., climate change) - increased diversions - reduced return flows - water consumption by riparian vegetation.	**Impacts to environmental uses and users of surface water, including GDEs**. 435 acres of the Basin's GDEs are characterized as "site appears to be supported by a shallow water-bearing zone upgradient of the Springs Fault" (classification "B") or "site appears to be supported by the regional aquifer" (classification "R"). These could be impacted in case of Undesirable Results of Depletions of Interconnected Surface Water.	Undesirable Results would be experienced in the Basin if and when the health of the GDEs is adversely impacted by lowering of groundwater levels as a result of SGMA-related groundwater management activities in the Principal Aquifer, rather than effects of natural or climactic processes and/or unfavorable hydrologic conditions. **Significant and unreasonable effects** associated with Undesirable Results would include: - A 30% reduction of, or visual impact to, the health of GDEs based on their conditions observed during 2018 through 2020.	**Groundwater levels are used as a proxy** for monitoring potential Depletions of Interconnected Surface Water. **Initial MT are set at the three designated RMW-ISWs**. Based on limited available information, preliminary MTs are set as follows: - For RMW-ISWs where the current depth to water is less than 30 feet below ground surface (ft bgs), initial MTs are set at a water level depth of 30 ft bgs. - For RMW-ISWs where the current depth to water is greater than 30 ft bgs, initial MTs are set at the projected depth to water at the end of October 2021 based on the June 2021 trend. MTs will be revised and refined upon collection of monitoring data from the Depletions of Interconnected Surface Water monitoring network, including the RMW-ISWs and other monitoring points.	There is no interconnected surface water throughout the main portion of the Basin due to the deep groundwater levels, typically dry streams, and no beneficial uses of surface water (exceptions exist around the periphery where surface water is diverted and used for irrigation) White Wolf GSA has installed three shallow monitoring wells (RMW-ISWs) on the upgradient side of the Springs Fault, in close proximity to the mapped GDE units to study the effect of water management on groundwater conditions and to fill data gaps. For RMW-ISWs where the current depth to water is less than 30 ft bgs, **the 30-ft depth to groundwater is justified as a reasonable cutoff below which GDEs are not likely to be present based on the predominant vegetation types within the mapped GDEs**. For wells where the current depth to water is greater than 30 ft bgs, **the trend-extended depth to groundwater is justified for wells as it captures the expected decline in water levels over the dry season**.	Undesirable Results are defined to occur **if and groundwater levels in one or more of the RMW-ISWs (1 of 3) exceeds (falls below) their MTs over four consecutive seasonal measurements during years** (i.e., measurements spanning a total of two years, including two seasonal high groundwater level periods and two seasonal low groundwater level periods) as a result of SGMA-related groundwater management activities.	Most of the streams entering the Basin are ephemeral and the net effect between gaining and losing reaches based on model results represent an addition to groundwater from leakage. Based on NDVI trends between 2009 and 2018, the average change in size of the GDE areas of interest was approximately 30%. Therefore, a 30% reduction in GDE area is within the historical natural range of GDE area fluctuation and response to climatic conditions. Given the lack of historical data for groundwater conditions in the vicinity of interconnected surface water and GDEs, the criterion is conservatively based on an MT exceedance at just one of three RMW-ISW (33%), which is consistent with the natural 30% GDE area fluctuations historically observed. **Ongoing data collection** will inform groundwater conditions and will allow the GSA to modify SMCs in the future, as appropriate.

Abbreviations:

ft bgs = feet below ground surface
GSA = Groundwater Sustainability Agency
GDE = groundwater dependent ecosystem
GPS = global positioning system
GWL = groundwater level
ISW = Interconnected surface water
MCL = Maximum Contaminant Level
mg/L = milligrams per liter
MT = Minimum Threshold
NDVI = Normalized Derived Vegetation Index
RMW = Representative Monitoring Well
SGMA = Sustainable Groundwater Management Act
SMC = Sustainable Management Criteria UR = Undesirable Result
USEPA = United States Environmental Protection Agency
WQ = Water Quality
WWGFM = White Wolf Groundwater Flow Model

13.1. Undesirable Results for Chronic Lowering of Groundwater Levels

Per SGMA, Undesirable Results for the Chronic Lowering of Groundwater Levels means a "chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon" (California Water Code [CWC] § 10721(x)(1)). However, it is important to note that SGMA also states that "overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods" (CWC § 10721(x)(1)).

The Undesirable Result for Chronic Lowering of Groundwater Levels is defined herein as follows:

> *Undesirable Results would be experienced if and when a chronic decline in groundwater levels in the Principal Aquifer negatively affects the reasonable and beneficial use of, and access to, groundwater for beneficial uses and users within the Basin.*
>
> *Significant and unreasonable effects associated with Undesirable Results would include complete dewatering of more than 25% of existing wells.*

The primary beneficial users of groundwater from the Principal Aquifer are groundwater pumpers (environmental beneficial users are addressed in ***Section 13.6 Undesirable Results for Depletions of Interconnected Surface Water***). As such, the definition of URs is focused on potential well impacts. The associated allowable impacts to existing wells (up to 25%) considers the percentage of wells in the Basin that are currently greater than 50 years old[80] and that therefore would likely need to be replaced during the 20-year Groundwater Sustainability Plans (GSP) implementation period (i.e., 2022-2042) irrespective of groundwater conditions[81]. Specifically, given that 78% of Basin wells are greater than 50 years old and would reasonably have to be replaced in the next 20 years due to age alone, it cannot be considered "significant and unreasonable" if fewer than 25% of wells in the Basin were to be impacted due to chronic lowering of groundwater levels.

13.1.1. Potential Causes of Undesirable Results

Potential causes of Undesirable Results related to Chronic Lowering of Groundwater Levels could include increased pumping and/or reduced recharge.

Because the current primary use of groundwater in the Basin is for agricultural purposes, increased groundwater pumping could occur if water use per acre on irrigated land increases or if new land is put into agricultural production. Pumping from the Principal Aquifer for potable use is relatively small. The Grapevine Specific Plan development is a significant non-agricultural development planned in the

[80] Well ages are based on well construction information contained in the White Wolf Subbasin Data Management System (DMS).
[81] Others have estimated the well retirement age/lifespan to be lower at approximately 28 to 33 years (Gailey, 2018; Pauloo et al., 2020). The assumption used herein of a 50-year well lifespan is considered conservative.

southern area of the Basin. However, the Grapevine development will rely on imported surface water for potable water demands and recycled water for non-potable demands to the maximum extent possible. Therefore, absent additional non-agricultural development in the Basin, groundwater extraction for potable use is unlikely to substantially increase.

Reduced recharge could occur due to increased agricultural irrigation efficiency, climate change that results in decreased precipitation, decreased surface water inflows from contributing watersheds, and/or increased evapotranspiration (ET), and/or decreased deliveries of imported surface water supplies.

13.1.2. Criteria Used to Define Undesirable Results

As discussed further below in ***Section 14 Minimum Thresholds*** and in ***Section 17 Monitoring Network***, the MTs for groundwater levels have been established at 14 Representative Monitoring Wells for Chronic Lowering of Groundwater Levels (RMW-WLs) with consideration of groundwater levels and trends, well depths (i.e., in relation to impacts to groundwater pumpers as the primary beneficial user), and proximity to critical infrastructure (i.e., the California Aqueduct and the 850 Canal). Per Section 354.26(b)(2) of the California Code of Regulations Title 23 (23 CCR) Division 2 Chapter 1.5 Subchapter 2, the description of URs must include the criteria used to define when and where the effects of groundwater conditions cause URs, based on a quantitative description of the number of MT exceedances and RMW-WL locations that constitute an UR.

Based on the significant and unreasonable effects described above, the criteria for Undesirable Results for Chronic Lowering of Groundwater Levels are as follows:

> *Undesirable Results for Chronic Lowering of Groundwater Levels would be experienced in the Basin if and when groundwater levels in the Principal Aquifer decline below the established MTs in 40% or more of the RMW-WLs over four consecutive seasonal measurements (i.e., measurements spanning a total of two years, including two seasonal high groundwater level periods and two seasonal low groundwater level periods)*.

The UR criteria are justified based on results from a well impact analysis (***Section 14.1.2 Well Impact Analysis****)* including five domestic/public supply wells and 20 irrigation wells for which well screen depth information is available, which showed that even if water levels in all RMW-WLs reached their MTs no wells within the Basin would be completely dewatered and only four wells (all irrigation wells) that were not already partially dewatered at the Fall 2015 groundwater elevation would be partially dewatered at the MT. This number of partially dewatered wells is well below the 78% of wells that are likely to require replacement based on well age and lifespan, as discussed above. Furthermore, since this UR criterion is based on only 40% of RMW-WLs reaching their MTs, the number of wells that would be partially dewatered at the point where an UR is deemed to occur is likely even lower. Thus, the criteria are protective and will avoid significant and unreasonable effects.

The component of the criteria requiring two consecutive years of MT exceedances provides for confirmation that the chronic lowering of groundwater levels is not drought related, consistent with the definition of undesirable results for this indicator in CWC § 10721(x)(1).

Further, the above criteria for URs for this sustainability indicator are the same as those used in the Arvin-Edison and Wheeler Ridge-Maricopa Kern Subbasin Management Area Plans for consistency with cross-boundary interactions and management strategies.

As discussed in ***Section 18.8 Expected Benefits***, the White Wolf Groundwater Sustainability Agency (GSA) will strive through the use of Projects and/or Management Actions (P/MAs) to maintain water levels at or above the MOs, which are in all cases above the MTs. It is further noted that, because the Basin will rely on at least one demand reduction P/MA to achieve the Sustainability Goal, there is an economic trade-off for agricultural users between increased pumping and increased fallowing. The UR definition and criteria seeks a balance to that trade-off.

13.1.3. Potential Effects of Undesirable Results

The primary potential effect of Undesirable Results caused by Chronic Lowering of Groundwater Levels on beneficial uses and users of groundwater in the Basin is groundwater well dewatering. Well dewatering can be detrimental to wells as it can lead to increased maintenance costs (e.g., well rehabilitation/ redevelopment/deepening and pump lowering) and reduced well lifespan due to corrosion of well casings and screens. As detailed in ***Section 14.1.2 Well Impact Analysis***, a Well Impact Analysis was conducted in which available well construction information was used to assess which, if any, wells would potentially be dewatered if groundwater levels were to decline to the MT of the closest RMW-WL. Based on the available data, if groundwater levels in the Basin decline to the MT values, no wells would be completely dewatered and only four wells would be partially dewatered.[82]

Additional potential effects include increased pumping lift and effects on correlated sustainability indicators. Increased pumping lift results in more energy use per unit volume of groundwater pumped and corresponding higher pumping costs, as well as increased wear and tear on well pump motors and reduced well efficiency. Potentially correlated Sustainability Indicators include land subsidence, depletion of interconnected surface waters, and degraded water quality, although the degree of correlation has not been determined with certainty and is a data gap that will continue to be explored as part of GSP implementation. For example, while potential impacts of water levels in the Principal Aquifer on interconnected surface water or GDEs have not been observed to date in the Basin, the issue does warrant further study. For this reason, monitoring infrastructure was installed in early 2021 to address this issue, as discussed in more detail in ***Section 13.6 Undesirable Results for Depletions of Interconnected Surface Water*** below.

13.2. Undesirable Results for Reduction of Groundwater Storage

Per SGMA, an Undesirable Result for the Reduction of Groundwater Storage means a "significant and unreasonable reduction of groundwater storage" (CWC § 10721(x)(1)) and is defined herein as follows:

[82] For purposes of the well impact analysis, the depth to groundwater at the MT in the nearest RMW-WL is used as a proxy depth to water in the supply wells. A well is identified as dewatered if the MT is below the total well depth. Wells with no construction information or wells that are more than 50 years old are not included in this analysis.

Undesirable Results would be experienced if and when a reduction in storage in the Principal Aquifer negatively affects the long-term viable access to groundwater for the beneficial uses and users within the Basin.

Significant and unreasonable effects associated with Undesirable Results would include reduction in usable groundwater storage of more than 20% relative to the Fall 2015 usable groundwater storage volume.

13.2.1. Potential Causes of Undesirable Results

Reduction of Groundwater Storage is directly correlated to Chronic Lowering of Groundwater Levels. Therefore, the potential causes of Undesirable Results due to Reduction of Groundwater Storage are generally the same as the potential causes listed above for Undesirable Results due to Chronic Lowering of Groundwater Levels (i.e., increased groundwater pumping and reduced recharge). Because of the direct correlation between groundwater elevation and groundwater storage volume, groundwater levels are used to measure conditions for this Sustainability Indicator.

13.2.2. Criteria Used to Define Undesirable Results

The criteria used to define Undesirable Results for Reduction of Groundwater Storage are consistent with the criteria used to define Undesirable Results for Chronic Lowering of Groundwater Levels, as follows:

Undesirable Results for Reduction of Groundwater Storage would be experienced in the Basin if and when groundwater storage in the Principal Aquifer was to be reduced by an amount that would cause the groundwater levels in at least 40% of the RMW-WLs to exceed their MTs for Chronic Lowering of Groundwater Levels over four consecutive seasonal measurements (i.e., measurements spanning a total of two years, including two seasonal high groundwater level periods and two seasonal low groundwater level periods).

The above criteria are justified based on calculations of the usable storage volume in the Basin (approximately 2.39 million acre-feet [MAF] as of Fall 2015)[83] and the volume of storage depletion that would occur if groundwater levels were to decline from Fall 2015 elevations to the Chronic Lowering of Groundwater Levels MTs (approximately 455,000 acre-feet [AF]). These calculations indicate that if all RMW-WLs were to decline from 2015 (i.e., the start of SGMA) to their Chronic Lowering of Groundwater Levels MTs, the percent of usable storage in the Basin would decrease by approximately 19%, which is less than the level deemed to be significant and unreasonable (20%). Furthermore, since this UR criterion is based on only 40% of RMW-WLs reaching their MTs, the amount of reduction in usable storage that would occur at the point that a UR occurs is likely even lower. As such, the criteria set for Chronic Lowering of Groundwater Levels are considered protective against significant and unreasonable effects for Reduction

[83] The usable storage volume in the Basin is calculated as the volume of groundwater between the groundwater level at the time of assessment (i.e., Fall 2015) and the median depth of production wells in the developed part of the Basin (1,050 ft, based on information in the White Wolf Subbasin DMS). See ***Section 14.2 Minimum Threshold for Reduction of Groundwater Storage*** for further discussion.

of Groundwater Storage, and thus serve as a reasonable proxy.

13.2.3. Potential Effects of Undesirable Results

The primary potential effect of URs caused by Reduction of Groundwater Storage on beneficial uses and users of groundwater in the Basin (i.e., groundwater pumpers) would be reduced groundwater supply reliability. The effect would be most significant during periods of reduced surface water supply availability due to, for example, natural drought conditions, regulatory restrictions, natural disasters, or other causes. However, as discussed below in ***Section 14.2 Minimum Threshold for Reduction of Groundwater Storage***, there is significant usable groundwater storage within the Basin, and so these effects are unlikely to occur over the GSP planning and implementation horizon.

13.3. Undesirable Results for Seawater Intrusion

The 23 CCR § 354.26(d) states that "An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators". Because the Basin is not located near any saline water bodies, seawater intrusion is not present and not likely to occur. The Seawater Intrusion Sustainability Indicator is therefore not applicable to the Basin, and no URs for this Sustainability Indicator are defined herein.

13.4. Undesirable Results for Degraded Water Quality

The SGMA defines an Undesirable Result for Degraded Water Quality as "significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies" (CWC § 10721(x)). The Undesirable Result for Degraded Water Quality is defined herein as follows:

> *Undesirable Results for Degraded Water Quality would be experienced in the Basin if and when water quality conditions of the Principal Aquifer are degraded as a result of SGMA-related groundwater level management activities such that they negatively impact the long-term viability of the groundwater resource for beneficial users and uses.*
>
> *Significant and unreasonable effects associated with Undesirable Results would include an increase, on a regional basis, in concentrations of identified constituents of concern above state and federal regulatory thresholds, as a result of SGMA-related groundwater level management activities.*

The component of the significant and unreasonable effects definition regarding a regional basis draws a distinction between local (e.g., well specific) effects, that are not generally under the purview of GSAs to manage (especially if related to well location and design relative to naturally occurring or anthropogenically-caused impacts that pre-dated SGMA), and broader, groundwater management-related effects which can fall under a GSA's purview. This approach is both consistent with the SGMA's definition of URs meaning "…effects caused by groundwater conditions occurring throughout the basin" (emphasis added) (CWC § 10721(x)) and reflects the fact that SGMA does not require GSPs to address URs that occurred before, and have not been corrected by January 1, 2015. (CWC § 10727.2(b)(4)). As such, the UR definition appropriately focuses on whether water quality conditions in "…*the Principal Aquifer are* [significantly and unreasonably] *degraded as a result of SGMA-related groundwater level management activities".*

It is further noted that most municipal and industrial (M&I) and domestic consumption (i.e., related to the Grapevine development) will come from surface water imports. The regulatory oversight authority for drinking water quality rests with the State Water Resources Control Board (SWRCB), and therefore general measures to address drinking water quality served to the public are generally beyond the purview of this GSP, except where directly impacted as a result of SGMA-related groundwater management. Those regulatory oversight and enforcement actions have and will occur on their own mandated timelines and in accordance with SWRCB permitting, reporting and enforcement processes. Water quality issues related to deep percolation of agricultural chemicals such as nitrate are also regulated separately under the Central Valley Regional Water Quality Control Board's (CVRWQCB's) Irrigated Lands Regulatory Program (ILRP). The above notwithstanding, the White Wolf GSA will continue to coordinate with these entities and programs in the collection, sharing and analysis of applicable data. Furthermore, as described in ***Section 17.1.4 Monitoring Network for Degraded Water Quality***, to the extent agreed to by local entities, the existing Public Water System (PWS) wells have been included in the SGMA Monitoring Network for the Basin to assess groundwater conditions related to the most sensitive beneficial users (i.e., drinking water users).

13.4.1. Potential Causes of Undesirable Results

Undesirable Results due to Degraded Water Quality are the result of increases in concentrations of constituents of concern (COCs) in groundwater in the Principal Aquifer. These increases in concentration can occur through a variety of processes, some of which are causatively related to groundwater management activities (i.e., potentially under the purview of GSAs) and some of which are not. The processes related to groundwater management include:

- Lateral migration from adjacent areas with poorer quality groundwater;
- Leaching from internal sources such as fine-grained, clay-rich interbeds;
- Upwards vertical flow from deeper zones below the bottom of the Basin; and
- Recharge from managed recharge projects.

Additional potential causes of URs for Degraded Water Quality which are not related to groundwater management activities under the authority of GSAs include:

- Deep percolation of some portion of ineffective precipitation;
- Seepage from various natural and man-made channels;
- Irrigation system backflow into wells and flow through well gravel pack and screens from one formation to another; and
- Deep percolation of excess applied irrigation water and other water applied for cultural practices (e.g., for soil leaching).

13.4.2. Criteria Used to Define Undesirable Results

As discussed further below in ***Section 14.4 Minimum Threshold for Degraded Water Quality*** and in ***Section 17.1.4 Monitoring Network for Degraded Water Quality***, the MTs for Degraded Water Quality are established at four (4) Representative Monitoring Wells for Degraded Water Quality (RMW-WQs). As discussed in ***Section 8.5 Groundwater Quality Concerns***, most wells in the Basin have very limited groundwater quality data. Evaluation of the available data suggests that some wells show a potential correlation between water levels and certain water quality constituent concentrations. However, additional data collection and analysis will be needed to confirm the validity and consistency, both in space and over time, of potential relationships. Therefore, until additional groundwater level and groundwater quality information is available to refine this definition, the URs are based on criteria defined for a select number of potential COCs (i.e., Arsenic, Nitrate, and Selenium) at the RMW-WQ locations.

Based on the significant and unreasonable effects described above, the criteria for URs for Degraded Water Quality are as follows:

> *Undesirable Results for Degraded Water Quality are defined to occur within the Basin if and when MTs are exceeded for any of the identified constituents of concern in 25% or more of the RMW-WQs at least two (2) consecutive years as a result of SGMA-related groundwater management activities.*

The above criteria are justified because they relate to a level of impact (25% of RMW-WQs) that corresponds to a regional, rather than a well-specific, water quality issue. Similar to the criteria for Chronic Lowering of Groundwater Levels, the component of the criteria requiring at least two consecutive years of MT exceedances provides for confirmation that the degraded water quality condition is not drought related. As discussed in ***Section 16 Action Plan Related to Minimum Threshold Exceedances***, in the case of an MT exceedance, the GSA will coordinate with the Public Water System to increase water quality sampling to at least twice a year, will determine the water year type based on DWR published data or using DWR methodology (DWR, 2021) if water year type is not published by DWR before annual reporting, and will conduct additional statistical analysis to evaluate the potential connection to SGMA-related groundwater management activities.

13.4.3. Potential Effects of Undesirable Results

The potential effects of URs caused by Degraded Water Quality on beneficial uses and users of groundwater may include: increased costs to treat groundwater to drinking water standards if it is to be used as a potable supply source; increased costs to blend relatively poor-quality groundwater with higher quality sources for drinking water users; and potential reduction in the usable volume of groundwater in the Basin if large areas are impaired to the point that they cannot be used to support beneficial uses and users. The above notwithstanding, it is important to note that drinking water use only accounts for less than 1% of total groundwater demand in the Basin[84] and most of the projected M&I and domestic consumption in the Basin will come from surface water imports and that applicable regulatory thresholds

[84] The upper-end estimate of pumping for drinking water purposes is approximately 100 AFY, compared to total Basin pumping in excess of 40,000 AFY (see ***Section 9 Water Budget Information***).

do not apply to the main beneficial user of groundwater in the Basin (i.e., irrigated agriculture).

13.5. Undesirable Results for Land Subsidence

SGMA defines an Undesirable Result for Land Subsidence as "significant and unreasonable land subsidence that substantially interferes with surface land uses" (CWC § 10721(x)). The Undesirable Result for Land Subsidence is defined herein as follows:

> *Undesirable Results would be experienced if and when land subsidence due to groundwater level declines in the Principal Aquifer negatively affects the ability to use existing critical infrastructure within the Basin.*
>
> *Significant and unreasonable effects associated with Undesirable Results would include subsidence-related damage to critical water conveyance infrastructure (i.e., the California Aqueduct and the 850 Canal), resulting in a loss of functional capacity of the infrastructure that prevents conveyance of available volumes of water that could otherwise be conveyed if the subsidence had not occurred.*

The above definition of significant and unreasonable effects is developed recognizing that small amounts of subsidence could occur without negatively affecting the ability to use the critical infrastructure, and that only to the extent that subsidence causes a loss of functional capacity does it qualify as significant and unreasonable.

13.5.1. <u>Potential Causes of Undesirable Results</u>

Land subsidence can be caused by several mechanisms, but the mechanism most relevant to sustainable groundwater management activities under the authority of GSAs is the depressurization of aquifers and aquitards due to lowering of groundwater levels, which can lead to compaction of compressible strata and lowering of the ground surface. Therefore, the potential causes of URs due to Land Subsidence are generally the same as the potential causes listed above for Undesirable Results due to Chronic Lowering of Groundwater Levels (i.e., increased pumping and/or reduced recharge).

13.5.2. <u>Criteria Used to Define Undesirable Results</u>

As discussed in ***Section 8.6 Land Subsidence,*** measured vertical displacement in the Basin has been minor to date indicating that land subsidence and damage to critical infrastructure is not a significant concern in the Basin, based on the best available information. Furthermore, given that land subsidence and lowering of groundwater levels are closely related, it is reasonable to expect that given continued trends in groundwater levels there would be continued trends in observed subsidence rates. Based on extrapolation of the average rate of subsidence at locations along the California Aqueduct between 2016 and 2019 (i.e., approximately 0.2 inches per year), if the rate were allowed to continue for ten (10) years (i.e., the maximum time allowable for continuation of declining groundwater level trends by the established Chronic Lowering of Groundwater Level MTs), additional subsidence would amount to only approximately two (2) inches, which is very unlikely to negatively affect the ability to use existing critical infrastructure within the Basin[85]. It is therefore expected that the MTs for Chronic Lowering of Groundwater Levels will be protective to prevent significant and unreasonable effects from land subsidence in the Basin. As such, no specific MTs and no specific UR criteria for Land Subsidence have been defined at this time.

Publicly available subsidence data will continue to be evaluated as part of GSP implementation. Should any indication of subsidence begin to be observed in the Basin, that issue will be addressed in future GSP updates, as needed.

13.5.3. Potential Effects of Undesirable Results

Potential effects of URs caused by Land Subsidence could include damage to critical infrastructure, including gravity-driven water conveyance infrastructure (i.e., the California Aqueduct and the 850 Canal), gas and petroleum pipelines, municipal water lines, etc. Potential effects could also include damage to other non-critical infrastructure such as groundwater well heads, discharges, and casings.

13.6. Undesirable Results for Depletions of Interconnected Surface Water

SGMA defines an Undesirable Result for Depletions of Interconnected Surface Water as "depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water" (CWC § 10721(x)). As described in more detail below, the most sensitive beneficial users of groundwater grouped under the Depletions of Interconnected Surface Water Sustainability Indicator are GDEs. These GDEs are located primarily either adjacent to surface water features or are supported by a shallow water-bearing zone upgradient of the Springs Fault. The definition of Undesirable Results for Depletions of Interconnected Surface Water and the associated SMCs (see ***Sections 14.6 Minimum Threshold for Depletions of Interconnected Surface Water*** and ***15.6 Measurable Objective for Depletion of Interconnected Surface Water***) and SGMA Monitoring Network (see ***Section 17.1.6 Monitoring Network for Depletions of Interconnected Surface Water***) have been designed to proactively monitor and respond to conditions affecting GDE health rather than stream depletions. The Undesirable Result for Depletions of Interconnected Surface Water is therefore defined herein as follows:

> *Undesirable Results would be experienced in the Basin if and when the health of the GDEs is adversely impacted by lowering of groundwater levels as a result of SGMA-related groundwater management activities in the Principal Aquifer, rather than effects of natural or climactic processes and/or unfavorable hydrologic conditions.*
>
> *Significant and unreasonable effects associated with Undesirable Results would include a 30% reduction of, or visual impact to, the health of GDEs based on their conditions observed during 2018 through 2020 that can be directly attributed to Principal Aquifer pumping-related lowering of*

[85] Plates 26 and 27 of DWR's California Aqueduct Subsidence Study Supplemental Report (DWR, 2019) show freeboard along the California Aqueduct in excess of four feet within the Basin.

groundwater levels rather than the effects of natural or climatic processes.[86]

The above definition of significant and unreasonable effects recognizes the fact that SGMA does not require GSPs to address URs that occurred before, and have not been corrected by January 1, 2015 (CWC § 10727.2(b)(4)).

As shown in ***Appendix M***, based on information provided by The Nature Conservancy (TNC)[87], the average change in the size of the GDE areas of interest (those categorized as being supported by the shallow water-bearing zone upgradient of the Springs Fault) between 2009 and 2018 was approximately 30% (i.e., the mapped GDE area in 2009 was 30% smaller than the GDE areas mapped in 2018). Visual inspection of aerial images confirms this reduction is a reasonable estimate. Based on the Normalized Derived Vegetation Index (NDVI) change in GDE area analysis, a 30% reduction in GDE area is within the historical natural range of GDE area fluctuation and response to climatic conditions, and therefore, it is not significant and unreasonable for the GDE area to reduce by 30% under recently observed natural climatic fluxes.

Interconnected surface water potentially exists around the periphery of the Basin where GDEs have been mapped (e.g., south of the Springs Fault). There are also beneficial users of surface water (i.e., surface water is diverted for irrigated agriculture). However, there is little monitoring infrastructure in those areas. Historical groundwater measurements and streamflow gauging are not sufficient to characterize the occurrence and nature of the potential interconnected surface water and GDEs, especially in relation to conditions in the Principal Aquifer. To fill this data gap, in January 2021, the White Wolf GSA installed three shallow monitoring wells (RMW-ISWs) in the vicinity of the GDEs and initiated high-frequency groundwater level monitoring. Furthermore, a long-term pumping test is planned to be conducted in an irrigation well located north of the Springs Fault. The data collected will allow the White Wolf GSA to further evaluate the degree of hydraulic connection between the Principal Aquifer and the shallow water-bearing zone and surface water located upgradient of the Springs Fault.

Given that the hydraulic connection between the Principal Aquifer and the surface water that supports the above beneficial uses is currently unquantified, the Undesirable Results definition for Depletion of Interconnected Surface water is considered preliminary. The Undesirable Result definition will be revisited during the GSP five-year update when more data are available.

---

[86] Conditions observed between 2018 and 2020, as delineated by the Natural Communities Commonly Associated with Groundwater (NCCAG) shapefile and subsequent revisions resulting from the May 2020 field verification study.

[87] Statewide Normalized Derived Vegetation Index (NDVI) raster data provided by The Nature Conservancy (TNC) on 30 August 2021. NDVI estimates vegetation greenness and can be used a proxy to indicate GDE vegetation growth. Change in GDE area can be estimated using the TNC GDE Pulse raster data that shows the NDVI trends between 2009 and 2018. Moderate to large increases in NDVI trends represent an increase in the GDE area and moderate to large decreases in NDVI trends represent a decrease in the GDE area. Therefore, the change in GDE area can be estimated by subtracting GDE areas with decreasing NDVI trends from GDE areas with increasing NDVI trends.

13.6.1. Potential Causes of Undesirable Results

Factors that can influence interconnected surface water depletions include, but are not limited to, declines in inter-connected groundwater levels, hydrology and climate change, increased surface water diversions, reduced return flows as a result of changes in land use or land use practices, and increased water consumption by riparian vegetation.

The area of the Basin that has been identified as having potential interconnected surface water and GDEs is largely undeveloped and is largely included within the Conservation Easement Area (see **Figure PA-3**). Further, as discussed in ***Section 8.7 Interconnected Surface Water Systems***, the degree of hydraulic connection between the Principal Aquifer from which pumping occurs and the shallow water-bearing zone/interconnected surface water is not quantified but is suspected to be small based on available information on water levels and existence of springs along the Springs Fault scarp (i.e., if there were a strong connection, the water levels and springs would have shown evidence of depletion when groundwater levels in nearby Principal Aquifer wells declined). As such, impacts to potential interconnected surface water and GDEs may primarily be driven by natural factors (e.g., climate) that are beyond the White Wolf GSA's control.

13.6.2. Criteria Used to Define Undesirable Results

Per 23 CCR Section 354.26(b)(2), the description of URs must include a quantitative description of the combination of MT exceedances that constitute an UR. As discussed in ***Section 14.6 Minimum Threshold for Depletions of Interconnected Surface Water,*** little historical data exist to support definition of MT for this Sustainability Indicator, nor is it at all clear that conditions in the potential areas of interest for this Sustainability Indicator are something that can be controlled by the White Wolf GSA. That being said, in a system where groundwater and surface water are in fact interconnected, groundwater levels can be potentially used as a proxy to assess the potential for Depletions of Interconnected Surface Water. As such, the White Wolf GSA has installed three shallow groundwater monitoring wells (RMW-ISWs) to assess the potential hydraulic connection between the Principal Aquifer and the shallow water-bearing zone (as a surrogate for interconnected surface water), and has defined preliminary MTs that use groundwater levels in these RMW-ISWs as a proxy. Similarly, a preliminary UR criterion is established as follows:

> *Undesirable Results for Depletion of Interconnected Surface Water would be experienced in the Basin if and when groundwater levels in one or more of the RMW-ISWs exceeds (falls below) their MTs over four consecutive seasonal measurements (i.e., measurements spanning a total of two years, including two seasonal high groundwater level periods and two seasonal low groundwater level periods) as a result of SGMA-related groundwater management activities.*

As discussed above, it is not significant and unreasonable for the GDE area to reduce by 30% under recent natural climatic fluxes. Setting metrics based on groundwater levels as proxy ensures that groundwater levels are generally above GDE rooting depths or above typical seasonal water table fluctuations. Specifying the UR criterion as one out of three (33%) RMW-ISWs falling below their MTs is consistent with the 30% GDE area reduction. Thus, the criteria are protective and will avoid significant and unreasonable effects.

Similar to the criteria for Chronic Lowering of Groundwater Levels and Degraded Water Quality, the component of the criteria requiring at least two consecutive years of MT exceedances provides for confirmation that the UR determination is not drought related. As discussed in ***Section 16 Action Plan Related to Minimum Threshold Exceedances,*** in the case of an MT exceedance, the GSA will determine the water year type based on DWR published data or using DWR methodology (DWR, 2021) if water year type is not published by DWR before annual reporting, and will conduct an additional statistical analysis to evaluate the potential connection to SGMA-related groundwater management activities.

Given the lack of historical data for groundwater conditions in the vicinity of interconnected surface water, the above criterion conservatively uses an MT exceedance at just one RMW-ISW. As additional monitoring data are collected, the Sustainable Management Criteria (SMCs) for Depletions of Interconnected Surface Water will be revisited and updated as appropriate.

13.6.3. Potential Effects of Undesirable Results

Potential effects of Undesirable Results of Depletion of Interconnected Surface Water may include impacts to environmental users, such as GDEs. Furthermore, there may be reduced surface water flows to support downstream or in-stream uses.

13.7. Undesirable Results Summary

Table SMC-2 below provides a summary of the criteria for URs for each Sustainability Indicator.

Table SMC-2. Summary of Undesirable Results Criteria

Sustainability Indicator	Undesirable Results Criteria
Chronic Lowering of Groundwater Levels	MT exceedance in 40% or more (i.e., 6 or more out of 14) of RMW-WLs over four consecutive seasonal (bi-annual) measurements.
Reduction of Groundwater Storage	MT exceedance for Chronic Lowering of Groundwater Levels used as a proxy.
Seawater Intrusion	Sustainability Indicator not applicable within the Basin; no Undesirable Results criteria given.
Degraded Water Quality	MT exceedance in 25% or more of the RMW-WQs (1 out of 4) for at least two (2) consecutive years as a result of SGMA-related groundwater management activities.
Land Subsidence	MT exceedance for Chronic Lowering of Groundwater Levels used as a proxy.
Depletion of Interconnected Surface Water	MT exceedance at one or more of the three RMW-ISWs over four consecutive seasonal (bi-annual) measurements as a result of SGMA-related groundwater management activities.

14. MINIMUM THRESHOLDS

§ 354.28. Minimum Thresholds

(a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

(b) The description of minimum thresholds shall include the following:

(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.

(2) The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

(3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.

(4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

(5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.

(6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.

Minimum Thresholds (MTs) are the numeric criteria for each Sustainability Indicator that, if exceeded, may cause Undesirable Results (URs) for that indicator or for other indicators by proxy. This section describes the MTs that have been developed to avoid URs for each applicable Sustainability Indicator in the White Wolf Subbasin (Basin).

Table SMC-3 shows the spatial scale at which MTs are defined for each Sustainability Indicator. The MTs within the Basin are defined, as applicable, at representative monitoring wells (RMWs) for water levels (RMW-WL), water quality (RMW-WQ), and interconnected surface water (RMW-ISW). Where appropriate, the MTs for certain Sustainability Indicators have been established using groundwater levels as a proxy, based on demonstration "that there is a significant correlation between groundwater levels and the other metrics" (California Department of Water Resources [DWR] Sustainable Management Criteria Best Management Criteria [BMP] document; DWR, 2017b).

Table SMC-3. Spatial Scale of Minimum Threshold Definition

Sustainability Indicator	Minimum Threshold Metric(s) Defined in 23 CCR § 354.28(c)	Sites for Minimum Threshold Compliance
Chronic Lowering of Groundwater Levels	Groundwater elevation	14 RMW-WLs
Reduction of Groundwater Storage	Total volume of groundwater	14 RMW-WLs *(Chronic Lowering of Groundwater Levels used as a proxy)*
Seawater Intrusion	Chloride concentration isocontour	No MTs defined. Sustainability Indicator not applicable to the Basin.
Degraded Water Quality	- Number of supply wells - Volume of groundwater - Location of isocontour	Four (4) RMW-WQs
Land Subsidence	Rate and extent of land subsidence	Five (5) RMW-WLs (*Chronic Lowering of Groundwater Levels used as a proxy*)[88]
Depletion of Interconnected Surface Water	Rate or volume of surface water depletions	Three (3) RMW-ISWs (*groundwater levels used as a proxy*). MTs are considered preliminary and will be refined as additional water level data are collected.

Abbreviations:
CCR = California Code of Regulations
GSP = Groundwater Sustainability Plan
MT = Minimum Threshold
RMW-ISW = Representative Monitoring Well for Depletions of Interconnected Surface Water
RMW-WL = Representative Monitoring Well for Chronic Lowering of Groundwater Levels
RMW-WQ = Representative Monitoring Well for Degraded Water Quality

[88] In addition to the RMW-WLs for land subsidence, two Land Surface Checkpoints will be established and monitored as part of GSP implementation. These sites have not yet been installed, are not considered representative sites, and currently have no MTs established for them. Once installed, MTs for these sites may be developed in the future after data are collected and analyzed by the GSA.

14.1. Minimum Threshold for Chronic Lowering of Groundwater Levels

§ 354.28. Minimum Thresholds

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:
(1) Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following:
(A) The rate of groundwater elevation decline based on historical trends, water year type, and projected water use in the basin.
(B) Potential effects on other sustainability indicators.

Chronic Lowering of Groundwater Levels is arguably the most fundamental Sustainability Indicator, as it influences several other key Sustainability Indicators, including Reduction of Groundwater Storage, Land Subsidence, Depletions of Interconnected Surface Water, and potentially Degraded Water Quality. Groundwater levels are also the most readily available and measurable metrics of groundwater conditions, which allows for a systematic, data-driven approach to development of MTs to be applied. There are no state, federal, or local standards that relate to this Sustainability Indicator.

14.1.1. Minimum Threshold Development

Consistent with the California Code of Regulations Title 23 (23 CCR) Division 2 Chapter 1.5 Subchapter 2 § 354.28(c), the definition of MTs for Chronic Lowering of Groundwater Levels in the Basin is based on consideration of trends in historical groundwater levels, projected water use in the Basin, and the relationship to other Sustainability Indicators. Specifically, the information and criteria relied on to establish the MTs for Chronic Lowering of Groundwater Levels include:

- Historical water level data from Representative Monitoring Wells for Chronic Lowering of Groundwater Levels (RMW-WLs)[89];
- The proximity to critical infrastructure (i.e., for consideration of potential land subsidence impacts);
- Well construction information (i.e., for consideration of impacts to beneficial users); and
- Consideration of the Sustainable Management Criteria (SMCs) developed in the adjacent Kern County Subbasin.

This information was used to develop MT estimates using a quantitative algorithm that accounted for trends, historical lows, and water level variability (discussed below). This approach allowed for the most

[89] The representativeness of the RMW-WLs is illustrated on **Figure SMC-1**, which shows the Fall 2015 groundwater level at each well compared to the average Fall 2015 groundwater elevation by Public Land Survey System (PLSS) section for all sections "associated with" (i.e., closest to) each well hydrograph location. The figure shows that the percent difference in water level in the local area around each well is small in most cases, indicating that the well is representative of that local area. Exceptions occur near the fringes of the contouring dataset and near the White Wolf Fault where water levels are influenced by the dip of the White Wolf Fault.

complete and representative historical water level information to inform the MTs.

14.1.1.1. Minimum Threshold Algorithm

The Minimum Thresholds for Chronic Lowering of Groundwater Levels were developed using a multi-step process that included evaluation of historical groundwater elevation data, projected trends, and analysis of potential impacts to existing wells. Initial MT estimates were developed for each RMW-WL location as follows:

- Historical low water levels over a relevant time period are used as a starting point for MTs based on the fact that significant and unreasonable impacts to beneficial uses and users of groundwater due to low groundwater levels are not known to have occurred since the time when water levels were at their historical low. The relevant time period for historical low determination is defined as Water Years (WY) 1966 – 2019 for the following reasons[90]:
    - The assumed upper-end usable lifespan of groundwater wells is approximately 50 years, and therefore most wells would likely not have experienced conditions prior to about 50 years ago;
    - Surface water importation into the Basin was started by the Arvin-Edison Water Storage District (AEWSD) in 1966. The Wheeler Ridge-Maricopa Water Storage District (WRMWSD) began importing water in 1975. These actions represented a significant change to water management in the Basin; and
    - The relevant time period includes conditions observed up to the most recently available complete fall dataset (Fall 2019).
- Variability in groundwater levels, due in large part to variations in water year type, is accounted for by calculating a Variability Correction Factor as the product of the observed water level range over a relevant time period and a “Range Fraction.” This Variability Correction Factor is applied to the historical low (as discussed below) and acknowledges the fact that different locations within the Basin have experienced different amounts of water level variability.
    - The time period for water level range determination is defined as WY 1995 – 2015 for the following reasons:
        - The 21-year length of this period is roughly the same as the 20-yr Sustainable Groundwater Management Act (SGMA) implementation period; therefore, the SGMA implementation period is expected to include a similar range of variability as the groundwater level range period;
        - The period includes a mix of wet and dry water year types and so variability in groundwater levels during this time should be reflective of variable climate;

[90] For wells that do not have long-term water level records, historical lows were estimated based on linear correlation with other nearby wells with long-term hydrograph.

- The period is climatically close to the long-term average for precipitation;
- This period is the same as the historical and current water budget period of interest, and therefore water budget and model results are available for this period; and
- SGMA went into effect in 2015. SGMA does not require restoring groundwater levels to conditions prior to 2015 (California Water Code [CWC] § 10727.2(b)(4)).

  - The Range Fraction is set at 25% as a conservative allowance for water level fluctuation within a well.

- Recent trends in groundwater levels and projected water use are accounted for by extending the trend for a certain amount of time (the "Trend Extension Period") to determine a Trend Continuation Factor. This factor is also applied to recent water levels (as discussed below) in order to allow time for implementation of any Projects and/or Management Actions needed to eliminate declining trends, and thereby avoid potential rapid disruption to land uses.
  - The time period for water level trend calculation is defined as WY 2010 – 2019 for the following reasons:
    - This period reflects the effects of changes to State Water Project (SWP) / Central Valley Project (CVP) deliveries resulting from 2007 Delta-related federal District Court rulings; and
    - The period includes the 2012 to 2016 significant drought, and therefore allows the Trend Continuation Factor to incorporate the possibility of another long-term drought in the future (e.g., potentially exacerbated by climate change).
  - The Trend Extension Period was set to ten years for the following reasons:
    - This is the minimum length of time considered reasonable and necessary to implement any Projects & Management Actions that may be required to reverse declining groundwater level trends, especially in consideration of the potential regulatory, environmental, logistical, engineering, socioeconomic and other challenges that the various Projects & Management Actions may entail, even before any lag between Action implementation and measurable hydrologic feedback; and
    - This length of time is half the duration of the SGMA implementation period, suggesting that by the halfway point at the latest, the Basin should be on a trajectory towards achieving the Sustainability Goal.
- Using the above values (i.e., the Historical Low, the Variability Correction Factor, and the Trend Continuation Factor), the initial MT estimates for Chronic Lowering of Groundwater Levels at each RMW-WL location are calculated as the lower of the following: (a) the historic low groundwater level minus the Variability Correction Factor and (b) the groundwater level in Fall 2015 (i.e., the first Fall after SGMA went into effect) minus the greater of either the Variability Correction Factor or the Trend Continuation Factor. In mathematical terms, the algorithm for defining the initial MT estimates for Chronic Lowering of Groundwater Levels at each RMW-WL

location is as follows:

$$MT = min\begin{cases} HL - VCF \\ GWL_{Fall\ 2015} - max\begin{cases} VCF \\ TCF \end{cases} \end{cases}$$

$$VCF = Range * 25\%$$

$$TCF = Trend * 10\ yrs$$

where:

MT is the Minimum Threshold estimate (feet above mean sea level [ft msl]);

HL is the historical low groundwater level over the WY 1966 – 2019 period (ft msl),

VCF is the Variability Correction Factor (feet [ft]);

TCF is the Trend Continuation Factor (ft);

$GWL_{Fall\ 2015}$ is the Fall 2015 groundwater level (ft msl);

$Range$ is the water level range over the WY 1995 – 2015 period; and

$Trend$ is the groundwater level trend over the WY 2010 – 2019 period (feet per year [ft/yr]).

14.1.1.2. Adjustment in Areas Proximal to Critical Infrastructure

In areas proximal to critical infrastructure that may be particularly sensitive to significant and unreasonable effects from land subsidence (discussed further below), an adjustment to the initial MT estimates was applied in the algorithm to ensure that the calculated MT was no lower than the historical low groundwater levels. Specifically, for the five RMW-WL locations that were within one mile of the California Aqueduct or the 850 Canal, which are part of the Monitoring Network for Land Subsidence, the MT estimates were set to their historical low groundwater levels, as doing so is considered protective of subsidence (i.e., further subsidence would theoretically not occur if groundwater levels are maintained at or above these levels). Results from the MT estimation exercise described above are shown on **Figure SMC-2**.

14.1.1.3. Consideration of Adjacent Basins

The MTs were developed in consideration of and in coordination with the neighboring Kern County Subbasin. Through their membership in both the Kern Groundwater Authority (KGA) and the White Wolf Groundwater Sustainability Agency (GSA), WRMWSD, AEWSD, and Tejon-Castac Water District (TCWD) have and will continue to consider the ability of both basins to achieve their respective Sustainability Goals. Specifically, the MTs and Measurable Objectives (MOs) for the Basin have been developed herein using similar methodology and similar definitions of Undesirable Results that WRMWSD, AEWSD and TCWD used to develop MTs and MOs for their Management Area Plans in the Kern County Subbasin.

Figure SMC-5 compares the Basin's MTs to the MTs established within the AEWSD, WRMWSD, and TCWD Management Area Plans in the adjacent Kern County Subbasin. The Basin's MTs are higher than those in the adjacent area in Kern County Subbasin, which ensures that if water levels were to reach MTs in both basins the horizontal gradient of groundwater flow from the Basin to the Kern County Subbasin will remain within the range of current conditions (i.e., between 0.004 and 0.009 ft/ft).

14.1.2. Well Impact Analysis

By design, the RMW-WLs were chosen to be representative of groundwater levels in their area, as discussed above and shown on **Figure SMC-1**. It follows that water level changes observed in an RMW-WL would also be expected to occur at nearby wells, and potential impacts to those wells (e.g., dewatering) could occur depending on the levels and the well's construction details. In order to examine the potential impacts on other Basin wells of water levels declining to MTs in each RMW-WL, a well impact analysis was performed based on the simplifying assumption that the water level in any given Basin well will be similar to the water level in the nearest RMW-WL. These estimated water levels were plotted graphically for the domestic, irrigation, and public supply wells in the Basin to assess the potential of dewatering at the proposed MTs (**Figure SMC-3**).

For this analysis, a well is considered to be completely dewatered if the water level is at or below the elevation of the well's total depth and is considered to be partially dewatered if the water level is below the midpoint elevation of the well screen. Only wells with available well construction information could be assessed using this method. Wells older than 50 years are also excluded, assuming that the usable lifespan of groundwater wells is approximately 50 years[91]. Results from this well impact analysis are shown on **Figure SMC-3**. The proposed MTs are not expected to result in complete dewatering in any of the wells analyzed, and are only expected to result in partial dewatering of four wells that were not already partially dewatered at the Fall 2015 groundwater elevation; as such, the extent of potential impacts is not considered to be significant and unreasonable. Further, by definition the MTs are the minimum values that water levels would theoretically be allowed to reach, and the GSA will strive through the use of Projects and/or Management Actions to maintain water levels at or above the MOs, which are in all cases above the MTs, as described in ***Section 15.1 Measurable Objective and Interim Milestones for Chronic Lowering of Groundwater Levels***.

14.1.3. Final Minimum Thresholds for Chronic Lowering of Groundwater Levels

The final MTs for Chronic Lowering of Groundwater Levels at each RMW-WL, after having considered the results of the well impacts analysis in Section 14.1.2, the proximity to critical infrastructure, and the MTs set in the adjacent subbasins, are summarized in **Table SMC-4** and on **Figure SMC-4**.

These final MTs have been set to ensure that no Undesirable Results occur at the MT levels for the wells.

[91] Others have estimated the well retirement age/lifespan to be lower at approximately 28 to 33 years (Gailey, 2018; Pauloo et al., 2020). The assumption used herein of a 50-year well lifespan is considered conservative.

Table SMC-4. Summary of Minimum Thresholds, Interim Milestones, and Measurable Objectives for Chronic Lowering of Groundwater Levels

RMW-WL	Minimum Threshold (ft msl)	Interim Milestones (ft msl)			Trigger Threshold (ft msl)[(a)]	Measurable Objective (ft msl)	Margin of Operational Flexibility (ft)
		2027	2032	2037			
RMW-WWB-001	**680**	800	800	800	740	**800**	119
RMW-WWB-002	**177**	273	273	273	225	**273**	96
RMW-WWB-003	**196**	224	210	231	--	**252**	57
RMW-WWB-004	**103**	127	115	133	127	**151**	48
RMW-WWB-005	**93**	128	110	136	128	**162**	69
RMW-WWB-006	**152**	162	157	164	162	**171**	19
RMW-WWB-007	**123**	151	137	159	151	**180**	58
RMW-WWB-008	**104**	127	115	132	127	**149**	45
RMW-WWB-009	**130**	145	137	148	145	**160**	30
RMW-WWB-010	**159**	181	181	181	170	**181**	21
RMW-WWB-011	**380**	433	433	433	406	**433**	53
RMW-WWB-012	**123**	142	133	147	142	**161**	38
RMW-WWB-013	**92**	136	114	147	--	**181**	89
RMW-WWB-014	**96**	124	110	130	--	**151**	55

Abbreviations:

ft = feet
ft msl = feet above mean sea level
RMW-WL = Representative Monitoring Well for Chronic Lowering of Groundwater Levels

Notes:

a. Trigger thresholds are established for RMW-WLs in which the trend over current conditions is stable to increasing to values above the MO. See ***Section 15.1 Measurable Objective and Interim Milestones for Chronic Lowering of Groundwater Levels*** for details.

14.2. Minimum Threshold for Reduction of Groundwater Storage

> *§ 354.28. Minimum Thresholds*
>
> *(c) Minimum thresholds for each sustainability indicator shall be defined as follows:*
> *(2) Reduction of Groundwater Storage. The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be supported by the sustainable yield of the basin, calculated based on historical trends, water year type, and projected water use in the basin.*

As discussed above, the UR definition for Reduction of Groundwater Storage equates to a volumetric decrease in storage amounting to a reduction in 20% of usable supply over the planning and implementation horizon and the criteria for the URs are tied to groundwater levels measured in RMW-WLs. It is logical to tie these two Sustainability Indicators together, as the amount of groundwater in storage is directly, if not linearly, related to groundwater levels. Because of the close relationship between these two Sustainability Indicators, and because the MTs for Chronic Lowering of Groundwater Levels (discussed above) are protective of the beneficial uses and users of groundwater, the MTs for Chronic Lowering of Groundwater Levels are used as a proxy for the Reduction of Groundwater Storage Sustainability Indicator. There are no state, federal, or local standards that relate to this Sustainability Indicator.

14.2.1. Use of Groundwater Levels as Proxy

Pursuant to the 23 CCR § 354.28(d) and as further described in the DWR Sustainable Management Criteria BMP (DWR, 2017b), MTs for Reduction of Groundwater Storage may be set by using groundwater levels as a proxy if it is demonstrated that a correlation exists between the two metrics. The White Wolf Groundwater Flow Model (WWGFM) projects water levels and changes in groundwater storage. A visual comparison between model-calculated water levels in a RMW-WL and the cumulative change in groundwater storage over the water budget periods demonstrates that when groundwater levels increase, groundwater storage increases and when groundwater levels decrease, groundwater storage decreases (see **Figure SMC-6**). Therefore, there is a clear correlation between Basin water levels and cumulative change in groundwater storage can be established.

Another approach to using groundwater levels as a proxy, described in the DWR Sustainable Management Criteria BMP, is to demonstrate that MTs for Chronic Lowering of Groundwater Levels are sufficiently protective to ensure prevention of significant and unreasonable occurrences of the Sustainability Indicator in question.

To support the use of MTs for Chronic Lowering of Groundwater Levels as proxy for Reduction of Groundwater Storage, the volume of "usable storage" in the Principal Aquifer was calculated based on the WWGFM. The usable storage was assumed to be to the groundwater storage available between the model-calculated Fall 2015 water table and the median depth of production wells (1,050 ft) in the developed part of the Basin and is estimated to be 2.39 million acre-feet (AF).

If groundwater levels were reduced to the MT levels in the developed part of the Basin relative to model-calculated Fall 2015 levels, the reduction is groundwater storage would be approximately 455,000 AF. This is approximately 19% of the estimated usable storage in the developed part of the Basin. This demonstrates that the MTs for Chronic Lowering of Groundwater Levels are protective of the groundwater storage in the Basin and can be used as proxy for the Reduction of Groundwater Storage Sustainability Indicator.

14.3. Minimum Threshold for Seawater Intrusion

§ 354.28. Minimum Thresholds

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:
(3) Seawater Intrusion. The minimum threshold for seawater intrusion shall be defined by a chloride concentration isocontour for each principal aquifer where seawater intrusion may lead to undesirable results. Minimum thresholds for seawater intrusion shall be supported by the following:
(A) Maps and cross-sections of the chloride concentration isocontour that defines the minimum threshold and measurable objective for each principal aquifer.
(B) A description of how the seawater intrusion minimum threshold considers the effects of current and projected sea levels.

As discussed in ***Section 13.3 Undesirable Results for Seawater Intrusion***, Seawater Intrusion Sustainability Indicator is not applicable for the Basin; thus, no SMCs for this Sustainability Indicator are defined.

14.4. Minimum Threshold for Degraded Water Quality

§ 354.28. Minimum Thresholds

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:
(4) Degraded Water Quality. The minimum threshold for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results. The minimum threshold shall be based on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin. In setting minimum thresholds for degraded water quality, the Agency shall consider local, state, and federal water quality standards applicable to the basin.

The 23 CCR § 354.28(c) states that the MT for Degraded Water Quality shall be the "degradation of water, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results". The 23 CCR further state that the MT "shall be based on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin," and that "the Agency shall consider local, state, and federal water quality standards applicable to the basin." This language indicates that MTs for Degraded Water Quality can reasonably be based on concentrations of water quality constituents of concern (COCs), as quantified by sampling measurements at the Representative Monitoring Wells for Degraded Water Quality (RMW-WQs).

14.4.1. Minimum Threshold Development

14.4.1.1. Constituents of Concern

Per CWC Section 10725, the powers and authorities granted to GSAs to affect sustainable groundwater management under SGMA include, but are not limited to, conducting investigations, registration and metering of groundwater extraction facilities, acquiring surface water or groundwater, reclaiming waters for subsequent beneficial use, regulating groundwater extraction, and establishing accounting rules for groundwater extraction allocations. SGMA does not empower GSAs to develop or enforce water quality standards; that authority rests with the State Water Resources Control Board (SWRCB) and Regional Water Quality Control Boards (RWQCBs), and, in the case of the Basin, the Kern County Public Health Services Department. Because of the limited purview of GSAs with respect to water quality, and the rightful emphasis on those constituents that may affect the supply and beneficial uses of groundwater, SMCs for water quality in the Basin are only developed at the designated RMW-WQs—four public water system (PWS) public supply wells—for three constituents: arsenic, nitrate, and selenium.

As described in ***Section 8.5 Groundwater Quality Concerns***, arsenic, nitrate, and selenium have been identified as potential COCs in the Basin groundwater. These COCs can pose significant health risks at elevated concentrations and have established Primary Maximum Contaminant Levels (MCLs). As discussed in ***Section 17.1.4 Monitoring Network for Degraded Water Quality***, the benefits of utilizing PWS wells as RMW-WQs are that they inherently consider groundwater quality effects on sensitive beneficial uses (i.e., drinking water users) and are also already required to be sampled for constituents of health concern on a regular and known schedule (i.e., compliance with Title 22 CCR drinking water regulations for MCLs). Other non-PWS wells have been designated as supplemental water quality wells and will be used for continued evaluation of groundwater quality trends within the Basin throughout Groundwater Sustainability Plan (GSP) implementation.

Although 1,2,3-trichloropropane (1,2,3-TCP) is an emerging COC that is affecting recharge project operations in other areas of Kern County, very limited detections have occurred within the Basin, and ongoing groundwater monitoring will occur during GSP implementation. Several other constituents (i.e., Total Dissolved Solids (TDS), sulfate, iron, boron, and sodium) were identified in ***Section 8.5 Groundwater Quality Concerns*** as having exceeded their applicable screening levels in 15% or more of samples in the White Wolf Data Management System (DMS). However, the screening levels for these constituents are mostly Secondary MCLs associated with aesthetic concerns (i.e., taste, odor or color) or irrigation Water Quality Objectives (WQOs), and are not health-related standards. Because these constituents are not expected to have significant impacts to the most sensitive beneficial use of groundwater in the Basin (i.e., drinking water), SMCs have not been developed for those constituents. However, these constituents will continue to be monitored as part of the existing monitoring programs, and the White Wolf GSA may re-evaluate establishing SMCs for additional constituents or at additional well locations if future data analysis suggests the need for revision of Water Quality SMCs.

14.4.1.2. Consideration of State, Federal and/or Local Standards

The State of California and the U.S. Environmental Protection Agency (USEPA) set Primary MCLs for constituents that may pose potential human health risks. MCLs are appropriate to consider when establishing MTs for Degraded Water Quality, as this approach meets the requirement to consider the beneficial uses and users of groundwater. The Primary MCLs for arsenic, nitrate as nitrogen, and selenium are 0.01 milligrams per liter (mg/L), 10 mg/L, and 0.05 mg/L, respectively. Concentrations of these three constituents have been below their respective MCLs in all samples from PWS wells within the Basin.

14.4.2. Final Minimum Thresholds for Degraded Water Quality

Given that measured concentrations have been below the MCLs, it is appropriate to consider the MCLs as MTs. However, given the limited regulatory authority of GSAs with respect to water quality, it is not appropriate to consider setting the MTs lower than the MCLs. Therefore, the MTs for Degraded Water Quality are set for arsenic, nitrate, and selenium at their respective MCLs at the four RMW-WQs. The final MTs are shown in **Table SMC-5** and **Figure SMC-7.**

It should be noted that monitoring for these and other water quality parameters will continue to be conducted at all water quality monitoring well locations, as discussed further in ***Section 17.1.4 Monitoring Network for Degraded Water Quality***.

Table SMC-5. Summary of Minimum Thresholds, Interim Milestones, and Measurable Objectives for Degraded Water Quality

RMW-WQ	Constituent of Concern	Minimum Threshold (mg/L)	Measurable Objective (mg/L)	Margin of Operational Flexibility (mg/L)	Trigger Threshold (mg/L)
RMW-WWB-015	Arsenic	**0.01**	**0.0075**	0.0025	0.005
	Nitrate	**10**	**7.5**	2.5	5
	Selenium	**0.05**	**0.0375**	0.0125	0.025
RMW-WWB-016	Arsenic	**0.01**	**0.0075**	0.0025	0.005
	Nitrate	**10**	**7.5**	2.5	5
	Selenium	**0.05**	**0.0375**	0.0125	0.025
RMW-WWB-017	Arsenic	**0.01**	**0.0075**	0.0025	0.005
	Nitrate	**10**	**7.5**	2.5	5
	Selenium	**0.05**	**0.0375**	0.0125	0.025
RMW-WWB-018	Arsenic	**0.01**	**0.0075**	0.0025	0.005
	Nitrate	**10**	**7.5**	2.5	5
	Selenium	**0.05**	**0.0375**	0.0125	0.025

Abbreviations:
mg/L = milligrams per liter
RMW-WQ = Representative Monitoring Well for Degraded Water Quality

Notes:
(1) Nitrate concentrations are nitrate as nitrogen (N).

14.5. Minimum Threshold for Land Subsidence

§ 354.28. Minimum Thresholds

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:
(5) Land Subsidence. The minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results. Minimum thresholds for land subsidence shall be supported by the following:
(A) Identification of land uses and property interests that have been affected or are likely to be affected by land subsidence in the basin, including an explanation of how the Agency has determined and considered those uses and interests, and the Agency's rationale for establishing minimum thresholds in light of those effects.
(B) Maps and graphs showing the extent and rate of land subsidence in the basin that defines the minimum threshold and measurable objectives.

Land Subsidence can be caused by several mechanisms, but the mechanism most relevant to sustainable groundwater management is the depressurization of aquifers and aquitards due to lowering of groundwater levels. This depressurization can lead to compaction of compressible strata and lowering of the ground surface. Given the relationship between groundwater levels and land subsidence, it is reasonable to relate the Land Subsidence Sustainability Indicator with the Chronic Lowering of Groundwater Levels Sustainability Indicator. As discussed below, because the MTs for Chronic Lowering of Groundwater Levels are established with consideration for the prevention of significant and unreasonable land subsidence, it is not necessary to set a unique MT for Land Subsidence; rather, the MTs for Chronic Lowering of Groundwater will be used as a proxy.

14.5.1. Use of Groundwater Levels as Proxy

Pursuant to the 23 CCR § 354.28(d) and as further described in the DWR Sustainable Management Criteria BMP (DWR, 2017b), MTs for Land Subsidence may be set by using groundwater levels as a proxy if it is demonstrated that MTs for Chronic Lowering of Groundwater Levels are sufficiently protective to ensure significant and unreasonable occurrences of land subsidence will be prevented.

Within the Basin, the areas most sensitive to land subsidence are those proximal to critical infrastructure which includes the California Aqueduct and the 850 Canal. As described in ***Section 14.1 Minimum Threshold for Chronic Lowering of Groundwater Levels***, potential impacts to the areas proximal to critical infrastructure have been taken into consideration in the development of MTs for Chronic Lowering of Groundwater Levels. Specifically, for the five (5) RMW-WL locations that are within one mile of the California Aqueduct or the 850 Canal, the MTs are set to their historical low groundwater levels. This theoretically ensures that avoidance of the MTs for groundwater levels will also prevent further subsidence from occurring.

In addition to groundwater levels monitoring, subsidence along the California Aqueduct will continue to be monitored directly through ground surface elevation measurements by DWR at their survey benchmark locations and by University Navstar Consortium (UNAVCO) at their Global Positioning System (GPS) sites. There are currently no ground surface elevation monitoring sites along the 850 Canal. However, the White Wolf GSA is planning to establish two checkpoints along the 850 Canal for ongoing monitoring moving forward. The monitoring data will be compiled together with other readily available data for analysis at the next five-year update of the GSP.

14.6. Minimum Threshold for Depletions of Interconnected Surface Water

> *§ 354.28. Minimum Thresholds*
>
> *(c) Minimum thresholds for each sustainability indicator shall be defined as follows:*
> *(6) Depletions of Interconnected Surface Water. The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results. The minimum threshold established for depletions of interconnected surface water shall be supported by the following:*
> *(A) The location, quantity, and timing of depletions of interconnected surface water.*
> *(B) A description of the groundwater and surface water model used to quantify surface water depletion. If a numerical groundwater and surface water model is not used to quantify surface water depletion, the Plan shall identify and describe an equally effective method, tool, or analytical model to accomplish the requirements of this Paragraph.*

The 23 CCR § 354.28(c) states that the MT for Depletions of Interconnected Surface Water "shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results" (emphasis added).

As discussed in ***Section 8.7 Interconnected Surface Water Systems***, there is no interconnected surface water throughout the main portion of the Basin due to the deep groundwater levels in the Principal Aquifer, typically dry streams, and no beneficial uses of surface water. However, around the periphery of the Basin there are beneficial uses of surface water in the form of diversions for irrigated agriculture, as well as some locations where the presence of GDEs has been confirmed (e.g., south of the Springs Fault). The influence of water management on groundwater conditions in these peripheral parts of the Basin is unknown but thought to be minimal given the largely undeveloped nature of this portion of the Basin.

The above uncertainty notwithstanding, the White Wolf GSA has established preliminary MTs for Interconnected Surface Water at three newly installed shallow monitoring wells on the upgradient side of the Springs Fault. The three monitoring wells are considered Representative Monitoring Wells for Depletions of Interconnected Surface Water (RMW-ISW).

Because insufficient data currently exist from these new wells to tie specific groundwater level conditions to potential effects on the beneficial uses of interconnected surface water, a conservative approach has been taken to establish preliminary MTs at these three wells based on the process outlined below with results shown in **Table SMC-6**.

- Observed depth to groundwater levels are used as a starting point for developing the MTs based on the fact that data only exist for 2021.
- Recent trends in depth to groundwater levels are extended for a certain amount of time (the "Trend Extension Period") to determine a Trend Continuation Factor. The time period for water level trend calculation is defined based on water level trends observed in June 2021 and extended

through October 2021 (i.e., to capture an expected decline in water levels over the dry season).

- Maximum rooting depth of mapped GDEs, which were all less than 30 feet below ground surface (see **Table GWC-6**).

Using the above values, the initial MT estimates at each RMW-ISW location are calculated as the lower of the following: (a) the projected depth to groundwater at the end of October 2021 calculated based on observed June 2021 water levels and the Trend Continuation Factor, and (b) 30 ft bgs.

Table SMC-6. Summary of Minimum Thresholds and Measurable Objectives for Depletions of Interconnected Surface Water

RMW-ISW	Minimum Threshold (ft bgs)	Measurable Objective (ft bgs)	Margin of Operational Flexibility (ft)
RMW-WWB-019	**30**	**15**	15
RMW-WWB-020	**30**	**19**	11
RMW-WWB-021	**36**	**36**	0

Abbreviations:
ft bgs = feet below ground surface
ft = feet
RMW-ISW = Representative Monitoring Well for Interconnected Surface Water

During GSP implementation, the White Wolf GSA will endeavor to fill the identified data gaps to refine the understanding of the potential correlation between pumping in the Principal Aquifer and Depletions of Interconnected Surface Water. In the first five years of GSP implementation, depth to groundwater will be monitored at the RMW-ISWs on a high-frequency basis (e.g., monthly). A pumping test over the 2021 irrigation season is being conducted to monitor fluctuations and will be analyzed after GSP submission. If the data collected during these efforts indicates any influence from Basin pumping on the adjacent GDE units, the preliminary MTs for this Sustainability Indicator will be revised and reevaluated as appropriate.

Furthermore, as part of the supplemental SGMA Monitoring Network for Depletions of Interconnected Surface Water, data from stream gauges located on four streams will be compiled from publicly available data sources and the White Wolf GSA is working to install a streamflow datalogger on El Paso Creek. This data will allow better quantification of the amount of surface water contributions to Basin recharge.

15.MEASURABLE OBJECTIVES AND INTERIM MILESTONES

§ 354.30. Measurable Objectives

(a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.

(b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.

(c) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.

(d) An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.

(e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

(f) Each Plan may include measurable objectives and interim milestones for additional Plan elements described in Water Code Section 10727.4 where the Agency determines such measures are appropriate for sustainable groundwater management in the basin.

(g) An Agency may establish measurable objectives that exceed the reasonable margin of operational flexibility for the purpose of improving overall conditions in the basin, but failure to achieve those objectives shall not be grounds for a finding of inadequacy of the Plan.

This section discusses the development of Measurable Objectives (MOs) and Interim Milestones (IMs) for all relevant Sustainability Indicators for the White Wolf Subbasin (Basin).

15.1. Measurable Objective and Interim Milestones for Chronic Lowering of Groundwater Levels

15.1.1. Measurable Objectives for Chronic Lowering of Groundwater Levels

The MOs for Chronic Lowering of Groundwater Levels were developed based on the groundwater levels that were observed or simulated in the 14 Representative Monitoring Wells for Chronic Lowering of Groundwater Levels (RMW-WLs) during the “current” period (i.e., Fall 2015 through 2019). This time period was selected to be consistent with the “current” period defined in the Basin water budget (***Section 9 Water Budget Information***) as well as it reflects a reasonable “baseline” condition for defining Basin sustainability that reflects current land and water use practices and reliability. Specifically, Fall 2015 was chosen because the Sustainable Groundwater Management Act (SGMA) does not require Groundwater Sustainability Agencies (GSAs) to address potential undesirable results that occurred before, and have not been corrected by, January 1 2015 (California Water Code [CWC] § 10727.2(b)(4)) and Fall 2019 was selected to represent more recent Basin conditions and operations in light of reduced surface supply reliability. At each RMW-WL, the lower of either Fall 2015 or Fall 2019, measured when available or model-calculated when measured was unavailable, was set as the MO.

As described in the Sustainable Management Criteria Best Management Practices (BMP) document (California Department of Water Resources [DWR], 2017), "Measurable Objectives should be set such that there is a reasonable margin of operation flexibility (or 'margin of safety'), between the minimum threshold and measurable objective that will accommodate droughts, climate change, conjunctive use operations, or other groundwater management activities." Therefore, the margin of operational flexibility within the Basin is the difference between the Minimum Threshold (MT) and the MO. The MOs and margins of operational flexibility for the RMW-WLs within the Basin are shown in **Table SMC-4** and **Figure SMC-8**.

Figure SMC-9 compares the Basin's MOs to the MOs established within the Arvin-Edison Water Storage District (AEWSD), Wheeler Ridge-Maricopa Water Storage District (WRMWSD), and Tejon-Castac Water Storage District (TCWD) Management Area Plans which is the portion of the Kern County Subbasin that is immediately adjacent to the Basin. The Basin's MOs are higher than those in the adjacent area in Kern County Subbasin, which ensures that the horizontal gradient of groundwater flow from the Basin to the Kern County Subbasin will remain similar to historical conditions as water levels reach MOs.

15.1.2. Interim Milestones for Chronic Lowering of Groundwater Levels

The IMs for Chronic Lowering of Groundwater Levels are defined herein based on the MTs and the MOs, wherein:

- For RMW-WLs where the current (Fall 2015 through Fall 2019) groundwater level trend is stable to increasing at values above the MO, the subsequent IMs are all equal to the MO. Furthermore, a "trigger threshold" has been established as the mid-point between the MO and MT. If groundwater levels in 40% or more of the RMW-WLs fall below the trigger threshold, the Groundwater Sustainability Agency (GSA) will consider whether additional groundwater management action is warranted.
- For all other RMW-WLs, IMs are defined based on a trajectory for groundwater levels informed by current groundwater levels, the MTs, and the MOs. This trajectory assumes a continuation of current groundwater level trends for the first 5-year period, a deviation (slowing) from that trend over the second 5-year period, a recovery to the 5-year IM in the third 5-year period, and recovery towards the MO over the fourth (last) 5-year period (**Table SMC-7**). Specifically, the trajectory for groundwater levels prescribed in the IMs is as follows:

Table SMC-7. Interim Milestone Trajectory for Chronic Lowering of Groundwater Levels

Calendar Year	Interim Milestone for Chronic Lowering of Groundwater Levels	Basis for Interim Milestone
2022	Not applicable	Not applicable
2027	$IM\text{-}5_{GWL}$	$\frac{1}{2} * (MO_{GWL} + MT_{GWL})$
2032	$IM\text{-}10_{GWL}$	$\frac{1}{2} * (IM\text{-}5_{GWL} + MT_{GWL})$
2037	$IM\text{-}15_{GWL}$	$\frac{1}{2} * (IM\text{-}10_{GWL} + MO_{GWL})$
2042	MO_{GWL}	MO_{GWL}

where:

> $IM\text{-}5_{GWL}$, $IM\text{-}10_{GWL}$, and $IM\text{-}15_{GWL}$ are the Interim Milestones for Chronic Lowering of Groundwater Levels after 5 years, 10 years and 15 years, respectively;
>
> MT_{GWL} is the Minimum Threshold for Chronic Lowering of Groundwater Levels (defined previously); and
>
> MO_{GWL} is the Measurable Objective for Chronic Lowering of Groundwater Levels (defined previously)

The IMs and MOs for Chronic Lowering of Groundwater Levels are presented in **Table SMC-4**, and are displayed relative to historical water levels at each RMW-WL on **Figure SMC-10**.

15.2. Measurable Objective for Reduction of Groundwater Storage

As discussed in ***Section 14.2 Minimum Threshold for Reduction of Groundwater Storage***, because of the close relationship between the Reduction of Groundwater Storage and Chronic Lowering of Groundwater Levels Sustainability Indicators, the MOs for Chronic Lowering of Groundwater Levels serve as a proxy for Reduction of Groundwater Storage, and it is not necessary to set a unique MO for Reduction of Groundwater Storage. As stated above, the MOs for Chronic Lowering of Groundwater Levels provide an adequate Margin of Operational Flexibility.

15.3. Measurable Objective for Seawater Intrusion

As discussed in ***Section 13.3 Undesirable Results for Seawater Intrusion***, the Seawater Intrusion Sustainability Indicator is not applicable for the Basin; thus, no Sustainable Management Criteria (SMCs) for this Sustainability Indicator are defined.

15.4. Measurable Objective and Interim Milestones for Degraded Water Quality

As with the MTs, the MOs for Degraded Water Quality are defined at public supply wells in the Basin for the three potential constituents of concern (COCs) with Primary Maximum Contaminant Levels (MCLs): arsenic, nitrate, and selenium. Concentrations of the three COCs have been below their respective MCLs, which are also being used as the MTs. Maintaining concentrations at approximately current levels, while allowing an adequate Margin of Operational Flexibility is considered to be an appropriate goal. Therefore, in pursuit of that goal, the MOs are set at 75% of the MTs.

As current concentrations are below the MOs, setting IMs for Degraded Water Quality based on extrapolation between current concentrations and the MOs would suggest a degradation in water quality. Therefore, setting variable IMs is not applicable. Instead, the White Wolf GSA has established “trigger thresholds” for Degraded Water Quality at 50% of the respective MT/MCL concentrations. If concentrations of a potential COC in a Representative Monitoring Well for Water Quality (RMW-WQ) reach the trigger threshold, the White Wolf GSA will consider whether there is a need for additional action, including additional monitoring to confirm the accuracy of the previous sampling results. The trigger thresholds and the MOs for Degraded Water Quality are presented in **Table SMC-5**. Further actions to address MT exceedances for Degraded Water Quality are discussed in ***Section 16 Action Plan Related to Minimum Threshold Exceedances***.

15.5. Measurable Objective for Land Subsidence

As discussed in ***Section 14.5 Minimum Threshold for Land Subsidence,*** the Land Subsidence Sustainability Indicator and the Chronic Lowering of Groundwater Levels Sustainability Indicator are closely linked. As with the MTs, the MOs for Chronic Lowering of Groundwater Levels are used as proxy for the Land Subsidence Sustainability Indicator and would provide an adequate Margin of Operational Flexibility. It is therefore unnecessary to set a unique MO for Land Subsidence.

15.6. Measurable Objective for Depletion of Interconnected Surface Water

As discussed in ***Section 14.6 Minimum Threshold for Depletions of Interconnected Surface Water*** above, preliminary MTs for Depletions of Interconnected Surface Water have been established based on the lower of 30 feet below ground surface and the projected depth to groundwater at the end of October 2021 based on trends observed during June 2021.

Without historical water level data to rely on, establishing MOs for Depletions of Interconnected Surface Water is similarly challenging. The preliminary MOs have been calculated as the projected depth to groundwater at the end of October 2021 based on trends observed during June 2021. In this case, the preliminary MOs provide for a small but non-zero Margin of Operational Flexibility. Given the preliminary nature of the data at this time, IMs have not been established. These preliminary MO values will be reevaluated, updated, and revised as appropriate upon review and analysis of data from the three RMW-ISWs to be collected over the first five years of Groundwater Sustainability Plan (GSP) implementation. Additionally, the GSA has developed a streamlined approach to address future MT exceedances for Depletion of Interconnected Surface Water as described in ***Section 16 Action Plan Related to Minimum Threshold Exceedances.***

16. ACTION PLAN RELATED TO MINIMUM THRESHOLD EXCEEDANCES

This Groundwater Sustainability Plan (GSP) for the White Wolf Subbasin (Basin) defines sustainability under the Sustainable Groundwater Management Act (SGMA) as the avoidance of Undesirable Results (URs). URs occur when there is an impact to the Principal Aquifer that negatively affects the reasonable and beneficial use of, and access to, groundwater for beneficial uses and users within the Basin. The unique criteria for monitoring whether URs are being experienced in the Basin is when a certain percentage of Representative Monitoring Sites (RMSs) exceed their respective Minimum Thresholds (MTs). While a single or isolated MT exceedance will not, by itself, cause an UR, such an exceedance may be indicative of future or trending exceedances which could result in URs.

The White Wolf Groundwater Sustainability Agency (GSA) is responsible for monitoring groundwater conditions, complying with GSP / SGMA requirements and coordinating with other agencies and entities (e.g., public water systems, etc.) within the Basin. However, the White Wolf GSA also relies upon its member districts to facilitate SGMA implementation. For example, each GSA member district collects and compiles necessary data within their service areas in order to support preparation of an annual report (see ***Section 19.1.7 Annual Reporting***) which is submitted to the California Department of Water Resources (DWR) each year on April 1. The annual reports include progress towards achieving interim milestones and identifies whether any MT exceedances have occurred.

It is important to monitor compliance with MTs and Measurable Objectives (MOs) over time to understand the Basin's likelihood of achieving sustainability and avoiding URs. The following six-step action plan is proposed to proactively address MT exceedances if they occur.

1. <u>Identify Exceedance and Investigate the RMS Area</u>:

After each annual report, the White Wolf GSA technical committee will review data, identify any MT exceedance(s) at RMS(s), and will compile a summary of MT exceedances for review by the White Wolf GSA Board. This summary will evaluate whether the MT exceedance is associated with a single RMS or indicates a potential regional issue. Various conditions surrounding the RMS will be considered. For example: Are water levels declining in nearby wells? If so, how large of an area is affected? Has a new well been installed nearby or localized groundwater extraction increased? Is the problem related to area-wide drought conditions? Has local demand increased?

2. <u>Evaluate Outside Contributing Factors:</u>

Declining water levels, degraded water quality, or depletions of interconnected surface water in a portion of the Basin may be the result of natural factors or due to operations within the service area of a GSA member district or in the adjacent Kern County Subbasin. In the latter case, a coordinated effort by the GSA member districts (as directed by the White Wolf GSA Board) could include discussions with Kern County Subbasin GSAs, the evaluation of modifying operations, adjusting MTs to account for aforementioned outside contributing factors, and/or adding or moving a RMS if the existing RMS is found to no longer be representative of the area or an alternate RMS is determined to be a better measure of sustainability. Updates or proposals for how to address any observed issues shall be reported back to and approved by the White Wolf GSA Board.

3. Consider the Need for Increased or Expanded Monitoring:

The White Wolf GSA technical committee shall evaluate the efficacy of increasing the monitoring frequency, expanding the monitoring area, adding or re-assigning RMS(s), or other monitoring-related actions necessary to identify the cause of declining water levels. Updates or results from this effort shall be reported back to and approved by the White Wolf GSA Board. In the case of MT exceedances for Degraded Water Quality, the GSA will coordinate with Public Water Systems to increase water sampling frequency as needed to further assess water quality trends.

4. Consider Initiating Projects and/or Management Actions (P/MAs):

If there are repeated MT exceedances observed, the White Wolf GSA Board will consider initiating one of the proposed P/MAs (see ***Section 18.2 List of Projects and Management Actions***). This will require coordination with each GSA member district, as most P/MAs are district specific and details pertaining to initiation, projected benefits, payments, and cost allocations will need to be negotiated. Examples of P/MAs that could be initiated in response to MT exceedances include, but are not limited to, purchasing or obtaining new and/or wet year supplies via water transfers/exchanges, development of new water supplies, recapturing cross-boundary flows, increasing recharge in select areas, in-lieu banking, or management actions/policies to reduce overall groundwater demand.

5. Evaluate Whether GSP Implementation Is Causing or Exacerbating MT Exceedance for Water Quality and/or Interconnected Surface Water:

MT exceedances in an RMW-WQ are assumed to be correlated with SGMA-related groundwater management activities and thus contribute to a UR if all of the following criteria are met:

a. The constituent concentrations in the RMW-WQ exceed the established MT over a period of two (2) consecutive years.

b. The constituent concentrations in the RMW-WQ show a statistically significant deviation or increasing trend after the implementation of any P/MAs. The GSP will determine baseline values for groundwater levels and water quality conditions for the RMWs in the annual reporting and GSP updates. Once the baseline values are determined, a deviation will be determined through calculation of the t-test using pre- and post-P/MA datasets, and trend will determined using the Mann-Kendall trend test, similar to the analysis conducted on existing 1995 – 2018 data as described in ***Section 8.5.3 Water Quality Trends.*** Both statistical tests will use a p-value of 0.05. As stated above, the GSA will coordinate with the Public Water Systems to increase monitoring frequency to at least twice a year if any constituent exceeds its MT in a RMW-WQ. This will generate at least four water quality measurements over the next two years, which will provide a sufficient dataset to conduct the Mann-Kendall trend test.

c. The affected RMW-WQ is located within an area of influence of any P/MAs. The area of influence is conservatively assumed to be that area within a one-mile radius of a local P/MA that has been implemented, in the down gradient direction from the P/MA based on pre-P/MA groundwater flow gradients.

d. There is a statistically significant correlation between groundwater elevation and constituent concentrations in the RMW-WQ where MTs are exceeded when the measurements and sampling events are taken over the course of at least two consecutive years, and constituent detections exceed MTs over those consecutive years. The correlation will be determined through calculation of the cross-correlation coefficient (p-value = 0.05), similar to the analysis conducted on existing data as described in ***Section 8.5.3 Water Quality Trends***.

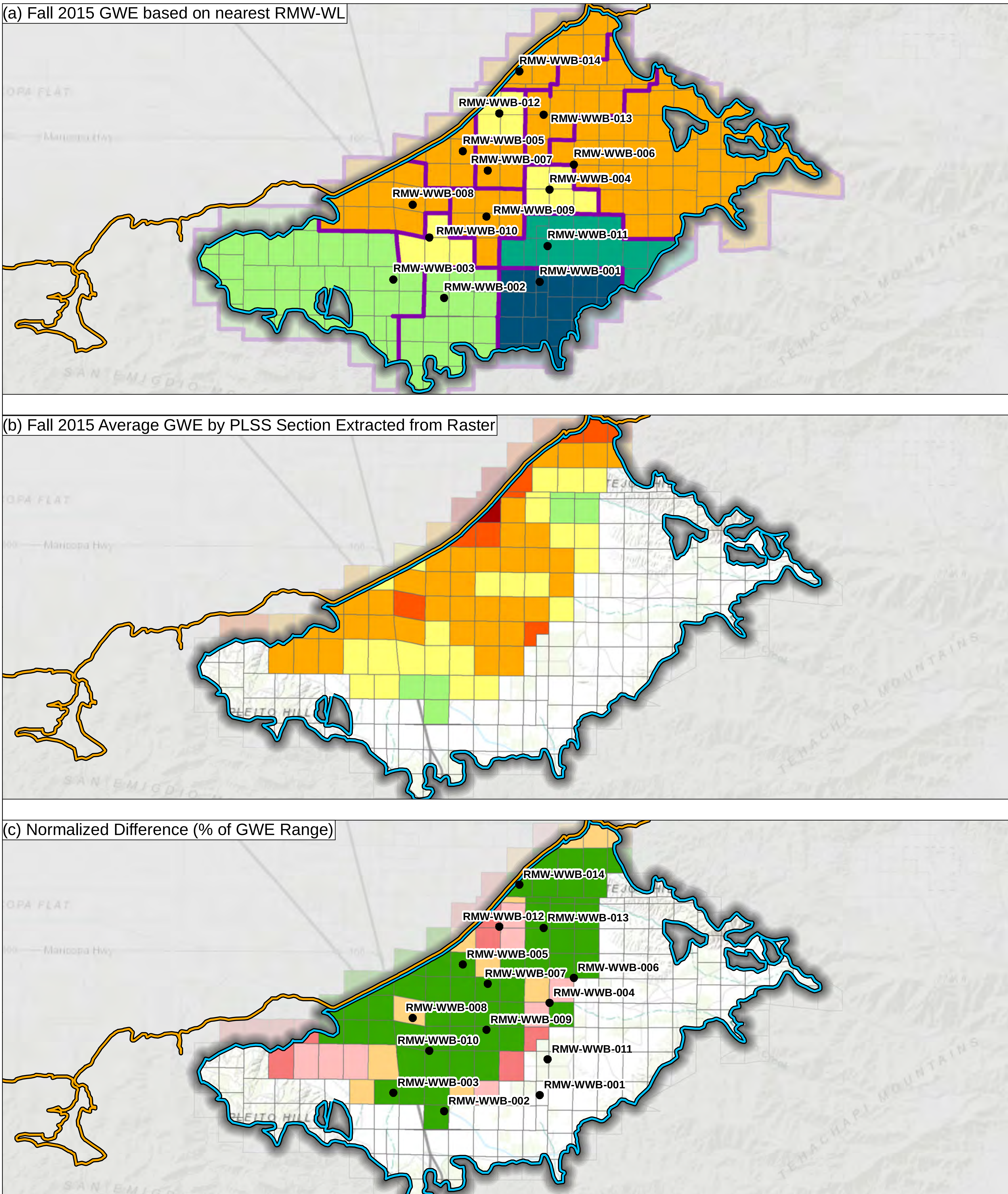
MT exceedances in an RMW-ISW are assumed to be related to SGMA-related groundwater management activities and thus contribute to a UR if both of the following criteria are met:

e. The water levels in the RMW-ISW exceed the established MT leading to a 30% or greater reduction of, or visual impact to, the health of GDEs based on their conditions observed during 2018 through 2020 over a period of two (2) consecutive years.

f. There is a statistically significant correlation between groundwater elevation in nearby RWM-WLs in the Principal Aquifer and groundwater elevation in the RMW-ISW where MTs are exceeded when the measurements are taken over the course of at least two consecutive years, and the MT exceedances occur over those consecutive years. The correlation will be determined through calculation of the cross-correlation coefficient (p-value = 0.05).

6. Consider Enforcement Action:

MT exceedances that result in UR(s) as defined in the GSP (see ***Section 13 Undesirable Results***) will require the White Wolf GSA to establish an enforcement plan. The enforcement plan will outline specific P/MAs that must be initiated to eliminate the UR and will demonstrate how these P/MAs will be sufficient to avoid URs.



Legend

Groundwater Subbasin
- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- RMW-WL
- Representative Monitoring Area
- Section with No Available Data

Fall 2015 GWE (ft msl)
- 50 - 100
- 100 - 150
- 150 - 200
- 200 - 250
- 250 - 300
- 300 - 500
- 500 - 700
- 700 - 900

Normalized Difference
- <10%
- 10% - 20%
- 20% - 30%
- > 30%

Sources
1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 18 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.

Abbreviations

DWR	= California Department of Water Resources
ft msl	= feet above mean sea level
GWE	= Groundwater Elevation
PLSS	= Public Land Survey System
RMW-WL	= Representative Monitoring Well for Water Level

N

0 4 8
(Scale in Miles)

Notes
1. All locations are approximate.
2. For RMW-WLs that do not have Fall 2015 GWE, Fall GWE from a year closest to 2015 are presented. For RMW-WWB-006, Fall 2015 modeled GWE is used.
3. "Normalized Difference" is defined herein as the difference between the Fall 2015 GWE at the RMW-WL and the average Fall 2015 GWE within each section, divided by the total range of Fall 2015 GWE within the White Wolf Basin.
4. Negative normalized differences (i.e. where the GWE at RMW-WL is less than the average Fall 2015 GWE within the section) are represented in green as these sections have an RMW-WL that is considered "overprotective" of local water level conditions.
5. Approximately 62% of the sections with data available are showing less than 10% of differences, indicating that the RMW-WLs are representative of the local area. Differences larger than 10% are mostly due to lack of data or impacts of the faults.

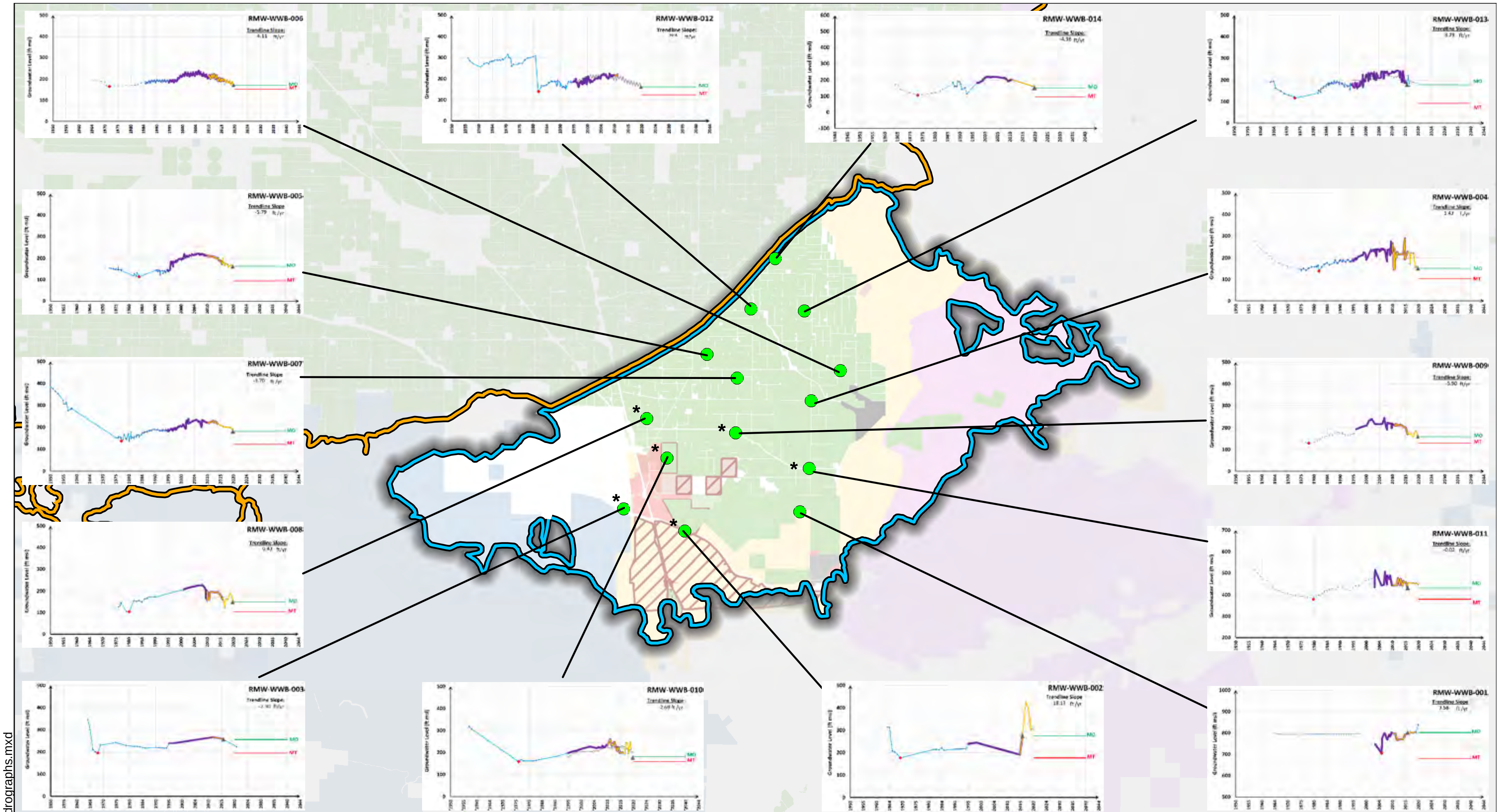
Path: X:\B50001.05\Maps\GSP\2022\01\FigSMC-1_Representativeness.mxd

Representativeness of RMW-WLs

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure SMC-1



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- RMW-WL
- Estimated Water Level
- Hydrograph
- Range Period
- Trend Period
- MO
- MT
- Historical Low
- Water Level for MO determination
- Linear Regression (Trend Period)

Land Use

- Agricultural Land
- Developed
- Grazing
- Mining
- Oil Field
- Conservation Easement Area
- California Protected Areas
- Proposed Grapevine Development

Abbreviations

DWR = California Department of Water Resources
ft msl = feet above mean sea level
MO = Measurable Objective
MT = Minimum Threshold
RMW-WL = Representative Monitoring Well for Water Level

Notes

1. All locations are approximate.
2. Asterisks denote RMW-WLs located within 1-mile of critical infrastructure and therefore whose MTs are no lower than the histroical low groundwater levels.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 21 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Land Use simplified from Figure PA-3 and Figure PA-8.

N 0 5 10 (Scale in Miles)

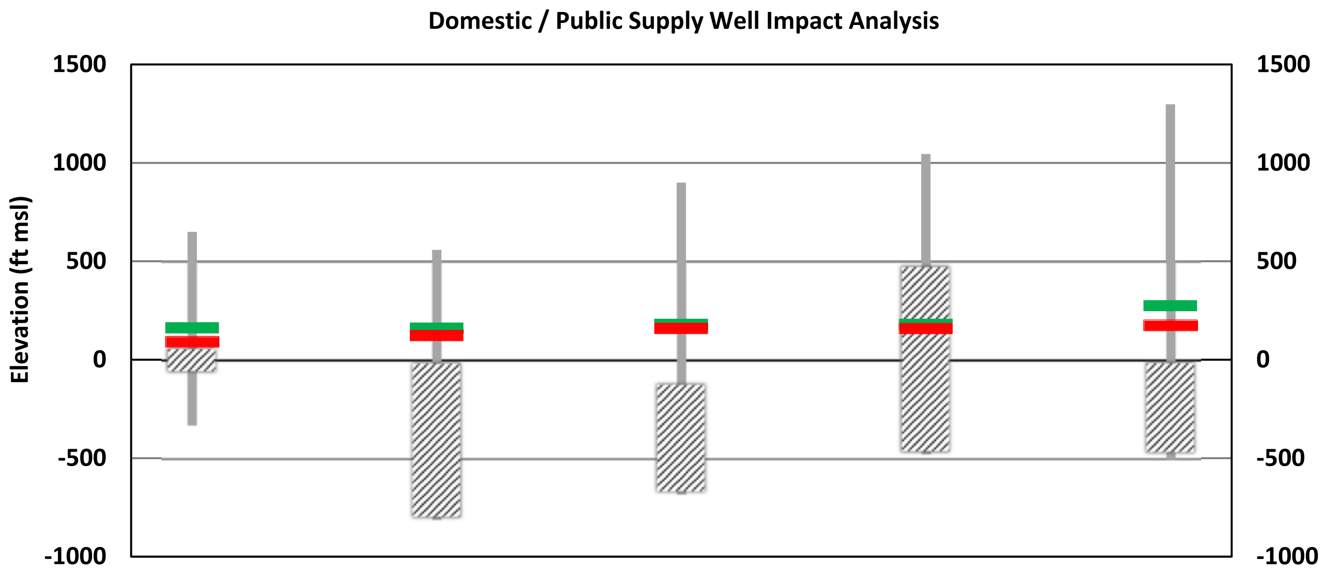
Water Level Sustainability Criteria - Hydrograph Analysis

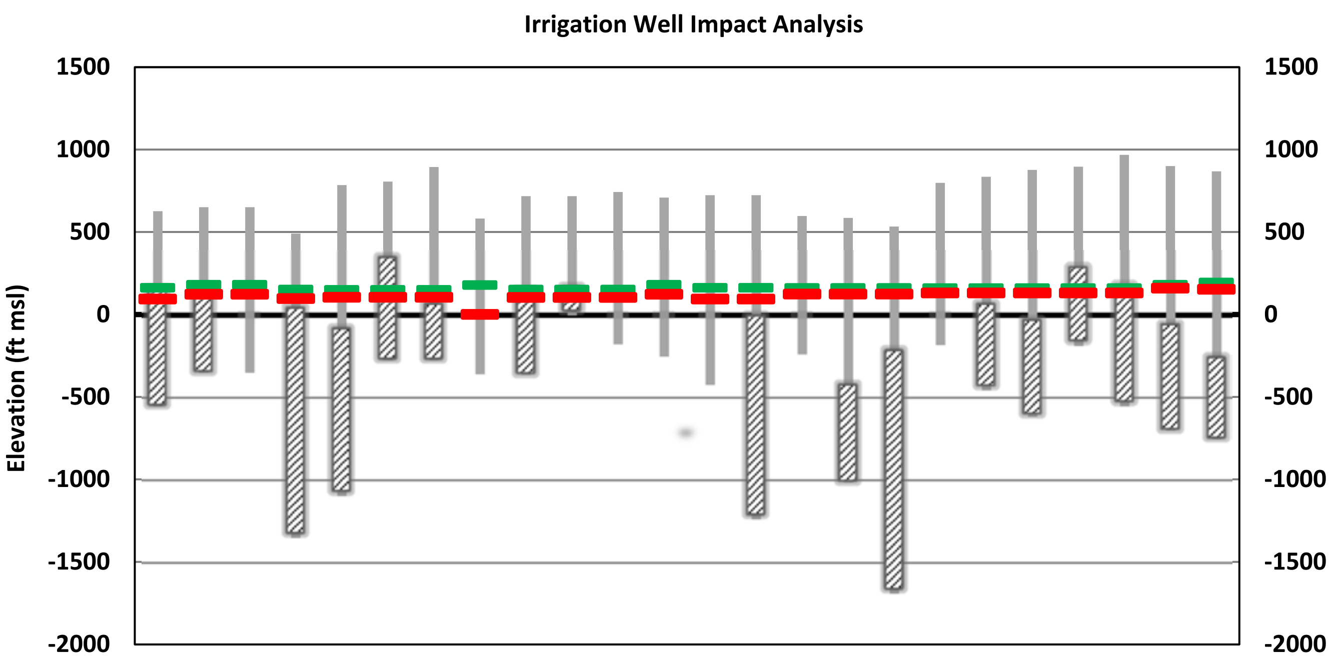
White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure SMC-2

Path: X:\B50001.05\Maps\GSP\2022\01\FigSMC-2_Hydrographs.mxd





Legend:

- Well Depth
- Screen Interval
- MO
- MT

Abbreviations:
ft msl = feet above mean sea level
MO = Measurable Objective
MT = Minimum Threshold

Notes:

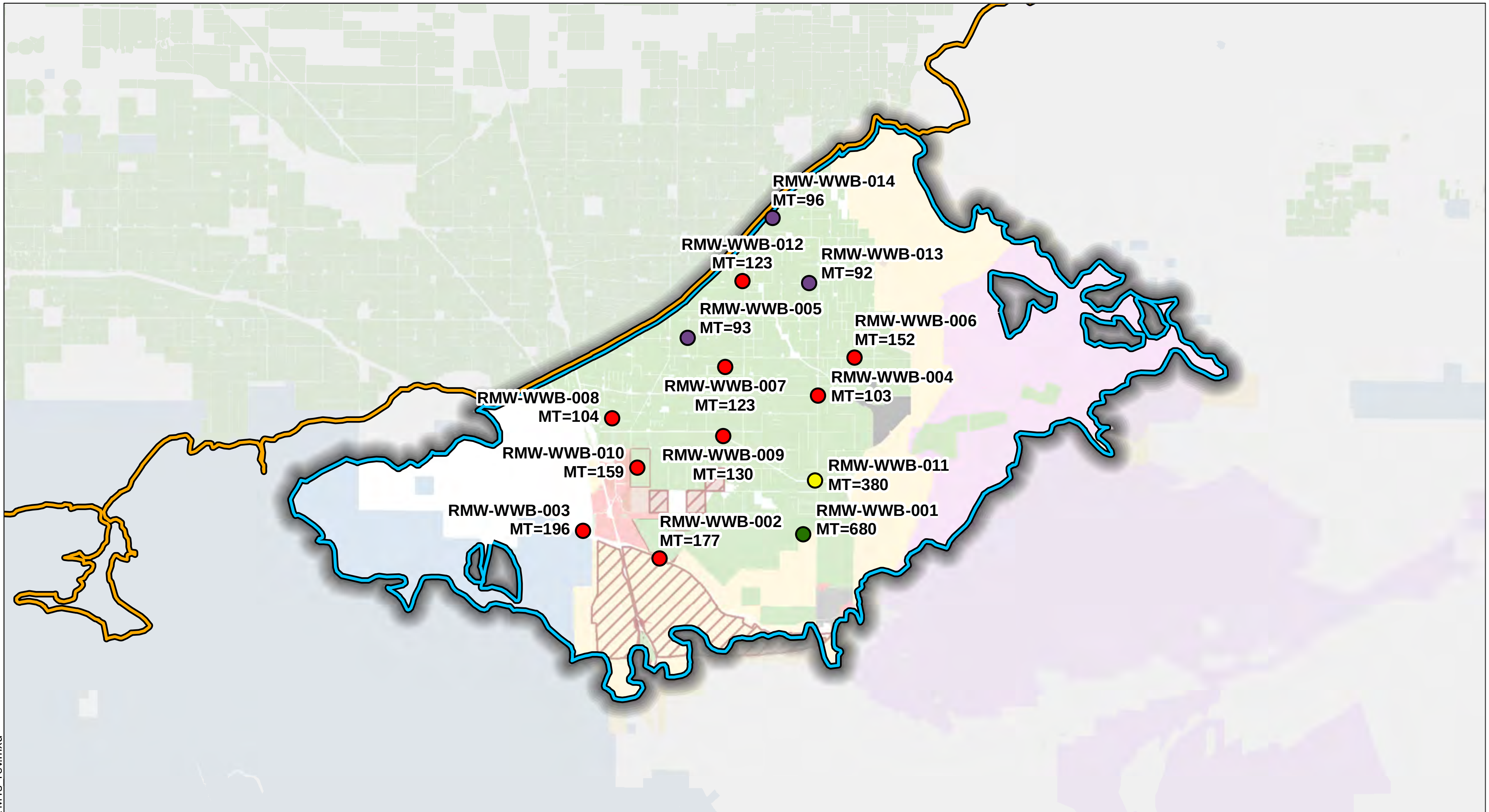
1. Wells considered in the analysis were those with available well depth and screened interval information and are less than 50 years old. In addition, four wells north of the Springs Fault were excluded because of the large elevation change in that area. Groundwater conditions of that area will be better informed by the newly installed shallow monitoring wells.

Well Impact Analysis

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

eki environment & water

Figure SMC-3



Legend

Groundwater Subbasin
- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)

MT (ft msl)
- < 100
- 100 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- > 600

Land Use
- Agricultural Land
- Developed
- Grazing
- Mining
- Oil Field
- Conservation Easement
- Proposed Grapevine Development

Abbreviations

DWR = California Department of Water Resources
ft msl = feet above mean sea level
MT = Minimum Threshold

Notes

1. All locations are approximate.
2. MT values are shown in ft msl.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 20 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Land Use simplified from Figure PA-3 and Figure PA-8.

N
0 4 8
(Scale in Miles)

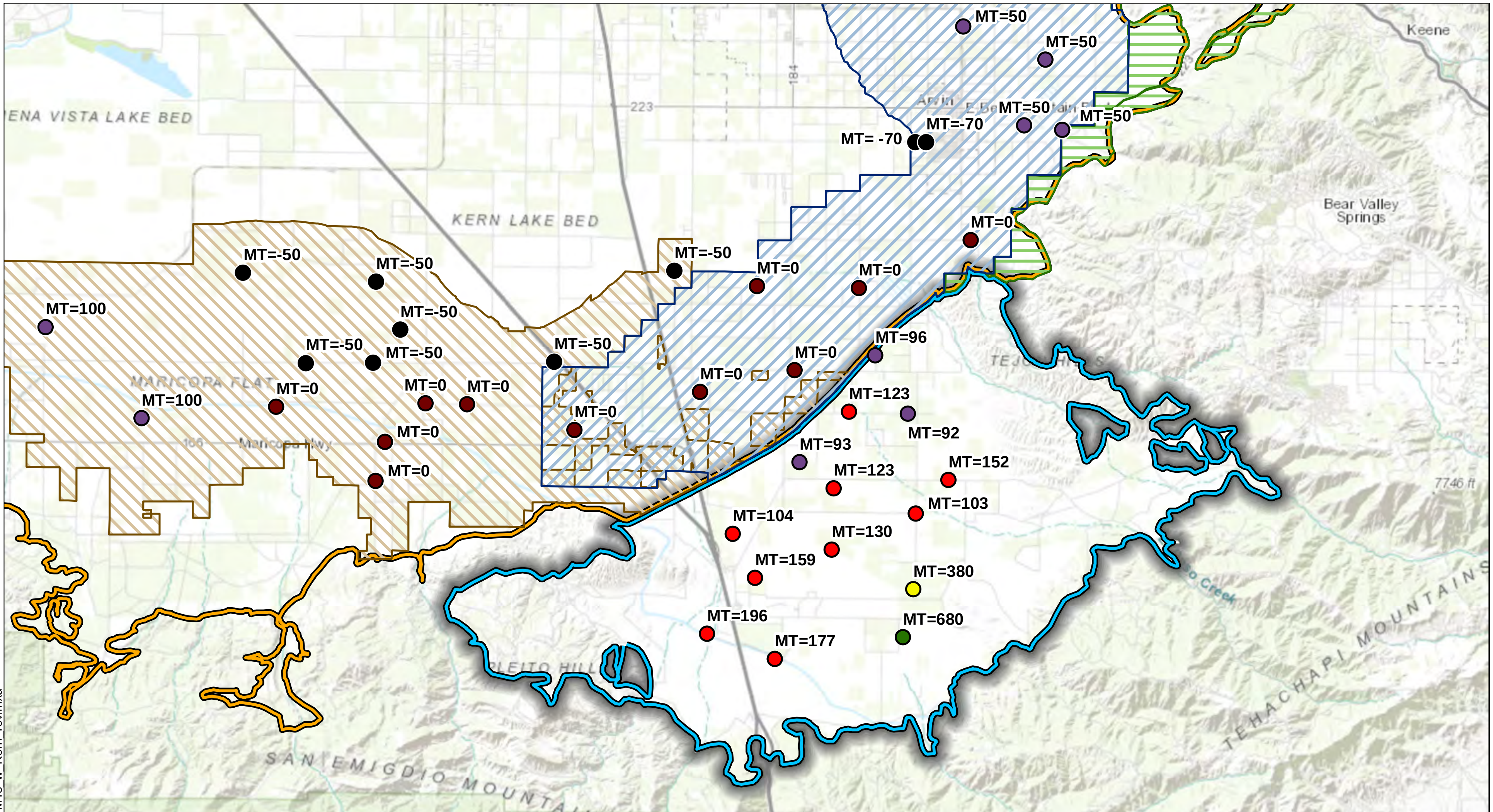
Proposed Water Level Minimum Thresholds

eki environment & water

White Wolf GSA
Kern County, California
December 2021
B50001.05

Figure SMC-4

Path: X:\B50001.05\Maps\GSP\2022\01\FigSMC-4_WL MTs_rev.mxd



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- Arvin-Edison Management Area Plan
- WRMWSD Management Area Plan
- TCWD Management Area Plan

MT (ft msl)

- -100 - -50
- -50 - 0
- 0 - 100
- 100 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- > 600

Abbreviations

DWR	= California Department of Water Resources
ft msl	= feet above mean sea level
MT	= Minimum Threshold
TCWD	= Tejon-Castac Water District
WRMWSD	= Wheeler Ridge-Maricopa Water Storage District

Notes

1. All locations are approximate.
2. MT values are shown in ft msl.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 18 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Kern County Subbasin's MTs are obtained from its Management Area Plans.

N

0 4.5 9

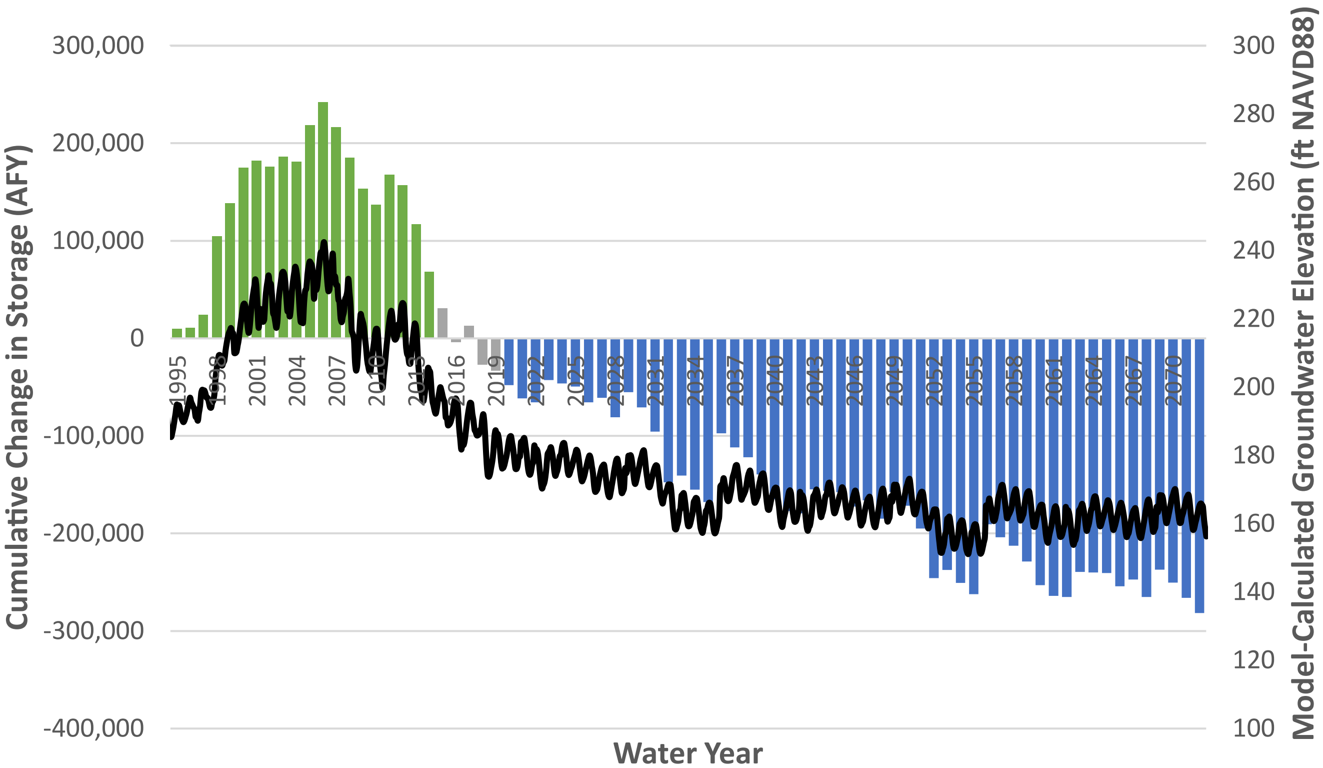
(Scale in Miles)

Comparison of Water Level MTs with Adjacent Kern County Subbasin

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure SMC-5



Legend

- Historical cumulative storage change (WY 1995-2014)
- Current cumulative storage change (WY 2015-2019)
- Projected cumulative storage change (WY 2020-2072)
- Model-calculated groundwater elevation

Abbreviations

AFY = acre-feet per year
ft = feet
NAVD88 = North American Vertical Datum of 1988

Notes

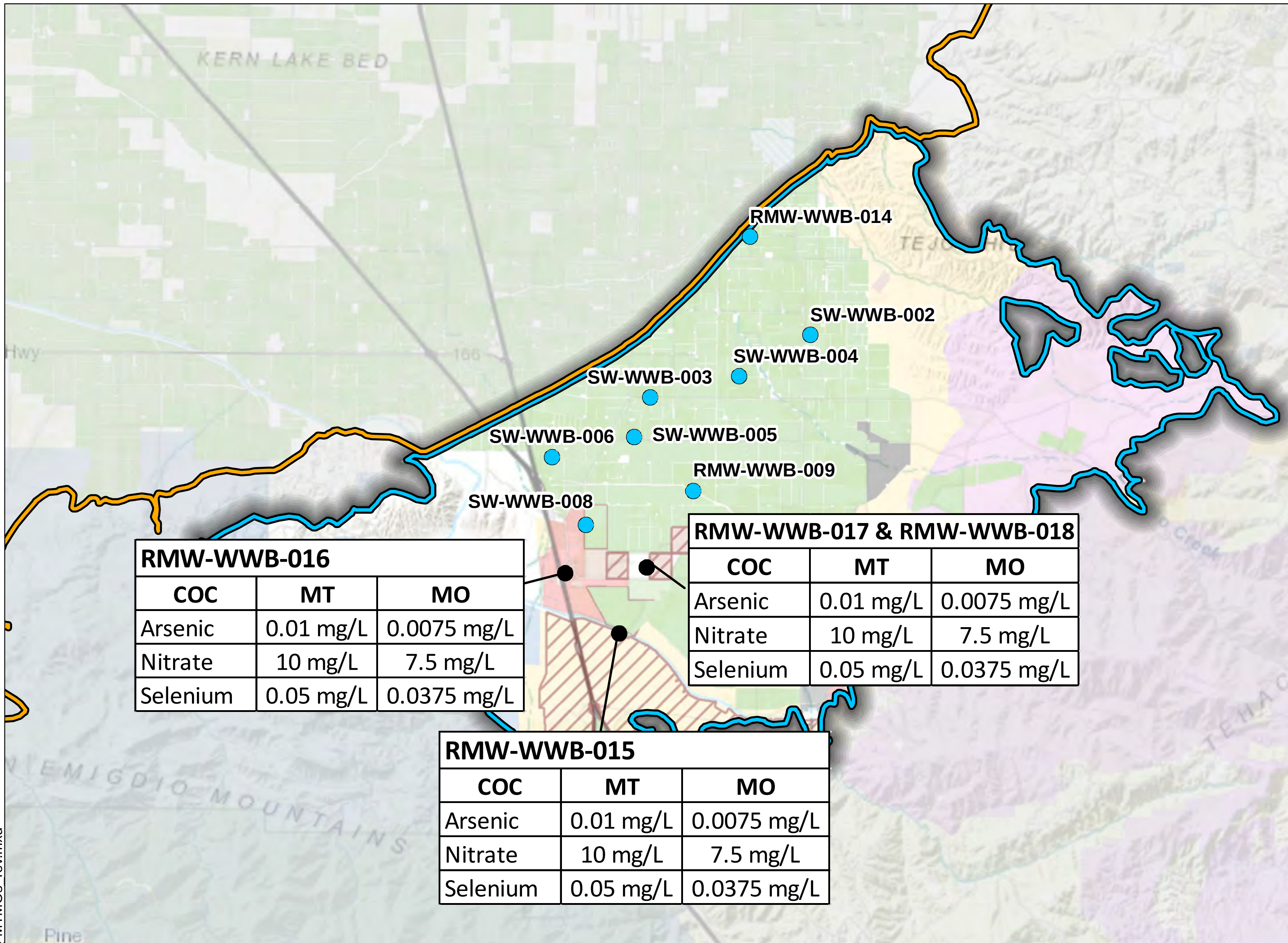
1. Model-calculated groundwater elevations from calibration (and representative monitoring) well RMW-WWB-004.

Model-calculated Groundwater Elevations and Cumulative Groundwater Storage Change

White Wolf GSA
Kern County, California
December 2021
EKI B50001.05

eki environment & water

Figure SMC-6



RMW-WWB-016

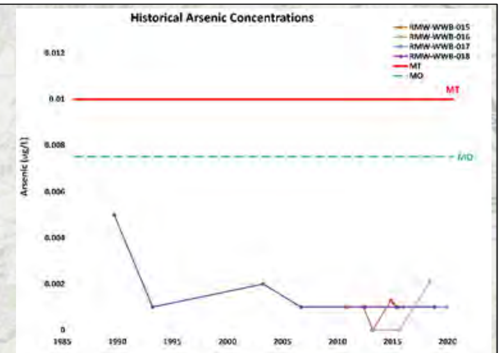
COC	MT	MO
Arsenic	0.01 mg/L	0.0075 mg/L
Nitrate	10 mg/L	7.5 mg/L
Selenium	0.05 mg/L	0.0375 mg/L

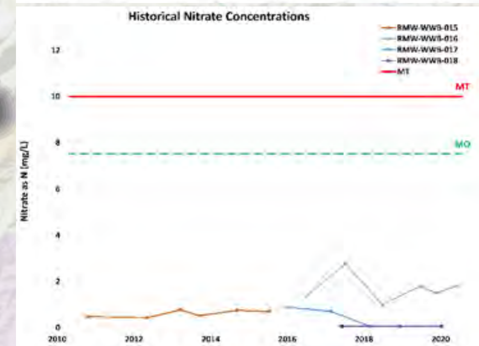
RMW-WWB-017 & RMW-WWB-018

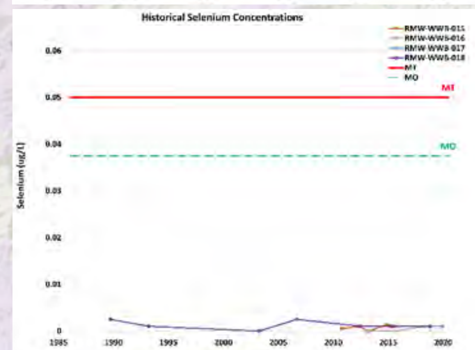
COC	MT	MO
Arsenic	0.01 mg/L	0.0075 mg/L
Nitrate	10 mg/L	7.5 mg/L
Selenium	0.05 mg/L	0.0375 mg/L

RMW-WWB-015

COC	MT	MO
Arsenic	0.01 mg/L	0.0075 mg/L
Nitrate	10 mg/L	7.5 mg/L
Selenium	0.05 mg/L	0.0375 mg/L







Legend

Groundwater Subbasin
- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- RMW-WQ
- MW-WQ

Land Use
- Agricultural Land
- Developed
- Grazing
- Mining
- Oil Field
- Conservation Easement Area
- California Protected Areas
- Proposed Grapevine Development

Abbreviations

COC = Constituent of Concern
DWR = California Department of Water Resources
mg/L = milligrams per liter
MO = Measurable Objective
MT = Minimum Threshold
MW-WQ = Monitoring Well for Water Quality
RMW-WQ = Representative Monitoring Well for Water Quality

Notes

1. All locations are approximate.
2. There are two RMW-WQs (RMW-WWB-017 and RMW-WWB-018) on Tut Brothers Farm #96.
3. Nitrate concentrations are shown in nitrogen (N).

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Land Use simplified from Figure PA-3 and Figure PA-8.

N

0 4 8

(Scale in Miles)

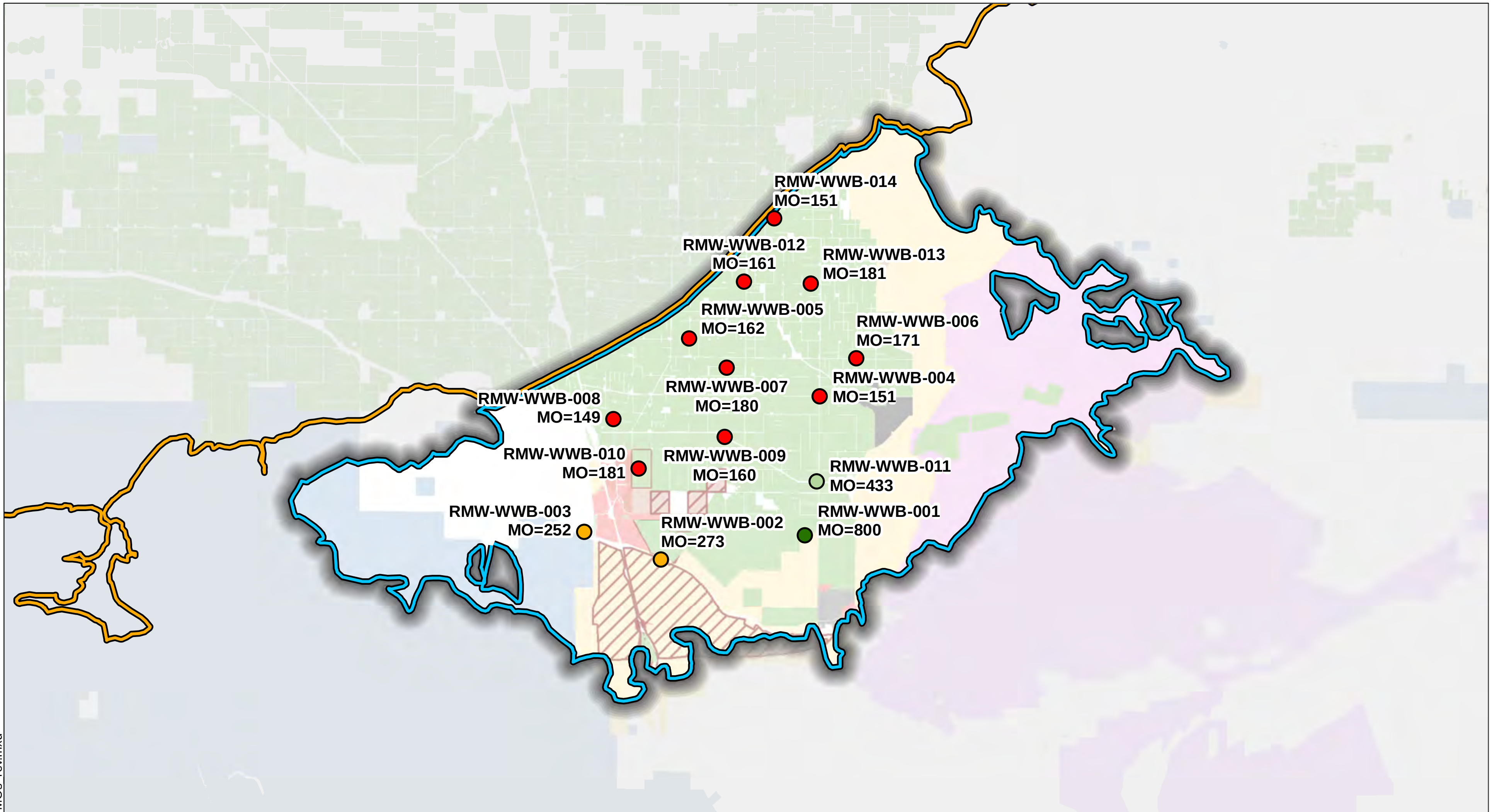
Proposed Water Quality MTs and MOs

eki environment & water

White Wolf GSA
Kern County, California
December 2021
B50001.05

Figure SMC-7

Path: X:\B50001.05\Maps\GSP\2022\01\FigSMC-7_WQ MTMOs_rev.mxd



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)

MO (ft msl)

- < 100
- 100 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- > 600

Land Use

- Agricultural Land
- Developed
- Grazing
- Mining
- Oil Field
- Conservation Easement
- California Protected
- Proposed Grapevine Development

Abbreviations

DWR = California Department of Water Resources
ft msl = feet above mean sea level
MO = Measurable Objective

Notes

1. All locations are approximate.
2. MO values are shown in ft msl.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 18 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Land Use simplified from Figure PA-3 and Figure PA-8.

N

0 4 8

(Scale in Miles)

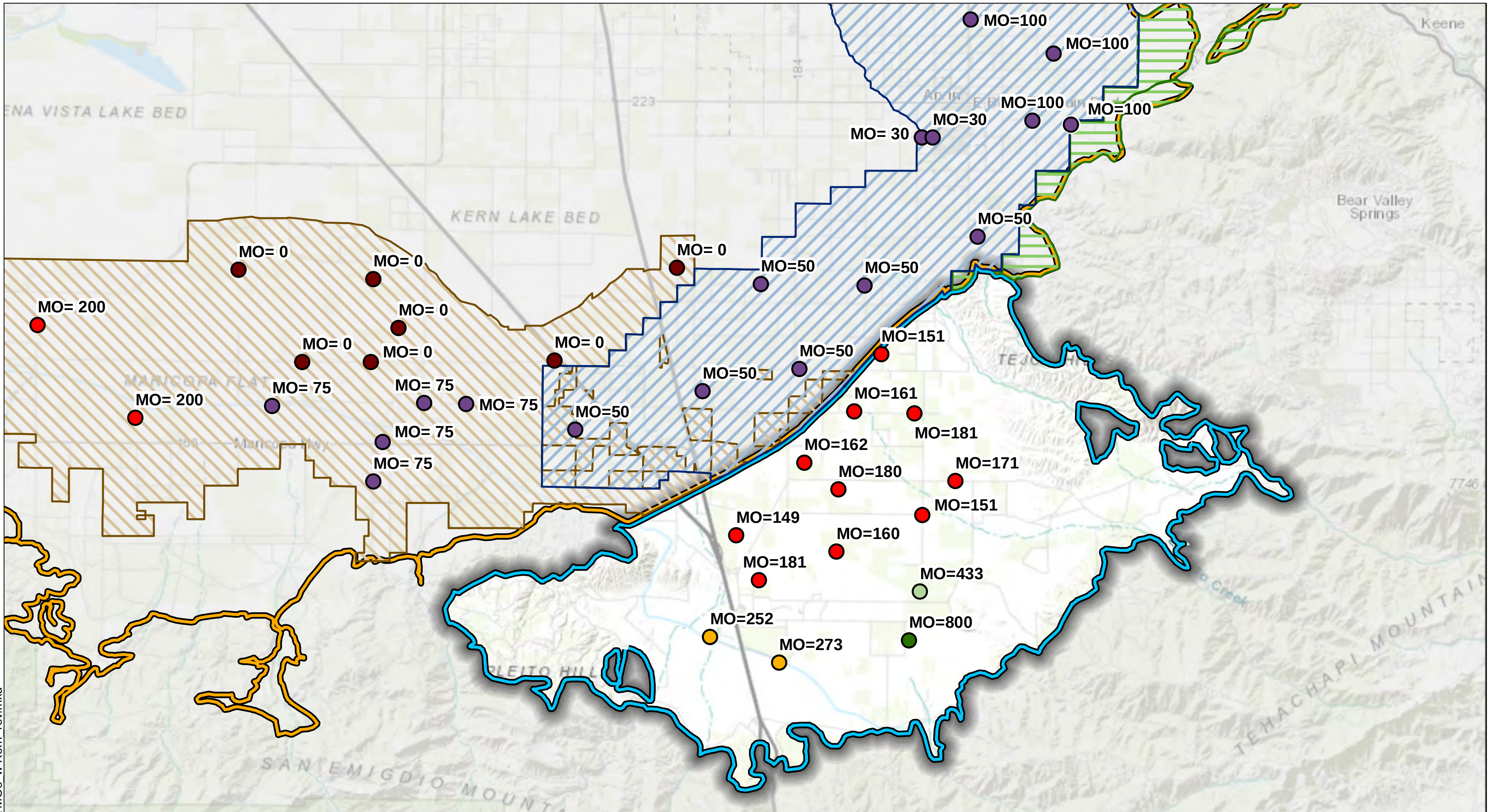
Proposed Water Level Measurable Objectives

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure SMC-8

Path: X:\B50001.05\Maps\GSP\2022\01\FigSMC-8_WL MOs_rev.mxd



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- Arvin-Edison Management Area Plan
- WRMWSD Management Area Plan
- TCWD Management Area Plan

MO (ft msl)

- -50 - 0
- 0 - 100
- 100 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 600
- > 600

Abbreviations

DWR = California Department of Water Resources
ft msl = feet above mean sea level
MO = Measurable Objective
TCWD = Tejon-Castac Water District
WRMWSD = Wheeler Ridge-Maricopa Water Storage District

Notes

1. All locations are approximate.
2. MO values are shown in ft msl.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 18 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Kern County Subbasin's MOs are obtained from its Management Area Plans.

N 0 4.5 9 (Scale in Miles)

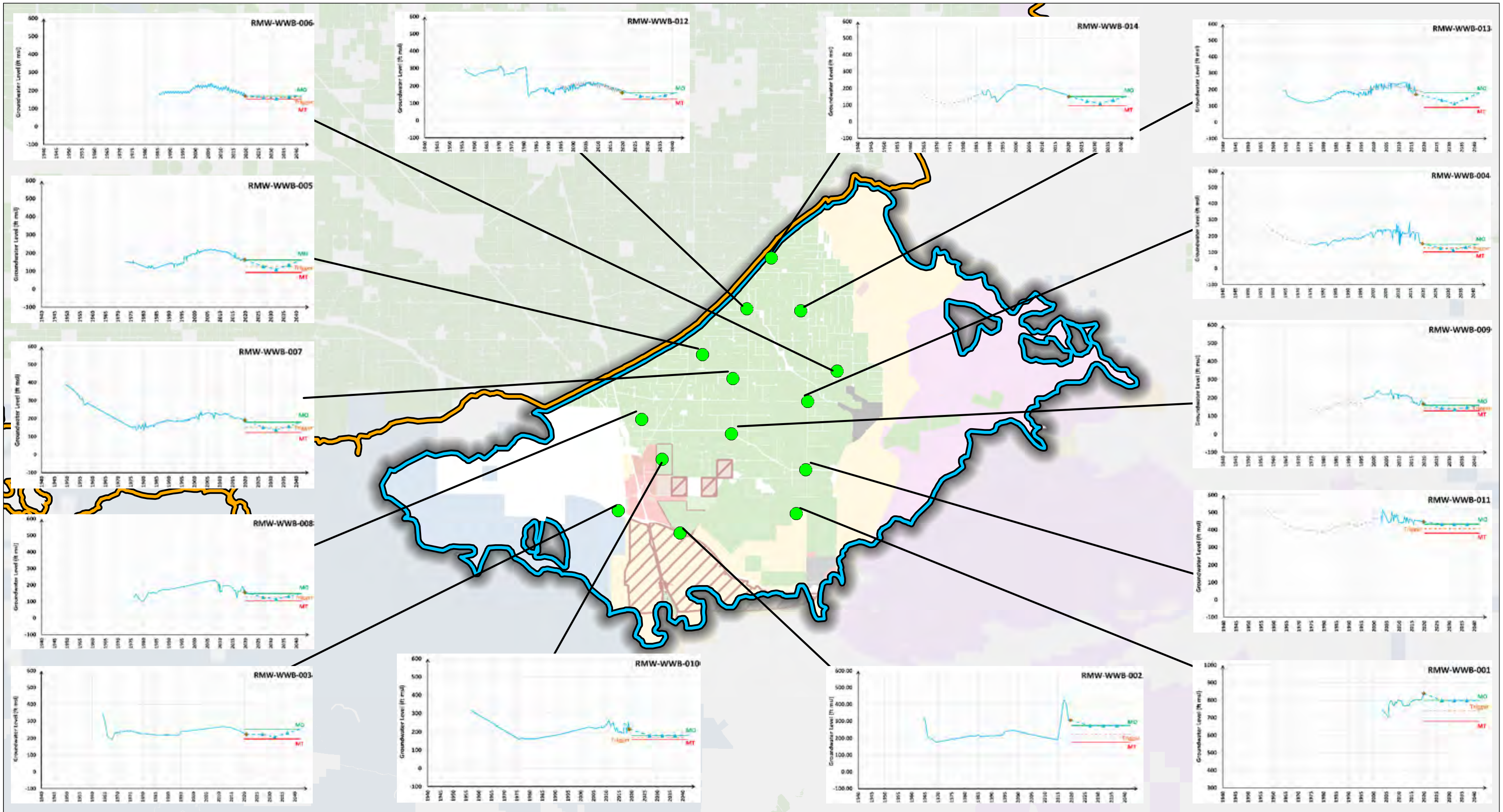
Comparison of Water Level MOs with Adjacent Kern County Subbasin

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure SMC-9

Path: X:\B50001.05\Maps\GSP\2022\01\FigSMC-9_WL MOs_w Kern_rev.mxd



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- RMW-WL
- Hydrograph
- "Current" Water Level
- Estimated Water Level
- IM
- Glide Path
- MT
- MO

Land Use

- Agricultural Land
- Developed
- Grazing
- Mining
- Oil Field
- Conservation Easement Area
- California Protected Areas
- Proposed Grapevine Development

Abbreviations

DWR	= California Department of Water Resources
ft msl	= feet above mean sea level
IM	= Interim Milestone
MO	= Measurable Objective
MT	= Minimum Threshold
RMW-WL	= Representative Monitoring Well for Water Level

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 18 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Land Use simplfied from Figure PA-3 and Figure PA-8.

N

0 5 10

(Scale in Miles)

Water Level Sustainability Criteria - Interim Milestones

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure SMC-10

Path: X:\B50001.05\Maps\GSP\2022\01\FigSMC-10_WL IMs_rev.mxd

MONITORING NETWORK

17. MONITORING NETWORK

§ 354.32. Introduction to Monitoring Networks

This Subarticle describes the monitoring network that shall be developed for each basin, including monitoring objectives, monitoring protocols, and data reporting requirements. The monitoring network shall promote the collection of data of sufficient quality, frequency, and distribution to characterize groundwater and related surface water conditions in the basin and evaluate changing conditions that occur through implementation of the Plan.

This section describes the Monitoring Network designed for the White Wolf Subbasin (Basin), subsequently referred to as the "Sustainable Groundwater Management Act (SGMA) Monitoring Network." Pursuant to the California Code of Regulations Title 23 (23 CCR) Division 2 Chapter 1.5 Subchapter 2, the objective of the design and management of the Basin's SGMA Monitoring Network is to collect sufficient data for the assessment of the Sustainability Indicators relevant to the Basin (see ***Section 13 Undesirable Results***), and potential impacts to the beneficial uses and users of groundwater.

Per 23 CCR § 354.32(e), the SGMA Monitoring Network incorporates elements, to the extent possible, from the existing monitoring programs occurring within the Basin (see ***Section 5.2.1 Existing Monitoring Programs)*** and includes additional components to comply with the 23 CCR. All monitoring will be performed in accordance with the protocols developed for the Basin, as described in ***Section 17.2 Monitoring Protocols for Data Collection and Monitoring***.

17.1. Description of Monitoring Network

§ 354.34. Monitoring Network

(a) Each Agency shall develop a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions, and yield representative information about groundwater conditions as necessary to evaluate Plan implementation.

(b) Each Plan shall include a description of the monitoring network objectives for the basin, including an explanation of how the network will be developed and implemented to monitor groundwater and related surface conditions, and the interconnection of surface water and groundwater, with sufficient temporal frequency and spatial density to evaluate the affects and effectiveness of Plan implementation. The monitoring network objectives shall be implemented to accomplish the following:

(1) Demonstrate progress toward achieving measurable objectives described in the Plan.

(2) Monitor impacts to the beneficial uses or users of groundwater.

(3) Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds.

(4) Quantify annual changes in water budget components.

…

(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.

(e) A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.

(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:

(1) Amount of current and projected groundwater use.

(2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.

(3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.

(4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.

§ 354.34. Monitoring Network

(a) Each Plan shall describe the following information about the monitoring network:

(1) Scientific rationale for the monitoring site selection process.

(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.

(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36.

(b) The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.

(c) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.

(d) An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish a monitoring network related to those sustainability indicators.

As shown on **Figure MN-1** through **Figure MN-4,** the Basin's SGMA Monitoring Network includes multiple monitoring sites. The SGMA Monitoring Network is composed of: (1) Representative Monitoring Sites (RMSs) where Sustainability Management Criteria (SMCs) have been established and (2) additional monitoring sites where data will be compiled or collected on an ongoing basis to support understanding of the Basin where SMCs are not established. The SGMA Monitoring Network includes:

- Chronic Lowering of Groundwater Levels: Fourteen (14) water level Representative Monitoring Wells (RMW-WL) and one supplemental monitoring well (MW-WL) (**Figure MN-1**);
- Reduction of Groundwater Storage: using Chronic Lowering of Groundwater Levels monitoring network as a proxy;
- Degraded Water Quality: Four (4) water quality Representative Monitoring Wells (RMW-WQ) and eight supplemental water quality monitoring wells (MW-WQ) **(Figure MN-2**);
- Land Subsidence: using five (5) RMW-WLs from the Chronic Lowering of Groundwater Levels monitoring network as a proxy, two supplemental land surface elevation checkpoint monitoring sites along the 850 Canal, 34 supplemental land surface elevation monitoring sites along the California Aqueduct, and two supplemental Global Positioning System (GPS) subsidence monitoring stations (**Figure MN-3**); and

- Depletions of Interconnected Surface Water: using three Representative Monitoring Wells for Depletions of Interconnected Surface Water (RMW-ISW) as a proxy, four supplemental stream gauges, two supplemental artesian spring observation points, and two supplemental domestic wells (MW-ISWs) (**Figure MN-4**).

The objective of this SGMA Monitoring Network is to collect data with sufficient temporal frequency and spatial density necessary to evaluate Groundwater Sustainability Plan (GSP) implementation in the Basin as it relates to:

- Monitoring short-term, seasonal, and long-term trends in groundwater and surface water conditions;
- Demonstrating progress toward achieving the Measurable Objectives (MOs) described in the GSP;
- Monitoring impacts to the beneficial uses and users of groundwater;
- Monitoring changes in groundwater conditions relative to the MOs and Minimum Thresholds (MTs); and
- Quantifying annual changes in water budget components.

The SGMA Monitoring Network consists of a series of monitoring sites that meet the following criteria: (1) Some sites are included in the monitoring programs already implemented by the White Wolf Groundwater Sustainability Agency (GSA) and/or other existing monitoring programs that are active within the Basin; (2) The sites have been demonstrated to be representative of groundwater or other relevant conditions within the Basin; (3) The sites are spatially distributed and located in proximity to beneficial uses and users of groundwater (e.g., public supply wells, production wells, and groundwater dependent ecosystems [GDEs]); and (4) The RMSs are where SMCs (e.g., MOs, MTs and Interim Milestones [IMs]) will be defined for at least one of the relevant Sustainability Indicators for the Basin[92]:

- Chronic Lowering of Groundwater Levels;
- Reduction of Groundwater Storage;
- Degraded Water Quality;
- Land Subsidence; and
- Depletions of Interconnected Surface Water.

Per 23 CCR § 354.32(g), other factors considered in the development of the SGMA Monitoring Network and the selection of each monitoring site and RMS include:

- Availability of existing technical information (e.g., well location, construction information, condition, status, etc.);
- Quality and reliability of historical data at the site;

[92] As discussed below in ***Section 17.1.3 Monitoring Network for Seawater Intrusion***, the Basin is at little to no risk for seawater Intrusion; therefore, the Sustainability Indicator is not applicable.

- "Representativeness" to local groundwater conditions and nearby well populations inferred from the SGMA Monitoring Network (per 23 CCR § 354.36); and
- Projected availability of long-term access to the site.

Pursuant to 23 CCR § 354.32(f), the spatial distribution, spatial density, and temporal frequency of measurements collected from each site is determined for each applicable Sustainability Indicator based on the following considerations:

- Amount of current and projected groundwater use;
- Aquifer characteristics, including any vertical and/or lateral barriers to groundwater flow;
- Potential impacts to beneficial uses and users of groundwater, land uses and property interests affected by groundwater production, and the adjacent Kern County Subbasin; and
- Availability of historical data to evaluate long-term trends in groundwater conditions associated with the above factors.

Table MN-1 summarizes the site type, site count, measured constituent(s), measurement frequency, and spatial density of the SGMA Monitoring Network for each of the relevant Sustainability Indicators mentioned above. As discussed in ***Section 17.3 Representative Monitoring***, the SMCs for Chronic Lowering of Groundwater Levels will be used as a proxy for several of the Sustainability Indicators, including Reduction of Groundwater Storage and Land Subsidence. As such, the SGMA Monitoring Network for water levels will also be used to address the Groundwater Storage and Land Subsidence Sustainability Indicators. Further details about the SGMA Monitoring Network for each Sustainability Indicator can be found in ***Sections 17.1.1*** through ***17.1.6***.

Pursuant to 23 CCR § 354.32(i), in all cases the SGMA Monitoring Network will adhere to the monitoring protocols specified for the Basin as described in ***Section 17.2 Monitoring Protocols for Data Collection and Monitoring***.

Table MN-1. Summary of SGMA Monitoring Network

Sustainability Indicator	Monitoring Network Type	Site Type	Site Count	Measurement	Measurement Frequency	Spatial Density (# sites/100 mi²)
Chronic Lowering of Groundwater Levels	SGMA Representative	RMW-WL	14	Water Level	Semiannually	10
	Supplemental	*MW-WL*	*1*	*Water Level*	*Semiannually*	
Reduction of Groundwater Storage	SGMA Representative	RMW-WL *as proxy*	14	Water Level	Semiannually	10
Degraded Water Quality	SGMA Representative	RMW-WQ	4	Title 22 constituents	Annually	6.5
	Supplemental	*MW-WQ*	*8*	*See constituent list in **Section 17.1.4***	*Annually*	
Land Subsidence	SGMA Representative	RMW-WL *as proxy*	5	Water Level	Semiannually	NA[b]
	Supplemental	*Land Surface Checkpoint*	*2*	*Ground Surface Elevation*	*Annually*	
	Supplemental	*Stationary GPS*	*2*	*Ground Surface Elevation*	*Daily*	
	Supplemental	*Land Surface Checkpoint*	*34*	*Ground Surface Elevation*	*Annually*	
Depletions of Interconnected Surface Water	SGMA Representative	RMW-ISW	3	Water Level	Semiannually or Monthly	NA[c]
	Supplemental	MW-ISW	2	Water Level	*Semiannually*	
	Supplemental	*Gauge*	*4*	*Stage and/or Stream Flow*	*Per Event*	
	Supplemental	*Artesian Spring Observation Point*	*2*	*Water Level and/or Flow Observation*	*Semiannually*	

Abbreviations:
GPS = Global Positioning System
mi^2 = square miles
MW-WL = Monitoring Well for Chronic Lowering of Groundwater Levels
MW-WQ = Monitoring Well for Degraded Water Quality
NA = not applicable
RMW-ISW = Representative Monitoring Well for Depletions of Interconnected Surface Water
RMW-WL = Representative Monitoring Well for Chronic Lowering of Groundwater Levels
RMW-WQ = Representative Monitoring Well for Degraded Water Quality

Notes:
(a) Shaded cells represent supplemental monitoring sites.
(b) The number of subsidence monitoring stations and wells is determined by proximity to critical infrastructure (i.e., California Aqueduct and 850 Canal).
(c) The number of gauges and wells is determined by local hydrogeologic conditions (i.e., where there is known or suspected surface water / groundwater connection or GDEs).

17.1.1. Monitoring Network for Chronic Lowering of Groundwater Levels

> *§ 354.34. Monitoring Network*
>
> *(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*
>
> *(1) Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:*
>
> *(A) A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.*
>
> *(B) Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.*

The SGMA Monitoring Network for Chronic Lowering of Groundwater Levels consists of 14 RMW-WLs distributed across the Basin. Specific details regarding these wells are listed in **Table MN-2**, and the RMW-WL locations are shown on **Figure MN-1**.

Per 23 CCR § 354.32(e), the selection of these RMW-WLs has been informed by the existing local monitoring programs, including the former California Statewide Groundwater Elevation Monitoring (CASGEM) monitoring program, and leverages historical data wherever possible to help assess and quantify Basin response to GSP implementation relative to historical and projected future groundwater conditions. The RMW-WLs were selected based on the following considerations:

- **Current and projected groundwater use** – The RMW-WLs are distributed across the central portion of the Basin where agricultural lands are the predominant land use and agricultural pumping is the primary use of groundwater in the Basin.
- **Aquifer characteristics** – All RMW-WLs are screened within the Principal Aquifer defined for the Basin[93].
- **Potential impacts to beneficial uses and users of groundwater, land uses or property interests, and adjacent basins** – As mentioned above, most RMW-WLs are located in the central portion of the Basin where the majority of groundwater is used, primarily for agricultural uses. Two RMW-WLs are located adjacent to the California Aqueduct and three RMW-WLs are located adjacent to the 850 Canal, which are considered critical infrastructure within the Basin. Three RMW-WLs are proximate to the Basin boundary and will be used to monitor cross-boundary flows between the Basin and Kern County Subbasin. As discussed below in ***Section 17.1.6 Monitoring Network for Depletions of Interconnected Surface Water***, water levels in the RMW-ISW will be monitored to determine hydraulic gradients between the uplands surface water features, GDEs, and the underlying Principal Aquifer.
- **Availability, quality, and reliability of historical data** – All of the RMW-WLs have water records

[93] Well 10N19W01K001S is screened exclusively in the Chanac Formation above the Springs Fault.

that are seven or more years in length. About 75% of the RMW-WLs have associated water level records spanning back at least 20 years and have at least one water level measurement recorded in the last ten years (i.e., since January 2010). Five of the RMW-WLs are included in the Basin's CASGEM network. In preparing and populating the Basin Data Management System (DMS), Quality Assurance/Quality Control (QA/QC) checks were implemented to help ensure entry and maintenance of valid and accurate data.

- **Availability of site-specific technical information** – All of the RMW-WLs have known geographic coordinates, ground surface elevations, and reference point elevations. Moreover, 12 of the 14 sites contain known well depths and well screen intervals. For the two RMW-WLs where well construction information is incomplete or currently unavailable, the GSA developed plans to fill these data gaps in accordance with 23 CCR § 354.38 and as part of GSP implementation. All wells have been confirmed to have access ports for water level measurement collection.
- **"Representativeness" to local groundwater conditions** – The RMW-WL "representativeness" to local groundwater conditions is determined by the following factors: Well construction (i.e., the well depth and perforated interval) must be sufficient to represent the Principal Aquifer); well location must be representative of land and water use practices in the surrounding area; and the measured water level response to short- and longer-term conditions (i.e., seasonal and multi-year trends) is consistent with measurements in other nearby wells. For example, the Basin's CASGEM network include general "clusters" of wells. As such, one CASGEM well per "cluster" that had the most representative water level data compared to nearby wells was chosen as the RMW-WL. Other CASGEM wells not selected as RMW-WLs are owned by Wheeler Ridge-Maricopa Water Storage District (WRMWSD), and water level data collection at these wells will be occur on a voluntary basis.
- **Long-term access** – For each RMW-WL, the California Department of Water Resources (DWR) "Best Management Practices #2 for Monitoring Network and Identification of Data Gaps" (BMP #2; DWR, 2016d) recommends that GSAs secure long-term agreements with associated landowners/well owners allowing local GSA representatives year-round, long-term access to the site to conduct monitoring for SGMA compliance purposes. All wells have been confirmed to have landowner access for water level measurement collection.

In addition, the planned monitoring includes one additional well (MW-WL) selected from WRMWSD's existing water level monitoring program. The White Wolf GSA has secured long-term agreements with associated land/well owners allowing long-term access to the site to conduct monitoring**.** This site will be used to collect supplemental data to allow for continued evaluation of groundwater quality trends within the Basin throughout the GSP implementation.

17.1.1.1. Monitoring Well Density

According to DWR's BMP#2, monitoring well density should be between 0.2 and 10 wells per 100 square miles. In the Basin, where there is more than 10,000 acre-feet per year (AFY) of pumping per 100 square miles, the recommended monitoring well density is at least four wells per 100 square miles (DWR, 2016d).

Accordingly, for the 168 square mile Basin, the recommended number of wells is at least seven, and therefore the 15 wells that the White Wolf GSA intends to monitor (i.e., as a combination of 14 RMW-WLs and 1 MW-WL) complies with this recommendation.

17.1.1.2. Monitoring Schedule

Water levels will be measured semiannually (Spring and Fall) to document seasonal fluctuations in groundwater levels. Specifically, Spring levels will be measured between January and March to represent a seasonal high prior to summer irrigation demands. Fall levels will be measured between September and November to represent a seasonal low after the summer irrigation demands. All RMW-WLs will be monitored in accordance with the monitoring protocols described in ***Section 17.2 Monitoring Protocols for Data Collection and Monitoring***. All data will be subject to a QA/QC process and incorporated into the Basin DMS. The data collected at the RMW-WLs will be reported to DWR per the requirements specified under ***Section 17.5 Reporting Monitoring Data to the Department***.

17.1.2. Monitoring Network for Reduction of Groundwater Storage

§ 354.34. Monitoring Network

(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:

(2) Reduction of Groundwater Storage. Provide an estimate of the change in annual groundwater in storage.

The criteria used to define SMCs for the Reduction of Groundwater Storage are directly tied to those developed for the Chronic Lowering of Groundwater Levels. As such, the SGMA Monitoring Network for Reduction of Groundwater Storage is comprised of the same RMSs described in ***Section 17.1.1 Monitoring Network for Chronic Lowering of Groundwater Levels***. The information collected from the Chronic Lowering of Groundwater Levels SGMA Monitoring Network will be sufficient to estimate the change in annual groundwater in storage.

Table MN-2. SGMA Monitoring Network for Chronic Lowering of Groundwater Levels

Monitoring Site ID	Well/Site ID	Site Type	SGMA Monitoring Type	Owner on Record	CASGEM Details			Monitoring Site Location			Reference Point	
					Station ID	Well ID	Well Type (CASGEM / Voluntary)	X Coordinate (State Plane Zone 5, ft)	Y Coordinate (State Plane Zone 5, ft)	Accessibility	Ground Surface Elevation (ft, NAVD88)	Reference Point Elevation (ft, NAVD88)
RMW-WWB-001	10N19W01K001S	Well	SGMA Representative	Tejon Ranch Corp	349764N1188520W001	51673	CASGEM	6306215	2178772	Confirmed	950.40	951.74
RMW-WWB-002	10N19W08A001S	Well	SGMA Representative	Tejon Ranch Corp	--	--	--	6285700	2175294	Confirmed	1250.20	1251.93
RMW-WWB-003	10N20W01H001S	Well	SGMA Representative	Wheeler Ridge Farms	349836N1189228W001	32402	Voluntary	6274804	2179297	Confirmed	1239.98	1240.70
SW-WWB-001	11N18W09M001S	Well	supplemental	Vista Orchards	--	--	--	6318965	2205404	Confirmed	778.95	779.93
RMW-WWB-004	11N18W19D001S	Well	SGMA Representative	WRMWSD	350308N1188465W001	10720	CASGEM	6308268	2198562	Confirmed	717.89	720.10
RMW-WWB-005	11N19W09F001S	Well	SGMA Representative	Diamond Farming	350527N1189099W001	11412	Voluntary	6289680	2206779	Confirmed	647.32	648.56
RMW-WWB-006	11N18W07R002S	Well	SGMA Representative	Delano Farms	--	--	--	6313485	2203942	Confirmed	714.00	--
RMW-WWB-007	11N19W15G001S(3)	Well	SGMA Representative	Sapphire Property Holdings	350414N1188913W001	38978	Voluntary	6295074	2202620	Confirmed	702.72	706.37
RMW-WWB-008	11N19W19P001S	Well	SGMA Representative	WRMWSD	350211N1189452W001	30725	CASGEM	6278925	2195333	Confirmed	817.24	818.11
RMW-WWB-009	11N19W27C001S*	Well	SGMA Representative	WRMWSD	350144N1188901W001	51678	CASGEM	6294770	2192777	Confirmed	855.86	857.27
RMW-WWB-010	11N19W29N001S	Well	SGMA Representative	Tejon Ranch Corp	350033N1189366W001	30732	Voluntary	6282526	2188299	Confirmed	961.03	961.19
RMW-WWB-011	11N19W36A001S	Well	SGMA Representative	WRMWSD	349976N1188463W001	51681	CASGEM	6307897	2186479	Confirmed	849.48	849.52
RMW-WWB-012	12N19W34R001S	Well	SGMA Representative	Anthony Vineyards Inc	350750N1188828W001	33852	Voluntary	6297533	2214874	Confirmed	558.73	560.81
RMW-WWB-013	12N19W36Q001S	Well	SGMA Representative	Crystal Organic Farms	350750N1188518W001	33853	Voluntary	6307007	2214578	Confirmed	603.62	604.50
RMW-WWB-014	32S29E33F001M*	Well	SGMA Representative	Sapphire Property Holdings	351036N1188640W001	23152	Voluntary	6301791	2223886	Confirmed	519.98	520.20

Notes

(1) Only one Principal Aquifer is defined for the White Wolf Subbasin.
(2) Asterisk (*) denotes wells that are also Monitoring Wells for Degraded Water Quality.
(3) Well 11N19W15G001S is a problematic well for water level measurements.

Abbreviations

bgs = below ground surface
CASGEM = California Statewide Groundwater Elevation Monitoring
DWR = California Department of Water Resources
ft = feet
in = inches
NA = Not Available
NAVD88 = North American Vertical Datum of 1988
SGMA = Sustainable Groundwater Management Act

Table MN-2. SGMA Monitoring Network for Chronic Lowering of Groundwater Levels

				Well Construction Details						Water Level Data Record			
Monitoring Site ID	Well Use	Status	Well Completion Type	Total Completed Depth (ft bgs)	Borehole Depth (ft bgs)	Top of Perforations Depth (ft bgs)	Bottom of Perforations Depth (ft bgs)	Casing Diameter (in)	DWR Well Completion Report No.	First Measurement Date	Last Measurement Date	Count	Principal Aquifer(s) Monitored (1)
RMW-WWB-001	Monitoring	Active	Nested	460	1,370	420	440	6.125	785632	3/6/2003	2/12/2018	27	Principal Aquifer
RMW-WWB-002	Monitoring	Active	Single	1,765	1,779	1,100	1,765	16, 12	88711	2/25/1964	2/12/2018	27	Principal Aquifer
RMW-WWB-003	Monitoring	Active	Single	1,765	1,770	1,100	1,765	16, 12	88710	2/25/1964	2/8/2016	30	Principal Aquifer
SW-WWB-001	Irrigation	Active	Single	1,620	--	1,117	1,620	--	EO 187415	10/6/2016	2/12/2018	4	Unpumped
RMW-WWB-004	Irrigation	Active	Single	984	984	432	978	14	74109	3/10/1975	1/15/2018	115	Principal Aquifer
RMW-WWB-005	Monitoring	Active	Single	1,385	--	253	1,385	--	Unnumbered	10/19/1972	10/1/2019	130	Principal Aquifer
RMW-WWB-006	Irrigation	Active	Single	1,020	1,000	500	1,000	16	131,967	12/21/2021	12/21/2021	1	Principal Aquifer
RMW-WWB-007	Monitoring	Active	Single	831	--	450	831	--	--	5/6/1949	10/15/2019	128	Principal Aquifer
RMW-WWB-008	Irrigation	Active	Single	1,160	--	458	1,160	--	--	2/10/1976	1/15/2018	94	Principal Aquifer
RMW-WWB-009	Irrigation	Active	Single	1,493	--	900	1,483	--	289372	3/4/1996	1/15/2018	30	Principal Aquifer
RMW-WWB-010	Monitoring	Active	Single	1,220	--	651	1,220	--	--	2/27/1957	2/13/2018	41	Principal Aquifer
RMW-WWB-011	Monitoring	Active	Single	1,000	1,530	960	1,000	6.125	785627	3/6/2003	2/13/2018	27	Principal Aquifer
RMW-WWB-012	Monitoring	Active	Single	1,206	1,220	240	1,206	--	Unnumbered	2/9/1956	1/13/2011	132	Principal Aquifer
RMW-WWB-013	Irrigation	Active	Single	940	--	--	--	--	--	9/17/1963	10/4/2016	129	Principal Aquifer
RMW-WWB-014	Irrigation	Active	Single	1,004	--	300	1,000	--	--	11/30/1919	11/1/2016	27	Principal Aquifer

Notes

(1) Only one Principal Aquifer is defined for the White Wolf Subbasin.
(2) Asterisk (*) denotes wells that are also Monitoring Wells for Degraded Water Quality.
(3) Well 11N19W15G001S is a problematic well for water level measurements.

Abbreviations

bgs = below ground surface
CASGEM = California Statewide Groundwater Elevation Monitoring
DWR = California Department of Water Resources
ft = feet
in = inches
NA = Not Available
NAVD88 = North American Vertical Datum of 1988
SGMA = Sustainable Groundwater Management Act

17.1.3. Monitoring Network for Seawater Intrusion

§ 354.34. Monitoring Network

(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:

(3) Seawater Intrusion. Monitor seawater intrusion using chloride concentrations, or other measurements convertible to chloride concentrations, so that the current and projected rate and extent of seawater intrusion for each applicable principal aquifer may be calculated.

…

(j) An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish a monitoring network related to those sustainability indicators.

As described in ***Section 8.4 Seawater Intrusion***, the Seawater Intrusion Sustainability Indicator is not applicable to the Basin, and, per 23-CCR §354.34(j), a SGMA Monitoring Network has not been defined.

17.1.4. Monitoring Network for Degraded Water Quality

§ 354.34. Monitoring Network

(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:

(4) Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.

Per California Water Code (CWC) Section 10725, the powers and authorities granted to GSAs to affect sustainable groundwater management under SGMA include, but are not limited to, conducting investigations, registration and metering of groundwater extraction facilities, acquiring surface water or groundwater, reclaiming waters for subsequent beneficial use, regulating groundwater extraction, and establishing accounting rules for groundwater extraction allocations. Monitoring data can represent the potential nexus between groundwater elevations in the Basin and constituent concentrations in the water produced by wells. This requires adequate spatial well density, depth discrete well perforation interval, and measurements that capture temporal water quality conditions in the Principal Aquifer. Per 23 CCR § 354.32(e), the selection of the water quality RMSs has been informed by existing local monitoring programs and leverages historical data wherever possible to help assess and quantify Basin response to GSP implementation relative to historical and projected future groundwater conditions.

The SGMA Monitoring Network for Degraded Water Quality consists of four RMW-WQ which are public water system (PWS) wells located within the Basin and for which water quality SMCs are defined. The SGMA Monitoring Network for Degraded Water Quality was selected based on the following considerations:

- **Current and projected groundwater use** – The RMW-WQs include PWS wells which are already sampled and analyzed relative to drinking water quality which represents the most stringent current and projected water quality standards in the Basin. The network also includes eight additional wells that are not part of the SGMA Representative monitoring network (designed as MW-WQs). These additional wells are mostly located in agricultural areas, which currently represent the primary use of the Basin's developed lands.

- **Aquifer characteristics** – All RMW-WQs (and MW-WQs) are screened within the Principal Aquifer defined for the Basin. Since all of the RMW-WQs are production wells, they are pumped regularly; therefore, the water extracted is representative of the Principal Aquifer formation water.
- **Potential impacts to beneficial uses and users of groundwater, land uses or property interests, and adjacent Basins** –The benefits of including PWS wells as RMW-WQs are: (1) they consider the groundwater quality of sensitive beneficial users of groundwater; and (2) they are already required to sample for constituents of health concern on a regular and known schedule (i.e., compliance with Title 22 CCR drinking water regulations for Primary and Secondary Maximum Contaminant Levels, or MCLs).
- **Availability, quality, and reliability of historical data** – All RMW-WQs have been monitored as part of PWS compliance. The PWS are required by the State Water Resources Control Board (SWRCB) Drinking Water Program to monitor water quality and report results where they are publicly available through the Safe Drinking Water Information System (SDWIS) Drinking Water Watch website.
- **Availability of site-specific technical information** – As shown in **Table MN-3**, two of the RMW-WQs have known geographic coordinates, ground surface elevations, reference point elevations, well depths, and well screen intervals. The remaining two RMW-WQs in which exact well location and well construction information is currently unavailable, the GSA developed plans to fill these data gaps in accordance with 23 CCR § 354.38 and as part of GSP implementation.
- **"Representativeness" to local groundwater conditions** – As described above, the RMW-WQs are located within the developed area of the Basin and pump from the Principal Aquifer.
- **Long-term access** – Data from the RMW-WQ wells will be accessed via the SDWIS Drinking Water Watch website**.** Furthermore, the White Wolf GSA's coordination with the PWS owners for well sampling at the appropriate frequency for the required constituents is ongoing (see ***Section 19.1.2 Data Gap Filling Efforts***).

In addition, the planned monitoring includes eight additional wells (MW-WQs) selected from WRMWSD's, TCWD's, and Arvin-Edison Water Storage District (AEWSD)'s existing water quality sampling program, including one MW-WQ sampled under the Irrigated lands Regulatory Program (ILRP). The White Wolf GSA has secured long-term agreements with associated land/well owners allowing long-term access to the site to conduct monitoring**.** These sites will be used to collect supplemental data to allow for continued evaluation of groundwater quality trends within the Basin throughout the GSP implementation. For wells with uncertain accessibility as indicated on **Table MN-3**, the White Wolf GSA will rely on online public water system data.

As discussed in ***Section 8.5 Groundwater Quality Concerns**,* historical water quality data indicate that some Basin wells exceed (1) Primary MCLs for arsenic, nitrate as nitrogen, and selenium, (2) Secondary MCLs for Total Dissolved Solids (TDS), sulfate, and iron, and (3) the Basin Water Quality Objective for boron and sodium. Limited data suggest there may be a potential correlation with some constituents of concern and groundwater levels. As such, two of the MW-WQs are also RMW-WLs (i.e., part of the SGMA Monitoring Network for Chronic Lowering of Groundwater Levels) and both water quality concentration data and water level data and any associated trends will be evaluated in future reporting and consideration of SMCs.

Specific details regarding each of the RMW-WQs and MW-WQs are listed in **Table MN-3** and locations are shown on **Figure MN-2.**

17.1.4.1. Monitoring Well Density

According to DWR's BMP#2, monitoring well density should be between 0.2 and 10 wells per 100 square miles. In the Basin, where there is more than 10,000 AFY pumping per 100 square miles, the recommended monitoring well density is at least four wells per 100 square miles (DWR, 2016d). Accordingly, for the 168 square mile Basin, the recommended number of wells is at least seven, and therefore the 12 wells that the White Wolf GSA intends to monitor (i.e., as a combination of 4 RMW-WQs and 8 MW-WQs) complies with this recommendation.

17.1.4.2. Monitoring Schedule

The ILRP well data will be downloaded from the GeoTracker website. The RMW-WQ PWS wells are already regularly sampled for Title 22 constituents. These data will be downloaded on an annual basis from the SDWIS Drinking Water Watch website. Missing constituents may be added to the annual sample analyses for the ILRP and PWS wells as part of the SGMA Monitoring Program[94].

The supplemental MW-WQs will be sampled annually in accordance with the monitoring protocols described in ***Section 17.2 Monitoring Protocols for Data Collection and Monitoring***, and the samples will be analyzed for the following potential constituents of concern, as identified in ***Section 8.5 Groundwater Quality Concerns***.

- Arsenic
- Nitrate as nitrogen
- Selenium
- TDS
- Boron
- Sodium

[94] Constituents that may be analyzed from PWS well water samples include TDS, major ions, or other potential COCs not sampled on an at least annual basis.

- Sulfate
- Iron
- 1,2,3-Trichloropropane (1,2,3-TCP)

Additionally, the MW-WQs will be sampled annually for other relevant groundwater quality constituents which may include constituents within some or all the following categories:

- Descriptive parameters (temperature, pH, etc.)
- Major ions, which includes calcium, magnesium, potassium, sodium, chloride, bicarbonate, and sulfate.

The analytical results from the RMW-WQs and MW-WQs will be subject to a QA/QC process and incorporated into the Basin DMS. The data collected at the RMW-WQs will be reported to DWR per the requirements specified under ***Section 17.5 Reporting Monitoring Data to the Department***.

Table MN-3. SGMA Monitoring Network for Degraded Water Quality

					CASGEM Details			Monitoring Site Location			Reference Point	
Monitoring Site ID	Well/Site ID	Site Type	SGMA Monitoring Type	Owner on Record	Station ID	Well ID	Well Type (CASGEM / Voluntary)	X Coordinate (State Plane Zone 5, ft)	Y Coordinate	Accessibility	Ground Surface Elevation (ft, NAVD88)	Reference Point Elevation (ft, NAVD88)
RMW-WWB-015	10N19W08A002S	Well	SGMA Representative	TCWD	--	--	--	6285762	2175221	Confirmed	1250.98	1251.49
SW-WWB-002	11N18W06M001S	Well	supplemental	Delano Farms Co Inc	350667N1188431W001	31446	Voluntary	6309200	2211816	Confirmed	634.28	634.99
SW-WWB-003	11N19W09P002S	Well	supplemental	Benham&Johnson-Ridge Side Farms	350456N1189009W001	11413	Voluntary	6289547	2204163	Confirmed	686.00	687.47
SW-WWB-004	11N19W11K002S	Well	supplemental	Diamond Farming	--	--	--	6300453	2206733	Confirmed	649.18	649.77
SW-WWB-005	11N19W16N001S	Well	supplemental	Cuyama Orchards		11422	Voluntary	6287592	2199305	Uncertain	764.53	765.53
SW-WWB-006	11N19W19M001S	Well	supplemental	WRMWSD	350253N1189496W001	11427	CASGEM	6277531	2196853	Confirmed	784.72	785.54
RMW-WWB-009	11N19W27C001S*	Well	supplemental	WRMWSD	350144N1188901W001	51678	CASGEM	6294770	2192777	Confirmed	855.86	857.27
SW-WWB-008	11N19W29N002S	Well	supplemental	TCWD	--	--	--	6281683	2188517	Confirmed	957.55	959.02
RMW-WWB-016	11N19W31Q001S	Well	SGMA Representative	TCWD	--	--	--	6279126	2182626	Confirmed	1110.45	1111.39
RMW-WWB-014	32S29E33F001M*	Well	supplemental	Sapphire Property Holdings	351036N1188640W001	23152	Voluntary	6301791	2223886	Confirmed	519.98	520.20
RMW-WWB-017	Tut Brothers Well 3	Well	SGMA Representative	Tut Brothers Farm #96	--	--	--	--	--	Uncertain	--	--
RMW-WWB-018	Tut Brothers Well 96	Well	SGMA Representative	Tut Brothers Farm #96	--	--	--	--	--	Uncertain	--	--

Notes

(1) Only one Principal Aquifer is defined for the White Wolf Subbasin.
(2) Asterisk (*) denotes wells that are also Representative Monitoring Wells for Chronic Lowering of Groundwater Levels.

Abbreviations

bgs = below ground surface
CASGEM = California Statewide Groundwater Elevation Monitoring
DWR = California Department of Water Resources
ft = feet
in = inches
NAVD88 = North American Vertical Datum of 1988
TCWD = Tejon-Castac Water District
SGMA = Sustainable Groundwater Management Act

Table MN-3. SGMA Monitoring Network for Degraded Water Quality

Monitoring Site ID	Well Use	Status	Well Completion Type	Well Construction Details: Total Completed Depth (ft bgs)	Borehole Depth (ft bgs)	Top of Perforations Depth (ft bgs)	Bottom of Perforations Depth (ft bgs)	Casing Diameter (in)	DWR Well Completion Report No.	Water Quality Data Record: First Measurement Date	Last Measurement Date	Principal Aquifer(s) Monitored (1)
RMW-WWB-015	Public Supply	Active	Single	1800	1,820	1,300	1,780	16	e0115274	7/1/2010	12/13/2019	Principal Aquifer
SW-WWB-002	Irrigation	Active	Single	1,005	1,203	564	1,005	14	24385	8/12/1981	7/6/2017	Principal Aquifer
SW-WWB-003	Irrigation	Active	Single	1,206	--	557	649	14	111606	8/15/1969	7/11/2012	Principal Aquifer
SW-WWB-004	Irrigation	Active	Single	1,000	1,020	500	1,000	16	e0081187	11/11/2013	10/8/2018	Principal Aquifer
SW-WWB-005	Public Supply	Active	Single	--	--	--	--	--	--	6/16/1966	10/3/2018	Principal Aquifer
SW-WWB-006	Irrigation	Active	Single	1,082	--	482	1,082	--	--	6/22/1966	3/29/2016	Principal Aquifer
RMW-WWB-009	Irrigation	Active	Single	1,493	--	900	1,483	--	289372	6/15/1992	3/1/2016	Principal Aquifer
SW-WWB-008	Irrigation	Active	Single	1,580	1,600	1,010	1,580	16	e0182815	1/29/2014	4/11/2018	Principal Aquifer
RMW-WWB-016	Public Supply	Active	Single	1,520	1,522	560, 1050	600, 1520	16	68927	8/12/1974	6/12/2020	Principal Aquifer
RMW-WWB-014	Irrigation	Active	Single	1,004	--	300	1,000	--	--	5/26/1966	9/27/2018	Principal Aquifer
RMW-WWB-017	Public Supply	Active	--	--	--	--	--	--	--	10/7/2015	5/6/2020	Principal Aquifer
RMW-WWB-018	Public Supply	Active	--	--	--	--	--	--	--	8/26/1986	5/6/2020	Principal Aquifer

Notes

(1) Only one Principal Aquifer is defined for the White Wolf Subbasin.
(2) Asterisk (*) denotes wells that are also Representative Monitoring Wells for Chronic Lowering of Groundwater Levels.

Abbreviations

bgs = below ground surface
CASGEM = California Statewide Groundwater Elevation Monitoring
DWR = California Department of Water Resources
ft = feet
in = inches
NAVD88 = North American Vertical Datum of 1988
TCWD = Tejon-Castac Water District
SGMA = Sustainable Groundwater Management Act

17.1.5. Monitoring Network for Land Subsidence

§ 354.34. Monitoring Network

(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:

(5) Land Subsidence. Identify the rate and extent of land subsidence, which may be measured by extensometers, surveying, remote sensing technology, or other appropriate method.

The SGMA Monitoring Network for Land Subsidence consists of five (5) RMW-WLs from the SGMA Monitoring Network for Chronic Lowering of Groundwater Levels to be used as proxy.

Specific details regarding each of the above sites are listed in **Table MN-4** and site locations are shown on **Figure MN-3**. These sites were selected based on the following considerations:

- **Potential impacts to beneficial uses and users of groundwater, land uses or property interests** – The sites are situated in proximity to critical infrastructure facilities within the Basin, including the California Aqueduct and the 850 Canal.
- **Availability, quality, and reliability of historical data** – All of the RMW-WLs have water records that are sixteen or more years in length, the oldest of which have data that extend back to the early 1960s.
- **Long-term access** – As mentioned above, all RMW-WLs have been confirmed to have sufficient access for water level measurement collection.

In addition to the above monitoring, the White Wolf GSA will gather data from the 34 land surface monitoring checkpoints monitored by DWR along the California Aqueduct[95] and the two existing UNAVCO GPS subsidence monitoring stations. To evaluate changes in ground surface elevation along the 850 Canal, the White Wolf GSA has established two land surface elevation checkpoints located at two WRMWSD pump stations.

17.1.5.1. Monitoring Well Density

The proposed monitoring is considered sufficient for monitoring potential subsidence in the vicinity of critical infrastructure in the Basin based on the following: (1) 34 land surface monitoring checkpoints, two GPS stations, and two RMW-WLs from the SGMA Monitoring Network for Chronic Lowering of Groundwater Levels located adjacent to the California Aqueduct, and (2) two land surface monitoring checkpoints and three RMW-WLs from the SGMA Monitoring Network for Chronic Lowering of Groundwater Levels located adjacent to the 850 Canal.

17.1.5.2. Monitoring Schedule

Land surface elevation at checkpoints along the 850 Canal will be measured annually. It is assumed that

[95] DWR maintains 34 ground surface elevation survey benchmark locations within the Basin, between Mileposts 278.93 and 293.39 of the California Aqueduct (only including mile markers; duplicates at the same location are removed; DWR, 2017).

DWR will continue annual measurements of land surface elevation along the California Aqueduct. The White Wolf GSA assumes that these data will continue to be made available to the public for consideration and inclusion in annual reports and GSP updates. The White Wolf GSA will coordinate with DWR to obtain access to future survey data collected from this regional monitoring program. Daily data from GSP stations will be downloaded from the UNAVCO website. Water levels will be measured semiannually (Spring and Fall) to document seasonal fluctuations in groundwater levels. Specifically, Spring levels will be measured between January and March to represent a seasonal high prior to summer irrigation demands. Fall levels will be measured between September and November to represent a seasonal low after the summer irrigation demands.

All RMSs will be monitored in accordance with the monitoring protocols described in ***Section 17.2 Monitoring Protocols for Data Collection and Monitoring***. All data will be subject to a QA/QC process and incorporated into the Basin DMS. Applicable data will be reported to DWR per the requirements outlined under ***Section 17.5 Reporting Monitoring Data to the Department***.

Table MN-4. SGMA Monitoring Network for Land Subsidence

Monitoring Site ID	Well/Site ID	Site Type	SGMA Monitoring Type	Owner on Record	CASGEM Details: Station ID	CASGEM Details: Well ID	CASGEM Details: Well Type (CASGEM / Voluntary)	Monitoring Site Location: X Coordinate (State Plane Zone 5, ft)	Monitoring Site Location: Y Coordinate (State Plane Zone 5, ft)	Monitoring Site Location: Accessibility	Reference Point: Ground Surface Elevation (ft, NAVD88)	Reference Point: Reference Point Elevation (ft, NAVD88)
SS-WWB-001	Checkpoint #1	Survey Location	supplemental	WRMWSD	NA			6281161	2193489	Confirmed	858.42	NA
SS-WWB-002	Checkpoint #2	Survey Location	supplemental	WRMWSD				6294768	2192782		857.37	
SS-WWB-003	EDPP	GPS	supplemental	UNAVCO	NA			6312816	2167755	NA	--	NA
SS-WWB-004	WGPP	GPS	supplemental	UNAVCO				6267114	2191700		--	
SS-WWB-005	MILE 278.93A	Survey Location	supplemental	DWR	NA			6263291	2197380	NA	742.07	NA
SS-WWB-006	MILE 279.05A	Survey Location	supplemental					6263881	2197063		740.41	
SS-WWB-007	MILE 279.45A	Survey Location	supplemental					6265501	2196320		742.54	
SS-WWB-008	MILE 280.06A	Survey Location	supplemental					6268353	2194837		736.03	
SS-WWB-009	MILE 280.36B	Survey Location	supplemental					6268610	2193538		734.12	
SS-WWB-010	MILE 280.74A	Survey Location	supplemental					6267299	2191613		1253.91	
SS-WWB-011	MILE 280.88B	Survey Location	supplemental					6266975	2191027		1249.22	
SS-WWB-012	MILE 281.16A	Survey Location	supplemental					6266198	2189750		1256.57	
SS-WWB-013	MILE 281.41A	Survey Location	supplemental					6265671	2188648		1257.62	
SS-WWB-014	MILE 281.78A	Survey Location	supplemental					6264929	2186798		1257.49	
SS-WWB-015	MILE 282.00	Survey Location	supplemental					6264354	2185855		1257.12	
SS-WWB-016	MILE 282.44A	Survey Location	supplemental					6264545	2183568		1257.27	
SS-WWB-017	MILE 283.19A	Survey Location	supplemental					6267682	2182198		1257.58	
SS-WWB-018	MILE 283.95A	Survey Location	supplemental					6271496	2180889		1251.03	
SS-WWB-019	MILE 283.98A	Survey Location	supplemental					6271709	2180733		1251.69	
SS-WWB-020	MILE 284.80A	Survey Location	supplemental					6275373	2178857		1257.36	
SS-WWB-021	MILE 285.00A	Survey Location	supplemental					6276422	2178461		1250.55	
SS-WWB-022	MILE 285.70B	Survey Location	supplemental					6279690	2177363		1247.98	
SS-WWB-023	MILE 285.99A	Survey Location	supplemental					6281425	2177256		1246.57	
SS-WWB-024	MILE 287.06B	Survey Location	supplemental					6286711	2175221		1248.25	
SS-WWB-025	MILE 287.09A	Survey Location	supplemental					6286866	2175106		1248.71	
SS-WWB-026	MILE 287.12A	Survey Location	supplemental					6287037	2175023		1248.31	
SS-WWB-027	MILE 287.60B	Survey Location	supplemental					6289253	2173927		1245.67	
SS-WWB-028	MILE 288.27B	Survey Location	supplemental					6291975	2171667		1245.63	
SS-WWB-029	MILE 288.99A	Survey Location	supplemental					6294171	2168542		1255.11	
SS-WWB-030	MILE 289.94A	Survey Location	supplemental					6298580	2166682		1254.40	
SS-WWB-031	MILE 290.21A	Survey Location	supplemental					6299852	2165902		1247.56	
SS-WWB-032	MILE 290.34A	Survey Location	supplemental					6300436	2165612		1253.52	
SS-WWB-033	MILE 290.58A	Survey Location	supplemental					6301514	2164971		1253.73	
SS-WWB-034	MILE 291.19A	Survey Location	supplemental					6304610	2164969		1253.59	
SS-WWB-035	MILE 291.26A	Survey Location	supplemental					6305006	2164953		1247.35	
SS-WWB-036	MILE 292.11A	Survey Location	supplemental					6309135	2165944		1250.45	
SS-WWB-037	MILE 293.07B	Survey Location	supplemental					6313056	2168193		1244.32	
SS-WWB-038	MILE 293.39B	Survey Location	supplemental					6314427	2167204		1249.55	
RMW-WWB-002	10N19W08A001S*	Well	SGMA Representative	Tejon Ranch Corp	--	--	--	6285700	2175294	Confirmed	1250.20	1251.93
RMW-WWB-003	10N20W01H001S*	Well	SGMA Representative	Wheeler Ridge HQ	349836N1189228W001	32402	Voluntary	6274804	2179297	Confirmed	1239.98	1240.70
RMW-WWB-008	11N19W19P001S*	Well	SGMA Representative	WRMWSD	350211N1189452W001	30725	CASGEM	6278925	2195333	Confirmed	817.24	818.11
RMW-WWB-009	11N19W27C001S*	Well	SGMA Representative	WRMWSD	350144N1188901W001	51678	CASGEM	6294770	2192777	Confirmed	855.86	857.27
RMW-WWB-011	11N19W36A001S*	Well	SGMA Representative	WRMWSD	349976N1188463W001	51681	CASGEM	6307897	2186479	Confirmed	849.48	849.52

Notes

(1) Only one Principal Aquifer is defined for the White Wolf Subbasin.
(2) Asterisk (*) denotes wells that are also Representative Monitoring Wells for Chronic Lowering of Groundwater Levels.
(3) The two proposed checkpoints will be installed at surveying benchmarks located at WRMWSD pump stations along the 850 Canal.
(4) The ground surface elevations of DWR Checkpoints along the mile markers of the California Aqueduct are 2019 measurements.

Abbreviations

bgs = below ground surface
CASGEM = California Statewide Groundwater Elevation Monitoring
DWR = California Department of Water Resources
ft = feet
GPS = Global Positioning System
in = inches
NA = not applicable
NAVD88 = North American Vertical Datum of 1988
SGMA = Sustainable Groundwater Management Act
WRMWSD = Wheeler Ridge-Maricopa Water Storage District

Table MN-4. SGMA Monitoring Network for Land Subsidence

				Well Construction Details						Water Level Data Record			
Monitoring Site ID	**Well Use**	**Status**	**Well Completion Type**	**Total Completed Depth (ft bgs)**	**Borehole Depth (ft bgs)**	**Top of Perforations Depth (ft bgs)**	**Bottom of Perforations Depth (ft bgs)**	**Casing Diameter (in)**	**DWR Well Completion Report No.**	**First Measurement Date**	**Last Measurement Date**	**Count**	**Principal Aquifer(s) Monitored [1]**
SS-WWB-001	NA												
SS-WWB-002													
SS-WWB-003	NA												
SS-WWB-004													
SS-WWB-005	NA												
SS-WWB-006													
SS-WWB-007													
SS-WWB-008													
SS-WWB-009													
SS-WWB-010													
SS-WWB-011													
SS-WWB-012													
SS-WWB-013													
SS-WWB-014													
SS-WWB-015													
SS-WWB-016													
SS-WWB-017													
SS-WWB-018													
SS-WWB-019													
SS-WWB-020													
SS-WWB-021													
SS-WWB-022													
SS-WWB-023													
SS-WWB-024													
SS-WWB-025													
SS-WWB-026													
SS-WWB-027													
SS-WWB-028													
SS-WWB-029													
SS-WWB-030													
SS-WWB-031													
SS-WWB-032													
SS-WWB-033													
SS-WWB-034													
SS-WWB-035													
SS-WWB-036													
SS-WWB-037													
SS-WWB-038													
RMW-WWB-002	Monitoring	Active	Single	1,765	1,779	1,100	1,765	16, 12	88711	2/25/1964	2/12/2018	27	Principal Aquifer
RMW-WWB-003	Monitoring	Active	Single	1,765	1,770	1,100	1,765	16, 12	88710	2/25/1964	2/8/2016	30	Principal Aquifer
RMW-WWB-008	Irrigation	Active	Single	1,160	--	458	1,160	--	--	2/10/1976	1/15/2018	94	Principal Aquifer
RMW-WWB-009	Irrigation	Active	Single	1,493	--	900	1,483	--	289372	3/4/1996	1/15/2018	30	Principal Aquifer
RMW-WWB-011	Monitoring	Active	Single	1,000	1,530	960	1,000	6.125	785627	3/6/2003	2/13/2018	27	Principal Aquifer

Notes

(1) Only one Principal Aquifer is defined for the White Wolf Subbasin.
(2) Asterisk (*) denotes wells that are also Representative Monitoring Wells for Chronic Lowering of Groundwater Levels.
(3) The two proposed checkpoints will be installed at surveying benchmarks located at WRMWSD pump stations along the 850 Canal.
(4) The ground surface elevations of DWR Checkpoints along the mile markers of the California Aqueduct are 2019 measurements.

Abbreviations

bgs = below ground surface
CASGEM = California Statewide Groundwater Elevation Monitoring
DWR = California Department of Water Resources
ft = feet
GPS = Global Positioning System
in = inches
NA = not applicable
NAVD88 = North American Vertical Datum of 1988
SGMA = Sustainable Groundwater Management Act
WRMWSD = Wheeler Ridge-Maricopa Water Storage District

17.1.6. Monitoring Network for Depletions of Interconnected Surface Water

> *§ 354.34. Monitoring Network*
>
> *(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:*
>
> *(6) Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:*
>
> *(A) Flow conditions including surface water discharge, surface water head, and baseflow contribution.*
>
> *(B) Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.*
>
> *(C) Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.*
>
> *(D) Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.*

The 23 CCR § 354.28(c) states that the SMCs for Depletions of Interconnected Surface Water "shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results." Monitoring the depletion of interconnected surface water must therefore characterize the spatial and temporal changes in the exchange between surface water and groundwater conditions by collecting data to characterize the following:

- Flow conditions including surface water discharge, surface water head ("stage"), and baseflow contribution.
- The approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.
- Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.
- Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.

Water table and streamflow changes can be characterized with measured water levels in shallow wells located near stream gauging stations (stream gauges are locations where surface water level elevation [stage] and/or volumetric discharge [flow] are measured). Since stream gauging records are very sparse, the SGMA Monitoring Network for Depletions of Interconnected Surface Water that was developed for the Basin is comprised of three (3) Representative Monitoring Wells for Depletions of Interconnected Surface Water (RMW-ISW) which were installed by the White Wolf GSA in January 2021, as shown on **Figure MN-4** and summarized in **Table MN-5**. The sites were selected based on the following considerations:

- **Current and projected groundwater use** – To the extent possible, the RMW-ISWs are located near surface water features and the GDEs. The RMW-ISWs include three shallow dedicated monitoring wells that were installed for shallow groundwater level monitoring along the upgradient edge of the Springs Fault.
- **Aquifer characteristics** – The three newly installed RMW-ISW with depths of 50 feet below ground surface (ft bgs) are screened within shallow alluvial materials. These relatively shallow well depths are considered representative of the shallow water-bearing zone conditions. As such, the SGMA Monitoring Network is sufficient to monitor potential shallow groundwater level changes due to GSA management actions in the Basin.
- **Potential impacts to beneficial uses and users of groundwater, land uses or property interests** – As described in ***Section 8.7 Interconnected Surface Water Systems*** and ***Section 8.8 Groundwater Dependent Ecosystems (GDEs)***, groundwater levels in the Principal Aquifer are encountered well below the land surface (i.e., greater than 200 ft bgs under average current conditions) within most of the Basin and therefore there is no interconnected surface water throughout most of the Basin. An exception is up-gradient of the Springs Fault where there is evidence of spring flow that appears to be caused by groundwater backing up behind the fault and rising to the ground surface. In these upland areas of the Basin, depth to water is typically shallower, surface water is diverted for irrigation, and flowing artesian springs are used for stock watering. Furthermore, GDEs are located south of the Springs Fault and within the upland areas of the Basin (**Figure MN-4)**. As such, the RMW-ISWs are located near surface water features and the GDEs of interest to monitor any potential impacts of groundwater use and management to beneficial users (including environmental users).
- **Availability, quality, and reliability of historical data** –The lack of historical groundwater elevation data in the area near GDEs is a data gap that the White Wolf GSA is filling through installation (in 2021) and ongoing monitoring of the three shallow RMW-ISWs. Specifically, the White Wolf GSA has installed high-frequency data loggers in the RMW-ISWs for ongoing monitoring of shallow conditions supporting GDEs.
- **Availability of site-specific technical information** – As shown in **Table MN-5**, the three existing RMW-ISWs have location coordinates and known construction information that includes perforated intervals.
- **"Representativeness" to local groundwater conditions** – The sites "representativeness" to local groundwater conditions is determined by location relative to the surface water features and well construction. **Figure MN-4** indicates that the RMW-ISWs are located along streams and/or near GDEs and are representative of water table conditions in the Basin near these surface water features.
- **Long-term access** – The White Wolf GSA has secured long-term access for the three RMW-ISWs to conduct monitoring for SGMA compliance purposes.

Additional monitoring sites include four stream gauges, two artesian spring observation points, and two existing domestic wells (MW-WLs) located near either El Paso Creek or GDEs. These sites will be used to collect supplemental data to allow for continued evaluation of streamflow and groundwater levels upgradient of the Springs Fault throughout the GSP implementation.

17.1.6.1. Monitoring Well Density

The sites are all located in the southwestern portion of the Basin where potential interconnected surface water/GDEs have been mapped. Limited existing wells were available to monitoring in this area; as such, the GSA has installed three shallow monitoring wells to supplement the SGMA Monitoring Network. This has ensured adequate coverage near most of the mapped GDE units.

17.1.6.2. Monitoring Schedule

Dedicated shallow RMW-ISWs will be instrumented to record monthly water level changes. Water levels from the MW-WLs will be measured semiannually (Spring and Fall) to document seasonal fluctuations in groundwater levels. Specifically, Spring levels will be measured between January and March to represent a seasonal high prior to summer irrigation demands. Fall levels will be measured between September and November to represent a seasonal low after the summer irrigation demands. A qualitative "flowing" or "not flowing" documentation will occur semiannually at the spring observation points.

Although most stream gauges have measured very limited flow rates and/or no flow during their period of record, the White Wolf GSA will obtain and download any streamflow data measured from the gauge owners, operators, and/or associated public data portals (e.g., California Environmental Data Exchange Network [CEDEN]). Furthermore, the White Wolf GSA acknowledges that these gauges are operated by others and as such, has no control over the ongoing maintenance and validity of data collection[96].

All data will be subject to a QA/QC process and incorporated into the Basin DMS. All data for the RMW-ISWs will be reported to DWR per the requirements specified under ***Section 17.5 Reporting Monitoring Data to the Department***.

[96] The Grapevine Creek gauge is overgrown with vegetation, thereby preventing peak streamflow measurements in recent years (Personal communication, Jason Scheer, Kern County, 7 January 2019).

Table MN-5. SGMA Monitoring Network for Depletions of Interconnected Surface Water

Monitoring Site ID	Well/Site ID	Site Type	SGMA Monitoring Type	Owner on Record	CASGEM Details: Station ID	CASGEM Details: Well ID	CASGEM Details: Well Type (CASGEM / Voluntary)	Monitoring Site Location: X Coordinate (State Plane Zone 5, ft)	Monitoring Site Location: Y Coordinate (State Plane Zone 5, ft)	Accessibility	Reference Point: Ground Surface Elevation (ft, NAVD88)	Reference Point: Reference Point Elevation (ft, NAVD88)
SW-WWB-010	11N18W14M001S	Well	supplemental	Tejon Ranch Corp	--	--	--	6330621	2200673	Confirmed	1127.88	1129.18
SW-WWB-011	11N18W24H001S	Well	supplemental	Tejon Ranch Corp	--	--	--	6340130	2196334	Confirmed	1464.83	1465.70
RMW-WWB-019	RMW-ISW1	Well	SGMA Representative	TCWD	--	--	--	6317609	2187990	Confirmed	905.27	908.06
RMW-WWB-020	RMW-ISW2	Well	SGMA Representative	TCWD	--	--	--	6328599	2201081	Confirmed	1078.48	1080.61
RMW-WWB-021	RMW-ISW3	Well	SGMA Representative	TCWD	--	--	--	6338773	2207581	Confirmed	1298.87	1301.56
SS-WWB-039	11N18W14H001S	Spring	supplemental	Tejon Ranch Corp	NA			6334108	2201970	Confirmed	1207.46	1209.75
SS-WWB-040	32S29E24G001M	Spring	supplemental	Tejon Ranch Corp				6318636	2234396	Confirmed	633.80	633.36
SS-WWB-041	557ELPCRK	Stream Gauge	supplemental	--	NA			6305633	2203776	--	NA	
SS-WWB-042	Grapevine Creek 175	Stream Gauge	supplemental	Kern County				6284476	2157741	--		
SS-WWB-043	SLCNY	Stream Gauge	supplemental	WRMWSD				6263981	2168025	Assumed		
SS-WWB-044	TYCNY	Stream Gauge	supplemental	WRMWSD				6274369	2161469	Assumed		

Notes

(1) Only one Principal Aquifer is defined for the White Wolf Subbasin.
(2) Asterisk (*) denotes wells that are also Representative Monitoring Wells for Chronic Lowering of Groundwater Levels.

Abbreviations

bgs = below ground surface
CASGEM = California Statewide Groundwater Elevation Monitoring
DWR = California Department of Water Resources
ft = feet
in = inches
NA = not applicable
NAVD88 = North American Vertical Datum of 1988
SGMA = Sustainable Groundwater Management Act

Table MN-5. SGMA Monitoring Network for Depletions of Interconnected Surface Water

Monitoring Site ID	Well Use	Status	Well Completion Type	Well Construction Details: Total Completed Depth (ft bgs)	Borehole Depth (ft bgs)	Top of Perforations Depth (ft bgs)	Bottom of Perforations Depth (ft bgs)	Casing Diameter (in)	DWR Well Completion Report No.	Water Level / Flow Data Record: First Measurement Date	Last Measurement Date	Count	Principal Aquifer(s) Monitored (1)
SW-WWB-010	Domestic	Active	--	500	500	--	--	--	--	--	--	--	unknown
SW-WWB-011	Domestic	Active	Single	106	106	16	106	10	Unnumbered	4/25/2003	11/7/2019	3	Shallow water-bearing zone
RMW-WWB-019	Monitoring	Active	Single	50	50	20	50	4	WCR2021-003246	1/18/2021	7/1/2021	3	Shallow water-bearing zone
RMW-WWB-020	Monitoring	Active	Single	50	50	20	50	4	WCR2021-003251	1/19/2021	7/1/2021	3	Shallow water-bearing zone
RMW-WWB-021	Monitoring	Active	Single	50	50	20	50	4	WCR2021-003255	1/19/2021	6/30/2021	3	Shallow water-bearing zone
SS-WWB-039	Stock	Active	NA							--	--	--	
SS-WWB-040	Stock	Active								--	--	--	
SS-WWB-041	NA									--	--	--	NA
SS-WWB-042										2005	2015	--	
SS-WWB-043										--	--	--	
SS-WWB-044										--	--	--	

Notes

(1) Only one Principal Aquifer is defined for the White Wolf Subbasin.
(2) Asterisk (*) denotes wells that are also Representative Monitoring Wells for Chronic Lowering of Groundwater Levels.

Abbreviations

bgs = below ground surface
CASGEM = California Statewide Groundwater Elevation Monitoring
DWR = California Department of Water Resources
ft = feet
in = inches
NA = not applicable
NAVD88 = North American Vertical Datum of 1988
SGMA = Sustainable Groundwater Management Act

17.2. Monitoring Protocols for Data Collection and Monitoring

§ 352.2. Monitoring Protocols
Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:

(a) Monitoring protocols shall be developed according to best management practices.

(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department or may adopt similar monitoring protocols that will yield comparable data.

(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan and modified as necessary.

Pursuant to 23 CCR § 354.32(i), in all cases the SGMA Monitoring Network will adhere to the monitoring protocols developed by the White Wolf GSA. Monitoring is needed to track changes in Basin conditions, Sustainability Indicators, and the effectiveness of GSP implementation to achieve groundwater sustainability. Data collection protocols for groundwater levels, groundwater quality, land subsidence, and surface water are detailed below and are designed for compatibility with the 23 CCR and DWR's "BMP #1 for Groundwater Monitoring Protocols, Standards, and Sites" (DWR, 2016e).

The Basin's monitoring protocols are designed to ensure the following:

- Data are collected from the correct location with proper site identification;
- Data are accurate and reproducible;
- Data represent conditions in the Basin;
- All salient information is recorded to check and correct data; and
- Data are handled in a way that ensures data integrity.

17.2.1. <u>Protocols for Groundwater Level Measurements</u>

Groundwater level measurements will be collected, at a minimum, semiannually (Spring and Fall) to document seasonal fluctuations in groundwater levels. Specifically, Spring levels will be measured between January and March to represent the seasonal high prior to summer irrigation demands and Fall levels will be measured between August and November to represent the seasonal low after the increased summer irrigation demands. The groundwater level data will be the basis for the development of Basin-wide groundwater elevation maps. The following data collection protocols will be followed by the field technician:

- Measurements will be taken in wells that are not influenced by recent pumping. Measurements should be taken at least two hours, and preferably longer, after the well was last pumped. Multiple measurements can be collected from the well to verify that equilibrium has been reached.
- Depth to groundwater will be measured by an electronic sounder, chalked steel tape, or

datalogging pressure transducer. As required by 23-CCR § 352.4(a)(3), depth to groundwater will be recorded to at least the nearest 0.1 foot and preferably to the nearest 0.01 foot. Other measurement methods such as airlines and acoustic sounders may not provide the required accuracy of 0.1 foot but may be used in instances by which sounding equipment cannot fit inside the well casing.

- Depth to groundwater will be measured from a specific, easily identifiable, and clearly marked Reference Point (RP) on the well casing. As required by 23-CCR § 352.4(a)(4), the reference point elevation (RPE) will be surveyed relative to the North American Vertical Datum of 1988 (NAVD 88) to an accuracy of 0.5 foot and preferably to an accuracy of 0.1 foot or less.
- For measuring wells that are under pressure or artesian, allow a period of time for the water level to stabilize and take multiple measurements take multiple measurements to confirm the water level has reached equilibrium. For artesian wells, site-specific procedures will be developed to collect accurate water level data.
- Groundwater elevation will be calculated as:

$$GWE = RPE - DTW$$

where:

GWE = Groundwater Elevation;
RPE = Reference Point Elevation; and
DTW = Depth to Water

- Consistent units of feet, tenths of feet, and hundredths of feet will be used, and measurements will not be recorded in units of feet and inches.
- Record the site identifier, date, time (24-hour format), method of measurement, height of RPE above or below the ground surface, depth to water, groundwater elevation, and any factors that may influence the depth to water measurements such as weather, nearby irrigation or pumping, flooding, or well condition. If a measurement cannot be obtained, record the reason the measurement was not collected.
- Any well caps, plugs, or locks will be replaced and access points such as doors or gates returned to the condition found upon arrival at the site.
- The measurement devices will be decontaminated after measuring each well and routinely maintained and tested in accordance with manufacturer's instructions to ensure measurement accuracy.

Where and when deemed appropriate, data loggers may be implemented to record water levels more frequently (e.g., hourly, daily, weekly, and so forth). Groundwater levels may be recorded using pressure transducers equipped with data loggers installed in monitoring wells. The following general protocols must be followed when installing a pressure transducer in a monitoring well or for recording stream stage:

- Utilize protocols above to determine the water levels in the monitoring well and properly program and reference the installation.

- Record the well identifier, the associated transducer serial number, transducer range, transducer accuracy, and cable serial number.
- Employ transducers able to record groundwater levels with an accuracy of at least 0.1 foot, and confirm the instrument has sufficient battery life, and data storage capacity, and can accommodate a range of groundwater level fluctuations and natural pressure drift.
- If employing non-vented units, consistent logging of barometric pressures that coincide with the water level measurement intervals is required.
- Follow manufacturer specifications for installation, calibration, data logging intervals, battery life, correction procedure (if non-vented cables used), and anticipated life expectancy to assure that data quality objectives are being met for the GSP.
- Secure the cable to the well head with a well dock or another reliable method. Monitor against potential future cable slippage by marking cable at the same elevation of the RP.
- The transducer data will periodically be checked against hand measured groundwater levels to monitor electronic drift or cable movement. This will happen during routine site visits, at least annually or as necessary to maintain data integrity.

The data will be downloaded as necessary to ensure no data is lost, undergo QA/QC checks, and be entered into the Basin's DMS. Data collected with non-vented data logger cables will be corrected for atmospheric barometric pressure changes, as appropriate. After the sampler is confident that the transducer data have been safely downloaded and stored, the data will be deleted from the data logger to ensure adequate memory storage remains

17.2.2. Protocols for Water Quality Sampling

Water quality samples will be collected annually. General steps for water quality sampling include depth to groundwater measurement prior to purging, multi-meter calibration, installation of sampling pump (if required), purging of the well casing, water quality sample collection in lab-specified bottles, and following standard chain-of-custody guidelines for sample preservation and transport. All analyses will be performed by a laboratory certified under the State Environmental Laboratory Accreditation Program. The following data collection protocols will be followed by the field technician in addition to protocols identified in the United States Geological Survey (USGS) National Manual for the Collection of Water-Quality Data:

- Record the site identifier, date, time, condition of the well, depth to groundwater measurement, meter calibration information[97], purge volumes, meter readings during purging, and water quality samples that were collected and preservation methods used.
- Production wells will be sampled while the well pump is running, with well-water collected from a spigot near the wellhead. Samples will not be collected from storage tanks, at a long distance from

[97] Ideally, a multi-meter shall be used to collect field parameters prior to sample collection. As applicable, multi-meter probes shall be calibrated per manufacturer specifications using standards closest to that of the anticipated well-water.

the wellhead, or after any water treatment. Sample ports and sampling equipment must be cleaned prior to sample collection.

- Monitoring wells without a permanent pump installation will be purged and sampled using a submersible pump or bailer. Submersible pump, tubing, and sampling equipment will be cleaned and decontaminated between sample sites.
- If possible, a minimum of three casing volumes will be purged from the well prior to sample collection. For larger wells and wells with permanent pump installations, purging of three casing volumes may not be necessary or practical depending on the well's operational history and operational constraints. If a well is pumped dry, the well will be allowed to recover within 90% of original water level prior to sampling. Professional judgment will be used to determine well purging required to achieve a representative sample from the well.
- If applicable, field parameters (e.g., pH, specific conductance, temperature, and dissolved oxygen) will be monitored using a multi-meter and flow cell during purging. Field parameters will be allowed to stabilize during purging so that variation of each parameter is within appropriate pre-defined limits for three casing volumes. In cases where purging of three casing volumes is not practical, field parameters will be stable for three successive measurements collected at least three minutes apart. All field instruments will be calibrated daily and evaluated for drift throughout the day.
- Prior to collection, new sample bottles appropriate to each analysis will be obtained from the analytical lab contracted for chemical analysis. Each sample bottle will be clearly labeled after sampling with the site identifier, sample personnel, date, time of sample collection, preservative used, and required analysis. Samples will be collected according to appropriate standards such as those listed in the Standard Methods for the Examination of Water and Wastewater, the USGS *National Field Manual for the Collection of Water-Quality Data* (USGS, variously dated) or other appropriate guidance. The specific sample collection procedure will reflect the type of analysis to be performed. Sample will be collected under laminar flow conditions which may require reducing the flow rate prior to sample collection. Samples will be filtered as recommended for the specific analytes.
- After collection, all sample bottles will immediately be preserved as required, dried, sealed in zip-closure polyethylene bags, and placed on ice in an insulated cooler for temporary storage and transport to the analytical lab. All samples will be delivered to the laboratory following standard chain-of-custody control guidelines within their prescribed holding times.
- Field duplicates and field blank samples will be collected and analyzed for QA/QC purposes. Duplicate samples will be collected, processed, and analyzed in the field using the same methodology for the primary sample, with an assigned dummy site identifier. Field blanks will be collected for quality assurances purposes. Field blanks will be collected using deionized water, processed in the field, and then submitted to the laboratory with a dummy site identifier.

17.2.3. Protocols for Subsidence Measurements

Pursuant to DWR's BMP#1 (DWR, 2016e), evaluating and monitoring land subsidence can utilize multiple data sources and numerous techniques to evaluate the specific conditions and associated causes. The following guidelines will be followed:

- The use of existing subsidence monitoring sites will be incorporated to the greatest extent possible. Publicly available data will be downloaded and stored in the Basin's DMS following QA/QC.
- Leveling and GPS surveys conducted by the GSA will follow surveying standards set out in the California Department of Transportation's Caltrans Surveys Manual (Caltrans, variously dated).
- Measurements will be in the same vertical datum, preferably NAVD88.

17.2.4. Protocols for Streamflow Measurements

Monitoring of streamflow is important for water budget analysis (e.g., quantifying the amount of surface flow entering the Basin) and the evaluation of stream depletions associated with groundwater conditions. The following guidelines have been adopted from the CCR and DWR's BMP#1 (DWR, 2016e):

- The use of existing streamflow monitoring sites will be incorporated to the greatest extent possible.
- Most of the existing gauges collect peak streamflow only. If desired, to establish a new continuous flow measurement streamflow monitoring site, a relationship of stream stage and discharge is necessary to provide continuous estimates of streamflow. Several measurements of discharge at several stream stages are necessary to develop rating curves correlating stage and discharge. A stilling well and pressure transducer with a datalogger can be used to record stage on a continuous basis and discharge can be estimated using the rating curves.
- Streamflow measurements will be collected, analyzed, and reported in accordance with the procedures outlined in USGS Water Supply Paper 2175, *Volume 1 – Measurement of Stage and Discharge* and *Volume 2 – Computation of Discharge* (Rantz and others, 1982a; 1982b). This methodology is currently being used by the USGS and DWR for existing streamflow monitoring.

17.2.5. Protocols for Data Management and Reporting

Records of all data collected will be maintained in the Basin DMS. Prior to importation, standard QA/QC checks will be undertaken to help ensure the validity and accuracy of data.

- Depth to groundwater measurements will be converted to groundwater elevation by subtracting the depth to groundwater from the reference point elevation following the protocols for groundwater level measurements described above.
- Groundwater elevation will be plotted on individual well hydrographs. Groundwater elevations which vary significantly from previous measurements will be evaluated to determine if the measurement is questionable due to a substantial change relative to historical conditions. If

determined that the measurement is anomalous, the measurement will be flagged as questionable in the Basin DMS.

- Laboratory reports will be checked to ensure all samples were analyzed within the prescribed holding times.
- Laboratory reports will be checked to ensure all laboratory blank analyses were determined acceptable by the laboratory.
- Constituent detections in the field blank will be tabulated and compared to their respective practical quantitation limit.
- Field duplicate results will be compared to the primary sample results. Ideally, concentrations will agree within 10% or have differences within their respective practical quantitation limit. If concentrations from duplicate samples vary by more than 25%, the GSA may ask the laboratory to reanalyze the constituent to confirm the result is reasonable.
- Major cations and anions represent a positive and negative charge respectively, and therefore the sum of cations will equal the sum of anions in neutral groundwater. An anion-cation charge balance will be calculated for each sample collected using concentrations of the major anions and cations in milliequivalents per liter (meq/L), with the difference between the two sums reported as a percentage where:

$$\frac{Anions - Cations}{Anions + Cations} * 100$$

  In general, an up to a 5% difference is acceptable. Deviations can be greater if other constituents in the groundwater are not accounted for within the major anions and cations categories. If the anion/cation charge balance difference exceeds 15%, the GSA may ask the laboratory to reanalyze certain constituents or the entire sample to confirm the result is accurate.
- At a minimum, TDS, nitrate as nitrogen, arsenic, sodium, and selenium concentrations will be plotted on individual well chemographs to monitor trends and ensure concentrations are reasonable.

After QA/QC, all data collected will be imported into the Basin DMS. Data for the RMSs will also be integrated into Annual Reports, as required by DWR, and will be uploaded to the SGMA data portal. Per the 23 CCR § 352.4, the following reporting standards apply to all categories of information, unless otherwise indicated:

- Water volumes will be reported in acre-feet (AF).
- Surface water flow will be reported in cubic feet per second (cfs) and groundwater flow will be reported in AFY.
- Field measurements of elevations of groundwater, surface water, and land surface will be measured and reported in feet to an accuracy of at least 0.1 feet relative to NAVD88, or another national standard that is convertible to NAVD88, and the method of measurement described.

- Reference point elevations will be measured and reported in feet to an accuracy of at least 0.5 feet, or the best available information, relative to NAVD88, or another national standard that is convertible to NAVD88, and the method of measurement described.
- Geographic locations will be reported in GPS coordinates by latitude and longitude in decimal degree to seven decimal places, to a minimum accuracy of 30 feet, relative to NAD83, or another national standard that is convertible to NAD83.

17.3. Representative Monitoring

§ 354.36. Representative Monitoring
Each Agency may designate a subset of monitoring sites as representative of conditions in the basin or an area of the basin, as follows:

(a) . Representative monitoring sites may be designated by the Agency as the point at which sustainability indicators are monitored, and for which quantitative values for minimum thresholds, measurable objectives, and interim milestones are defined.

(b) Groundwater elevations may be used as a proxy for monitoring other sustainability indicators if the Agency demonstrates the following:

(1) Significant correlation exists between groundwater elevations and the sustainability indicators for which groundwater elevation measurements serve as a proxy.

(2) Measurable objectives established for groundwater elevation shall include a reasonable margin of operational flexibility taking into consideration the basin setting to avoid undesirable results for the sustainability indicators for which groundwater elevation measurements serve as a proxy.

(c) The designation of a representative monitoring site shall be supported by adequate evidence demonstrating that the site reflects general conditions in the area.

“Representative monitoring” refers to monitoring sites within a broader network of sites that typifies one or more conditions within the Basin or a subarea of the Basin. As described in ***Section 17.1 Description of Monitoring Network,*** the White Wolf GSA has defined a SGMA Monitoring Network for each relevant Sustainability Indicator. The SGMA Monitoring Network is composed of both RMSs for which SMCs have been established and supplemental monitoring sites for which either data will be compiled or collected to improve understanding of Basin conditions. The rationale for selecting RMSs is described for each Sustainability Indicator in ***Sections 17.1.1*** through ***17.1.6***.

The RMSs and associated data collection activities are comprised primarily of a subset of sites and activities that are already part of existing monitoring and reporting programs that will now also be used for SGMA reporting purposes. The data from these RMSs will be used to monitor the Sustainability Indicators and evaluate GSP implementation with respect to meeting the Sustainability Goal defined for the Basin. This objective can be achieved by data showing compliance with the Basin SMCs.

Water level measurements and calculated groundwater elevations may be used as a proxy for monitoring other Sustainability Indicators when they are correlated, uncertainty is adequately represented by the specified margin of operational flexibility, and the RMSs are shown to reflect general conditions in the Basin or subarea of the Basin. Reduction of Groundwater Storage and Land Subsidence are correlated to water levels. Because groundwater storage changes are quantified by the physical properties of the aquifer (storativity) and water level change, Reduction of Groundwater Storage is correlated to water levels. Similarly, Land Subsidence occurs when water levels decrease to a point where the burden of overlying sediments compress clay beds within the aquifer and result in a lowering of the land surface. Accordingly, Land Subsidence is also correlated to water levels. The SGMA Monitoring Network for Chronic Lowering of Groundwater Levels will therefore be used as a proxy to monitor Reduction of Groundwater Storage and Land Subsidence, and the SMCs have been defined to be protective of Reduction of Groundwater Storage and Land Subsidence.

As discussed above in ***Section 17.1 Description of Monitoring Network***, each RMS was selected to ensure that it represents general conditions in the area, with specific considerations regarding the following: (1) current and projected groundwater use, (2) aquifer characteristics, (3) potential impacts to beneficial uses and users of groundwater, land uses or property interests, and adjacent basins, (4) availability, quality, and reliability of historical data, (5) availability of site-specific technical information, and (6) “representativeness” to local groundwater conditions.

17.4. Assessment and Improvement of Monitoring Network

§ 354.38. Assessment and Improvement of Monitoring Network

(a) Each Agency shall review the monitoring network and include an evaluation in the Plan and each five-year assessment, including a determination of uncertainty and whether there are data gaps that could affect the ability of the Plan to achieve the sustainability goal for the basin.

(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.

(c) If the monitoring network contains data gaps, the Plan shall include a description of the following:

(1) The location and reason for data gaps in the monitoring network.

(2) Local issues and circumstances that limit or prevent monitoring.

(d) Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

(e) Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:

(1) Minimum threshold exceedances.

(2) Highly variable spatial or temporal conditions.

(3) Adverse impacts to beneficial uses and users of groundwater.

(4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

Data gaps identified in the SGMA compliant monitoring program will be filled as part of GSP implementation and include:

- The White Wolf GSA continues to actively engage landowners to confirm access through written agreements to all proposed monitoring wells.
- Incomplete or unavailable monitoring well location and well construction information. The White Wolf GSA will conduct survey and video logging of wells with incomplete well location and construction information as part of early stages GSP implementation. For wells in which video logging is not feasible or economical (e.g., the well is an active production well with a pump installed), the White Wolf GSA will work with landowners to attempt to locate documented well construction information.
- Limited land subsidence monitoring checkpoint sites near the 850 Canal. The White Wolf GSA plans to utilize existing benchmark locations at two pumping stations along the 850 Canal as monitoring

checkpoints to supplement the Land Subsidence Monitoring Network.

- Limited land subsidence monitoring sites near the Mettler groundwater recharge project. As the project is expected to only be used for recharge activities, the current land subsidence monitoring network, which includes one checkpoint and one RMW-WL near the recharge project is considered to be sufficient to monitor the potential impacts on water levels. If the project becomes more active to involve extraction activities in the future, additional monitoring wells will be considered to supplement the Land Subsidence Monitoring Network.
- Limited shallow wells and availability of historical groundwater levels upgradient of the Springs Fault near the GDEs. The White Wolf GSA has installed three shallow monitoring wells upgradient to the Springs Fault. Dataloggers will be used to measure water levels at a high resolution.
- Limited quantification of stream inflows. The White Wolf GSA plans to install a data logger in El Paso Creek to measure the streamflow rate at the Basin boundary.

The SGMA Monitoring Network developed for each Sustainability Indicator includes a sufficient density and spatial distribution of monitoring sites to meet the monitoring objectives outlined in ***Section 17.1 Description of Monitoring Network***. In most cases, the existing sites selected for each Sustainability Indicator conform to the BMPs for monitoring networks outlined in DWR's BMP#2 (DWR, 2016d). However, the Basin SGMA Monitoring Network will be reevaluated in each five-year GSP update, including a determination of uncertainty and whether there are additional data gaps that could affect the ability of the Plan to achieve the Sustainability Goal for the Basin.

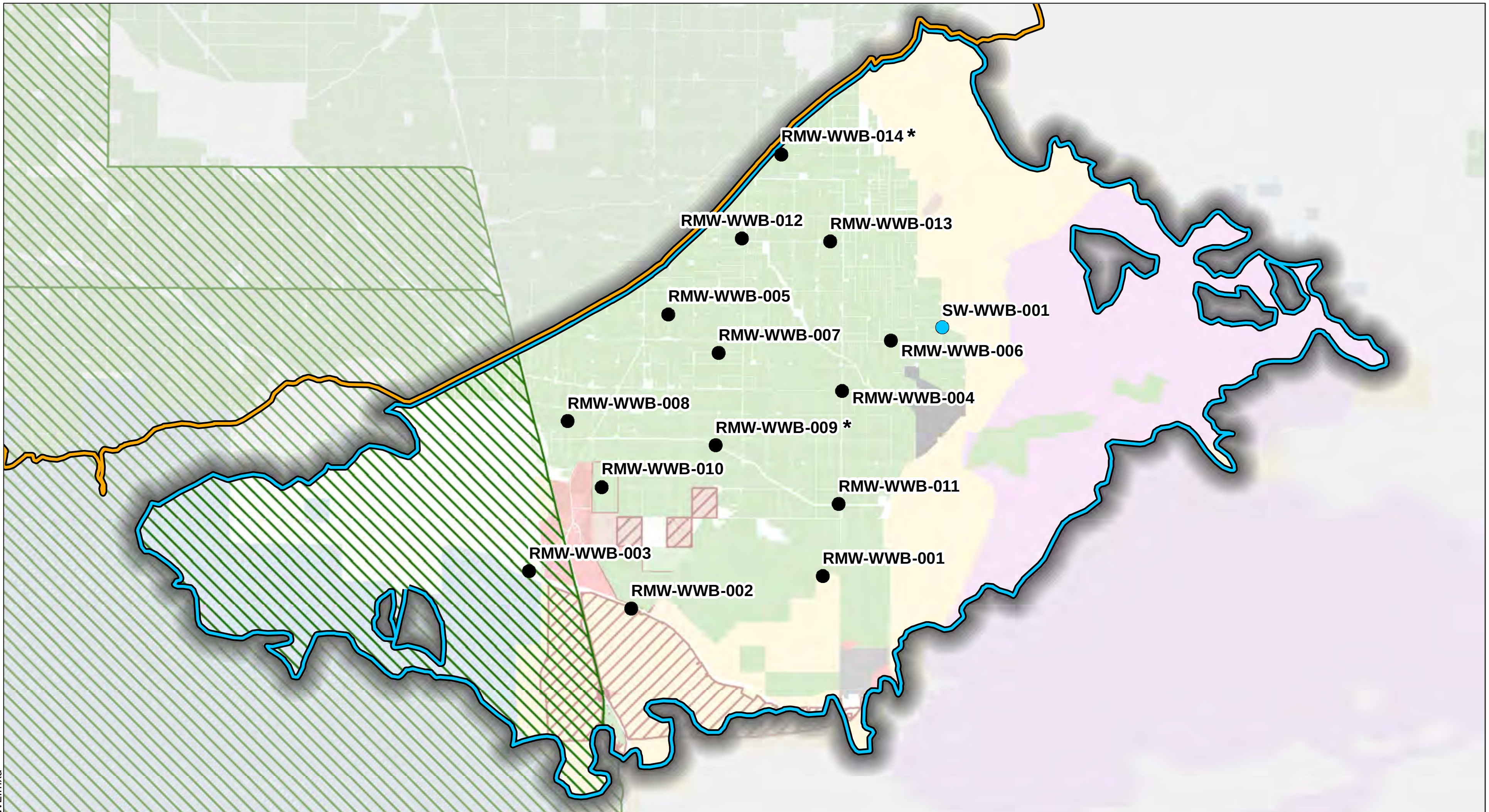
As described in ***Section 16 Action Plan Related to Minimum Threshold Exceedances*** above, following each Annual Report, if an MT exceedance occurs at one or more of the RMSs or if there are highly variable spatial or temporal conditions leading to adverse impacts to beneficial uses and users of groundwater the GSA will assess the RMS(s) in question and may revise the monitoring network, as deemed appropriate.

17.5. Reporting Monitoring Data to the Department

§ 354.40. Reporting Monitoring Data to the Department

Monitoring data shall be stored in the data management system developed pursuant to Section 352.6. A copy of the monitoring data shall be included in the Annual Report and submitted electronically on forms provided by the Department.

Applicable data collected from the SGMA Monitoring Network will be uploaded to the Basin DMS, and data for the RMSs will be reported to the DWR in accordance with the Monitoring Protocols developed for the Basin. Additional data collected as part of other regular monitoring programs implemented within the Basin (see ***Section 5.2.1 Existing Monitoring Programs****)* may be used in conjunction with data collected from the SGMA Monitoring Network to meet compliance with the 23 CCR regarding Annual Reporting (23 CCR § 356.2) or as otherwise deemed necessary by the White Wolf GSA.



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- RMW-WL
- MW-WL

Disadvantaged Communities

- Severely Disadvantaged Communities
- Disadvantaged Communities

Land Use

- Agricultural Land
- Developed
- Grazing
- Mining
- Oil Field
- Conservation Easement
- California Protected Areas
- Proposed Grapevine Development

Abbreviations

DWR = California Department of Water Resources
MW-WL = Monitoring Well for Chronic Lowering of Groundwater Levels
RMW-WL = Representative Monitoring Well for Chronic Lowering of Groundwater Levels
SGMA = Sustainable Groundwater Management Act

Notes

1. All locations are approximate.
2. Asterisk (*) denotes wells that are also Monitoring Wells for Degraded Water Quality.
3. Well RMW-WWB-007 is a problematic well for water level measurements.
4. RMW-WLs are designated as the SGMA Monitoring Network. Water level data from RMW-WLs will be collected and submitted to DWR per California Code of Regulations Section 354.34(c)(1)(B) and 354.40.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 20 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Land Use simplified from Figure PA-3 and Figure PA-8.

N

0 3 6

(Scale in Miles)

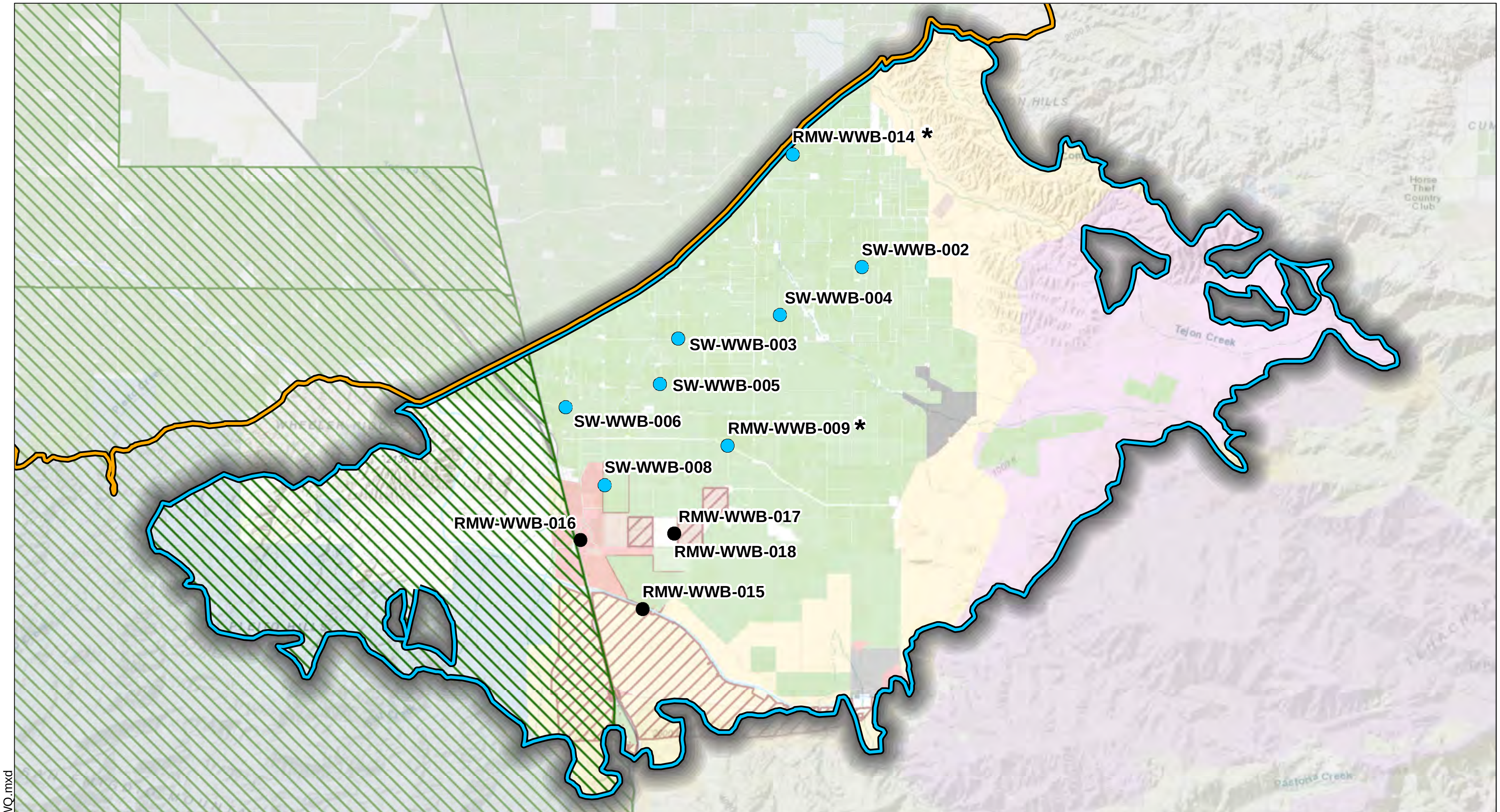
SGMA Monitoring Network for Chronic Lowering of Groundwater Levels

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure MN-1

Path: X:\B50001.05\Maps\GSP\2022\01\FigMN-1_MN-WL.mxd



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- RMW-WQ
- MW-WQ

Disadvantaged Communities

- Severely Disadvantaged Communities
- Disadvantaged Communities

Land Use

- Agricultural Land
- Developed
- Grazing
- Mining
- Oil Field
- Conservation Easement Area
- California Protected Areas
- Proposed Grapevine Development

Abbreviations

DWR = California Department of Water Resources
MW-WQ = Monitoring Well for Degraded Water Quality
RMW-WQ = Representative Monitoring Well for Degraded Water Quality
SGMA = Sustainable Groundwater Management Act

Notes

1. All locations are approximate.
2. Asterisk (*) denotes wells that are also Representative Monitoring Wells for Chronic Lowering of Groundwater Levels.
3. Water quality data from the RMW-WQs will be downloaded and compiled from the Division of Drinking Water. Annual water quality data from MW-WQs will be collected to fill data gaps.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 18 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Land Use simplified from Figure PA-3 and Figure PA-8.

N 0 3 6
(Scale in Miles)

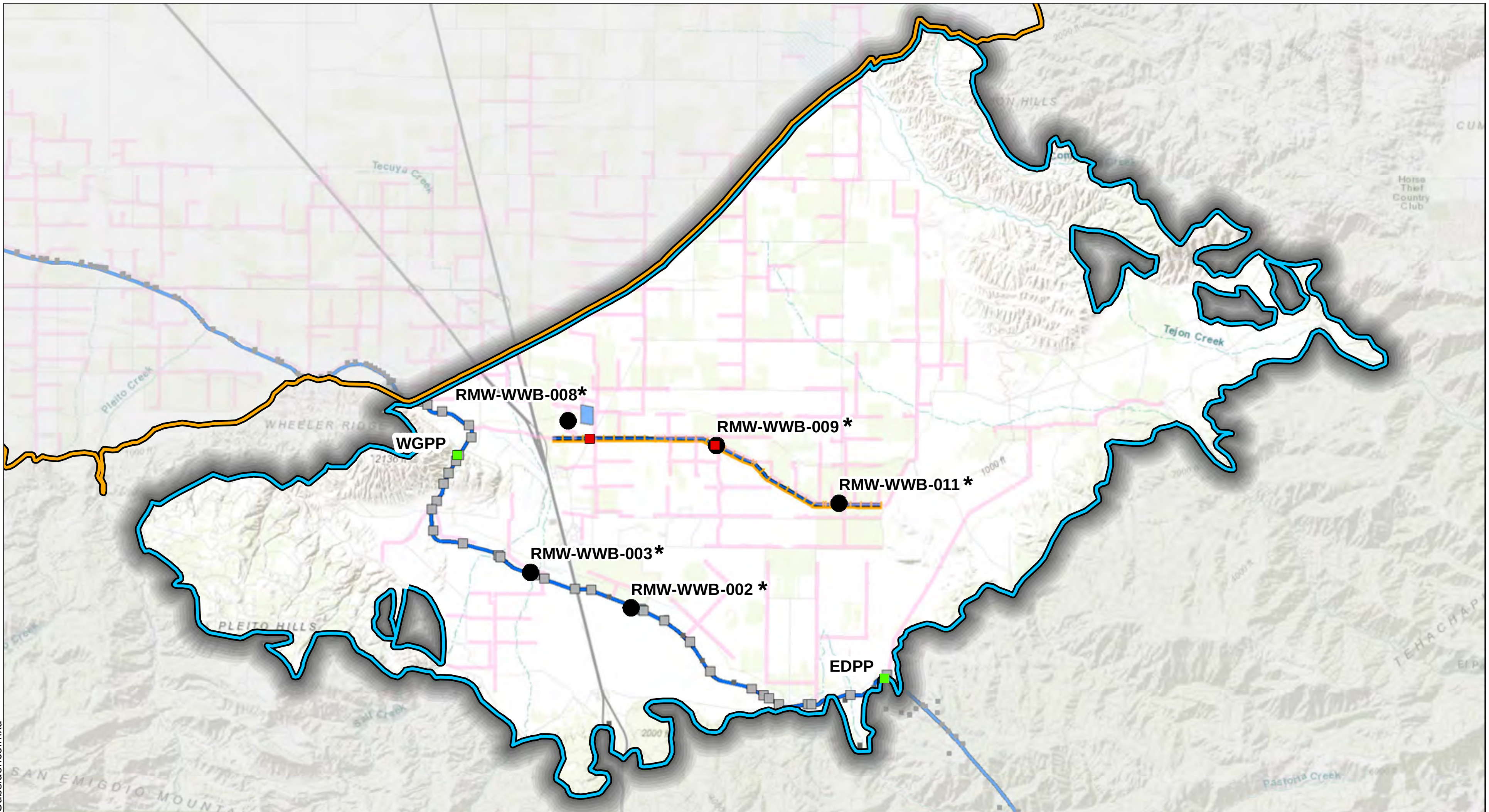
SGMA Monitoring Network for Degraded Water Quality

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure MN-2

Path: X:\B50001.05\Maps\GSP\2022\01\FigMN-2 MN-WQ.mxd



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

Mettler Recharge Project

California Aqueduct

850 Canal

Pipeline

Representative Monitoring Site

Proposed Checkpoint

GPS Subsidence Monitoring Station

DWR Checkpoint

Representative Monitoring Well

Abbreviations

DWR = California Department of Water Resources
GPS = Global Positioning System
SGMA = Sustainable Groundwater Management Ac
UNACVO = University Navstar Consortium

Notes
1. All locations are approximate.
2. Asterisk (*) denotes wells that are also Representative Monitoring Wells for Chronic Lowering of Groundwater Levels.
3. The proposed checkpoints along 850 Canal will be installed at surveying benchmarks located within the pump stations.

Sources
1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 18 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. California Aqueduct location is from the National Hydrography Dataset.
4. GPS subsidence monitoring locations are from UNAVCO's Plate Boundary Observatory database https://www.unavco.org/instrumentation/networks/map/map.html
5. DWR checkpoints received from DWR in response to Public Records Request, 22 July 2019.
6. Mettler Recharge Project from Provost and Pritchard Consulting Group, 2018, "Wheeler Ridge-Maricopa Water Storage District Mettler Groundwater Recharge Project Initial Study/Mitigated Negative Declaration", dated July 2018.

N

0 3 6

(Scale in Miles)

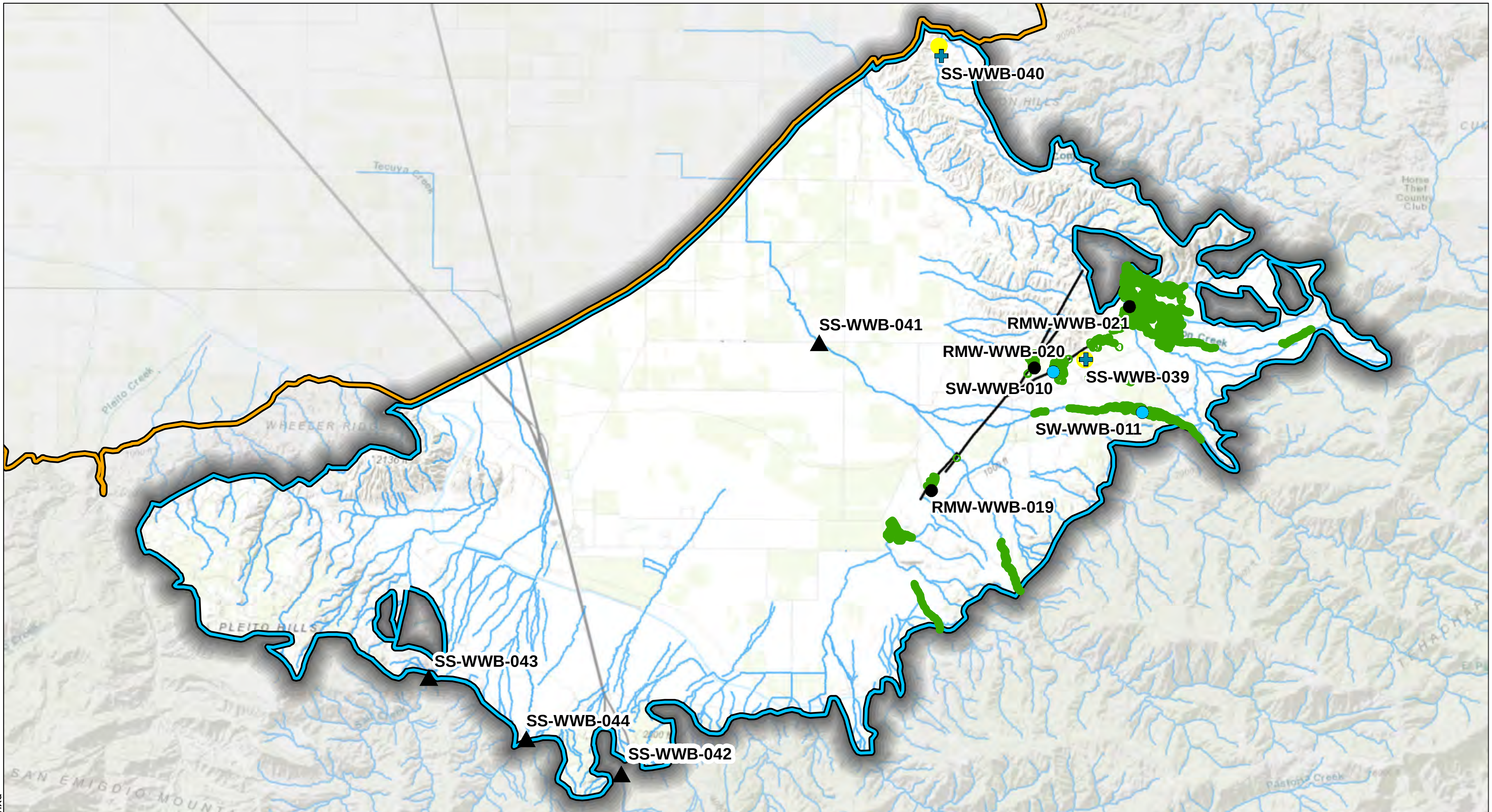
SGMA Monitoring Network for Land Subsidence

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure MN-3

Path: X:\B50001.05\Maps\GSP\2022\01\FigMN-3_MN_Subsidence.mxd



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

GDEs of Interest

B

R

Stream

Springs Fault

RMW-ISW

MW-ISW

Monitoring Gauge

Spring Observation Point

Abbreviations

DWR = California Department of Water Resources
GDE = Groundwater Dependent Ecosystem
MW-ISW = Monitoring Well for Depletion of Interconnected Surface Water
RMW-ISW = Representative Monitoring Well for Depletion of Interconnected Surface Water
SGMA = Sustainable Groundwater Management Act

Notes

1. All locations are approximate.
2. GDEs of interest are those supported by the shallow Quaternary alluvial aquifer upgradient of the Springs Fault ("B") or the Regional Aquifer ("R").
3. RMW-ISWs are designated as the SGMA monitoring network. Water Level data from RMW-ISWs will be collected and submitted to DWR per California Code of Regulations Section 354.34(c)(1)(B) and 354.40. Water level data from RMW-ISWs will be collected to fill data gaps.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 18 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Surface water features from National Hydrography Dataset (https://viewer.nationalmap.gov/basic/).
4. Surface water gauge locations from California Environmental Data Exchange Network (https://ceden.waterboards.ca.gov), Wheeler Ridge-Maricopa Water Storage District, 2018 Memorandum: Gaging Stations - Southern Stream Group– Project Update, and Kern County personal communication 7 January 2019.
5. GDEs of interest shapefile provided by GeoSystems Analysis, Inc., 7 October 2020.

N

0 3 6

(Scale in Miles)

SGMA Monitoring Network for Depletions of Interconnected Surface Water

eki environment & water

White Wolf GSA
Kern County, California
December 2021
B50001.05

Figure MN-4

Path: X:\B50001.05\Maps\GSP\2022\01\FigMN-4 ISW.mxd

PROJECTS AND MANAGEMENT ACTIONS

18. PROJECTS AND MANAGEMENT ACTIONS

> *§ 354.42. Introduction to Projects and Management Actions*
> *This Subarticle describes the criteria for projects and management actions to be included in a Plan to meet the sustainability goal for the basin in a manner that can be maintained over the planning and implementation horizon.*

This section presents the Projects and Management Actions (P/MAs) proposed to support achievement of the Sustainability Goal within the White Wolf Subbasin (Basin). The P/MAs were developed using a portfolio approach whereby individual P/MAs were identified and grouped into categories based on their expected benefits. Implementation of P/MAs within those benefit categories is estimated to occur along a "glide path" that will result in closing of the currently identified storage deficit under the 2030 Climate Change Scenario by the January 2042 Groundwater Sustainability Plan (GSP) implementation deadline (see ***Section 9.4.4 Projected Water Budget Results***). The proposed P/MAs thus represent a path to achieve the Sustainability Goal for the Basin, as further demonstrated by results from the White Wolf Groundwater Flow Model (WWGFM) that projects that groundwater levels will be stable to increasing when the P/MAs are implemented. This approach allows for the flexible implementation of P/MAs as needed to address future conditions throughout the 50-year GSP planning and implementation horizon (i.e., out to 2072).

To the extent that information was available, the P/MAs presented herein were developed with consideration of costs, benefits, and feasibility; however, each P/MA will require significant further evaluation (i.e., engineering, economic, environmental, legal, etc.) as part of implementation. In addition to the P/MAs presented herein, the White Wolf Groundwater Sustainability Agency (GSA) will continue to conduct data gap filling activities as part of Plan Implementation that may include, but are not limited to: (1) collecting and analyzing additional data related to aquifer conditions and properties (e.g., aquifer tests, water level measurements, and water quality data), (2) refining the water budget parameters based on additional data and modeling, and (3) conducting additional data compilation and analysis of relevant Basin information (see ***Section 19 Plan Implementation***).

This section presents the goals and objectives of the P/MAs, including the relevant Sustainability Indicators and the categories of expected benefits from P/MA implementation. A list of specific P/MAs grouped by benefit category and type is presented and summarized in **Table PMA-1** (detailed P/MA Information Forms are included in ***Appendix N***). Finally, an explanation is provided for how the P/MAs address the following:

- Sustainability Indicators and Undesirable Results (e.g., water levels or water quality);
- Potentially applicable permitting and regulatory requirements;

- P/MA status and implementation timeline;
- Expected benefits and how benefits will be evaluated;
- Sources of outside water that will be relied upon for P/MA implementation;
- Legal authority required to implement the P/MAs; and
- Summary of estimated costs and how the GSA plans to fund P/MA implementation.

18.1. Goals and Objectives of Projects and Management Actions

18.1.1. Relevant Sustainability Indicators

Per the California Code of Regulations Title 23 (23 CCR) § 354.44, GSPs must include P/MAs to address any existing or potential future Undesirable Results for the identified relevant Sustainability Indicators. Projected conditions for the Basin suggest that Sustainable Management Criteria (SMCs) may be exceeded for the Chronic Lowering of Groundwater Levels Sustainability Indicator. Accordingly, the P/MAs are currently directed towards avoiding projected Undesirable Results from the Chronic Lowering of Groundwater Levels.

Additionally, as discussed in ***Sections 13** to **15***, the other relevant Sustainability Indicators in the Basin also include: Reduction of Groundwater Storage, Land Subsidence, Degraded Water Quality, and Depletions of Interconnected Surface Waters. The SMCs for Reduction of Groundwater Storage and Land Subsidence utilize groundwater levels as proxy, and therefore are also protected by avoiding Chronic Lowering of Groundwater Levels. Furthermore, the SMCs for Depletions of Interconnected Surface Waters utilize groundwater levels from a shallow monitoring network as proxy for avoiding Undesirable Results. While not used as a direct proxy, avoiding Undesirable Results from Chronic Lowering of Groundwater Levels likely supports efforts to avoid Undesirable Results related to Degraded Water Quality. For example, avoiding Undesirable Results from lower water levels may also protect against water quality changes that might occur due to alterations in vertical and horizontal groundwater-flow gradients. As summarized in **Table PMA-1**, each P/MA addresses one or more of these applicable Sustainability Indicators.

18.1.2. Benefit Categories

The primary water management "tools" by which GSAs can address conditions that may lead to Undesirable Results associated with water quantity (e.g., Chronic Lowering of Groundwater Levels and Reduction of Groundwater Storage) pertain to management of water inflows (supplies) and outflows (demands). Therefore, the primary categories of expected benefits from P/MAs include:

1) Water supply augmentation, including
    a. Develop or obtain new and/or wet year supplies
    b. Recapture cross-boundary flows
    c. Expand in-lieu recharge

d. Increase surface storage capacity and/or delivery flexibility

2) Water demand reduction, and
3) "Other" P/MAs

In addition, some of the P/MAs also have secondary benefits, such as flood control, water management flexibility/efficiency, environmental benefits, and data gap filling.

18.2. List of Projects and Management Actions

§ 354.44. Projects and Management Actions

(b) Each Plan shall include a description of the projects and management actions that include the following:

(1) A list of projects and management actions proposed in the Plan with a description of the measurable objective that is expected to benefit from the project or management action. The list shall include projects and management actions that may be utilized to meet interim milestones, the exceedance of minimum thresholds, or where undesirable results have occurred or are imminent. The Plan shall include the following:

(A) A description of the circumstances under which projects or management actions shall be implemented, the criteria that would trigger implementation and termination of projects or management actions, and the process by which the Agency shall determine that conditions requiring the implementation of particular projects or management actions have occurred.

(B) The process by which the Agency shall provide notice to the public and other agencies that the implementation of projects or management actions is being considered or has been implemented, including a description of the actions to be taken.

This section provides a list of the P/MAs preliminarily identified by the White Wolf GSA. Specific details of the P/MAs are provided in **Table PMA-1** and in the P/MA information forms included in ***Appendix N.*** **Figure PMA-1** shows the approximate locations of these P/MAs.

Each GSA member district has identified P/MAs, some combination of which will be implemented. At this time, the White Wolf GSA acknowledges that details pertaining to which P/MAs will ultimately be initiated, P/MA timing, projected benefits, payments and cost allocations, etc. will be negotiated as part of P/MA and GSP implementation. Each P/MA will have a distinct implementation process depending on lead agency and the details will be determined on a case-by-case basis and may differ depending upon observed conditions in the Basin, available opportunities, and the particulars of each district.

18.2.1. Water Supply Augmentation Projects

18.2.1.1. Projects to Develop or Obtain New and/or Wet Year Supplies

P/MA #1. Recharge from Grapevine Development

The Grapevine Development will be annexed into and receive water and wastewater treatment service from Tejon-Castac Water District (TCWD). Water sources for the development include up to 6,693 acre-feet per year (AFY) of Nickel Agreement water from the Kern River which will be imported through the Tupman Turnout on the California Aqueduct (EKI, 2015). The imported surface water will primarily be used for potable demand, but will also supplement non-potable outdoor demand that exceeds the available recycled water supply. It is anticipated there will be approximately 2,000 AFY of recycled water available for use to meet outdoor water demand (EKI, 2015). Some of this water is expected to recharge the groundwater system from distribution system leakage and infiltration from outdoor watering applications.

Modeling of the Grapevine Development assumes a break-ground date of October 2026 and six phases of build-out, with full build-out completed by 2046. It is estimated that P/MA #1, if implemented as modeled (see ***Section 9.4.3.4 Projected 2030 Climate Change with Grapevine Development P/MA Scenario*** for details), could increase groundwater recharge to the Basin by an average of 600 AFY through 2072.

P/MA #2. Oilfield Reclaimed Water from the Tejon Oil Field

Reclaiming water from oil production facilities ("produced water") is currently an untapped water source in the TCWD service area. Tejon Oil Field has a yield of approximately 20,000 barrels per day of produced water, or approximately 940 AFY (1.3 cubic feet per second [cfs]). In cooperation with California Resources Corporation (CRC), TCWD conducted a Phase 1 pilot study in 2015 to assess the feasibility of treating produced water to applicable water quality standards for pumping into the California Aqueduct. The Phase 1 study results indicated that treated produced water was able to meet drinking water standards for the constituents analyzed; however, a few constituents exceeded the background quality of the California Aqueduct (e.g., bromide). A Phase 2 Pilot Treatment Plant Study is recommended to further refine the treatment process to meet all current drinking water standards and agricultural water quality objectives (e.g., for boron).

A major benefit of produced water is that it is available year-round irrespective of climatic conditions. Treated produced water could be pumped into existing water conveyance and distribution system infrastructure (e.g., 850 Canal for blending and distribution by Wheeler Ridge-Maricopa Water Storage District [WRMWSD] or pumped into the California Aqueduct) and either delivered to serve irrigation demands in-lieu of groundwater pumping or utilized for recharge projects (e.g., at the Mettler recharge facility, see P/MA #7, or along El Paso Creek, see P/MA #9). After treatment, it is estimated that P/MA #2 could increase total available supplies by 940 AFY. Furthermore, as a secondary benefit, recharging groundwater with the treated, high-quality produced water would potentially improve water quality within the 850 Canal and/or beneath the recharge area.

P/MA #3. Oilfield Reclaimed Water in AEWSD

Reclaiming water from oil production facilities ("produced water") for irrigation purposes is currently an untapped water source in Arvin-Edison Water Storage District (AEWSD). After treatment and cooling, water could be pumped into AEWSD facilities to serve irrigation demands in-lieu of groundwater pumping. It is estimated that P/MA #3 could increase total available AEWSD supplies by 1,000 AFY, some of which would be utilized to meet demands in the Basin. For the purposes of this GSP, it is assumed that approximately 300 AFY could be distributed to the Basin between 2042 and 2070.

P/MA #4. Purchase Additional Surface Water Supplies

All White Wolf GSA member districts continually seek to purchase additional surface water supplies, as available, including unused allocations of wet year Central Valley Project (CVP) water, SWP water, or high flow Kern River supplies or transfer/exchange agreements with out-of-basin entities. For example, TCWD, WRMWSD, and others have recently signed an agreement with Patterson Irrigation District in which approximately 500 AFY of water will be available to supplement existing surface water supplies. The exact amount of available increased surface water supplies varies by water year. In general, these surface water supplies would most likely be available during wet years. Expected benefits would be increases in deliveries to growers during wet years to minimize reliance on groundwater pumping (e.g., in-lieu recharge) or storage in existing or planned recharge basins for later use.

P/MA #5. WRMWSD "Thru Delta" Facility

WRMWSD is actively participating in planning efforts surrounding a "Thru Delta" Facility. This is a State-led effort to increase SWP water reliability with a projected supply benefit for WRMWSD of up to 25,000 AFY upon Cal WaterFix Project completion (anticipated 2035).

P/MA #6. WRMWSD Desalination Facility

WRMWSD is planning to develop a facility whereby poor-quality groundwater (i.e., high in total dissolved solids) that is encountered in areas of poor water quality for beneficial use will be treated to a point where it is usable for agricultural use. This previously unused groundwater source will be used to supplement irrigation supply.

18.2.1.2. Projects to Recapture Cross-Boundary Flows

P/MA #7. Recapture of Basin Groundwater

As discussed in ***Section 8.2.2 Long-Term Groundwater Elevation Trends***, the work that the White Wolf GSA member districts have done to import surface water into the Basin has caused water levels to increase and stabilize relative to historical lows. These elevated water levels have resulted in an outflow across the Basin boundary of approximately 9,000 AFY. To recapture this water that has been added to the Basin, the GSA will consider either installing a line of pumping wells along the White Wolf Fault (WWF) or increasing the use of existing private pumping wells along the WWF. Details on the utilization and/or installation of wells will need to be assessed and selected during P/MA planning.

18.2.1.3. Project to Expand In-Lieu Recharge

P/MA #8. WRMWSD Mettler Recharge Project

The Mettler Recharge Project would entail the operation and maintenance of a 60-acre groundwater recharge facility for the artificial recharge of available surface water to groundwater for later use by WRMWSD. The Metter recharge facility was constructed in 2019 and is connected to the 850 Canal near the existing PA-1 pumping plant. The project would deliver surface water imported from unused allocations of CVP and SWP water, as well as high flow Kern River supplies that may become available, to the recharge basin via gravity flow from the 850 Canal (Provost & Prichard, 2018). Another potential source of water for recharge is treated produced water (P/MA #2), recaptured water (P/MA #7), or other unused allocations of wet year CVP water, SWP water, or high flow Kern River supplies (P/MA #4). According to the Mitigated Negative Declaration (MND), the Project is anticipated to recharge up to 36,000 AFY into the aquifer, assuming that the water supply was available (Provost & Prichard, 2018).

P/MA #9. WRMWSD El Paso Creek Recharge Project

The El Paso Creek Recharge Project is an artificial recharge project along El Paso Creek in which water would be gravity fed through mostly existing conveyance pipelines to conduct in-stream and off-stream recharge on adjacent native vegetation lands. Phase 1 would entail utilizing check structures to encourage in-stream recharge through the permeable stream bed sediments. Phase 1 infiltration rates are estimated at approximately 145 AF per day (up to 17,400 AFY if enough supplies are available). Phase 2 would entail utilizing off-stream recharge ponds developed on existing native lands adjacent to El Paso Creek. Phase 2 infiltration rates are estimated at approximately 125 AF per day (up to 15,000 AFY if enough supplies are available). Potential water supplies include recaptured water (P/MA #7), treated produced water (P/MA #2), and other unused allocations of wet year CVP water, SWP water, or high flow Kern River supplies (P/MA #4).

Upon completion of both phases, the total recharge capacity is estimated to be up to 32,400 AFY. Additional potential benefits of the project include: (a) utilizing the recaptured for direct recharge into the Basin, (b) minimizing new facilities, (c) to the extent in-stream recharge can replenish Basin groundwater, irrigated lands taken out of production are minimized, and (d) except for lifting water into the 850 Canal and pumping groundwater to the surface, the conveyance system works by gravity thereby minimizing energy consumption and operational expenses.

P/MA #10. AEWSD In-Lieu Banking Program

With the In-lieu Banking Program, AEWSD will supply surface water when available through new facilities to the Groundwater Service Area within AEWSD with the intent of reducing AEWSD-wide groundwater use. However, when surface water is in short supply and under agreement, the landowners could recover and return groundwater from their own wells to the AEWSD canal system through new pipelines once they have satisfied their own water needs. As a part of the program, District landowners could provide their wells for overall AEWSD operations and in return AEWSD would provide the landowners surface water during times of available supplies.

The total expected benefits of P/MA #10 are dependent upon the service area. The approximate yield would be 1.2 acre-feet per acre (AF/acre). Assuming an approximate total District-wide service area of 5,000 acres could provide 15,000 AF, resulting in a yield of 6,000 AFY; however, it is unknown how many of these acres will fall within the Basin. As a secondary benefit, considering AEWSD is a participant in the Power and Water Resources Pooling Authority (PWRPA), there is potential for a landowner to be eligible to receive PWRPA power instead of current PG&E service. Connections to WRMWSD may also allow for use of other local recharge facilities.

P/MA #11. AEWSD Private & Caltrans Basin Connections

There are multiple on-farm private basins and some Caltrans sumps near AEWSD facilities that could be connected by gravity pipeline and utilized for groundwater recharge and floodwater capture. Depending on number of basin connections, the expected total benefits range from approximately 50 to 500 AFY across the entire AEWSD service area.

18.2.1.4. Projects to Increase Surface Storage Capacity/Delivery Flexibility

P/MA #12. AEWSD South Canal WRMWSD 850 Canal Intertie

To facilitate water exchanges between AEWSD and WRMWSD, P/MA #12 would either improve existing interties and/or construct new interties between AEWSD's South Canal and WRMWSD's 850 Canal. Many existing and potential future water exchange and banking programs benefiting the two districts and their banking and exchange partners in Kern County and Southern California depend upon successful construction and operation of the project. Primary benefits of the project are improved water supplies and operational efficiency. Ancillary benefits include water quality improvements for SWP customers, floodplain management in Kern County and other areas in the San Joaquin Valley, and assisting in exchanges between other conveyance facilities in the near vicinity (i.e., California Aqueduct). The expected benefit would be increased delivery flexibility and transfer/exchange potential of up to approximately 24,000 AF across the entire AEWSD service area.

P/MA #13. AEWSD South Canal Balancing Reservoir Project

AEWSD is in need of additional infrastructure to allow water storage and regulation of flow mismatches in its canal system during operation or emergencies (e.g., a local/global power outage in one or more pumping plants). This infrastructure is most needed in the lower third of the canal system. Additional storage may also allow AEWSD to better match available surface water supply to its peak irrigation season demands and groundwater supply (i.e., well capacity) to demands any time of year, both of which will increase water supply for the year. Additional in-District storage will also provide delivery flexibility to on-farm users and may allow increased water ordering and delivery flexibility (more variable rate and duration allowed with shorter notice vs. now). This will benefit customers District-wide and result in improved water use efficiency and increased crop yields and quality. Ancillary floodplain management benefits would result from additional ability to capture and store floodwaters. Depending on the selected location, the expected benefit is approximately 500 AF across the entire AEWSD service area.

18.2.2. Water Demand Reduction Management Actions

The Management Actions listed below have water demand reduction as their primary expected benefit and include Management Actions / Policies to Reduce Overall Water Demand and Management Actions / Policies to Reduce Groundwater Pumping.

P/MA #14. AEWSD Groundwater Subsidies for Land Conversion

AEWSD may adopt a management action to provide subsidies to incentivize groundwater users to convert land to alternative land uses and reduce groundwater extractions. The subsidy program would be voluntary, and subsidies could be provided to growers willing to implement one or more of the following:

- Change crop type to one with lower water demand;
- Rotate crops and temporarily fallow portions of their irrigated acreage to reduce water demand;
- Retire, or permanently fallow, land for alternative uses such as solar arrays or upland habitat creation; and/or
- Recharge/regulation basin infrastructure for increased surface water use and recharge.

Expected benefits are based on land use conversion, where fallowed lands (either temporary or permanent) would yield approximately 2.75 AF/ac, agricultural lands converted to a recharge/regulation basin would yield approximately 2.75 AF/ac, and permanent crops converted to annual crops would yield approximately 0.5-1.0 AF/ac. However, currently the number of willing participates are unknown and therefore the expected benefits to the groundwater system would need to be quantified once a better estimate of willing participates is available. A secondary benefit is potential renewable energy and habitat creation.

P/MA #15. WRMWSD Land Retirement and/or Conversion

WRMWSD may purchase and permanently fallow previously irrigated acreage within the WRMWSD service area to reduce overall water demand and groundwater extractions. Expected water saving benefits are approximately 2.75 AF/ac. The number of irrigated parcels in which landowners would be willing to sell is currently unknown.

P/MA #16. AEWSD Groundwater Allocation per Acre

AEWSD may adopt a program which provides a finite groundwater allocation on a per acre basis. The policy would identify and forecast the demands associated with prior rights, domestic and environmental uses. AEWSD, through collaboration with its users and beneficial users, may consider whether an equal-, reduced-, or zero-allocation is given to lands with unexercised groundwater rights. The goals of the groundwater allocation are to ensure a fair groundwater allocation and extract groundwater in a sustainable manner. See detailed P/MA information form in ***Appendix N*** for more details. P/MA #16 alone may not generate a quantifiable demand reduction. However, it would serve other management actions and encourage growers to implement water conservation Best Management Practices (BMPs).

P/MA #17. AEWSD Groundwater Fee Increase

AEWSD may adopt a management action to increase Groundwater Service Area costs to incentivize groundwater users to reduce groundwater extractions and take surface water when available. The potential fee structures would affect groundwater users differently, so a composite fee structure may also be considered. The expected benefits would be tied to P/MA #16 and P/MA #23. This P/MA can potentially mitigate local overdraft by incentivizing groundwater extractors to reduce pumping or pump groundwater supplies in a sustainable fashion. Ancillary benefits include additional funds for investment in other P/MAs.

P/MA #18. AEWSD Groundwater Marketing & Trading

Once P/MA #16 and P/MA #23 have been adopted, AEWSD would pursue a groundwater market and trading program to provide users and beneficial users more flexibility in utilizing their allocation. AEWSD may also adopt a policy to define a groundwater banking program. The banking program would consider using surface water supplies when available in lieu of groundwater pumping. Though not feasible for all users, growers capable of surface water recharge on-farm may be able to percolate floodwater, or other transferred water, for recharge credits. There are many complexities and considerations required to initiate and successfully manage a banking program; see detailed P/MA information form in ***Appendix N*** for AEWSD considerations. Trading may be executed through short-and long-term leases, permanent transfers, inter-annual water exchanges, or dry-year option contracts. Expected benefits of P/MA #18 include improved flexibility to groundwater users when other management actions are adopted, such as groundwater fees and pumping restrictions.

P/MA #19. WRMWSD Groundwater Allocation and Market

WRMWSD may develop a groundwater pumping allocation methodology, including a market system for trading and/or transferring of allocations between water users.

P/MA #20. WRMWSD Voluntary Pumping Limitations

WRMWSD may set non-binding pumping limitations in conjunction with a fee for pumping above limits. P/MA #20 has the capacity to reduce water demand across WRMWSD's service area by up to 21,000 AFY.

P/MA #21. WRMWSD Mandatory Pumping Limitations

WRMWSD may set binding pumping limitations in conjunction with a fee for pumping above limits. P/MA #21 has the capacity to reduce water demand across WRMWSD's service area by up to 21,000 AFY.

18.2.3. "Other" P/MAs

As mentioned above, other GSA member District specific P/MAs are included below. Detailed information for each P/MA can be found in **Table PMA-1** and ***Appendix N***.

P/MA #22. Improved Stormwater Management and Flood Control in AEWSD

AEWSD's canal system requires modifications/improvements to comply with storm runoff pollution prevention. Additionally, there is a need to modify old and build new facilities for flood protection from intermittent creeks (e.g., Tejon Creek, El Paso Creek, their tributaries and others).

P/MA #23. AEWSD Groundwater Extraction Quantification Method

AEWSD may adopt a policy to specify the approved method or methods to quantify the individual and aggregate groundwater extractions for the required Sustainable Groundwater Management Act (SGMA) annual reporting. AEWSD may consider a variety or combination of quantification methods; see detailed P/MA information form in ***Appendix N*** for details. Expected benefits would be better quantification of groundwater extractions, thereby allowing the GSA to make more informed decisions about current groundwater conditions and water management in future GSP updates.

P/MA #24. WRMWSD Acreage Assessment

WRMWSD may set a policy to implement an acreage assessment to fund purchases of additional supplies, purchase of land for fallowing, and other investments to support SGMA compliance. The funds generated from could be used to finance other P/MAs.

Table PMA-1. Details of Projects and Management Actions

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Depletions of Interconnected Surface Water	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable / Circumstances for Initiation
Projects to Develop or Obtain New and/or Wet Year Supplies											
1	**Recharge from Grapevine Development**	The Grapevine Development will consist of approximately 4,778 acres at full build out and will include a combination of residential, commercial, industrial, agricultural, grazing, and open space land uses. Nickel Agreement SWP and Kern River water will be imported to supply the potable demand incurred by the Grapevine Development. Treated recycled water will be available for meeting most non-potable landscape irrigation demands.	x				To be implemented upon initiation of Grapevine construction	Public meetings	CEQA (completed); SWRCB Waste Discharge Requirements; coordination with Kern County and the State	CEQA completed	Estimated to initiate around 2026-2027
2	**Oilfield Reclaimed Water from the Tejon Oil Field**	Tejon Oil Field has a yield of approximately 20,000 barrels per day of produced water, or approximately 940 AFY (1.3 cubic feet per second [cfs]). In cooperation with California Resources Corporation (CRC), TCWD conducted a Phase 1 pilot study in 2015 to assess the feasibility of treating produced water to applicable water quality standards for pumping into the California Aqueduct. The treatment system initially included filtration, activated carbon and reverse osmosis, but mid-way through the pilot test, a walnut shell filter was added as a pretreatment step. The Phase 1 study results indicated that treated produced water was able to meet drinking water standards for the constituents analyzed; however, a few constituents exceeded the background quality of the California Aqueduct (e.g., bromide). A Phase 2 Pilot Treatment Plant Study is recommended to further refine the treatment process to meet all current drinking water standards and agricultural water quality objectives (e.g., for boron).	x	x			Upon completion of Pilot test, approximately by 2024	Public meetings	TBD	Not yet initiated	Upon grant funding & upon completion of Pilot test by 2024
3	**Oilfield Reclaimed Water in AEWSD**	Reclaiming water from oil production facilities for irrigation purposes is currently an untapped water source in AEWSD. After treatment and cooling, produced water could be pumped into AEWSD facilities to serve irrigation demands in-lieu of groundwater pumping.	x	x			To be implemented upon agreement with partnering oil field	Public meetings	TBD	Not yet initiated	Upon agreement with oil field producers
4	**Purchase Additional Surface Water Supplies**	Continual pursuit of additional surface water supplies via transfers, exchanges, and/or purchases with out-of-Basin entities. Supplies would generally be available during wet years.	x				Ongoing	Regular District Board meetings		Ongoing	Ongoing
5	**WRMWSD "Thru Delta" Facility**	WRMWSD is participating in planning efforts surrounding a "Thru Delta" Facility to increase access to contracted SWP water supplies.	x	x	x		State-led effort underway	Prop 218	CEQA	State-led effort underway	Underway
6	**WRMWSD Desalination Facility**	Desalination facilities to allow for use of additional poor quality groundwater for agricultural use, thereby easing demand on the principal aquifer.	x	x	x		Localized pumping lowering GW levels near MT	Regular District Board meetings	CEQA	Not yet initiated	TBD

Table PMA-1. Details of Projects and Management Actions

				Expected Benefits										
				Primary		Secondary						Estimated Costs		
P/MA Number	P/MA Name	Timetable for Completion	Timetable for Accrual of Expected Benefits	Water Supply Augmentation	Water Demand Reduction	Water Quality Improvement	Flood Control	Water Management Flexibility / Efficiency	Data Gap Filling/ Monitoring	Source(s) of Water, if applicable	Legal Authority Required	One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Projects to Develop or Obtain New and/or Wet Year Supplies														
1	**Recharge from Grapevine Development**	Phased over at least 19 years	Immediately upon project initiation	Approximately 630 AFY of recharge at full build out						SWP and Kern River	None	NA - Costs integrated into development and funded by developer	TBD	TCWD and project developer
2	**Oilfield Reclaimed Water from the Tejon Oil Field**	TBD	Upon project initiation	Approximately 1,000 AFY		x				Oil field produced and treated water	Consistent with White Wolf GSA authority pursuant to CWC Section 10726.2(b)	TBD	TBD	TRC, grants
3	**Oilfield Reclaimed Water in AEWSD**	TBD	1 year after construction	300 AFY assumed available for White Wolf Subbasin		x				Oil field produced water	Consistent with GSA authority pursuant to CWC Section 10726.2(b)	TBD	TBD	AEWSD and partnering oil field
4	**Purchase Additional Surface Water Supplies**	Ongoing	Immediately	Increase water supplies by up to 5,000 AFY		x				Additional imported water supplies from sources like SWP, CVP, and others	Pursuant to AEWSD and WRMWSD's authority as a water storage district; Pursuant to TCWD's authority as a water district	NA	TBD: average costs are approximately $500/AF	AEWSD; TCWD; WRMWSD
5	**WRMWSD "Thru Delta" Facility**	2035	1 year after completion	Up to 25,000 AFY		x				State Water Project	None	NA; as this project would be bundled through SWP, costs would occur on annual bills	TBD; estimates of CalWaterFix Project were >$600/AF	WRMWSD
6	**WRMWSD Desalination Facility**	Construction duration: 1-3 years	immediately upon completion of construction			x				poor quality (currently unused) groundwater	None	NA	Annual costs approx. $600/AF	WRMWSD; grants

Table PMA-1. Details of Projects and Management Actions

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Depletions of Interconnected Surface Water	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable / Circumstances for Initiation
Projects to Recapture Cross-Boundary Flows											
7	**Recapture of Basin Groundwater**	The GSA is considering either installation of a line of pumping wells along the WWF or increased use of existing private pumping wells along the WWF to recapture the water that would otherwise flow out of the Basin. As part of P/MA planning, the GSA will work to quantify the amount of flow across the WWF that is attributed to imported water. Pumped water would be available for distribution and/or use within existing surface water service areas.	x				Interbasin negotiations with Kern County Subbasin	Infrastructure improvement; no public noticing necessary	CEQA; If new wells installed, well permits from Kern County	Not yet initiated	2025
Projects to Expand In-Lieu Recharge											
8	**WRMWSD Mettler Recharge Project**	Operation and maintenance of a 60-acre groundwater recharge facility for the artificial recharge of available surface water to groundwater for later use by WRMWSD.	x				Availability of excess water supplies	Regular District Board meetings	CEQA	Ongoing	Ongoing
9	**WRMWSD El Paso Creek Recharge Project**	The project is an artificial recharge project that uses El Paso Creek, existing and planned pipeline, and planned recharging ponds. The project consists of two phases. Phase 1 will utilize the existing 850D Lateral pipeline to direct water into the El Paso Creek for in-stream recharge with check structures. Phase 2 will involve construction of new recharge pipeline parallel to 850D Lateral and off-stream ponds for recharge. Recharged water can be recovered using existing wells near the recovery pipeline.	x			x	To be implemented upon participant interest, grant funding, and permitting	Regular District Board meetings	CEQA; RWQCB, SWRCB Waste Discharge Requirements	Not yet initiated	
10	**AEWSD In-Lieu Banking Program**	Suppling surface water to landowners that previously relied only on groundwater (GWSA). New infrastructure would have to be built to facilitate the implementation of this program.	x	x			Grant funding	Infrastructure improvement; no public noticing necessary	CEQA; NEPA if federal grant funds are used; SJVAPCD dust control; PWRPA; possible Kern County encroachment permits	Not yet initiated	Upon grant funding
11	**AEWSD Private & Caltrans Basin Connections**	Construction of pipelines to connect several on-farm private basins and Caltrans sumps near AEWSD to utilize for groundwater recharge.	x				To be implemented upon participant interest, grant funding, and permitting	Infrastructure improvement; no public noticing necessary	Caltrans encroachment permitting; CEQA if longer pipeline connections are required; NEPA if federal grant funds are used	Not yet initiated	Upon grant funding
Projects to Increase Surface Storage Capacity / Delivery Flexibility											
12	**AEWSD South Canal WRMWSD 850 Canal Intertie**	Improving existing interties and/or constructing new interties between AEWSD's South Canal and WRMWSD's 850 Canal to facilitate water exchanges between the two districts.	x	x			Completion of feasibility study and design	Infrastructure improvement; no public noticing necessary	CEQA	Not yet initiated	TBD
13	**AEWSD South Canal Balancing Reservoir Project**	Creation of a reservoir to allow water storage and regulation of flow mismatches in the AEWSD canal system during operation or emergencies. Depending on the location, this reservoir would increase storage capacity by ~500 AF.	x				Grant funding, South County flooding response	Infrastructure improvement; no public noticing necessary	CEQA	Not yet initiated	TBD

Table PMA-1. Details of Projects and Management Actions

P/MA Number	P/MA Name	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits: Primary: Water Supply Augmentation	Expected Benefits: Primary: Water Demand Reduction	Expected Benefits: Secondary: Water Quality Improvement	Expected Benefits: Secondary: Flood Control	Expected Benefits: Secondary: Water Management Flexibility / Efficiency	Expected Benefits: Secondary: Data Gap Filling/ Monitoring	Source(s) of Water, if applicable	Legal Authority Required	Estimated Costs: One-time Costs	Estimated Costs: Ongoing Costs (per year)	Estimated Costs: Potential Funding Source(s)
Projects to Recapture Cross-Boundary Flows														
7	**Recapture of Basin Groundwater**	TBD	Immediately upon completion	Recapture an average of 8000 AFY					x	Imported surface water that has infiltrated into the Basin	Consistent with White Wolf GSA authority pursuant to CWC Section 10726.2(b)	TBD	TBD	GSA, grants
Projects to Expand In-Lieu Recharge														
8	**WRMWSD Mettler Recharge Project**	Completed in 2019	First wet year after application	Up to 36,000 AFY of recharge						Unused imported water supplies, high flow Kern River supplies, or treated oil field produced water (P/MA #2)	None			WRMWSD
9	**WRMWSD El Paso Creek Recharge Project**		Upon project initiation	Dependent on operating days, approximately 32,400 AFY (17,400 AFY from Phase 1 and 15,000 AFY from Phase 2)			x			Recaptured groundwater (P/MA #4)	Consistent with White Wolf GSA authority pursuant to CWC Section 10726.2(b)			
10	**AEWSD In-Lieu Banking Program**	TBD	1-3 years after completion	Dependent on service area; approximate yield of 1.2 AFY/ac		x				Additional wet-year imported water supplies	None	$1M - $10M	$5k	AEWSD
11	**AEWSD Private & Caltrans Basin Connections**	Construction duration: within 5 years	1-3 years after construction	50 - 500 AFY of recharge						Additional wet-year imported water supplies; Local stormwater	None	$100K - $500K	Not applicable	AEWSD, grants
Projects to Increase Surface Storage Capacity / Delivery Flexibility														
12	**AEWSD South Canal WRMWSD 850 Canal Intertie**	TBD	1 year after construction	Transfer/exchange potential of up to approximately 24,000 AF		x		x		Existing sources	None	$15M	$40K	AEWSD and WRMWSD
13	**AEWSD South Canal Balancing Reservoir Project**	TBD	1-3 years after construction	500 AF of increased storage capacity			x	x		Additional wet-year imported water supplies	None	$1M - $10M	~$5k	AEWSD and partnering agencies

Table PMA-1. Details of Projects and Management Actions

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Depletions of Interconnected Surface Water	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable / Circumstances for Initiation
Water Demand Reduction Management Actions											
14	**AEWSD Groundwater Subsidies for Land Conversion**	The District may adopt a management action to provide subsidies to incentivize groundwater users to convert land to alternative land uses and reduce groundwater extractions. The District may consider a subsidy structure study to determine which subsidies would result in the greatest expected annual benefit in acre-feet per year.	x		x		As needed to meet milestones, if other new supplies are not developed as anticipated	District flyers, direct mail, public meetings	None	Not yet initiated	3-5 years after GSP adoption
15	**WRMWSD Land Retirement and/or Conversion**	Purchase and permanently fallow previously irrigated acreage to reduce overall water demand and groundwater extractions.	x		x		If other P/MAs are insufficient	Prop 218	CEQA	Not yet initiated	2035
16	**AEWSD Groundwater Allocation per Acre**	The District may adopt a program which provides a finite groundwater allocation on a per acre basis. The policy would identify and forecast the demands associated with prior rights, domestic, and environmental uses. The sustainable yield and ultimate groundwater allocation would take into consideration the existing water rights holders and applicable beneficial uses and users of groundwater. Once an individual groundwater allocation is determined, the District may adopt a policy which provides a gradual “ramp-down” allocation decrease over time to arrive at the actual groundwater allocation to allow growers time to adjust to the concept of an allocation and, for some growers, a reduction in groundwater use. The policy would detail the number of years and amount of reduction each year. The District may adopt a policy which describes an "adaptive management" approach, whereby the groundwater allocation may be reviewed, changed, and reestablished every 5 years or during extreme drought as necessary to achieve long term sustainability.	x		x		As needed to meet milestones, if other new supplies are not developed as anticipated	District flyers, direct mail, public meetings	GSA adoption of resolution	Not yet initiated	3-5 years after GSP adoption
17	**AEWSD Groundwater Fee Increase**	The District may adopt a management action to increase GWSA costs to incentivize groundwater users to reduce groundwater extractions and take surface water when available. The District may consider modifying its fee structure study to determine the best strategy for curbing groundwater overdraft without causing inequitable economic impact. The potential fee structures would affect groundwater users differently, so a composite fee structure may also be considered.	x		x		As needed to meet milestones, if other new supplies are not developed as anticipated	District flyers, direct mail, public meetings	GSA adoption of resolution	Not yet initiated	3-5 years after GSP adoption
18	**AEWSD Groundwater Market and Trading**	Contingent on the groundwater extraction quantification and allocation programs, AEWSD would pursue a groundwater market and trading program to provide uses and beneficial users more flexibility in utilizing a groundwater allocation. The District may adopt a policy to define groundwater trading program, acknowledging that many complexities and considerations required to successfully initiate and manage a trading program may arise. The District may adopt a policy to define a groundwater banking program, which would consider using surface water supplies when available in lieu of groundwater pumping. The District should discuss any other water bank/credit systems in existence. The District may adopt a groundwater trading structure and consider a variety of structures including: (1) Bilateral contracts or "coffee shop" markets; (2) Brokerage; (3) Bulletin boards; (4) Auctions and reverse auctions; (5) Electronic clearing-houses or "smart markets"; and (6) Other trade structures.	x		x		Contingent on P/MAs 16 and 23	District flyers, direct mail, public meetings	GSA adoption of resolution	Not yet initiated	3-5 years after GSP adoption

Table PMA-1. Details of Projects and Management Actions

				Expected Benefits								Estimated Costs		
				Primary		Secondary								
P/MA Number	P/MA Name	Timetable for Completion	Timetable for Accrual of Expected Benefits	Water Supply Augmentation	Water Demand Reduction	Water Quality Improvement	Flood Control	Water Management Flexibility / Efficiency	Data Gap Filling/ Monitoring	Source(s) of Water, if applicable	Legal Authority Required	One-time Costs	Ongoing Costs (per year)	Potential Funding Source(s)
Water Demand Reduction Management Actions														
14	**AEWSD Groundwater Subsidies for Land Conversion**	TBD	1 year after implementation		2.75 AFY/acre of land fallowed or converted to basin, 0.5 - 1.0 AFY/acre of land converted from permanent to annual crop					NA	Consistent with White Wolf GSA authority pursuant to CWC Section 10726.2(b)	$15K - $30K, or around $500 per AF	~$10k - $1M	AEWSD; grants
15	**WRMWSD Land Retirement and/or Conversion**	TBD; Depending on landowner interest	1 year after completion		Up to 21,000 AFY					NA	Consistent with White Wolf GSA authority pursuant to CWC Section 10726.2(b)	Approx. $40K per acre for land purchase (inc. interest); 30 yrs of water savings at 2.75 AFY/ac gives net cost of ~$500 per AF	$250/yr per acre for maintenance	WRMWSD; grants
16	**AEWSD Groundwater Allocation per Acre**	TBD	1-3 years after implementation		Quantity TBD			x		mandatory reduction in district-wide groundwater pumping	Consistent with White Wolf GSA authority pursuant to CWC Section 10726.2(b)	$25K - $100K	Not applicable	AEWSD
17	**AEWSD Groundwater Fee Increase**	Remain indefinitely after implementation or until other programs are enacted	1-3 years after implementation		~2.75 AF/ac fallowed (temporary or permanent), ~2.75 AF/ac converted to basin, ~0.5-1.0 AF/ac permanent to annual crop						Consistent with White Wolf GSA authority pursuant to CWC Section 10726.2(b)	$15K - $30K	Approx. $25k	AEWSD
18	**AEWSD Groundwater Market and Trading**	Remain indefinitely after implementation or until other programs are enacted	1-3 years after implementation					x		NA	Consistent with White Wolf GSA authority pursuant to CWC Section 10726.2(b)	$25K - $100K	Approx. $25k	AEWSD

Table PMA-1. Details of Projects and Management Actions

P/MA Number	P/MA Name	Summary Description	Relevant Sustainability Indicators Affected: Groundwater Levels & Storage	Groundwater Quality	Land Subsidence	Depletions of Interconnected Surface Water	Circumstances for Implementation	Public Noticing Process	Permitting and Regulatory Process Requirements	Status	Timetable / Circumstances for Initiation
19	**WRMWSD Groundwater Allocation and Market**	Develop a groundwater pumping allocation methodology, including a market system for the trading and/or transferring of allocations	x		x		GSP adoption	Regular District Board Meetings	CEQA	Not yet initiated	2022
20	**WRMWSD Voluntary Pumping Limitations**	Set non-binding pumping limitations in conjunction with a fee for pumping above limits.	x		x		GSP adoption	Prop 218	CEQA	Not yet initiated	2030
21	**WRMWSD Mandatory Pumping Limitations**	Set binding pumping limitations in conjunction with a fee for pumping above limits.	x		x		If other P/MAs are insufficient	Prop 218	CEQA	Not yet initiated	2035
"Other" P/MAs											
22	**Improved Stormwater Management and Flood Control in AEWSD**	Potential construction of new sedimentation/detention basins, flood ditch erosion protection, Spillway Basin expansion, lengthening the South Canal's siphon under David Road or extension of the South Canal liner through designated floodplain reaches.	x	x			Grant funding	Infrastructure improvement; no public noticing necessary	CEQA; NEPA if federal grant funds are used; SMARA exemption	Not yet initiated	TBD upon available funding; excessive flooding or further damages may expedite initiation
23	**AEWSD Groundwater Extraction Quantification Method**	Application of a new policy to specify an approved method to quantify the individual and aggregated groundwater extractions for the required SGMA annual reporting. Some methods to consider (or a combination of them) are the following: (1) Irrigated acreage determined by aerial imagery; (2) Irrigated area hybrid determined by annual crop survey alongside aerial imagery; (3) Calibrated energy records; (4) Volumetric flow measurement; (5) Remote sensing of evapotranspiration; (6) Other.	x		x		GSP adoption	District flyers, direct mail, public meetings	GSA adoption of resolution	Not yet initiated	Shortly after GSP adoption
24	**WRMWSD Acreage Assessment**	Set policy to implement an acreage assessment to fund purchase of additional supplies, purchase of land for fallowing, and other investments to support SGMA compliance	x		x		GSP adoption	Prop 218	CEQA	Not yet initiated	2022

Table PMA-1. Details of Projects and Management Actions

P/MA Number	P/MA Name	Timetable for Completion	Timetable for Accrual of Expected Benefits	Expected Benefits: Primary: Water Supply Augmentation	Expected Benefits: Primary: Water Demand Reduction	Expected Benefits: Secondary: Water Quality Improvement	Expected Benefits: Secondary: Flood Control	Expected Benefits: Secondary: Water Management Flexibility / Efficiency	Expected Benefits: Secondary: Data Gap Filling/ Monitoring	Source(s) of Water, if applicable	Legal Authority Required	Estimated Costs: One-time Costs	Estimated Costs: Ongoing Costs (per year)	Estimated Costs: Potential Funding Source(s)
19	**WRMWSD Groundwater Allocation and Market**	Upon modification of water service contracts	1 year after completion					x		NA	Consistent with White Wolf GSA authority pursuant to CWC Section 10726.2(b)	approx. $50K	Minimal	WRMWSD; grants
20	**WRMWSD Voluntary Pumping Limitations**	Upon modification of water service contracts	1-3 years after completion		Up to 21,000 AFY					NA	Consistent with White Wolf GSA authority pursuant to CWC Section 10726.2(b)	approx. $100K	approx. $100,000/yr for monitoring costs; this management action would be used to fund other P/MAs	WRMWSD; grants
21	**WRMWSD Mandatory Pumping Limitations**	2030	1-3 years after completion		Up to 21,000 AFY					NA	Consistent with White Wolf GSA authority pursuant to CWC Section 10726.2(b)	Minimal additional cost beyond Voluntary Pumping Limitations P/MA	Minimal additional cost beyond Voluntary Pumping Limitations P/MA	WRMWSD; grants
"Other" P/MAs														
22	**Improved Stormwater Management and Flood Control in AEWSD**	Construction duration: approx. 1 year	1-3 years after construction	TBD		x	x			Local stormwater	None	$1M - $10M	TBD	AEWSD and partnering agencies
23	**AEWSD Groundwater Extraction Quantification Method**	Remain indefinitely after implementation or until other programs are enacted	1 year after implementation		x			x	x	NA	Consistent with White Wolf GSA authority pursuant to CWC Section 10726.2(b)	$25K - $1M	~$25k	AEWSD
24	**WRMWSD Acreage Assessment**	Upon modification of water service contracts	1-3 years after completion		x					NA	WRMWSD authority as a Water Storage District	approx. $50,000	This management action would be used to fund other P/MAs	WRMWSD; grants

Abbreviations:

AEWSD = Arvin-Edison Water Storage District
AFY = acre-feet per year
AFY/ac = acre-feet per year per acre
CEQA = California Environmental Quality Act
CVP = Central Valley Project
CWC = California Water Code
GSA = Groundwater Sustainability Agency
GSP = Groundwater Sustainability Plan
GWSA = Groundwater Only Service Area
NA = Not Applicable
NEPA = National Environmental Protection Act
P/MA = Project/Management Action
PWRPA = Power and Water Resources Pooling Authority
SGMA = Sustainable Groundwater Management Act
SMARA = Surface Mining and Reclamation Act
SJVAPCD = San Joaquin Valley Air Pollution Control District
SWP = State Water Project
SWRCB = State Water Resources Control Board
TBD = to be determined
TCWD = Tejon-Castac Water District
WRMWSD = Wheeler Ridge-Maricopa Water Storage District
WWF = White Wolf Fault

Notes:

(a) Summary table developed based off information provided by AEWSD, WRMWSD, and TCWD.

18.3. Circumstances for Implementation

This section describes the circumstances under which P/MAs shall be implemented, the criteria that would trigger implementation and termination of P/MAs, and the process by which the GSA determines conditions requiring the implementation of P/MAs have occurred.

As stated above, the goals and objectives of the P/MAs presented herein are to address any existing or potential Undesirable Results by the GSP implementation deadline (i.e., by January 2042). At this time, the White Wolf GSA anticipates that implementation of P/MAs will be necessary to ensure sustainability of the Basin under the uncertainty of future climate and land use conditions. Construction of the Grapevine Development (P/MA #1) is anticipated to break ground around 2026-2027. Other P/MAs will be implemented incrementally on an as-needed basis to achieve this goal. For example, P/MAs will be selected for implementation based on observed Basin conditions (i.e., if Minimum Thresholds are exceeded in Representative Monitoring Wells, as discussed in steps 4 and 5 of the Action Plan Related to Minimum Threshold Exceedances, see ***Section 16***), further consideration of the magnitude of expected P/MA benefit, the relative cost and ease of implementation, and other factors (e.g., when grant funds are obtained or upon completion of feasibility studies, economic evaluations, and/or other necessary planning studies). More details regarding a general implementation schedule ("glide path") are provided in ***Section 18.7 Status and Implementation Timetable*** below. The planning of P/MAs will be supported by the best available information and science. Should Undesirable Results for Degraded Water Quality occur (as defined in ***Section 13.4.2 Criteria Used to Define Undesirable Results***) or Depletion of Interconnected Surface Water (as defined in ***Section 13.6.2 Criteria Used to Define Undesirable Results***) after any P/MA's implementation, the GSA will follow the actions stated in ***Section 16 Action Plan Related to Minimum Threshold Exceedances*** above to evaluate the impact of the P/MAs and mitigate such impacts accordingly.

18.4. Public Notice Process

Public notice requirements vary for each P/MA (see **Table PMA-1**). Some P/MAs that involve infrastructure improvements may not require specific public noticing other than that related to construction or permitting. Certain other management actions that involve, for example, imposition of fees, may require public noticing pursuant to Proposition 218 or Proposition 26. In general, the P/MAs being considered for implementation will be discussed during regular White Wolf GSA Board Meetings or the respective lead District's Board Meeting which are open to the public. In many instances, the P/MAs will also each be subject to California Environmental Quality Act (CEQA) review and other permitting process that are subject to public notice and review. Additional stakeholder outreach efforts will be conducted prior to and during P/MA implementation by the project proponent(s), as needed and as required by law.

18.5. Addressing Overdraft Conditions

> *§ 354.44. Projects and Management Actions*
>
> *(b) Each Plan shall include a description of the projects and management actions that include the following:*
>
> *…*
>
> *(2) If overdraft conditions are identified through the analysis required by Section 354.18, the Plan shall describe projects or management actions, including a quantification of demand reduction or other methods, for the mitigation of overdraft.*

As discussed in ***Section 9.3.4 Change in Groundwater Storage***, the Basin shows a net storage surplus over the historical period (i.e., Water Year [WY] 1995-2014), however the Basin has a storage deficit under current conditions (WY 2015-2019). Future projections without P/MAs show groundwater levels and storage changes continue to steadily decrease over the 50-year implementation horizon.

The WWGFM was employed to evaluate the uncertainty in future Basin storage conditions due to near and longer-term climate uncertainty. Specifically, the WWGFM was employed to project future storage conditions under a Baseline Scenario, the 2030 Climate Change Scenario, and the 2070 Climate Change Scenario (Central Tendency) using climate change factors provided by the California Department of Water Resources (DWR, 2018). The model results indicated that projected groundwater storage declines increased under the Climate Change Scenarios (see **Table WB-11** and **Figure WB-21**); however, only the 2070 Climate Change Scenario projected the potential occurrence of Undesirable Results based on the definition established in ***Section 13.1.2 Criteria Used to Define Undesirable Results*** and the absence of P/MAs.

The P/MAs presented herein were designed to meet the projected deficits under the 2030 Climate Change Scenario, as there is much greater uncertainty when projecting 2070 conditions. The GSAs plan to implement the P/MAs, as needed, to achieve the Basin Sustainability Goal in even under projected climate change conditions (see ***Section 18.7 Status and Implementation Timetable***).

18.6. Permitting and Regulatory Process

> *§ 354.44. Projects and Management Actions*
>
> *(b) Each Plan shall include a description of the projects and management actions that include the following:*
>
> *…*
>
> *(3) A summary of the permitting and regulatory process required for each project and management action.*

As shown in **Table PMA-1**, the permitting and regulatory requirements vary for the different P/MAs depending on whether they are infrastructure projects, recharge projects, management actions, and so forth. The various types of permitting and regulatory requirements (not all applicable to every P/MA) include the following:

- Federal
    - National Environmental Policy Act (NEPA) documentation, if federal grant funds are used;
    - National Pollution Discharge Elimination System (NPDES) stormwater program permit (administered by the California State Water Resources Control Board [SWRCB]);
- State
    - CEQA documentation, including one or more of the following: Initial Study (IS), Categorical Exemption (CE), Negative Declaration (ND), Mitigated Negative Declaration (MND), Environmental Impact Report (EIR);
    - SWRCB permits and regulations regarding recycled water use, waste discharge, and stormwater capture for recharge;
    - California Surface Mining and Reclamation Act (SMARA) regulations;
    - California Division of Safety of Dams regulations;
- Regional
    - San Joaquin Valley Air Pollution Control District (SJVAPCD) permit and regulations;
    - Power and Water Resources Pooling Authority (PWRPA);
- County/Local
    - Encroachment permits – Kern County, CalTrans, and others;
    - Kern County grading permit;
    - Kern County well construction permit.

Specific currently-identified permitting and regulatory requirements for each P/MA are listed in **Table PMA-1**. Upon initiation of each P/MA, the regulatory and permitting requirements of the P/MA will be re-examined. As with any P/MA planned or implemented under the SGMA, actions undertaken will remain in compliance with existing water rights constraints and processes under California and Federal law.

18.7. Status and Implementation Timetable

§ 354.44. Projects and Management Actions

(b) Each Plan shall include a description of the projects and management actions that include the following:

…

(4) The status of each project and management action, including a time-table for expected initiation and completion, and the accrual of expected benefits.

With a few exceptions, the current status of P/MAs listed in **Table PMA-1** is "not yet initiated".[98] While the exact schedule and timetable for implementation of individual P/MAs is not known at this time, a general implementation schedule, also known as a "glide path", has been developed and is summarized in **Table PMA-2** below. This preliminary "glide path" aims to address a certain percentage of the projected deficit during each five-year period through 2042, which in turn will increase Basin groundwater levels. The P/MAs will be initiated in a manner and sequence that achieves the "glide path" level of expected benefits shown in **Table PMA-2**, with accelerated implementation if Minimum Thresholds (MTs) begin to be exceeded in the Basin, as discussed in steps 4 and 5 of the Action Plan Related to Minimum Threshold Exceedances (see ***Section 16***). **Table PMA-1** presents preliminary estimates of the time required to complete/implement each P/MA and a timetable for accrual of expected benefits. These estimates will be refined, as necessary, upon further evaluation of the P/MAs.

Table PMA-2. General Project and Management Action Implementation Schedule ("Glide Path")

Year	2027	2032	2037	2042
P/MA Contributions	**(AFY)**			
Grapevine Development	1,000	1,400	1,900	2,400
Wet Year Supplies	0	1,500	3,500	5,000
Other New Supplies	0	0	1,000	1,000
Pumping Reduction	2,700	5,000	7,200	9,500
P/MA Total Contributions	**3,700**	**7,900**	**13,600**	**17,900**

Abbreviations:
P/MA = Project and/or Management Action
AFY = acre-feet per year

18.8. Expected Benefits

§ 354.44. Projects and Management Actions

(b) Each Plan shall include a description of the projects and management actions that include the following:

…

(5) An explanation of the benefits that are expected to be realized from the project or management action, and how those benefits will be evaluated.

The different categories of expected benefits are presented above in ***Section 18.1.2 Benefit Categories***, and the specific expected benefits of each P/MA are presented in **Table PMA-1** and in ***Section 18.2 List of Projects and Management Actions***. Most P/MAs have expected benefits related to water quantity, with

[98] WRMWSD has completed construction of the Mettler recharge facility (P/MA #7) and AEWSD has begun expanding the in-lieu service area (P/MA #10).

a direct or indirect benefit to the other Sustainability Indicators. Once a P/MA is implemented, it is important to evaluate, ideally to quantify, the benefits resulting from that P/MA as part of monitoring and data collection activities. The specific way in which P/MA benefits are evaluated and/or quantified depends on the P/MA.

The goals and objectives of P/MA implementation are not necessarily to achieve a certain water budget outcome, but rather to ensure that Undesirable Results for relevant Sustainability Indicators are avoided by the end of the SGMA implementation period (i.e., by 2042). For this reason, while the relative effectiveness of each P/MA is assessed based on benefits to the water budget, ultimately the success of the collective implementation of P/MAs will be determined by whether the Sustainability Goal for the Basin is achieved.

As discussed in ***Section 9.4.3.5 Projected 2030 Climate Change with Combined P/MAs Scenario***, to quantify the expected benefits from P/MA implementation, various P/MAs were integrated into the WWGFM Projected 2030 Climate Change Scenario. As a key indicator of Basin sustainability, the projected groundwater storage change and water level responses at each RMW-WL was assessed relative to the Projected 2030 Climate Change Scenario and the proposed Chronic Lowering of Groundwater Levels Sustainable Management Criteria (SMCs). As demonstrated in **Figure PMA-2**, for each of the RMW-WLs, groundwater elevations are expected to remain above their MTs under P/MA implementation. Furthermore, water levels also begin trending toward or surpassing their MOs under P/MA implementation (i.e., 64% of RMW-WLs meet or exceed their MO by Spring 2042).

For those P/MAs that involve direct supply augmentation, the benefit is quantified directly through measurement of those flows. For P/MAs that involve indirect supply augmentation through, for example, increased surface water storage capacity and delivery flexibility, quantification of the benefit will require a comparison of the observed water supply condition (e.g., total imported water) against a hypothetical condition where the P/MA was not in place. For the P/MA that involves recapture of cross-boundary flows, the benefit would be quantified through modeling of reduced cross-boundary flows, simultaneously with water level response in Basin RMW-WLs. For the P/MAs that involve water demand reduction the benefit will be evaluated by comparison of the water demand before and after the P/MA was in place. Because it is not possible to determine with certainty what the condition without the P/MA would be like, quantification of the benefits is inherently uncertain.

18.9. Source and Reliability of Water from Outside the Basin

> *§ 354.44. Projects and Management Actions*
>
> *(b) Each Plan shall include a description of the projects and management actions that include the following:*
>
> *…*
>
> *(6) An explanation of how the project or management action will be accomplished. If the projects or management actions rely on water from outside the jurisdiction of the Agency, an explanation of the source and reliability of that water shall be included.*

Several of the PMAs discussed below and shown in **Table PMA-1** rely on additional water supplies from outside the Basin. Water supply for each applicable P/MA is discussed below.

P/MA #1 relies on the availability of imported surface water (Nickel Water) and the associated availability of recycled water. Because of the nature of the water supply contracts, Nickel Water is considered 100% reliable and delivery is not subject to hydrological variability, regulatory requirements, or supply constraints that may affect other water sources (TCWD, 2016). The anticipated imported water supply and the associated recycled water is projected to fully meet or exceed total projected demand of the Grapevine Development (EKI, 2015). In addition, TCWD has various management options (e.g., water banking operations) and access to other water sources that can be purchased outside of its contracts.

P/MA #4 (and several of the potential recharge projects) relies on the ability of the GSA member districts to obtain additional and/or wet year supplies to supplement their contractual CVP and SWP allocations. Certain P/MAs rely on the availability of water during wet years to fill surface storage, conduct managed recharge, and offset groundwater pumping. P/MA #7 assumes additional wet year supplies may be available from SWP, CVP, or Kern River for recharge. P/MA #10 assumes a certain level of AEWSD CVP Paragraph 16(b) water will be available to meet the additional demand for wet year supplies created by implementation of this P/MA.

All GSA member districts will continue efforts to refine modeling results but also continue to secure additional water supplies for importation into the Basin through transfers, exchanges, and purchases, as necessary and possible given pricing and timing constraints.

18.10. Legal Authority Required

§ 354.44. Projects and Management Actions

(b) Each Plan shall include a description of the projects and management actions that include the following:

…

(7) A description of the legal authority required for each project and management action, and the basis for that authority within the Agency.

Per California Water Code (CWC) § 10725 through 10726.8, the White Wolf GSA possesses the legal authority necessary to implement the supply augmentation and demand management P/MAs described herein and will enforce these P/MAs as necessary to enforce the GSP. Legal authority for each of the P/MAs is detailed in **Table PMA-1**. It should be noted that, pending P/MA implementation, authority may switch dependent on which districts are involved. Furthermore, as mentioned above, each GSA member district has identified P/MAs. The White Wolf GSA is organized as a Joint Powers Authority (JPA). All three GSA member districts possess the legal authority to implement the supply augmentation P/MAs discussed herein.

18.11. Estimated Costs and Plans to Meet Them

§ 354.44. Projects and Management Actions

(b) Each Plan shall include a description of the projects and management actions that include the following:

…

(8) A description of the estimated cost for each project and management action and a description of how the Agency plans to meet those costs.

Estimated costs for each P/MA are presented in **Table PMA-1**. Given the uncertainty in the scope and timing of these P/MAs, the costs are presented as ranges. These costs include "one-time" costs and ongoing costs. The one-time costs may include capital costs associated with construction, feasibility studies, permitting, environmental compliance (e.g., CEQA), or any other costs required to initiate a given P/MA. The ongoing costs are associated with operations & maintenance (O&M), water purchases, and/or costs to otherwise continue implementing a given P/MA. It should be noted that depending on the source and nature of funding for the P/MAs, the one-time costs may or may not be incurred entirely at the beginning of the P/MA; in some instances, grants or other financing options may allow for spreading out of "one-time" costs over time.

As mentioned above, each GSA member district has identified P/MAs. At this time, the GSA acknowledges that details pertaining to cost allocations needs to be negotiated as part of P/MA and GSP implementation. Potential sources of funding for P/MAs one-time costs and ongoing costs are presented in **Table PMA-1**, and include the following:

- AEWSD, WRMWSD, or TCWD funds, generally supported by fees charged to landowners within each district, including potentially the following:
    - General fund
    - SGMA compliance subaccount (to be created)
- Partnering agencies for certain P/MAs (e.g., project developer, oil field producers)
- Grant funding from sources including but not limited to DWR, United States Bureau of Reclamation (USBR), or the Federal Emergency Management Agency (FEMA)
- Other

The lead district proposing the P/MA will be responsible for securing funding for the P/MA. Upon implementation of any given P/MA, the available funding sources for that P/MA will be re-examined and confirmed.

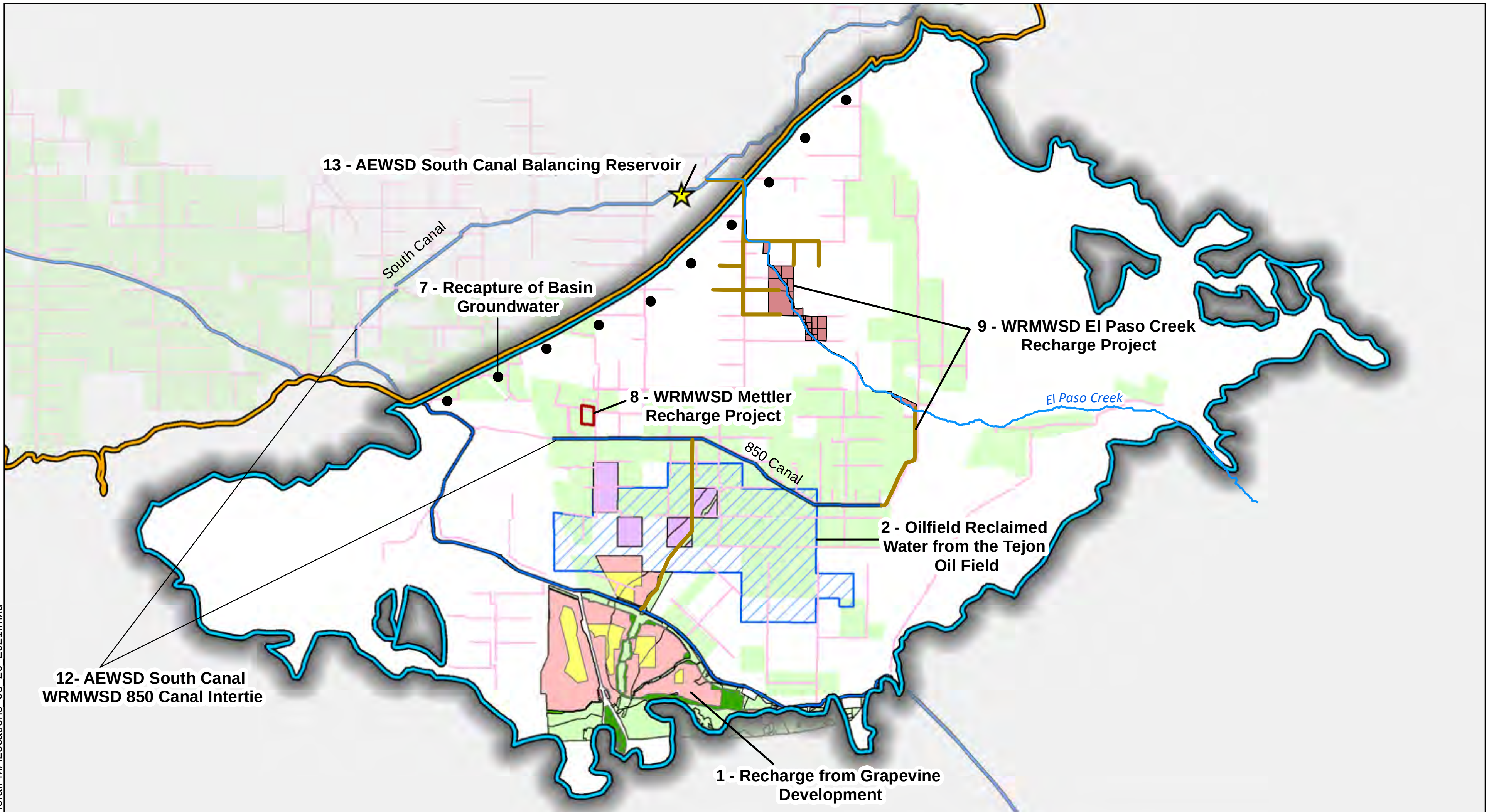
18.12. Management of Recharge and Groundwater Extractions

> *§ 354.44. Projects and Management Actions*
>
> *(b) Each Plan shall include a description of the projects and management actions that include the following:*
>
> *…*
>
> *(9) A description of the management of groundwater extractions and recharge to ensure that chronic lowering of groundwater levels or depletion of supply during periods of drought is offset by increases in groundwater levels or storage during other periods.*

As stated previously in Section *9 Water Budget Information*, under historical conditions (WY 1995–2014), the Basin was in a state of approximate water supply/demand balance (i.e., a net surplus of 3,200 AFY). Historical trends in Basin groundwater levels and storage were driven primarily by the extraction of groundwater and availability of surface water. After the Wanger decision of 2008 and especially during drought years, as was seen during the extreme Statewide drought of 2012-2016 and in 2021, surface water reliability decreased and therefore more groundwater extraction occurred. Furthermore, since the 1990s, there has been an increase in irrigated planted acreage in the Basin. This combination of reduced surface water supply and increased demand resulted in a decrease in groundwater levels and therefore groundwater storage, as was seen during current conditions (WY 2015-2019) where there was a groundwater storage deficit of approximately 20,200 AFY. Under the Projected Baseline, 2030, and 2070 Central Tendency Climate Change Scenarios, a net groundwater storage deficit is projected to continue to occur (approximately 4,600 to 15,500 AFY). The projected deficit is due to an irrigated water demand consistent with WY 2019, and a projected inconsistent supply of imported water supplemented by an increase in groundwater pumping. Modeling scenarios indicate that some combination of both supply augmentation and demand reduction will be required for the Basin to avoid Undesirable Results.

The supply augmentation P/MAs described above are designed to increase the likelihood that groundwater levels and storage declines during future drought periods will be offset, to the extent possible, by increases in groundwater levels and storage during other periods, especially during wet years. For example, P/MA #7 takes advantage of additional supplies that are assumed to be available during wet years to enhance recharge. P/MA #12 will help to increase storage capacity and delivery flexibility. Furthermore, the potential for utilizing produced water (P/MA #2 and P/MA #3), which is available year-round irrespective of climatic conditions, will allow for increased groundwater recharge and/or supplemental non-potable supply to offset drought period demands.

In addition to these supply augmentation P/MAs, the portfolio also includes policy-based management actions aimed at demand reduction. Some of these management actions aim to reduce overall water demand, and others are more specifically focused on reducing groundwater pumping. These management actions will rely initially on financial incentives (e.g., tiered pricing and/or fees) to drive voluntary demand reduction, but also may include establishing groundwater pumping allocations, if necessary. A groundwater allocation program would likely include mechanisms to allow for trading or exchange of pumping allocations within designated areas, subject to constraints dictated by groundwater conditions observed within the Monitoring Network. Through this combination of increased recharge during wet years and demand reduction, the P/MA efforts will ensure that chronic lowering of groundwater levels and storage during drought will be offset by increases in groundwater levels and storage during other periods.



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)

Grapevine Development Zoning

- Exclusive Agriculture District
- Industrial District
- Mixed Use District
- Open Area District
- Village Mixed Use District
- Mettler Recharge Project
- Tejon Oil Field
- Surface Water Service Area
- Aqueduct or Canal
- Distribution Pipeline
- Conceptual Wells along White Wolf Fault
- Proposed El Paso Project Pipelines
- Proposed El Paso Spreading Basins

Abbreviations

AEWSD = Arvin-Edison Water Storage District
DWR = California Department of Water Resources
NHD = National Hydrography Dataset
P/MA = Projects and Management Actions
WRMWSD = Wheeler Ridge- Maricopa Water Storage District

Notes

1. All locations are approximate.
2. P/MAs outside the extent of the map include:
   3 - Oilfield Reclaimed Water in AEWSD
   5 - WRMWSD "Thru Delta" Facility
   6 - WRMWSD Desalination Facility
   10 - AEWSD In-Lieu Banking Program
3. Additional P/MAs not displayed on map include:
   4 - Purchase Additional Surface Water Supplies
   11- AEWSD Private & Caltrans Basin Connections
   22 - Improved Stormwater Management and Flood Control
   23 - AEWSD Groundwater Extraction Quantification Method
   24 - WRMWSD Acreage Assessment
4. Projects 14-21 are water demand reduction management actions.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 20 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Grapevine zoning provided by Tejon Ranch Company on 3 December 2018.
4. Surface Water Service Area provided by AEWSD and WRMWSD.
5. Surface water features and California Aqueduct location from NHD (https://viewer.nationalmap.gov/basic/).

N

0 3 6

(Scale in Miles)

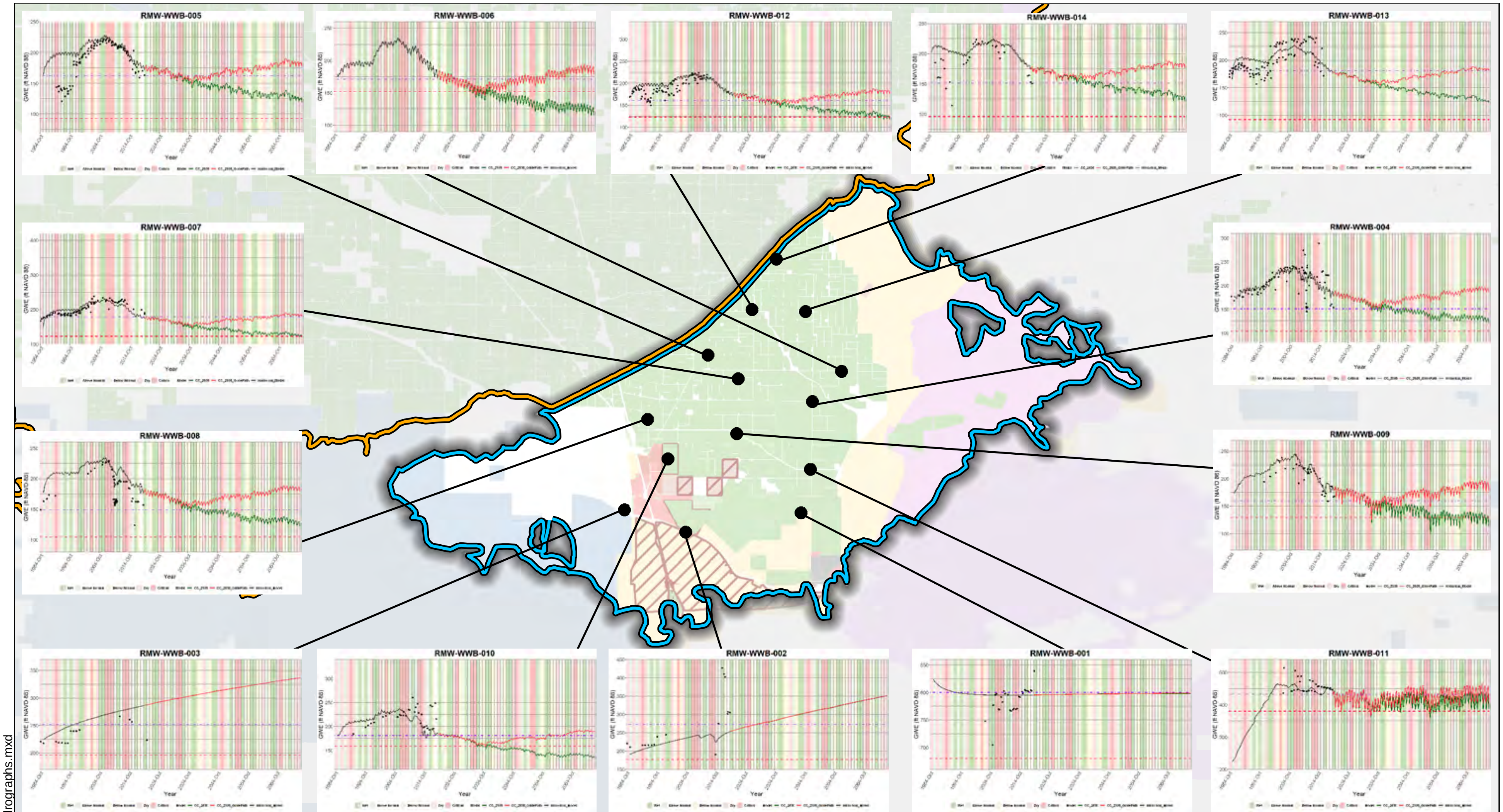
Locations of Proposed Projects and Management Actions

White Wolf GSA
Kern County, California
December 2021
B50001.05

eki environment & water

Figure PMA-1

Path: X:\B50001.05\Maps\GSP\2022\01\FigPMA-1_GeneralPMALocations_08_20_2021.mxd



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

RMW-WL

Measurable Objective

Minimum Threshold

WWGFM-calculated Groundwater Elevations

Historical

Projected 2030 Climate Change

Projected 2030 Climate Change with Combined P/MAs

Land Use

Agricultural Land

Developed

Grazing

Mining

Oil Field

Conservation Easement Area

California Protected Areas

Proposed Grapevine Development

Abbreviations

DWR = California Department of Water Resources
ft msl = feet above mean sea level
MO = Measurable Objective
MT = Minimum Threshold
P/MAs = Projects and/or Management Actions
RMW-WL = Representative Monitoring Well for Water Level
WWGFM = White Wolf Groundwater Flow Model

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 January 2022.
2. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019.
3. Land Use simplified from Figure PA-3 and Figure PA-8.

N 0 5 10 (Scale in Miles)

WWGFM Projected 2030 Climate Change Scenario Hydrographs with and without P/MA Implementation

eki environment & water

White Wolf GSA
Kern County, California
December 2021
B50001.05

Figure PMA-2

Path: X:\B50001.05\Maps\GSP\2022\01\FigPMA-2_Hydrographs.mxd

PLAN IMPLEMENTATION

19. PLAN IMPLEMENTATION

§ 351. Definitions

(y) "Plan implementation" refers to an Agency's exercise of the powers and authorities described in the Act, which commences after an Agency adopts and submits a Plan or Alternative to the Department and begins exercising such powers and authorities.

Per the California Code of Regulations Title 23 (23 CCR) § 351(y), "plan implementation" refers to "an [Groundwater Sustainability] Agency's exercise of the powers and authorities described in the Act, which commences after an Agency adopts and submits a Plan or Alternative to the Department and begins exercising such powers and authorities". This section describes the activities that will be performed by the White Wolf Groundwater Sustainability Agency (GSA) as part of Groundwater Sustainability Plan (GSP) implementation within the White Wolf Subbasin (Basin), with a focus on the first five years (i.e., through 2027). Key GSP implementation activities to be undertaken by the White Wolf GSA over the next five years include:

- Monitoring and data collection;
- Data gap filling efforts;
- Intra-basin and inter-basin coordination;
- Continued outreach and engagement with stakeholders;
- Response to the California Department of Water Resources (DWR) comments on the GSP;
- Annual reporting;
- Evaluation and updates, as necessary, of the GSP as part of the required periodic evaluations (i.e., "five-year updates");
- Enforcement and response actions; and
- Projects and/or Management Action (P/MA) implementation and grant application(s).

Each of these activities is discussed in more detail below.

19.1. Plan Implementation Activities

19.1.1. Monitoring and Data Collection

Successful sustainable groundwater management relies on a foundation of data to support decision making. As such, collection of data within the Basin will be a key part of GSP implementation. These data collection efforts include monitoring of applicable Sustainability Indicators to be collected from the Sustainable Groundwater Management Act (SGMA) Monitoring Network, as well as other data and information required for management and reporting under the SGMA, as described below.

Section 17 Monitoring Network discusses the SGMA Monitoring Network and associated Representative Monitoring Wells (RMWs) supplemental monitoring sites, and protocols that will be used for the applicable Sustainability Indicators in the Basin, including Chronic Lowering of Groundwater Levels, Reduction of Groundwater Storage (using groundwater levels as proxy), Degraded Water Quality, Land Subsidence (using groundwater levels as proxy), and Depletions of Interconnected Surface Water. Those protocols will be followed as part of GSP implementation. Data collected will be incorporated into the Basin's Data Management System (DMS) and will be used to support Annual Reporting (see ***Section 19.1.7 Annual Reporting***). Furthermore, monitoring results will be evaluated against applicable Sustainable Management Criteria (SMCs; i.e., Undesirable Results, Minimum Thresholds [MTs], and Measurable Objectives [MOs]) to support groundwater management decisions.

The GSA anticipates that within the first five years of GSP implementation (i.e., in the 2022 to 2027 timeframe), the following monitoring related efforts will be performed.

Data collected from the RMWs will be reported to DWR as part of the Annual Report:

- Semi-annual water level monitoring at the Representative Monitoring Wells for Chronic Lowering of Groundwater Levels (RMW-WLs);
- Annual water quality data compilation from the Drinking Water Watch website for the Representative Monitoring Wells for Degraded Water Quality (RMW-WQs); and
- High-frequency water level monitoring using data loggers at the Representative Monitoring Wells for Depletions of Interconnected Surface Waters (RMW-ISW), downloaded semi-annually.

The GSA anticipates that additional data collected for supplemental Basin analysis will include:

- Semi-annual water level monitoring from the two MW-WLs to inform groundwater conditions;
- Annual water quality data collection from MW-WQs to inform groundwater conditions. Specific constituents to be monitored include arsenic, nitrate, selenium, total dissolved solids (TDS), sulfate, iron, sodium, boron, and 1,2,3-trichloropropane (1,2,3-TCP).
- Annual land surface elevation monitoring at the two checkpoints established adjacent to the 850 Canal;
- Compilation and review of publicly available subsidence data (e.g., InSAR, DWR surveys along the California Aqueduct, etc.);
- Semi-annual water level monitoring from the MW-ISWs to inform groundwater conditions near groundwater dependent ecosystems (GDEs);
- Flow observation (flow or no flow) at the two artesian springs locations; and
- Stage and/or stream flow data compilation from the four stream gauges.

The GSA anticipates that additional data processing and data collection will include:

- Quality assurance and quality control (QA/QC) checks;
- DMS importation; and
- Data gap filling efforts as it pertains to the monitoring network (see Section *19.1.2 Data Gap Filling Efforts* below).

Besides the data collected to support evaluation and reporting relative to the Sustainability Indicators described above, collection and reporting of other types of information is required under SGMA or is being done by the GSA to improve Basin characterization and understanding (see further discussion in Section *19.1.7 Annual Reporting*). These other types of information include:

- Groundwater extraction information by water use sector:
    - Groundwater extraction for irrigation is currently estimated by using satellite-based ITRC-METRIC evapotranspiration data. The GSA plans to continue to work with the Irrigation Training and Research Center (ITRC) Cal Poly to obtain ongoing ITRC-METRIC evapotranspiration data.
    - Groundwater extraction for municipal and industrial (M&I) use is currently unknown. Two public water systems which solely rely on groundwater wells (Tut Brothers #96 and Cuyama Orchards) have been informed on the GSP development process via multiple direct outreach attempts, but to date has generally been uninterested in the GSP process. Very limited publicly accessible groundwater use data is available and is typically very small quantities (e.g., less than 15 AFY)[99]. As discussed in Section *19.1.2 Data Gap Filling Efforts* below, the GSA will continue stakeholder outreach to the three public water systems in the Basin.
    - Groundwater extraction for domestic use in the Basin is considered de minimus (i.e., 2 AFY), and therefore will not be quantified per SGMA (California Water Code [CWC] Section 10721(e)).
- Surface water supply data by water use sector:
    - Imported surface water supplies from AEWSD and WRMWSD are used primarily for irrigation and are metered at turnouts along the California Aqueduct, Friant Canal, and the Districts' conveyance and distribution systems.
    - TCWD's imported water is for M&I use and is metered at turnouts from the California Aqueduct and by customer.
    - TCWD deliveries non-potable recycled water for irrigation, which is metered by customer.
    - Tejon Ranch also diverts flows from streams for irrigation use, which are monitored at points of diversion (PODs) and storage reservoirs. Monthly diversion totals are uploaded to

[99] Available online at: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/eardata.html

the State Water Resources Control Board (SWRCB)'s website Electronic Water Rights Information Management System (eWRIMS).

19.1.2. Data Gap Filling Efforts

The White Wolf GSA will prioritize and begin to fill the key data gaps identified in this GSP related to the hydrogeological conceptual model, groundwater conditions, and water budgets, among other things. These data gap filling efforts will include, but not be limited to:

- SGMA Monitoring Network updates, including well use, well status, well construction information, etc. This includes continued outreach to Tut Brothers #96 regarding their currently unknown well construction and location information.
- Compilation and review of The Nature Conservancy GDE Pulse satellite data.
- One biologist field trip in which conditions of the GDEs visited in 2020 will be catalogued, including photographic documentation.
- Stream flow monitoring on El Paso Creek to better quantify surface flows into the Basin.
- Outreach to Tut Brothers #96 and Cuyama Orchards Public Water Systems in the Basin to estimate and meter their groundwater extraction volumes for Annual Reporting, if extractions are above those defined as de minimis (i.e., 2 AFY; CWC Section 10721(e)).
- Quantification of subsurface flow across the White Wolf Fault pertaining to imported surface water.
- Conducting additional data compilation and analysis of groundwater conditions using other public datasets and tools as they become available.
- Long-term aquifer testing and monitoring to further assess the nature of the hydraulic barrier provided by the Springs Fault.

19.1.3. Coordination

Intra-basin coordination efforts, including ad-hoc technical committee meetings, will occur on an approximately quarterly basis to facilitate data collection and management efforts and planning for stakeholder engagement opportunities.

Inter-basin coordination efforts with the adjacent Kern County Subbasin GSAs will occur on an as-needed basis. Through their membership in both the Kern Groundwater Authority (KGA) and the White Wolf GSA, AEWSD, WRMWSD, and TCWD have and will continue to coordinate with other entities on water management efforts that involve both basins. Specifically, one coordination effort would be discussions and modeling regarding imported water contributions to cross-boundary flows between the Basin and Kern County Subbasin.

19.1.4. Stakeholder Engagement

The GSA's Stakeholder Communication and Engagement Plan (SCEP; ***Appendix B***) will continue to be refined, updated, and executed during GSP implementation. Anticipated stakeholder engagement activities include, but are not limited to:

- Continued quarterly GSA Board meetings;
- Hosting annual stakeholder workshops, as needed; and
- Posting of relevant announcements and information on the GSA's website (whitewolfgsa.org) and other direct mailings, as needed.

19.1.5. Response to DWR Comments on the GSP

The GSP is required to be submitted to DWR by 31 January 2022. DWR will evaluate the GSP within two years of its submittal and issue a written assessment. The GSA will work to address comments on the GSP and any unforeseen deficiencies to ensure the GSP is deemed "Approved" by DWR.

19.1.6. Project and Management Action Implementation

To prevent potential Undesirable Results, P/MAs are planned as part of GSP implementation. As described in ***Section 18 Projects and Management Actions***, a portfolio of P/MAs has been developed with the goal of proactively addressing relevant Sustainability Indicators. **Table PMA-1** provides the required details about each P/MA, including the circumstances under which they may be implemented.

The GSA plans to begin implementation of selected P/MAs (**Table PMA-1**) based on the general "glide path" developed (see ***Section 18.7 Status and Implementation Timetable***). As such, at this time, exact timing and specific P/MAs is unknown. Based on the "glide path," the Grapevine Development will break-ground by 2027, some form of demand reduction will occur by 2027, and additional supplies will begin supplementing baseline imported supplies by 2032.

In some cases, initial steps in implementation will include performing various studies or analyses to refine the concepts into actionable projects. Studies and work efforts may include, but are not limited to, California Environmental Quality Act (CEQA) studies and documentation, and engineering feasibility studies and preliminary design reports. The planning of P/MAs will be supported by the best available information and science.

In other cases, initial steps in implementation will be applying for grant funding to conduct pilot studies. For example, the DWR Sustainable Groundwater Management Grant Program will have $77 million of available funding through Proposition 68 to support implementation projects, with a solicitation opening in Spring 2022. Solicitations will require preparation of a grant application package.

Once the necessary initial studies are completed and funding mechanisms are established, P/MAs will undergo, as necessary, final engineering design (in the case of infrastructure projects) and public noticing and outreach. At that point, construction of projects will occur, followed by ongoing operations and maintenance, as necessary. It is anticipated that each implemented P/MA will have its own set of monitoring or data collection components to allow for P/MA assessment and, if necessary, modification.

19.1.7. Annual Reporting

§ 356.2. Annual Reports.
Each Agency shall submit an annual report to the Department by April 1 of each year following the adoption of the Plan. The annual report shall include the following components for the preceding water year:

(2) A detailed description and graphical representation of the following conditions of the basin managed in the Plan:

(1) Groundwater elevation data from monitoring wells identified in the monitoring network shall be analyzed and displayed as follows:

(A) Groundwater elevation contour maps for each principal aquifer in the basin illustrating, at a minimum, the seasonal high and seasonal low groundwater conditions.

(B) Hydrographs of groundwater elevations and water year type using historical data to the greatest extent available, including from January 1, 2015, to current reporting year.

(2) Groundwater extraction for the preceding water year. Data shall be collected using the best available measurement methods and shall be presented in a table that summarizes groundwater extractions by water use sector, and identifies the method of measurement (direct or estimate) and accuracy of measurements, and a map that illustrates the general location and volume of groundwater extractions.

(3) Surface water supply used or available for use, for groundwater recharge or in-lieu use shall be reported based on quantitative data that describes the annual volume and sources for the preceding water year.

(4) Total water use shall be collected using the best available measurement methods and shall be reported in a table that summarizes total water use by water use sector, water source type, and identifies the method of measurement (direct or estimate) and accuracy of measurements. Existing water use data from the most recent Urban Water Management Plans or Agricultural Water Management Plans within the basin may be used, as long as the data are reported by water year.

(5) Change in groundwater in storage shall include the following:

(A) Change in groundwater in storage maps for each principal aquifer in the basin.

(B) A graph depicting water year type, groundwater use, the annual change in groundwater in storage, and the cumulative change in groundwater in storage for the basin based on historical data to the greatest extent available, including from January 1, 2015, to the current reporting year.

Per the 23 CCR, an annual report on basin conditions and GSP implementation status is required to be submitted to DWR by April 1 of each year following GSP adoption (23-CCR § 356.2). These annual reports will be prepared by the GSA using data collected during GSP implementation, as described above. Annual reports will include, but not be limited to, the following:

- Groundwater elevation contour maps for both Spring and Fall conditions;
- Hydrographs of groundwater elevations in the RMW-WLs and RMW-ISWs;
- Annual groundwater extraction volumes by water use sector for the entire Basin, an explanation as to how groundwater extraction volumes were estimated, an accounting of accuracy, and an explanation as to how accuracy was determined;
- Annual surface water supply volumes used for the entire Basin, quantified by source type;
- Annual total water use for the entire Basin, quantified by water use sector and type, with an explanation for the method of measurement (direct or estimate) and accounting of accuracy; and
- Estimates of annual change in groundwater storage. The White Wolf Groundwater Flow Model (WWGFM) will be updated and extended to include the groundwater elevation data, groundwater extraction volumes, and hydrology datasets (i.e., precipitation and evapotranspiration) to estimate the annual change in groundwater storage.

19.1.8. Enforcement and Response Actions

Part of successful Basin management involves the ability to adapt and respond to unforeseen or uncertain circumstances. To the extent possible, methods to address foreseeable problems should be developed before those problems arise. It is not anticipated that there will be a need to enforce compliance with this GSP and any policies adopted thereunder. However, if such actions are necessary, they will be taken by the White Wolf GSA and/or its member districts in accordance with applicable laws and authorities.

In other cases, a response action may be needed that is driven not by a physical, social or economic condition. One such condition that may arise is that of wells being impacted by declining groundwater levels. Impacts could include dewatering of pumps or dewatering of well screens to the point of significant reduction in production. Although a well impact analysis shows that no full well dewatering is anticipated to occur (see ***Section 14.1.2 Well Impact Analysis***), to address this potential occurrence, one or more of the White Wolf GSA-member districts will develop an Impacted Well Mitigation Program whereby a potential remedy will be provided to owners of wells that are demonstrably unreasonably impacted by groundwater conditions, as defined within the policy. Funding for such a program is to be determined but may be sourced from a GSA general fund or from a dedicated fund supported by a fee on owners of commercial (i.e., agricultural or industrial) supply wells. The program may be modeled after similar programs developed elsewhere in the Kern County Subbasin or around the state (e.g., the Kern Water Bank's program [Kern Water Bank, 2017]), and may include, but not limited to, remedies such as lowering of pumps, deepening of wells, drilling new wells, and support for access to alternative water sources. The program will be developed in coordination with and in consideration of the interests of local stakeholders within the Basin.

19.1.9. Periodic GSP Evaluations

§ 356.4. Periodic Evaluation by Agency
Each Agency shall evaluate its Plan at least every five years and whenever the Plan is amended and provide a written assessment to the Department. The assessment shall describe whether the Plan implementation, including implementation of projects and management actions, are meeting the sustainability goal in the basin, and shall include the following:

- *(a) A description of current groundwater conditions for each applicable sustainability indicator relative to measurable objectives, interim milestones and minimum thresholds.*
- *(b) A description of the implementation of any projects or management actions, and the effect on groundwater conditions resulting from those projects or management actions.*
- *(c) Elements of the Plan, including the basin setting, management areas, or the identification of undesirable results and the setting of minimum thresholds and measurable objectives, shall be reconsidered and revisions proposed, if necessary.*
- *(d) An evaluation of the basin setting in light of significant new information or changes in water use, and an explanation of any significant changes. If the Agency's evaluation shows that the basin is experiencing overdraft conditions, the Agency shall include an assessment of measures to mitigate that overdraft.*
- *(e) A description of the monitoring network within the basin, including whether data gaps exist, or any areas within the basin are represented by data that does not satisfy the requirements of Sections 352.4 and 354.34(c). The description shall include the following:*
  - *(1) An assessment of monitoring network function with an analysis of data collected to date, identification of data gaps, and the actions necessary to improve the monitoring network, consistent with the requirements of Section 354.38.*
  - *(2) If the Agency identifies data gaps, the Plan shall describe a program for the acquisition of additional data sources, including an estimate of the timing of that acquisition, and for incorporation of newly obtained information into the Plan.*
  - *(3) The Plan shall prioritize the installation of new data collection facilities and analysis of new data based on the needs of the basin.*
- *(f) A description of significant new information that has been made available since Plan adoption or amendment, or the last five-year assessment. The description shall also include whether new information warrants changes to any aspect of the Plan, including the evaluation of the basin setting, measurable objectives, minimum thresholds, or the criteria defining undesirable results.*
- *(g) A description of relevant actions taken by the Agency, including a summary of regulations or ordinances related to the Plan.*
- *(h) Information describing any enforcement or legal actions taken by the Agency in furtherance of the sustainability goal for the basin.*
- *(i) A description of completed or proposed Plan amendments.*
- *(j) Where appropriate, a summary of coordination that occurred between multiple Agencies in a single basin, Agencies in hydrologically connected basins, and land use agencies.*

> *§ 356.4. Periodic Evaluation by Agency*
>
> *(k) Other information the Agency deems appropriate, along with any information required by the Department to conduct a periodic review as required by Water Code Section 10733*
>
> *(l) Where appropriate, a summary of coordination that occurred between multiple Agencies in a single basin, Agencies in hydrologically connected basins, and land use agencies.*
>
> *(m) Other information the Agency deems appropriate, along with any information required by the Department to conduct a periodic review as required by Water Code Section 10733*

Per the 23-CCR § 356.4, the White Wolf GSA will conduct a periodic evaluation of its GSP, at least every five years, and will modify the GSP as necessary to ensure that the Sustainability Goal for the Basin is achieved. The GSP elements that will be covered in the periodic evaluation are described below. It is anticipated that the 2027 plan will require revision, especially on matters related to the Basin Setting, SMCs, and P/MA sections.

19.1.9.1. Sustainability Evaluation

This section will evaluate the current groundwater conditions for each applicable Sustainability Indicator, including progress toward achieving Interim Milestones and MOs.

19.1.9.2. Plan Implementation Progress

This section will evaluate the current implementation status of P/MAs, along with an updated implementation schedule and any new P/MAs that are not included in this GSP.

19.1.9.3. Reconsideration of GSP Elements

Per 23-CCR § 356.4(c), elements of the GSP, including the Basin Setting, SMCs, and P/MAs sections will be reviewed and revised if necessary.

19.1.9.4. Monitoring Network Description

This section will provide a description of the SGMA Monitoring Network, including identification of data gaps, assessment of monitoring network function with an analysis of data collected to date, identification of actions that are necessary to improve the monitoring network, and development of plans or programs to fill data gaps.

19.1.9.5. New Information

This section will provide a description of significant new information that has been made available since the adoption or amendment of the GSP, or the last five-year assessment, including data obtained to fill identified data gaps. As discussed above under ***Section 19.1.9.3 Reconsideration of GSP Elements***, if evaluation of the Basin Setting or SMCs definitions warrant changes to any aspect of the GSP, this new information would also be included.

19.1.9.6. Regulations or Ordinances

The White Wolf GSA possesses the legal authority to implement regulations or ordinances related to the GSP. This section will provide a description of relevant actions taken by the White Wolf GSA, including a summary of related regulations or ordinances, as appropriate.

19.1.9.7. Legal or Enforcement Actions

This section will summarize legal or enforcement actions taken by the White Wolf GSA in relation to the GSP, along with how such actions support sustainability in the Basin.

19.1.9.8. Plan Amendments

This section will provide a description of proposed or complete amendments to the GSP.

19.2. Plan Implementation Costs

> *§ 354.6. Agency Information*
>
> *When submitting an adopted Plan to the Department, the Agency shall include a copy of the information provided pursuant to Water Code Section 10723.8, with any updates, if necessary, along with the following information:*
>
> *(d) An estimate of the cost of implementing the Plan and a general description of how the Agency plans to meet those costs.*

Per the 23-CCR § 354.6(e) and 354.44(b)(8), this section provides estimates of the costs to implement this GSP and potential sources of funding to meet those costs.

19.2.1. Estimated Costs

The estimated costs for the White Wolf GSA to implement this GSP can be divided into several groups, as follows:

1) Costs of monitoring, data collection, and data gap filling;
2) Costs associated with stakeholder outreach and coordination;
3) Costs associated with reporting;
4) Costs of enforcements and response actions; and
5) Costs to implement P/MAs, including capital/one-time costs and ongoing costs.

Table PI-1 provides a high-level estimate of the annual costs for the above groups 1 through 4 over the first 5-year period (i.e., 2022-2027). Costs associated with continued GSA activities (groups 1 through 4) are estimated to be approximately $295,000 per year, not including GSA and GSA member district staff time. At this time, the White Wolf GSA acknowledges that details pertaining to projected cost allocations, etc. need to be negotiated as part of GSP and P/MA implementation. Furthermore, estimated annual costs for individual P/MAs (group 5) will primarily be determined in the future.

19.2.2. Sources of Funding to Meet Costs

As shown in **Table PI-1**, required direct costs for GSP implementation (i.e., groups 1 through 4) are estimated to range from $290,000 to $345,000 annually over the next five years, not including GSA and GSA member district personnel time. The White Wolf GSA will likely meet the estimated costs through a combination of contributions from landowners, grant funding, if available, and through rate payers.

19.3. Plan Implementation Schedule

This section discusses a general estimated schedule for GSP implementation. The 23 CCR do not specifically require that a schedule for GSP implementation over the 20-year implementation period (i.e., 2022 through 2042) be provided, and any such schedule would be subject to considerable uncertainty. However, the following factors and constraints inherent to the GSP process guide the schedule for GSP implementation:

- The 23 CCR require achievement of the Sustainability Goal (i.e., avoidance of Undesirable Results) within 20 years of GSP adoption, which means by 2042.
- Annual reports are due on April 1 of every year following GSP submission.
- Periodic evaluations are required at least every five years, meaning this GSP will be updated no later than 2027.

Table PI-1. Estimated GSP Implementation Costs

Local Groundwater Management Activity	Estimated Average Annual GSP Implementation Cost[1]				
	Year 1	Year 2	Year 3	Year 4	Year 5
1. Costs of Monitoring, Data Collection, and Data Gap Filling					
Monitoring of Applicable Sustainability Indicators (RMS)	$15,000	$15,000	$15,000	$15,000	$15,000
Collection of Other Required Water Use Information	$25,000	$25,000	$25,000	$25,000	$25,000
Voluntary Monitoring of Groundwater Quality at MW-WQ	$10,000	$10,000	$10,000	$10,000	$10,000
Interconnected Surface Water and GDEs Monitoring	$19,000	$19,000	$37,000	$19,000	$19,000
Land Surface Monitoring at Benchmarks	$3,000	$3,000	$3,000	$3,000	$3,000
Specific Technical Analysis (e.g., Quantification of Flow across the WWF)	$10,000	$20,000	$20,000	$20,000	$20,000
Annual Subtotal	**$82,000**	**$92,000**	**$110,000**	**$92,000**	**$92,000**
2. Costs associated with Stakeholder Outreach and Coordination					
Local Stakeholder Engagement (meetings, workshops, website)	$19,000	$19,000	$19,000	$19,000	$19,000
Intra-Basin Coordination	$12,000	$12,000	$12,000	$12,000	$12,000
Inter-Basin Coordination	$10,000	$10,000	$10,000	$10,000	$10,000
Annual Subtotal	**$41,000**	**$41,000**	**$41,000**	**$41,000**	**$41,000**
3. Costs associated with Reporting					
Response to DWR Comments on the GSP	$25,000	$0	$0	$0	$0
Annual Reporting	$50,000	$40,000	$40,000	$40,000	$40,000
Periodic Evaluation of GSP - 5-year update	$0	$0	$0	$260,000	$260,000
Annual Subtotal	**$75,000**	**$40,000**	**$40,000**	**$300,000**	**$300,000**
4. Costs of Enforcement and Response Actions					
Enforcement Actions (Legal)	TBD	TBD	TBD	TBD	TBD
Impacted Well Mitigation Program	$10,000	$10,000	$10,000	$10,000	$10,000
Annual Subtotal	**$10,000**	**$10,000**	**$10,000**	**$10,000**	**$10,000**
5. Costs to Implement P/MAs					
Grant Application(s)	$50,000	TBD	TBD	$50,000	TBD
Demand Reduction P/MA(s)	TBD	TBD	TBD	TBD	TBD
Other P/MA Implementation	TBD	TBD	TBD	TBD	TBD
Annual Subtotal	**To Be Determined**				
Total Required Costs of GSP Implementation[2]	**$258,000 + P/MA costs**	**$183,000 + Grant Application cost + P/MA cost**	**$201,000 + Grant Application cost + P/MA cost**	**$493,000 + Grant Application cost + P/MA cost**	**$443,000 + Grant Application cost + P/MA cost**

Abbreviations:

DWR = California Department of Water Resources
GDEs = Groundwater Dependent Ecosystems
GSP = Groundwater Sustainability Plan
MW-WQ = Monitoring well for Degraded Water Quality
P/MA = Project and/or Management Action
RMS = Representative Monitoring Site
TBD = to be determined
WWF = White Wolf Fault

Notes:

(1) Costs are estimated for technical consultant, laboratory, contractor, or other direct costs. It is assumed GSA member Districts will conduct monitoring activities, however District personnel costs are not estimated herein.
(2) Cost allocations to be determined.

REFERENCES AND TECHNICAL STUDIES

§ 354.4. General Information

Each Plan shall include the following general information:

(b) A list of references and technical studies relied upon by the Agency in developing the Plan. Each Agency shall provide to the Department electronic copies of reports and other documents and materials cited as references that are not generally available to the public.

AEWSD, 2003. Arvin-Edison Water Storage District, Groundwater Management Plan, June 2003.

AEWSD, 2018. Arvin-Edison Water Storage District Water Management Plan Update (Prepared under the USBR Mid-Pacific Region 2017 Standard Criteria), dated October 2018.

Agency for Toxic Substances and Disease Registry, 2011. *Toxic Substances Portal*, accessed July 2020. https://www.atsdr.cdc.gov/substances/indexAZ.asp#A

Anderson et al., 1979. Anderson, S.C., Sanchez, D.K., and A.A. Swanson, Preliminary Evaluation of State Water Project Ground Water Storage Program, White Wolf Basin, State of California Department of Water Resources, Southern District, September 1979.

Ayers, R.S., and Westcot, D.W., 1985. Water Quality for Agriculture, FAO Irrigation and Drainage Paper 29.

Bartow, J.A., 1984. Tertiary Stratigraphy of the Southeastern San Joaquin Valley, California, U.S. Geological Survey Bulletin 1529-J.

Belitz K, Phillips SP, Gronberg JM, 1993. Numerical Simulation of Ground-Water Flow in the Central Part of the Western San Joaquin Valley, California. U.S. Geological Water-Supply Paper 2396. 69 pp.

Bookman-Edmonston, 1975. Bookman-Edmonston, Report on Investigation of Planned Operation and Management of the White Wolf Ground Water Basin, prepared for Wheeler Ridge-Maricopa Water Storage District, June 1975.

Bookman-Edmonston, 1995. Bookman-Edmonston, Ground Water Studies, prepared for Wheeler Ridge-Maricopa Water Storage District, September 1995.

Bookman-Edmonston, 2007. Bookman-Edmonston, Groundwater Storage and Recovery Pilot Project in White Wolf Basin, Final Project Report, prepared for Wheeler Ridge-Maricopa Water Storage District, revised 26 January 2007.

Brush CF, Dogrul EC, Kadir TN, 2013. Development and Calibration of the California Central Valley Groundwater-Surface Water Simulation Model (C2VSim), Version 3.02-CG, dated June 2013.

Brush, C.F., E.C. Dogrul, and T.N. Kadir, 2016. Development and Calibration of the California Central Valley Groundwater-Surface Water Simulation Model (C2VSim), Version 3.02-CG, DWR Technical Memorandum, 193 pp.

Buwalda, 1954. Buwalda J. P., Geology of the Tehachapi Mountains, California, in Geology of the natural provinces, chap. 2 of Geology of southern California: California Dept. Nat. Resources, Div. Mines Bull. 170, pp. 131-142, 1954.

Caltrans, variously dated, Caltrans Surveys Manual, available online at https://dot.ca.gov/programs/right-of-way/surveys-manual-and-interim-guidelines.

California Division of Mines, 1955. *Earthquakes in Kern County California During 1952*, Bulletin 171, 283 pp.

CDMG, 1964. California Division of Mines and Geology, Geologic Map of California, Olaf P. Jenkins Edition, Bakersfield Sheet, 1964.

CDMG, 1969. California Division of Mines and Geology, Geologic Map of California, Olaf P. Jenkins Edition, Los Angeles Sheet, 1969.

CA DPW, 1952. California Department of Public Works, Division of Water Resources, Report on Physical Effects of Arvin Earthquake of July 21, 1952, 44 pp., 1952.

CEDEN, 2018. California Environmental Data Exchange Network. Station Code 557ELPCRK https://ceden.waterboards.ca.gov/AdvancedQueryTool.php accessed 13 September 2018.

California Institute of Technology, 2016. California Institute of Technology Jet Propulsion Laboratory Progress Report: Subsidence in California, March 2015-September 2016.

Croft, 1972. Croft, M.G., 1972. Subsurface geology of the late Tertiary and Quaternary water-bearing deposits of the southern part of the San Joaquin Valley, California, USGS Water Supply Paper 1999-H, 29 pp.

Davis et al., 1959. Davis, G. H., Green, J. H., Olmsted, F. H., and D. W. Brown, Ground-water conditions and storage capacity in the San Joaquin Valley, California: U.S. Geol. Survey Water-Supply Paper 1469, 271 pp., 1959.

Dibblee, 1955. Dibblee, T.W., Jr., 1955, Geology of the southeastern margin of the San Joaquin Valley California, in Earthquakes in Kern County, California, during 1952, California Dept. Nat. Resources, Div. Mines Bull. 171, pp. 23-34, 1955.

Dibblee and Oakeshott, 1953. Dibblee, T.W. Jr. and G.B. Oakeshott, White Wolf fault in relation to geology of the southeastern margin of San Joaquin Valley, California, GSA Bulletin, vol. 64, p. 1502-1503, 1953.

DOGGR, 1998. California Division of Oil, Gas, and Geothermal Resources, California Oil and Gas Fields, Volume I - Central California, 1998.

Driscoll, 1986. Driscoll, F.G., Groundwater and Wells (2nd ed.), Johnson Filtration Systems, Inc., St. Paul, Minnesota, 1089 p., 1986.

California Department of Water Resources (DWR), 1980. Ground Water Basins in California, A Report to the Legislature in Response to Water Code Section 12924, dated January 1980, 73 pp.

DWR, 2003. California Department of Water Resources, California's Groundwater – Bulletin 118, Update 2003, October 2003.

DWR, 2014. California Department of Water Resources, Summary of Recent, Historical, and Estimated Potential for Future Land Subsidence in California, 2014.

DWR, 2016a. California Department of Water Resources, Hydrogeologic Conceptual Model Best Management Practice, dated December 2016, 23 pp.

DWR, 2016b. California Department of Water Resources, Water Budget Best Management Practice, dated December 2016, 51 pp.

DWR, 2016c. California Department of Water Resources, Bulletin 118 – Interim Update 2016, California's Groundwater, Working Towards Sustainability, 58 pp.

DWR, 2016d. California Department of Water Resources, Best Management Practices for the Sustainable Management of Groundwater Monitoring Networks and Identification of Data Gaps BMP, dated December 2016, 34 pp.

DWR, 2016e. California Department of Water Resources, Best Management Practices for the Sustainable Management of Groundwater Monitoring Protocols, Standards, and Sites BMP, dated December 2016, 27 pp.

DWR, 2017a. *California Aqueduct Subsidence Study*, San Luis Field Division, San Joaquin Field Division, 206 pp.

DWR, 2017b. Sustainable Management Criteria Best Management Practice, dated November 2017, 38 pp.

DWR, 2018. DWR guidance document for "*Climate Change Data Use During Groundwater Sustainability Plan Development*", dated July 2018.

DWR, 2019. Sustainable Groundwater Management Act 2019 Basin Prioritization Process and Results, April 2019, 64pp.

DWR, 2020a. California Valley Groundwater-Surface Water Simulation Model – Fine Grid (C2VSimFG), Development and Calibration, Version 1.0, December 2020.

DWR, 2020b. DWR climate change datasets, available online at https://data.cnra.ca.gov/dataset/sgma-climate-change-resources.

DWR, 2020c. The Final State Water Project Delivery Capability Report 2019, August 2020.

DWR, 2021. Sustainable Groundwater Management Act Water Year Type Data Set Development Report, January 2021, 17pp. https://data.cnra.ca.gov/dataset/sgma-water-year-type-dataset/resource/79c7b9c1-1203-4203-b956-844554fcec79

EKI Environment & Water, Inc. (EKI), 2015. *Evaluation of Potable, Non-Potable and Recycled Water Demands Grapevine Project*, dated November 2015.

EKI, 2016. White Wolf Subbasin Technical Report, prepared for: Wheeler Ridge-Maricopa Water Storage District, Arvin-Edison Water Storage District, Tejon-Castac Water District, 68 pp.

Faunt et al., 2009. Faunt, C.C., ed., Groundwater Availability of the Central Valley Aquifer, California: USGS Professional Paper 1766, 225 pp.

Flint et al., 2013. Flint, Lorraine E., A.L. Flint, J.H. Thorne, and R. Boynton, Fine-scale hydrologic modeling for regional landscape applications: the California Basin Characterization Model development and performance, Ecological Process 2013 2:25.

Friant Water Authority (FWA), 2018. Technical Memorandum Estimate of Future Friant Division Supplies for use in Groundwater Sustainability Plans, California, dated December 2018.

GEI Consultants, 2018. Kern River Hydrology Under Climate Change, December 2018.

GEI Consultants, 2020. Kern Groundwater Authority Groundwater Sustainability Plan Kern County, CA. dated January 2020.

Goodman et al., 1989. Goodman, E.D., Malin, P.E., Ambos, E.L, and J.C. Crowell, The southern San Joaquin Valley as an example of Cenozoic basin evolution in California, in The Origin and Evolution of Sedimentary Basins and Their Energy and Mineral Resources, edited by R.A. Price, Geophys. Monogr. Ser. 48, pp. 87-107, AGU, Washington, D.C., 1989.

Goodman, E.D., and P.E. Malin, 1992. Evolution of the Southern San Joaquin Basin and Mid-Tertiary "Transitional" Tectonics, Central California, *Tectonics*, Vol. 11, No. 3, pages 478-498.

Hagan, 2001. Hagan, K., The Effects of the White Wolf Fault on Groundwater Hydrology in the Southern San Joaquin Valley, California, Thesis presented to the faculty of the School of Arts and Sciences of California State University, Bakersfield in partial fulfillment of the Requirements for the Degree of Master of Science in Geology, 2001.

Hem JD, 1970. Study and Interpretation of the Chemical Characteristics of Natural Water. U.S. Geological Survey Water-Supply Paper 2254, 263 pp

Howes, D. 2017. 1993-2015 ITRC-METRIC ETc for Kern County. prepared for the Kern Groundwater Authority. Irrigation Training & Research Center California Polytechnic State University.

Howes D, 2020. 1993-2019 ITRC METRIC ETc for Kern County. Prepared for Kern Groundwater Authority. Irrigation Training & Research Center California Polytechnic State University.

Howes D, 2021. 2017-2020 ITRC-METRIC ETc for White Wolf Subbasin Draft v2. Prepared for the White Wolf GSA. Irrigation Training & Research Center California Polytechnic State University.

Hoots, 1930. Hoots, H. W., Geology and oil resources along the southern border of San Joaquin Valley, California: U.S. Geol. Survey Bull. 812, p. 243-332. 1943, Origin, migration, and accumulation of oil in California, in Geologic formations and economic development of the oil and gas fields of California: California Div. Mines Bull. 118, p. 253-275, 1930.

Jaspar, 1974. Jaspar, D.E., Memorandum report of ground water studies. Wheeler Ridge-Maricopa Water Storage District, 9 pp., 1974.

Kern County, 2009. Land Use, Open Space, and Conservation Element (Chapter 1) Kern County General Plan, Kern County, 76pp.

Kern Water Bank, 2017. Project Recovery Operations Plan Regarding Pioneer Project, Rosedale-Rio Bravo Water Storage District, and Kern Water Bank Authority Projects. Joint Operating Plan. 6 p.

Lofgren, 1963. Lofgren, B.E, Land subsidence in the Arvin-Maricopa area, San Joaquin Valley, California, in Geological Survey research 1963, USGS Professional Paper 475-B, p. B171-B175, 1963.

Lofgren, 1975. Lofgren, B.E., Land subsidence due to ground-water withdrawal, Arvin-Maricopa area, California, USGS Professional Paper 437-D, 55 pp., 1975.

Metzger and Landon, 2018. Metzger, L.F., and Landon, M.K., 2018, Preliminary Groundwater Salinity Mapping Near Selected Oil Fields Using Historical Water-Sample Data, Central and Southern California: USGS Scientific Investigations Report 2018–5082, 54 p., https://doi.org/10.3133/sir20185082.

Nilsen, 1987. Nilsen, T.H., Stratigraphy and sedimentology of the Eocene Tejon Formation, western Tehachapi and San Emigdio Mountains, California, USGS Professional Paper 1268, 100 pp., 1987.

NOAA, 1982. Mean Monthly, Seasonal, and Annual Pan Evaporation for the United States. NOAA Technical Report NWS 34, dated December 1982, https://www.nws.noaa.gov/ohd/hdsc/Technical_reports/TR34.pdf

Osborn et al., 2013. Osborn, N.I., Smith, S.J., and C.H. Seger, Hydrogeology, distribution, and volume of saline groundwater in the southern midcontinent and adjacent areas of the United States: USGS Scientific Investigations Report 2013–5017, 58 p., 2013.

Provost & Pritchard, 2015. Provost & Pritchard Consulting Group. Kern River Watershed Coalition Authority Surface Water Monitoring Plan Revision 1. Resubmittal February 2, 2015.

Provost & Pritchard, 2016. Provost & Pritchard Consulting Group. Kern River Watershed Coalition Authority Annual Monitoring Report Water Year Reporting Period: October 1, 2014 through September 30, 2015. May, 2016.

Provost & Pritchard, 2017. Provost & Pritchard Consulting Group. Kern River Watershed Coalition Authority Annual Monitoring Report Water Year Reporting Period: October 1, 2015 through September 30, 2016. August, 2017.

Provost & Pritchard, 2018a. Provost & Pritchard Consulting Group. Wheeler Ridge-Maricopa Water Storage District Mettler Groundwater Recharge Project Initial Study/Mitigated Negative Declaration. Kern County, California. July, 2018.

Provost & Pritchard, 2018b. Provost & Pritchard Consulting Group. Kern River Watershed Coalition Authority Annual Monitoring Report Water Year Reporting Period: 2017 Water Year: October 1, 2016 through September 30, 2017. August, 2018.

Provost & Pritchard, 2020. Tulare Lake Basin Portion of Kern County Integrated Regional Water Management Plan, Final Update, Kern County Water Agency. March, 2020.

Rantz SE and others, 1982a, Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge, U.S. Geological Survey Water Supply Paper 2175, 313 pp.

Rantz SE and others, 1982b, Measurement and Computation of Streamflow: Volume 2. Computation of Discharge, U.S. Geological Survey Water Supply Paper 2175, 373 pp.

Scheirer, A.H., 2013. The three-dimensional geologic model used for the 2003 National Oil and Gas Assessment of the San Joaquin Basin Province, California: Chapter 7 in Petroleum systems and geologic assessment of oil and gas in the San Joaquin Basin Province, California, U.S. Geological Survey Professional Paper 1713-7, 81 pp.

SDWIS, 2018. Safe Drinking Water Information System, CA Drinking Water System Details (Water System No. CA1500516)
https://sdwis.waterboards.ca.gov/PDWW/JSP/WaterSystemDetail.jsp?tinwsys_is_number=1364&tinwsys_st_code=CA accessed 23 October 2018.

SDWIS, 2021. Safe Drinking Water Information System, CA Drinking Water System Details (Water System No. CA1503679) https://sdwis.waterboards.ca.gov/PDWW/JSP/WaterSystemDetail.jsp?tinwsys_is_number=14505&tinwsys_st_code=CA&counter=0 accessed 14 May 2021.

Shelton et al., 2008. Shelton, J.L., Pimentel, I., Fram, M.S., and Belitz, K., 2008, Ground-water quality data in the Kern County subbasin study unit, 2006—Results from the California GAMA Program, U.S. Geological Survey Data Series 337, 75 pp.

Snyder RL, Orang M, Matyac S, Grismer ME, 2005. Simplified Estimation of Reference Evapotranspiration from Pan Evaporation Data in California. Journal of Irrigation and Drainage Engineering: May/June 2005: 249-253. doi: 10.1061/(ASCE)0733-9437(2005)131:3(249)

Tejon-Castac Water District (TCWD), 2016. Grapevine Project Water Supply Assessment, dated January 2016.

Tejon Ranchcorp, 2016. Grapevine Final Specific and Community Plan. Kern County Planning and Natural Resources Department. Applicant: Tejon Ranchcorp; Technical Assistance by: Dudek 340 pp., December, 2016.

The Nature Conservancy (TNC), 2018a. Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act Guidance for Preparing Groundwater Sustainability Plans, dated January 2018. https://groundwaterresourcehub.org/public/uploads/pdfs/GWR_Hub_GDE_Guidance_Doc_2-1-18.pdf

TNC, 2018b. Maximum rooting depth database, published 19 April 2018. Available online: https://groundwaterresourcehub.org/sgma-tools/gde-rooting-depths-database-for-gdes/

TNC, 2019. IDENTIFYING GDEs UNDER SGMA Best Practices for using the NC Dataset, dated July 2019. Available online: https://groundwaterresourcehub.org/public/uploads/pdfs/TNC_NCdataset_BestPracticesGuide_2019.pdf

TODD Groundwater, 2020. SGMA Water Budget Development using C2VSimFG-Kern in support of the Kern County Subbasin Groundwater Sustainability Plans (GSPs). Memorandum to Mark Mulkay and Patty Poire, dated 7 January 2020. Attachment H of the Kern Groundwater Authority Groundwater Sustainability Plan, available online at http://www.kerngwa.com/assets/kga-umbrella-gsp_final.pdf.

TRC, 1984. Tejon Ranch Company, 1984 Report of Water Conditions and Outlook, October 1984.

TRC, 2008. Tejon Ranch Company, Conservation & Land Use Agreement, 280 pp., June 2008.

TRE Altamira, 2021. InSAR Land Survey and Mapping Services to DWR supporting SGMA – 2020 update, prepared by TRE Altamira Inc., dated 22 March 2021.

USGS, variously dated, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1-A10, available online at http://pubs.water.usgs.gov/twri9A.

Wood and Dale, 1964. Wood P.R. and R. H. Dale, Geology and Ground-Water Features of the Edison-Maricopa Area, Kern County, California, USGS Water Supply Paper 1656, 1964.

WRMWSD, 2007. Wheeler Ridge-Maricopa Water Storage District, AB3030 Groundwater Management Plan, 2007.

WRMWSD, 2021. Wheeler Ridge-Maricopa Water Storage District, 2020 Agricultural Water Management Plan, dated 14 July 2021, available online at: https://wrmwsd.com/wp-content/uploads/2021/07/WRMWSD-2020-AWMP-Final-Draft.pdf.

WRMWSD, 2018. Wheeler Ridge-Maricopa Water Storage District, Memorandum “Gaging Stations – Southern Stream Group – Project Update” from Thomas Suggs, October 15, 2018.

WZI, 2013. WZI, Inc., Grapevine Regional Groundwater Assessment, Kern County, California, November 2013.

Appendix A

Joint Powers Agreement for Formation of a Groundwater Sustainability Agency for the White Wolf Subbasin under the Sustainable Groundwater Management Act

JOINT POWERS AGREEMENT
FOR FORMATION OF A GROUNDWATER SUSTAINABILITY AGENCY FOR THE WHITE WOLF SUBBASIN
UNDER THE
SUSTAINABLE GROUNDWATER MANAGEMENT ACT

THIS JOINT POWERS AGREEMENT (JPA) is made and effective as of May 9, **2017,** by and between **Arvin-Edison Water Storage District** (AEWSD), **Wheeler Ridge-Maricopa Water Storage District** (WRMWSD), **Tejon-Castac Water District** (TCWD), and the **County of Kern** (COUNTY), each a "Party" and collectively the "Parties," with reference to the following facts:

A. In 2014, the State of California enacted the Sustainable Groundwater Management Act (Water Code Sections 10720 et seq.), referred to in this JPA as the "SGMA" or "Act," as subsequently amended, pursuant to which certain public agencies may become or participate in a "Groundwater Sustainability Agency" (GSA) and adopt a "Groundwater Sustainability Plan" (GSP) in order to manage groundwater in underlying groundwater basins. The Act defines "basin" as a basin or subbasin identified and defined in California Department of Water Resources (DWR) Bulletin 118.

B. On February 10, 2016, AEWSD, WRMWSD and TCWD entered into a Memorandum of Understanding (MOU) to, among other things, seek a boundary modification in accordance with Chapter 3 of the Act for the White Wolf Subbasin, which has long been recognized and documented as a separate subbasin. With the support of the COUNTY, AEWSD, WRMWSD, and TCWD conducted a technical investigation and submitted a boundary modification request in March 2016. In July 2016 the DWR issued a draft report recommending the modification, and on October 18, 2016, the California Water Commission confirmed DWR's recommendation and formally established the White Wolf Subbasin as a separate subbasin from the Kern County Subbasin. On December 23, 2016, DWR determined that the White Wolf Subbasin was not in critical overdraft.

C. The Parties are the agencies qualified to be a GSA under the Act for the White Wolf Subbasin, and collectively encompass the entire Subbasin. The map attached hereto as Exhibit A designates the boundaries of the White Wolf Subbasin.

D. Lands within the White Wolf Subbasin that have been developed to uses that utilize any significant groundwater are located within AEWSD, WRMWSD and TCWD. The White Wolf Subbasin lands which are not located within these districts but which are within the unincorporated County portions, are believed to utilize small or de minimis quantities of groundwater.

E. The Parties wish to provide a framework to form a GSA and to implement SGMA in the White Wolf Subbasin, such that the implementation is through local control and management and is implemented effectively, efficiently, fairly and at a reasonable cost.

F. As authorized by the Joint Exercise of Powers Act (Government Code Section 6500 et seq.), the parties are entering into this JPA to form the White Wolf GSA, share certain costs, and other matters provided for herein, but are not currently creating a separate entity or authority.

THEREFORE, in consideration of the mutual promises set forth below and to implement the goals described above, the Parties agree as follows:

1. Formation of the White Wolf Subbasin GSA. The purpose of this JPA is to form a GSA for the White Wolf Subbasin prior to June 30, 2017, and to facilitate a cooperative and ongoing working relationship between the Parties that will allow them to explore, study, evaluate, develop and implement mutually beneficial approaches and strategies for development and implementation of a GSP for the White Wolf Subbasin. By execution of this JPA, the Parties collectively determine and elect to be the GSA for the White Wolf Subbasin ("White Wolf GSA"), subject to the procedures provided for in the Act. It is presumed that this White Wolf GSA will be the sole GSA for the White Wolf Subbasin.

By entering into this JPA, the Parties are not currently creating a separate entity or joint powers authority.

2. Development of a Groundwater Sustainability Plan. The GSP for the Subbasin ("White Wolf GSP") will be prepared by the White Wolf GSA. The TCWD will coordinate efforts of the Parties and be the point of contact with DWR, as defined by the Act, to meet and cooperatively develop the White Wolf GSP. In developing the White Wolf GSP, the White Wolf GSA shall consider all beneficial uses and users of groundwater in the Subbasin, including the interests listed at Section §10723.2 of the Act.

3. GSA Governing Body. There is hereby established a seven member JPA Board for the White Wolf GSA, which shall be subject to the following:

a. AEWSD, WRMWSD and TCWD ("Voting Parties") shall each have two votes in the JPA Board and will be represented by two persons designated by the respective entities. The COUNTY shall be a non-voting board member of the JPA Board and will be represented by a person it designates, and shall be a Party to this JPA as an Additional Entity. Each Party may appoint one or more alternate JPA Board members.

b. The JPA Board may adopt resolutions, bylaws and policies to provide further details for conducting its affairs consistent with this JPA and applicable law and amend the same from time to time. Meetings of the JPA Board shall be called, noticed and conducted subject to the provisions of the Ralph M. Brown Act (California Government Code Sections 54950 et seq.)

c. A quorum of the JPA Board to transact business shall consist of four representatives from the Voting Parties. In order to pass any proposition or resolution, an affirmative vote of a majority of the JPA Board members present and voting will be required, provided that to adopt or make any amendment to the GSP, the unanimous consent of the Voting Parties shall be required.

d. The composition, voting procedures and powers of the JPA Board shall be reviewed and reaffirmed or modified as part of the process to adopt a GSP, including determining, if any of the Parties deems appropriate, forming a joint powers authority as a separate entity to submit and/or implement the GSP. This must occur no later than January 31, 2022.

4. Powers/Development of GSP.

(a) Under the Conditions and with the exceptions set forth in the Agreement, the White Wolf GSA shall have all the powers that a GSA is authorized to exercise as provided by the Act, including, but not limited to, developing a GSP that is consistent with the Act and DWR's regulations and imposing fees to pay for GSA and GSP activities. The JPA Board shall proceed in a timely fashion to develop and adopt a GSP for the White Wolf Subbasin by January 31, 2022.

(b) The White Wolf GSA shall not have the power to control, limit or empower a Party's rights and authorities over its own surface water supplies, facilities, operations, water management, water supply projects and financial affairs. As provided in Water Code Section 10720.5 of the Act, the White Wolf GSA and all of its Parties confirm that groundwater management under this White Wolf GSA shall not modify rights or priorities to use or store groundwater consistent with Section 2 of Article X of the California Constitution and that any groundwater management plan adopted by the White Wolf GSA shall not determine or alter surface water rights or groundwater rights under common law or any provision of law that determines or grants surface water rights.

5. Matters Related to County Powers.

(a) If the COUNTY is requested by the White Wolf GSA to use the COUNTY's police powers for a specific GSA purpose, then the White Wolf GSA shall indemnify and defend the COUNTY against liability for such exercise of its police powers.

(b) The Parties agree that nothing in a GSP or any actions taken by this White Wolf GSA will modify, limit or preempt the COUNTY's police powers, including, but not limited to, its land use authority. The COUNTY shall not designate or zone a specific project with the expectation that this GSA will provide more water allotment than that which is determined by any GSP allotment and policies, if there were such allotments. Likewise, the White Wolf GSA will not restrict the use of groundwater within its boundaries to a specific use.

(c) In accordance with the terms and conditions of this JPA, the White Wolf GSA will manage the areas of the White Wolf Subbasin that are not within the boundaries of AEWSD, WRMWSD and TCWD.

(d) Consistent with Water Code Section 10726.4(b), well permitting (which is presently codified in Kern County's Code of Ordinances at Section 14.08) is under the COUNTY's jurisdiction. The White Wolf GSA shall not issue permits for the construction, modification, and/or abandonment of groundwater wells except as authorized by the COUNTY. The White Wolf GSA will not transform, or trigger the transformation of, the well-permitting process from a ministerial function (which does not trigger CEQA) to a discretionary function (which may trigger CEQA) without prior consultation with the COUNTY. If the White Wolf GSA causes CEQA to be triggered with respect to any particular well permitting application within the White Wolf GSA, then the White Wolf GSA shall indemnify and defend the COUNTY against liability, costs and attorney's fees awarded to petitioner(s) in any CEQA challenge to well permitting within the Subbasin.

(e) Water transfers within the Subbasin will be considered as part of the White Wolf GSP development. In the event the adopted GSP includes extraction allocations pursuant to Water Code section 10726.4, the GSP will include conditions under which those allocations will be transferrable within the Subbasin without materially adversely affecting others, including, but not limited to, providing that any such transfer does not materially harm any Party to this Agreement, any portion of the Subbasin, degrade water quality, or materially harm any other groundwater user within the Subbasin. The Parties acknowledge that material harm is difficult to determine objectively in advance and agree to work to include a hydrologic review process for any transfers that are authorized in the GSP. Notwithstanding the foregoing, the respective Parties reserve all applicable rights they have with respect to preserving water supplies within their boundaries.

(f) The White Wolf GSA will ensure that any additional local agencies have a continuous opportunity to participate in the preparation, review and adoption of the White Wolf GSP. The term "participate" in this context means access to all non-privileged drafts, reports, technical information and other materials and communications, and an ability to actively engage in all open meetings related to the preparation, review and adoption of the White Wolf GSP. With respect to the COUNTY, as an Additional Entity and signatory to this JPA, its opportunities for participation and review are more than members of the general public and the COUNTY will be afforded access to all documents, drafts, reports, technical information and other materials and communications of the GSA.

(g) The White Wolf GSA will actively work with the COUNTY to preserve and protect available water supplies. Before adopting any GSP covering the White Wolf GSA's jurisdiction or agreeing to the coordination of the GSP with other GSPs, the White Wolf GSA shall consider the mitigation measures adopted in the COUNTY's certified Final Oil and Gas Environmental Impact Report (SCH# 2013081079), which was adopted by the Kern County Board of Supervisors on November 9, 2015, to address the creation of any GSP practices related to the implementation of SGMA and the Oil and Gas permitting.

6. <u>Costs</u>. Each Party shall bear its own costs incurred with respect to activities under this JPA to participate on the JPA Board and its proceedings and related matters. Costs incurred to retain consultants to assist with development of the White Wolf GSP and perform related studies as approved by the JPA Board and to implement the White Wolf GSP shall be borne equally by the Voting Parties (AEWSD, WRMWSD and TCWD). The Parties may consider levying a charge pursuant to the Act, or other legal authority. Certain costs for special projects may be funded under separate agreements among the benefited Parties.

7. <u>Staff</u>. Each Party shall designate a principal contact person, if other than the designated JPA Board members, and other appropriate staff members and consultants to participate on such Party's behalf in activities undertaken pursuant to this JPA. The TCWD shall be responsible for coordinating meetings and other activities under this JPA with the JPA Board and principal contact persons for the other Parties. Informal staff meetings may occur as needed.

8. Ongoing Cooperation. The Parties acknowledge that activities under this JPA will require the frequent interaction between them in order to pursue opportunities and resolve issues that arise. The Parties shall work cooperatively and in good faith.

9. Notices. Any formal notice or other formal communication given under the terms of this JPA shall be in writing and shall be given personally, by facsimile, by electronic mail (email), or by certified mail, postage prepaid and return receipt requested. Any notice shall be delivered or addressed to the Parties at the addressees' facsimile numbers or email addresses set forth below under each signature and at such other address, facsimile number or email address as shall be designated by notice in writing in accordance with the terms of this JPA. The date of receipt of the notice shall be the date of actual personal service, confirmed facsimile transmission or email, or three days after the postmark on certified mail.

10. Entire Agreement/Amendments/Counterparts. This JPA incorporates the entire and exclusive agreement of the Parties with respect to the matters described herein and supersedes all prior negotiations and agreements (written, oral, or otherwise) related thereto. This JPA may be amended only in a writing executed by all of the Parties. This JPA may be executed in two or more counterparts, each of which shall be deemed an original, but all of which together shall constitute one and the same instrument.

11. Termination/Withdrawal.

(a) This JPA shall remain in effect unless terminated by the unanimous consent of the voting Parties.

(b) Upon 60 days written notice, any of the Parties may withdraw from this JPA and the JPA shall remain in effect for the remaining Parties. A withdrawing Party shall be liable for expenses incurred through the effective date of the withdrawal (that is 60 days after the written notice, unless a later date is specified in the notice) and for its share of any contractual obligations incurred by the White Wolf GSA while the withdrawing Party was a party to this JPA, however, as provided a paragraph 6, the COUNTY is not participating in GSP development costs. Upon withdrawal as a Party, whether occurring before or after June 30, 2017, it is contemplated the withdrawing Party may concurrently become (or designate) a GSA for the lands within its boundaries, so that such lands of the withdrawing Party would continue to be subject to a GSA, and if applicable a GSP and the powers of such withdrawing Party within its boundaries would not be limited by this JPA. In such event this GSA and its remaining Parties (i) shall not object to or interfere with the lands in the withdrawing Parties' boundaries being in a GSA, as designated by such withdrawing Party, (ii) shall facilitate such transition to the extent necessary, and (iii) this GSA shall withdraw from managing the Subbasin as a GSA (if it has already elected to be a GSA) for that portion of the Subbasin within the boundaries of the withdrawing Party and so notify DWR. In such event, the withdrawing Party shall reconcile and reach agreement with any other Party with respect to overlapping boundaries of the Parties to determine which GSA the respective overlapping lands will be within.

12. Assignment. No rights or duties of any of the Parties under this JPA may be assigned or delegated without the express prior written consent of all of the other Parties, and any attempt to assign or delegate such rights or duties without such written consent shall be null and void.

13. Indemnification. No Party, nor any officer, director, employee or agent of a Party, shall be responsible for any damage or liability occurring by reason of anything done or omitted to be done by another Party under or in connection with this JPA. The Parties further agree, pursuant to California Government Code Section 895.4, that each party shall fully indemnify and hold harmless each other Party and its officers, directors, employees and agents from an against any claims, damages, losses, judgments, liabilities, expenses, and other cost, including litigation costs and attorney fees, arising out of, resulting from, or in connection with any action taken or omitted to be taken by such Party under this JPA. Notwithstanding the foregoing, the Voting Parties agree to fully indemnify, defend, and hold harmless the COUNTY and its officers, directors, employees and agents from and against any claims, damages, losses, judgements, liabilities, expenses or other costs, including litigation costs and attorney fees, arising out of, resulting from, or in connection with any action taken or omitted to be taken by the GSA, except to the extent directly caused by the COUNTY, or its officers, directors, employees or agents, negligence or wrongful acts, provided that the forgoing exception shall not apply to any claim that the COUNTY was negligent in entering into this Agreement, providing oversight of the GSA, the actions of GSA or the Voting Parties.

IN WITNESS WHEREOF, the Parties have executed this JPA as of the date first above written.

Arvin-Edison Water Storage District

By: ______________________
President

Address: P.O. Box 175
Arvin, CA 93203

Email arvined@aewsd.org

Facsimile (661) 854-5573

Wheeler Ridge-Maricopa Water Storage District

By: Robert J. Kunde
Engineer - Manager

Address: 12109 Highway 166
Bakersfield, CA 93313-9630

Email RKUNDE@WRMWSD.COM

Facsimile 661-858-2643

Tejon-Castac Water District

By: ______________________
President

Address: P.O. Box 478
Lebec, CA 93243

Email datkinson@tcwd.info

Facsimile (661) 248-3400

County Of Kern

By: ______________________
Zack Scrivner, Chairman
County of Kern Board of Supervisors

APPROVED AND RECOMMENDED:
COUNTY ADMINISTRATIVE OFFICE

By: ______________________
Alan Christensen, Chief Deputy
CAO for Water Resources

APPROVED AS TO FORM:
OFFICE OF COUNTY COUNSEL

By: ______________________
Phillip Hall, Deputy County Counsel

IN WITNESS WHEREOF, the Parties have executed this JPA as of the date first above written.

Arvin-Edison Water Storage District

By: ____________________________

Address: ________________________

____

Email ________________________

Facsimile ________________________

Wheeler Ridge-Maricopa Water Storage District

By: ____________________________

Address: ________________________

____

Email ________________________

Facsimile ________________________

Tejon-Castac Water District

By: ____________________________

Address: ________________________

____

Email ________________________

Facsimile ________________________

County Of Kern

By: Zack Scrivner

Zack Scrivner, Chairman
County of Kern Board of Supervisors

APPROVED AND RECOMMENDED:
COUNTY ADMINISTRATIVE OFFICE

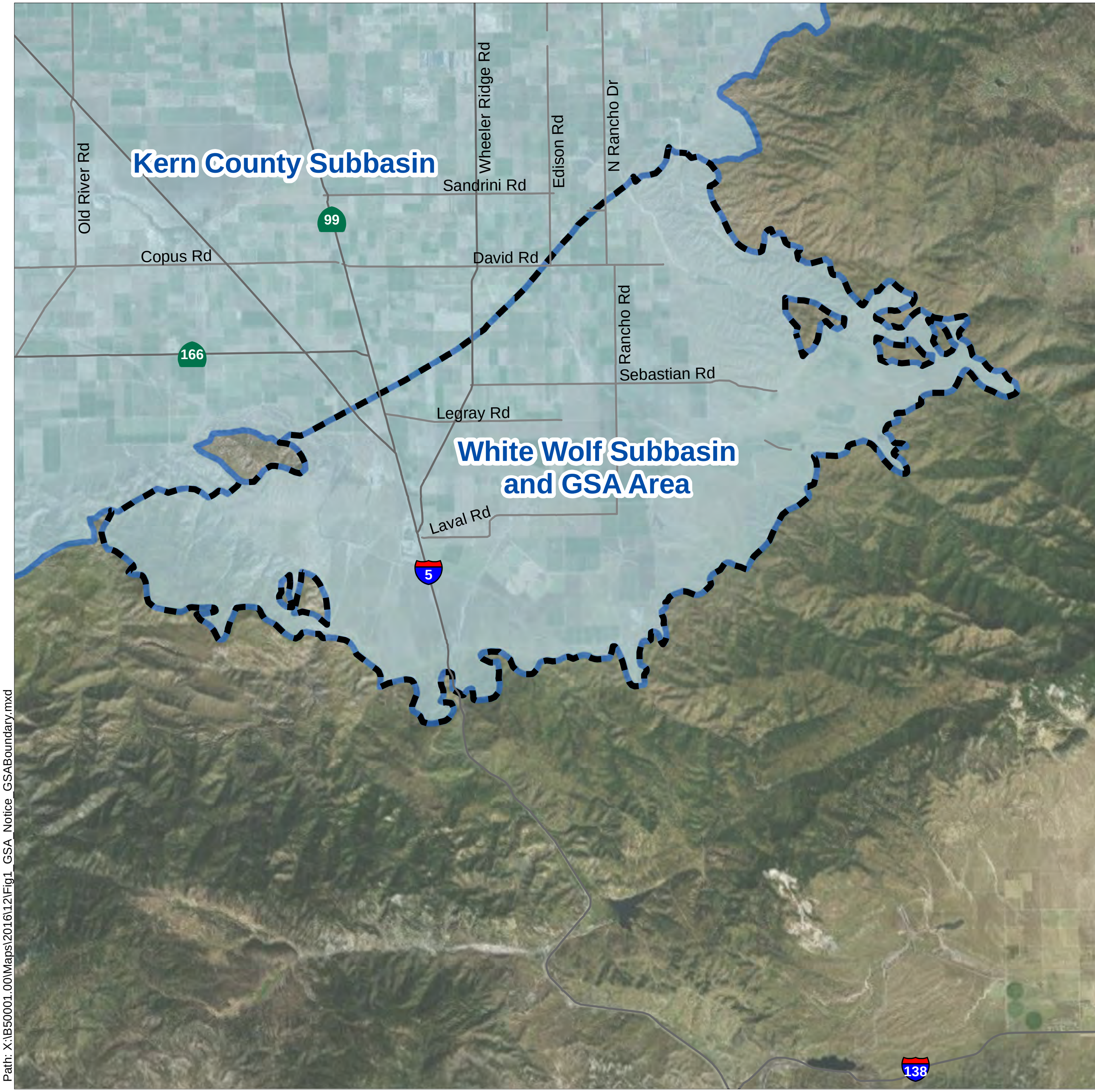
By: ____________________________

Alan Christensen, Chief Deputy
CAO for Water Resources

APPROVED AS TO FORM:
OFFICE OF COUNTY COUNSEL

By: P. Hall

Phillip Hall, Deputy County Counsel



Legend

White Wolf Subbasin and GSA Area

DWR Groundwater Basin

Road

Abbreviations

DWR = California Department of Water Resources
GSA = Groundwater Sustainability Agency

Notes

1. All locations are approximate.

Sources

1. DWR groundwater basins are based on the Final 2016 Basin Boundaries, dated 18 October, 2016.
2. The White Wolf GSA Area is the same as the White Wolf Subbasin.
3. Aerial photograph provided by ESRI's ArcGIS Online, obtained 14 December 2016.

Erler & Kalinowski, Inc.

White Wolf Subbasin and GSA Area

Tejon-Castac Water District
Kern County, CA
May 2017
EKI B50001.00

Exhibit A

Path: X:\B50001.00\Maps\2016\12\Fig1_GSA_Notice_GSABoundary.mxd

Appendix B

Stakeholder Communication and Engagement Plan
White Wolf Basin

Stakeholder Communication and Engagement Plan

White Wolf Basin

Prepared for the White Wolf Groundwater Sustainability Agency

FINAL
14 June 2018

EKI ENVIRONMENT & WATER, INC.

www.ekiconsult.com
577 Airport Blvd, Suite 500 • Burlingame, CA 94010

TABLE OF CONTENTS

List of Tables

List of Figures

Glossary / Abbreviations

AEWSD	Arvin-Edison Water Storage District
CASGEM	California Statewide Groundwater Elevation Monitoring
CWC	California Water Code
C&E	Communications and Engagement
DAC	Disadvantaged Communities
DWR	California Department of Water Resources
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
HCM	Hydrogeologic Conceptual Model
JPA	Joint Powers Agreement
SCEP	Stakeholder Communication and Engagement Plan
SGMA	Sustainable Groundwater Management Act
TC	Technical Committee
TCCWD	Tehachapi Cummings County Water District
TCWD	Tejon-Castac Water District
TRC	Tejon Ranch Corporation
TRCC	Tejon Ranch Commerce Center
WRMWSD	Wheeler Ridge-Maricopa Water Storage District

1. INTRODUCTION

§ 354.10. Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:

(a) A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.

(b) A list of public meetings at which the Plan was discussed or considered by the Agency.

(c) Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.

(d) A communication section of the Plan that includes the following:

(1) An explanation of the Agency's decision-making process.

(2) Identification of opportunities for public engagement and a discussion of how public input and response will be used.

(3) A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.

(4) The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.

The White Wolf Groundwater Sustainability Agency (GSA) has developed this Stakeholder Communication and Engagement Plan (SCEP) to describe its approach to Communication & Engagement (C&E) throughout the Groundwater Sustainability Plan (GSP) development process. This SCEP was prepared in accordance with California Water Code (CWC), the GSP Regulations (Title 23 of the California Code of Regulations [CCR] §354.10 [see above]), and the California Department of Water Resources (DWR) Guidance Document for Groundwater Sustainability Plan Stakeholder Communication and Engagement (DWR, 2018), as well as additional reference documents recommended by DWR for guidance.

C&E efforts carried out as described in this SCEP will help to ensure that beneficial uses and users of groundwater are adequately considered in the GSP development process as required by GSP Regulations (23-CCR §354.10). Specifically, in this SCEP:

- Section 2.2 describes the GSA decision-making process (23-CCR §354.10(d)(1));
- Section 6 identifies opportunities for public engagement and how public input and response will be used (23-CCR §354.10(d)(2));
- Section 3 identifies stakeholders and how the GSA intends to engage with them, and Section 4 describes how the GSA intends to build upon its current understanding of stakeholders in the Basin (23-CCR §354.10(d)(3) and CWC §10723.4); and
- Section 7 describes the C&E implementation timeline, including when this SCEP will be updated to describe methods to inform the public about GSP implementation progress, including the status of projects and actions (23 CCR §354.10(d)(4)).

2. GOALS AND DESIRED OUTCOMES

This program for C&E is designed to effectively engage a variety of relevant stakeholders in the development of a GSP that will guide the GSA to demonstrate sustainability by 31 January 2042 and maintain sustainability through the Sustainable Groundwater Management Act (SGMA)'s 50-year planning timeline.

2.1. GSA Description and Boundary

The GSA is comprised of Arvin-Edison Water Storage District (AEWSD), Tejon-Castac Water District (TCWD), Wheeler Ridge-Maricopa Water Storage District (WRMWSD), and Kern County (County). The GSA covers the entirety of the White Wolf Subbasin (Basin; DWR 5-022.18) of the San Joaquin Valley Basin, as shown in **Figure 1**. The Basin was originally designated as high priority following its delineation in the 2016 Basin Boundary Modification process. The Draft 2018 SGMA Prioritization designated the Basin as medium priority. The Basin is not critically overdrafted and thus has a GSP submission deadline of 31 January 2022.

2.2. GSA Structure and Decision-Making Process

Key GSP development and implementation decisions are made by the GSA Board of Directors (Board). The ad-hoc Technical Committee helps to guide the GSP development technical consultant team and provides feedback on draft work products.

2.2.1. GSA Board Structure and Meetings

Per the Joint Powers Agreement (JPA) executed on 9 May 2017, the GSA Board is composed of two voting representatives from AEWSD, TCWD, and WRMWSD and one non-voting representative from the County.

Board meetings are held on the first Tuesday of every third month (e.g., March, June, September, December) and are open to the public. Board meeting agendas and packets are posted to the GSA website (http://whitewolfgsa.org/) at least 72 hours before each Board meeting.

2.2.2. Ad-hoc Technical Committee Structure and Meetings

The ad-hoc Technical Committee (TC) is composed of one to two (1-2) representatives from each voting party of the GSA. The TC does not have regular meetings and instead meets as necessary to provide feedback to and guide the GSP development technical consultant team. The TC helps to identify and compile key data sources, refine key GSP components, and to translate technical GSP components for presentation to the Board and stakeholders.

2.3. Desired Outcome

The GSA aims to develop a GSP that sets the Plan Area on a path to maintain sustainability through SGMA's 50-year planning timeline.

2.4. Communication Objectives to Support the GSP

The GSA's C&E efforts aim to support a GSP that best meets the needs of beneficial uses and users of groundwater in the White Wolf Basin and reflects and incorporates stakeholder input as appropriate. The GSA aims to be knowledgeable about and anticipate stakeholder interests and concerns.

2.5. Challenges for the Plan Area

The GSA is aware of and plans to address the following challenges:

- Several large landowners overlie both the Basin and the Kern County Subbasin (Kern Basin; DWR 5-022.14). The GSA will need to coordinate with entities in the Kern Basin to ensure that C&E conducted by the GSA will align with and complement C&E conducted by entities in the Kern Basin. This coordination should be facilitated by the fact that AEWSD and WRMWSD currently overlie both basins and TCWD is anticipated to overlie both basins upon completion of a pending annexation. All three agencies will be closely involved in the GSP development process and C&E efforts in both basins. Should substantially different groundwater management decisions be made in each basin, the GSA will ensure that stakeholders near and straddling the basin boundary understand how GSP implementation in each basin will impact them.

- Irrigated agriculture is the primary land use in the Basin, and there will be concerns about SGMA compliance. The GSA will aim to be open and transparent in any decisions that will have a substantial impact on beneficial users of groundwater in the basin, and will aim to engage stakeholders early in the decision-making process to consider their interests and concerns.

- A major development (i.e., Grapevine at Tejon Ranch) will occur in the Basin during GSP implementation. While the development's entire demand will be met with surface water and recycled water, the GSP will need to describe how this major land use change will impact groundwater and C&E efforts will need to effectively communicate about changing land use in the Basin.

3. STAKEHOLDER IDENTIFICATION

The GSA identified current beneficial uses and users of groundwater in the Basin in its formation Notice submitted on 26 May 2017 in accordance with the interests listed in CWC §10723.2. The following are the identified beneficial uses and users of groundwater within the Basin. Representatives of specific organizations on this list form the basis of the GSA's list of interested parties, required by CWC §10723.2.

3.1. Holders of overlying groundwater rights

3.1.1. Agricultural Users

The primary land use in the Basin is irrigated agriculture, comprising 41% of the total land area in the Basin in 2013[1]. Collectively, WRMWSD and AEWSD provide water service to the majority of the agricultural water users in the Basin. Each water district maintains a list of landowners within its service area, and input from agricultural groundwater users will be integral to the development of the GSP.

Agricultural groundwater users in areas outside of the WRMWSD and AEWSD service areas will be engaged through the public outreach process prior to and during the development and implementation of the GSP.

3.1.2. Domestic Well Owners

The quantity and distribution of domestic well owners within the Basin is currently unknown. The GSA seeks to compile information on the number and location of domestic wells in the Basin, as well as the concerns and interests of domestic well owners, through the stakeholder survey described in Section 4.

3.1.3. Commercial and Industrial Users

The Pastoria Energy Facility, owned and operated by Calpine Corporation, is located on the southern border of the Basin, adjacent to the A.D. Edmonston Pumping Plant. The Pastoria Energy Facility relies exclusively on surface water supplies. Griffith Company operates a sand and gravel mine in the Basin and relies on both surface and groundwater supplies. Both facilities will be invited to participate in the GSP development process by sending representatives to GSA Board meetings and stakeholder workshops.

The Basin has historically been a productive region for oil and gas exploration. Active oil fields in the Basin include the following: Comanche Point, North Tejon, Pleito, Tejon, Tejon Hills, Valpredo, and Wheeler Ridge. Oil and gas groundwater users generally extract water from hydrocarbon-bearing zones beneath the vertical extent of the Basin. Representatives of the oil and gas industry are welcome to participate in the GSP development process by attending GSA Board meetings and stakeholder workshops.

The Tejon Ranch Commerce Center (TRCC), owned and operated by the Tejon Ranch Corporation (TRC) and served by TCWD, is the only large non-agricultural development in the Basin. The interests of the TRCC will be considered in the development and implementation of the GSP through TCWD's participation in the GSA.

[1] Kern County Department of Agriculture and Measurement Standards, 2013.

Additional commercial and industrial groundwater users, if identified, will be engaged prior to and during the development and implementation of the GSP.

3.2. Municipal Well Operators

Except for TCWD's three wells located generally in the vicinity of the TRCC that serve primarily as an emergency water supply, there are currently no identified municipal well operators within the basin.

3.3. Public Water Systems

Although all four GSA parties are public agencies, only TCWD is a Public Water Agency providing potable water service from both surface water and groundwater sources. WRMWSD and AEWSD provide untreated water for irrigation and industrial purposes, and the County of Kern does not provide water service.

Tehachapi Cummings County Water District (TCCWD) may overlie a very small portion of the Basin in the eastern uplands. As part of the 2016 basin boundary modification process[2], TCWD informed TCCWD of the overlap. TCCWD stated that it had no interest in the management of the White Wolf Basin under SGMA, and that the apparent overlap was likely a result of imperfect shapefiles[3].

Tut Brothers Farm #96 is noted as a community water system that serves 30 residents year-round with groundwater as its primary source (SDWIS). The GSA intends to engage with the operators of this water system to understand their interests.

While publicly available data have been examined to identify Public Water Systems in the Basin[4], the GSA acknowledges that these datasets are known to be incomplete and thus seeks to identify and engage any additional water systems during the development and implementation of the GSP.

3.4. Local Land Use Planning Agencies

The entire Basin is comprised of unincorporated County land, and the Kern County Planning and Community Development is responsible for land use planning in the Basin. The County will be actively involved in the development and implementation of the GSP through its participation in the GSA.

3.5. Environmental Users of Groundwater

There is minimal interaction between groundwater and surface water in the Basin. In most of the Basin, the water table lies more than 300 feet below land surface[5] and thus there is no groundwater contribution to stream flow. In the vicinity of the Springs Fault in the southeastern corner of the Basin, however, there is evidence of spring flow contributing to a strip of natural well-watered vegetation in an otherwise dry

---

[2] TCWD submitted a Basin Boundary Modification Request (BBMR) separating the White Wolf Basin from the rest of the Kern Basin in March 2016, and this BBMR was approved in October 2016.
[3] TCCWD clarified the apparent area overlap in a letter to TCWD dated 4 April 2016.
[4] Including the California Environmental Health Tracking Program Water System Map Viewer (http://www.cehtp.org/page/water/water_system_map_viewer).
[5] California Department of Water Resources, Groundwater Information Center, Spring 2016 Depth to Water Point Data, accessed 27 July 2016.

land cover. The spring discharge rate is estimated to be approximately 200 to 500 acre-feet per year (EKI, 2016).

Wind Wolves Preserve is a nature preserve that overlies a portion of the Basin and has expressed interest in participating in the GSP development process.

To the extent that additional environmental users of groundwater are identified, they will be considered and engaged during the development and implementation of the GSP.

3.6. Surface Water Users

Surface water features in the Basin include ephemeral streams draining the Tehachapi Mountains, several small lakes and ponds, the California Aqueduct, and a network of irrigation canals and ditches.

TRC holds appropriative water rights to several of the ephemeral tributaries to the Basin. As a landowner in the Basin, TRC will be will be engaged during the development and implementation of the GSP.

3.7. The Federal Government

There are no identified federal lands within the Basin.

3.8. California Native American Tribes

There are no identified California Native American tribal lands within the Basin.

3.9. Disadvantaged Communities

A portion of US Census Tract 62.02, which overlies an area of the northern portion of the Basin along Interstate 5, was identified as a Disadvantaged Community Tract based on an average household income less than 80% of the State median (U.S. Census, 2015). There were no Disadvantaged Community Places identified within the Basin (U.S. Census, 2015). The GSA aims to engage residents of disadvantaged communities during the development and implementation of the GSP through identification in the stakeholder survey and coordination with relevant community groups.

3.10. Groundwater Monitoring Entities

The GSA and AEWSD are Monitoring Entities in the Basin under the California Statewide Groundwater Elevation Monitoring (CASGEM) Program. WRMWSD conducts the CASGEM monitoring effort on behalf of the GSA. AEWSD will be actively involved in the development and implementation of the GSP through its participation in the GSA.

4. STAKEHOLDER SURVEY AND MAPPING

The GSA intends to frequently update its list of stakeholders based on new information. To learn more about its stakeholders, the GSA plans to distribute a stakeholder survey (Appendix A) by:

- Posting the survey on the GSA website (http://whitewolfgsa.org/);
- Having copies of the survey available at all GSA Board meetings and stakeholder workshops;
- Sending the survey in water bill mailings from AEWSD, TCWD, and WRMWSD; and
- Coordinating with the community organizations (e.g., Kern County Farmers Bureau, Self-Help Enterprises, etc.) to distribute the survey to diverse members of the population that may not be otherwise be reached.

Based on current knowledge of stakeholders, the GSA has completed a "Lay of the Land" exercise in **Table 1**, identifying specific stakeholder organizations/individuals, stakeholder type, key interests and issues, the sections of the GSP likely to be relevant to this stakeholder, and the level of engagement (e.g., inform, consult, involve) expected with each stakeholder organization/individual.

Given that the GSA will gain more knowledge of the interests, issues, and challenges of stakeholders over the course of GSP development, **Table 1** will be updated during each phase of GSP development. Should the GSA need to learn more about specific stakeholders, individual meetings will be arranged to find out more about their issues, interests, and challenges.

In addition to the more detailed stakeholder survey, the GSA intends to maintain a simple form on its webpage for individuals to enroll in the GSA interested parties list and provide their contact information.

Table 1
Stakeholder Constituency – "Lay of the Land" Exercise

Organization/ Individual	Type of Stakeholder (a)	Anticipated Key Interests	Anticipated Key Issues (b)	Relevant GSP Sections	Level of Engagement and Rationale (c)
Agricultural Water Users	Agricultural Users	Preserving access to high quality groundwater for irrigation	• Potential curtailment of pumping • GSP development and implementation costs	• Sustainable Management Criteria • Projects and Management Actions	Collaborate to ensure sustainable management of groundwater
Domestic Well Users	Domestic Well Owners	Preserving access to high quality groundwater for domestic users	• Water quality degradation • Declining water levels • Potential curtailment of pumping • GSP development and implementation costs	• Sustainable Management Criteria • Projects and Management Actions	Inform and involve to avoid negative impact to these users
Kern County Planning and Community Development	Local Land Use Planning Agency	Managing County-wide land use	*Need to identify*	• Plan Area • Projects and Management Actions	Consult and involve to ensure land use policies are supporting GSPs
Tejon Ranch Commerce Center	Commercial User	Maintain access to groundwater supplies	• Potential curtailment of pumping • GSP development and implementation costs	• Sustainable Management Criteria • Projects and Management Actions	Inform and involve to avoid negative impact to these users
Tejon Ranch Corporation	Commercial User and Environmental Users	Ensure viability of future developments	• Ensure that changing land use will complement GSP projects and management actions	• Projects and Management Actions	Inform and involve to avoid negative impact to these users
Griffith Company	Industrial User	Maintain access to groundwater supplies	• Potential curtailment of pumping • GSP development and implementation costs	• Sustainable Management Criteria • Projects and Management Actions	Inform and involve to avoid negative impact to these users
Active oil field operators	Industrial Users	Continue to operate oil fields	• Definition of vertical extent of the groundwater basin based on salinity	• Basin Setting • Sustainable Management Criteria • Projects and Management Actions	Inform and involve to avoid negative impact to these users
Tejon-Castac Water District	Public Water System	Continue to provide potable water service	• Potential curtailment of pumping • GSP development and implementation costs	• Basin Setting • Sustainable Management Criteria • Projects and Management Actions	Collaborate to ensure sustainable management of groundwater
Tut Brothers Farm #96	Public Water System	*Need to identify*	*Need to identify*	*Need to identify*	*Need to identify*

Table 1
Stakeholder Constituency – "Lay of the Land" Exercise

Organization/ Individual	Type of Stakeholder (a)	Anticipated Key Interests	Anticipated Key Issues (b)	Relevant GSP Sections	Level of Engagement and Rationale (c)
Arvin-Edison Water Storage District	Agricultural Users, Groundwater Monitoring Entity	Preserve access to high quality groundwater for irrigation	• Potential curtailment of pumping • GSP development and implementation costs • Operation of recharge basins	• Basin Setting • Sustainable Management Criteria • Projects and Management Actions	Collaborate to ensure sustainable management of groundwater
Wheeler Ridge-Maricopa Water Storage District	Agricultural Users, Groundwater Monitoring Entity	Preserve access to high quality groundwater for irrigation	• Potential curtailment of pumping • GSP development and implementation costs	• Basin Setting • Sustainable Management Criteria • Projects and Management Actions	Collaborate to ensure sustainable management of groundwater
Wind Wolves Preserve	Environmental Users	Preserve ecosystem	• Analyzing potential groundwater dependence of ecosystems	• Basin Setting • Sustainable Management Criteria • Projects and Management Actions	Inform and involve to sustain ecosystem

Abbreviations:

CWC = California Water Code
DWR = California Department of Water Resources
GSA = Groundwater Sustainability Agency
GSP = Groundwater Sustainability Plan
SGMA = Sustainable Groundwater Management Act

Notes:

(a) Type of stakeholder based on CWC §10723.2 (e.g., agricultural groundwater users, municipal well operators, etc.).
(b) Any documented issues (media coverage, statements, reports, etc.), specific issues such as past events, or issues that have been otherwise communicated to or are anticipated by the GSA.
(c) Level of engagement based on the International Association of Public Participation Spectrum of Public Participation, as referenced in DWR's Guidance Document for Groundwater Sustainability Plan Stakeholder Communication and Engagement (DWR, 2018).

5. MESSAGES

The GSA aims to convey consistent high-level messaging to all stakeholders throughout GSP development and implementation. The following are the key messages that will form the foundation for all C&E efforts:

1. The GSA aims to engage with diverse stakeholders to best represent their interests in the GSP development process;
2. Key GSP development decisions will be made in an open and transparent fashion during public GSA Board meetings; and
3. Technical GSP development progress will be communicated in an accessible manner to encourage stakeholder understanding and support effective stakeholder input.

The GSA will maintain these messages in all venues for engaging, as described in Section 6. Additionally, the GSA has developed **Table 2** to document anticipated questions as well as possible responses. **Table 2** will be updated to add additional, frequently received questions as well as to build upon responses based on GSP development progress.

Table 2 Likely Questions and Responses

Likely Questions	Responses
How can I participate in the GSP development and implementation process?	GSA Board meetings are open to the public and held at 1:00 PM on the first Tuesday of every third month (e.g., March, June, September, December) in the Conference Room of the Iron Skillet, 5821 Dennis McCarthy Drive, Lebec CA 93243. Stakeholder workshops will be held throughout the GSP development process, and will be publicized on the GSA website (http://whitewolfgsa.org/).
Will I have to fallow my land?	We are currently in the initial phases of GSP development. Projects and management actions to achieve sustainability will be discussed later in the process, with ample opportunity for stakeholder input.
What types of management actions or projects are going to occur in my area?	We are currently in the initial phases of GSP development. Projects and management actions to achieve sustainability will be discussed later in the process, with ample opportunity for stakeholder input.
Are pump meters going to be required? Who will pay for meters?	We are currently in the initial phases of GSP development. Projects and management actions to achieve sustainability will be discussed later in the process, with ample opportunity for stakeholder input.
Who is paying for GSP development and implementation?	The GSA has obtained state funding to support GSP development (https://www.water.ca.gov/Work-With-Us/Grants-And-Loans/Sustainable-Groundwater). AEWSD, TCWD, and WRMWSD will share the remaining cost and actual cost to the landowner has yet to be determined.

6. VENUES FOR ENGAGING

The GSA intends to provide a variety of opportunities for engagement with stakeholders. Stakeholder input received will inform and be incorporated into corresponding sections of the GSP as appropriate.

6.1. GSA Board Meetings

As described in Section 2.2.1, the GSA Board meetings are open to the public and are a consistent venue for public engagement.

6.2. Stakeholder Workshops

Stakeholder workshops will be held to communicate progress on GSP technical components to stakeholders and to receive input on upcoming decisions and work efforts. At least two stakeholder workshops and one public hearing will be held during GSP development:

- **Stakeholder Workshop #1** – SGMA Overview, draft results of Basin Setting Information, Preliminary Undesirable Results, and Introduction to Sustainable Management Criteria.
- **Stakeholder Workshop #2** – Draft Sustainable Management Criteria and Discussion of Projects and Management Actions.
- **Public Hearing** – Review of the draft GSP.

The GSA will publicize all stakeholder workshops on its website (http://whitewolfgsa.org/) and to its list of interested parties and will coordinate with GSA parties (AEWSD, WRMWSD, TCWD) and community organizations (e.g., Kern County Farmers Bureau, Self-Help Enterprises, etc.) to send out emails and mailings as appropriate.

Additional stakeholder workshops may be held during GSP implementation. The timing and content of these stakeholder workshops will be determined when the GSP Implementation Plan is developed shortly before GSP submission.

6.3. Fact Sheets/Newsletters

The GSA intends to develop at least two fact sheets during GSP development, related to the information to be presented during the stakeholder workshops described in Section 6.2. These fact sheets will complement the material covered during the workshops and will be distributed at the workshops, on the GSA website, and through the GSA parties and community organizations.

6.4. Website Communication

The GSA will update its website with GSA Board meeting materials as described in Section 2.2.1, and will additionally update the website with key GSP updates.

6.5. Stakeholder Surveys

The GSA intends to learn about stakeholder interests using surveys that will be distributed as discussed in Section 4. A draft stakeholder survey is included as Appendix A.

7. IMPLEMENTATION TIMELINE

The GSA's C&E implementation timeline aligns with a four phase GSP development timeline, as described in **Table 3** below.

Table 3 GSP Development and C&E Efforts by Phase

Phase	Timeframe	Overall GSP Efforts	C&E Efforts
GSP Foundation	May 2018 – July 2018	• Submit Initial Notification of GSP development • Select and design a Data Management System (DMS) • Conduct data gaps assessment • Evaluate numerical groundwater model options	• Develop SCEP • Distribute Stakeholder Survey • Assess C&E progress based on survey results • Update Stakeholder Constituency Table
Basin Characterization and Analysis	July 2018 – July 2019	• Implement plan for filling data gaps • Develop Hydrogeologic Conceptual Model (HCM) and definition of groundwater conditions • Develop water budget • Assess existing monitoring programs	• Develop and distribute SGMA Fact Sheet #1 • Conduct Stakeholder Workshop #1 • Assess C&E progress based on results of Stakeholder Workshop #1 • Update Stakeholder Constituency Table
Sustainability Planning	July 2019 – July 2020	• Evaluate potential management areas • Develop sustainable management criteria • Identify projects and management actions • Create GSP implementation plan • Finalize monitoring network and protocols	• Develop and distribute SGMA Fact Sheet #2 • Conduct Stakeholder Workshop #2 • Assess C&E progress based on results of Stakeholder Workshop #2 • Update Stakeholder Constituency Table • Update SCEP to reflect plan for C&E efforts during GSP Implementation
GSP Preparation and Submittal	July 2020 – January 2022	• Compile complete draft GSP • Revise draft GSP (if necessary) per stakeholder feedback • Finalize GSP and submit to DWR	• Distribute draft GSP • Hold Public Hearing on draft GSP • Assess C&E progress and plan for C&E related to GSP Implementation • Update Stakeholder Constituency Table

The GSA will update this SCEP while creating a GSP implementation plan. This update will focus on informing the public about GSP implementation progress, including the status of projects and actions (23-CCR §354.10(d)(4)).

8. EVALUATION AND ASSESSMENT

The GSA intends to assess its C&E implementation during each phase of GSP development, as shown in **Table 3**. The TC and/or the technical consultant team will present brief summaries of C&E progress at GSA Board meetings and will lead a discussion about lessons learned and what can be improved in the next phase of GSP development. The following questions will guide C&E evaluation:

- What worked well?
  - What allowed us insight into stakeholder concerns?
  - What types of materials best communicated GSP development to stakeholders?
- What didn't work as planned?
  - Could materials (e.g., presentation slides, fact sheets, website pages) have been improved to better communicate GSP development progress?
  - Are certain stakeholder groups less represented in the GSP development process than they should be?
- What do we plan on doing differently during the next phase based on what we have learned?
- How much of our C&E budget have we spent relative to work completed? Do we have enough remaining budget to complete our C&E plan?

REFERENCES AND TECHNICAL STUDIES

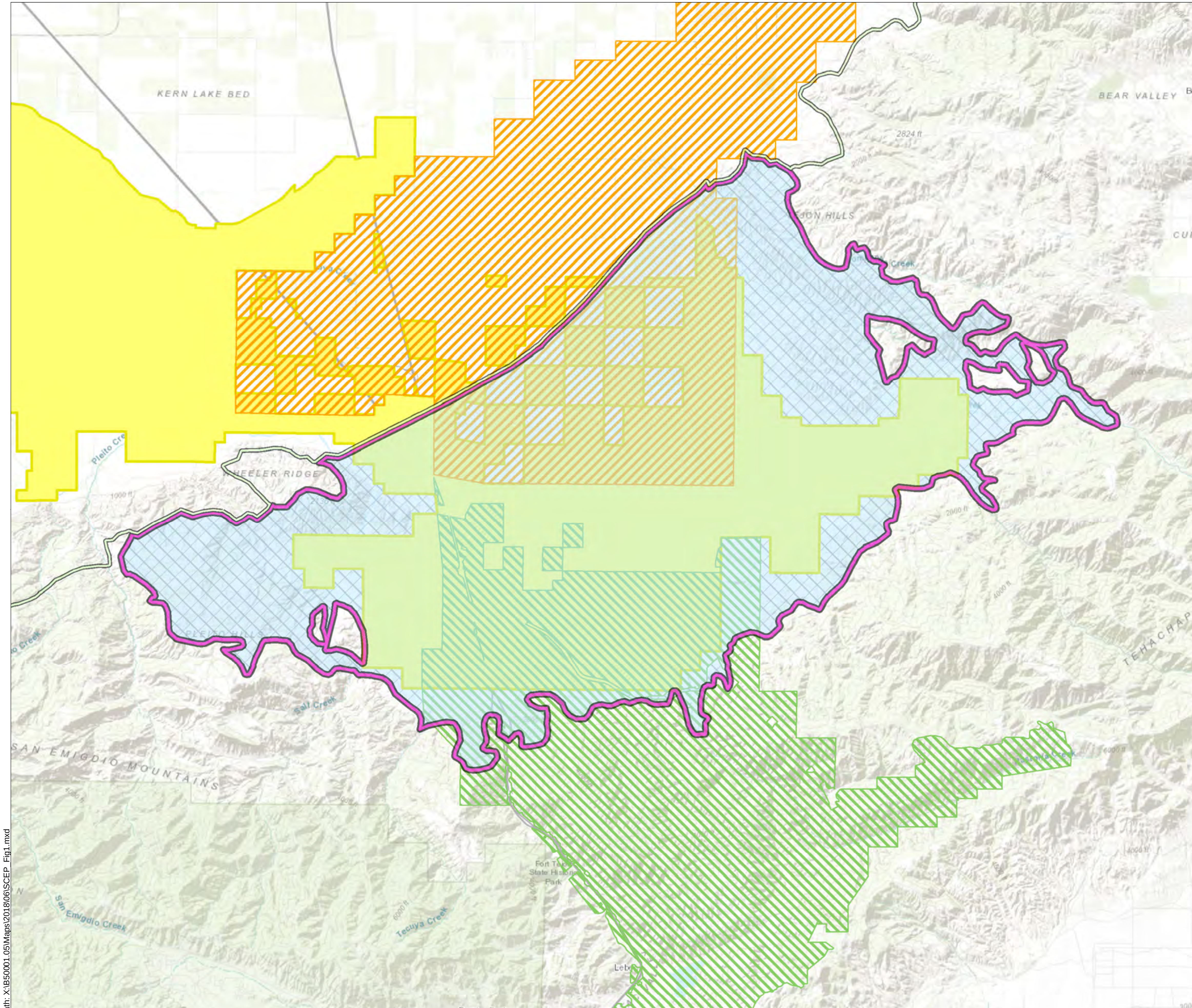
CWC, 2015. Community Water Center. Collaborating for Success: Stakeholder Engagement for Sustainable Groundwater Management Act Implementation. July 2015.

DWR, 2018. California Department of Water Resources. Guidance Document for Groundwater Sustainability Plan Stakeholder Communication and Engagement. January 2018.

EKI, 2016. Erler & Kalinowski, Inc. White Wolf Subbasin Technical Report, 16 March 2016.

SDWIS. Safe Drinking Water Information System. Water System Details, accessed 14 May 2018. https://sdwis.waterboards.ca.gov/PDWW/JSP/WaterSystemDetail.jsp?tinwsys_is_number=1364&tinwsys_st_code=CA&counter=0.

U.S. Census, 2015. US Census American Community Survey, 2010-2014.



Legend

Groundwater Subbasin

- White Wolf
- Kern County

Jurisdictional Area

- White Wolf GSA
- AEWSD Service Area
- TCWD Service Area
- WRMWSD Service Area
- Kern County (outside of other GSA parties' jurisdictions)

Abbreviations

AEWSD = Arvin-Edison Water Storage District
DWR = California Department of Water Resources
GSA = Groundwater Sustainability Agency
TCWD = Tejon-Castac Water District
WRMWSD = Wheeler Ridge-Maricopa Water Storage District

Notes

1. All locations are approximate.
2. White Wolf GSA boundary is coterminous with the White Wolf Subbasin (5-022.18) boundary.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 14 June 2018.
2. DWR groundwater basins are based on the Final 2016 Basin Boundaries, dated 18 October, 2016.
3. Service area boundaries for AEWSD, TCWD, and WRMWSD obtained from each district.

N

0 2.5 5

(Scale in Miles)

GSA Area

eki environment & water

Tejon-Castac Water District
Kern County, CA
June 2018
EKI B50001.05

Figure 1

Path: X:\B50001.05\Maps\2018\06\SCEP_Fig1.mxd

APPENDIX A – STAKEHOLDER SURVEY

White Wolf Groundwater Sustainability Agency
Stakeholder Survey

The White Wolf Groundwater Sustainability Agency (GSA) is conducting this survey to understand more about its stakeholders in the White Wolf Basin. Answers to these questions will support the development of a Groundwater Sustainability Plan (GSP) for the White Wolf Basin.

Date: _______________

Affiliated organization or business name (if applicable): ________________________________

Name of primary contact or individual stakeholder: ___________________________________

Contact information:

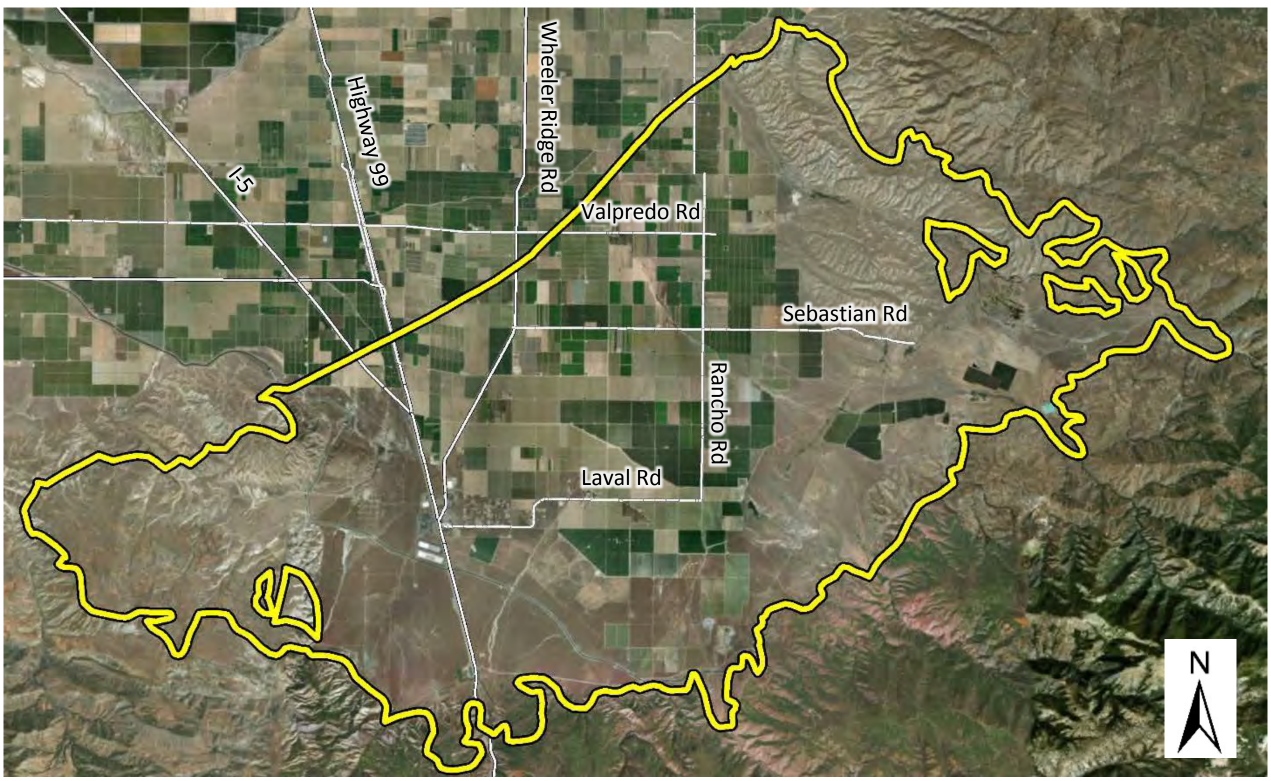
Email: ____

Phone Number: ____

Address: ____

Website: ____

Please indicate the approximate location of your land, home, business, or well(s) with an X on the below map of the White Wolf Basin:



Stakeholder Type (check all that apply):

- ☐ Agricultural Groundwater User
- ☐ Domestic Well Owner/User
- ☐ Municipal Well Operator
- ☐ Commercial/Industrial Groundwater User
- ☐ Public Water System
- ☐ Local Land Use Planning Agency
- ☐ Environmental User
- ☐ Surface Water User
- ☐ Federal Government
- ☐ Native American Tribe
- ☐ Disadvantaged Community Resident or Organization
- ☐ City Resident
- ☐ Groundwater Monitoring Entity

White Wolf Groundwater Sustainability Agency
Stakeholder Survey

Questions:

1. Are you familiar with the Sustainable Groundwater Management Act (SGMA) regulations?

2. Are you currently engaged in activities or discussions regarding groundwater management in this region?

3. Do you own or manage land in this region?

4. Where do you get your water supply?
   - ☐ City or Community Water System
   - ☐ Surface Water
   - ☐ Groundwater
   - ☐ Both Groundwater and Surface Water
   - ☐ Unknown

5. What is your primary interest in land or water resources management?

6. (For agricultural and domestic well owners/users): What are the depth(s), screen interval(s), reference point elevation(s), and location of your wells?

7. (For agricultural and domestic well owners/users): Are you willing to share the following data with the White Wolf GSA to support GSP development?[1] (check all that apply)
   - ☐ Well Completion Report(s)
   - ☐ Pump test report(s)
   - ☐ Other: _______________________
   - ☐ Water level data
   - ☐ Water quality data

8. (For agricultural and domestic well owners/users): Has/have your well(s) ever gone dry or otherwise been impacted by declining water levels? If yes, when?

9. Do you have concerns about groundwater management? If so, what are they?

10. Do you have recommendations that you would like the White Wolf GSA to consider while developing a GSP? If so, what are they?

---

[1] Documents and data can be sent to the White Wolf GSA at amartin@tejonranch.com or to Angelica Martin at 4436 Lebec Road, Lebec, CA 93243.

Appendix C

GSP Public Comments

November 6, 2021

White Wolf GSA
4436 Lebec Road
Lebec, CA 93243

Submitted via email: amartin@tejonranch.com

Re: Public Comment Letter for White Wolf Subbasin Draft GSP

Dear Angelica Martin,

On behalf of the above-listed organizations, we appreciate the opportunity to comment on the Draft Groundwater Sustainability Plan (GSP) for the White Wolf Subbasin being prepared under the Sustainable Groundwater Management Act (SGMA). Our organizations are deeply engaged in and committed to the successful implementation of SGMA because we understand that groundwater is critical for the resilience of California's water portfolio, particularly in light of changing climate. Under the requirements of SGMA, Groundwater Sustainability Agencies (GSAs) must consider the interests of all beneficial uses and users of groundwater, such as domestic well owners, environmental users, surface water users, federal government, California Native American tribes and disadvantaged communities (Water Code 10723.2).

As stakeholder representatives for beneficial users of groundwater, our GSP review focuses on how well disadvantaged communities, drinking water users, tribes, climate change, and the environment were addressed in the GSP. While we appreciate that some basins have consulted us directly via focus groups, workshops, and working groups, we are providing public comment letters to all GSAs as a means to engage in the development of 2022 GSPs across the state. Recognizing that GSPs are complicated and resource intensive to develop, the intention of this letter is to provide constructive stakeholder feedback that can improve the GSP prior to submission to the State.

Based on our review, we have significant concerns regarding the treatment of key beneficial users in the Draft GSP and consider the GSP to be **insufficient** under SGMA. We highlight the following findings:

1. Beneficial uses and users **are not sufficiently** considered in GSP development.
    a. Human Right to Water considerations **are not sufficiently** incorporated.
    b. Public trust resources **are not sufficiently** considered.
    c. Impacts of Minimum Thresholds, Measurable Objectives and Undesirable Results on beneficial uses and users **are not sufficiently** analyzed.

2. Climate change **is not sufficiently** considered.
3. Data gaps **are not sufficiently** identified and the GSP **needs additional plans** to eliminate them.
4. Projects and Management Actions **do not sufficiently consider** potential impacts or benefits to beneficial uses and users.

Our specific comments related to the deficiencies of the White Wolf Subbasin Draft GSP along with recommendations on how to reconcile them, are provided in detail in **Attachment A.**

Please refer to the enclosed list of attachments for additional technical recommendations:

Attachment A	GSP Specific Comments
Attachment B	SGMA Tools to address DAC, drinking water, and environmental beneficial uses and users
Attachment C	Freshwater species located in the basin
Attachment D	The Nature Conservancy's "Identifying GDEs under SGMA: Best Practices for using the NC Dataset"
Attachment E	Maps of representative monitoring sites in relation to key beneficial users

Thank you for fully considering our comments as you finalize your GSP.

Best Regards,

Ngodoo Atume
Water Policy Analyst
Clean Water Action/Clean Water Fund

J. Pablo Ortiz-Partida, Ph.D.
Western States Climate and Water Scientist
Union of Concerned Scientists

Samantha Arthur
Working Lands Program Director
Audubon California

Danielle V. Dolan
Water Program Director
Local Government Commission

E.J. Remson
Senior Project Director, California Water Program
The Nature Conservancy

Melissa M. Rohde
Groundwater Scientist
The Nature Conservancy

Attachment A

Specific Comments on the White Wolf Subbasin Draft Groundwater Sustainability Plan

1. Consideration of Beneficial Uses and Users in GSP development

Consideration of beneficial uses and users in GSP development is contingent upon adequate identification and engagement of the appropriate stakeholders. The (A) identification, (B) engagement, and (C) consideration of disadvantaged communities, drinking water users, tribes,[1] groundwater dependent ecosystems, streams, wetlands, and freshwater species are essential for ensuring the GSP integrates existing state policies on the Human Right to Water and the Public Trust Doctrine.

A. Identification of Key Beneficial Uses and Users

Disadvantaged Communities and Drinking Water Users
The identification of Disadvantaged Communities (DACs) and drinking water users is **incomplete**. The GSP provides information on DACs, including identification by name and location on a map (Figure PA-2), and identifies the population of each identified DAC. However, the GSP fails to include the population dependent on groundwater as their source of drinking water in the basin.

While the plan provides a density map of domestic wells in the basin (Figure PA-4), the GSP fails to provide depth of these wells (such as minimum well depth, average well depth, or depth range) within the basin. This information is necessary to understand the distribution of shallow and vulnerable drinking water wells within the basin.

These missing elements are required for the GSA to fully understand the specific interests and water demands of these beneficial users, and to support the consideration of beneficial users in the development of sustainable management criteria and selection of projects and management actions.

RECOMMENDATIONS
• Identify the sources of drinking water for DAC members, including an estimate of how many people rely on groundwater (e.g., domestic wells, state small water systems, and public water systems). • Include a map showing domestic well locations and average well depth across the basin.

[1] Our letter provides a review of the identification and consideration of federally recognized tribes (Data source: SGMA Data viewer) within the GSP from non-tribal members and NGOs. Based on the likely incomplete information available to our organizations for this review, we recommend that the GSA utilize the California Department of Water Resources' "Engagement with Tribal Governments" Guidance Document (https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents) to comprehensively address these important beneficial users in their GSP.

Interconnected Surface Waters

The identification of Interconnected Surface Waters (ISW) is **insufficient**, due to lack of supporting information provided for the ISW analysis. The GSP states (p. 87): *"As discussed above, groundwater levels in the Principal Aquifer are far below the land surface within most of the Basin (Figure GWC-4), and therefore there is no interconnected surface water throughout most of the Basin."* Figure GWC-4 presents point locations of average depth groundwater over the period 2015-2019. However, averaging depth to groundwater dampens the seasonal and interannual variability of these data. In California's Mediterranean climate, groundwater interconnections with surface water can vary seasonally and interannually. Using seasonal groundwater elevation data over multiple water year types is an essential component of identifying ISWs.

The GSP discusses the ephemeral nature of the stream reaches as evidence that stream reaches are disconnected from groundwater. The GSP states (p. 87): *"Furthermore, the definition of interconnected surface water requires that the surface water feature not be completely depleted (i.e., not dry)."* However, this sentence is a misinterpretation of the regulations [23 CCR §351(o)], which define ISW as "surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted". "At any point" has both a spatial and temporal component. Even short durations of interconnections of groundwater and surface water can be crucial for surface water flow and supporting environmental users of groundwater and surface water.

The GSA used the ICONS web mapping application as further evidence that ISWs are not present in the basin, stating that streams in the portion of the basin shown on this map are all designated as "likely disconnected". However, the ICONS web map data only covers a small portion of the basin.

Finally, the GSP states that the possible exception to the disconnected nature of groundwater and surface water in the basin is near the Springs Fault. The GSP states (p. 88): *"Furthermore, based on the available data (see Appendix D), water level data installed in co-located shallow monitoring wells show no impact from groundwater production from the Principal Aquifer. This suggests that this area is hydraulically disconnected from, and at a minimum should be managed separately from, the Principal Aquifer."* However, shallow aquifers that have the potential to support well development, support ecosystems, or provide baseflow to streams are principal aquifers, even if the majority of the basin's pumping is occurring in deeper principal aquifers.[2] If areas of shallow or perched groundwater are discounted as ISWs, the GSP should provide more supporting evidence of 1) vertical groundwater gradients between the perched system and deeper principal aquifers, and 2) whether perched groundwater is providing significant or economic quantities of water to streams, wells (e.g., domestic wells), and ecosystems (e.g., GDEs).

RECOMMENDATIONS
● Provide a map showing all the stream reaches in the basin, with reaches clearly labeled as interconnected (gaining/losing) or disconnected. Consider any segments with data gaps as potential ISWs and clearly mark them as such on maps provided in the GSP.

[2] "'Principal aquifers' refer to aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems." [23 CCR §351(aa)]

- Use seasonal data over multiple water year types to capture the variability in environmental conditions inherent in California's climate, when mapping ISWs. We recommend the 10-year pre-SGMA baseline period of 2005 to 2015.

- Overlay the basin's stream reaches on depth-to-groundwater contour maps to illustrate groundwater depths and the groundwater gradient near the stream reaches. Show the location of groundwater wells used in the analysis.

- For the depth-to-groundwater contour maps, use the best practices presented in Attachment D. Specifically, ensure that the first step is contouring groundwater elevations, and then subtracting this layer from land surface elevations from a Digital Elevation Model (DEM) to estimate depth-to-groundwater contours across the landscape. This will provide accurate contours of depth to groundwater along streams and other land surface depressions where GDEs are commonly found.

Groundwater Dependent Ecosystems

The identification of Groundwater Dependent Ecosystems (GDEs) is **insufficient**. The GSP took initial steps to identify and map GDEs using the Natural Communities Commonly Associated with Groundwater dataset (NC dataset) and other sources. However, we found that mapped features in the NC dataset were improperly disregarded. NC dataset polygons were incorrectly removed based on the assumption that they are supported by a shallow water bearing zone separate from the regional aquifer (i.e., categories A and S on Figure GWC-18). However, shallow aquifers that have the potential to support well development, support ecosystems, or provide baseflow to streams are principal aquifers, even if the majority of the basin's pumping is occurring in deeper principal aquifers. If there are no data to characterize groundwater conditions in the shallow principal aquifer, then the GDE should be retained as a potential GDE and data gaps reconciled in the Monitoring Network section of the GSP.

The GSP presents depth-to-groundwater data on Figure GWC-17 (Natural Communities Commonly Associated with Groundwater and Spring 2015 Depth to Groundwater). This is the only dataset used to characterize groundwater conditions in the basin's GDEs. We recommend using groundwater data from multiple seasons and water year types to determine the range of depth to groundwater around NC dataset polygons.

Table GW-6 presents a rooting depth of 24 feet for Valley Oak (*Quercus lobata*). We recommend instead that an 80-foot depth-to-groundwater threshold be used when inferring whether Valley Oak polygons in the NC dataset are likely reliant on groundwater. This recommendation is based on a recent correction in TNC's rooting depth database,[3] after finding a typo in the max rooting depth units for Valley Oak. This resulted in a specific change in the max rooting depth of Valley Oak from 24 feet to 24 meters (80 feet).

RECOMMENDATIONS

- Use depth-to-groundwater data from multiple seasons and water year types (e.g., wet, dry, average, drought) to determine the range of depth to groundwater around NC dataset polygons. We recommend that a pre-SGMA baseline period (10 years from 2005 to 2015) be established to characterize groundwater conditions over multiple

[3] TNC. 2021. Plant Rooting Depth Database. Available at: https://groundwaterresourcehub.org/sgma-tools/gde-rooting-depths-database-for-gdes/

water year types. Refer to Attachment D of this letter for best practices for using local groundwater data to verify whether polygons in the NC Dataset are supported by groundwater in an aquifer.

- Refer to Attachment B for more information on TNC's plant rooting depth database. Deeper thresholds are necessary for plants that have reported maximum root depths that exceed the averaged 30-ft threshold, such as Valley Oak (*Quercus lobata*). We recommend that the reported max rooting depth for these deeper-rooted plants be used. For example, a depth-to-groundwater threshold of 80 feet should be used instead of the 30-ft threshold, when verifying whether Valley Oak polygons from the NC Dataset are connected to groundwater. It is important to emphasize that actual rooting depth data are limited and will depend on the plant species and site-specific conditions such as soil and aquifer types, and availability to other water sources.

- If insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons as "Potential GDEs" in the GSP until data gaps are reconciled in the monitoring network.

Native Vegetation and Managed Wetlands

Native vegetation and managed wetlands are water use sectors that are required to be included in the water budget.[4,5] The integration of native vegetation into the water budget is **sufficient**. We commend the GSA for including the groundwater demands of this ecosystem in the historical, current and projected water budgets. Managed wetlands are not mentioned in the GSP, so it is not known whether or not they are present in the basin.

RECOMMENDATION

- State whether or not there are managed wetlands in the basin. If there are, ensure that their groundwater demands are included as separate line items in the historical, current, and projected water budgets.

B. Engaging Stakeholders

Stakeholder Engagement During GSP Development

Stakeholder engagement during GSP development is **insufficient**. SGMA's requirement for public notice and engagement of stakeholders is not fully met by the description in the Stakeholder Communication and Engagement Plan (Appendix B).[6]

---

[4] "'Water use sector' refers to categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, managed wetlands, managed recharge, and native vegetation." [23 CCR §351(al)]

[5] "The water budget shall quantify the following, either through direct measurements or estimates based on data: (3) Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow." [23 CCR §354.18]

[6] "A communication section of the Plan shall include a requirement that the GSP identify how it encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin." [23 CCR §354.10(d)(3)]

We note the following deficiencies with the overall stakeholder engagement process:

- The opportunities for public involvement and engagement during the GSP development and implementation phases are described in general terms. They include participation through stakeholder workshops, GSA Board meetings, distribution of a stakeholder survey, letters sent to the public water systems, development of fact sheets and newsletters, and updates to the GSA's website. The GSP states that DACs are engaged through use of the stakeholder survey and coordination with relevant community groups, but no further details are provided.

- While environmental stakeholders are listed as beneficial users within the basin, specific outreach and engagement targeted to this group is not described beyond informing stakeholders about the development process.

- Aside from the continuation of engagement strategies used during the GSP development process, the Stakeholder Communication and Engagement Plan does not include a detailed plan for continual opportunities for engagement through the *implementation* phase of the GSP that is specifically directed to DACs, domestic well owners, and environmental stakeholders.

RECOMMENDATIONS

- In the Stakeholder Communication and Engagement Plan, describe active and targeted outreach to engage DACs, domestic well owners, and environmental stakeholders throughout the GSP development and implementation phases. Refer to Attachment B for specific recommendations on how to actively engage stakeholders during all phases of the GSP process.

- Utilize DWR's tribal engagement guidance to comprehensively address all tribes and tribal interests in the basin within the GSP.[7]

C. Considering Beneficial Uses and Users When Establishing Sustainable Management Criteria and Analyzing Impacts on Beneficial Uses and Users

The consideration of beneficial uses and users when establishing sustainable management criteria (SMC) is **insufficient**. The consideration of potential impacts on all beneficial users of groundwater in the basin are required when defining undesirable results and establishing minimum thresholds.[8,9,10]

---

[7] Engagement with Tribal Governments Guidance Document. Available at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Guidance-Doc-for-SGM-Engagement-with-Tribal-Govt_ay_19.pdf

[8] "The description of undesirable results shall include [...] potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results." [23 CCR §354.26(b)(3)]

[9] "The description of minimum thresholds shall include [...] how minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests." [23 CCR §354.28(b)(4)]

[10] "The description of minimum thresholds shall include [...] how state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the agency shall explain the nature of and the basis for the difference." [23 CCR §354.28(b)(5)]

Disadvantaged Communities and Drinking Water Users

For chronic lowering of groundwater levels, minimum thresholds are calculated as the lower of the following (p. 165): *"(a) the historic low groundwater level minus the Variability Correction Factor and (b) the groundwater level in Fall 2015 (i.e., the first Fall after SGMA went into effect) minus the greater of either the Variability Correction Factor or the Trend Continuation Factor."* Undesirable results are established as follows (p. 149): *"Undesirable Results for Chronic Lowering of Groundwater Levels would be experienced in the Basin if and when groundwater levels in the Principal Aquifer decline below the established MTs in 40% or more of the RMW-WLs over four consecutive seasonal measurements during non-drought years (i.e., measurements spanning a total of two non-drought years, including two seasonal high groundwater level periods and two seasonal low groundwater level periods)."* By only using 40% of minimum threshold exceedances in RMW-WLs during non-drought years to define undesirable results for groundwater levels, significant and unreasonable impacts to beneficial users experienced during dry years or periods of drought will not result in an undesirable result. This is problematic since the GSP is failing to manage the basin in such a way that strives to minimize significant adverse impacts to beneficial users, which are often felt greatest in below-average, dry, and drought years.

The GSP justifies these SMC based on a well impact analysis presented in Section 14.1.2. However, this analysis only assesses wells with available well construction information and wells that are newer than 50 years, under the assumption that the usable lifespan of groundwater wells is approximately 50 years. The GSP states that 78% of basin wells are greater than 50 years old, thereby neglecting most of the basin's wells from the well impact analysis. Given these criteria, only five wells in the domestic and public supply wells category (along with 24 wells in the irrigation category) could be analyzed. The GSP states (p. 167): *"The proposed MTs are not expected to result in complete dewatering in any of the wells analyzed, and are only expected to result in partial dewatering of four wells that were not already partially dewatered at the Fall 2015 groundwater elevation; as such, the extent of potential impacts is not considered to be significant and unreasonable."* Despite this well impact analysis, the GSP does not sufficiently describe whether minimum thresholds are consistent with California's Human Right to Water policy and will avoid significant and unreasonable loss of drinking water,[11] especially given the absence of a domestic well mitigation plan in the GSP.

In addition, the GSP does not sufficiently describe or analyze direct or indirect impacts on DACs when defining undesirable results, nor does it describe how the groundwater level minimum thresholds are consistent with Human Right to Water policy and will avoid significant and unreasonable impacts on DACs.

For degraded water quality, minimum thresholds are set for arsenic, nitrate, and selenium at their respective MCLs. The GSP states (p. 171): *"Several other constituents (i.e., Total Dissolved Solids (TDS), sulfate, iron, boron, and sodium) were identified in Section 8.5 Groundwater Quality Concerns as having exceeded their applicable screening levels in 15% or more of samples in the White Wolf Data Management System (DMS). However, the screening levels for these constituents are mostly Secondary MCLs associated with aesthetic concerns (i.e., taste, odor or color) or irrigation Water Quality Objectives (WQOs), and are not health-related standards. Because these constituents are not expected to have significant impacts to the most sensitive beneficial use of groundwater in the Basin (i.e., drinking water), SMCs have not been developed for those constituents."* However, according to the state's anti-degradation policy,[12]

---

[11] California Water Code §106.3. Available at:
https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=WAT&sectionNum=106.3

[12] Anti-degradation Policy
https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/1968/rs68_016.pdf

high water quality should be protected and is only allowed to worsen if a finding is made that it is in the best interest of the people of the State of California. No analysis has been done and no such finding has been made. SMC should be established for all constituents in the basin that are impacted or exacerbated by groundwater use and/or management, in addition to coordinating with water quality regulatory programs.

RECOMMENDATIONS

Chronic Lowering of Groundwater Levels

- Consider minimum threshold exceedances during drought years when defining the groundwater level undesirable result across the basin.
- In the well impact assessment, utilize well data from older wells (>50 years old) to better represent minimum threshold impacts to wells across the basin.
- Describe direct and indirect impacts on DACs and drinking water users when describing undesirable results and defining minimum thresholds for chronic lowering of groundwater levels.

Degraded Water Quality

- Describe direct and indirect impacts on DACs and drinking water users when defining undesirable results for degraded water quality. For specific guidance on how to consider these users, refer to "Guide to Protecting Water Quality Under the Sustainable Groundwater Management Act."[13]
- Evaluate the cumulative or indirect impacts of proposed minimum thresholds for degraded water quality on DACs and drinking water users.
- Set minimum thresholds and measurable objectives for all water quality constituents within the basin that are impacted by groundwater use and/or management. Ensure they align with drinking water standards.[14]
- Set minimum thresholds that do not allow water quality to degrade to levels at or above the MCL trigger level.

Groundwater Dependent Ecosystems and Interconnected Surface Waters

The GSP only considers GDEs with respect to the depletion of interconnected surface water sustainability indicator, but not the chronic lowering of groundwater levels sustainability indicator. No analysis or discussion is provided in the GSP that describes impacts to GDEs or establishes SMC for GDEs that are directly dependent on groundwater. This is problematic because without identifying potential impacts to GDEs, minimum thresholds may compromise these environmental beneficial users. Since GDEs are present in the basin, they must be considered when developing

[13] Guide to Protecting Water Quality under the Sustainable Groundwater Management Act https://d3n8a8pro7vhmx.cloudfront.net/communitywatercenter/pages/293/attachments/original/1559328858/Guide_to_Protecting_Drinking_Water_Quality_Under_the_Sustainable_Groundwater_Management_Act.pdf?1559328858.

[14] "Degraded Water Quality [...] collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues." [23 CCR §354.34(c)(4)]

SMC for chronic lowering of groundwater levels. Our comments above in the GDE section note that the GDE analysis may have disregarded some GDEs in the basin which could be directly dependent on groundwater, including deeper-rooted plants such as Valley Oak.

For depletion of interconnected surface water, the GSP uses groundwater elevations as a proxy for establishing SMC. The GSP states (p. 156): *"Significant and unreasonable effects associated with Undesirable Results would include a 30% reduction of, or visual impact to, the health of GDEs based on their conditions observed during 2018 through 2020 that can be directly attributed to Principal Aquifer pumping-related lowering of groundwater levels rather than the effects of natural or climatic processes."* The GSA has established preliminary minimum thresholds for interconnected surface water at three newly installed shallow monitoring wells, which are the representative monitoring wells for depletions of ISW. The minimum thresholds are set as follows (p. 176): *"Using the above values, the initial MT estimates at each RMW-ISW location are calculated as the lower of the following: (a) the projected depth to groundwater at the end of October 2021 calculated based on observed June 2021 water levels and the Trend Continuation Factor, and (b) 30 ft bgs."* While the GSP recognizes that there could be impacts on terrestrial GDEs through its definition of significant and unreasonable effects, no further details on these impacts are provided, such as which habitat types could be affected, or the anticipated physiological responses based on minimum threshold groundwater levels. The GSP should also evaluate how the proposed minimum thresholds and measurable objectives avoid significant and unreasonable effects on surface water beneficial users in the basin, such as increased mortality and inability to perform key life processes (e.g., reproduction, migration). Furthermore, the GSP should describe how SMC for depletion of interconnected surface water will be updated once more data is gathered from the newly installed monitoring wells.

RECOMMENDATIONS

- When defining undesirable results for chronic lowering of groundwater levels, provide specifics on what biological responses (e.g., extent of habitat, growth, recruitment rates) would best characterize a significant and unreasonable impact to GDEs. Undesirable results to environmental users occur when 'significant and unreasonable' effects on beneficial users are caused by one of the sustainability indicators (i.e., chronic lowering of groundwater levels, degraded water quality, or depletion of interconnected surface water). Thus, potential impacts on environmental beneficial uses and users need to be considered when defining undesirable results in the basin.[15] Defining undesirable results is the crucial first step before the minimum thresholds can be determined.[16]

- When defining undesirable results for depletion of interconnected surface water, include a description of potential impacts on instream habitats within ISWs when minimum thresholds in the basin are reached.[17] The GSP should confirm that minimum thresholds for ISWs avoid adverse impacts on environmental beneficial users of interconnected surface waters as these environmental users could be left unprotected

---

[15] "The description of undesirable results shall include [...] potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results". [23 CCR §354.26(b)(3)]

[16] The description of minimum thresholds shall include [...] how minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests." [23 CCR §354.28(b)(4)]

[17] "The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results." [23 CCR §354.28(c)(6)]

by the GSP. These recommendations apply especially to environmental beneficial users that are already protected under pre-existing state or federal law.[6,18]

- When establishing SMC for the basin, consider that the SGMA statute [Water Code §10727.4(l)] specifically calls out that GSPs shall include "impacts on groundwater dependent ecosystems".

2. Climate Change

The SGMA statute identifies climate change as a significant threat to groundwater resources and one that must be examined and incorporated in the GSPs. The GSP Regulations require integration of climate change into the projected water budget to ensure that projects and management actions sufficiently account for the range of potential climate futures.[19] The effects of climate change will intensify the impacts of water stress on GDEs, making available shallow groundwater resources especially critical to their survival. Condon *et al.* (2020) shows that GDEs are more likely to succumb to water stress and rely more on groundwater during times of drought.[20] When shallow groundwater is unavailable, riparian forests can die off and key life processes (e.g., migration and spawning) for aquatic organisms, such as steelhead, can be impeded.

The integration of climate change into the projected water budget is **insufficient**. The GSP incorporates climate change into the projected water budget using DWR change factors for 2030 and 2070. However, the plan does not consider multiple climate scenarios (e.g., the 2070 extremely wet and extremely dry climate scenarios) in the projected water budget. The GSP should clearly and transparently incorporate the extremely wet and dry scenarios provided by DWR into projected water budgets or select more appropriate extreme scenarios for the basin. While these extreme scenarios may have a lower likelihood of occurring, their consequences could be significant and their inclusion can help identify important vulnerabilities in the basin's approach to groundwater management.

The GSP includes climate change into key inputs (e.g., precipitation, evapotranspiration, and surface water flow) of the projected water budget, and calculates a sustainable yield based on the projected water budget with climate change incorporated. However, if the water budgets are incomplete, including the omission of extremely wet and dry scenarios, then there is increased uncertainty in virtually every subsequent calculation used to plan for projects, derive measurable objectives, and set minimum thresholds. Plans that do not adequately include climate change projections may underestimate future impacts on vulnerable beneficial users of groundwater such as ecosystems, DACs, and domestic well owners.

---

[18] Rohde MM, Seapy B, Rogers R, Castañeda X, editors. 2019. Critical Species LookBook: A compendium of California's threatened and endangered species for sustainable groundwater management. The Nature Conservancy, San Francisco, California. Available at: https://groundwaterresourcehub.org/public/uploads/pdfs/Critical_Species_LookBook_91819.pdf

[19] "Each Plan shall rely on the best available information and best available science to quantify the water budget for the basin in order to provide an understanding of historical and projected hydrology, water demand, water supply, land use, population, climate change, sea level rise, groundwater and surface water interaction, and subsurface groundwater flow." [23 CCR §354.18(e)]

[20] Condon et al. 2020. Evapotranspiration depletes groundwater under warming over the contiguous United States. Nature Communications. Available at: https://www.nature.com/articles/s41467-020-14688-0

RECOMMENDATIONS
● Integrate climate change, including extremely wet and dry scenarios, into all elements of the projected water budget to form the basis for development of sustainable management criteria and projects and management actions. ● Incorporate climate change scenarios into projects and management actions.

3. Data Gaps

The consideration of beneficial users when establishing monitoring networks is **insufficient**, due to lack of specific plans to increase the Representative Monitoring Wells (RMWs) in the monitoring network that represent water quality conditions and shallow groundwater elevations around DACs and domestic wells in the basin.

Figure MN-1 (SGMA Monitoring Network for Chronic Lowering of Groundwater Levels) shows insufficient representation of DACs for groundwater elevation monitoring. Figure MN-2 (SGMA Monitoring Network for Degraded Water Quality) shows insufficient representation of DACs and drinking water users for water quality monitoring. Refer to Attachment E for maps of these monitoring sites in relation to key beneficial users of groundwater (note we were only able to prepare groundwater elevation monitoring maps with information from the Draft GSP). These beneficial users may remain unprotected by the GSP without adequate monitoring and identification of data gaps in the shallow aquifer. The Plan therefore fails to meet SGMA's requirements for the monitoring network.[21]

RECOMMENDATIONS
● Provide maps that overlay current and proposed monitoring well locations with the locations of DACs, domestic wells, and GDEs to clearly identify monitored areas. ● Increase the number of RMWs in the shallow aquifer across the basin as needed to map ISWs and adequately monitor all groundwater condition indicators across the basin and at appropriate depths for *all* beneficial users. Prioritize proximity to DACs, domestic wells, GDEs, and ISWs when identifying new RMWs. ● Ensure groundwater elevation and water quality RMWs are monitoring groundwater conditions spatially and at the correct depth for *all* beneficial users - especially DACs, domestic wells, and GDEs. ● Describe biological monitoring that can be used to assess the potential for significant and unreasonable impacts to GDEs or ISWs due to groundwater conditions in the basin.

[21] "The monitoring network objectives shall be implemented to accomplish the following: [...] (2) Monitor impacts to the beneficial uses or users of groundwater." [23 CCR §354.34(b)(2)]

4. Addressing Beneficial Users in Projects and Management Actions

The consideration of beneficial users when developing projects and management actions is **insufficient**, due to the failure to completely identify benefits or impacts of identified projects and management actions, including water quality impacts, to key beneficial users of groundwater such as GDEs, aquatic habitats, surface water users, DACs, and drinking water users. Therefore, potential project and management actions may not protect these beneficial users. Groundwater sustainability under SGMA is defined not just by sustainable yield, but by the avoidance of undesirable results for *all* beneficial users.

While Section 18.2.1.3 documents several projects to expand in-lieu recharge, the GSP fails to describe the projects' explicit benefits or impacts to beneficial users, including the environment and DACs. The plan also fails to include a domestic well mitigation program to avoid significant and unreasonable loss of drinking water. We strongly recommend inclusion of a drinking water well impact mitigation program to proactively monitor and protect drinking water wells through GSP implementation.

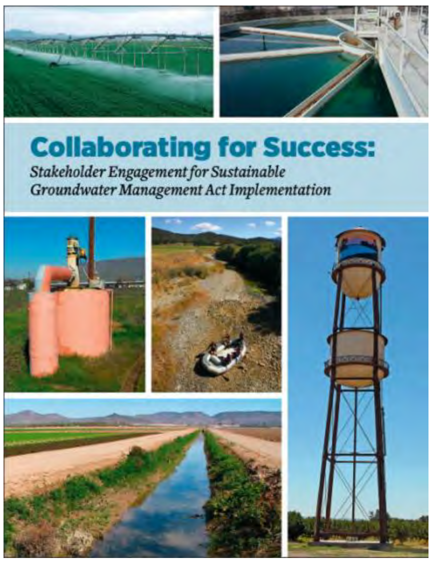
RECOMMENDATIONS

- For DACs and domestic well owners, include a drinking water well impact mitigation program to proactively monitor and protect drinking water wells through GSP implementation. Refer to Attachment B for specific recommendations on how to implement a drinking water well mitigation program.
- For DACs and domestic well owners, include a discussion of whether potential impacts to water quality from projects and management actions could occur and how the GSA plans to mitigate such impacts.
- Recharge ponds, reservoirs, and facilities for managed aquifer recharge can be designed as multiple-benefit projects to include elements that act functionally as wetlands and provide a benefit for wildlife and aquatic species. For further guidance on how to integrate multi-benefit recharge projects into your GSP, refer to the "Multi-Benefit Recharge Project Methodology Guidance Document."[22]
- Develop management actions that incorporate climate and water delivery uncertainties to address future water demand and prevent future undesirable results.

[22] The Nature Conservancy. 2021. Multi-Benefit Recharge Project Methodology for Inclusion in Groundwater Sustainability Plans. Sacramento. Available at: https://groundwaterresourcehub.org/sgma-tools/multi-benefit-recharge-project-methodology-guidance/

Attachment B
SGMA Tools to address DAC, drinking water, and environmental beneficial uses and users

Stakeholder Engagement and Outreach



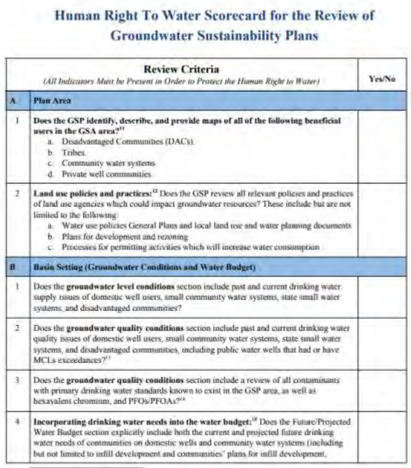
Clean Water Action, Community Water Center and Union of Concerned Scientists developed a guidance document called Collaborating for success: Stakeholder engagement for Sustainable Groundwater Management Act Implementation. It provides details on how to conduct targeted and broad outreach and engagement during Groundwater Sustainability Plan (GSP) development and implementation. Conducting a targeted outreach involves:

- Developing a robust Stakeholder Communication and Engagement plan that includes outreach at frequented locations (schools, farmers markets, religious settings, events) across the plan area to increase the involvement and participation of disadvantaged communities, drinking water users and the environmental stakeholders.

- Providing translation services during meetings and technical assistance to enable easy participation for non-English speaking stakeholders.

- GSP should adequately describe the process for requesting input from beneficial users and provide details on how input is incorporated into the GSP.

The Human Right to Water

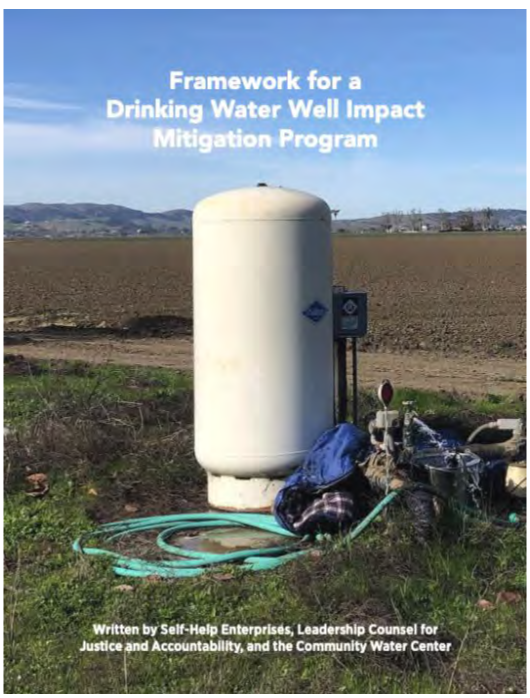


Human Right To Water Scorecard for the Review of Groundwater Sustainability Plans

	Review Criteria *(All Indicators Must be Present in Order to Protect the Human Right to Water)*	Yes/No
A	**Plan Area**	
1	**Does the GSP identify, describe, and provide maps of all of the following beneficial users in the GSA area?**[11] a. Disadvantaged Communities (DACs). b. Tribes. c. Community water systems d. Private well communities	
2	**Land use policies and practices:**[12] Does the GSP review all relevant policies and practices of land use agencies which could impact groundwater resources? These include but are not limited to the following: a. Water use policies General Plans and local land use and water planning documents b. Plans for development and rezoning c. Processes for permitting activities which will increase water consumption	
B	**Basin Setting (Groundwater Conditions and Water Budget)**	
1	Does the **groundwater level conditions** section include past and current drinking water supply issues of domestic well users, small community water systems, state small water systems, and disadvantaged communities?	
2	Does the **groundwater quality conditions** section include past and current drinking water quality issues of domestic well users, small community water systems, state small water systems, and disadvantaged communities, including public water wells that had or have MCLs exceedances?[13]	
3	Does the **groundwater quality conditions** section include a review of all contaminants with primary drinking water standards known to exist in the GSP area, as well as hexavalent chromium, and PFOs/PFOAs?[14]	
4	**Incorporating drinking water needs into the water budget:**[15] Does the Future/Projected Water Budget section explicitly include both the current and projected future drinking water needs of communities on domestic wells and community water systems (including but not limited to infill development and communities' plans for infill development,	

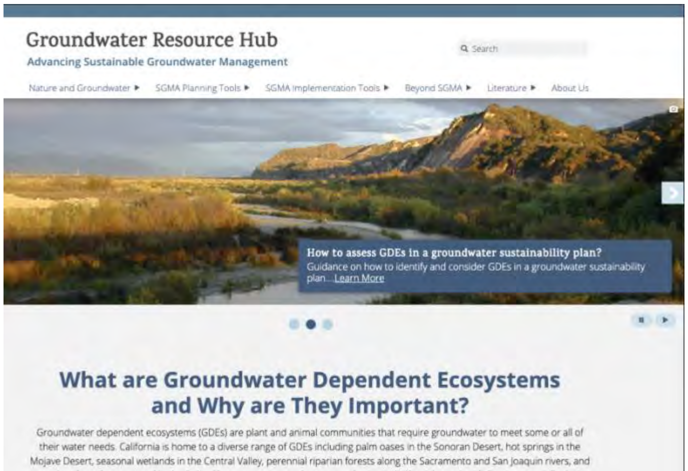
The Human Right to Water Scorecard was developed by Community Water Center, Leadership Counsel for Justice and Accountability and Self Help Enterprises to aid Groundwater Sustainability Agencies (GSAs) in prioritizing drinking water needs in SGMA. The scorecard identifies elements that must exist in GSPs to adequately protect the Human Right to Drinking water.

Drinking Water Well Impact Mitigation Framework



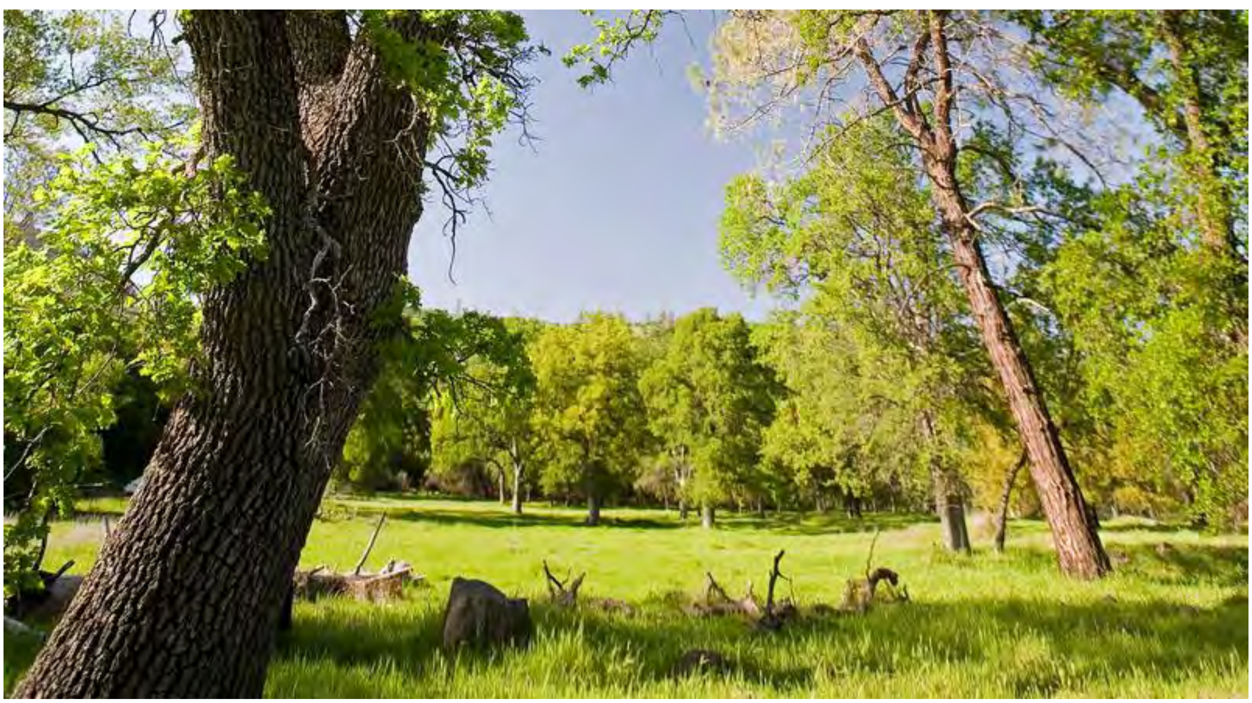
The Drinking Water Well Impact Mitigation Framework was developed by Community Water Center, Leadership Counsel for Justice and Accountability and Self Help Enterprises to aid GSAs in the development and implementation of their GSPs. The framework provides a clear roadmap for how a GSA can best structure its data gathering, monitoring network and management actions to proactively monitor and protect drinking water wells and mitigate impacts should they occur.

Groundwater Resource Hub



The Nature Conservancy has developed a suite of tools based on best available science to help GSAs, consultants, and stakeholders efficiently incorporate nature into GSPs. These tools and resources are available online at GroundwaterResourceHub.org. The Nature Conservancy's tools and resources are intended to reduce costs, shorten timelines, and increase benefits for both people and nature.

Rooting Depth Database



The [Plant Rooting Depth Database]() provides information that can help assess whether groundwater-dependent vegetation are accessing groundwater. Actual rooting depths will depend on the plant species and site-specific conditions, such as soil type and availability of other water sources. Site-specific knowledge of depth to groundwater combined with rooting depths will help provide an understanding of the potential groundwater levels are needed to sustain GDEs.

How to use the database

The maximum rooting depth information in the Plant Rooting Depth Database is useful when verifying whether vegetation in the Natural Communities Commonly Associated with Groundwater (NC Dataset) are connected to groundwater. A 30 ft depth-to-groundwater threshold, which is based on averaged global rooting depth data for phreatophytes[1], is relevant for most plants identified in the NC Dataset since most plants have a max rooting depth of less than 30 feet. However, it is important to note that deeper thresholds are necessary for other plants that have reported maximum root depths that exceed the averaged 30 feet threshold, such as valley oak (*Quercus lobata*), Euphrates poplar (*Populus euphratica*), salt cedar (*Tamarix spp.*), and shadescale (*Atriplex confertifolia*). The Nature Conservancy advises that the reported max rooting depth for these deeper-rooted plants be used. For example, a depth-to groundwater threshold of 80 feet should be used instead of the 30 ft threshold, when verifying whether valley oak polygons from the NC Dataset are connected to groundwater. It is important to re-emphasize that actual rooting depth data are limited and will depend on the plant species and site-specific conditions such as soil and aquifer types, and availability to other water sources.

The Plant Rooting Depth Database is an Excel workbook composed of four worksheets:

1. California phreatophyte rooting depth data (included in the NC Dataset)
2. Global phreatophyte rooting depth data
3. Metadata
4. References

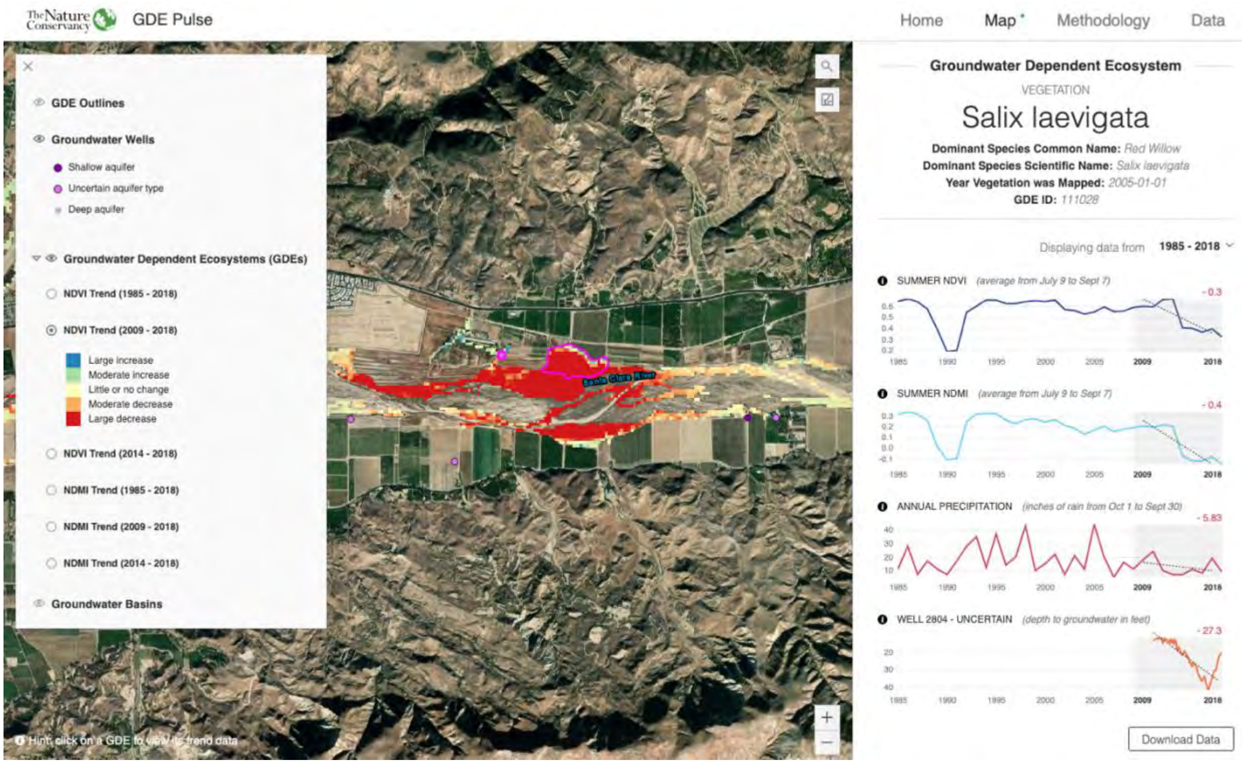
How the database was compiled

The Plant Rooting Depth Database is a compilation of rooting depth information for the groundwater-dependent plant species identified in the NC Dataset. Rooting depth data were compiled from published scientific literature and expert opinion through a crowdsourcing campaign. As more information becomes available, the database of rooting depths will be updated. Please Contact Us if you have additional rooting depth data for California phreatophytes.

---

[1] Canadell, J., Jackson, R.B., Ehleringer, J.B. et al. 1996. Maximum rooting depth of vegetation types at the global scale. Oecologia 108, 583–595. https://doi.org/10.1007/BF00329030

GDE Pulse



GDE Pulse is a free online tool that allows Groundwater Sustainability Agencies to assess changes in groundwater dependent ecosystem (GDE) health using satellite, rainfall, and groundwater data. Remote sensing data from satellites has been used to monitor the health of vegetation all over the planet. GDE pulse has compiled 35 years of satellite imagery from NASA's Landsat mission for every polygon in the Natural Communities Commonly Associated with Groundwater Dataset. The following datasets are available for downloading:

Normalized Difference Vegetation Index (NDVI) is a satellite-derived index that represents the greenness of vegetation. Healthy green vegetation tends to have a higher NDVI, while dead leaves have a lower NDVI. We calculated the average NDVI during the driest part of the year (July - Sept) to estimate vegetation health when the plants are most likely dependent on groundwater.

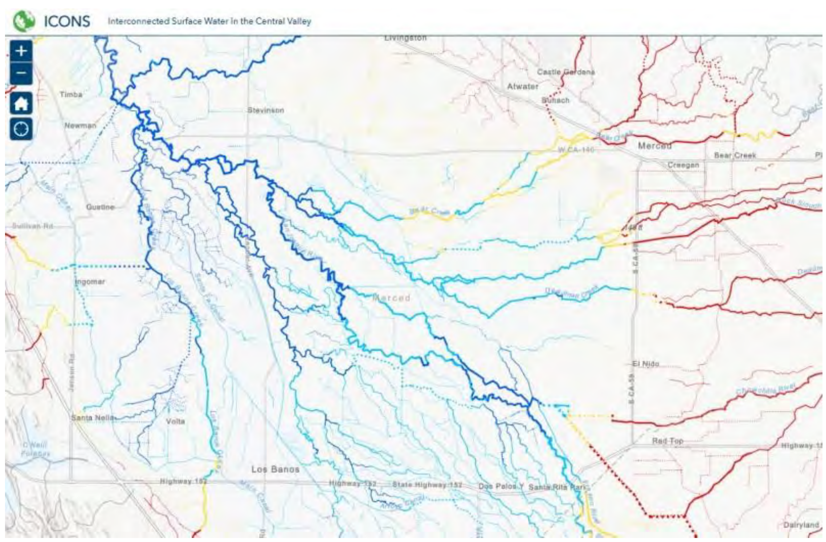
Normalized Difference Moisture Index (NDMI) is a satellite-derived index that represents water content in vegetation. NDMI is derived from the Near-Infrared (NIR) and Short-Wave Infrared (SWIR) channels. Vegetation with adequate access to water tends to have higher NDMI, while vegetation that is water stressed tends to have lower NDMI. We calculated the average NDVI during the driest part of the year (July–September) to estimate vegetation health when the plants are most likely dependent on groundwater.

Annual Precipitation is the total precipitation for the water year (October 1st – September 30th) from the PRISM dataset. The amount of local precipitation can affect vegetation with more precipitation generally leading to higher NDVI and NDMI.

Depth to Groundwater measurements provide an indication of the groundwater levels and changes over time for the surrounding area. We used groundwater well measurements from nearby (<1km) wells to estimate the depth to groundwater below the GDE based on the average elevation of the GDE (using a digital elevation model) minus the measured groundwater surface elevation.

ICONOS Mapper

Interconnected Surface Water in the Central Valley



ICONS maps the likely presence of interconnected surface water (ISW) in the Central Valley using depth to groundwater data. Using data from 2011-2018, the ISW dataset represents the likely connection between surface water and groundwater for rivers and streams in California’s Central Valley. It includes information on the mean, maximum, and minimum depth to groundwater for each stream segment over the years with available data, as well as the likely presence of ISW based on the minimum depth to groundwater. The Nature Conservancy developed this database, with guidance and input from expert academics, consultants, and state agencies.

We developed this dataset using groundwater elevation data available online from the California Department of Water Resources (DWR). DWR only provides this data for the Central Valley. For GSAs outside of the valley, who have groundwater well measurements, we recommend following our methods to determine likely ISW in your region. The Nature Conservancy’s ISW dataset should be used as a first step in reviewing ISW and should be supplemented with local or more recent groundwater depth data.

Attachment C

Freshwater Species Located in the White Wolf Basin

To assist in identifying the beneficial users of surface water necessary to assess the undesirable result "depletion of interconnected surface waters", Attachment C provides a list of freshwater species located in the White Wolf Basin. To produce the freshwater species list, we used ArcGIS to select features within the California Freshwater Species Database version 2.0.9 within the basin boundary. This database contains information on ~4,000 vertebrates, macroinvertebrates and vascular plants that depend on fresh water for at least one stage of their life cycle. The methods used to compile the California Freshwater Species Database can be found in Howard et al. 2015[1]. The spatial database contains locality observations and/or distribution information from ~400 data sources. The database is housed in the California Department of Fish and Wildlife's BIOS[2] as well as on The Nature Conservancy's science website[3].

Scientific Name	Common Name	Legal Protected Status		
		Federal	State	Other
BIRDS				
Actitis macularius	Spotted Sandpiper			
Aechmophorus occidentalis	Western Grebe			
Agelaius tricolor	Tricolored Blackbird	Bird of Conservation Concern	Special Concern	BSSC - First priority
Anas acuta	Northern Pintail			
Anas americana	American Wigeon			
Anas crecca	Green-winged Teal			
Anas platyrhynchos	Mallard			
Anas strepera	Gadwall			
Ardea alba	Great Egret			
Ardea herodias	Great Blue Heron			
Aythya affinis	Lesser Scaup			
Aythya americana	Redhead		Special Concern	BSSC - Third priority
Aythya collaris	Ring-necked Duck			
Aythya valisineria	Canvasback		Special	
Bucephala albeola	Bufflehead			
Cistothorus palustris palustris	Marsh Wren			
Egretta thula	Snowy Egret			
Fulica americana	American Coot			

[1] Howard, J.K. et al. 2015. Patterns of Freshwater Species Richness, Endemism, and Vulnerability in California. PLoSONE, 11(7). Available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0130710

[2] California Department of Fish and Wildlife BIOS: https://www.wildlife.ca.gov/data/BIOS

[3] Science for Conservation: https://www.scienceforconservation.org/products/california-freshwater-species-database

Haliaeetus leucocephalus	Bald Eagle	Bird of Conservation Concern	Endangered	
Himantopus mexicanus	Black-necked Stilt			
Lophodytes cucullatus	Hooded Merganser			
Megaceryle alcyon	Belted Kingfisher			
Mergus merganser	Common Merganser			
Numenius americanus	Long-billed Curlew			
Oxyura jamaicensis	Ruddy Duck			
Phalacrocorax auritus	Double-crested Cormorant			
Plegadis chihi	White-faced Ibis		Watch list	
Podiceps nigricollis	Eared Grebe			
Podilymbus podiceps	Pied-billed Grebe			
Tachycineta bicolor	Tree Swallow			
HERPS				
Actinemys marmorata marmorata	Western Pond Turtle		Special Concern	ARSSC
Anaxyrus boreas boreas	Boreal Toad			
Rana draytonii	California Red-legged Frog	Threatened	Special Concern	ARSSC
Spea hammondii	Western Spadefoot	Under Review in the Candidate or Petition Process	Special Concern	ARSSC
Thamnophis couchii	Sierra Gartersnake			
Thamnophis sirtalis sirtalis	Common Gartersnake			
PLANTS				
Alnus rhombifolia	White Alder			
Ammannia coccinea	Scarlet Ammannia			
Anemopsis californica	Yerba Mansa			
Arundo donax	NA			
Azolla filiculoides	NA			
Azolla microphylla	Mexican mosquito fern		Special	CRPR - 4.3
Baccharis salicina				Not on any status lists
Berula erecta	Wild Parsnip			
Bidens laevis	Smooth Bur-marigold			
Bolboschoenus maritimus paludosus	NA			Not on any status lists
Bolboschoenus robustus				Not on any status lists
Callitriche marginata	Winged Water-starwort			
Carex alma	Sturdy Sedge			
Carex densa	Dense Sedge			
Carex lasiocarpa	Slender Sedge		Special	CRPR - 2B.3

Carex pellita	Woolly Sedge			
Carex senta	Western Rough Sedge			
Castilleja miniata miniata	Greater Red Indian-paintbrush			
Castilleja minor minor	Alkali Indian-paintbrush			
Cephalanthus occidentalis	Common Buttonbush			
Cicuta douglasii	Western Water-hemlock			
Cirsium crassicaule	Slough Thistle		Special	CRPR - 1B.1
Cirsium scariosum scariosum	Drummond's Thistle			Not on any status lists
Cotula coronopifolia	NA			
Crassula aquatica	Water Pygmyweed			
Cyperus erythrorhizos	Red-root Flatsedge			
Datisca glomerata	Durango Root			
Downingia bella	Hoover's Downingia			
Downingia pulchella	Flat-face Downingia			
Echinodorus berteroi	Upright Burhead			
Eleocharis bella	Delicate Spikerush			
Eleocharis macrostachya	Creeping Spikerush			
Eleocharis montevidensis	Sand Spikerush			
Eleocharis parishii	Parish's Spikerush			
Epilobium oregonense	Oregon Willow-herb			
Epipactis gigantea	Giant Helleborine			
Euthamia occidentalis	Western Fragrant Goldenrod			
Helenium bigelovii	Bigelow's Sneezeweed			
Helenium puberulum	Rosilla			
Iris missouriensis	Western Blue Iris			
Isolepis cernua	Low Bulrush			
Juncus acutus leopoldii	Spiny Rush		Special	CRPR - 4.2
Juncus dubius	Mariposa Rush			
Juncus macrandrus	Long-anther Rush			
Juncus macrophyllus	Longleaf Rush			
Juncus textilis	Basket Rush			
Juncus xiphioides	Iris-leaf Rush			
Lasthenia ferrisiae	Ferris' Goldfields		Special	CRPR - 4.2
Lemna gibba	Inflated Duckweed			
Lemna minuta	Least Duckweed			
Limosella aquatica	Northern Mudwort			
Lythrum californicum	California Loosestrife			
Marsilea vestita vestita	NA			Not on any status lists
Myosurus minimus	NA			
Myriophyllum aquaticum	NA			

Navarretia intertexta	Needleleaf Navarretia			
Paspalum distichum	Joint Paspalum			
Perideridia parishii latifolia	Parish's Yampah			
Perideridia parishii parishii	Parish's Yampah		Special	CRPR - 2B.2
Perideridia pringlei	Pringle's Yampah		Special	CRPR - 4.3
Persicaria lapathifolia				Not on any status lists
Persicaria maculosa	NA			Not on any status lists
Persicaria pensylvanica	NA			Not on any status lists
Phacelia distans	NA			
Phalaris arundinacea	Reed Canarygrass			
Phragmites australis australis	Common Reed			
Phyla nodiflora	Common Frog-fruit			
Pilularia americana	NA			
Plagiobothrys acanthocarpus	Adobe Popcorn-flower			
Plagiobothrys leptocladus	Alkali Popcorn-flower			
Plantago elongata elongata	Slender Plantain			
Platanthera sparsiflora sparsiflora	Canyon Bog Orchid			
Platanus racemosa	California Sycamore			
Pluchea odorata odorata	Scented Conyza			
Pluchea sericea	Arrow-weed			
Psilocarphus brevissimus brevissimus	Dwarf Woolly-heads			
Psilocarphus tenellus	NA			
Puccinellia simplex	Little Alkali Grass			
Rhododendron occidentale occidentale	Western Azalea			
Rorippa curvisiliqua curvisiliqua	Curve-pod Yellowcress			
Rorippa palustris palustris	Bog Yellowcress			
Rumex conglomeratus	NA			
Rumex salicifolius salicifolius	Willow Dock			
Salix exigua exigua	Narrowleaf Willow			
Salix exigua hindsiana				Not on any status lists
Salix gooddingii	Goodding's Willow			
Salix laevigata	Polished Willow			
Salix lasiandra lasiandra				Not on any status lists
Salix lasiolepis lasiolepis	Arroyo Willow			
Schoenoplectus acutus occidentalis	Hardstem Bulrush			
Schoenoplectus americanus	Three-square Bulrush			
Schoenoplectus pungens pungens	NA			
Scirpus microcarpus	Small-fruit Bulrush			

Sesbania herbacea				Not on any status lists
Sidalcea neomexicana	Rocky Mountain Checker-mallow		Special	CRPR - 2B.2
Sphenosciadium capitellatum	Swamp Whiteheads			
Stachys albens	White-stem Hedge-nettle			
Typha domingensis	Southern Cattail			
Veronica americana	American Speedwell			
Veronica anagallis-aquatica	NA			
Veronica catenata	NA			Not on any status lists
Zannichellia palustris	Horned Pondweed			

Attachment D

The Nature Conservancy

July 2019

IDENTIFYING GDEs UNDER SGMA
Best Practices for using the NC Dataset

The Sustainable Groundwater Management Act (SGMA) requires that groundwater dependent ecosystems (GDEs) be identified in Groundwater Sustainability Plans (GSPs). As a starting point, the Department of Water Resources (DWR) is providing the Natural Communities Commonly Associated with Groundwater Dataset (NC Dataset) online[1] to help Groundwater Sustainability Agencies (GSAs), consultants, and stakeholders identify GDEs within individual groundwater basins. To apply information from the NC Dataset to local areas, GSAs should combine it with the best available science on local hydrology, geology, and groundwater levels to verify whether polygons in the NC dataset are likely supported by groundwater in an aquifer (Figure 1)[2]. This document highlights six best practices for using local groundwater data to confirm whether mapped features in the NC dataset are supported by groundwater.

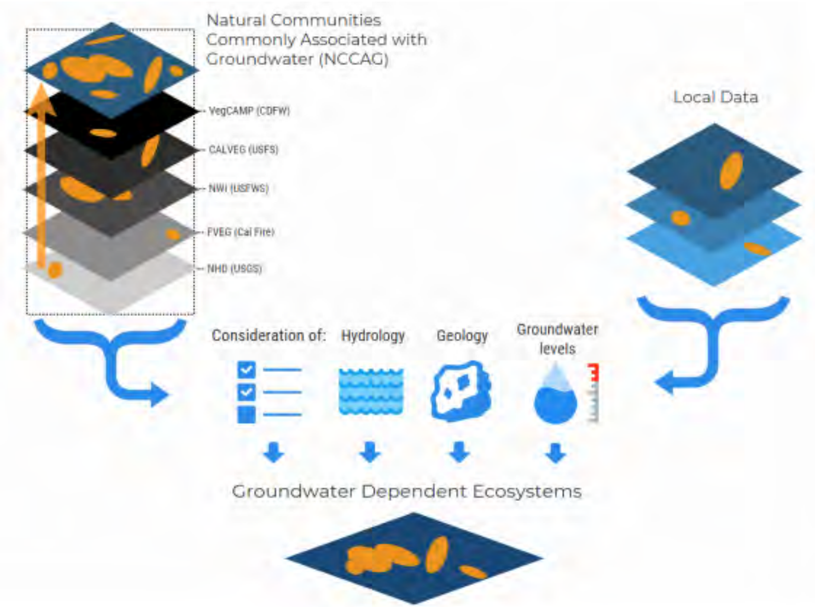


Figure 1. Considerations for GDE identification.
Source: DWR[2]

[1] NC Dataset Online Viewer: https://gis.water.ca.gov/app/NCDatasetViewer/
[2] California Department of Water Resources (DWR). 2018. Summary of the "Natural Communities Commonly Associated with Groundwater" Dataset and Online Web Viewer. Available at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Data-and-Tools/Files/Statewide-Reports/Natural-Communities-Dataset-Summary-Document.pdf

The NC Dataset identifies vegetation and wetland features that are good indicators of a GDE. The dataset is comprised of 48 publicly available state and federal datasets that map vegetation, wetlands, springs, and seeps commonly associated with groundwater in California[3]. It was developed through a collaboration between DWR, the Department of Fish and Wildlife, and The Nature Conservancy (TNC). TNC has also provided detailed guidance on identifying GDEs from the NC dataset[4] on the Groundwater Resource Hub[5], a website dedicated to GDEs.

BEST PRACTICE #1. Establishing a Connection to Groundwater

Groundwater basins can be comprised of one continuous aquifer (Figure 2a) or multiple aquifers stacked on top of each other (Figure 2b). In unconfined aquifers (Figure 2a), using the depth-to-groundwater and the rooting depth of the vegetation is a reasonable method to infer groundwater dependence for GDEs. If groundwater is well below the rooting (and capillary) zone of the plants and any wetland features, the ecosystem is considered disconnected and groundwater management is not likely to affect the ecosystem (Figure 2d). However, it is important to consider local conditions (e.g., soil type, groundwater flow gradients, and aquifer parameters) and to review groundwater depth data from multiple seasons and water year types (wet and dry) because intermittent periods of high groundwater levels can replenish perched clay lenses that serve as the water source for GDEs (Figure 2c). Maintaining these natural groundwater fluctuations are important to sustaining GDE health.

Basins with a stacked series of aquifers (Figure 2b) may have varying levels of pumping across aquifers in the basin, depending on the production capacity or water quality associated with each aquifer. If pumping is concentrated in deeper aquifers, SGMA still requires GSAs to sustainably manage groundwater resources in shallow aquifers, such as perched aquifers, that support springs, surface water, domestic wells, and GDEs (Figure 2). This is because vertical groundwater gradients across aquifers may result in pumping from deeper aquifers to cause adverse impacts onto beneficial users reliant on shallow aquifers or interconnected surface water. The goal of SGMA is to sustainably manage groundwater resources for current and future social, economic, and environmental benefits. While groundwater pumping may not be currently occurring in a shallower aquifer, use of this water may become more appealing and economically viable in future years as pumping restrictions are placed on the deeper production aquifers in the basin to meet the sustainable yield and criteria. Thus, identifying GDEs in the basin should done irrespective to the amount of current pumping occurring in a particular aquifer, so that future impacts on GDEs due to new production can be avoided. A good rule of thumb to follow is: *if groundwater can be pumped from a well - it's an aquifer*.

[3] For more details on the mapping methods, refer to: Klausmeyer, K., J. Howard, T. Keeler-Wolf, K. Davis-Fadtke, R. Hull, A. Lyons. 2018. Mapping Indicators of Groundwater Dependent Ecosystems in California: Methods Report. San Francisco, California. Available at: https://groundwaterresourcehub.org/public/uploads/pdfs/iGDE_data_paper_20180423.pdf
[4] "Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans" is available at: https://groundwaterresourcehub.org/gde-tools/gsp-guidance-document/
[5] The Groundwater Resource Hub: www.GroundwaterResourceHub.org

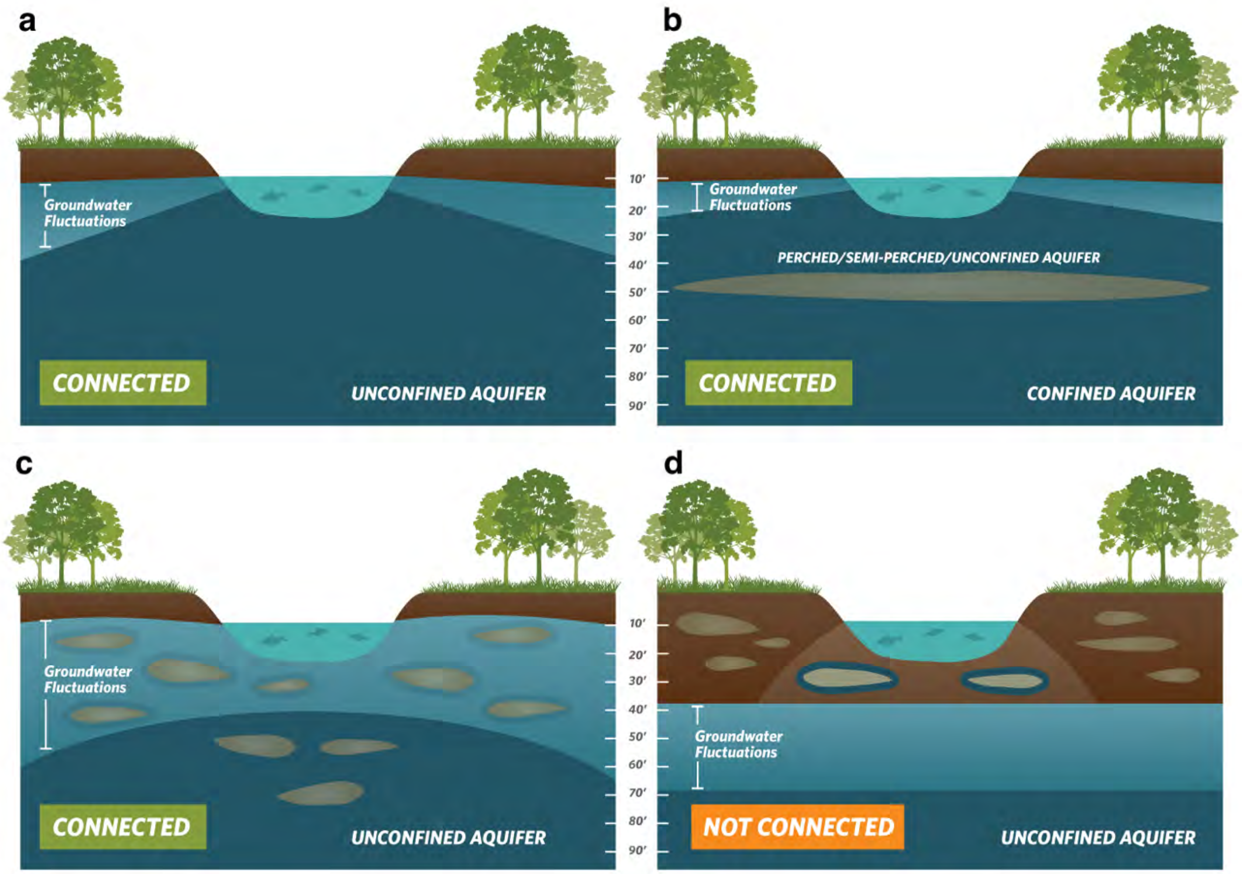


Figure 2. Confirming whether an ecosystem is connected to groundwater. Top: (a) Under the ecosystem is an unconfined aquifer with depth-to-groundwater fluctuating seasonally and interannually within 30 feet from land surface. (b) Depth-to-groundwater in the shallow aquifer is connected to overlying ecosystem. Pumping predominately occurs in the confined aquifer, but pumping is possible in the shallow aquifer. Bottom: (c) Depth-to-groundwater fluctuations are seasonally and interannually large, however, clay layers in the near surface prolong the ecosystem's connection to groundwater. (d) Groundwater is disconnected from surface water, and any water in the vadose (unsaturated) zone is due to direct recharge from precipitation and indirect recharge under the surface water feature. These areas are not connected to groundwater and typically support species that do not require access to groundwater to survive.

BEST PRACTICE #2. Characterize Seasonal and Interannual Groundwater Conditions

SGMA requires GSAs to describe current and historical groundwater conditions when identifying GDEs [23 CCR §354.16(g)]. Relying solely on the SGMA benchmark date (January 1, 2015) or any other single point in time to characterize groundwater conditions (e.g., depth-to-groundwater) is inadequate because managing groundwater conditions with data from one time point fails to capture the seasonal and interannual variability typical of California's climate. DWR's Best Management Practices document on water budgets[6] recommends using 10 years of water supply and water budget information to describe how historical conditions have impacted the operation of the basin within sustainable yield, implying that a baseline[7] could be determined based on data between 2005 and 2015. Using this or a similar time period, depending on data availability, is recommended for determining the depth-to-groundwater.

GDEs depend on groundwater levels being close enough to the land surface to interconnect with surface water systems or plant rooting networks. The most practical approach[8] for a GSA to assess whether polygons in the NC dataset are connected to groundwater is to rely on groundwater elevation data. As detailed in TNC's GDE guidance document[4], one of the key factors to consider when mapping GDEs is to contour depth-to-groundwater in the aquifer that is supporting the ecosystem (see Best Practice #5).

Groundwater levels fluctuate over time and space due to California's Mediterranean climate (dry summers and wet winters), climate change (flood and drought years), and subsurface heterogeneity in the subsurface (Figure 3). Many of California's GDEs have adapted to dealing with intermittent periods of water stress, however if these groundwater conditions are prolonged, adverse impacts to GDEs can result. While depth-to-groundwater levels within 30 feet[4] of the land surface are generally accepted as being a proxy for confirming that polygons in the NC dataset are supported by groundwater, it is highly advised that fluctuations in the groundwater regime be characterized to understand the seasonal and interannual groundwater variability in GDEs. Utilizing groundwater data from one point in time can misrepresent groundwater levels required by GDEs, and inadvertently result in adverse impacts to the GDEs. Time series data on groundwater elevations and depths are available on the SGMA Data Viewer[9]. However, if insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons in the GSP <u>until</u> data gaps are reconciled in the monitoring network (see Best Practice #6).

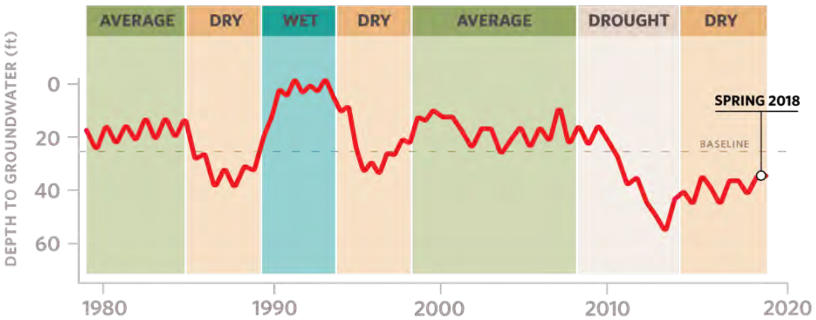


Figure 3. Example seasonality and interannual variability in depth-to-groundwater over time. Selecting one point in time, such as Spring 2018, to characterize groundwater conditions in GDEs fails to capture what groundwater conditions are necessary to maintain the ecosystem status into the future so adverse impacts are avoided.

---

[6] DWR. 2016. Water Budget Best Management Practice. Available at: https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_Water_Budget_Final_2016-12-23.pdf

[7] Baseline is defined under the GSP regulations as "historic information used to project future conditions for hydrology, water demand, and availability of surface water and to evaluate potential sustainable management practices of a basin." [23 CCR §351(e)]

[8] Groundwater reliance can also be confirmed via stable isotope analysis and geophysical surveys. For more information see The GDE Assessment Toolbox (Appendix IV, GDE Guidance Document for GSPs[4]).

[9] SGMA Data Viewer: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer

BEST PRACTICE #3. Ecosystems Often Rely on Both Groundwater and Surface Water

GDEs are plants and animals that rely on groundwater for all or some of its water needs, and thus can be supported by multiple water sources. The presence of non-groundwater sources (e.g., surface water, soil moisture in the vadose zone, applied water, treated wastewater effluent, urban stormwater, irrigated return flow) within and around a GDE does not preclude the possibility that it is supported by groundwater, too. SGMA defines GDEs as "ecological communities and species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" [23 CCR §351(m)]. Hence, depth-to-groundwater data should be used to identify whether NC polygons are supported by groundwater and should be considered GDEs. In addition, SGMA requires that significant and undesirable adverse impacts to beneficial users of surface water be avoided. Beneficial users of surface water include environmental users such as plants or animals[10], which therefore must be considered when developing minimum thresholds for depletions of interconnected surface water.

GSAs are only responsible for impacts to GDEs resulting from groundwater conditions in the basin, so if adverse impacts to GDEs result from the diversion of applied water, treated wastewater, or irrigation return flow away from the GDE, then those impacts will be evaluated by other permitting requirements (e.g., CEQA) and may not be the responsibility of the GSA. However, if adverse impacts occur to the GDE due to changing groundwater conditions resulting from pumping or groundwater management activities, then the GSA would be responsible (Figure 4).

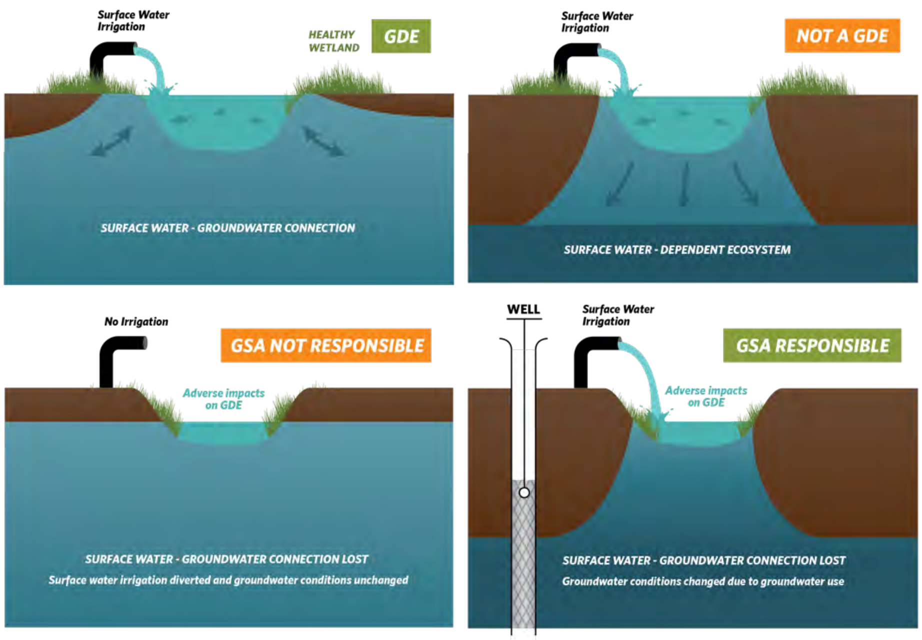


Figure 4. Ecosystems often depend on multiple sources of water. Top: (Left) Surface water and groundwater are interconnected, meaning that the GDE is supported by both groundwater and surface water. (Right) Ecosystems that are only reliant on non-groundwater sources are not groundwater-dependent. Bottom: (Left) An ecosystem that was once dependent on an interconnected surface water, but loses access to groundwater solely due to surface water diversions may not be the GSA's responsibility. (Right) Groundwater dependent ecosystems once dependent on an interconnected surface water system, but loses that access due to groundwater pumping is the GSA's responsibility.

[10] For a list of environmental beneficial users of surface water by basin, visit: https://groundwaterresourcehub.org/gde-tools/environmental-surface-water-beneficiaries/

BEST PRACTICE #4. Select Representative Groundwater Wells

Identifying GDEs in a basin requires that groundwater conditions are characterized to confirm whether polygons in the NC dataset are supported by the underlying aquifer. To do this, proximate groundwater wells should be identified to characterize groundwater conditions (Figure 5). When selecting representative wells, it is particularly important to consider the subsurface heterogeneity around NC polygons, especially near surface water features where groundwater and surface water interactions occur around heterogeneous stratigraphic units or aquitards formed by fluvial deposits. The following selection criteria can help ensure groundwater levels are representative of conditions within the GDE area:

- Choose wells that are within 5 kilometers (3.1 miles) of each NC Dataset polygons because they are more likely to reflect the local conditions relevant to the ecosystem. If there are no wells within 5km of the center of a NC dataset polygon, then there is insufficient information to remove the polygon based on groundwater depth. Instead, it should be retained as a potential GDE until there are sufficient data to determine whether or not the NC Dataset polygon is supported by groundwater.

- Choose wells that are screened within the surficial unconfined aquifer and capable of measuring the true water table.

- Avoid relying on wells that have insufficient information on the screened well depth interval for excluding GDEs because they could be providing data on the wrong aquifer. This type of well data should not be used to remove any NC polygons.

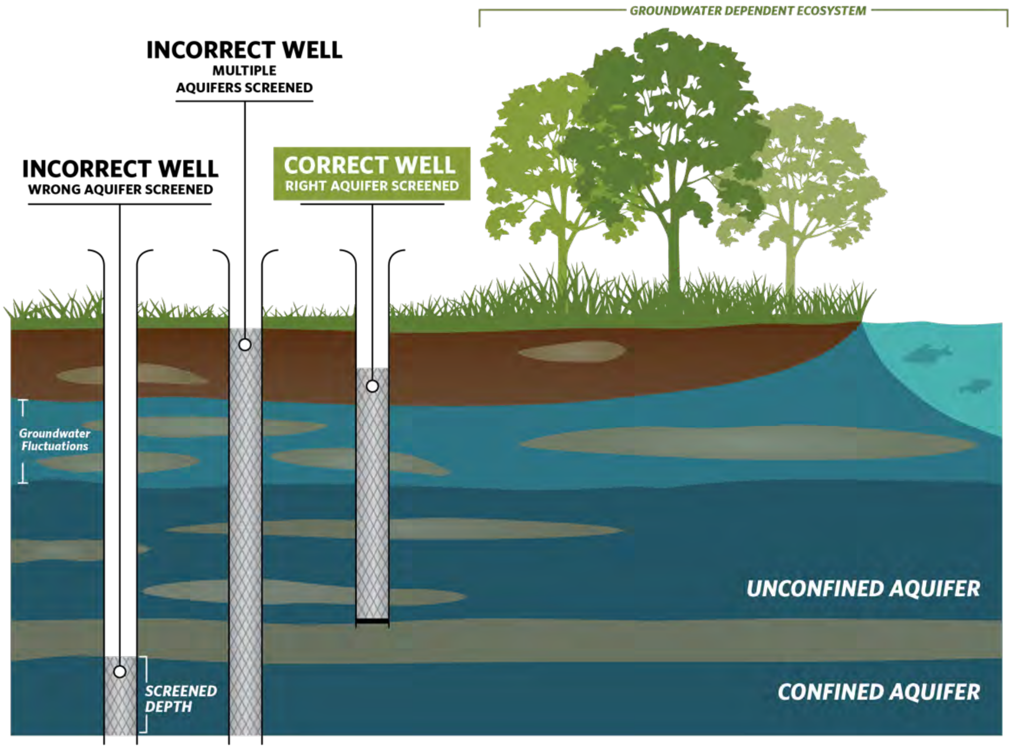


Figure 5. Selecting representative wells to characterize groundwater conditions near GDEs.

BEST PRACTICE #5. Contouring Groundwater Elevations

The common practice to contour depth-to-groundwater over a large area by interpolating measurements at monitoring wells is unsuitable for assessing whether an ecosystem is supported by groundwater. This practice causes errors when the land surface contains features like stream and wetland depressions because it assumes the land surface is constant across the landscape and depth-to-groundwater is constant below these low-lying areas (Figure 6a). A more accurate approach is to interpolate groundwater elevations at monitoring wells to get groundwater elevation contours across the landscape. This layer can then be subtracted from land surface elevations from a Digital Elevation Model (DEM)[11] to estimate depth-to-groundwater contours across the landscape (Figure b; Figure 7). This will provide a much more accurate contours of depth-to-groundwater along streams and other land surface depressions where GDEs are commonly found.

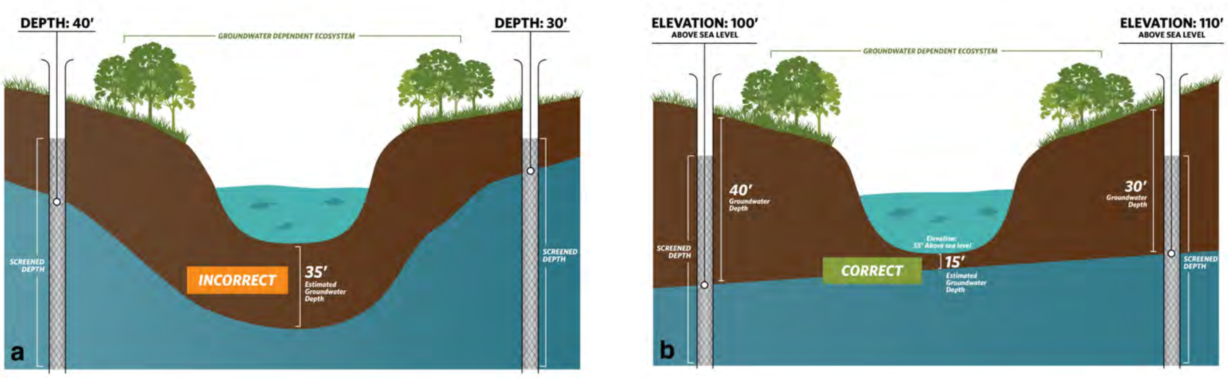


Figure 6. Contouring depth-to-groundwater around surface water features and GDEs. (a) Groundwater level interpolation using depth-to-groundwater data from monitoring wells. (b) Groundwater level interpolation using groundwater elevation data from monitoring wells and DEM data.

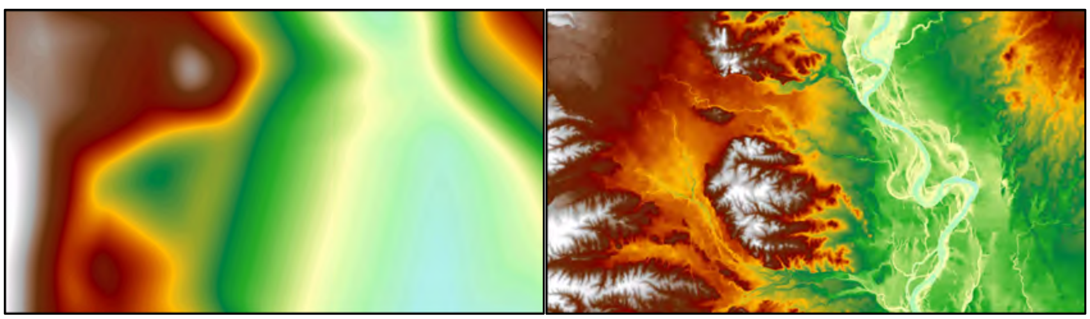


Figure 7. Depth-to-groundwater contours in Northern California. (Left) Contours were interpolated using depth-to-groundwater measurements determined at each well. (Right) Contours were determined by interpolating groundwater elevation measurements at each well and superimposing ground surface elevation from DEM spatial data to generate depth-to-groundwater contours. The image on the right shows a more accurate depth-to-groundwater estimate because it takes the local topography and elevation changes into account.

[11] USGS Digital Elevation Model data products are described at: https://www.usgs.gov/core-science-systems/ngp/3dep/about-3dep-products-services and can be downloaded at: https://iewer.nationalmap.gov/basic/

BEST PRACTICE #6. Best Available Science

Adaptive management is embedded within SGMA and provides a process to work toward sustainability over time by beginning with the best available information to make initial decisions, monitoring the results of those decisions, and using the data collected through monitoring programs to revise decisions in the future. In many situations, the hydrologic connection of NC dataset polygons will not initially be clearly understood if site-specific groundwater monitoring data are not available. If sufficient data are not available in time for the 2020/2022 plan, **The Nature Conservancy strongly advises that questionable polygons from the NC dataset be included in the GSP until data gaps are reconciled in the monitoring network.** Erring on the side of caution will help minimize inadvertent impacts to GDEs as a result of groundwater use and management actions during SGMA implementation.

KEY DEFINITIONS

Groundwater basin is an aquifer or stacked series of aquifers with reasonably well-defined boundaries in a lateral direction, based on features that significantly impede groundwater flow, and a definable bottom. *23 CCR §341(g)(1)*

Groundwater dependent ecosystem (GDE) are ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface. *23 CCR §351(m)*

Interconnected surface water (ISW) surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted. *23 CCR §351(o)*

Principal aquifers are aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems. *23 CCR §351(aa)*

ABOUT US

The Nature Conservancy is a science-based nonprofit organization whose mission is *to conserve the lands and waters on which all life depends*. To support successful SGMA implementation that meets the future needs of people, the economy, and the environment, TNC has developed tools and resources (www.groundwaterresourcehub.org) intended to reduce costs, shorten timelines, and increase benefits for both people and nature.

Attachment E

Maps of representative monitoring sites in relation to key beneficial users

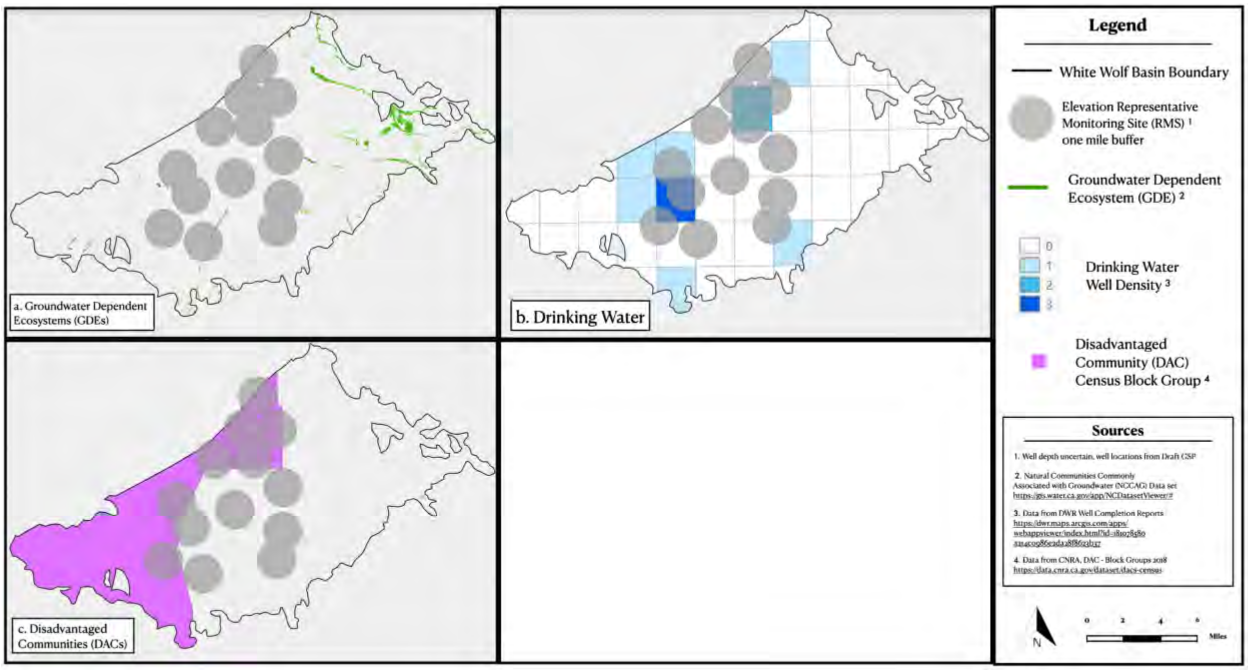


Figure 1. Groundwater elevation representative monitoring sites in relation to key beneficial users: a) Groundwater Dependent Ecosystems (GDEs), b) Drinking Water users, c) Disadvantaged Communities (DACs), and d) Tribes.

ID (#)	Date Received	Commenter / Organization	Chapter / Section Title	Provided Comment	Response to Comment	Revision to the Groundwater Sustainability Plan (GSP)
1	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists	Plan Area 5.1.3	**The identification of Disadvantaged Communities (DACs) and drinking water users is incomplete.** The GSP provides information on DACs, including identification by name and location on a map (Figure PA-2), and identifies the population of each identified DAC. However, the GSP fails to include the population dependent on groundwater as their source of drinking water in the basin. While the plan provides a density map of domestic wells in the basin (Figure PA-4), the GSP fails to provide depth of these wells (such as minimum well depth, average well depth, or depth range) within the basin. This information is necessary to understand the distribution of shallow and vulnerable drinking water wells within the basin. These missing elements are required for the GSA to fully understand the specific interests and water demands of these beneficial users, and to support the consideration of beneficial users in the development of sustainable management criteria and selection of projects and management actions. **Recommendations:** • Identify the sources of drinking water for DAC members, including an estimate of how many people rely on groundwater (e.g., domestic wells, state small water systems, and public water systems). • Include a map showing domestic well locations and average well depth across the basin.	Drinking water in the Basin is provided from three Public Water Systems (PWS) as described in Section 5.1.4 - Existing Land Use and Water Use. Drinking water from these sources is a mix of surface water and groundwater, with a total of five supply wells. On average between 2013 and 2019, one of the wells provided 15 acre feet per year (AFY), two contributed 40 AFY (only during select years as emergency backup), and the other two wells contributed less than one AFY. As described in Section 5.1.3.4 - Disadvantaged Communities of the Groundwater Sustainability Plan (GSP), most of the DAC/SDAC areas within the Basin are lightly populated (i.e., <u>it is estimated that approximately 390 people currently live within the Basin</u> [DWR, 2019]). Therefore, a maximum of 390 people of the DAC members rely on groundwater, based on the best available data. The DAC classification is based on U.S. Census blocks, and has a spatial resolution coarser than the total area of the basin (see GSP Figure PA-2). The White Wolf Basin straddles two census blocks separated by Interstate-5; the designation of DACs and SDACs are found only in the block west of I-5, which incorporates the towns of Maricopa (pop. 1,154) and Taft (pop. 9,327), both of which are outside of the White Wolf basin boundary. Domestic well locations are provided in Figure HCM-10 "Well Locations, Use, and Status". Well construction statistics are provided in Figure HCM-4 "Summary of Well Depth Data". Wells in the Basin range from 400 to 2,200 feet in depth, and the average depth of well completion is 1,000 to 1,200 feet below groundwater surface (ft bgs). Furthermore, as described in Section 14.1.2 Well Impact Analysis, the proposed Minimum Thresholds (MTs) for Chronic Lowering of Groundwater Levels are not expected to result in complete dewatering in any of the wells analyzed, and are only expected to result in reduction of water levels in four wells that were not already partially dewatered at the Fall 2015 groundwater elevation. As such, the extent of potential impacts on the DAC members is not considered to be significant and unreasonable.	Please see response to this comment at left. No revision to the GSP is proposed.
2	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists	GWC 8.7	**The identification of Interconnected Surface Waters (ISW) is insufficient, due to lack of supporting information provided for the ISW analysis.** The GSP states (p. 87): "As discussed above, groundwater levels in the Principal Aquifer are far below the land surface within most of the Basin (Figure GWC-4), and therefore there is no interconnected surface water throughout most of the Basin." Figure GWC-4 presents point locations of average depth groundwater over the period 2015-2019. **However, averaging depth to groundwater dampens the seasonal and interannual variability of these data.** In California's Mediterranean climate, groundwater interconnections with surface water can vary seasonally and interannually. **Using seasonal groundwater elevation data over multiple water year types is an essential component of identifying ISWs.**	Figure <u>GWC-6</u> (modified) illustrates seasonal and interannual variability of piezometric heads in Basin representative monitoring wells over the period 1994 - 2019, which contains the period requested. Available data clearly show that interconnected surface water in the basin does not occur except in limited areas near and upgradient of the Springs Fault. Three dedicated interconnected surface water (ISW) monitoring wells were constructed in spring of 2021 to monitor conditions in this area, and data collection is ongoing. Groundwater elevation data to support analysis of seasonal piezometric surface elevation changes over multiple water year types are not yet available in this part of the basin.	A ground surface elevation line is added to each hydrograph in Figure GWC-6, to allow intuitive visualization of groundwater depth variations in the mapped wells over multiple seasons, years, and water year types. The data support the GSP's assessment that interconnected surface water is not common in the Basin.
3	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists		The GSP discusses the ephemeral nature of the stream reaches as evidence that stream reaches are disconnected from groundwater. The GSP states (p. 87): "Furthermore, the definition of interconnected surface water requires that the surface water feature not be completely depleted (i.e., not dry)." However, **this sentence is a misinterpretation of the regulations [23 CCR §351(o)], which define ISW as "surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted**". "At any point" has both a spatial and temporal component. Even **short durations of interconnections of groundwater and surface water can be crucial for surface water flow** and supporting environmental users of groundwater and surface water.	The comment implies that if an ephemeral stream has been connected to groundwater at any time in the past, then the stream should be classified as interconnected surface water. This is a very broad interpretation of the regulations as written, and is not supported by current data. Additionally, SGMA does not retroactively require restoration of conditions present in the Basin prior to 2015. The characterization of the basin as having only very spatially-limited interconnected surface water is accurate, and will remain as written in the GSP.	Please see the response to this comment at left. No revision to the GSP is proposed.

ID (#)	Date Received	Commenter / Organization	Chapter / Section Title	Provided Comment	Response to Comment	Revision to the Groundwater Sustainability Plan (GSP)
4	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists		The GSA used the ICONS web mapping application as further evidence that ISWs are not present in the basin, stating that streams in the portion of the basin shown on this map are all designated as "likely disconnected". However**, the ICONS web map data only covers a small portion of the basin**.	As stated in the comment itself, the ICONS web mapping application was used as further evidence, i.e., building upon all the evidence available. Use of multiple lines of evidence is a generally-accepted practice, and given the disparate and spatially discontinuous nature of data that must be compiled and analyzed by a GSA, use of incomplete data is often useful or even necessary. Thus, no changes related to this comment are needed in the GSP.	Please see the response to this comment at left. No revision to the GSP is proposed.
5	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists		Finally, the GSP states that the possible exception to the disconnected nature of groundwater and surface water in the basin is near the Springs Fault. The GSP states (p. 88): "Furthermore, based on the available data (see Appendix D), water level data installed in co-located shallow monitoring wells show no impact from groundwater production from the Principal Aquifer. This suggests that this area is hydraulically disconnected from, and at a minimum should be managed separately from, the Principal Aquifer." **However, shallow aquifers that have the potential to support well development, support ecosystems, or provide baseflow to streams are principal aquifers, even if the majority of the basin's pumping is occurring in deeper principal aquifers**. If areas of shallow or perched groundwater are discounted as ISWs**, the GSP should provide more supporting evidence of 1) vertical groundwater gradients between the perched system and deeper principal aquifers, and 2) whether perched groundwater is providing significant or economic quantities of water to streams, wells** (e.g., domestic wells), and ecosystems (e.g.,GDEs).	The GSP clearly states in Section 7.1.4 that "the Principal Aquifer is defined as consisting of the deposits of Shallow Alluvium, Kern River Formation, and Chanac Formation," so the shallow alluvial aquifer is defined as part of the Principal Aquifer. The shallow aquifer on the upgradient (south) side of the Springs Fault supports very little water demand, consisting of two backup domestic wells and one backup irrigation well generally pumping less than two acre-feet per year, i.e., de minimis groundwater use under SGMA. Groundwater pumping has been infrequent and minor, reported as approximately 40 AFY in years when the backup wells were used, thus it contrasts greatly with the principal aquifer in the main part of the basin, which supports widespread agricultural and commercial use. Based on the limited data available, groundater-level fluctuations observed south of the Springs Fault appear to be disconnected from pumping, and are driven by seasonal and interannual changes in recharge and evapotranspiration. Additionally, given that pumping demand on the shallow upgradient aquifer is de minimis, no pumping restrictions can be enacted for this aquifer. The GSA will continue to collect and monitor the three dedicated interconnected surface water (ISW) monitoring wells constructed near the Springs Fault in 2021, as well as existing backup domestic supply wells, and will revisit the question of groundwater level trends and potential Management Actions such as pumping restrictions during the 5-year update to the GSP. North of the Springs Fault, the piezometric surface generally remains several hundred feet below ground surface even during seasonal wet periods, and no shallow aquifer currently is present, or is known to have been present historically within the timeframe of SGMA regulation. Thus, no changes related to this comment are needed in the GSP.	Please see the response to this comment at left. No revision to the GSP is proposed.

ID (#)	Date Received	Commenter / Organization	Chapter / Section Title	Provided Comment	Response to Comment	Revision to the Groundwater Sustainability Plan (GSP)
6	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists		**Recommendations:** • Provide a map showing all the stream reaches in the basin, with reaches clearly labeled as interconnected (gaining/losing) or disconnected. Consider any segments with data gaps as potential ISWs and clearly mark them as such on maps provided in the GSP. • Use seasonal data over multiple water year types to capture the variability in environmental conditions inherent in California's climate, when mapping ISWs. We recommend the 10-year pre-SGMA baseline period of 2005 to 2015. • Overlay the basin's stream reaches on depth-to-groundwater contour maps to illustrate groundwater depths and the groundwater gradient near the stream reaches. Show the location of groundwater wells used in the analysis. • For the depth-to-groundwater contour maps, use the best practices presented in Attachment D. Specifically, ensure that the first step is contouring groundwater elevations, and then subtracting this layer from land surface elevations from a Digital Elevation Model (DEM) to estimate depth-to-groundwater contours across the landscape. This will provide accurate contours of depth to groundwater along streams and other land surface depressions where GDEs are commonly found.	See responses to comments #2 through #5. Fig. GWC-17 and GWC-18 show all stream reaches in the basin, identifying both probable and field-assessed groundwater dependent ecosystems (GDEs). As discussed above, GDEs occur principally upgradient (south) of the Springs Fault, a region with minimal pumping. Fig. GWC-6 shows groundwater elevations and depths to groundwater in representative monitoring wells within the basin from 1994 to 2019, which spans the available seasonal and interannual groundwater level variation data. As discussed in the GSP and referenced above, areas with GDEs and shallow groundwater are located generally south of the Springs Fault or in areas of shallow low-permeability bedrock near the basin margins. The proposed method of mapping the differences between two interpolated raster datasets, i.e., the piezometric surface elevation and the DEM, is more appropriate for basins with significant topographic variation within the areas of GDE uncertainty. Fig. GWC-6 clearly shows that groundwater depths and variation are well below the range of topographic relief in the main basin area north of the Springs Fault, thus the proposed method is not particularly useful in this case.	Please see the response to this comment at left. Other than the addition of land surface elevations to Figure GWC-6 as discussed above, no revision to the GSP is proposed.
7	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists	GWC 8.8	**The identification of Groundwater Dependent Ecosystems (GDEs) is insufficient.** The GSP took initial steps to identify and map GDEs using the Natural Communities Commonly Associated with Groundwater dataset (NC dataset) and other sources. However**, we found that mapped features in the NC dataset were improperly disregarded**. **NC dataset polygons were incorrectly removed based on the assumption that they are supported by a shallow water bearing zone separate from the regional aquifer** (i.e., categories A and S on Figure GWC-18). However, shallow aquifers that have the potential to support well development, support ecosystems, or provide baseflow to streams are principal aquifers, even if the majority of the basin's pumping is occurring in deeper principal aquifers. **If there are no data to characterize groundwater conditions in the shallow principal aquifer, then the GDE should be retained as a potential GDE and data gaps reconciled in the Monitoring Network section of the GSP.**	See response to comment #5. A significant effort was performed to determine GDE areas as described in Section 8.8, Appendix H, An Evaluation and Determination of Groundwater Dependant Ecosystems in the White Wolf Sub-Basin, and Appendix I GDE Pulse Interactive Map Analysis. At this time, data to categorize groundwater conditions south of the Springs Fault are limited; this is considered a data gap within the GSP. To address this data gap, the GSA constructed three shallow monitoring wells to characterize water levels in the shallow water-bearing zone south of the Springs Fault. The GSA will conduct ongoing monitoring of these and other wells in the basin, and these data as well as SMCs will be assessed in the 5-Year update to the GSP.	Please see the response to this comment at left. No revision to the GSP is proposed.
8	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists		The GSP presents depth-to-groundwater data on Figure GWC-17 (Natural Communities Commonly Associated with Groundwater and Spring 2015 Depth to Groundwater). This is the only dataset used to characterize groundwater conditions in the basin's GDEs. **We recommend using groundwater data from multiple seasons and water year types to determine the range of depth to groundwater around NC dataset polygons.** Table GW-6 presents a rooting depth of 24 feet for Valley Oak (Quercus lobata). We recommend instead that an 80-foot depth-to-groundwater threshold be used when inferring whether Valley Oak polygons in the NC dataset are likely reliant on groundwater. **This recommendation is based on a recent correction in TNC's rooting depth database, after finding a typo in the max rooting depth units for Valley Oak. This resulted in a specific change in the max rooting depth of Valley Oak from 24 feet to 24 meters (80 feet).**	See response to comment #7. South of the Springs Fault, where seasonal ISW is present, groundwater level data from existing wells is sparse or nonexistent, and the three new ISW monitoring wells constructed in 2021 do not yet have sufficient data records to characterize groundwater variations over multiple seasons and water year types. An assumed 80-foot rooting depth for the deciduous species Valley Oak (*Q. lobata*) may not be accurate. The TNC database cites two sources of the 80-foot value; however both reference Lewis and Burgy (1964), a geochemical study that investigated oak tree roots in fractured bedrock using tritium isotopes injected into groundwater. In one experiment, Lewis and Burgy identified Blue Oak (*Q. douglasii*) and Live Oak (*Quercus spp*) but not Valley Oak, interpreting both as having rooting depths greater than 75 feet. Extrapolating this finding to Valley Oak may not be accurate, given that Valley Oak was not included in this experiment, and the environment studied is not common in the White Wolf Basin (i.e., fractured bedrock in which groundwater movement and root growth are restricted to a very small volume of interconnected fracture networks). The particular experiment Lewis and Burgy conducted using Valley Oak was at a location with much shallower groundwater depths (reported as approximately 24 feet below ground surface (ft bgs).	Please see the response to this comment at left. No revision to the GSP is proposed.

ID (#)	Date Received	Commenter / Organization	Chapter / Section Title	Provided Comment	Response to Comment	Revision to the Groundwater Sustainability Plan (GSP)
9	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists		**Recommendations:** • Use depth-to-groundwater data from multiple seasons and water year types (e.g., wet, dry, average, drought) to determine the range of depth to groundwater around NC dataset polygons. We recommend that a pre-SGMA baseline period (10 years from 2005 to 2015) be established to characterize groundwater conditions over multiple water year types. Refer to Attachment D of this letter for best practices for using local groundwater data to verify whether polygons in the NC Dataset are supported by groundwater in an aquifer. • Refer to Attachment B for more information on TNC's plant rooting depth database. Deeper thresholds are necessary for plants that have reported maximum root depths that exceed the averaged 30-ft threshold, such as Valley Oak (Quercus lobata). We recommend that the reported max rooting depth for these deeper-rooted plants be used. For example, a depth-to-groundwater threshold of 80 feet should be used instead of the 30-ft threshold, when verifying whether Valley Oak polygons from the NC Dataset are connected to groundwater. It is important to emphasize that actual rooting depth data are limited and will depend on the plant species and site-specific conditions such as soil and aquifer types, and availability to other water sources. If insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons as "Potential GDEs" in the GSP until data gaps are reconciled in the monitoring network.	See responses to comments #7 and #8. Note that 18,465 acres of land in the area south of the Springs Fault with significant GDEs is managed for ecosystem sustainability under a conservation easement (the Tejon Ranch Conservation Land Use Agreement). An additional 10,198 acres in the southwest portion of the basin is managed as the Wind Wolves Preserve by the Wildlands Conservancy. Additional information may be found in Section 5.1.4 of the GSP.	Please see the response to this comment at left. No revision to the GSP is proposed.
10	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists	Water Budget 9	**Native vegetation and managed wetlands are water use sectors** that are required to be included in the water budget[4,5]. **The integration of native vegetation into the water budget is sufficient**. We commend the GSA for including the groundwater demands of this ecosystem in the historical, current and projected water budgets. **Managed wetlands are not mentioned in the GSP, so it is not known whether or not they are present in the basin.** **Recommendations:** • State whether or not there are managed wetlands in the basin. If there are, ensure that their groundwater demands are included as separate line items in the historical, current, and projected water budgets.	Managed wetlands are not currently present in the basin.	Please see the response to this comment at left. No revision to the GSP is proposed.

ID (#)	Date Received	Commenter / Organization	Chapter / Section Title	Provided Comment	Response to Comment	Revision to the Groundwater Sustainability Plan (GSP)
11	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists	Plan Area/ Implementation 5.5.3, 5.5.4.3 & 19.1.4	**Stakeholder engagement during GSP development is insufficient**. SGMA's **requirement for public notice and engagement of stakeholders is not fully met** by the description in the Stakeholder Communication and Engagement Plan (Appendix B). We note the following deficiencies with the overall stakeholder engagement process: • The opportunities for public involvement and engagement during the GSP development and implementation phases are described in general terms. They include participation through stakeholder workshops, GSA Board meetings, distribution of a stakeholder survey, letters sent to the public water systems, development of fact sheets and newsletters, and updates to the GSA's website. **The GSP states that DACs are engaged through use of the stakeholder survey and coordination with relevant community groups, but no further details are provided.** • While environmental stakeholders are listed as beneficial users within the basin, **specific outreach and engagement targeted to this group is not described beyond informing stakeholders about the development process.** • Aside from the continuation of engagement strategies used during the GSP development process, the **Stakeholder Communication and Engagement Plan does not include a detailed plan for continual opportunities for engagement through the implementation phase of the GSP that is specifically directed to DACs, domestic well owners, and environmental stakeholders.** **Recommendations:** • In the Stakeholder Communication and Engagement Plan, describe active and targeted outreach to engage DACs, domestic well owners, and environmental stakeholders throughout the GSP development and implementation phases. Refer to Attachment B for specific recommendations on how to actively engage stakeholders during all phases of the GSP process. • Utilize DWR's tribal engagement guidance to comprehensively address all tribes and tribal interests in the basin within the GSP.	The GSA used a public Stakeholder Survey to acquire additional, relevant information about the Basin stakeholders, including DAC members and environmental users. The Stakeholder Survey is included in Appendix B of the GSP and also posted on the GSA website (http://whitewolfgsa.org/). As described in Section 5.5.4.3 - Stakeholder Involvement, results from 21 Stakeholder Survey responses were received and incorporated in the GSP development process. Future GSA Board meetings and Public Workshops will continue to be publicized in an effort to notify all relevant stakeholders within the Basin. Representatives from Wind Wolves Preserve, which is an environmental user identified in the GSP, and Tejon Ranch Corporation (responsible for implementation of Tejon Ranch Conservation Land Use Agreement) have been actively engaged during the GSP development. Public comments on the GSP and corresponding White Wolf GSA responses are documented in Table PA-2 of the GSP. As described in Section 5.1.3.3 Native American Tribal Communities and Lands, there are no tribal lands within or in the vicinity of the Basin based on the information made available by DWR in support of GSP development.	Please see response to this comment to the left. Revision to Table 1 of Appendix B of the GSP (SCEP) was made. Tejon Ranch Corporation was also identified as an environmental user.

ID (#)	Date Received	Commenter / Organization	Chapter / Section Title	Provided Comment	Response to Comment	Revision to the Groundwater Sustainability Plan (GSP)
12	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists	SMC	**The consideration of beneficial uses and users when establishing sustainable management criteria (SMC) is insufficient.** The consideration of potential impacts on all beneficial users of groundwater in the basin are required when defining undesirable results and establishing minimum thresholds. For chronic lowering of groundwater levels, minimum thresholds are calculated as the lower of the following (p. 165): "(a) the historic low groundwater level minus the Variability Correction Factor and (b) the groundwater level in Fall 2015 (i.e., the first Fall after SGMA went into effect) minus the greater of either the Variability Correction Factor or the Trend Continuation Factor." Undesirable results are established as follows (p. 149): "Undesirable Results for Chronic Lowering of Groundwater Levels would be experienced in the Basin if and when groundwater levels in the Principal Aquifer decline below the established MTs in 40% or more of the RMW-WLs over four consecutive seasonal measurements during non-drought years (i.e., measurements spanning a total of two non-drought years, including two seasonal high groundwater level periods and two seasonal low groundwater level periods)." **By only using 40% of minimum threshold exceedances in RMW-WLs during non-drought years to define undesirable results for groundwater levels, significant and unreasonable impacts to beneficial users experienced during dry years or periods of drought will not result in an undesirable result. This is problematic since the GSP is failing to manage the basin in such a way that strives to minimize significant adverse impacts to beneficial users, which are often felt greatest in below-average, dry, and drought years.** The GSP justifies these SMC based on a well impact analysis presented in Section 14.1.2. However, this analysis **only assesses wells with available well construction information and wells that are newer than 50 years, under the assumption that the usable lifespan of groundwater wells is approximately 50 years**. The GSP states that 78% of basin wells are greater than 50 years old, thereby neglecting most of the basin's wells from the well impact analysis. Given these criteria, **only five wells in the domestic and public supply wells category (along with 24 wells in the (irrigation category) could be analyzed**. The GSP states (p. 167): "The proposed MTs are not expected to result in complete dewatering in any of the wells analyzed, and are only expected to result in partial dewatering of four wells that were not already partially dewatered at the Fall 2015 groundwater elevation; as such, the extent of potential impacts is not considered to be significant and unreasonable." Despite this well impact analysis, the **GSP does not sufficiently describe whether minimum thresholds are consistent with California's Human Right to Water policy and will avoid significant and unreasonable loss of drinking water, especially given the absence of a domestic well mitigation plan in the GSP**. In addition, **the GSP does not sufficiently describe or analyze direct or indirect impacts on DACs when defining undesirable results, nor does it describe how the groundwater level minimum thresholds are consistent with Human Right to Water policy and will avoid significant and unreasonable impacts on DACs.** **Recommendations:** • Consider minimum threshold exceedances during drought years when defining the groundwater level undesirable result across the basin. • In the well impact assessment, utilize well data from older wells (>50 years old) to better represent minimum threshold impacts to wells across the basin. • Describe direct and indirect impacts on DACs and drinking water users when describing undesirable results and defining minimum thresholds for chronic lowering of groundwater levels.	Please see response to comment #1 regarding populations dependant on groundwater. In accordance with SGMA, the GSA has determined that groundwater at 2015 levels does not constitute an Undesirable Result. Requiring two consecutive non-drought years of MT exceedance provides confirmation that any observed decline is not simply due to drought-related reduced groundwater recharge, consistent with the definition of Undesirable Results in CWC 10721(x)(1). The GSA has not elected to attempt to address pre-2015 water level declines; per California Water Code (CWC) §10727.2(b)(4) "*The plan may, but is not required to, address undesirable results that occurred before, and have not been corrected by, January 1, 2015…., a groundwater sustainability agency has discretion as to whether to set measurable objectives and the timeframes for achieving any objectives for undesirable results that occurred before, and have not been corrected by, January 1, 2015.*" The GSP's well impact analysis attempts to estimate quantitative effects on wells for which data are available. Wells without construction information cannot be quantitatively assessed for pumping impacts, as two key factors (their total depths and perforated intervals) are not known. The assumption that the basin should not be managed to preserve wells past their useful lifespan (i.e., older than 50 years) is conservative. Other workers have estimated a well retirement age of approximately 28 to 33 years (Gailey, 2018; Pauloo et al., 2020; Pauloo et al., 2021). In the GSA's experience, older wells in the basin that were initially thought to be usable for pumping or water level measurement have turned out to be damaged and unsuitable. The assumption used herein of a 50-year well lifespan is considered conservative. The California State Water Resources Control Board (SWRCB) describes the state Human Right to Water Policy as "every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes." The SWRCB publishes a list of public water systems "that do not have, or are at risk of not having, safe, clean, affordable, and accessible water for drinking, cooking, and sanitary purposes." None of the public water systems in the basin are listed as being at risk. The SWRCB's Division of Drinking Water monitors groundwater quality from public water system wells. The two small public water systems located within the Basin (Tut Brothers Farm #96 and Cuyama Orchards) are monitored as part of this program. Additional information is provided in Section 5.2.1 of the GSP.	Please see the response to this comment at left. No revision to the GSP is proposed.

ID (#)	Date Received	Commenter / Organization	Chapter / Section Title	Provided Comment	Response to Comment	Revision to the Groundwater Sustainability Plan (GSP)
13	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists	GWC/ SMC 8.5, 13, 14 &15	**For degraded water quality, minimum thresholds are set for arsenic, nitrate, and selenium at their respective MCLs.** The GSP states (p. 171): "Several other constituents (i.e., Total Dissolved Solids (TDS), sulfate, iron, boron, and sodium) were identified in Section 8.5 Groundwater Quality Concerns as having exceeded their applicable screening levels in 15% or more of samples in the White Wolf Data Management System (DMS). However, the screening levels for these constituents are mostly Secondary MCLs associated with aesthetic concerns (i.e., taste, odor or color) or irrigation Water Quality Objectives (WQOs), and are not health-related standards. Because these constituents are not expected to have significant impacts to the most sensitive beneficial use of groundwater in the Basin (i.e., drinking water), SMCs have not been developed for those constituents." However, **according to the state's anti-degradation policy, high water quality should be protected and is only allowed to worsen if a finding is made that it is in the best interest of the people of the State of California**. No analysis has been done and no such finding has been made**. SMC should be established for all constituents in the basin that are impacted or exacerbated by groundwater use and/or management**, in addition to coordinating with water quality regulatory programs. **Recommendations:** • Describe direct and indirect impacts on DACs and drinking water users when defining undesirable results for degraded water quality. For specific guidance on how to consider these users, refer to "Guide to Protecting Water Quality Under the Sustainable Groundwater Management Act." • Evaluate the cumulative or indirect impacts of proposed minimum thresholds for degraded water quality on DACs and drinking water users. • Set minimum thresholds and measurable objectives for all water quality constituents within the basin that are impacted by groundwater use and/or management. Ensure they align with drinking water standards.	Multiple chemical constituents are monitored regularly in drinking water by other programs such as the Regional Water Quality Control Board's Irrigated Lands Regulatory Program (ILRP), so additional water quality SMCs for secondary constituents are unnecessary. SGMA's mandate is to address impacts since 2015, which are affected by pumping, or management actions related to pumping in the basin. Groundwater demand management through pumping reductions (the primary option currently available to manage the basin) is unlikely to be an effective mechanism to address concerns regarding secondary chemicals of concern beyond those already with a threshold value. Discussions of impacts on DACS must also weigh economic impact as a consideration of sustainability within SGMA. DWR's best management practices guidance states that "*GSAs should consider the following when developing their sustainability goal … The goal description should summarize the overall purpose for sustainably managing groundwater resources and reflect local economic, social, and environmental values within the basin.*" (emphasis added). Another nearby GSA in California performed an economic study of the impacts of agriculture in the basin, estimating gross farm revenue of approximately $110 million from approximately 16,000 acres, or roughly $6,900 per acre.	Please see the response to this comment at left. No revision to the GSP is proposed.
14	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists		The GSP only considers GDEs with respect to the depletion of interconnected surface water sustainability indicator, **but not the chronic lowering of groundwater levels sustainability indicator.** **No analysis or discussion is provided in the GSP that describes impacts to GDEs or establishes SMC for GDEs that are directly dependent on groundwater**. This is problematic because without identifying potential impacts to GDEs**, minimum thresholds may compromise these environmental beneficial users**. Since GDEs are present in the basin, **they must be considered when developing SMC for chronic lowering of groundwater levels**. Our comments above in the GDE section note that the **GDE analysis may have disregarded some GDEs in the basin which could be directly dependent on groundwater, including deeper-rooted plants such as Valley Oak.**	See response to comment #8. Throughout the Basin water levels are typically too deep to sustain GDEs as shown on Figure GWC-4 "Average Depth to Groundwater – WY 2015-2019". GDEs are addressed as part of the ISW Sustainability Indicator (SI), not the Chronic Lowering of Groundwater Level (GWL) SI. As described in Section 13.6 and 17.1.6, the ISW monitoring network and SMCs are defined explicitly to address GDEs. In other words, the GSP provides a specific monitoring network and set of SMCs that address ISW and GDEs. Further, the interaction between all SMCs and SIs were considered as described in Table SMC-1 and GSP Section 13. As long as groundwater levels are maintained above the MTs, the associated rate of depletion of ISW is likely to be less than the rate prior to the 1 January 2015 effective date of SGMA, thus the SMCs are protective and avoid Undesirable Results, inclduing impacts to GDEs. In fact, the MTs and other SMCs were selected on this basis.	Please see the response to this comment at left. No revision to the GSP is proposed.

ID (#)	Date Received	Commenter / Organization	Chapter / Section Title	Provided Comment	Response to Comment	Revision to the Groundwater Sustainability Plan (GSP)
15	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists		For depletion of interconnected surface water, the GSP uses groundwater elevations as a proxy for establishing SMC. The GSP states (p. 156): "Significant and unreasonable effects associated with Undesirable Results would include a 30% reduction of, or visual impact to, the health of GDEs based on their conditions observed during 2018 through 2020 that can be directly attributed to Principal Aquifer pumping-related lowering of groundwater levels rather than the effects of natural or climatic processes." The GSA has established preliminary minimum thresholds for interconnected surface water at three newly installed shallow monitoring wells, which are the representative monitoring wells for depletions of ISW. The minimum thresholds are set as follows (p. 176): "Using the above values, the initial MT estimates at each RMW-ISW location are calculated as the lower of the following: (a) the projected depth to groundwater at the end of October 2021 calculated based on observed June 2021 water levels and the Trend Continuation Factor, and (b) 30 ft bgs." **While the GSP recognizes that there could be impacts on terrestrial GDEs through its definition of significant and unreasonable effects, no further details on these impacts are provided, such as which habitat types could be affected, or the anticipated physiological responses based on minimum threshold groundwater levels**. The GSP should **also evaluate how the proposed minimum thresholds and measurable objectives avoid significant and unreasonable effects on surface water beneficial users in the basin, such as increased mortality and inability to perform key life processes** (e.g., reproduction, migration). Furthermore, the GSP should describe **how SMC for depletion of interconnected surface water will be updated once more data is gathered from the newly installed monitoring wells.**	See responses to comments #5 and #14. Available data are currently insufficient to directly calculate surface water depletions from streamflow measurements or estimate depletions from a surface water budget. This information is needed to assess the relationship between GSP implementation, changes in the depletion of interconnected surface water, and instream habitats. As described in Appendix M, Change in GDE Area Anlalysis, UR were developed utilizing natural variation in GDE area. Furthermore there are other factors that affect GDEs which are beyond control of SGMA (e.g. climate change). Data from the shallow monitoring wells will be collected and analyzed over the long term to improve understanding of the relationships between shallow groundwater and surface water flows. This includes investigating any linkage between water levels in monitoring wells and groundwater pumping from nearby domestic wells. Additionally, the GSA has plans underway to install a stream gage on El Paso Creek to provide additional streamflow characterization. Understanding these relationships is vital to adapatively manage the Basin.	Please see the response to this comment at left. No revision to the GSP is proposed.
16	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists		**Recommendations:** • When defining undesirable results for chronic lowering of groundwater levels, provide specifics on what biological responses (e.g., extent of habitat, growth, recruitment rates) would best characterize a significant and unreasonable impact to GDEs. Undesirable results to environmental users occur when 'significant and unreasonable' effects on beneficial users are caused by one of the sustainability indicators (i.e., chronic lowering of groundwater levels, degraded water quality, or depletion of interconnected surface water). Thus, potential impacts on environmental beneficial uses and users need to be considered when defining undesirable results in the basin. Defining undesirable results is the crucial first step before the minimum thresholds can be determined. • When defining undesirable results for depletion of interconnected surface water, include a description of potential impacts on instream habitats within ISWs when minimum thresholds in the basin are reached. The GSP should confirm that minimum thresholds for ISWs avoid adverse impacts on environmental beneficial users of interconnected surface waters as these environmental users could be left unprotected by the GSP. These recommendations apply especially to environmental beneficial users that are already protected under pre-existing state or federal law. When establishing SMC for the basin, consider that the SGMA statute [Water Code §10727.4(l)] specifically calls out that GSPs shall include "impacts on groundwater dependent ecosystems".	See reponses to comments #14 and #15.	Please see the response to this comment at left. No revision to the GSP is proposed.

ID (#)	Date Received	Commenter / Organization	Chapter / Section Title	Provided Comment	Response to Comment	Revision to the Groundwater Sustainability Plan (GSP)
17	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists		The SGMA statute identifies climate change as a significant threat to groundwater resources and one that must be examined and incorporated in the GSPs. The GSP Regulations require integration of climate change into the projected water budget to ensure that projects and management actions sufficiently account for the range of potential climate futures. The effects of climate change will intensify the impacts of water stress on GDEs, making available shallow groundwater resources especially critical to their survival. Condon et al. (2020) shows that GDEs are more likely to succumb to water stress and rely more on groundwater during times of drought. When shallow groundwater is unavailable, riparian forests can die off and key life processes (e.g., migration and spawning) for aquatic organisms, such as steelhead, can be impeded. **The integration of climate change into the projected water budget is insufficient**. The GSP incorporates climate change into the projected water budget using DWR change factors for 2030 and 2070. However, the plan does not consider multiple climate scenarios (e.g., the 2070 extremely wet and extremely dry climate scenarios) in the projected water budget**. The GSP should clearly and transparently incorporate the extremely wet and dry scenarios provided by DWR into projected water budgets or select more appropriate extreme scenarios for the basin**. While these extreme scenarios may have a lower likelihood of occurring, their consequences could be significant and their inclusion can help identify important vulnerabilities in the basin's approach to groundwater management. The GSP includes climate change into key inputs (e.g., precipitation, evapotranspiration, and surface water flow) of the projected water budget, and calculates a sustainable yield based on the projected water budget with climate change incorporated. However, **if the water budgets are incomplete, including the omission of extremely wet and dry scenarios, then there is increased uncertainty in virtually every subsequent calculation used to plan for projects, derive measurable objectives, and set minimum thresholds**. Plans that do not adequately include climate change projections may underestimate future impacts on vulnerable beneficial users of groundwater such as ecosystems, DACs, and domestic well owners. **Recommendations:** • Integrate climate change, including extremely wet and dry scenarios, into all elements of the projected water budget to form the basis for development of sustainable management criteria and projects and management actions. • Incorporate climate change scenarios into projects and management actions.	As discussed in Section 9.4 Projected Water Budget, the "late future extreme" 2070 drier with extreme warming and wetter with moderate warming climate change scenarios were considered during the White Wolf GSA June 2021 Board of Directors meeting. Due to the uncertainty surrounding projected climate change conditions, only the central tendencies are presented herein. The Board meeting agenda, package, and technical presentation can be accessed here http://whitewolfgsa.org/meetings/. The regulations state for Projects and Management Actions "*If overdraft conditions are identified through the analysis required by Section 354.18 [Water Budget], the Plan shall describe projects or management actions, including a quantification of demand reduction or other methods, for the mitigation of overdraft.*"§ 354.44. The GSP regulations do not specifically require an assessment of PMAs under climate change, but rather require GSAs to describe how they will trigger implementation of PMAs should climatic conditions materialize that require an adaptive response by the GSAs.	Please see response to this comment at left. No revision to the GSP is proposed.

ID (#)	Date Received	Commenter / Organization	Chapter / Section Title	Provided Comment	Response to Comment	Revision to the Groundwater Sustainability Plan (GSP)
18	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists	Monitoring Nework	**The consideration of beneficial users when establishing monitoring networks is insufficient, due to lack of specific plans to increase the Representative Monitoring Wells** (RMWs) in the monitoring network that represent water quality conditions and shallow groundwater elevations around DACs and domestic wells in the basin. Figure MN-1 (SGMA Monitoring Network for Chronic Lowering of Groundwater Levels) shows insufficient representation of DACs for groundwater elevation monitoring. Figure MN-2 (SGMA Monitoring Network for Degraded Water Quality) shows insufficient representation of DACs and drinking water users for water quality monitoring. Refer to Attachment E for maps of these monitoring sites in relation to key beneficial users of groundwater (note we were only able to prepare groundwater elevation monitoring maps with information from the Draft GSP). **These beneficial users may remain unprotected by the GSP without adequate monitoring and identification of data gaps in the shallow aquifer. The Plan therefore fails to meet SGMA's requirements for the monitoring network**. **Recommendations:** • Provide maps that overlay current and proposed monitoring well locations with the locations of DACs, domestic wells, and GDEs to clearly identify monitored areas. • Increase the number of RMWs in the shallow aquifer across the basin as needed to map ISWs and adequately monitor all groundwater condition indicators across the basin and at appropriate depths for all beneficial users. Prioritize proximity to DACs, domestic wells, GDEs, and ISWs when identifying new RMWs. • Ensure groundwater elevation and water quality RMWs are monitoring groundwater conditions spatially and at the correct depth for all beneficial users - especially DACs, domestic wells, and GDEs. • Describe biological monitoring that can be used to assess the potential for significant and unreasonable impacts to GDEs or ISWs due to groundwater conditions in the basin.	There are three RMW-WLs and one RMW-WQ located in, or less than one mile away from areas with identified DACs, as shown updated Figure MN-1 and Figure MN-2. Note that there are no tribal lands within or in the vicinity of the Basin as described in Section 5.1.3.3 of the GSP. Figure MN-4 shows the proposed monitoring well (RMW-ISWs) locations with GDEs of interest. As stated in Section 17.4 Assessment and Improvement of Monitoring Network, in most cases, the existing sites selected for each Sustainability Indicator conform to the BMPs for monitoring networks outlined in DWR's BMP#2 (DWR, 2016d). The current monitoring networks are therefore considered to sufficiently represent DACs, domestic wells, and GDEs. However, the Basin SGMA Monitoring Network will be reevaluated in each five-year GSP update, including a determination of uncertainty and whether there are additional data gaps that could affect the ability of the Plan to achieve the Sustainability Goal for the Basin. As described in Appendix I GDE Pulse Interactive Map Analysis, an analysis on the NDVI and NDMI trends for selected GDEs were performed to evaluate GDE health. Future depth to water data collected from the newly installed shallow monitoring wells and the supplemental interconnected surface waters monitoring network will improve future correlation analyses between depth to groundwater and vegetative metrics. Such analysis will be performed at regular intervals (i.e., for 5-year updates) in the future.	Please see response to this comment to the left. DAC boundaries are added to Figure MN-1 and Figure MN-2 of the GSP.

ID (#)	Date Received	Commenter / Organization	Chapter / Section Title	Provided Comment	Response to Comment	Revision to the Groundwater Sustainability Plan (GSP)
19	11/04/2021	Audubon California, Clean Water Action, Clean Water Fund, Local Government Commission, The Nature Conservancy, and Union of Concerned Scientists		**The consideration of beneficial users when developing projects and management actions is insufficient, due to the failure to completely identify benefits or impacts of identified projects and management actions, including water quality impacts, to key beneficial users of groundwater such as GDEs, aquatic habitats, surface water users, DACs, and drinking water users.** Therefore, potential project and management actions may not protect these beneficial users. Groundwater sustainability under SGMA is defined not just by sustainable yield, but by the avoidance of undesirable results for all beneficial users. While Section 18.2.1.3 documents several projects to expand in-lieu recharge, the GSP fails to describe the projects' explicit benefits or impacts to beneficial users, including the environment and DACs. **The plan also fails to include a domestic well mitigation program to avoid significant and unreasonable loss of drinking water.** We strongly recommend inclusion of a drinking water well impact mitigation program to proactively monitor and protect drinking water wells through GSP implementation. **Recommendations:** • For DACs and domestic well owners, include a drinking water well impact mitigation program to proactively monitor and protect drinking water wells through GSP implementation. Refer to Attachment B for specific recommendations on how to implement a drinking water well mitigation program. • For DACs and domestic well owners, include a discussion of whether potential impacts to water quality from projects and management actions could occur and how the GSA plans to mitigate such impacts. • Recharge ponds, reservoirs, and facilities for managed aquifer recharge can be designed as multiple-benefit projects to include elements that act functionally as wetlands and provide a benefit for wildlife and aquatic species. For further guidance on how to integrate multi-benefit recharge projects into your GSP, refer to the "Multi-Benefit Recharge Project Methodology Guidance Document." • Develop management actions that incorporate climate and water delivery uncertainties to address future water demand and prevent future undesirable results.	The Sustainability Goal is described in Section 2 of the GSP and identifies the beneficial users and uses of groundwater as "*urban, domestic, agricultural, industrial, environmental and others.*" The PMAs were selected to achieve the sustainability goal, and to avoid Undesirable Results. The quantitative criteria for determining Undesirable Results are the exceedance of MTs established for the Basin. As described in Section 19.1.8 Enforcement and Response Actions, although a well impact analysis shows that no full well dewatering is likely to occur (see Section 14.1.2 - Well Impact Analysis), to address this potential occurrence, one or more of the White Wolf GSA-member districts will develop an Impacted Well Mitigation Program whereby a potential remedy will be provided to owners of wells that are demonstrably unreasonably impacted by groundwater conditions, as defined within the policy. The program will be developed in coordination with and in consideration of the interests of local stakeholders within the Basin. Section 8.5.3 - Water Quality Trend reports that the limited spatial extent and frequency of available data complicate the application of statistical results to basin-wide conditions, and do not clearly illustrate the potential nexus between water quality, a GSA's groundwater management actions, and possible future changes owing to GSP implementation (for example, changes in well extractions, groundwater elevations, and storage). As discussed in Section 17 - Monitoring Network, future monitoring efforts will include routine collection of water level and quality data. Those data and any associated trends will be evaluated in future reporting and GSP updates. Section 18.2 - List of Projects and Management Actions discussed expected benefits for each P/MA. Climate change and water delivery uncertainty are incorporated in the assumptions of water availability when these benefits are calculated. Moreover, recharge projects described in Section 18.2 are designed to seek to incorporate multiple benefits to the extent practical and feasible.	Please see response to this comment to the left. No revision to the GSP is proposed.

Appendix D

Shallow Water-Bearing Zone Upgradient to the Springs Fault Connectivity to the Principal Aquifer – Preliminary Monitoring Results

26 January 2022

TECHNICAL MEMORANDUM

To: White Wolf Groundwater Sustainability Agency (GSA)

From: Anona Dutton, PG, CHg, EKI Environment & Water, Inc. (EKI)
Christina Lucero, PG, EKI
Jeff Shaw, PG, CHg, EKI

Subject: Shallow Water-Bearing Zone Upgradient to the Springs Fault Connectivity to the Principal Aquifer – Preliminary Monitoring Results
(EKI B50001.06)

During Groundwater Sustainability Plan (GSP) development, the White Wolf Groundwater Sustainability Agency (GSA) identified a data gap regarding the hydrogeological conceptual model and groundwater conditions in the southeastern portion of the White Wolf Subbasin (Basin). To fill this data gap, the White Wolf GSA obtained Proposition 68 Grant funding through the California Department of Water Resources (DWR) to install groundwater monitoring infrastructure and conduct a field study. In 2021, on behalf of the White Wolf GSA, EKI began conducting a field study and groundwater conditions assessment. This technical memorandum (TM) describes the work performed to date, the results of which are incorporated into the 2022 GSP. On-going efforts will support subsequent GSP updates and annual reporting, as applicable.

1. INTRODUCTION

The Basin encompasses approximately 107,500 acres in the southernmost region of the San Joaquin Valley Groundwater Basin within Kern County, California. The Basin is a structural trough filled with continental and shallow marine sedimentary deposits and bounded by three mountain ranges to the south, east, and west. The Basin includes four potentially water-bearing units: (1) Quaternary/Recent fan, terrace, and alluvial deposits (referred to herein as the Shallow Alluvium), (2) the Kern River Formation, (3) the Chanac Formation, and (4) the Santa Margarita Formation (Wood and Dale, 1964; Arvin-Edison Water Storage District, 2003; Wheeler Ridge-Maricopa Water Storage District [WRMWSD], 2007). However, except near the fringes of the Basin, the Santa Margarita is typically below the depth of active production wells. Moreover, it is a known oil producing formation. As such, The Shallow Alluvium, Kern River Formation, and Chanac Formation have been defined as the Principal Aquifer for the purposes of the GSP.

The Basin is located in a tectonically active region and contains both high-angle and oblique-slip faults and surrounding thrust faults. The White Wolf Fault (WWF) system forms the northern Basin boundary. The Springs Fault is a southeastern-dipping high angle fault with evidence of oblique movement that displaces impermeable strata, resulting in an interior subdivision of the Basin by creating a partial hydraulic barrier to flow in the southeastern corner of the Basin (Bookman-Edmonston, 1995; Goodman and Malin, 1992). At the surface, the Springs Fault has a visible escarpment and clusters of artesian springs are present on the south side of the mapped fault zone (Goodman and Malin, 1992). Similarly, clusters of groundwater dependent ecosystems (GDEs) have been mapped in the shallow alluvium located south of the Springs Fault (Geosystems Analysis, Inc., 2020).

The surficial geology in this area is comprised of Pleistocene age older alluvium underlying terraces along modern streams and older alluvial fans, which are typically composed of sand, gravel, silt, and clay (Bartow, 1984). Due to the visible presence of groundwater at the surface, past studies have identified the Springs Fault as forming a barrier to groundwater flow (Anderson et al. 1979) and have conceptually sub-divided the Basin into the White Wolf and Springs basins (Bookman-Edmonston, 1995). However, to date, very little measured groundwater level data has been available to verify and quantify a hydraulic separation between shallow groundwater located south (upgradient) of the Springs Fault and groundwater located in the Principal Aquifer to the north.

During 2021, extensive field work, data collection, and data analysis occurred in order to quantify the effects of Principal Aquifer pumping on groundwater levels located upgradient to the Springs Fault. Work efforts included: (1) installation of three new shallow monitoring wells on the upgradient side of the Springs Fault near mapped GDE units, (2) monitoring of groundwater levels in the three new wells during the irrigation season, (3) comparison of timing of pumping in production wells to quantify if the shallow monitoring wells display water level response to either Principal Aquifer well pumping, and (4) collection of general water quality and stable isotopes sample to assess water quality and whether there is a significant difference in source water in the shallow water-bearing zone that is supporting GDEs.

2. DATA COLLECTION

2.1. Shallow Monitoring Well Installations

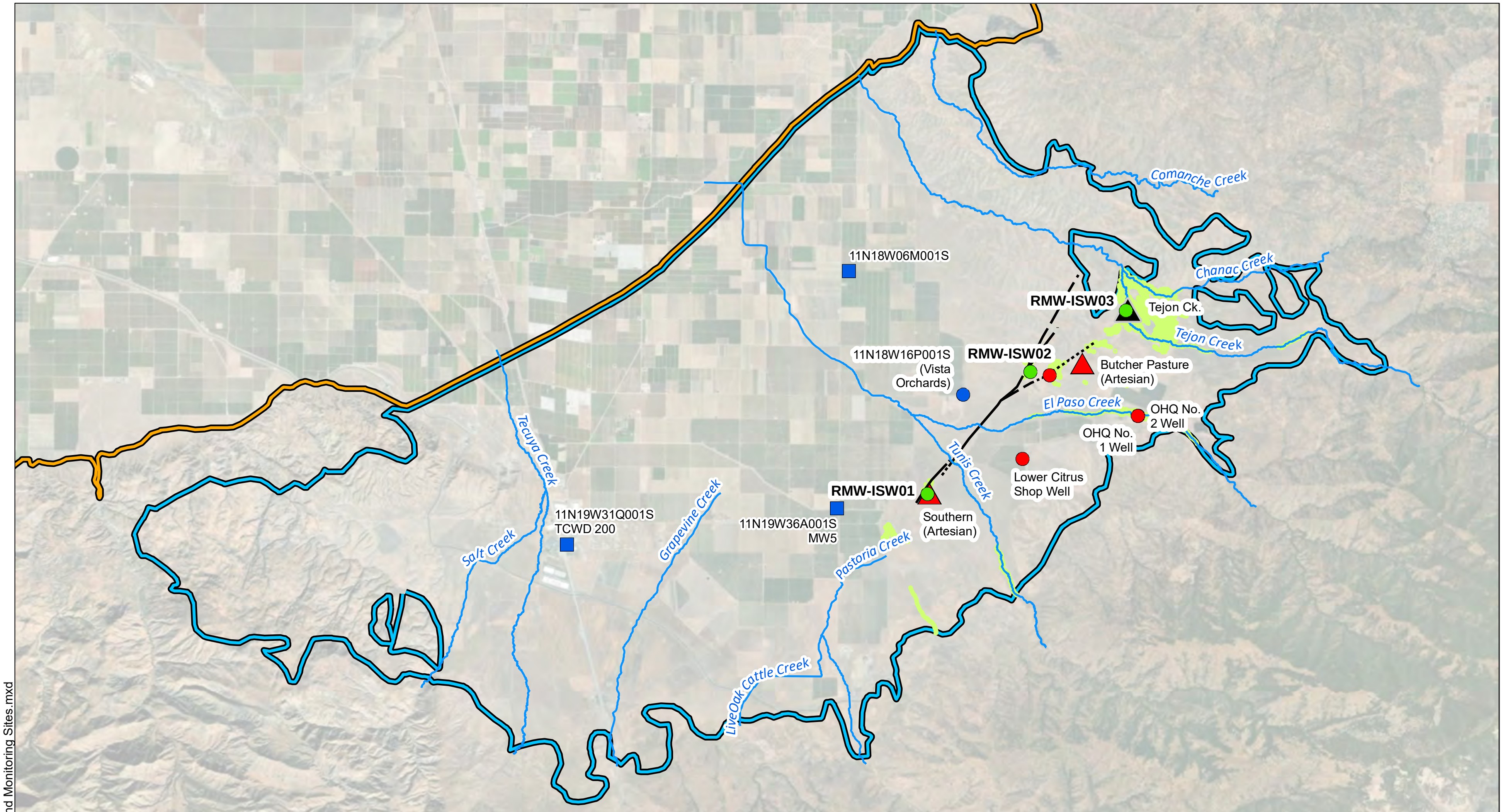
In January 2021, three shallow monitoring wells were installed along the upgradient side of the Springs Fault in the vicinity of mapped GDEs (**Figure 1**). Monitoring well RMW-ISW01 is located at the southern end of the Springs Fault, approximately 370 ft south-southeast of a mapped GDE unit and 210 ft west of a flowing artesian well. The mapped GDE unit is mostly comprised of willow and cottonwood, whose rooting depths are typically very shallow, estimated to average about five feet below ground surface (ft bgs) or less, with a maximum depth of approximately 12 to 14 ft bgs[1]. The flowing artesian well is anecdotally understood to be an old cased oil exploration borehole whose depth is at least 200 ft bgs[2].

Monitoring well RMW-ISW02 is located along the middle of the Springs Fault trace, approximately 350 ft south of a mapped GDE unit. The mapped GDE unit is mostly comprised of nettle, canyon grape, and willow, whose rooting depths are typically shallow, estimated to average approximately five feet with a maximum of approximately 14 ft bgs or less[3].

Monitoring well RMW-ISW03 is the northernmost well, located near Tejon Creek and its convergence through the bedrock outcrop. Mapped GDE units are located approximately 150 ft east of RMW-ISW03 are mostly comprised of Valley Oak, cottonwood, and seep willow whose rooting depths are typically deeper than those observed at the other two well sites, estimated at approximately 24 ft bgs.[4]

---

[1] The Nature Conservancy Plant Rooting Depth Database (https://groundwaterresourcehub.org/sgma-tools/gde-rooting-depths-database-for-gdes/); accessed 21 November 2019.
[2] Personal communication, Efren Munoz, Tejon Ranch Company.
[3] Ibid [1].
[4] Ibid [1].



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

Springs Fault

Certain

Approximately Located

Concealed

GDEs of Interest

Stream

Shallow Monitoring Well

Spring Observation Point (artesian)

TRC Domestic/Stock Watering Well

Pumping Test Well

Principal Aquifer Well

Creek Sample Location

Abbreviations

GDE = Groundwater Dependent Ecosystem

OHQ = Old Headquarters

Notes

1. All locations are approximate.
2. GDEs of interest for the purpose of the White Wolf Groundwater Sustainability Plan are those categorized as sites appearing to be supported by the shallow water bearing zone upgradient of the Springs Fault ("B") or the Regional Aquifer ("R").

Sources

1. Springs Fault trace from Bartow (1984).

N

0 3 6

(Scale in Miles)

Location of Shallow Monitoring Wells and Other Monitoring Sites

White Wolf GSA
Kern County, California
September 2021
B50001.06

eki environment & water

Figure 1

Path: X:\B50001.05\Maps\2021\09\AppD_Fig1_Wells and Monitoring Sites.mxd

In October 2020, ABC Liovin Drilling obtained well construction permits from the Kern County Environmental Health Division. Copies of the signed well permits are included in **Attachment 1**. Between 12 January 2021 and 14 January 2021, ABC Liovin Drilling drilled and installed the shallow monitoring wells using a hollow stem auger drilling rig under the direct supervision of an EKI hydrogeologist licensed as a California Professional Geologist (PG) and Certified Hydrogeologist (CHg). The EKI hydrogeologist supervised all drilling activities and logged the drill cuttings. The DWR Well Completion Reports documenting the borehole lithology and well construction are included in **Attachment 2**.

The monitoring wells were constructed consistent with the Kern County standards and DWR standards outlined in DWR Bulletin 74-90. The monitoring wells were designed and constructed to monitor shallow groundwater conditions in the upper-most water bearing alluvium. As such, the boreholes were drilled to a total depth of 50 ft bgs. Wells were completed using new 4-inch diameter Schedule 40 PVC well casing. Each well was constructed with a 30 ft screened interval of 0.020-inch machine slotted casing (i.e., screened interval of 20 to 50 ft bgs), and was plugged at the base with a flush threaded PVC end cap.

A continuous filter pack of #2/12 Monterey sand was emplaced around the screens and extended to 17 ft bgs. A two-ft transition seal of medium bentonite chips was placed above the sandpack and hydrated in place with potable water. Grout was emplaced above the top of the transition seal (i.e., from 15 ft bgs to the surface). Grout was mixed in a drum at the ratio 28 gallons of potable water to six bags Portland Type I/II/V cement and either tremie-grouted using a 1” hose (for well RMW-ISW03 only) or slowly poured until visible at surface. Surface completions are above-ground locking stovepipes with four surrounding concrete-filled bollards.

Between 18 January 2021 and 19 January 2021, ABC Liovin Drilling developed the new monitoring wells under the direct supervision of an EKI hydrogeologist licensed as a California PG and CHg. Development entailed using a 3-inch diameter stainless-steel bailer to remove residual sediment from the bottom of the well casing. After bailing, a five-inch long surge block was surged within the well to force groundwater through the sandpack along the entire length of the well screen. The wells were then pumped using a submersible pump; temperature, pH, electrical conductivity, and turbidity were measured from the discharged water using Myron L 6PFCE and HF Scientific DRT-15CE water quality meters. Pumping continued until either the water quality parameters stabilized, turbidity substantially cleared, or until the casing was fully dewatered. Well development logs are included in **Attachment 3**.

2.2. High-Frequency Water Level Measurements

Newly installed shallow monitoring wells RMW-ISW01, RMW-ISW02, and RMW-ISW03 were instrumented with Bluetooth-enabled submersible data-logging pressure transducers (Onset model MX2001-02-SS) on 30 March 2021. Transducers were programmed to record the height of the water column above the transducer in feet and the water temperature at six-hour intervals. During instrumentation deployment and subsequent data downloads, manual depth to water readings were collected using an electric water level sounder while manual readings from the transducer were recorded to facilitate conversion of the transducer reading to a depth to groundwater in ft bgs.

Additionally, a transducer was deployed in a monitoring well located north of the Springs Fault that is screened in the Principal Aquifer (**Figure 1**). Well 11N19W36A001 is a WRMWSD dedicated monitoring well (MW-5) which has been integrated into the White Wolf GSA’s Sustainable Groundwater Management Act (SGMA) Monitoring Networks for Chronic Lowering of Groundwater Levels and Land Subsidence. The well is located approximately 700 ft north of the Springs Fault and screened between 960 and 1,000 ft bgs, exclusively in the Chanac formation. Well 11N19W36A001 was temporarily instrumented with an Onset model U20 HOBO pressure transducer on 4 August 2021 and an associated datalogging barometric pressure transducer was installed on 17 August 2021.

2.3. Pumping and Temperature Data Logging

In order to monitor typical pumping from the Principal Aquifer, the closest production well located on the north side of the Springs Fault (11N18W16P001S or the "Vista Orchards well") was chosen for monitoring over the irrigation season (**Figure 1**). On 31 March 2021, EKI attempted to connect with and program high frequency pumping data logging from the existing McCrometer flowmeter. However, upon connecting in June while the pump was running, and subsequent correspondence with McCrometer, the flowmeter was deemed faulty and therefore did not and will not be able to record pumping flow data. In lieu of direct pumping flow data, temperature loggers were installed at the well, one on the discharge pipe and one to monitor ambient air temperature, to be used as an indirect measure of pumping timing and duration using methodology described by Massuel et al. (2009) and Botha (2017). A description of this methodology can be found in Section 4.1.1. Additionally, power consumption (PG&E) records were obtained from the landowner for the meter attached to the Vista Orchards well for 26 May 2021 through 26 July 2021.

There are four wells providing de minimus water for domestic and stock watering located in the vicinity of the RMW-ISWs (**Figure 1**). In order to isolate any pumping impacts from these wells from the impacts that may be occurring as a result of pumping from these wells, temperature data loggers were installed on four wells (Old Headquarters 1, Old Headquarters 2, Vaquero, and Citrus Shop) on 4 August 2021. Two temperature data loggers were installed at each site, one on a discharge pipe and one to monitor ambient air temperature. Data loggers were programed to collect temperature at 10-minute intervals.

2.4. Water Quality Sampling

EKI conducted groundwater sampling at select wells, artesian springs, and Tejon Creek (**Figure 1**). The three newly installed shallow monitoring wells were sampled on 31 March 2021 through 1 April 2021 for general water quality (i.e., major cations and anions, total dissolved solids [TDS], and alkalinity), selected potential Basin constituents of concern (i.e., arsenic, selenium, and 1,2,3-trichlororpopane [1,2,3-TCP]), and stable isotopes (oxygen-18 and deuterium). For the shallow monitoring wells, a submersible pump (Prosonic Mini Monsoon) with disposable tubing was used to purge and sample each well. The low-flow sampling technique was used in which the purge rate was adjusted to minimize drawdown in the well (Puls and Barcelona, 1996). During purging, a Horiba U-5000 water quality meter was used to measure temperature, pH, electrical conductivity, dissolved oxygen, oxidation-reduction potential, and turbidity. Parameters were recorded approximately every five minutes; once all parameters stabilized within approximately 10% of the prior reading (or in general accordance with published guidance[5]), samples were collected. Selected samples for dissolved-metals analysis were field filtered into laboratory-supplied bottles preserved with nitric acid. After sample collection, the sample bottles were labeled and stored in

[5] U.S. Geological Survey Techniques of Water Resources Investigations, Guidelines for field-measured water-quality properties. (https://pubs.usgs.gov/twri/twri9a6/twri9a6_Chapter6.0v2.pdf).

an ice chest for transport to the laboratory under standard chain-of-custody protocols. Well purging and sampling logs are included in **Attachment 4**.

Other nearly pumping wells, artesian springs, and Tejon Creek were sampled on 30 June 2021 through 1 July 2021 for stable isotopes. Depending on the site, samples were collected by either (1) collecting a sample at a sample port on the discharge pipe from a pumping well, (2) filling bottles from the discharge point of an artesian well, or (3) filling bottles from a flowing surface water body while making effort to collect water with minimal creek bottom sediment. After sample collection, the sample bottles were labeled and stored for transport to the laboratory under standard chain-of-custody protocols.

BC Laboratories, of Bakersfield, California analyzed the samples for general water quality and Isotech Labs of Champaign, Illinois analyzed the samples for stable isotopes. Laboratory reports and chain-of-custody records are included as **Attachment 5**.

3. DATA ANALYSIS

3.1. Water Level Analysis

The water level time-series data from the RMW-ISWs were qualitatively reviewed to assess general water level trends and the impacts of diurnal and potential nearby pumping well interference on measured water levels. This discussion provides an analysis of data measured between 30 March 2021 and 2 August 2021.

Figure 2 compares the measured depth to water for RMW-ISW01, RMW-ISW02, and RMW-ISW03. Depth to water averaged 16.9, 14.0, and 31.4 ft bgs for wells RMW-ISW01, RMW-ISW02, and RMW-ISW03, respectively, for the March to August period. For all RMW-ISWs, the shallowest depth to water was observed sometime during the month of April and the deepest depth to water was observed in September or October.

As shown in **Figure 3**, groundwater levels in all wells declined from April through September (RMW-ISW01) or October (RMW-ISW02 and RMW-ISW03), recovering partially afterward through the end of the data period in December. Maximum declines were approximately 1.3 ft in RMW-ISW01, 1.8 ft in RMW-ISW02, and 3.4 ft in RMW-ISW03. The roughly sinusoidal pattern observed appears to reflect broad changes in water levels driven by seasonal changes in precipitation and infiltration. All RMW-ISW wells also displayed diurnal patterns, suggesting that temperature and evapotranspiration influenced the daily fluctuations of depth to water in these shallow wells.

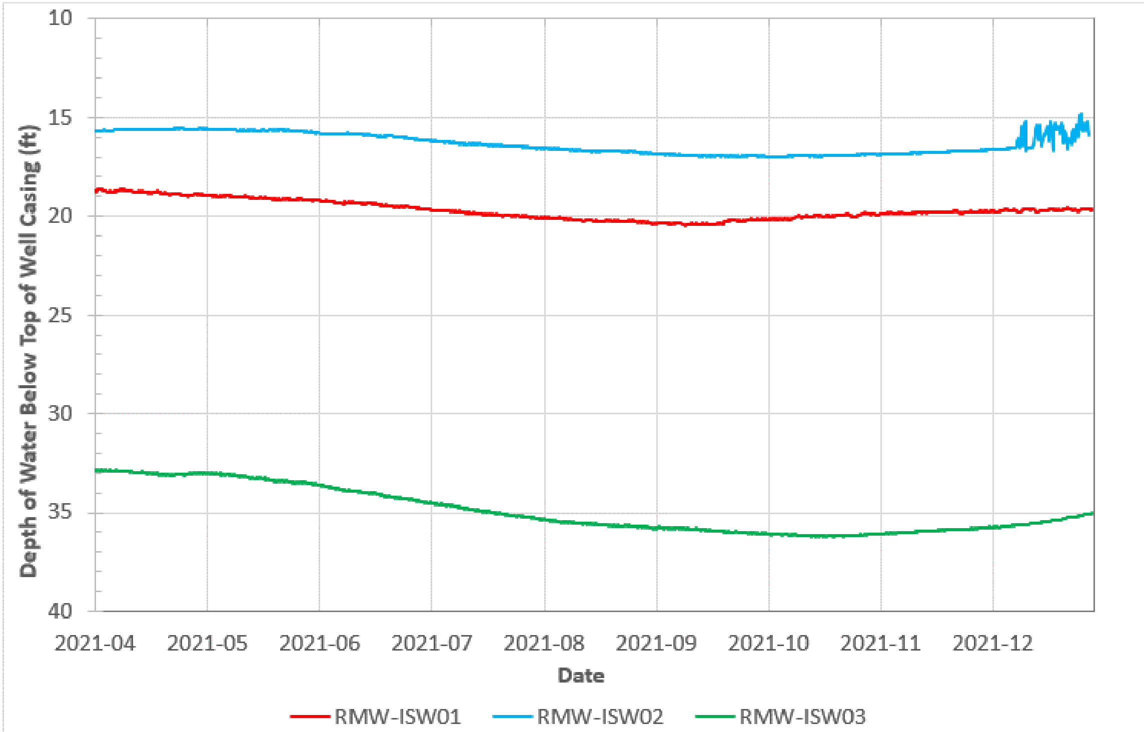


Figure 2. Measured Depth to Groundwater in RMW-ISWs (April – December 2021)

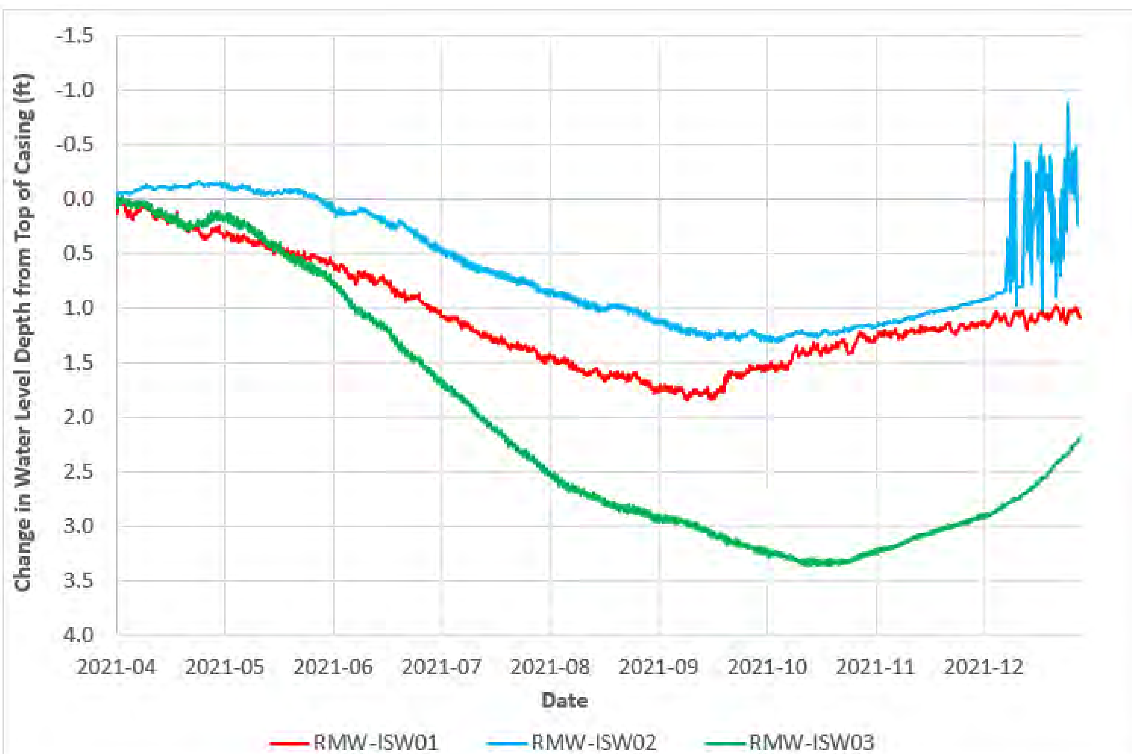


Figure 3. Change in Measured Depth to Groundwater in RMW-ISWs (April – August 2021)

Figure 4 shows that the mean water temperature recorded in RMW-ISW03 was notably lower than RMW-ISW01 and RMW-ISW02, with a mean difference of -2.3 degrees Fahrenheit (°F). RMW-ISW03 is located approximately 150 feet from Tejon Creek. The other two wells both are located to the southwest, immediately adjacent to the Springs Fault trace. During well installation, boulders were encountered at RMW-ISW03, suggesting that RMW-ISW03 is located within alluvial fan deposits noticeably coarser grained than those encountered at the RMW-ISW01 and RMW-ISW02 sites. RMW-ISW03 is located some distance away from the mapped Springs Fault trace, and typically is surrounded by GDEs with deeper rooting depths (e.g., Valley Oaks). The lower water temperature and the deeper depth to groundwater suggests that Tejon Creek may be a losing stream in the reach near RMW-ISW03.

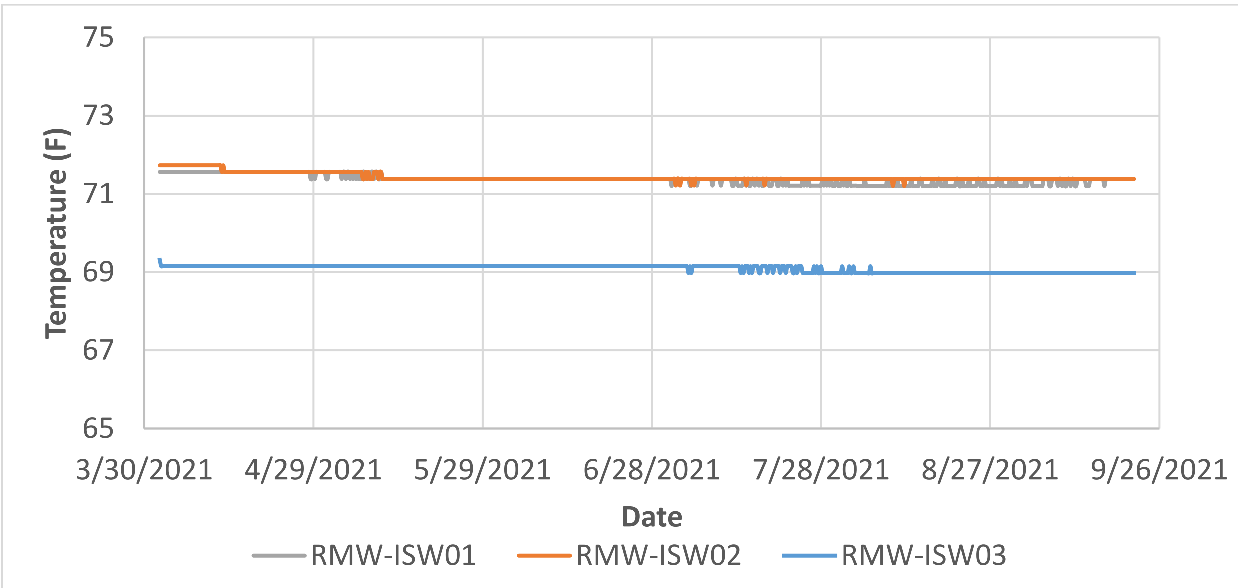


Figure 4. Measured Groundwater Temperature in RMW-ISWs (April – August 2021)

3.1.1. Potential Influence from Pumping Wells

Active large-flow pumping at the Vista Orchards well was qualitatively observed on 31 March 2021, 30 June 2021, and 1 July 2021. An examination of the daily kilowatt-hour electric usage of the Vista Orchards well shows that the well was pumping almost constantly between 26 May and 24 September 2021. This qualitative measurement of pumping when compared to RMW-ISW pressure transducer water level data allows an assessment of the effects of pumping on the north side of the WWF on groundwater levels south of the WWF. **Figure 5** (below) shows gradual, seasonal water level changes of approximately one foot in all three RMW-ISW wells, despite long-term pumping in the Vista Orchards agricultural supply well. The declining heads in the RMW-ISW wells are roughly contemporaneous to the pumping period of the supply well, but the water level time-series does not have the characteristic shape of a drawdown curve, and the same climatic factors drive both the slight decline in the monitoring wells and the pumping schedule in the supply well. Statistical analysis of pumping at the Vista Orchards well indicates that it does not appear to affect RMW-ISW groundwater levels (i.e., no correlation was observed between pumping in supply wells north of the Springs Fault and groundwater levels in shallow monitoring wells south of the fault). This lack of correlation indicates that groundwater levels fluctuate independently north and south of the Springs Fault (i.e., that the shallow aquifer zone that supports GDEs is hydraulically isolated from the

Principal Aquifer). The correlation coefficients calculated between the power consumption at the Vista Orchards well and the groundwater levels at RMW-ISW01, RMW-ISW02, and RMW-ISW03 suggest no statistical correlation between pumping and groundwater levels.[6]

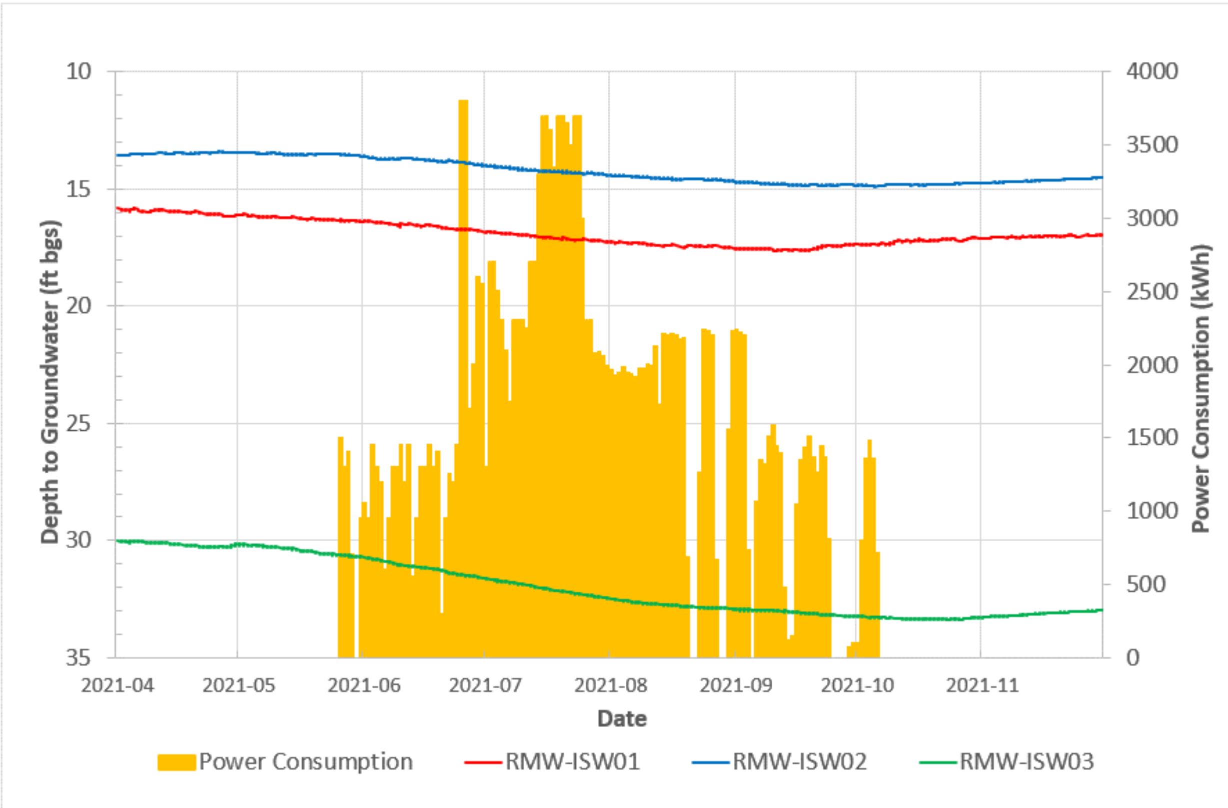


Figure 5. Vista Orchards Supply Well Power Consumption and RMW-ISW Wells Measured Depth to Groundwater (April - December 2021)

Temperature logger data can be used to indirectly determine when groundwater has been pumped using several published methods. The "Temperature Gradient Analysis" method infers periods of groundwater pumping by comparing sequential discharge pipe temperature differences to a pre-determined threshold (Massuel et al., 2009; Botha, 2017). This method calculates the absolute difference in temperatures over a time step, Δt. If the difference in sequential temperatures is greater than the pre-determined threshold (e.g., 1.08°F/Δt; Botha, 2017), groundwater is inferred to have recently started or stopped flowing through the pipe during the time step.

[6] Correlation coefficients between the time series data of daily kilowatt-hour usage at the Vista Orchards well and six-hour groundwater level monitoring at RMW-ISW01, RMW-ISW02, and RMW-ISW03 were calculated as 0.16, 0.11, 0.14 between 26 May 2021 and 25 June 2021 and 0.32, 0.26, and 0.31 between 26 June 2021 and 25 August 2021, respectively.

This method was applied for the four domestic and stock watering wells on which temperature loggers were installed (see Section 3.3), as well as the Vista Orchards agricultural production well. A snapshot of the current data record are shown on **Figure 6** and **Figure 7**, below. The Vista Orchards temperature loggers showed little to no distinct drops in temperature in the pipe discharge temperatures from the beginning of the temperature data logging record (1 July 2021) through about 1 August 2021 (**Figure 6**). However, pipe discharge temperatures were consistently lower and less variable compared to ambient air temperatures, indicating that the well may have been pumping continuously for the entire time period. Power consumption (PG&E) records from 25 June 2021 through 26 July 2021 showing high energy usage further indicate that the well was likely pumping every day throughout the time period. Ongoing data collection will provide real-time pumping data to compare to the high-frequency water level data for more refined analysis and interpretation. Available temperature data for pumping well discharge pipe and air at several domestic wells and one agricultural supply well are shown in **Attachment 6**.

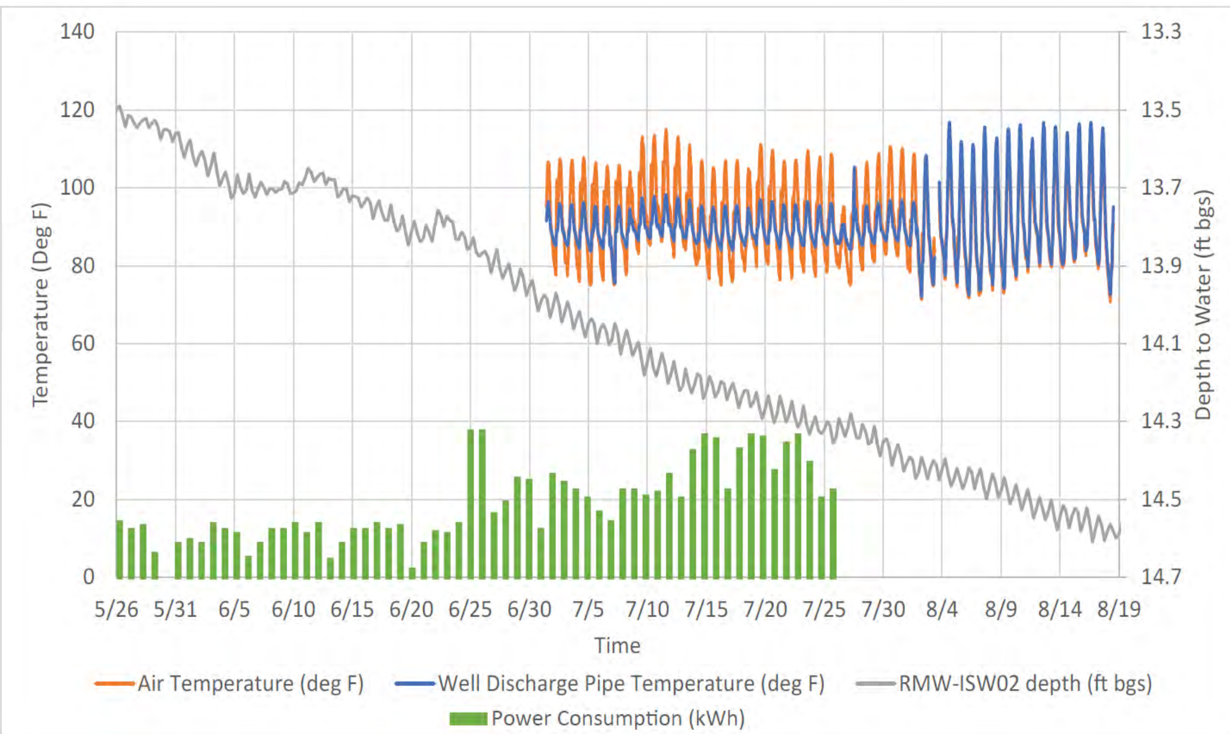


Figure 6. Vista Orchards Well Power Consumption, Temperature Data, and RMW-ISW02 Measured Depth to Groundwater (May – August 2021)

Distinct differences in temperature were observed when assessing the Δt discharge pipe temperature values in all four domestic and stock watering wells at varying times and durations throughout the time series, suggesting potential pumping events. Very preliminary snapshot figures showing three days of temperature data are provided as **Figure 7** below, where a potential pumping event is identified as a value of 1.0 (grey line). However, further analysis will be needed to more accurately determine pumping events using this methodology, including refinement of the Δt threshold for each specific well and field validation to compare observed pumping events with Δt values.

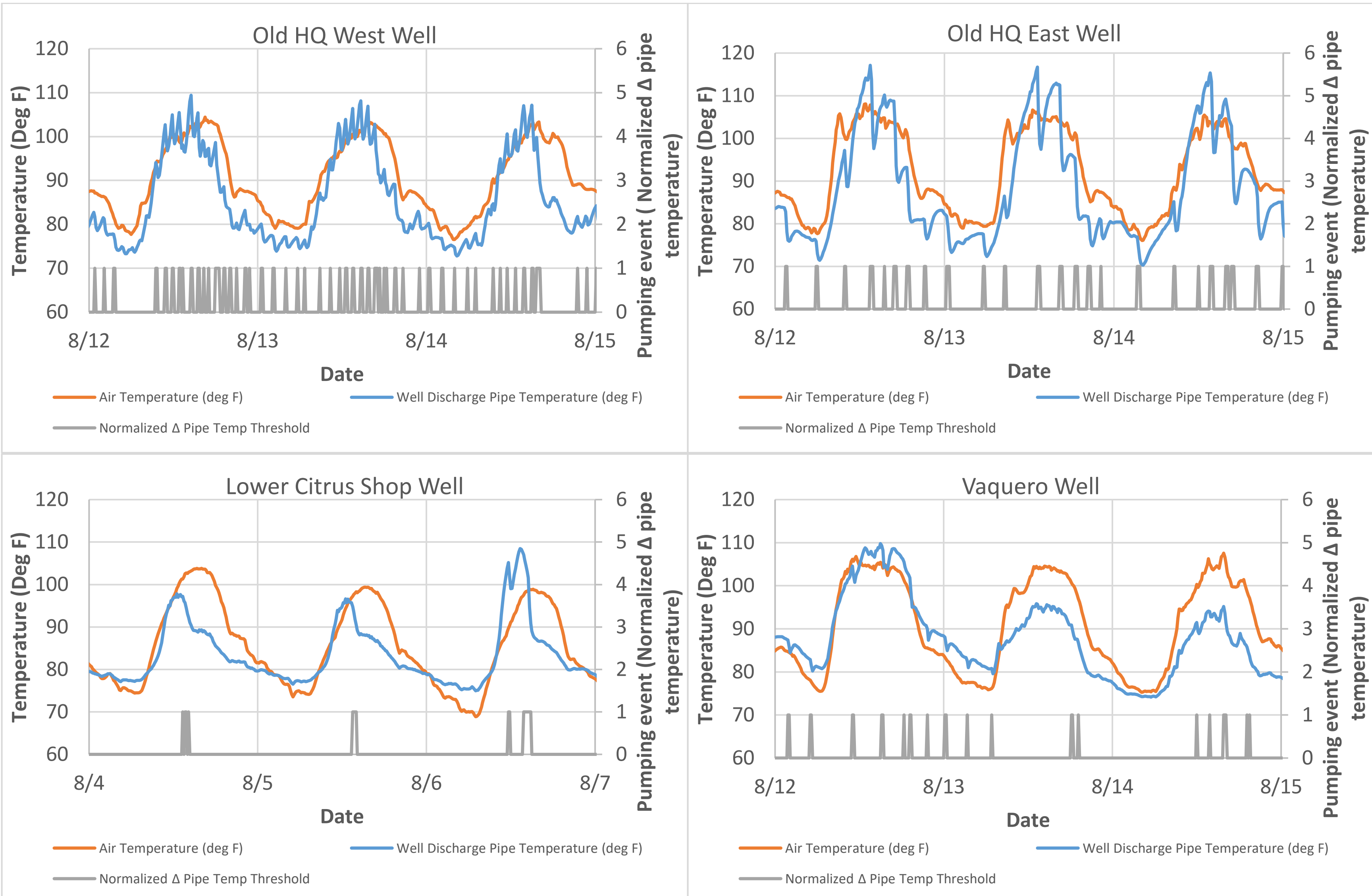


Figure 7. Snapshot Domestic Well Temperature Data

A noticeable limitation of the temperature data logging analysis includes lag times in pipe temperature equilibration (Botha, 2017). The lag time limitation occur since the pipe needs time to change temperature (between ambient air and groundwater temperatures) when pumping starts and stops, which does not occur immediately and depends on time of day, groundwater temperature, and pipe material. This results in a lag time of identified pumping episodes versus actual pumping episodes. For wells that may pump for only a couple of minutes (e.g., small domestic wells), the pipe temperature response and data logging frequency can impact data analysis and therefore prevent the ability to precisely determine the duration of pumping events. A qualitative analysis of the pipe temperature time-series plots can indicate short-duration pumping which does not thermally equilibrate the pipe (often located in direct sunlight) with groundwater, but which does produce a sharp decline in temperature. Use of derivative plots in future datasets along with actual pumping observations for calibration should improve the reliability of this technique in the future.

3.2. Water Quality Analysis

The water quality characteristics of the RMW-ISWs were compared with other wells in the Basin. Specifically, EKI conducted a general water quality analysis and a stable isotope analysis to determine whether there was an obvious difference in source water amongst the RMW-ISWs compared to other Basin wells, artesian wells, and creeks.

3.2.1. General Water Quality Analysis

General water quality types can be inferred from the ionic composition of water samples, plotted on either a Piper Diagram (trilinear diagram) or Stiff Diagram. Both diagrams display the relative proportions of the major cations and anions in water samples. The ionic composition is typically derived from soluble and partially soluble minerals that the groundwater contacts during its flow downgradient.

In a Piper Diagram, the proportions of major anions (chloride, sulfate, bicarbonate and carbonate) and cations (calcium, magnesium, potassium, and sodium) are plotted as points in lower triangles and the data points are projected into the central diamond plotting field along parallel lines (**Figure 8**). The Stiff Diagram plotting technique uses parallel horizontal axes extending on each side of a vertical zero axis (**Figure 9**). Concentrations of major cations (sodium, calcium, and magnesium, in milliequivalents per liter [meq/L]), are plotted sequentially on each axis to the left of zero. Similarly, major anion concentrations (chloride, bicarbonate, and sulfate) are plotted sequentially on each axis to the right of zero. The resulting points are connected to give an irregular polygonal shape or pattern, which can provide a distinctive method of showing water composition differences and similarities. The width of the pattern is proportional to the sample's total ionic content (i.e., TDS).

The Piper Diagram (**Figure 8**) represents the general water quality variability across the Basin. Many of the samples show no predominant cation. However, there is a significant cluster of samples with calcium as the predominant cation. Most samples are in the part of the diagram that indicates bicarbonate is the predominant anion. Therefore, most of the samples fall into the calcium bicarbonate region of the central diamond plotting field. There is no predominant grouping by depth on the Piper Diagram, but the ionic composition in the deeper wells is generally more variable than it is in the shallow wells. The deeper wells tend to have a slightly lower relative concentration of calcium and a higher relative concentration of sodium.

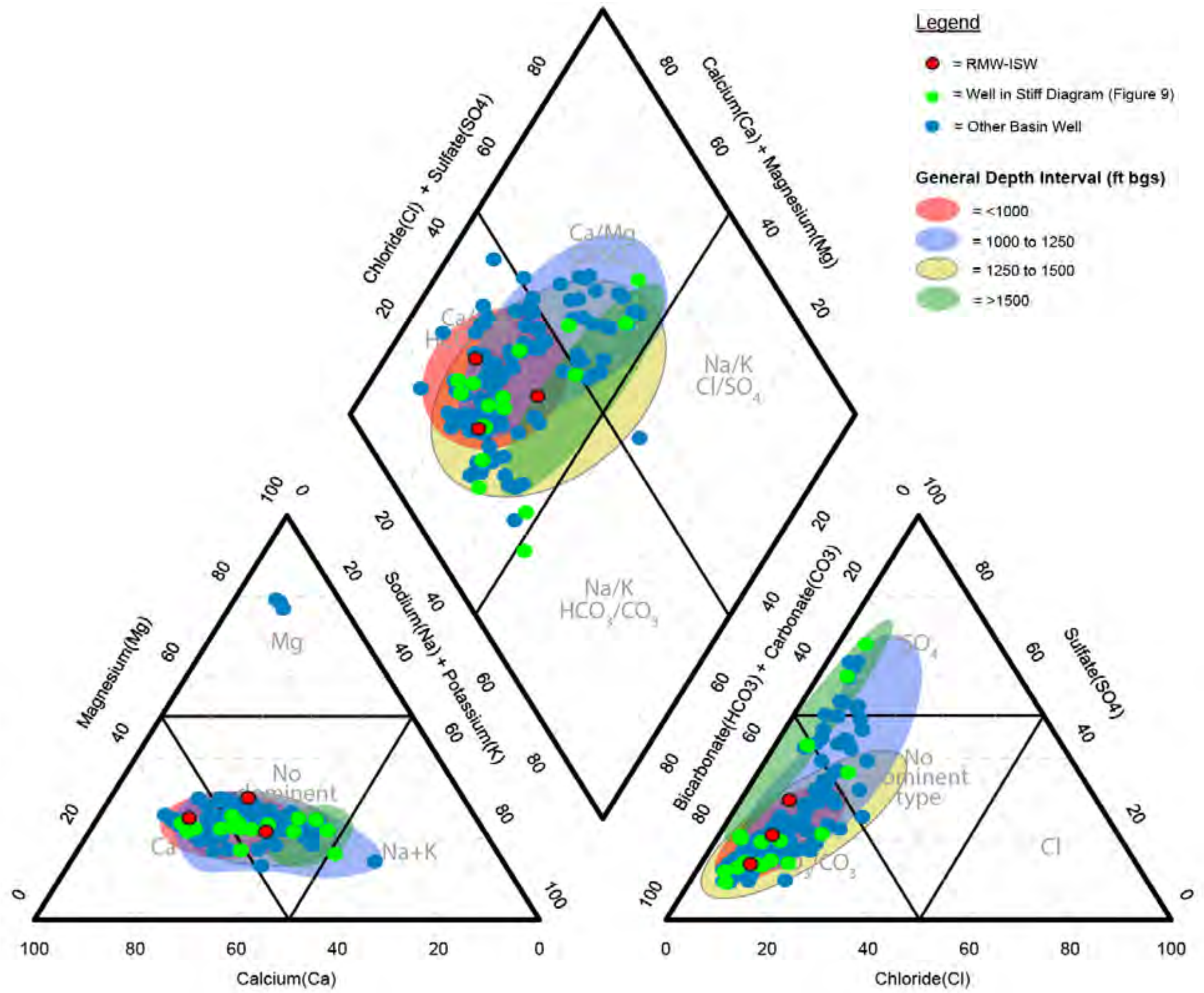
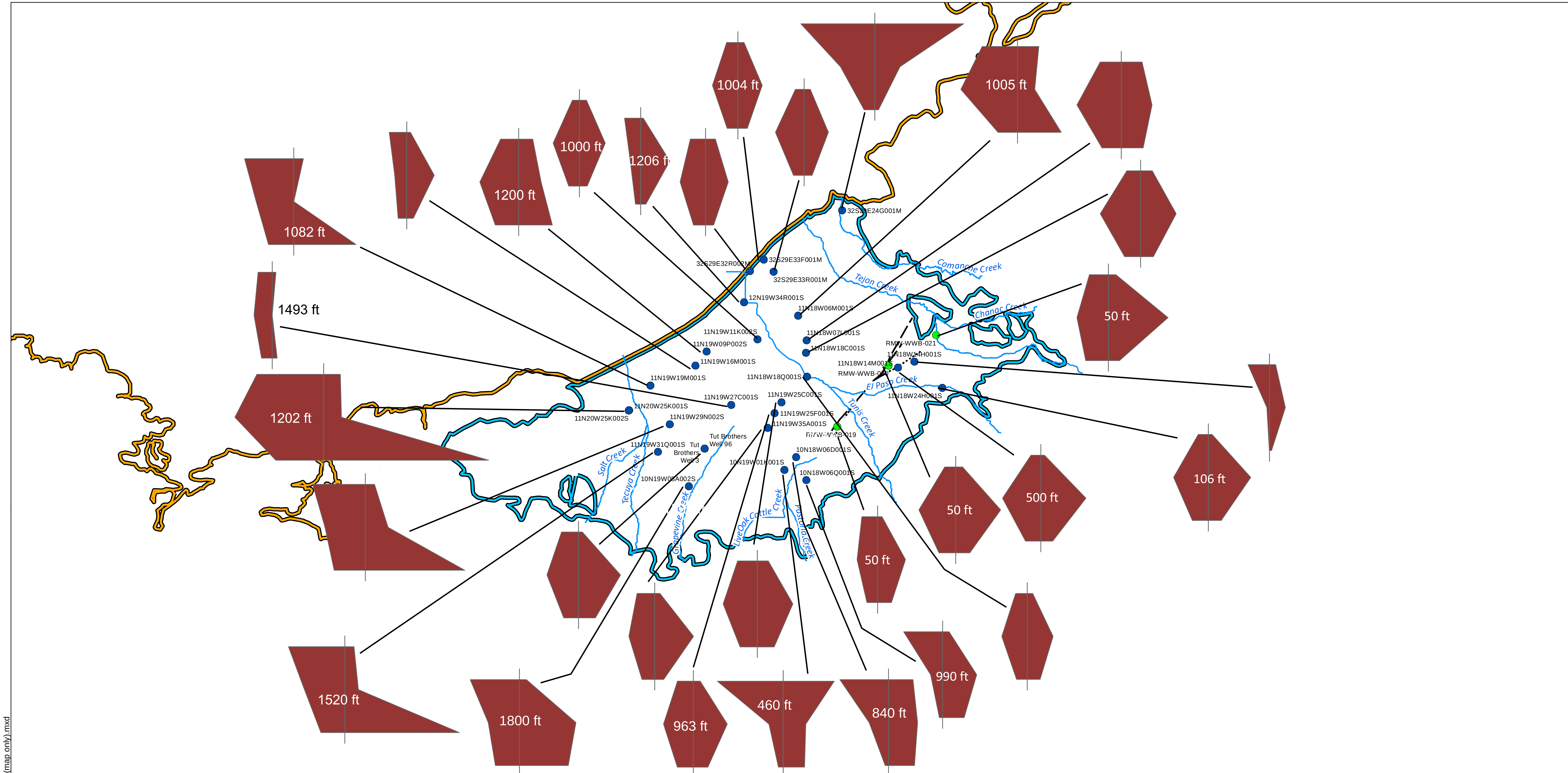


Figure 8. Piper Diagram

The Stiff Diagrams represent a subset of the water quality samples and their shapes are generally consistent with the characteristics represented by the Piper Diagram. Stiff Diagrams plotted on a map (**Figure 9**) provide additional insight into the spatial variability in water quality characteristics. The diagrams show that the composition of water samples from wells within the central portion of the Basin are generally similar in ionic composition and content, with mostly comprised primarily of calcium and bicarbonate. Exceptions occur near the Basin boundaries and surface drainage features. For example, the four western-most samples near Tecuya Creek are relatively high in sulfate ion concentrations. Similarly, in the south and near Live Oak Cattle Creek, and in the northeast near Comanche Creek, the well water samples are relatively high in sodium and chloride ion concentrations. These results suggest that the water quality in these wells is influenced by the dissolution of naturally occurring evaporite minerals that exist in the watersheds that feed these creeks, and introduced to the underlying groundwater with recharge as leakage. This is consistent with past conclusions of increased salinity and TDS concentrations on the western side of the Basin being attributed to recharge from Salt and Tecuya Creeks sourced from upland marine sediments (Anderson et al. 1979). The three RMW-ISW wells near the Springs Fault exhibit a calcium-bicarbonate composition similar to many of the wells in the central portion of the Basin. There are no discernable compositional differences between well depth and spatial location.



Legend

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)

Springs Fault

- Certain
- Approximately Located
- Concealed
- Stream

- RMW-ISW
- Well

Na — Cl
Ca — HCO₃
Mg — SO₄

Abbreviations

Ca	= Calcium	Cl	= Chloride
DWR	= California Department of Water Resources	HCO_3	= Bicarbonate
Mg	= Magnesium	Na	= Sodium
RMW-ISW	= Representative Monitoring Well for Depletions of Interconnected Surface Water	SO_4	= Sulfate

Notes

1. All locations are approximate.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater Bulletin 118 - Final Prioritization, dated February 2019
2. Springs Fault trace from Bartow (1984).

N

0 4 8

(Scale in Miles)

Stiff Diagrams

eki environment & water

White Wolf GSA
Kern County, CA
December 2021
B50001.05

Figure 9

Path: X:\B50001.05\Maps\GSP\2022\01\FigHCM-9_Stiff Diagrams (map only).mxd

3.2.2. Stable Isotope Analysis

The stable isotopes of oxygen and hydrogen, ^{18}O and Deuterium (^{2}H), are not radioactive and do not change in composition over time. Oxygen and hydrogen stable isotopic ratios of meteoric waters have become standard tools of meteorologists and hydrologists during the past few decades. These ratios are quite variable due to fractionation by common meteorologic and hydrologic processes (Fritz and Fontes, 1980; Gat and Gonfiantini, 1981). Such variations provide natural tracers of the water cycle, including isotopic changes of vapor and precipitation over continental areas, as well as evaporation, transport, and water mixing on and beneath the Earth's surface (Williams and Rodoni, 1997).

Oxygen isotope $\delta^{18}O$ values and deuterium isotope $\delta^{2}H$ values are defined and presented in standard notation:

$$\delta = (R_{sample}/R_{standard}-1)\times 1000;$$

where R_{sample} and $R_{standard}$ are the $^{18}O/^{16}O$ or $^{2}H/^{1}H$ ratios for the sample and standard, respectively. All $\delta^{18}O$ and $\delta^{2}H$ data are reported in per mil (‰) relative to Vienna Standard Mean Ocean Water (V-SMOW). The reported analysis of stable isotopes in a water sample has negative δ values if it is relatively "light," indicating that it has less ^{18}O and ^{2}H than V-SMOW. Conversely, positive δ values are relatively "heavy" and have more ^{18}O and ^{2}H than V-SMOW.

Isotopically lighter $\delta^{18}O$ and $\delta^{2}H$ signatures (depleted in the heavier isotopes) are observed in water that precipitates at lower temperature and farther inland. The "continental effect," whereby water vapor becomes isotopically lighter as it moves inland because the heavier isotope rains out, also controls the stable isotope pattern in precipitation in California (Ingraham & Taylor, 1991). In California, mean annual air temperature and stable isotope ratios are strongly affected by the physiographic gradient from the Pacific Ocean maritime climate (relatively warm and constant temperatures) to the Sierra Nevada (cold temperatures with wider fluctuations).

The Global Meteoric Water Line (GMWL) is based on precipitation data from around the world (Craig, 1961). A Local Meteoric Water Line (LMWL) is derived from precipitation collected from "local" sites and can be significantly different than the GMWL. Several processes cause the local water to plot off of the GMWL, including evaporation and mixing with evaporated waters, the results of which plot below the GMWL.

Isotopic ratios from well and surface water samples are plotted with the GWML and LMWL on **Figure 10**. The LMWL for Kern County was derived from groundwater isotopic data collected by the USGS Groundwater Ambient Monitoring and Assessment (GAMA) project in Kern County (McMahon et al, 2017). The point shown for State Water Project (SWP) water represents the isotopic composition of the Sacramento River (Visser et al., 2018) and the point shown for the California Aqueduct water represents a sample taken from the California Aqueduct at Missouri Triangle, near the intersection of Highway 33 and 7th Standard Road (Davis et al., 2018). The point shown for local precipitation represents the isotopic composition of rainfall to the San Joaquin Valley (Visser et al., 2018). Finally, Grapevine Creek feeds into the southern portion of the Basin; the points shown for Grapevine Creek were sampled in the upgradient Castac Lake Valley Groundwater Basin. Nearly all of the samples plot below the GMWL indicating that they have been subject to evaporation or mixing with evaporated waters.

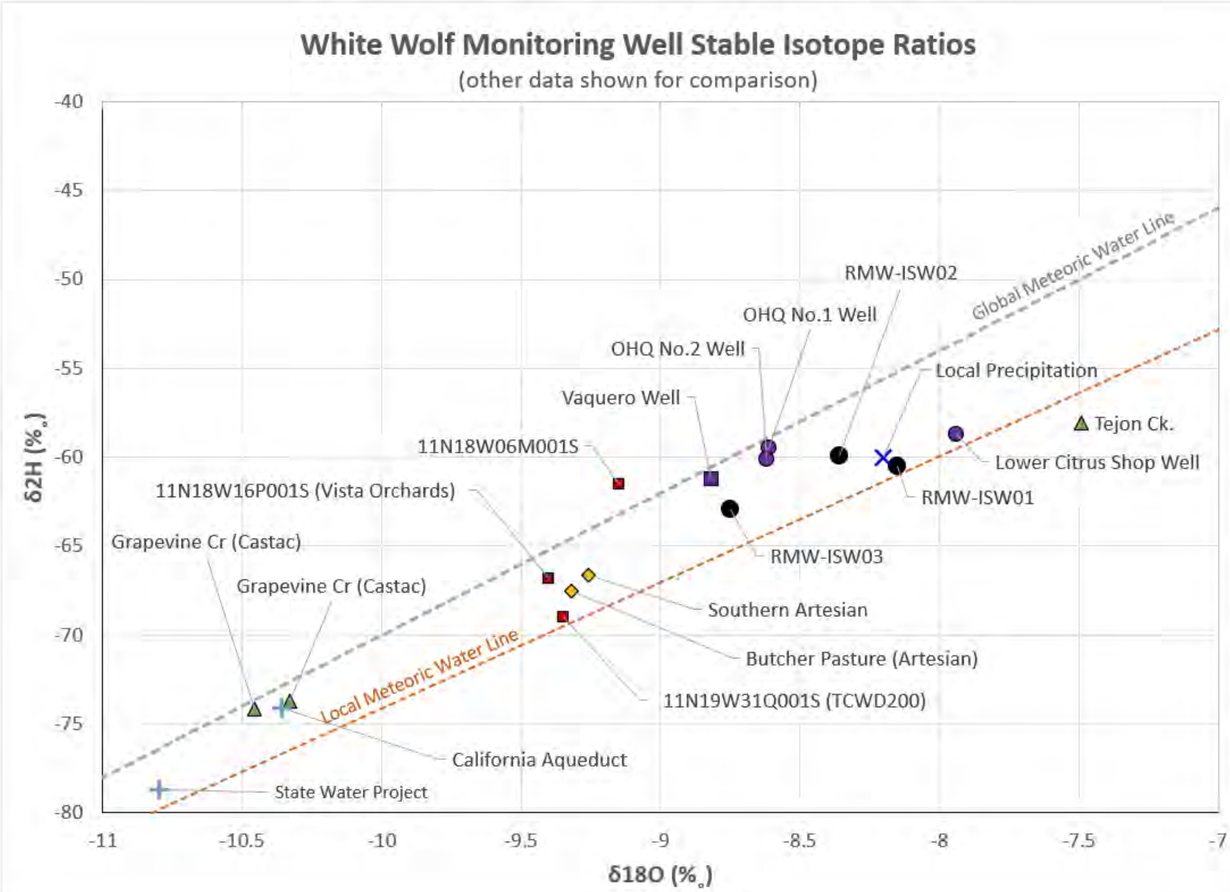


Figure 10. Stable Isotope Ratios

The primary sources of water in the Basin are local precipitation, runoff from surrounding watersheds, and imported SWP or Central Valley Project (CVP) water. The stable isotope results plotted on **Figure 10** show that the imported water (SWP water) is isotopically more depleted than local precipitation and local runoff (Tejon Creek). This is because the imported water comes from the Sierra Nevada and has a lighter isotopic signature than local water.

The plot of stable isotope data shows that wells located south of the Springs Fault (RMW-ISW01, RMW-ISW02, RMW-ISW03, OHQ No.1, OHW No.2, Vaquero, and Lower Citrus Shop) all plot closer to the local water samples (precipitation and runoff) than to SWP water. There is very little irrigated agriculture south of the Springs Fault, and the agriculture that exists is irrigated with a combination of local surface water and SWP water. Therefore, the isotopic signature of the groundwater in this area is expected to be influenced substantially by precipitation recharge and local water. Wells in the central part of the Basin (TCWD 200, 11N18W6M001S, Vista Orchards) plot closer to the isotopic signature of the imported water. Imported water is the predominant applied water source in the central part of the Basin and may influence water samples, although there is no direct conclusive evidence of SWP water influence on groundwater samples. The range in isotopic signatures is showing a variable mixture of natural recharge sources, where all groundwater samples fall within the range of Grapevine Creek and Tejon Creek waters, where Grapevine Creek enters the Basin on the south and Tejon Creek enters the Basin on the west.

A plot of the δ^{18}O values of samples by depth (**Figure 11**) shows that the deepest wells tend to be lighter, or more depleted in δ^{18}O. The deeper wells are generally located in the central part of the Basin. An exception is the two artesian wells which are presumed to be deep oil exploratory borings and likely are screened in deeper formations. The well with the most depleted δ^{18}O signature is the Vista Orchards well which is screened in the oil-producing Santa Margarita Formation. Isotopic signatures may further be influenced by upwards gradients between the deeper Santa Margarita and the overlying Chanac Formation, and/or mixing with formation waters originating from an older climatic regime.

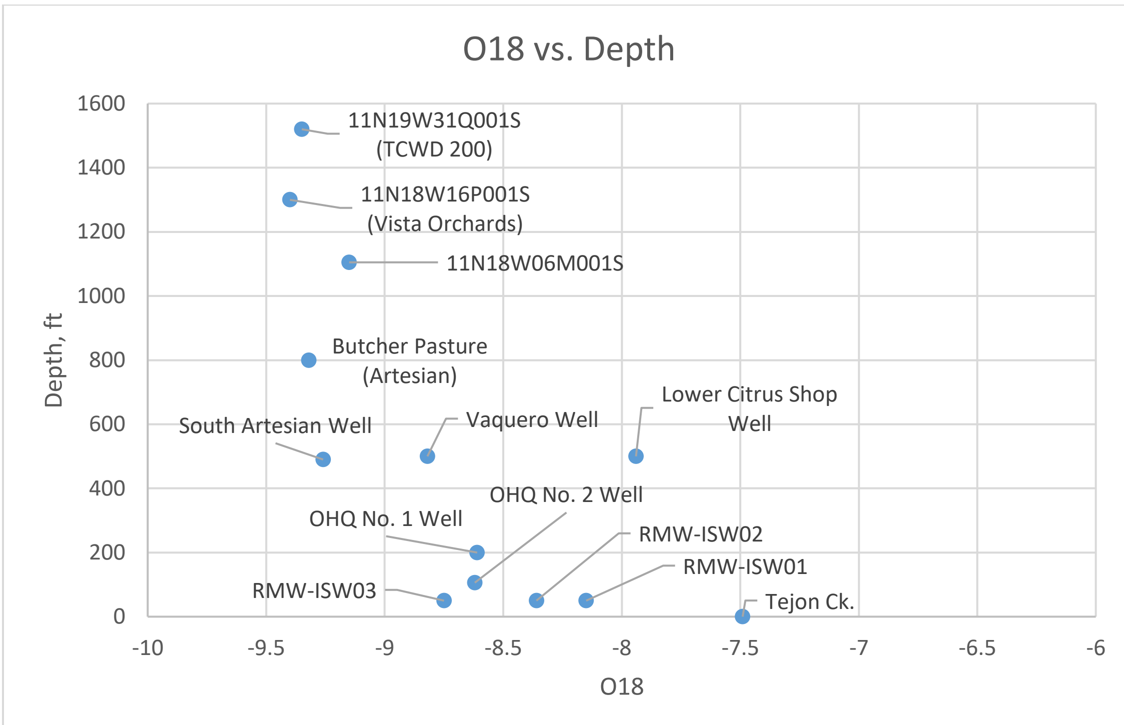


Figure 11. δ^{18}Oxygen vs. Depth

4. CONCLUSIONS AND NEXT STEPS

The limited available data appear to generally confirm that the shallow aquifer zone that supports GDEs is hydraulically isolated from the Principal Aquifer. As part of GSP implementation, on-going water level monitoring will occur, as well as additional analysis of pumping and water level trends in the Principal Aquifer relative to the shallow aquifer zone located north of the Springs Fault. These data will be used to better refine the HCM for the Basin, as well as the numerical groundwater flow model, and the definitions of applicable sustainable management criteria.

5. REFERENCES

Anderson SC, Sanchez DK, Swanson AA, 1979, Preliminary Evaluation of State Water Project Ground Water Storage Program, White Wolf Basin, State of California Department of Water Resources, Southern District, Technical Information Record Study Code No. 1610-4-J-1, dated September 1979.

Arvin-Edison Water Storage District, 2003, Arvin-Edison Water Storage District Groundwater Management Plan, June 2003.

Bartow JA, 1984, Tertiary Stratigraphy of the Southeastern San Joaquin Valley, California, U.S. Geological Survey Bulletin 1529-J.

Botha BE, 2017, Estimating household groundwater abstraction by means of a probability model. Thesis: Master of Engineering (Civil) in the Faculty of Engineering at Stellenbosch University, dated March 2017.

Craig H, 1961, Isotopic variations in meteoric waters. Science, 133: 1702-1703.

Fritz P and Fontes JCh, 1980, Environmental isotopes in groundwater hydrology. Netherlands: Elsevier.

Gat JR and Gonfiantini R (Ed.). 1981. Stable isotope hydrology Deuterium and oxygen-18 in the water cycle. International Atomic Energy Agency (IAEA): IAEA.

Geosystems Analysis, Inc., 2020, An Evaluation and Determination of Groundwater Dependent Ecosystems in the White Wolf Sub-Basin (DWR 5-022.18).

Ingraham NL and Taylor BE, 1991, Light stable isotope systematics of large-scale hydrologic regimes in California and Nevada. Water Resources Research 27: 77-90.

Massuel S, Perrin J, Wajid M, Mascre C, Dewandel B, 2009, A Simple, Low-Cost Method to Monitor Duration of Ground Water Pumping. Groundwater 47(1): 141-145.

McMahon PB, Kulongoski JT, Wright MT, Land MT, Landon MK, Cozzarelli IM, Vengosh A, Aiken GR, 2017, Preliminary results from exploratory sampling of wells for the California oil, gas, and groundwater program, 2014–15 (ver 1.1, January 2017): U.S. Geological Survey Open-File Report 2016–1100, 8 p., http://dx.doi.org/10.3133/ofr20161100.

Puls RW and Barcelona MJ, 1996, Low-Flow (Minimal) Drawdown Ground-Water Sampling Procedures, United States Environmental Protection Agency (USEPA) Ground Water Issue EPA/540/S-95-504, dated April 1996. Available online at: https://www.epa.gov/sites/default/files/2015-06/documents/lwflw2a.pdf

Visser A, Moran J, Singleton M, and Esser B, 2018, Importance of River Water Recharge to the San Joaquin Valley Groundwater System. Hydrological Processes. 32. 10.1002/hyp.11468.

WRMWSD, 2007, Wheeler Ridge-Maricopa Water Storage District, AB3030 Groundwater Management Plan, 2007.

Williams AE and Rodoni DP, 1997, Regional isotope effects and application to hydrologic investigations in southwestern California. Water Resources Research 33(7): 1721-1729.

Wood PR and Dale RH, 1964, Geology and Ground-Water Features of the Edison-Maricopa Area, Kern County, California, U.S. Geological Survey Water Supply Paper 1656.

ATTACHMENTS

Attachment 1. Well Construction Permits
Attachment 2. Well Completion Reports
Attachment 3. Well Development Logs
Attachment 4. Well Purging and Sampling Logs
Attachment 5. Laboratory Reports and Chain of Custody Records
Attachment 6. Time-Series Plots of Supply Well Discharge Pipe and Air Temperature Data

Attachment 1

Well Construction Permits

KERN COUNTY
Public Health Services
DEPARTMENT

MATTHEW CONSTANTINE
DIRECTOR

October 20, 2020

Tejon Castaic Water District
4436 Lebec Rd
Lebec, CA 93243

Ladies & Gentleman:

This is to advise you that your application for a permit to construct a monitoring well located in T 11N, R 18W, Section 15, APN 402-091-19, has been received and reviewed. Your permit number is WP 21026.

No additional conditions will be required at this time.

If you have any questions about your well, please contact our office at (661) 862-8740.

Sincerely,

Jeremy Ryan, R.E.H.S.
Environmental Health Specialist III
Water Quality Program

Enclosure

cc: ABC Liovin Drilling
File WP 21026

ENVIRONMENTAL HEALTH DIVISION

2700 M Street, Suite 300, Bakersfield, CA 93301
Phone # (661) 862-8740 Fax (661) 862-8701
Email EH@kerncounty.com

WATER WELL PERMIT APPLICATION

APPLICATION MUST BE SUBMITTED AT LEAST TEN (10) WORKING DAYS PRIOR TO THE PROPOSED STARTING DATE

TYPE OF PERMIT: ☒ Construct New ☐ Reconstruct ☐ Destroy

Permit/Well #: 21026
Starting Date:

TYPE OF WELL:

☐ Domestic/Private (1 connection)
☐ Domestic (2-4 connections)
☐ Domestic (5 -14 connections)
☐ Public Water System (15+ connections or 25+ people)
☐ Other

☐ Test Hole (Drill and Destroy)
☐ Cathodic Protection
☒ Monitoring/Vadose
☐ Agricultural/Industrial (Must complete **Intended Use Statement**)

☐ Adjudicated District
☐ Overdraft Basin

OWNER IS RESPONSIBLE FOR ANY ADDITIONAL PAYMENT OF FEES

OWNER'S INFORMATION		**WELL SITE/PROPERTY INFORMATION**	
Name: Tejon-Castac Water District		Name: Tejon ranch Co.	
Address: 4436 Lebec Road		Address: PO Box 1000	
City: Lebec	State: CA Zip: 93243	City: Lebec	State: CA Zip: 93243
Phone:	E-mail: amartin@Tejonranch.com.	APN: 40209119	T: 11 R: 18 Sec: 15
CONTRACTOR'S INFORMATION			
Environmental Contractor: Tejon Castac Water District		Driller: ABC Liovin Drilling, Inc	C-57: 422904
Address: 4436 Lebec Road		Address: 1180 East Burnett Street	
City: Lebec	State: CA Zip: 93243	City: Signal Hill	State: CA Zip: 90755
Contact: Angelica Martin	Phone: 661-663-4262	Contact: Ivan Liovin	Phone: 562-981-8575
E-mail: amartin@tejonranch.com		E-mail: van@abcdrilling.com	
PUMP INSTALLATION INFORMATION			
Name:		Contact:	Phone:
Address:		E-mail:	
City:	State: Zip:	☐ Water Quality Included	
CONTACT FOR PAYMENT	☐ Owner ☒ Contractor	☐ Driller	
WATER SAMPLE TO BE TAKEN BY:			**TOTAL ACRES:**
LOCATION OF WELL (GPS COORDINATES): see attached			
Provide detailed directions to site			

WELL CONSTRUCTION INFORMATION

METHOD: ☐ Reverse Rotary ☐ Rotary ☐ Air Rotary ☒ Hollow Stem Auger ☐ Other: ________

WELL NAME / NUMBER	Proposed #2		
MAXIMUM WELL DEPTH	50 ft		
SEALING MATERIAL	Neat Portland cement grout seal		
SEAL DEPTH (HARD ROCK/UNCONSOLIDATED)	0-15 ft below ground surface		
CASING MATERIAL & GAUGE	Sched 40 PVC threaded flush-joint with O-ring seals		
CASING - INSIDE DIAMETER	4"		
SCREEN/PERFORATION DEPTH	20-50 ft		
CONDUCTOR DEPTH	None		
CONDUCTOR DIAMETER	None		
DEPTH TO GROUNDW ATER	15 to 30 ft below ground surface		
LOCKING W ELL CAP	Locking metal standing monument with 4 concrete filled bollards		
BOREHOLE DIAMETER	10"		
SCREEN MATERIAL & GAUGE	Sched 40 PVC slot size 0.020		
TYPE OF BENTONITE PLUG & DEPTH	hydrated bentonite chip seal transition zone 15-17 ft below ground surface		
FILTER PACK MATERIAL & SIZE	2/12 filter sand, 17-50 ft below ground surface		
SCREEN SLOT SIZE & LENGTH	slot size 0.020, 30 ft length		
SEALANT PLACEMENT METHOD	Tremie		

WELL DESTRUCTION INFORMATION

WELL NUMBER			
WELL DEPTH			
CASING MATERIAL			
SEALANT MATERIAL			
SEALANT PLACEMENT METHOD			

GENERAL CONDITIONS FOR DESTRUCTION:

1. A well destruction application must be filed with this Division if a well is being destroyed that is not in conjunction with a test hole permit.
2. Steel tremie pipe must be used if seal material is pumped into well.
3. A representative of this Division must witness placement of the seal material. Forty-eight hour advanced notice is required for an appointment.

PLOT PLAN REQUIREMENTS:

Attach a plot plan with the exact location of water well with respect to the following items: property lines, adjoining properties, water bodies or courses, drainage pattern, roads, existing wells, structures, sewers or private disposal systems. Include distance from two property lines. For Domestic, Agriculture, Industrial well, provide location of any water wells or surface water within 200' radius of proposed well. For monitoring wells provide a description of the facility to monitor including location of tanks, proposed monitoring and placement.

GENERAL CONDITIONS FOR ALL PERMITS:

Permit applications may be submitted to the Planning Department by county staff for zoning, access, and flood plain clearances prior to approval of the Environmental Health Division (EHD). If you are drilling within city's limits, you will have to receive approval from their Planning Department.

1. Permit applications must be submitted to EHD at least ten (10) working days prior to the proposed starting date.
2. Well site approval is required before beginning any work related to water well construction. It is unlawful to continue work past the stage at which an inspection is required unless inspection is waived or completed.
3. Other required inspections include setting conductor casing, all seals, and final construction features.
4. In areas where a water well penetrates more than one aquifer, and one or more of the aquifers may contain water which is of a quality which may degrade the other aquifer(s) penetrated if allowed to commingle, an E-Log shall be required to determine the location of the confining clay layer(s) and assist in the placement of any required annular seal(s).
5. A phone call to the **Division Hotline at (661) 862-8788** is required 48 hours before the placement of any seals or plugs. **No seals shall be called for after 2:00 pm without prior approval or in case of an emergency.**
6. Approval of water quality and final construction features is required before the water well is put into use.
7. Construction under this permit is subject to any instructions by EHD representatives.
8. Any misrepresentation or noncompliance with required permit conditions, or regulations, will result in issuance of a "Stop Work Order."
9. A copy of the Department of Water Resources Well Completion Report and water quality analyses must be submitted to EHD within sixty-(60) days after completion of the work.
10. "Dry" and "Test" holes must be properly destroyed within two (2) weeks of drilling. A water well destruction application must be filed with EHD.
11. The permit is void one (1) year after date of issuance if work has not been started and reasonable progress toward completion made. Fees are not refundable ortransferable.
12. Lead appurtenances shall not be used in construction of any private or public water supply system. The use of solders containing more than 2/10 of 1% lead is prohibited in making joints and fittings in any private or public potable water system.
13. A C-57 contractor licensed in accordance with the provisions of the Contractor's License Law (Chapter 9, Division 3, of the Business and Professions Code) unless exempted by that act, and registered to drill within the County of Kern shall perform drilling of a water well.
14. Permittee shall assume entire responsibility for all activities and uses under this permit and shall indemnify, defend and save the County of Kern and/or Kern County Water Agency, its officers, agents, and employees, free and harmless from any and all expense, cost or liability in connection with or resulting from the exercise of this permit, including, but not limited to, property damage, personal injury, and wrongful death.

☒ **I UNDERSTAND THAT FUTURE DEVELOPMENT PERMITS MAY NOT BE ISSUED (KCOC 17.04.120) UNLESS RECORDED LEGAL ACCESS TO THE PROPERTY CAN BE DEMONSTRATED.**

I certify that I am the owner of the above-described property, or the authorized representative of such owner, and that all the information I have furnished is current and accurate to the best of my knowledge, and I intend to construct the water well as represented above. I understand that all work is to be done in accordance with Kern County Ordinance Code Chapter 14.08, Bulletin 74-81 and all subsequent bulletins and the conditions of the Permit Application, including any conditions, which may be added or changed by EHD upon review of this Application and issuance of the Permit. I further understand that any permit issued pursuant to this application is subject to such further conditions as may be deemed necessary to ensure compliance with the permit regulations.

Owner's Signature Angelica Martin Date 10/12/2020 Authorized Agent or Agency TCWD Angelica Martin Date 10/12/2020

THIS APPLICATION BECOMES A PERMIT WHEN APPROVED

For Internal Use Only	
Permit Approved By: JK	Total Fee: Date Paid:
Date: 10-20-20 Expires On:	Zoning: Date:
Per approved site plan; changes may be subject to review	Flood Plain Approval Required: ☐ Yes ☑ No
E-Log Required: ☐ Yes ☑ No	Elevate Casing Above Grade:

REASONS FOR DENIAL OR CONDITIONS OF PERMIT:

Proposed Monitoring Well #2
Lat: 35.038175
Long: -118.778632
Legend
Proposed Monitoring Well #2
White Wolf
Sebastian Rd
Proposed Monitoring Well #2
Google Earth
© 2020 Google
N
2000 ft

KERN COUNTY
Public Health Services
DEPARTMENT

MATTHEW CONSTANTINE
DIRECTOR

2700 M STREET SUITE 300 BAKERSFIELD CALIFORNIA 93301-2370 VOICE 661-862-8740 FAX 661-862-8701 KERNPUBLICHEALTH.COM

October 20, 2020

Tejon Castaic Water District
4436 Lebec Rd
Lebec, CA 93243

Ladies & Gentleman:

This is to advise you that your application for a permit to construct a monitoring well located in T 11N, R 18W, Section 12, APN 402-070-14, has been received and reviewed. Your permit number is WP 21027.

No additional conditions will be required at this time.

If you have any questions about your well, please contact our office at (661) 862-8740.

Sincerely,

Jeremy Ryan, R.E.H.S.
Environmental Health Specialist III
Water Quality Program

Enclosure

cc: ABC Liovin Drilling
File WP 21027

ENVIRONMENTAL HEALTH DIVISION
2700 M Street, Suite 300, Bakersfield, CA 93301
Phone # (661) 862-8740 Fax (661) 862-8701
Email EH@kerncounty.com

WATER WELL PERMIT APPLICATION

APPLICATION MUST BE SUBMITTED AT LEAST TEN (10) WORKING DAYS PRIOR TO THE PROPOSED STARTING DATE

TYPE OF PERMIT: [X] Construct New [ ] Reconstruct [ ] Destroy

Permit/Well #: 21027
Starting Date:

TYPE OF WELL:

- [ ] Domestic/Private (1 connection)
- [ ] Domestic (2-4 connections)
- [ ] Domestic (5 -14 connections)
- [ ] Public Water System (15+ connections or 25+ people)
- [ ] Other
- [ ] Test Hole (Drill and Destroy)
- [ ] Cathodic Protection
- [X] Monitoring/Vadose
- [ ] Agricultural/Industrial (Must complete **Intended Use Statement**)
- [ ] Adjudicated District
- [ ] Overdraft Basin

OWNER IS RESPONSIBLE FOR ANY ADDITIONAL PAYMENT OF FEES

OWNER'S INFORMATION			**WELL SITE/PROPERTY INFORMATION**	
Name: Tejon-Castac Water District			Name: Tejon ranch Co.	
Address: 4436 Lebec Road			Address: PO Box 1000	
City: Lebec	State: CA	Zip: 93243	City: Lebec	State: CA Zip: 93243
Phone:	E-mail:		APN: 40207014	T: 11 R: 18 Sec: 12
CONTRACTOR'S INFORMATION				
Environmental Contractor: Tejon Castac Water District			Driller: ABC Liovin Drilling, Inc	C-57: 422904
Address: 4436 Lebec Road			Address: 1180 East Burnett Street	
City: Lebec	State: CA	Zip: 93243	City: Signal Hill	State: CA Zip 90755
Contact : Angelica Martin	Phone: 661-663-4262		Contact: Ivan Liovin	Phone: 562-981-8575
E-mail: amartin@tejonranch.com			E-mail: van@abcdrilling.com	
PUMP INSTALLATION INFORMATION				
Name:			Contact:	Phone:
Address:			E-mail:	
City:	State:	Zip:	[ ] Water Quality Included	
CONTACT FOR PAYMENT	[ ] Owner	[X] Contractor	[ ] Driller	
WATER SAMPLE TO BE TAKEN BY:				**TOTAL ACRES:**
LOCATION OF WELL (GPS COORDINATES): see attached				

Provide detailed directions to site

GENERAL CONDITIONS FOR ALL PERMITS:

Permit applications may be submitted to the Planning Department by county staff for zoning, access, and flood plain clearances prior to approval of the Environmental Health Division (EHD). If you are drilling within city's limits, you will have to receive approval from their Planning Department.

1. Permit applications must be submitted to EHD at least ten (10) working days prior to the proposed starting date.
2. Well site approval is required before beginning any work related to water well construction. It is unlawful to continue work past the stage at which an inspection is required unless inspection is waived or completed.
3. Other required inspections include setting conductor casing, all seals, and final construction features.
4. In areas where a water well penetrates more than one aquifer, and one or more of the aquifers may contain water which is of a quality which may degrade the other aquifer(s) penetrated if allowed to commingle, an E-Log shall be required to determine the location of the confining clay layer(s) and assist in the placement of any required annular seal(s).
5. A phone call to the **Division Hotline at (661) 862-8788** is required 48 hours before the placement of any seals or plugs. **No seals shall be called for after 2:00 pm without prior approval or in case of an emergency.**
6. Approval of water quality and final construction features is required before the water well is put into use.
7. Construction under this permit is subject to any instructions by EHD representatives.
8. Any misrepresentation or noncompliance with required permit conditions, or regulations, will result in issuance of a "Stop Work Order."
9. A copy of the Department of Water Resources Well Completion Report and water quality analyses must be submitted to EHD within sixty-(60) days after completion of the work.
10. "Dry" and "Test" holes must be properly destroyed within two (2) weeks of drilling. A water well destruction application must be filed with EHD.
11. The permit is void one (1) year after date of issuance if work has not been started and reasonable progress toward completion made. Fees are not refundable ortransferable.
12. Lead appurtenances shall not be used in construction of any private or public water supply system. The use of solders containing more than 2/10 of 1% lead is prohibited in making joints and fittings in any private or public potable water system.
13. A C-57 contractor licensed in accordance with the provisions of the Contractor's License Law (Chapter 9, Division 3, of the Business and Professions Code) unless exempted by that act, and registered to drill within the County of Kern shall perform drilling of a water well.
14. Permittee shall assume entire responsibility for all activities and uses under this permit and shall indemnify, defend and save the County of Kern and/or Kern County Water Agency, its officers, agents, and employees, free and harmless from any and all expense, cost or liability in connection with or resulting from the exercise of this permit, including, but not limited to, property damage, personal injury, and wrongful death.

☒ **I UNDERSTAND THAT FUTURE DEVELOPMENT PERMITS MAY NOT BE ISSUED (KCOC 17.04.120) UNLESS RECORDED LEGAL ACCESS TO THE PROPERTY CAN BE DEMONSTRATED.**

I certify that I am the owner of the above-described property, or the authorized representative of such owner, and that all the information I have furnished is current and accurate to the best of my knowledge, and I intend to construct the water well as represented above. I understand that all work is to be done in accordance with Kern County Ordinance Code Chapter 14.08, Bulletin 74-81 and all subsequent bulletins and the conditions of the Permit Application, including any conditions, which may be added or changed by EHD upon review of this Application and issuance of the Permit. I further understand that any permit issued pursuant to this application is subject to such further conditions as may be deemed necessary to ensure compliance with the permit regulations.

Owner's Signature Angelica Martin Date 10/12/2020 Authorized Agent or Agency TCWD Angelica Martin Date 10/12/2020

THIS APPLICATION BECOMES A PERMIT WHEN APPROVED

For Internal Use Only	
Permit Approved By: JK	Total Fee: ______ Date Paid: ______
Date: 10-20-20 Expires On: ______	Zoning: ______ Date: ______
Per approved site plan; changes may be subject to review	Flood Plain Approval Required: ☐ Yes ☑ No
E-Log Required: ☐ Yes ☑ No	Elevate Casing Above Grade: ______

REASONS FOR DENIAL OR CONDITIONS OF PERMIT:

WELL CONSTRUCTION INFORMATION

METHOD: ☐ **Reverse Rotary** ☐ **Rotary** ☐ **Air Rotary** ☒ **Hollow Stem Auger** ☐ **Other:** ________

WELL NAME / NUMBER	**Proposed #3**		
MAXIMUM WELL DEPTH	50 ft		
SEALING MATERIAL	[illegible] Portland cement grout [illegible]		
SEAL DEPTH (HARD ROCK/UNCONSOLIDATED)	0-15 ft below ground surface		
CASING MATERIAL & GAUGE	Sched 40 PVC threaded flush joint with O-ring seals		
CASING - INSIDE DIAMETER	4"		
SCREEN/PERFORATION DEPTH	20-50 ft		
CONDUCTOR DEPTH	None		
CONDUCTOR DIAMETER	None		
DEPTH TO GROUNDW ATER	15 to 30 ft below ground surface		
LOCKING W ELL CAP	Locking metal standing monument with 4 concrete filled bollards		
BOREHOLE DIAMETER	10"		
SCREEN MATERIAL & GAUGE	Sched 40 PVC slot size 0.020		
TYPE OF BENTONITE PLUG & DEPTH	hydrated bentonite chip seal transition zone 15-17 ft below ground surface		
FILTER PACK MATERIAL & SIZE	2/12 filter sand, 17-50 ft below ground surface		
SCREEN SLOT SIZE & LENGTH	slot size 0.020, 30 ft length		
SEALANT PLACEMENT METHOD	Tremie		

WELL DESTRUCTION INFORMATION

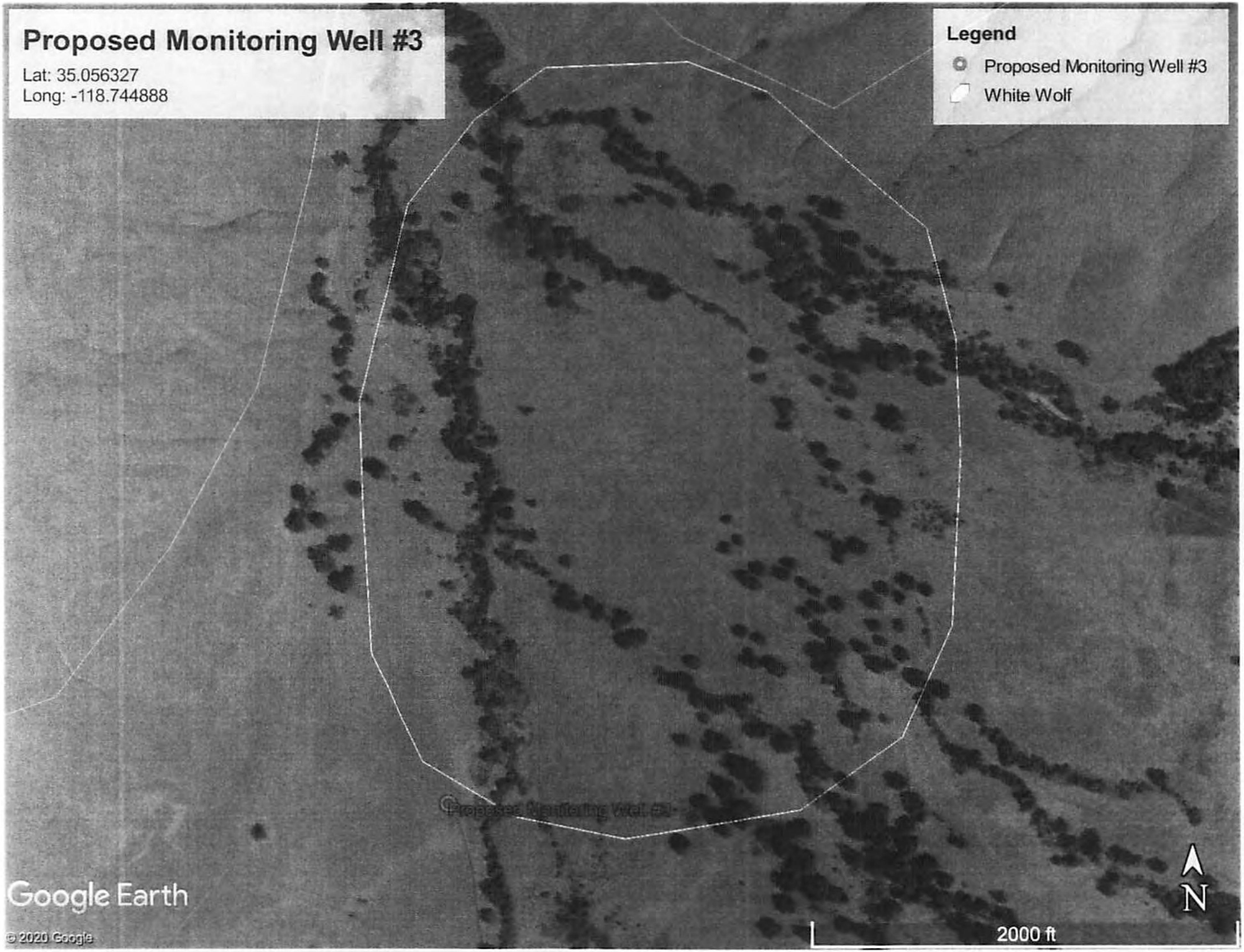
WELL NUMBER			
WELL DEPTH			
CASING MATERIAL			
SEALANT MATERIAL			
SEALANT PLACEMENT METHOD			

GENERAL CONDITIONS FOR DESTRUCTION:

1. A well destruction application must be filed with this Division if a well is being destroyed that is not in conjunction with a test hole permit.
2. Steel tremie pipe must be used if seal material is pumped into well.
3. A representative of this Division must witness placement of the seal material. Forty-eight hour advanced notice is required for an appointment.

PLOT PLAN REQUIREMENTS:

Attach a plot plan with the exact location of water well with respect to the following items: property lines, adjoining properties, water bodies or courses, drainage pattern, roads, existing wells, structures, sewers or private disposal systems. Include distance from two property lines. For Domestic, Agriculture, Industrial well, provide location of any water wells or surface water within 200' radius of proposed well. For monitoring wells provide a description of the facility to monitor including, location of tanks, proposed monitoring and placement.


Proposed Monitoring Well #3
Lat: 35.056327
Long: -118.744888
Legend
Proposed Monitoring Well #3
White Wolf
Proposed Monitoring Well #3
Google Earth
© 2020 Google
2000 ft
N

KERN COUNTY
Public Health Services
DEPARTMENT

MATTHEW CONSTANTINE
DIRECTOR

2700 M STREET SUITE 300 · BAKERSFIELD, CALIFORNIA 93301-2370 · VOICE 661-862-8740 · FAX 661-862-8701 · KERNPUBLICHEALTH.COM

October 20, 2020

Tejon Castaic Water District
4436 Lebec Rd
Lebec, CA 93243

Ladies & Gentleman:

This is to advise you that your application for a permit to construct a monitoring well located in T 11N, R 18W, Section 29, APN 402-120-12, has been received and reviewed. Your permit number is WP 21028.

No additional conditions will be required at this time.

If you have any questions about your well, please contact our office at (661) 862-8740.

Sincerely,

Jeremy Ryan, R.E.H.S.
Environmental Health Specialist III
Water Quality Program

Enclosure

cc: ABC Liovin Drilling
File WP 21028

ENVIRONMENTAL HEALTH DIVISION
2700 M Street, Suite 300, Bakersfield, CA 93301
Phone # (661) 862-8740 Fax (661) 862-8701
Email EH@kerncounty.com

WATER WELL PERMIT APPLICATION

APPLICATION MUST BE SUBMITTED AT LEAST TEN (10) WORKING DAYS PRIOR TO THE PROPOSED STARTING DATE

TYPE OF PERMIT: ☒ Construct New ☐ Reconstruct ☐ Destroy **Permit/Well #:** 21028
Starting Date:

TYPE OF WELL:

- ☐ Domestic/Private (1 connection)
- ☐ Domestic (2-4 connections)
- ☐ Domestic (5 -14 connections)
- ☐ Public Water System (15+ connections or 25+ people)
- ☐ Test Hole (Drill and Destroy)
- ☐ Cathodic Protection
- ☒ Monitoring/Vadose
- ☐ Agricultural/Industrial (Must complete **Intended Use Statement**)
- ☐ Other
- ☐ Adjudicated District
- ☐ Overdraft Basin

OWNER IS RESPONSIBLE FOR ANY ADDITIONAL PAYMENT OF FEES			
OWNER'S INFORMATION		**WELL SITE/PROPERTY INFORMATION**	
Name: Tejon-Castac Water District		Name: Tejon ranch Co.	
Address: 4436 Lebec Road		Address: PO Box 1000	
City: Lebec	State: CA Zip: 93243	City: Lebec	State: CA Zip: 93243
Phone:	E-mail:	APN: 40212012	T: 11 R: 18 Sec: 29
CONTRACTOR'S INFORMATION			
Environmental Contractor: Tejon Castac Water District		Driller: ABC Liovin Drilling, Inc	C-57: 422904
Address: 4436 Lebec Road		Address: 1180 East Burnett Street	
City: Lebec	State: CA Zip: 93243	City: Signal Hill	State: CA Zip: 90755
Contact: Angelica Martin	Phone: 661-663-4262	Contact: Ivan Liovin	Phone: 562-981-8575
E-mail: amartin@tejonranch.com		E-mail: van@abcdrilling.com	
PUMP INSTALLATION INFORMATION			
Name:		Contact:	Phone:
Address:		E-mail:	
City:	State: Zip:	☐ Water Quality Included	
CONTACT FOR PAYMENT	☐ Owner ☒ Contractor	☐ Driller	
WATER SAMPLE TO BE TAKEN BY:			**TOTAL ACRES:**
LOCATION OF WELL (GPS COORDINATES): see attached			
Provide detailed directions to site			

WELL CONSTRUCTION INFORMATION

METHOD: ☐ Reverse Rotary ☐ Rotary ☐ Air Rotary ☒ Hollow Stem Auger ☐ Other: ________

WELL NAME / NUMBER	Proposed #1		
MAXIMUM WELL DEPTH	50 ft		
SEALING MATERIAL	5-8 sack Portland Cement grout seal		
SEAL DEPTH (HARD ROCK/UNCONSOLIDATED)	0-15 ft below ground surface		
CASING MATERIAL & GAUGE	Sched 40 PVC threaded flush-joint with O-ring seals		
CASING - INSIDE DIAMETER	4"		
SCREEN/PERFORATION DEPTH	20-50 ft		
CONDUCTOR DEPTH	None		
CONDUCTOR DIAMETER	None		
DEPTH TO GROUNDW ATER	15 to 30 ft below ground surface		
LOCKING W ELL CAP	Locking metal standing monument with 4 concrete filled bollards		
BOREHOLE DIAMETER	10"		
SCREEN MATERIAL & GAUGE	Sched 40 PVC slot size 0.020		
TYPE OF BENTONITE PLUG & DEPTH	hydrated bentonite chip seal transition zone 15-17 ft below ground surface		
FILTER PACK MATERIAL & SIZE	2/12 filter sand, 17-50 ft below ground surface		
SCREEN SLOT SIZE & LENGTH	slot size 0.020, 30 ft length		
SEALANT PLACEMENT METHOD	Tremie		

WELL DESTRUCTION INFORMATION

WELL NUMBER			
WELL DEPTH			
CASING MATERIAL			
SEALANT MATERIAL			
SEALANT PLACEMENT METHOD			

GENERAL CONDITIONS FOR DESTRUCTION:

1. A well destruction application must be filed with this Division if a well is being destroyed that is not in conjunction with a test hole permit.
2. Steel tremie pipe must be used if seal material is pumped into well.
3. A representative of this Division must witness placement of the seal material. Forty-eight hour advanced notice is required for an appointment.

PLOT PLAN REQUIREMENTS:

Attach a plot plan with the exact location of water well with respect to the following items: property lines, adjoining properties, water bodies or courses, drainage pattern, roads, existing wells, structures, sewers or private disposal systems. Include distance from two property lines. For Domestic, Agriculture, Industrial well, provide location of any water wells or surface water within 200' radius of proposed well. For monitoring wells provide a description of the facility to monitor including: location of tanks, proposed monitoring and placement.

GENERAL CONDITIONS FOR ALL PERMITS:

Permit applications may be submitted to the Planning Department by county staff for zoning, access, and flood plain clearances prior to approval of the Environmental Health Division (EHD). If you are drilling within city's limits, you will have to receive approval from their Planning Department.

1. Permit applications must be submitted to EHD at least ten (10) working days prior to the proposed starting date.
2. Well site approval is required before beginning any work related to water well construction. It is unlawful to continue work past the stage at which an inspection is required unless inspection is waived or completed.
3. Other required inspections include setting conductor casing, all seals, and final construction features.
4. In areas where a water well penetrates more than one aquifer, and one or more of the aquifers may contain water which is of a quality which may degrade the other aquifer(s) penetrated if allowed to commingle, an E-Log shall be required to determine the location of the confining clay layer(s) and assist in the placement of any required annular seal(s).
5. A phone call to the **Division Hotline at (661) 862-8788** is required 48 hours before the placement of any seals or plugs. **No seals shall be called for after 2:00 pm without prior approval or in case of an emergency.**
6. Approval of water quality and final construction features is required before the water well is put into use.
7. Construction under this permit is subject to any instructions by EHD representatives.
8. Any misrepresentation or noncompliance with required permit conditions, or regulations, will result in issuance of a "Stop Work Order."
9. A copy of the Department of Water Resources Well Completion Report and water quality analyses must be submitted to EHD within sixty-(60) days after completion of the work.
10. "Dry" and "Test" holes must be properly destroyed within two (2) weeks of drilling. A water well destruction application must be filed with EHD.
11. The permit is void one (1) year after date of issuance if work has not been started and reasonable progress toward completion made. Fees are not refundable or transferable.
12. Lead appurtenances shall not be used in construction of any private or public water supply system. The use of solders containing more than 2/10 of 1% lead is prohibited in making joints and fittings in any private or public potable water system.
13. A C-57 contractor licensed in accordance with the provisions of the Contractor's License Law (Chapter 9, Division 3, of the Business and Professions Code) unless exempted by that act, and registered to drill within the County of Kern shall perform drilling of a water well.
14. Permittee shall assume entire responsibility for all activities and uses under this permit and shall indemnify, defend and save the County of Kern and/or Kern County Water Agency, its officers, agents, and employees, free and harmless from any and all expense, cost or liability in connection with or resulting from the exercise of this permit, including, but not limited to, property damage, personal injury, and wrongful death.

☒ **I UNDERSTAND THAT FUTURE DEVELOPMENT PERMITS MAY NOT BE ISSUED (KCOC 17.04.120) UNLESS RECORDED LEGAL ACCESS TO THE PROPERTY CAN BE DEMONSTRATED.**

I certify that I am the owner of the above-described property, or the authorized representative of such owner, and that all the information I have furnished is current and accurate to the best of my knowledge, and I intend to construct the water well as represented above. I understand that all work is to be done in accordance with Kern County Ordinance Code Chapter 14.08, Bulletin 74-81 and all subsequent bulletins and the conditions of the Permit Application, including any conditions, which may be added or changed by EHD upon review of this Application and issuance of the Permit. I further understand that any permit issued pursuant to this application is subject to such further conditions as may be deemed necessary to ensure compliance with the permit regulations.

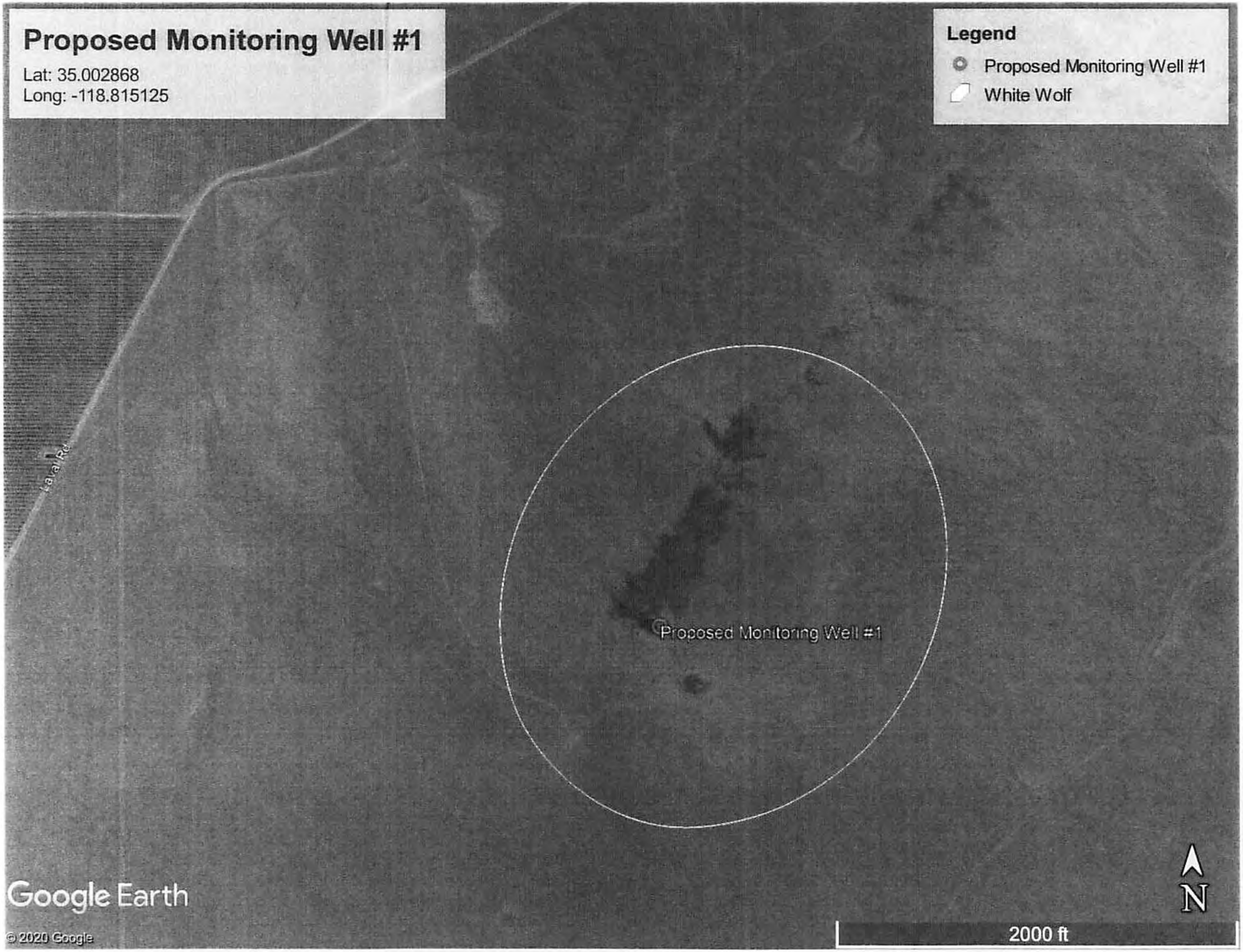
Owner's Signature: Angelica Martin Date: 10/12/2020

Authorized Agent or Agency: TCWD Angelica Martin Date: 10/12/2020

THIS APPLICATION BECOMES A PERMIT WHEN APPROVED

For Internal Use Only	
Permit Approved By: JR	Total Fee: ______ Date Paid: ______
Date: 10-20-20 Expires On: ______	Zoning: ______ Date: ______
Per approved site plan; changes may be subject to review	Flood Plain Approval Required: ☐ Yes ☑ No
E-Log Required: ☐ Yes ☑ No	Elevate Casing Above Grade: ______

REASONS FOR DENIAL OR CONDITIONS OF PERMIT:


Proposed Monitoring Well #1
Lat: 35.002868
Long: -118.815125
Legend
Proposed Monitoring Well #1
White Wolf
Laval Rd
Proposed Monitoring Well #1
Google Earth
© 2020 Google
N
2000 ft

Attachment 2

Well Completion Reports

State of California

Well Completion Report

Form DWR 188 Submitted 3/12/2021
WCR2021-003246

Owner's Well Number: RMW-ISW01 | Date Work Began: 01/12/2021 | Date Work Ended: 01/12/2021

Local Permit Agency: Department of Public Health Services - Environmental Health Department

Secondary Permit Agency: | Permit Number: 21028 | Permit Date: 10/20/2020

Well Owner (must remain confidential pursuant to Water Code 13752)

Name: TEJON-CASTAC WATER DISTRICT,

Mailing Address: 4436 Lebec Road

City: Lebec | State: CA | Zip: 93243

Planned Use and Activity

Activity: New Well

Planned Use: Monitoring

Well Location

Address: 0 PO Box 1000

City: Lebec | Zip: 93243 | County: Kern

Latitude: 35 Deg. 0 Min. 10.3247 Sec. N | Longitude: -118 Deg. 48 Min. 54.4499 Sec. W

Dec. Lat.: 35.001904 | Dec. Long.: -118.814959

Vertical Datum: | Horizontal Datum: WGS84

Location Accuracy: | Location Determination Method:

APN: 402-120-12

Township:

Range:

Section:

Baseline Meridian:

Ground Surface Elevation:

Elevation Accuracy:

Elevation Determination Method:

Borehole Information

Orientation: Vertical | Specify:

Drilling Method: Auger | Drilling Fluid: None

Total Depth of Boring: 50 Feet

Total Depth of Completed Well: 50 Feet

Water Level and Yield of Completed Well

Depth to first water: (Feet below surface)

Depth to Static

Water Level: (Feet) | Date Measured:

Estimated Yield*: (GPM) | Test Type:

Test Length: (Hours) | Total Drawdown: (feet)

*May not be representative of a well's long term yield.

Geologic Log - Free Form

Depth from Surface Feet to Feet		Description
0	7	Silty Sand with Clay; brown; 20% silt, 10% clay; tr med ang gravel; clasts qtz; tr musc.; loose, dry.
7	13	Clay with Sand; dk grey brown; 25% f-c sand; micaceous; strong FeOx mott comm; moist.
13	16	Sand; brown, medium coarse; cobbles of decomp. granite; dry; poorly sort.
16	18	Clayey Sand; light yellow brown, 25% clay; 5% grav; clasts decomp. granitic rx; altered aplite (?) with chlorite?/hbl?; CaCO3 on fx in clay-rich intvls, moist to dry, clay rich intvls comm.
18	31	Sandy Clay; v. pale brown; 35% m-c sand, sand is decomp granitics; ang; mostly feldspars; rare cobbles; moist.
31	37	Clayey Sand; v. pale brown; 30% clay; hard; clasts decomp granitic rx comm; prob granodiorite; f-m grained; micaceous; feldspars wx; sand is f-c; ang; weak yell FeOx stain comm; moist.
37	50	Sand with Clay; v. pale brown; m-c ang sand; 10% clay; mostly decomp granitics; wet, dense; hard; intvls comm with increased clay; some intvls v. compacted; moist-wet, poor sort; qtz cobbles; at 45ft. core v. wet, sat'd.

Casings

Casing #	Depth from Surface Feet to Feet		Casing Type	Material	Casings Specificatons	Wall Thickness (inches)	Outside Diameter (inches)	Screen Type	Slot Size if any (inches)	Description
1	0	20	Blank	PVC	N/A	0	4			Sch 40
1	20	50	Screen	PVC	N/A	0	4	Milled Slots	0.02	Sch 40

Annular Material

Depth from Surface Feet to Feet		Fill	Fill Type Details	Filter Pack Size	Description
0	15	Cement	Portland Cement/Neat Cement		5% Neat Portland Cement Grout
15	17	Bentonite	Other Bentonite		Hydrated Bentonite Chip
17	50	Filter Pack	Other Gravel Pack		2/12 Filter Sand

Other Observations:

Borehole Specifications

Depth from Surface Feet to Feet		Borehole Diameter (inches)
0	50	10

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name A B C LIOVIN DRILLING INC
Person, Firm or Corporation

1180 E BURNETT STREET — SIGNAL HILL — CA — 90755
Address — City — State — Zip

Signed *electronic signature received* — 03/12/2021 — 422904
C-57 Licensed Water Well Contractor — Date Signed — C-57 License Number

DWR Use Only

CSG #	State Well Number	Site Code	Local Well Number

N — W

Latitude Deg/Min/Sec **Longitude Deg/Min/Sec**

TRS:

APN:

State of California

Well Completion Report

Form DWR 188 Submitted 3/12/2021
WCR2021-003251

Owner's Well Number	RMW-ISW02	Date Work Began	01/13/2021	Date Work Ended	01/13/2021
Local Permit Agency	Department of Public Health Services - Environmental Health Department				
Secondary Permit Agency		Permit Number	21026	Permit Date	10/20/2020

Well Owner (must remain confidential pursuant to Water Code 13752)

Name: TEJON-CASTAC WATER DISTRICT,
Mailing Address: 4436 Lebec Road
City: Lebec State: CA Zip: 93243

Planned Use and Activity

Activity: New Well
Planned Use: Monitoring

Well Location

Address: 0 PO Box 1000
City: Lebec Zip: 93243 County: Kern
Latitude: 35 Deg. 2 Min. 17.43 Sec. N
Longitude: -118 Deg. 46 Min. 43.0752 Sec. W
Dec. Lat.: 35.038175 Dec. Long.: -118.778632
Vertical Datum: Horizontal Datum: WGS84
Location Accuracy: Location Determination Method:

APN: 402-091-19
Township:
Range:
Section:
Baseline Meridian:
Ground Surface Elevation:
Elevation Accuracy:
Elevation Determination Method:

Borehole Information

Orientation: Vertical Specify:
Drilling Method: Auger Drilling Fluid: None

Total Depth of Boring: 50 Feet
Total Depth of Completed Well: 50 Feet

Water Level and Yield of Completed Well

Depth to first water: (Feet below surface)
Depth to Static Water Level: (Feet) Date Measured:
Estimated Yield*: (GPM) Test Type:
Test Length: (Hours) Total Drawdown: (feet)
*May not be representative of a well's long term yield.

Geologic Log - Free Form

Depth from Surface Feet to Feet		Description
0	6	Clay with Sand; brown, sand is f-m; micaceous; 20% sand; moist to dry.
6	14	Sand with Clay; light olive brown; m-c; secondary CaCO3; 15% clay; grains ang; feldspars comm; mod dense; moist to wet.
14	23	Sand; dark grey; m-c; ang felds + mica comm; wet, finer with depth; oxidized intvl at 16-21 ft. (brown); at 22ft. CaCO3 on fx.
23	44	Sand with Gravel; dark grey, 10% f-c gravel; rare lithic cobbles; sand sr-ang; predom qtz + feld; cobbles qtz & mfm lithic frags; loose; wet. at 31-35 ft. incr clay to 5%, core has minor cohesion. at 42-43 ft clay rich intvl.
44	50	Sand with Clay; v. pale brown; 10% clay; dense; sand f-c; ang-subang; wet.

Casings

Casing #	Depth from Surface Feet to Feet		Casing Type	Material	Casings Specificatons	Wall Thickness (inches)	Outside Diameter (inches)	Screen Type	Slot Size if any (inches)	Description
1	0	20	Blank	PVC	N/A	0	4			Sch 40
1	20	50	Screen	PVC	N/A	0	4	Milled Slots	0.02	Sch 40

Annular Material

Depth from Surface Feet to Feet		Fill	Fill Type Details	Filter Pack Size	Description
0	15	Cement	Portland Cement/Neat Cement		5% Neat Portland Cement Grout
15	17	Bentonite	Other Bentonite		Hydrated Bentonite Chip
17	50	Filter Pack	Other Gravel Pack		2/12 Filter Sand

Other Observations:

Borehole Specifications

Depth from Surface Feet to Feet		Borehole Diameter (inches)
0	50	10

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name A B C LIOVIN DRILLING INC
Person, Firm or Corporation

Address	City	State	Zip
1180 E BURNETT STREET	SIGNAL HILL	CA	90755

Signed *electronic signature received* (C-57 Licensed Water Well Contractor)
Date Signed: 03/12/2021
C-57 License Number: 422904

DWR Use Only

CSG #	State Well Number	Site Code	Local Well Number

N
Latitude Deg/Min/Sec

W
Longitude Deg/Min/Sec

TRS:

APN:

State of California

Well Completion Report

Form DWR 188 Submitted 3/12/2021
WCR2021-003255

Owner's Well Number	RMW-ISW03	Date Work Began	01/14/2021	Date Work Ended	01/14/2021
Local Permit Agency	Department of Public Health Services - Environmental Health Department				
Secondary Permit Agency		Permit Number	21027	Permit Date	10/20/2020

Well Owner (must remain confidential pursuant to Water Code 13752)

Name: TEJON-CASTAC WATER DISTRICT,
Mailing Address: 4436 Lebec Road
City: Lebec State: CA Zip: 93243

Planned Use and Activity

Activity: New Well
Planned Use: Monitoring

Well Location

Address	0 PO Box 1000			APN	402-070-14
City	Lebec	Zip	93243	County	Kern
Latitude	35 Deg. 3 Min. 22.7772 Sec. N	Longitude	-118 Deg. 44 Min. 41.5968 Sec. W	Township	
Dec. Lat.	35.056327	Dec. Long.	-118.744888	Range	
Vertical Datum		Horizontal Datum	WGS84	Section	
Location Accuracy		Location Determination Method		Baseline Meridian	
				Ground Surface Elevation	
				Elevation Accuracy	
				Elevation Determination Method	

Borehole Information

Orientation	Vertical	Specify	
Drilling Method	Auger	Drilling Fluid	None
Total Depth of Boring	50	Feet	
Total Depth of Completed Well	50	Feet	

Water Level and Yield of Completed Well

Depth to first water		(Feet below surface)		
Depth to Static Water Level		(Feet)	Date Measured	
Estimated Yield*		(GPM)	Test Type	
Test Length		(Hours)	Total Drawdown	(feet)

*May not be representative of a well's long term yield.

Geologic Log - Free Form

Depth from Surface Feet to Feet		Description
0	11	Sand; dark grey brown; f-c; qtz + musc comm; loose; dry to slightly moist; rare ang qtz + granite gravels; sand poorly sorted.
11	14	Clay; brown; plastic; stiff; 10% f-c sand; moist.
14	17	Sand; v. pale brown; m-c ang grains; predom qtz in $CaCO_3$ matrix; str. rxn HCl; moist.
17	24	Gravel with Sand; grey; sa-ang clasts; granitic; f-m grav; 30% f-m sand; bimodal; dry to moist; color change to yellow at 19 ft.; FeOx stain comm; grav to 1.5in. diameter.
24	40	Sand with Gravel; yellow-brown; f-c; ang-subang grains; biotite common; 20% f-m ang-subang gravel; predom granodiorite(?) clasts to 3/4-in., cobbles & boulders? (no recovery) at 31' cored fg qtz + musc igneous intrusive; no recovery 35-40 ft.
40	46	Sand with Gravel; yellow-red; 15% c sr-ang gravel; sand is m-c; grav predom qtz + lithic frags; dense; wet; at 43 ft. color change to yellow-brown, wet.
46	50	Sand with Clay; light yellow-brown 10% clay; f-c sand; sr-sa grains; dense; qtz + bio comm; moist to wet, 5% coarse gravel.

Casings

Casing #	Depth from Surface Feet to Feet		Casing Type	Material	Casings Specificatons	Wall Thickness (inches)	Outside Diameter (inches)	Screen Type	Slot Size if any (inches)	Description
1	0	20	Blank	PVC	N/A	0	4			Sch 40
1	20	50	Screen	PVC	N/A	0	4	Milled Slots	0.02	Sch 40

Annular Material

Depth from Surface Feet to Feet		Fill	Fill Type Details	Filter Pack Size	Description
0	15	Cement	Portland Cement/Neat Cement		5% Neat Portland Cement Grout
15	17	Bentonite	Other Bentonite		Hydrated Bentonite Chip
17	50	Filter Pack	Other Gravel Pack		2/12 Filter Sand

Other Observations:

Borehole Specifications

Depth from Surface Feet to Feet		Borehole Diameter (inches)
0	50	10

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name A B C LIOVIN DRILLING INC
Person, Firm or Corporation

1180 E BURNETT STREET	SIGNAL HILL	CA	90755
Address	City	State	Zip

Signed *electronic signature received* — 03/12/2021 — 422904
C-57 Licensed Water Well Contractor — Date Signed — C-57 License Number

DWR Use Only

CSG #	State Well Number	Site Code	Local Well Number

N — Latitude Deg/Min/Sec

W — Longitude Deg/Min/Sec

TRS:

APN:

Borehole & Well Construction Log

eki environment & water

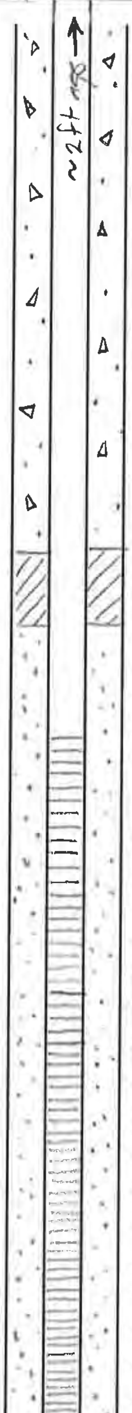
Borehole Location	Tejon Ranch - White Wolf
Drilling Company	ABC Liovan
Driller / Helper	Julio / Jose / Tony
Drilling Method(s)	Hollow-stem auger
Borehole Diameter (IN)	11" cutter, 9 5/8" augers
Isolation Casing	/ — From — To — FT
Blank Casing	4" Sch 40 PVC — From 20' To ~2' AGS FT
Perforated Casing	4" Sch 40 PVC 0.020" slot — From 50' To 20' FT
Size & Type of Filter Pack	#2/12 Cemex Lapis Lustre — From 50' To 17' FT
Seal	Wyoben Enviroplug med bentonite — From 17' To 15' FT
Grout	Type I/II/V Portland neat cement — From 15' To GS FT
Borehole/Well ID	RMW-ISWØ1
Project	White Wolf
Project Number	B60001.06 T3
Elevation and Datum	TOC = 2.4' ags
Total Depth	50'
Date Started	12 Jan 2021
Date Completed	→
Groundwater Depth	Final 18.81 ft bTOC
Logged By	J. Shaw
Sampling Methods	split spoon
Well Completion	[ ] Surface Housing [X] Standpipe 3 FT

Samples

Type	Recovery (feet)	Penetration Resist (Blows)	OVM Reading (ppmV)
HA	HA		
	1.5	10 10 0	
	1.5	9 9 10	
	2.0	12 12 [illegible]	
	1.5	11 10	
	1.0	8 11 12 10	
	0.5	12 12 13	
	1.0	15 13 13 15	
	1.5	13 13 12	
	1.9	10 12 14 16	
	1.2	– – –	
	1.2	15 15 20	
	2.0	13 13 17	
	1.2	17 12 12 14	
	1.5	50 60 17	
	1.8	14 14 15	
	1.5	17 15 15	
	1.5	22 14 15 15	
	2.0	– – –	
	1.5	10 10 12	
	1.5	9 9 12	
	2.0	10 12 14 16	

Depth (feet): 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40

Well Construction (or other notes)

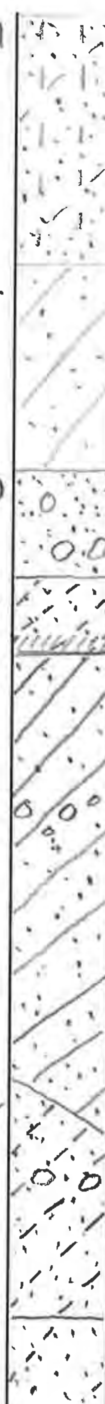


Poor recov.

hard drilling

Core wet @ 37 ft

Fill ?



USCS Log	Color	Sample Description and Drilling Remarks
SM	10YR 4/3	Silty sand w/ clay; brown; 20% silt, 10% clay; tr med-crs gravel; clasts qtz; tr. musc.; loose, dry.
CL	10YR 4/2	clay w/ sand; dk grey brn; 25% f-c sand; micaceous; str FeOx mott comm; moist.
SW	10YR 4/3	sand; brn; med-coarse; cobbles of decomp. granite; dry; poorly sort.
SC	10YR 6/4	clayey sand; lt. yell brn; 25% clay; 5% grvl; clasts decomp. granitic rx; altered aplite(?) w/ mafics chlorite?/hbl?; $CaCO_3$ on fx in clay-rich intvls, moist to dry. Clay rich intvls comm.
CL	10YR 7/4	Sandy clay; v. pale brn; 35% m-c sand, sand is decomp granitics; ang; mostly felds; rare cobbles; moist.
SC	10YR 7/3	Clayey sand; v. pale brn; 30% clay; hard; clasts decomp granitic rx comm; prob granodiorite; f-m grained; micaceous; felds wx; sand is f-c; ang; weak yell FeOx stain comm; moist.
SW	10YR 7/3	Sand w/ clay; v. pale brn; m-c ang sand; 10% clay; mostly decomp granitics; wet, dense, hard; →

Borehole & Well Construction Log

eki environment & water

Project Name: White Wolf **Project Number:** B50001.06 T3 **Borehole/Well Name:** RMW-15W01

Samples: Type	Recovery (feet)	Penetration Resist (Blows)	OVM Reading (ppmV)	Depth (feet)	WELL CONSTRUCTION (OR OTHER NOTES)	Fill ?	USCS Log	Stratigraphy	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
	13 15 17	1.5		40					SW	Sand w/clay (cont'd) intvls comm w/ incr clay; some intvls v. compacted; moist-wet. poor sort; qtz cobbles. @ 45 ft core v. wet, sat'd.
	12 12 16	1.5		42						
	13 13 17 17	2.0		44	core sat'd					
	9 9 12	1.5		46						
	6 6 12	1.5		48						
	9 12 14 16	1.0		50	Threaded cap 0.6 ft			TD 1105		

SHEET 2 OF 2

Borehole & Well Construction Log

eki environment & water

		From	To (FT)
BOREHOLE LOCATION	Tejon Ranch, near feedlot		
DRILLING COMPANY	ABC Liovin		
DRILLER / HELPER	Julio / Jose / Tony		
DRILLING METHOD(S)	Hollow-stem auger		
BOREHOLE DIAMETER (IN)	11" cutter, 9 5/8" auger		
ISOLATION CASING	none	—	—
BLANK CASING	4" Sch. 40 PVC		
PERFORATED CASING	4" Sch. 40 PVC, 0.020" slot	50	20
SIZE & TYPE OF FILTER PACK	#2/12 Monterey Lapis Lustre	50	17
SEAL	Wyoben med bentonite chips	17	15
GROUT	Type I/II/V Portland neat cement	15	0.5

Borehole/Well ID:	RMW-ISW02
Project:	White Wolf
Project Number:	B50001.06
ELEVATION AND DATUM	TOC = 1.9' ags
TOTAL DEPTH	50 ft bgs
DATE STARTED	13 Jan 2021
DATE COMPLETED	→
GROUNDWATER DEPTH	final 16.5 ft bTOC
LOGGED BY	J. Shaw
SAMPLING METHODS	split spoon
WELL COMPLETION	[ ] SURFACE HOUSING; [X] STANDPIPE 3 FT

SAMPLES

Type	Recovery (feet)	Penetration Resist (Blows)	OVM Reading (ppmV)
HA	HA		
	1.5	7 7 10 8	
	1.5	9 12	
	2.0	7 8 9 10	
	1.2	8 9 10	
	1.5		
	1.2	9 10 11 13	
	1.5	7 7 9	
	1.5	10 10 12	
	1.5	9 9 12 14	
	1.2	7 7	
	1.5	9 5 5 7	
	2.0	7 12 11 14	
	1.2	9 9 11	
	1.5	11 12	
	0.8	10 10 12	
	1.0	14 9 9 11	
	0.2	12 12	
	1.3	12 12 14 16	
	0.2	7 11 16	
	1.0	14 14	
	2.0	16 13 13 14 16	

Depth (feet): 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40

WELL CONSTRUCTION (OR OTHER NOTES):
- +2 ft ags (TOC)
- initial? ▽
- Poor recov.
- rig chatter
- rig chatter

USCS Log	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
CL	10YR4/3	Clay w/Sand; brown, sand is f-m; micaceous; 20% moist to dry
SC	2.5Y 5/3	Sand w/Clay; lt. olive brn; m-c; sec CaCO3; 15% clay grains ang; feld comm; mod dense; moist to wet.
SW	10YR4/1, 10YR4/3	Sand, dk grey; m-c; ang felds + mica comm; wet. finer w depth; ox intvl @16-21 ft; (brn).
		@ 22 ft $CaCO_3$ cntx
SW	10YR4/2	Sand w/Gravel; dk grey, 10% f-c gravel; rare lithic cobbles; sand sr-ang; predom qtz + feld; cobbles qtz & mtm lithic frags; loose wet.
		@ 31-35 ft incr. clay to 5%, core has minor cohesion

Borehole & Well Construction Log

eki environment & water

Project Name: White Wolf **Project Number:** B50001.06 T3 **Borehole/Well Name:** RMW-ISW02

SAMPLES Type	SAMPLES Recovery (feet)	SAMPLES Penetration Resist (Blows)	OVM Reading (ppmV)	Depth (feet)	WELL CONSTRUCTION (OR OTHER NOTES)	Fill ?	USCS Log	Stratigraphy	Color	SAMPLE DESCRIPTION and DRILLING REMARKS
	1.2	14 16 18		40						Sand w/Gravel; cont'd
	1.5	9 9 11		42						@ 42-43 ft clay rich intvl
	2.0	11 14 16 21		44					10YR 7/3	Sand w/Clay; v. pale brn; 10% clay; dense; sand f-c; ang-sr; wet;
	1.5	13 13 15		46						
	1.5	10 14 16								
	2.0	14 16 17 21		48						
				50	Threaded cap 0.6 ft			TD@1105		

SHEET 2 OF 2

Borehole & Well Construction Log

eki environment & water

		From	To
BOREHOLE LOCATION	Tejon Ranch, N. well loc		
DRILLING COMPANY	ABC Liovin Drilling		
DRILLER / HELPER	Julio/Jose/Tony		
DRILLING METHOD(S)	Hollow-Stem Auger		
BOREHOLE DIAMETER (IN)	9 5/8" augers		
ISOLATION CASING	none	—	—
BLANK CASING	4" Sch. 40 PVC	20'	+2' ags
PERFORATED CASING	4" Sch. 40 PVC, 0.020" slots	50'	20'
SIZE & TYPE OF FILTER PACK	#2/12 Monterey Lapis Lustre	50'	17'
SEAL	Wyoben med bentonite chips	17'	15'
GROUT	Type I/II/V Portland neat cement	15'	GS

Borehole/Well ID	RMW-ISW03
Project	White Wolf
Project Number	B50001.06T3
ELEVATION AND DATUM	TOC = 2.4' ags
TOTAL DEPTH	50'
DATE STARTED	14 Jan 2021 →
DATE COMPLETED	
GROUNDWATER DEPTH	final 34.18 ft bTOC
LOGGED BY	J. Shaw
SAMPLING METHODS	split spoon
WELL COMPLETION	[ ] SURFACE HOUSING [x] STANDPIPE 3 FT

Type	Recovery (feet)	Penetration Resist (Blows)	OVM Reading (ppmV)	Depth (feet)	Well Construction (or other notes)	Fill?	USCS Log	Stratigraphy	Color	Sample Description and Drilling Remarks
HA	HA	—		0–5			SW		10YR 4/2	Sand; dk grey brn; f-c; qtz + musc comm; loose; dry to sl. moist; rare ang qtz + granitic gravels; sand poorly sorted.
	1.5	3, 4, 7		5						
	1.5	5, 5, 7		6.5						
	2.0	7, 8, 7		8						
	1.5	9, 5, 5		9.5						
	1.5	7, 7, 8		11			CL		10YR 4/3	Clay; brown; plastic; stiff; 10% f-c sand; moist.
	2.0	9, 9, 11, 14		12.5						
	1.2	9, 9, 11		14.5			SW		10YR 8/4	Sand; v. pale brn; m-c ang grains, predom qtz in CaCO3 matrix; str. rxn HCl; moist.
	1.0	12, 12, 14		16						
	1.3	11, 14, 17, 18		17.5			SW		10YR 6/1	Gravel w/Sand; grey; sa-ang clasts; granitic; f-m grav; 30% f-m sand; bimodal; dry to moist; color chg to yellow @ 19 ft; FeOx stain comm; grav to 1.5-in diam.
	Ø	9, 9, 11		19.5	No recov. Rig chatter					
	1.1	10, 15, 21		21						
	1.5	30, 50		22.5	Hard drilling, slow					
	1.2	20, 20, 30		24.5			SW		10YR 5/4	Sand w/Gravel; yell-brn; f-c; a-sa grains; biotite common; 20% f-m a-sa gravel; predom grano-diorite (?) clasts to 3/4-in
	0.5	50/4		26	Poor recov.					
	1.5	50, 50, 50		28						Cobbles & Boulders ??
	0.2	50		30	Poor recov. On boulder? Rig chatter v. slow					(no recov) @31' cored fg qtz + musc ig intrusive;
	0.1	50		31.5						
	0.1	50		33						
NR	NR			35–40	Drilled only, no split spoon 35'-40' in boulders					No Recovery 35'-40'

Borehole & Well Construction Log

eki environment & water

Project Name: White Wolf **Project Number:** B50001.06 **Borehole/Well Name:** RMW-ISW03

Samples: Type	Samples: Recovery (feet)	Samples: Penetration Resist (Blows)	OVM Reading (ppmV)	Depth (feet)	Well Construction (or other notes)	Fill ?	USCS Log	Stratigraphy	Color	Sample Description and Drilling Remarks
	0.2			40	initial ▽		SW		5YR5/6	Sand w/Gravel; yell-red; 15% c sr-ang gravel; sand is m-c; grains predom qtz + lithic frags; dense; wet; @ 43 ft color chg to yell-brn, wet.
	0.8			42						
	1.4	10 10 15 15		44						
	1.3	15 18 21 50		46			SC		10YR6/4	Sand w/clay; lt. yell-brn 10% clay; f-c sand, sr-sa grains; dense; qtz + bio comm; moist to wet. 5% c. gravel.
	1.0	70 21 50		48						
	0.5			50				TD 1425		
				52						
				54						
				56						
				58						
				60						
				62						
				64						
				66						
				68						
				70						
				72						
				74						
				76						
				78						
				80						
				82						
				84						
				86						
				88						

Attachment 3

Well Development Logs

Well Purging & Sampling Data

eki environment & water

PROJECT: White Wolf	DATE: 18 Jan 2021	Well ID: DMW-ISW01	
PROJECT No: B50001.06	PERSONNEL: JRS, SX, LY	PURPOSE: ☐ Sampling ☒ Development	
Pump: Proactive submersible	FIELD INSTRUMENT CALIBRATION:	WELL VOLUME CALCULATION:	
Intake Depth: 51 ft bTOC	Parameter / Standard / Field Measurement	Well Casing Diameter = 4 (in)	
Discharge Tubing: ½" OD	pH (1): 4.00 / 3.99	Total Casing Depth: = 52.02 (ft)	
Sounder: Geotech 300S	pH (2): 10.00 / 10.01	Initial Depth to Water: - 18.81 (ft)	
WQ Meter #1: Myron L 6PFCE	Elec Cond: 3900 uS / 3900 uS	Water Column: = 33.21 (ft)	
WQ Meter #2: HF Sci DRT-15CE	Turbidity: 100 NTU / 97.1 NTU	Multiplier (gal / ft): x 0.65	3/4"=0.023, 1"=0.041, 2"=0.16, 4"=0.65, 12"=5.9
Start & End Time: 1000/1700	Other: T2 1000 / 950 NTU	Casing Volume: = 21.6 (gals)	
[Sp. Cap.]₁ (gpm/ft): 0.1 @ t₁ (min): 100	[Sp. Cap.]₂ (gpm/ft) @ t₂ (min)	Volume Purged: (gals) (CVs)	

Samples Collected / Well Location / Site Conditions / Other:

Top of Casing Height (+) or Depth (-), relative to ground surface: + 2.4' ags

Screened Interval (ft bgs): 50' - 20'

Final Depth to Water (ft bTOC):

Clock Time	Purge Rate (gpm)	Depth to water (feet)	Volume Purged (gal)	Temp (°C) [± 0.2]	Elec. Cond. (µS/cm) [±5% if≤100] [±3% if>100]	pH [± 0.1]	Turbidity (NTU) [±10% if>10]	DO (mg/L) [± 0.2]	ORP (mV) [± 10]	Activity / Notes / Other
1000	—	18.81								Start surging
1035	—	—								Bail 1 CV
1048	2.5	34.21								Start purge #1
1052	1.5	34.49								
1055	"	—	~25	20.3	773	8.27	~~299~~	—	+188	Erroneous Turbid.
1100	0.83	36.40	—	—	—	—	—	—	—	
1108	—	38.28	~40	21.3	754	8.23	~~334~~	—	+179	
1119	0.94	40.40	~50	—	—	—	~~240~~	—	—	
1132	—	—	—	21.3	655	7.56	>1000	—	—	Turb more likely
1137	0.81	43.69	~65	—	—	—		—	—	
1140	—	44.41	—	—	—	—	—	—	—	
1150	Ø	~45	—	—	—	—	—	—	—	Shut off pump
1214	Ø	37.23	—	—	—	—	—	—	—	
1255	Ø	28.89	—	—	—	—	—	—	—	Pull pump; surge
1325	—	—	—	—	—	—	—	—	—	Bail (purge #2)
1336	Ø	~46	—	—	—	—	—	—	—	Recovery
1401	Ø	34.60	~110	—	—	—	—	—	—	
1420	Ø	30.00	—	—	—	—	—	—	—	
1432	Ø	27.37	—	—	—	—	—	—	—	Begin surge #3
1502	Ø	22.05	—	—	—	—	—	—	—	Stop surge; bail
1506	0.43	~25	—	—	—	—	—	—	—	Purge #3, pump ~50ft
1512	—	25.74	—	—	—	—	—	—	—	
1514	—	—	—	23.0	675	8.20	>1000	—	+92	
1522	0.45	27.01	~122	23.0	652	8.01	>1000	—	+192	
1535	0.47	28.35	~127	22.8	656	7.86	>1000	—	+252	
1547	0.46	29.34	~131	22.5	648	7.83	>1000	—	+271	
1553	3.0	—	—	—	—	—	—	—	—	Incr. Q to 3gpm
1557	—	35.1	~145	22.1	634	7.90	>1000	—	+278	
1603	—	43.4	—	—	—	—	—	—	—	
1607	1.9	~48	~162	21.6	654	7.99	>1000	—	+242	Stop purge #3
1610	Ø	48.55	—	—	—	—	—	—	—	
1622	Ø	42.65	—	—	—	—	—	—	—	

Additional Notes:

1 gal = 3785 mL

Well Purging & Sampling Data

eki environment & water

PROJECT: White Wolf	DATE: 18 Jan 2021	Well ID: RMW-ISWØ1
PROJECT No: B50001.06	PERSONNEL: JRS, SX, LY	PURPOSE: ☐ Sampling ☒ Development

Clock Time	Purge Rate ( )	Depth to water (feet)	Volume Purged (gal)	Temp. (°C) [± 0.2]	Elec. Cond. (µS/cm) [±5% if≤100] [±3% if>100]	pH [± 0.1]	Turbidity (NTU) [±10% if<100]	DO (mg/L) [± 10%]	ORP (mV) [± 10%]	Activity / Notes / Other
1642	Ø	36.53	162	—	—	—	—	—	—	disch line set
1644	2.5	-	—	20.7	608	7.61	~1450	—	245	Purge #4
1648	—	41.6	—	21.2	620	7.75	~1300	—	256	
1650	2.3	45.2		21.0	612	7.81	~1370	—	266	
1651	—	~47	~177	—	—	—	—	—	—	pump dewatered (~8.2 CVs)

Additional Notes:

Well Purging & Sampling Data

eki environment & water

PROJECT: White Wolf	DATE: 19 Jun 2021	Well ID: RMW-ISWØ2
PROJECT No: B50001.06	PERSONNEL: JRS	PURPOSE: ☐ Sampling ☒ Development
Pump: Proactive submersible	FIELD INSTRUMENT CALIBRATION:	WELL VOLUME CALCULATION:
Intake Depth: 50 ft bTOC	Parameter / Standard / Field Measurement	Well Casing Diameter = 4 (in.)
Discharge Tubing: 1/2" OD PE	pH (1): 4.00 / 4.01	Total Casing Depth: = 52.90 (ft)
Sounder: Geotech 300'	pH (2): 7.00 / 7.00	Initial Depth to Water: - 16.56 (ft)
WQ Meter #1: Myron L 6PFCE	Elec Cond: 3900 / 3899	Water Column: = 36.34 (ft)
WQ Meter #2: HF Sci DRT-15CE	Turbidity: 1000 / 902	Multiplier (gal / ft): x 0.65 (3/4"=0.023, 1"=0.041, 2"=0.16, 4"=0.65, 12"=5.9)
Start & End Time: 0730 /	Other:	Casing Volume: = 23.6 (gals)
[Sp. Cap.]₁ (gpm/ft): @ t₁ (min):	[Sp. Cap.]₂ (gpm/ft): @ t₂ (min):	Volume Purged: (gals) (CVs)

Samples Collected / Well Location / Site Conditions / Other:

Top of Casing Height (+) or Depth (-), relative to ground surface: + 1.9' ags

Screened Interval (ft bgs): 20' - 50'

Final Depth to Water (ft bTOC):

Clock Time	Purge Rate (gpm)	Depth to water (feet)	Volume Purged (gal)	Temp. (°C) [± 0.2]	Elec. Cond. (µS/cm) [±5% if≤100] [±3% if>100]	pH [± 0.1]	Turbidity (NTU) [±10% if>10]	DO (mg/L) [± 0.2]	ORP (mV) [± 10]	Activity / Notes / Other
0730	Ø	16.56	Ø	—	—	—	—	—	—	Initial bail
0802	—	~48	38	—	—	—	—	—	—	Start recov
0815	Ø	28.2	—	—	—	—	—	—	—	Recovered 20 ft +/-
0828	Ø	23.98	—	—	—	—	—	—	—	Recovering
0835	Ø	—	—	—	—	—	—	—	—	Surge
0900	—	—	—	—	—	—	—	—	—	Start bailing #2
0905	Ø	~47	72	—	—	—	—	—	—	Stop bail; recov #2
0925	Ø	28.1	—	—	—	—	—	—	—	Recovering
0940	3.0	22.5	—	—						Start purge #3
0942	—	—	—	18.4	875	8.17	>1000	—	-7?	
0944	—	29.56	7?	—	—	—	—	—	—	
0950	2.5	37.64	—	—	—	—	—	—	—	
0952	—	42.6	—	18.9	911	7.56	—	—	+94	
0954	—	—	—	—	—	—	—	—	—	
0958	Ø	49.5	114	—	—	—	>1000	—	—	Stop purge;
1013	Ø	33.65	—	—	—	—	—	—	—	Recovering
1035	Ø	23.18	—	—	—	—	—	—	—	
1036	3.0	—	114	20.3	844	7.65	>1000	—	+93	Purge #4
1041	3.0	33.6	129	19.3	833	7.77	1240	—	+122	
1047	2.5	41.9	144	19.4	837	7.89	1424	—	+91	
1053	Ø	49.2	159	—	—	—	—	—	—	Stop purge #4
1124	Ø	25.58	—	—	—	—	—	—	—	Recovering
1125	3.0	25.00	159	19.2	831	7.71	1419	—	+162	Start purge
1132	3.0	—	180	19.9	820	7.88	612	—	+204	Recovery
1134	—	39.4	—	—	—	—	—	—	—	
1139	3.0	—	—	—	—	—	—	—	—	
1142	Ø	49.4	—	—	—	—	—	—	—	Stop purge #5
1154	Ø	36.6	—	—	—	—	—	—	—	
1220	Ø	22.28	—	—	—	—	—	—	—	
1222	3.0	—	180	20.5	810	7.69	520	—	+139	Start purge #6
1226	3.0	31.9	192	20.8	805	7.92	204	—	—	
1230	3.0	38.2	204	20.8	807	7.99	495	—	+197	

Additional Notes:

1 gal = 3785 mL

Well Purging & Sampling Data

eki environment & water

PROJECT:	DATE:	Well ID:
PROJECT No:	PERSONNEL:	PURPOSE: ☐ Sampling ☐ Development

Clock Time	Purge Rate ( )	Depth to water (feet)	Volume Purged ( )	Temp. (°C) [± 0.2]	Elec. Cond. (µS/cm) [±5% if≤100] [±3% if>100]	pH [± 0.1]	Turbidity (NTU) [±10% if<100]	DO (mg/L) [± 10%]	ORP (mV) [± 10%]	Activity / Notes / Other
1236	3.0	45.70	222	20.7	792	7.98	440	–	+198	still purge #6
1239	∅	49.6	231	–	–	–	–	–	–	stop pump

Additional Notes:

Well Purging & Sampling Data

eki environment & water

PROJECT: White Wolf	DATE: 19 Jan 2021	Well ID: RMW-ISW03
PROJECT No: B50001.06	PERSONNEL: JRS	PURPOSE: ☐ Sampling ☒ Development
Pump: Proactive submers.	FIELD INSTRUMENT CALIBRATION:	WELL VOLUME CALCULATION:
Intake Depth:	Parameter / Standard / Field Measurement	Well Casing Diameter = 4 (in.)
Discharge Tubing: 1/2" OD PE	pH (1): (calib this a.m.;	Total Casing Depth: = 52.69 (ft)
Sounder: Geotech 300'	pH (2): See sheet for	Initial Depth to Water: - 34.18 (ft)
WQ Meter #1: Myron L 6PFCE	Elec Cond: RMW-ISW02)	Water Column: = 18.51 (ft)
WQ Meter #2: HF Sci DRT-15CE	Turbidity:	Multiplier (gal / ft): x 0.65 (3/4"=0.023; 1"=0.041; 2"=0.16; 4"=0.65; 12"=5.9)
Start & End Time: 1330/	Other:	Casing Volume: = 12.0 (gals)
[Sp. Cap.]₁ (gpm/ft): @ t₁ (min)	[Sp. Cap.]₂ (gpm/ft): @ t₂ (min)	Volume Purged: (gals) (CVs)

Samples Collected / Well Location / Site Conditions / Other:

Top of Casing Height (+) or Depth (-), relative to ground surface: + 2.4' ags

Screened Interval (ft bgs): 20 - 50

Final Depth to Water (ft bTOC): 50.1 (after purge)

Clock Time	Purge Rate (gpm)	Depth to water (feet)	Volume Purged (gal)	Temp. (°C) [± 0.2]	Elec. Cond. (µS/cm) [±5% if≤100] [±3% if>100]	pH [± 0.1]	Turbidity (NTU) [±10% if>10]	DO (mg/L) [± 0.2]	ORP (mV) [± 10]	Activity / Notes / Other
1335	Ø	34.18	Ø	—	—	—	—	—	—	Initial
1338	Ø	—	Ø	—	—	—	—	—	—	Begin surge #1
1355	—	—	—	—	—	—	—	—	—	Bail #1
1410	~1.9	50.8	28	—	—	—	—	—	—	Bailed dry; recov.
1428	Ø	36.0	—	—	—	—	—	—	—	Surge #2
1444	Ø	34.61	—	—	—	—	—	—	—	Bail #2
1453	~3.0	—	55	—	—	—	—	—	—	Bailing
1502	~3.0	49.9	~84	—	—	—	—	—	—	Recov #2
1522	Ø	34.95	—	—	—	—	—	—	—	Recovered
1525	3.0	—	~84	19.7	947	7.64	743	—	+13	Purge #3
1527	3.0	39.5	~93	19.[illegible]	901	7.84	795	—	+200	
1534	3.0	45.0	~111	—	—	—	—	—	—	
1535	—	—	—	19.3	908	7.82	830	—	+12	
1538	2.5	—	~117	19.4	922	7.93	203	—	+50	
1540	Ø	49.0	~122	—	—	—	—	—	—	Stop purge #3
1553	Ø	36.0	—	—	—	—	—	—	—	Recovered
1554	3.0	—	122	19.2	893	8.12	90	—	+36	Purge #4
1557	3.0	—	131	19.5	889	7.68	83	—	+148	
1600	2.5	41.4	139	—	—	—	—	—	—	
1602	2.5	—	144	19.5	888	7.84	363	—	+53	(near BOW)
1607	2.5	50.1	157	19.5	891	7.99	118		+51	End Purge #4

Additional Notes:

1 gal = 3785 mL

Attachment 4

Well Purging and Sampling Logs

Well Purging & Sampling Data

eki environment & water

PROJECT: White Wolf	DATE: 31 Mar 2021	Well ID: RMW-IJW01	
PROJECT No: B50001.06	PERSONNEL: JRS	PURPOSE: ☒ Sampling ☐ Development	
Pump: Proactive Mini Monsoon	FIELD INSTRUMENT CALIBRATION:	WELL VOLUME CALCULATION:	
Intake Depth: ~48 ft bTOC	Parameter / Standard / Field Measurement	Well Casing Diameter = 4.0 (in.)	
Discharge Tubing: ½" PE	pH (1): 4.00 / 3.98 pH	Total Casing Depth: = 52.02 (ft)	
Sounder: Geotech 300'	pH (2): — / —	Initial Depth to Water: - 18.70 (ft) w/pump	
WQ Meter #1: Horiba U-5000	Elec Cond: 4,490 / 4,540 uS/cm	Water Column: = 33.32 (ft)	
WQ Meter #2: n/a	Turbidity: 0.0 / 1.1 NTU	Multiplier (gal / ft): x 0.65	3/4"=0.023; 1"=0.041; 2"=0.16; 4"=0.65; 12"=5.9
Start & End Time: 1230 → 1350	Other: — / —	Casing Volume: = 21.6 (gals)	
[Sp. Cap.]$_1$ (gpm/ft): @ t_1 (min):	[Sp. Cap.]$_2$ (gpm/ft): @ t_2 (min):	Volume Purged: 9.7 (gals) 0.45 (CVs)	

Samples Collected / Well Location / Site Conditions / Other:
Cations; Anions; Alk.; TDS; 1,2,3-TCP; As; Se; 18O & 2H isotopes

Top of Casing Height (+) or Depth (-), relative to ground surface: +2.4 ft ags

Screened Interval (ft bgs): 20-50 ft bgs

Final Depth to Water (ft bTOC): ~23 ft bTOC

Clock Time	Purge Rate (mL/m)	Depth to water (feet)	Volume Purged (gal)	Temp. (°C) [± 0.2]	Elec. Cond. (µS/cm) [±5% if≤100] [±3% if>100]	pH [± 0.1]	Turbidity (NTU) [±10% if>10]	DO (mg/L) [± 0.2]	ORP (mV) [± 10]	Activity / Notes / Other
1135	Ø	18.65	Ø	—	—	—	—	—	—	Pump in.
1227	Ø	18.76	Ø	—	—	—	—	—	—	Recov from displacement
1230	1,000	—	—	—	—	—	—	—	—	
1237	400	—	1.2	—	—	—	—	—	—	
1244	1,000	21.30	2.2	27.0	649	7.22	58.4	11.3	262	
[illegible]	460	21.82	3.0	27.0	649	7.24	35.5	9.32	241	
1255	520	21.93	~~3.8?~~	28.1	650	7.25	35.5	8.70	227	
1301	440	22.06	4.8	28.0	652	7.26	36.8	9.27	221	
1315	500	22.13	6.2	28.6	645	7.27	33.7	9.61	219	
1321	500	22.36	7.1	28.0	642	7.28	36.5	9.12	218	
1326	500	22.45	7.6	28.3	643	7.28	34.2	8.42	218	
1331	500	22.50	8.5	28.7	644	7.28	33.0	7.80	218	
1340	500	—	9.7	—	—	—	—	—	—	Sample

Additional Notes: XD @ 35.2 ft bTOC

1 gal ≈ 3785 mL

Well Purging & Sampling Data

eki environment & water

PROJECT: White Wolf	DATE: 31 Mar 2021	Well ID: RMW-ISW02
PROJECT No: B50001.06	PERSONNEL: J. Shaw	PURPOSE: ☒ Sampling ☐ Development
Pump: Proactive Mini Monsoon	FIELD INSTRUMENT CALIBRATION:	WELL VOLUME CALCULATION:
Intake Depth: 48 ft bTOC	Parameter / Standard / Field Measurement	Well Casing Diameter = 4 (in.)
Discharge Tubing: 1/2" PE	pH (1): calibrated	Total Casing Depth: = 52.90 (ft)
Sounder: Geotech 300'	pH (2): earlier	Initial Depth to Water: - 15.67 (ft)
WQ Meter #1: Horiba U-5000	Elec Cond:	Water Column: = 37.23 (ft)
WQ Meter #2: —	Turbidity: (see RMW-ISW01)	Multiplier (gal / ft): x 0.65 (3/4"=0.023; 1"=0.041; 2"=0.16; 4"=0.65; 12"=5.9)
Start & End Time: 1537 -> 1655	Other:	Casing Volume: = 24.2 (gals)
[Sp. Cap.]₁ (gpm/ft): @ t₁ (min):	[Sp. Cap.]₂ (gpm/ft): @ t₂ (min):	Volume Purged: (gals) (CVs)

Samples Collected / Well Location / Site Conditions / Other: Cations; Anions; Alk.; TDS; 1,2,3-TCP; As; Se; isotopes (^{18}O + ^{2}H)

Top of Casing Height (+) or Depth (-), relative to ground surface: + 1.9 ft ags

Screened Interval (ft bgs): 20 - 50 ft bgs

Final Depth to Water (ft bTOC): 15.67 (pump out)

Clock Time	Purge Rate (mL/m)	Depth to water (feet)	Volume Purged (gal)	Temp. (°C) [± 0.2]	Elec. Cond. (µS/cm) [±5% if≤100] [±3% if>100]	pH [± 0.1]	Turbidity (NTU) [±10% if>10]	DO (mg/L) [± 0.2]	ORP (mV) [± 10]	Activity / Notes / Other
1530	Ø	15.67	—	—	—	—	—	—	—	
1537	1,200	—	—	—	—	—	—	—	—	Pump on
1544	600	-	—	—	—	—	—	—	—	Q is stable
1546	600	15.96	—	—	—	—	—	—	—	(not stable)
1549	800	15.96	—	26.6	864	6.95	5.2	5.01	342	
1556	500	16.06	3.5	25.6	864	6.93	12.2	3.80	301	stable (+/-)
1606	840	16.17	7.6	25.0	861	6.90	14.2	4.48	248	sev. Q adj.
1616	880	16.10	9.7	25.1	859	6.91	17.3	3.83	244	
1633	600	15.97	12.5	26.1	859	6.91	14.4	3.94	245	
1640	800	16.05	13.7	25.3	858	6.92	11.8	3.97	245	
1645	-	—	—	—	—	—	—	—	—	Sample
1655	-	—	15.5	-	—	—	—	—	—	pump off

Additional Notes: XD @ 31.3 ft bTOC

1 gal = 3785 mL

Well Purging & Sampling Data

eki environment & water

PROJECT: White Wolf	DATE: 1 Apr 2021	Well ID: RMW-ISW03	
PROJECT No: B50001.06	PERSONNEL: J. Shaw	PURPOSE: ☒ Sampling ☐ Development	
Pump: Proactive Mini Monsoon	FIELD INSTRUMENT CALIBRATION: (Check)	WELL VOLUME CALCULATION:	
Intake Depth: ~ 48 ft bTOC	Parameter / Standard / Field Measurement	Well Casing Diameter = 4" (in.)	
Discharge Tubing: 1/2" PE	pH (1): 6.98 / 6.73	Total Casing Depth: = 52.69 (ft)	
Sounder: Geotech 300'	pH (2): — / —	Initial Depth to Water: - 32.89 (ft)	
WQ Meter #1: Horiba U-500	Elec Cond: 7630 / 8770	Water Column: = 19.8 (ft)	
WQ Meter #2: —	Turbidity: — / —	Multiplier (gal / ft): x 0.65 (3/4"=0.023, 1"=0.041, 2"=0.16, 4"=0.65, 12"=5.9)	
Start & End Time: 1000 → 1130	Other: ORP 217 / 161	Casing Volume: = 12.87 (gals)	
[Sp. Cap.]₁ (gpm/ft): @ t₁ (min)	[Sp. Cap.]₂ (gpm/ft): @ t₂ (min)	Volume Purged: (gals) (CVs)	

Samples Collected / Well Location / Site Conditions / Other:
Cations; Anions; Alk.; TDS; 1,2,3-TCP; As, Se
isotopes (^{18}O + ^{2}H)

Top of Casing Height (+) or Depth (-), relative to ground surface: + 2.4 ft ags

Screened Interval (ft bgs): 50'-20' nom.

Final Depth to Water (ft bTOC): 32.92

Clock Time	Purge Rate (gpm)	Depth to water (feet)	Volume Purged (gal)	Temp. (°C) [± 0.2]	Elec. Cond (µS/cm) [±5% if≤100] [±3% if>100]	pH [± 0.1]	Turbidity (NTU) [±10% if>10]	DO (mg/L) [± 0.2]	ORP (mV) [± 10]	Activity / Notes / Other
1005	—	32.89	Ø	—	—	—	—	—	—	
1019	—	—	—	—	—	—	—	—	—	Pump on (Flow@TC)
1022	840	33.29	—	23.5	961	6.90	0.2	7.74	296	
1027	1,000	33.50	—	22.7	964	6.87	0.0	3.06	263	
1033	1,000	33.59	3.6	22.8	964	6.87	0.0	2.49	235	
1044	1,120	33.71	6.1	22.8	956	6.87	0.0	2.34	239	
1050	1,120	33.74	8.3	22.8	958	6.89	0.4	2.15	219	
1105	960	33.77	12.7	22.9	961	6.87	0.1	2.12	210	
1115	—	—	—	—	—	—	—	—	—	Sample
1127	1,800	34.00	—	—	—	—	—	—	—	
1129	Ø	—	17.8	—	—	—	—	—	—	Pump off
1243	Ø	32.92	—	—	—	—	—	—	—	final DTW

Additional Notes: XD @ 48.1 ft bTOC

1 gal = 3785 mL

Attachment 5

Laboratory Reports and Chain of Custody Records

Date of Report: 04/16/2021

Christina Lucero

EKI Environment & Water, Inc.
2001 Junipero Serra Blvd, Suite 300
Daly City, CA 94014

Client Project:	B50001.06T3
BCL Project:	White Wolf Basin GDE Monitoring Wells
BCL Work Order:	2110187
Invoice ID:	B413464

Enclosed are the results of analyses for samples received by the laboratory on 4/1/2021. If you have any questions concerning this report, please feel free to contact me.

Sincerely,

K Gamboa

Contact Person: Kristina Gamboa
Client Services Rep

Stuart Buttram
Technical Director

Certifications: CA ELAP #1186; NV #CA00014; OR ELAP #4032-001; AK UST101

Table of Contents

EKI Environment & Water, Inc. 21-1087 CHAIN OF CUSTODY RECORD

PAGE 1 OF 1

CONSULTING ENGINEERS AND SCIENTISTS 2001 Junipero Serra Blvd, Suite 300, Daly City, CA 94014 PHONE: 650-292-9100 http://www.ekiconsult.com

Project Name: White Wolf Basin GDE Monitoring Wells

Project / P.O. No.: B50001.06T3

Location: Arvin, CA

Sampled By: J. Shaw

Reporting:
Electronic Format: — Hard Copy Format: PDF
EPA Data Report Level: —
Please report results to the following people:
(1) Data Archive: labs@ekiconsult.com
(2) Christina Lucero: clucero@ekiconsult.com
(3) Jeff Shaw: jshaw@ekiconsult.com
(4)

Laboratory:
BC Laboratories
4100 Atlas Court
Bakersfield, CA 93313
(661) 327-4911

EKI COC No.: (YYYYMMDD-#) 20210331-1

Revision: ____ (A, B, C, D, etc.)
Date: By:

ANALYSES REQUESTED

Field Sample ID	Lab Sample No.	Date	Time	Matrix	Container Count & Type	EPA 200.8 Cations (Ca, Mg, Na, K)	SM2540C-1997 Total Dissolved Solids	SM2320B-1997 Alk (CO3, HCO3, OH, Total)	EPA 300.0 Anions (Cl, NO3, SO4)	EPA 524 1,2,3-TCP	EPA 200.8 As + Se, dissolved (c)	Extract and HOLD	HOLD	EXPECTED TURNAROUND TIME	Remarks
RMW-ISW01	-1	31 Mar 2021	1340	H_2O	500 mL PE	X								std.	unpreserved
↓		↓	↓	↓	1 L PE		X	X	X					↓	unpreserved
					3x 40mL VOAs					X					+ HCl
					500 mL PE + HNO_3						X				field-filtered
RMW-ISW02	-2		1645		500 mL PE	X									unpreserved
↓			↓		1 L PE		X	X	X						unpreserved
					3x 40mL VOAs					X					+ HCl
		↓	↓	↓	500 mL PE + HNO_3						X			↓	field-filtered

CHK BY DISTRIBUTION
GRC ~~AM~~ TKR
SUB OUT

SHORT HOLDING TIME
C+6 NO3 NO2 OP SS
DO Cl2 BOD MBAS COT

Special Instructions: 200.8 cations unpreserved (rinsed)

Relinquished by: (Signature/Affiliation)	Date & Time	Received by: (Signature/Affiliation or Carrier/Air Bill No.)
[signature] EKI	1 Apr 2021 1325	[signature] BCL
Relinquished by: (Signature/Affiliation) [signature]	Date & Time 4-1-21 1407	Received by: (Signature/Affiliation)
Relinquished by: (Signature/Affiliation)	Date & Time	Received by: (Signature/Affiliation)

WW WQ Analyses 2021-03-27.xlsx

Chain of Custody and Cooler Receipt Form for 2110187 Page 2 of 2

BC LABORATORIES INC. COOLER RECEIPT FORM Page 1 Of 1

Submission #: 21-10187

SHIPPING INFORMATION	SHIPPING CONTAINER	FREE LIQUID
Fed Ex ☐ UPS ☐ Ontrac ☐ Hand Delivery ☐ BC Lab Field Service ☒ Other ☐ (Specify)______	Ice Chest ☒ None ☐ Box ☐ Other ☐ (Specify)______	YES ☐ NO ☐ W / S

Refrigerant: Ice ☒ Blue Ice ☐ None ☐ Other ☐ Comments:

Custody Seals: Ice Chest ☐ Intact? Yes ☐ No ☐ Containers ☐ Intact? Yes ☐ No ☐ None ☒ Comments:

All samples received? Yes ☒ No ☐ All samples containers intact? Yes ☒ No ☐ Description(s) match COC? Yes ☒ No ☐

COC Received		
☒ YES ☐ NO	Emissivity: 0.97 Container: PE Thermometer ID: 208 Temperature: (A) 3.3 °C / (C) 3.3 °C	Date/Time 4/1/21 14: Analyst Init ___/SM

SAMPLE CONTAINERS	1	2	3	4	5	6	7	8	9	10
QT PE UNPRES	D	D								
4oz / 8oz / 16oz PE UNPRES	E	E								
2oz Cr+6										
QT INORGANIC CHEMICAL METALS										
INORGANIC CHEMICAL METALS 4oz / 8oz / 16oz	F	F								
PT CYANIDE										
PT NITROGEN FORMS										
PT TOTAL SULFIDE										
2oz. NITRATE / NITRITE										
PT TOTAL ORGANIC CARBON										
PT CHEMICAL OXYGEN DEMAND										
PtA PHENOLICS										
40ml VOA VIAL TRAVEL BLANK										
40ml VOA VIAL X(8)	A-C	A-C								
QT EPA 1664										
PT ODOR										
RADIOLOGICAL										
BACTERIOLOGICAL										
40 ml VOA VIAL- 504										
QT EPA 508/608/8080										
QT EPA 515.1/8150										
QT EPA 525										
QT EPA 525 TRAVEL BLANK										
40ml EPA 547										
40ml EPA 531.1										
8oz EPA 548										
QT EPA 549										
QT EPA 8015M										
QT EPA 8270										
8oz / 16oz / 32oz AMBER										
8oz / 16oz / 32oz JAR										
SOIL SLEEVE										
PCB VIAL										
PLASTIC BAG										
TEDLAR BAG										
FERROUS IRON										
ENCORE										
SMART KIT										
SUMMA CANISTER										

Comments:

Sample Numbering Completed By: W Date/Time: 4/1/21 1725

A = Actual / C = Corrected

Rev 21 05/23/2016

[S:\WPDocs\WordPerfect\LAB_DOCS\FORMS\SAMREC.rev 20]

EKI Environment & Water, Inc.
2001 Junipero Serra Blvd, Suite 300
Daly City, CA 94014

Reported: 04/16/2021 16:36
Project: White Wolf Basin GDE Monitoring Wells
Project Number: B50001.06T3
Project Manager: Christina Lucero

Laboratory / Client Sample Cross Reference

Laboratory	Client Sample Information			
2110187-01	**COC Number:**	20210331-1	**Receive Date:**	04/01/2021 14:07
	Project Number:	---	**Sampling Date:**	03/31/2021 13:40
	Sampling Location:	---	**Sample Depth:**	---
	Sampling Point:	RMW-ISW01	**Lab Matrix:**	Water
	Sampled By:	---	**Sample Type:**	Water
			Metal Analysis: 1-Field Filtered and Acidified	
2110187-02	**COC Number:**	20210331-1	**Receive Date:**	04/01/2021 14:07
	Project Number:	---	**Sampling Date:**	03/31/2021 16:45
	Sampling Location:	---	**Sample Depth:**	---
	Sampling Point:	RMW-ISW02	**Lab Matrix:**	Water
	Sampled By:	---	**Sample Type:**	Water
			Metal Analysis: 1-Field Filtered and Acidified	

EKI Environment & Water, Inc.
2001 Junipero Serra Blvd, Suite 300
Daly City, CA 94014

Reported: 04/16/2021 16:36
Project: White Wolf Basin GDE Monitoring Wells
Project Number: B50001.06T3
Project Manager: Christina Lucero

DHS Low Level 1,2,3-TCP by SRL 524M

BCL Sample ID: 2110187-01	**Client Sample Name:** RMW-ISW01, 3/31/2021 1:40:00PM							
Constituent	**Result**	**Units**	**PQL**	**MDL**	**Method**	**MB Bias**	**Lab Quals**	**Run #**
1,2,3-Trichloropropane	ND	ug/L	0.0050	0.00060	SRL 524M	ND		1

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID	Prep Method
1	SRL 524M	04/05/21 07:41	04/05/21 15:14	ADC	MS-V16	1	B104957	EPA 524.2

EKI Environment & Water, Inc. 2001 Junipero Serra Blvd, Suite 300 Daly City, CA 94014	**Reported:** 04/16/2021 16:36 Project: White Wolf Basin GDE Monitoring Wells Project Number: B50001.06T3 Project Manager: Christina Lucero

Water Analysis (General Chemistry)

BCL Sample ID: 2110187-01 **Client Sample Name:** RMW-ISW01, 3/31/2021 1:40:00PM

Constituent	Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Dissolved Calcium	**51**	**mg/L**	**0.10**	**0.016**	**EPA-200.7**	ND		1
Dissolved Magnesium	**16**	**mg/L**	**0.050**	**0.019**	**EPA-200.7**	ND		2
Dissolved Sodium	**45**	**mg/L**	**0.50**	**0.051**	**EPA-200.7**	ND		1
Dissolved Potassium	**4.0**	**mg/L**	**1.0**	**0.10**	**EPA-200.7**	ND		1
Bicarbonate	**210**	**mg/L**	**5.0**	**5.0**	**SM-2320B**	ND		3
Carbonate	ND	mg/L	2.5	2.5	SM-2320B	ND		3
Hydroxide	ND	mg/L	1.4	1.4	SM-2320B	ND		3
Total Alkalinity as CaCO3	**170**	**mg/L**	**4.1**	**4.1**	**SM-2320B**	ND		3
Chloride	**19**	**mg/L**	**0.50**	**0.13**	**EPA-300.0**	0.19		4
Nitrate as NO3	**28**	**mg/L**	**0.44**	**0.11**	**EPA-300.0**	ND		4
Sulfate	**82**	**mg/L**	**1.0**	**0.14**	**EPA-300.0**	ND		4
Total Dissolved Solids @ 180 C	**370**	**mg/L**	**20**	**10**	**SM-2540C**	ND	**A07**	5

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID	Prep Method
1	EPA-200.7	04/13/21 16:27	04/13/21 21:11	JRG	PE-OP4	1	B105827	200.7/ No Digest
2	EPA-200.7	04/13/21 16:27	04/14/21 15:02	JRG	PE-OP4	1	B105827	200.7/ No Digest
3	SM-2320B	04/07/21 07:00	04/07/21 15:22	RML	MET-1	1	B103161	No Prep
4	EPA-300.0	04/01/21 22:30	04/02/21 00:19	SAV	IC5	1	B104644	No Prep
5	SM-2540C	04/02/21 14:40	04/02/21 14:40	NW1	MANUAL	2	B104639	No Prep

EKI Environment & Water, Inc.	**Reported:** 04/16/2021 16:36
2001 Junipero Serra Blvd, Suite 300	Project: White Wolf Basin GDE Monitoring Wells
Daly City, CA 94014	Project Number: B50001.06T3
	Project Manager: Christina Lucero

Metals Analysis

BCL Sample ID: 2110187-01 **Client Sample Name:** RMW-ISW01, 3/31/2021 1:40:00PM

Constituent	Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Dissolved Arsenic	**3.8**	**ug/L**	**2.0**	**0.38**	**EPA-200.8**	ND		1
Dissolved Selenium	**3.0**	**ug/L**	**2.0**	**0.25**	**EPA-200.8**	ND		1

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID	Prep Method
1	EPA-200.8	04/07/21 08:47	04/09/21 11:08	KHS	PE-EL4	1	B104979	EPA 200.8 Dissolved

EKI Environment & Water, Inc. 2001 Junipero Serra Blvd, Suite 300 Daly City, CA 94014	**Reported:** 04/16/2021 16:36 Project: White Wolf Basin GDE Monitoring Wells Project Number: B50001.06T3 Project Manager: Christina Lucero

DHS Low Level 1,2,3-TCP by SRL 524M

BCL Sample ID: 2110187-02 **Client Sample Name:** RMW-ISW02, 3/31/2021 4:45:00PM

Constituent	Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
1,2,3-Trichloropropane	ND	ug/L	0.0050	0.00060	SRL 524M	ND		1

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID	Prep Method
1	SRL 524M	04/05/21 07:41	04/05/21 15:39	ADC	MS-V16	1	B104957	EPA 524.2

EKI Environment & Water, Inc. 2001 Junipero Serra Blvd, Suite 300 Daly City, CA 94014	**Reported:** 04/16/2021 16:36 Project: White Wolf Basin GDE Monitoring Wells Project Number: B50001.06T3 Project Manager: Christina Lucero

Water Analysis (General Chemistry)

BCL Sample ID: 2110187-02 **Client Sample Name:** RMW-ISW02, 3/31/2021 4:45:00PM

Constituent	Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Dissolved Calcium	**91**	**mg/L**	**0.10**	**0.016**	**EPA-200.7**	ND		1
Dissolved Magnesium	**25**	**mg/L**	**0.050**	**0.019**	**EPA-200.7**	ND		2
Dissolved Sodium	**31**	**mg/L**	**0.50**	**0.051**	**EPA-200.7**	ND		1
Dissolved Potassium	**3.5**	**mg/L**	**1.0**	**0.10**	**EPA-200.7**	ND		1
Bicarbonate	**340**	**mg/L**	**5.0**	**5.0**	**SM-2320B**	ND		3
Carbonate	ND	mg/L	2.5	2.5	SM-2320B	ND		3
Hydroxide	ND	mg/L	1.4	1.4	SM-2320B	ND		3
Total Alkalinity as CaCO3	**280**	**mg/L**	**4.1**	**4.1**	**SM-2320B**	ND		3
Chloride	**30**	**mg/L**	**0.50**	**0.13**	**EPA-300.0**	0.19		4
Nitrate as NO3	**27**	**mg/L**	**0.44**	**0.11**	**EPA-300.0**	ND		4
Sulfate	**84**	**mg/L**	**1.0**	**0.14**	**EPA-300.0**	ND		4
Total Dissolved Solids @ 180 C	**490**	**mg/L**	**33**	**17**	**SM-2540C**	ND	**A07**	5

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID	Prep Method
1	EPA-200.7	04/13/21 16:27	04/13/21 21:14	JRG	PE-OP4	1	B105827	200.7/ No Digest
2	EPA-200.7	04/13/21 16:27	04/14/21 15:04	JRG	PE-OP4	1	B105827	200.7/ No Digest
3	SM-2320B	04/07/21 07:00	04/07/21 15:28	RML	MET-1	1	B103161	No Prep
4	EPA-300.0	04/01/21 22:30	04/02/21 01:31	SAV	IC5	1	B104644	No Prep
5	SM-2540C	04/02/21 14:40	04/02/21 14:40	NW1	MANUAL	3.333	B104639	No Prep

EKI Environment & Water, Inc.
2001 Junipero Serra Blvd, Suite 300
Daly City, CA 94014

Reported: 04/16/2021 16:36
Project: White Wolf Basin GDE Monitoring Wells
Project Number: B50001.06T3
Project Manager: Christina Lucero

Metals Analysis

BCL Sample ID: 2110187-02 | **Client Sample Name:** RMW-ISW02, 3/31/2021 4:45:00PM

Constituent	Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Dissolved Arsenic	**1.5**	**ug/L**	**2.0**	**0.38**	**EPA-200.8**	ND	**J**	1
Dissolved Selenium	**1.8**	**ug/L**	**2.0**	**0.25**	**EPA-200.8**	ND	**J**	1

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID	Prep Method
1	EPA-200.8	04/07/21 08:47	04/09/21 11:10	KHS	PE-EL4	1	B104979	EPA 200.8 Dissolved

EKI Environment & Water, Inc.	**Reported:** 04/16/2021 16:36
2001 Junipero Serra Blvd, Suite 300	Project: White Wolf Basin GDE Monitoring Wells
Daly City, CA 94014	Project Number: B50001.06T3
	Project Manager: Christina Lucero

DHS Low Level 1,2,3-TCP by SRL 524M

Quality Control Report - Method Blank Analysis

Constituent	QC Sample ID	MB Result	Units	PQL	MDL	Lab Quals
QC Batch ID: B104957						
1,2,3-Trichloropropane	B104957-BLK1	ND	ug/L	0.0050	0.00060	

EKI Environment & Water, Inc.	**Reported:** 04/16/2021 16:36
2001 Junipero Serra Blvd, Suite 300	Project: White Wolf Basin GDE Monitoring Wells
Daly City, CA 94014	Project Number: B50001.06T3
	Project Manager: Christina Lucero

DHS Low Level 1,2,3-TCP by SRL 524M

Quality Control Report - Laboratory Control Sample

Constituent	QC Sample ID	Type	Result	Spike Level	Units	Percent Recovery	RPD	Control Limits Percent Recovery	Control Limits RPD	Lab Quals
QC Batch ID: B104957										
1,2,3-Trichloropropane	B104957-BS1	LCS	0.052090	0.050000	ug/L	104		80 - 120		

EKI Environment & Water, Inc.
2001 Junipero Serra Blvd, Suite 300
Daly City, CA 94014

Reported: 04/16/2021 16:36
Project: White Wolf Basin GDE Monitoring Wells
Project Number: B50001.06T3
Project Manager: Christina Lucero

DHS Low Level 1,2,3-TCP by SRL 524M

Quality Control Report - Precision & Accuracy

Constituent	Type	Source Sample ID	Source Result	Result	Spike Added	Units	RPD	Percent Recovery	Control Limits RPD	Control Limits Percent Recovery	Lab Quals
QC Batch ID: B104957	Used client sample: N										
1,2,3-Trichloropropane	MS	2108269-81	ND	0.048750	0.050000	ug/L		97.5		70 - 130	
	MSD	2108269-81	ND	0.046510	0.050000	ug/L	4.7	93.0	30	70 - 130	

EKI Environment & Water, Inc.
2001 Junipero Serra Blvd, Suite 300
Daly City, CA 94014

Reported: 04/16/2021 16:36
Project: White Wolf Basin GDE Monitoring Wells
Project Number: B50001.06T3
Project Manager: Christina Lucero

Water Analysis (General Chemistry)

Quality Control Report - Method Blank Analysis

Constituent	QC Sample ID	MB Result	Units	PQL	MDL	Lab Quals
QC Batch ID: B103161						
Bicarbonate	B103161-BLK1	ND	mg/L	5.0	5.0	
Carbonate	B103161-BLK1	ND	mg/L	2.5	2.5	
Hydroxide	B103161-BLK1	ND	mg/L	1.4	1.4	
Total Alkalinity as CaCO3	B103161-BLK1	ND	mg/L	4.1	4.1	
QC Batch ID: B104639						
Total Dissolved Solids @ 180 C	B104639-BLK1	ND	mg/L	6.7	3.3	
QC Batch ID: B104644						
Chloride	**B104644-BLK1**	**0.19200**	**mg/L**	**0.50**	**0.13**	**J**
Nitrate as NO3	B104644-BLK1	ND	mg/L	0.44	0.11	
Sulfate	B104644-BLK1	ND	mg/L	1.0	0.14	
QC Batch ID: B105827						
Dissolved Calcium	B105827-BLK1	ND	mg/L	0.10	0.016	
Dissolved Magnesium	B105827-BLK2	ND	mg/L	0.050	0.019	
Dissolved Sodium	B105827-BLK1	ND	mg/L	0.50	0.051	
Dissolved Potassium	B105827-BLK1	ND	mg/L	1.0	0.10	

EKI Environment & Water, Inc.	**Reported:**	04/16/2021 16:36
2001 Junipero Serra Blvd, Suite 300	Project:	White Wolf Basin GDE Monitoring Wells
Daly City, CA 94014	Project Number:	B50001.06T3
	Project Manager:	Christina Lucero

Water Analysis (General Chemistry)

Quality Control Report - Laboratory Control Sample

Constituent	QC Sample ID	Type	Result	Spike Level	Units	Percent Recovery	RPD	Control Limits Percent Recovery	Control Limits RPD	Lab Quals
QC Batch ID: B103161										
Total Alkalinity as CaCO3	B103161-BS3	LCS	102.23	100.00	mg/L	102		90 - 110		
QC Batch ID: B104639										
Total Dissolved Solids @ 180 C	B104639-BS1	LCS	600.00	586.00	mg/L	102		90 - 110		
QC Batch ID: B104644										
Chloride	B104644-BS1	LCS	50.680	50.000	mg/L	101		90 - 110		
Nitrate as NO3	B104644-BS1	LCS	22.404	22.134	mg/L	101		90 - 110		
Sulfate	B104644-BS1	LCS	100.15	100.00	mg/L	100		90 - 110		
QC Batch ID: B105827										
Dissolved Calcium	B105827-BS1	LCS	9.0684	10.000	mg/L	90.7		85 - 115		
Dissolved Magnesium	B105827-BS2	LCS	9.6446	10.000	mg/L	96.4		85 - 115		
Dissolved Sodium	B105827-BS1	LCS	9.5025	10.000	mg/L	95.0		85 - 115		
Dissolved Potassium	B105827-BS1	LCS	9.0058	10.000	mg/L	90.1		85 - 115		

EKI Environment & Water, Inc.	**Reported:**	04/16/2021 16:36
2001 Junipero Serra Blvd, Suite 300	Project:	White Wolf Basin GDE Monitoring Wells
Daly City, CA 94014	Project Number:	B50001.06T3
	Project Manager:	Christina Lucero

Water Analysis (General Chemistry)

Quality Control Report - Precision & Accuracy

Constituent	Type	Source Sample ID	Source Result	Result	Spike Added	Units	RPD	Percent Recovery	Control Limits RPD	Control Limits Percent Recovery	Lab Quals
QC Batch ID: B103161	Used client sample: N										
Bicarbonate	DUP	2110685-04	55.282	54.721		mg/L	1.0		10		
Carbonate	DUP	2110685-04	11.494	11.674		mg/L	1.6		10		
Hydroxide	DUP	2110685-04	ND	ND		mg/L			10		
Total Alkalinity as CaCO3	DUP	2110685-04	64.500	64.350		mg/L	0.2		10		
QC Batch ID: B104639	Used client sample: N										
Total Dissolved Solids @ 180 C	DUP	2110146-01	910.00	890.00		mg/L	2.2		10		
QC Batch ID: B104644	Used client sample: Y - Description: RMW-ISW01, 03/31/2021 13:40										
Chloride	DUP	2110187-01	19.399	19.478		mg/L	0.4		10		
	MS	2110187-01	19.399	75.746	50.505	mg/L		112		80 - 120	
	MSD	2110187-01	19.399	75.673	50.505	mg/L	0.1	111	10	80 - 120	
Nitrate as NO3	DUP	2110187-01	28.088	28.571		mg/L	1.7		10		
	MS	2110187-01	28.088	52.397	22.358	mg/L		109		80 - 120	
	MSD	2110187-01	28.088	52.464	22.358	mg/L	0.1	109	10	80 - 120	
Sulfate	DUP	2110187-01	82.008	81.779		mg/L	0.3		10		
	MS	2110187-01	82.008	194.71	101.01	mg/L		112		80 - 120	
	MSD	2110187-01	82.008	194.24	101.01	mg/L	0.2	111	10	80 - 120	
QC Batch ID: B105827	Used client sample: N										
Dissolved Calcium	DUP	**2110137-01**	**100.61**	**101.34**		**mg/L**	**0.7**		**20**		
	MS	**2110137-01**	**100.61**	**108.91**	**10.204**	**mg/L**		**81.3**		**85 - 115**	**A03**
	MSD	**2110137-01**	**100.61**	**110.98**	**10.204**	**mg/L**	**1.9**	**102**	**20**	**85 - 115**	
Dissolved Magnesium	DUP	2110137-01	30.811	31.108		mg/L	1.0		20		
	MS	2110137-01	30.811	50.514	20.408	mg/L		96.5		85 - 115	
	MSD	2110137-01	30.811	51.813	20.408	mg/L	2.5	103	20	85 - 115	
Dissolved Sodium	DUP	**2110137-01**	**282.52**	**282.04**		**mg/L**	**0.2**		**20**		
	MS	**2110137-01**	**282.52**	**288.26**	**10.204**	**mg/L**		**56.3**		**85 - 115**	**A03**
	MSD	**2110137-01**	**282.52**	**288.69**	**10.204**	**mg/L**	**0.1**	**60.4**	**20**	**85 - 115**	**A03**
Dissolved Potassium	DUP	2110137-01	28.846	28.971		mg/L	0.4		20		
	MS	2110137-01	28.846	37.793	10.204	mg/L		87.7		85 - 115	
	MSD	2110137-01	28.846	38.278	10.204	mg/L	1.3	92.4	20	85 - 115	

EKI Environment & Water, Inc.		**Reported:**	04/16/2021 16:36
2001 Junipero Serra Blvd, Suite 300		Project:	White Wolf Basin GDE Monitoring Wells
Daly City, CA 94014		Project Number:	B50001.06T3
		Project Manager:	Christina Lucero

Metals Analysis

Quality Control Report - Method Blank Analysis

Constituent	QC Sample ID	MB Result	Units	PQL	MDL	Lab Quals
QC Batch ID: B104979						
Dissolved Arsenic	B104979-BLK1	ND	ug/L	2.0	0.38	
Dissolved Selenium	B104979-BLK1	ND	ug/L	2.0	0.25	

EKI Environment & Water, Inc. 2001 Junipero Serra Blvd, Suite 300 Daly City, CA 94014	**Reported:** 04/16/2021 16:36 Project: White Wolf Basin GDE Monitoring Wells Project Number: B50001.06T3 Project Manager: Christina Lucero

Metals Analysis

Quality Control Report - Laboratory Control Sample

								Control Limits		
Constituent	**QC Sample ID**	**Type**	**Result**	**Spike Level**	**Units**	**Percent Recovery**	**RPD**	**Percent Recovery**	**RPD**	**Lab Quals**
QC Batch ID: B104979										
Dissolved Arsenic	B104979-BS1	LCS	97.559	100.00	ug/L	97.6		85 - 115		
Dissolved Selenium	B104979-BS1	LCS	97.822	100.00	ug/L	97.8		85 - 115		

EKI Environment & Water, Inc.
2001 Junipero Serra Blvd, Suite 300
Daly City, CA 94014

Reported: 04/16/2021 16:36
Project: White Wolf Basin GDE Monitoring Wells
Project Number: B50001.06T3
Project Manager: Christina Lucero

Metals Analysis

Quality Control Report - Precision & Accuracy

QC Batch ID: B104979 Used client sample: N

Constituent	Type	Source Sample ID	Source Result	Result	Spike Added	Units	RPD	Percent Recovery	Control Limits RPD	Control Limits Percent Recovery	Lab Quals
Dissolved Arsenic	DUP	**2110227-01**	**0.74500**	**0.95400**		**ug/L**	**24.6**		**20**		**J,A02**
	MS	**2110227-01**	**0.74500**	**107.04**	**102.04**	**ug/L**		**104**		**70 - 130**	
	MSD	**2110227-01**	**0.74500**	**109.41**	**102.04**	**ug/L**	**2.2**	**106**	**20**	**70 - 130**	
Dissolved Selenium	DUP	2110227-01	ND	ND		ug/L			20		
	MS	2110227-01	ND	113.80	102.04	ug/L		112		70 - 130	
	MSD	2110227-01	ND	115.88	102.04	ug/L	1.8	114	20	70 - 130	

EKI Environment & Water, Inc.		**Reported:**	04/16/2021 16:36
2001 Junipero Serra Blvd, Suite 300		Project:	White Wolf Basin GDE Monitoring Wells
Daly City, CA 94014		Project Number:	B50001.06T3
		Project Manager:	Christina Lucero

Notes And Definitions

J	Estimated Value (CLP Flag)
MDL	Method Detection Limit
ND	Analyte Not Detected
PQL	Practical Quantitation Limit
A02	The difference between duplicate readings is less than the quantitation limit.
A03	The sample concentration was more than 4 times the spike level.
A07	Detection and quantitation limits were raised due to sample dilution caused by high analyte concentration or matrix interference.

Date of Report: 04/16/2021

Christina Lucero

EKI Environment & Water, Inc.
2001 Junipero Serra Blvd, Suite 300
Daly City, CA 94014

Client Project:	B50001.06T3
BCL Project:	White Wolf Basin GDE Monitoring Wells
BCL Work Order:	2110188
Invoice ID:	B413468

Enclosed are the results of analyses for samples received by the laboratory on 4/1/2021. If you have any questions concerning this report, please feel free to contact me.

Sincerely,

K Gamboa

Contact Person: Kristina Gamboa
Client Services Rep

Stuart Buttram
Technical Director

Table of Contents

EKI Environment & Water, Inc. 21-10188 **CHAIN OF CUSTODY RECORD** PAGE 1 OF 1

CONSULTING ENGINEERS AND SCIENTISTS 2001 Junipero Serra Blvd, Suite 300, Daly City, CA 94014 PHONE: 650-292-9100 http://www.ekiconsult.com

Project Name: White Wolf Basin GDE Monitoring Wells

Project / P.O. No.: B50001.06T3

Location: Arvin, CA

Sampled By: J. Shaw

Reporting:

Electronic Format: Hard Copy Format: PDF

EPA Data Report Level:

Please report results to the following people:
(1) Data Archive: labs@ekiconsult.com
(2) Christina Lucero: clucero@ekiconsult.com
(3) Jeff Shaw: jshaw@ekiconsult.com
(4)

Laboratory:
BC Laboratories
4100 Atlas Court
Bakersfield, CA 93313
(661) 327-4911

EKI COC No.: (YYYYMMDD-#) 20210401-1

Revision: ____ (A, B, C, D, etc.)

Date: By:

ANALYSES REQUESTED

Method No.	Analyte / Group
EPA 200.8	Cations (Ca, Mg, Na, K)
SM2540C-1997	Total Dissolved Solids
SM2320B-1997	Alk (CO3, HCO3, OH, Total)
EPA 300.0	Anions (Cl, NO3, SO4)
EPA 524	1,2,3-TCP
EPA 200.8	As + Se, dissolved (c)

Field Sample ID	Lab Sample No.	Date	Time	Matrix	Container Count & Type	EPA 200.8 Cations	SM2540C-1997 TDS	SM2320B-1997 Alk	EPA 300.0 Anions	EPA 524 1,2,3-TCP	EPA 200.8 As + Se	Extract and HOLD	HOLD	Expected Turnaround Time	Remarks
RMW-ISW03	-1	1 Apr 2021	1115	H2O	500 mL PE	X								std	unpres.
↓		↓	↓	↓	1L PE		X	X	X					↓	unpres.
					3x 40 mL VOAs					X					+HCl
					500 mL PE+HNO3						X				field-filtered

CHK BY [initials] DISTRIBUTION MAINT OTCR SUB-OUT

SHORT HOLDING TIME
Cr6 NO2 NO3 OP SS
DO Cl2 BOD MBAS COT

Special Instructions:

Relinquished by: (Signature/Affiliation)	Date & Time	Received by: (Signature/Affiliation or Carrier/Air Bill No.)
[signature] EKI	1 Apr 2021 1325	[signature] BCL
Relinquished by: (Signature/Affiliation) [signature]	Date & Time 4-1-21 1407	Received by: (Signature/Affiliation)
Relinquished by: (Signature/Affiliation)	Date & Time	Received by: (Signature/Affiliation)

WW WQ Analyses 2021-03-27.xlsx

Chain of Custody and Cooler Receipt Form for 2110188 Page 2 of 2

BC LABORATORIES INC.

COOLER RECEIPT FORM

Submission #: 21-10188

Page 1 Of 1

SHIPPING INFORMATION
Fed Ex ☐ UPS ☐ Ontrac ☐ Hand Delivery ☐
BC Lab Field Service ☒ Other ☐ (Specify)

SHIPPING CONTAINER
Ice Chest ☒ None ☐ Box ☐
Other ☐ (Specify)

FREE LIQUID
YES ☐ NO ☐
W / S

Refrigerant: Ice ☒ Blue Ice ☐ None ☐ Other ☐ Comments:

Custody Seals: Ice Chest ☐ Intact? Yes ☐ No ☐ | Containers ☐ Intact? Yes ☐ No ☐ | None ☒ Comments:

All samples received? Yes ☒ No ☐ All samples containers intact? Yes ☒ No ☐ Description(s) match COC? Yes ☒ No ☐

COC Received ☒ YES ☐ NO

Emissivity: 0.97 Container: PE Thermometer ID: 208 Date/Time 4/1/21

Temperature: (A) 3.3 °C / (C) 3.3 °C Analyst Init JM/SM 14:

SAMPLE CONTAINERS	1	2	3	4	5	6	7	8	9	10
QT PE UNPRES	D									
4oz / 8oz / 16oz PE UNPRES	E									
2oz Cr+6										
QT INORGANIC CHEMICAL METALS										
INORGANIC CHEMICAL METALS 4oz / 8oz / 16oz	F									
PT CYANIDE										
PT NITROGEN FORMS										
PT TOTAL SULFIDE										
2oz. NITRATE / NITRITE										
PT TOTAL ORGANIC CARBON										
PT CHEMICAL OXYGEN DEMAND										
PtA PHENOLICS										
40ml VOA VIAL TRAVEL BLANK										
40ml VOA VIAL X18	A-C									
QT EPA 1664										
PT ODOR										
RADIOLOGICAL										
BACTERIOLOGICAL										
40 ml VOA VIAL- 504										
QT EPA 508/608/8080										
QT EPA 515.1/8150										
QT EPA 525										
QT EPA 525 TRAVEL BLANK										
40ml EPA 547										
40ml EPA 531.1										
8oz EPA 548										
QT EPA 549										
QT EPA 8015M										
QT EPA 8270										
8oz / 16oz / 32oz AMBER										
8oz / 16oz / 32oz JAR										
SOIL SLEEVE										
PCB VIAL										
PLASTIC BAG										
TEDLAR BAG										
FERROUS IRON										
ENCORE										
SMART KIT										
SUMMA CANISTER										

Comments:
Sample Numbering Completed By: W Date/Time: 4/1/21 1729
A = Actual / C = Corrected

Rev 21 05/23/2016
[S:\WPDoc\WordPerfect\LAB_DOCS\FORMS\SAMREC rev 21]

EKI Environment & Water, Inc.		**Reported:**	04/16/2021 16:42
2001 Junipero Serra Blvd, Suite 300		Project:	White Wolf Basin GDE Monitoring Wells
Daly City, CA 94014		Project Number:	B50001.06T3
		Project Manager:	Christina Lucero

Laboratory / Client Sample Cross Reference

Laboratory	Client Sample Information			
2110188-01	**COC Number:**	20210401-1	**Receive Date:**	04/01/2021 14:07
	Project Number:	---	**Sampling Date:**	04/01/2021 11:15
	Sampling Location:	---	**Sample Depth:**	---
	Sampling Point:	RMW-ISW03	**Lab Matrix:**	Water
	Sampled By:	---	**Sample Type:**	Water
			Metal Analysis:	1-Field Filtered and Acidified

EKI Environment & Water, Inc. 2001 Junipero Serra Blvd, Suite 300 Daly City, CA 94014	**Reported:** 04/16/2021 16:42 Project: White Wolf Basin GDE Monitoring Wells Project Number: B50001.06T3 Project Manager: Christina Lucero

DHS Low Level 1,2,3-TCP by SRL 524M

BCL Sample ID: 2110188-01 | **Client Sample Name:** RMW-ISW03, 4/1/2021 11:15:00AM

Constituent	Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
1,2,3-Trichloropropane	ND	ug/L	0.0050	0.00060	SRL 524M	ND		1

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID	Prep Method
1	SRL 524M	04/05/21 07:41	04/05/21 13:35	ADC	MS-V16	1	B104957	EPA 524.2

EKI Environment & Water, Inc. 2001 Junipero Serra Blvd, Suite 300 Daly City, CA 94014	**Reported:** 04/16/2021 16:42 Project: White Wolf Basin GDE Monitoring Wells Project Number: B50001.06T3 Project Manager: Christina Lucero

Water Analysis (General Chemistry)

BCL Sample ID: 2110188-01 **Client Sample Name:** RMW-ISW03, 4/1/2021 11:15:00AM

Constituent	Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Dissolved Calcium	**78**	**mg/L**	**0.10**	**0.016**	**EPA-200.7**	ND		1
Dissolved Magnesium	**34**	**mg/L**	**0.050**	**0.019**	**EPA-200.7**	ND		2
Dissolved Sodium	**54**	**mg/L**	**0.50**	**0.051**	**EPA-200.7**	ND		1
Dissolved Potassium	**5.4**	**mg/L**	**1.0**	**0.10**	**EPA-200.7**	ND		1
Bicarbonate	**450**	**mg/L**	**5.0**	**5.0**	**SM-2320B**	ND		3
Carbonate	ND	mg/L	2.5	2.5	SM-2320B	ND		3
Hydroxide	ND	mg/L	1.4	1.4	SM-2320B	ND		3
Total Alkalinity as CaCO3	**370**	**mg/L**	**4.1**	**4.1**	**SM-2320B**	ND		3
Chloride	**33**	**mg/L**	**0.50**	**0.13**	**EPA-300.0**	0.19		4
Nitrate as NO3	**11**	**mg/L**	**0.44**	**0.11**	**EPA-300.0**	ND		4
Sulfate	**66**	**mg/L**	**1.0**	**0.14**	**EPA-300.0**	ND		4
Total Dissolved Solids @ 180 C	**540**	**mg/L**	**33**	**17**	**SM-2540C**	ND	**A07**	5

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID	Prep Method
1	EPA-200.7	04/13/21 16:27	04/13/21 21:16	JRG	PE-OP4	1	B105827	200.7/ No Digest
2	EPA-200.7	04/13/21 16:27	04/14/21 15:06	JRG	PE-OP4	1	B105827	200.7/ No Digest
3	SM-2320B	04/07/21 07:00	04/07/21 15:34	RML	MET-1	1	B103161	No Prep
4	EPA-300.0	04/01/21 22:30	04/02/21 01:49	SAV	IC5	1	B104644	No Prep
5	SM-2540C	04/02/21 14:40	04/02/21 14:40	NW1	MANUAL	3.333	B104639	No Prep

EKI Environment & Water, Inc.	**Reported:** 04/16/2021 16:42
2001 Junipero Serra Blvd, Suite 300	Project: White Wolf Basin GDE Monitoring Wells
Daly City, CA 94014	Project Number: B50001.06T3
	Project Manager: Christina Lucero

Metals Analysis

BCL Sample ID: 2110188-01 | **Client Sample Name:** RMW-ISW03, 4/1/2021 11:15:00AM

Constituent	Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Dissolved Arsenic	**1.3**	**ug/L**	**2.0**	**0.38**	**EPA-200.8**	ND	**J**	1
Dissolved Selenium	ND	ug/L	2.0	0.25	EPA-200.8	ND		1

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID	Prep Method
1	EPA-200.8	04/07/21 08:47	04/09/21 11:12	KHS	PE-EL4	1	B104979	EPA 200.8 Dissolved

EKI Environment & Water, Inc. 2001 Junipero Serra Blvd, Suite 300 Daly City, CA 94014	**Reported:** 04/16/2021 16:42 Project: White Wolf Basin GDE Monitoring Wells Project Number: B50001.06T3 Project Manager: Christina Lucero

DHS Low Level 1,2,3-TCP by SRL 524M

Quality Control Report - Method Blank Analysis

Constituent	QC Sample ID	MB Result	Units	PQL	MDL	Lab Quals
QC Batch ID: B104957						
1,2,3-Trichloropropane	B104957-BLK1	ND	ug/L	0.0050	0.00060	

EKI Environment & Water, Inc.	**Reported:**	04/16/2021 16:42
2001 Junipero Serra Blvd, Suite 300	Project:	White Wolf Basin GDE Monitoring Wells
Daly City, CA 94014	Project Number:	B50001.06T3
	Project Manager:	Christina Lucero

DHS Low Level 1,2,3-TCP by SRL 524M

Quality Control Report - Laboratory Control Sample

Constituent	QC Sample ID	Type	Result	Spike Level	Units	Percent Recovery	RPD	Control Limits Percent Recovery	Control Limits RPD	Lab Quals
QC Batch ID: B104957										
1,2,3-Trichloropropane	B104957-BS1	LCS	0.052090	0.050000	ug/L	104		80 - 120		

EKI Environment & Water, Inc.
2001 Junipero Serra Blvd, Suite 300
Daly City, CA 94014

Reported: 04/16/2021 16:42
Project: White Wolf Basin GDE Monitoring Wells
Project Number: B50001.06T3
Project Manager: Christina Lucero

DHS Low Level 1,2,3-TCP by SRL 524M

Quality Control Report - Precision & Accuracy

Constituent	Type	Source Sample ID	Source Result	Result	Spike Added	Units	RPD	Percent Recovery	Control Limits RPD	Control Limits Percent Recovery	Lab Quals
QC Batch ID: B104957	Used client sample: N										
1,2,3-Trichloropropane	MS	2108269-81	ND	0.048750	0.050000	ug/L		97.5		70 - 130	
	MSD	2108269-81	ND	0.046510	0.050000	ug/L	4.7	93.0	30	70 - 130	

EKI Environment & Water, Inc.		**Reported:**	04/16/2021 16:42
2001 Junipero Serra Blvd, Suite 300		Project:	White Wolf Basin GDE Monitoring Wells
Daly City, CA 94014		Project Number:	B50001.06T3
		Project Manager:	Christina Lucero

Water Analysis (General Chemistry)

Quality Control Report - Method Blank Analysis

Constituent	QC Sample ID	MB Result	Units	PQL	MDL	Lab Quals
QC Batch ID: B103161						
Bicarbonate	B103161-BLK1	ND	mg/L	5.0	5.0	
Carbonate	B103161-BLK1	ND	mg/L	2.5	2.5	
Hydroxide	B103161-BLK1	ND	mg/L	1.4	1.4	
Total Alkalinity as CaCO3	B103161-BLK1	ND	mg/L	4.1	4.1	
QC Batch ID: B104639						
Total Dissolved Solids @ 180 C	B104639-BLK1	ND	mg/L	6.7	3.3	
QC Batch ID: B104644						
Chloride	**B104644-BLK1**	**0.19200**	**mg/L**	**0.50**	**0.13**	**J**
Nitrate as NO3	B104644-BLK1	ND	mg/L	0.44	0.11	
Sulfate	B104644-BLK1	ND	mg/L	1.0	0.14	
QC Batch ID: B105827						
Dissolved Calcium	B105827-BLK1	ND	mg/L	0.10	0.016	
Dissolved Magnesium	B105827-BLK2	ND	mg/L	0.050	0.019	
Dissolved Sodium	B105827-BLK1	ND	mg/L	0.50	0.051	
Dissolved Potassium	B105827-BLK1	ND	mg/L	1.0	0.10	

EKI Environment & Water, Inc.
2001 Junipero Serra Blvd, Suite 300
Daly City, CA 94014

Reported: 04/16/2021 16:42
Project: White Wolf Basin GDE Monitoring Wells
Project Number: B50001.06T3
Project Manager: Christina Lucero

Water Analysis (General Chemistry)

Quality Control Report - Laboratory Control Sample

Constituent	QC Sample ID	Type	Result	Spike Level	Units	Percent Recovery	RPD	Control Limits Percent Recovery	Control Limits RPD	Lab Quals
QC Batch ID: B103161										
Total Alkalinity as CaCO3	B103161-BS3	LCS	102.23	100.00	mg/L	102		90 - 110		
QC Batch ID: B104639										
Total Dissolved Solids @ 180 C	B104639-BS1	LCS	600.00	586.00	mg/L	102		90 - 110		
QC Batch ID: B104644										
Chloride	B104644-BS1	LCS	50.680	50.000	mg/L	101		90 - 110		
Nitrate as NO3	B104644-BS1	LCS	22.404	22.134	mg/L	101		90 - 110		
Sulfate	B104644-BS1	LCS	100.15	100.00	mg/L	100		90 - 110		
QC Batch ID: B105827										
Dissolved Calcium	B105827-BS1	LCS	9.0684	10.000	mg/L	90.7		85 - 115		
Dissolved Magnesium	B105827-BS2	LCS	9.6446	10.000	mg/L	96.4		85 - 115		
Dissolved Sodium	B105827-BS1	LCS	9.5025	10.000	mg/L	95.0		85 - 115		
Dissolved Potassium	B105827-BS1	LCS	9.0058	10.000	mg/L	90.1		85 - 115		

EKI Environment & Water, Inc.
2001 Junipero Serra Blvd, Suite 300
Daly City, CA 94014

Reported: 04/16/2021 16:42
Project: White Wolf Basin GDE Monitoring Wells
Project Number: B50001.06T3
Project Manager: Christina Lucero

Water Analysis (General Chemistry)

Quality Control Report - Precision & Accuracy

Constituent	Type	Source Sample ID	Source Result	Result	Spike Added	Units	RPD	Percent Recovery	Control Limits RPD	Control Limits Percent Recovery	Lab Quals
QC Batch ID: B103161	Used client sample: N										
Bicarbonate	DUP	2110685-04	55.282	54.721		mg/L	1.0		10		
Carbonate	DUP	2110685-04	11.494	11.674		mg/L	1.6		10		
Hydroxide	DUP	2110685-04	ND	ND		mg/L			10		
Total Alkalinity as CaCO3	DUP	2110685-04	64.500	64.350		mg/L	0.2		10		
QC Batch ID: B104639	Used client sample: N										
Total Dissolved Solids @ 180 C	DUP	2110146-01	910.00	890.00		mg/L	2.2		10		
QC Batch ID: B104644	Used client sample: N										
Chloride	DUP	2110187-01	19.399	19.478		mg/L	0.4		10		
	MS	2110187-01	19.399	75.746	50.505	mg/L		112		80 - 120	
	MSD	2110187-01	19.399	75.673	50.505	mg/L	0.1	111	10	80 - 120	
Nitrate as NO3	DUP	2110187-01	28.088	28.571		mg/L	1.7		10		
	MS	2110187-01	28.088	52.397	22.358	mg/L		109		80 - 120	
	MSD	2110187-01	28.088	52.464	22.358	mg/L	0.1	109	10	80 - 120	
Sulfate	DUP	2110187-01	82.008	81.779		mg/L	0.3		10		
	MS	2110187-01	82.008	194.71	101.01	mg/L		112		80 - 120	
	MSD	2110187-01	82.008	194.24	101.01	mg/L	0.2	111	10	80 - 120	
QC Batch ID: B105827	Used client sample: N										
Dissolved Calcium	DUP	**2110137-01**	**100.61**	**101.34**		**mg/L**	**0.7**		**20**		
	MS	**2110137-01**	**100.61**	**108.91**	**10.204**	**mg/L**		**81.3**		**85 - 115**	**A03**
	MSD	**2110137-01**	**100.61**	**110.98**	**10.204**	**mg/L**	**1.9**	**102**	**20**	**85 - 115**	
Dissolved Magnesium	DUP	2110137-01	30.811	31.108		mg/L	1.0		20		
	MS	2110137-01	30.811	50.514	20.408	mg/L		96.5		85 - 115	
	MSD	2110137-01	30.811	51.813	20.408	mg/L	2.5	103	20	85 - 115	
Dissolved Sodium	DUP	**2110137-01**	**282.52**	**282.04**		**mg/L**	**0.2**		**20**		
	MS	**2110137-01**	**282.52**	**288.26**	**10.204**	**mg/L**		**56.3**		**85 - 115**	**A03**
	MSD	**2110137-01**	**282.52**	**288.69**	**10.204**	**mg/L**	**0.1**	**60.4**	**20**	**85 - 115**	**A03**
Dissolved Potassium	DUP	2110137-01	28.846	28.971		mg/L	0.4		20		
	MS	2110137-01	28.846	37.793	10.204	mg/L		87.7		85 - 115	
	MSD	2110137-01	28.846	38.278	10.204	mg/L	1.3	92.4	20	85 - 115	

EKI Environment & Water, Inc.
2001 Junipero Serra Blvd, Suite 300
Daly City, CA 94014

Reported: 04/16/2021 16:42
Project: White Wolf Basin GDE Monitoring Wells
Project Number: B50001.06T3
Project Manager: Christina Lucero

Metals Analysis

Quality Control Report - Method Blank Analysis

Constituent	QC Sample ID	MB Result	Units	PQL	MDL	Lab Quals
QC Batch ID: B104979						
Dissolved Arsenic	B104979-BLK1	ND	ug/L	2.0	0.38	
Dissolved Selenium	B104979-BLK1	ND	ug/L	2.0	0.25	

EKI Environment & Water, Inc.	**Reported:** 04/16/2021 16:42
2001 Junipero Serra Blvd, Suite 300	Project: White Wolf Basin GDE Monitoring Wells
Daly City, CA 94014	Project Number: B50001.06T3
	Project Manager: Christina Lucero

Metals Analysis

Quality Control Report - Laboratory Control Sample

Constituent	QC Sample ID	Type	Result	Spike Level	Units	Percent Recovery	RPD	Control Limits Percent Recovery	Control Limits RPD	Lab Quals
QC Batch ID: B104979										
Dissolved Arsenic	B104979-BS1	LCS	97.559	100.00	ug/L	97.6		85 - 115		
Dissolved Selenium	B104979-BS1	LCS	97.822	100.00	ug/L	97.8		85 - 115		

EKI Environment & Water, Inc. 2001 Junipero Serra Blvd, Suite 300 Daly City, CA 94014	**Reported:** 04/16/2021 16:42 Project: White Wolf Basin GDE Monitoring Wells Project Number: B50001.06T3 Project Manager: Christina Lucero

Metals Analysis

Quality Control Report - Precision & Accuracy

Constituent	Type	Source Sample ID	Source Result	Result	Spike Added	Units	RPD	Percent Recovery	Control Limits RPD	Control Limits Percent Recovery	Lab Quals
QC Batch ID: B104979	Used client sample: N										
Dissolved Arsenic	DUP	**2110227-01**	**0.74500**	**0.95400**		**ug/L**	**24.6**		**20**		**J,A02**
	MS	**2110227-01**	**0.74500**	**107.04**	**102.04**	**ug/L**		**104**		**70 - 130**	
	MSD	**2110227-01**	**0.74500**	**109.41**	**102.04**	**ug/L**	**2.2**	**106**	**20**	**70 - 130**	
Dissolved Selenium	DUP	2110227-01	ND	ND		ug/L			20		
	MS	2110227-01	ND	113.80	102.04	ug/L		112		70 - 130	
	MSD	2110227-01	ND	115.88	102.04	ug/L	1.8	114	20	70 - 130	

EKI Environment & Water, Inc.	**Reported:** 04/16/2021 16:42
2001 Junipero Serra Blvd, Suite 300	Project: White Wolf Basin GDE Monitoring Wells
Daly City, CA 94014	Project Number: B50001.06T3
	Project Manager: Christina Lucero

Notes And Definitions

J	Estimated Value (CLP Flag)
MDL	Method Detection Limit
ND	Analyte Not Detected
PQL	Practical Quantitation Limit
A02	The difference between duplicate readings is less than the quantitation limit.
A03	The sample concentration was more than 4 times the spike level.
A07	Detection and quantitation limits were raised due to sample dilution caused by high analyte concentration or matrix interference.

Lab #:	788083	Job #: 47361	IS-99843	Co. Job#:
Sample Name:	RMW-ISW01			Co. Lab#:
Company:	EKI Environment & Water, Inc.			
API/Well:				
Container:	Plastic Bottle			
Field/Site Name:	White Wolf Basin GDE Monitoring Wells / B50001.06T3			
Location:				
Formation/Depth:				
Sampling Point:				
Date Sampled:	3/31/2021 13:40	Date Received: 4/06/2021		Date Reported: 4/16/2021

δD of water	---------------	-60.5 ‰ relative to VSMOW
$\delta^{18}O$ of water	---------------	-8.15 ‰ relative to VSMOW
Tritium content of water	---------------	na
$\delta^{13}C$ of DIC	---------------	na
^{14}C content of DIC	---------------	na
$\delta^{15}N$ of nitrate	---------------	na
$\delta^{18}O$ of nitrate	---------------	na
$\delta^{34}S$ of sulfate	---------------	na
$\delta^{18}O$ of sulfate	---------------	na
Vacuum Distilled? *	---------------	No

Remarks:

nd = not detected. na = not analyzed.
*Indicates if vacuum distillation was utilized for hydrogen and oxygen isotopic analysis of water

ISOTECH
a Stratum Reservoir brand
www.isotechlabs.com

Lab #:	788084	Job #:	47361	IS-99843	Co. Job#:		
Sample Name:	RMW-ISW02				Co. Lab#:		
Company:	EKI Environment & Water, Inc.						
API/Well:							
Container:	Plastic Bottle						
Field/Site Name:	White Wolf Basin GDE Monitoring Wells / B50001.06T3						
Location:							
Formation/Depth:							
Sampling Point:							
Date Sampled:	3/31/2021 16:45	Date Received:	4/06/2021		Date Reported:	4/16/2021	

δD of water	---------------	-59.9 ‰ relative to VSMOW
$\delta^{18}O$ of water	---------------	-8.36 ‰ relative to VSMOW
Tritium content of water	---------------	na
$\delta^{13}C$ of DIC	---------------	na
^{14}C content of DIC	---------------	na
$\delta^{15}N$ of nitrate	---------------	na
$\delta^{18}O$ of nitrate	---------------	na
$\delta^{34}S$ of sulfate	---------------	na
$\delta^{18}O$ of sulfate	---------------	na
Vacuum Distilled? *	---------------	No

Remarks:

nd = not detected. na = not analyzed.
*Indicates if vacuum distillation was utilized for hydrogen and oxygen isotopic analysis of water

ISOTECH
a Stratum Reservoir brand
www.isotechlabs.com

Lab #:	788085	Job #: 47361	IS-99843	Co. Job#:
Sample Name:	RMW-ISW03			Co. Lab#:
Company:	EKI Environment & Water, Inc.			
API/Well:				
Container:	Plastic Bottle			
Field/Site Name:	White Wolf Basin GDE Monitoring Wells / B50001.06T3			
Location:				
Formation/Depth:				
Sampling Point:				

Date Sampled: 4/01/2021 11:15 Date Received: 4/06/2021 Date Reported: 4/16/2021

δD of water	---------------	-62.9 ‰ relative to VSMOW
$\delta^{18}O$ of water	---------------	-8.75 ‰ relative to VSMOW
Tritium content of water	---------------	na
$\delta^{13}C$ of DIC	---------------	na
^{14}C content of DIC	---------------	na
$\delta^{15}N$ of nitrate	---------------	na
$\delta^{18}O$ of nitrate	---------------	na
$\delta^{34}S$ of sulfate	---------------	na
$\delta^{18}O$ of sulfate	---------------	na
Vacuum Distilled? *	---------------	No

Remarks:

nd = not detected. na = not analyzed.
*Indicates if vacuum distillation was utilized for hydrogen and oxygen isotopic analysis of water

EKI Environment & Water, Inc.

CONSULTING ENGINEERS AND SCIENTISTS

CHAIN OF CUSTODY RECORD

2001 Junipero Serra Blvd, Suite 300, Daly City, CA 94014 PHONE: 650-292-9100 http://www.ekiconsult.com

Project Name: White Wolf Basin GDE Monitoring Wells

Project / P.O. No.: B50001.06T3

EKI COC No.: (YYYYMMDD-#) 20210401-3

Location: Arvin, CA

Sampled By: J. Shaw

Revision: ______ (A, B, C, D, etc.) Date: By:

Reporting:

Electronic Format: Hard Copy Format: PDF

EPA Data Report Level:

Please report results to the following people:

(1) Data Archive: labs@ekiconsult.com

(2) Christina Lucero: clucero@ekiconsult.com

(3) Jeff Shaw: jshaw@ekiconsult.com

(4)

Laboratory:

Isotech Laboratories
1308 Parkland Court
Champaign, IL 61821-1826
(217) 398-3490

ANALYSES REQUESTED — Method No.: Cavity Ring-Down Spectroscopy; Analyte / Group: $\delta^{18}O$ & δD; Extract and HOLD; HOLD; EXPECTED TURNAROUND TIME; Remarks

Field Sample ID	Lab Sample No.	Date	Time	Matrix	Container Count & Type	Cavity Ring-Down Spectroscopy / $\delta^{18}O$ & δD	Extract and HOLD	HOLD	Expected Turnaround Time	Remarks
RMW-IJW01		31 Mar 2021	1340	H_2O	500 mL PE	X			Std.	
RMW-IJW02		↓	1645	↓	↓	X			↓	
RMW-IJW03		1 Apr 2021	1115	↓	↓	X			↓	

Special Instructions:

Relinquished by: (Signature/Affiliation)	Date & Time	Received by: (Signature/Affiliation or Carrier/Air Bill No.)
[signature] EKI	2 Apr 2021 1730	Fed Ex
Relinquished by: (Signature/Affiliation)	**Date & Time**	**Received by: (Signature/Affiliation)**
	APR 06 2021 11:35	Abby Skube/SR Isotech
Relinquished by: (Signature/Affiliation)	**Date & Time**	**Received by: (Signature/Affiliation)**

ISOTECH
a Stratum Reservoir brand
www.isotechlabs.com

Lab #:	797212	Job #: 48155	IS-99843	Co. Job#:	
Sample Name:	Vista Orchards PW			Co. Lab#:	
Company:	EKI Environment & Water, Inc.				
API/Well:					
Container:	VOA Vial				
Field/Site Name:	White Wolf Basin GDE Monitoring Wells / B50001.06				
Location:					
Formation/Depth:					
Sampling Point:					
Date Sampled:	6/30/2021 8:35	Date Received:	7/09/2021	Date Reported:	7/14/2021

δD of water	---------------	-66.8 ‰ relative to VSMOW
$\delta^{18}O$ of water	---------------	-9.40 ‰ relative to VSMOW
Tritium content of water	---------------	na
$\delta^{13}C$ of DIC	---------------	na
^{14}C content of DIC	---------------	na
$\delta^{15}N$ of nitrate	---------------	na
$\delta^{18}O$ of nitrate	---------------	na
$\delta^{34}S$ of sulfate	---------------	na
$\delta^{18}O$ of sulfate	---------------	na
Vacuum Distilled? *	---------------	No

Remarks:

nd = not detected. na = not analyzed.
*Indicates if vacuum distillation was utilized for hydrogen and oxygen isotopic analysis of water

ISOTECH
a Stratum Reservoir brand
www.isotechlabs.com

Lab #:	797213	Job #: 48155	IS-99843	Co. Job#:	
Sample Name:	Tejon Ck.			Co. Lab#:	
Company:	EKI Environment & Water, Inc.				
API/Well:					
Container:	VOA Vial				
Field/Site Name:	White Wolf Basin GDE Monitoring Wells / B50001.06				
Location:					
Formation/Depth:					
Sampling Point:					
Date Sampled:	6/30/2021 12:30	Date Received:	7/09/2021	Date Reported:	7/14/2021

δD of water	---------------	-58.1 ‰ relative to VSMOW
$\delta^{18}O$ of water	---------------	-7.49 ‰ relative to VSMOW
Tritium content of water	---------------	na
$\delta^{13}C$ of DIC	---------------	na
^{14}C content of DIC	---------------	na
$\delta^{15}N$ of nitrate	---------------	na
$\delta^{18}O$ of nitrate	---------------	na
$\delta^{34}S$ of sulfate	---------------	na
$\delta^{18}O$ of sulfate	---------------	na
Vacuum Distilled? *	---------------	No

Remarks:

nd = not detected. na = not analyzed.
*Indicates if vacuum distillation was utilized for hydrogen and oxygen isotopic analysis of water

ISOTECH
a Stratum Reservoir brand
www.isotechlabs.com

Lab #:	797214	Job #: 48155	IS-99843	Co. Job#:
Sample Name:	Butcher Pasture			Co. Lab#:
Company:	EKI Environment & Water, Inc.			
API/Well:				
Container:	VOA Vial			
Field/Site Name:	White Wolf Basin GDE Monitoring Wells / B50001.06			
Location:				
Formation/Depth:				
Sampling Point:				

Date Sampled: 6/30/2021 12:58 Date Received: 7/09/2021 Date Reported: 7/14/2021

δD of water	---------------	-67.5 ‰ relative to VSMOW
$\delta^{18}O$ of water	---------------	-9.32 ‰ relative to VSMOW
Tritium content of water	---------------	na
$\delta^{13}C$ of DIC	---------------	na
^{14}C content of DIC	---------------	na
$\delta^{15}N$ of nitrate	---------------	na
$\delta^{18}O$ of nitrate	---------------	na
$\delta^{34}S$ of sulfate	---------------	na
$\delta^{18}O$ of sulfate	---------------	na
Vacuum Distilled? *	---------------	No

Remarks:

nd = not detected. na = not analyzed.
*Indicates if vacuum distillation was utilized for hydrogen and oxygen isotopic analysis of water

ISOTECH
a Stratum Reservoir brand
www.isotechlabs.com

Lab #:	797215	Job #: 48155	IS-99843	Co. Job#:	
Sample Name:	OHQ Well West			Co. Lab#:	
Company:	EKI Environment & Water, Inc.				
API/Well:					
Container:	VOA Vial				
Field/Site Name:	White Wolf Basin GDE Monitoring Wells / B50001.06				
Location:					
Formation/Depth:					
Sampling Point:					
Date Sampled:	6/30/2021 13:28	Date Received:	7/09/2021	Date Reported:	7/14/2021

δD of water	---------------	-60.1 ‰ relative to VSMOW
$\delta^{18}O$ of water	---------------	-8.62 ‰ relative to VSMOW
Tritium content of water	---------------	na
$\delta^{13}C$ of DIC	---------------	na
^{14}C content of DIC	---------------	na
$\delta^{15}N$ of nitrate	---------------	na
$\delta^{18}O$ of nitrate	---------------	na
$\delta^{34}S$ of sulfate	---------------	na
$\delta^{18}O$ of sulfate	---------------	na
Vacuum Distilled? *	---------------	No

Remarks:

nd = not detected. na = not analyzed.
*Indicates if vacuum distillation was utilized for hydrogen and oxygen isotopic analysis of water

ISOTECH
a Stratum Reservoir brand
www.isotechlabs.com

Lab #:	797216	Job #:	48155	IS-99843	Co. Job#:		
Sample Name:	OHQ Well East				Co. Lab#:		
Company:	EKI Environment & Water, Inc.						
API/Well:							
Container:	VOA Vial						
Field/Site Name:	White Wolf Basin GDE Monitoring Wells / B50001.06						
Location:							
Formation/Depth:							
Sampling Point:							
Date Sampled:	6/30/2021 13:35	Date Received:	7/09/2021		Date Reported:	7/14/2021	

δD of water	---------------	-59.5 ‰ relative to VSMOW
$\delta^{18}O$ of water	---------------	-8.61 ‰ relative to VSMOW
Tritium content of water	---------------	na
$\delta^{13}C$ of DIC	---------------	na
^{14}C content of DIC	---------------	na
$\delta^{15}N$ of nitrate	---------------	na
$\delta^{18}O$ of nitrate	---------------	na
$\delta^{34}S$ of sulfate	---------------	na
$\delta^{18}O$ of sulfate	---------------	na
Vacuum Distilled? *	---------------	No

Remarks:

nd = not detected. na = not analyzed.
*Indicates if vacuum distillation was utilized for hydrogen and oxygen isotopic analysis of water

ISOTECH
a Stratum Reservoir brand
www.isotechlabs.com

Lab #:	797217	Job #: 48155	IS-99843	Co. Job#:	
Sample Name:	Vaquero Well			Co. Lab#:	
Company:	EKI Environment & Water, Inc.				
API/Well:					
Container:	VOA Vial				
Field/Site Name:	White Wolf Basin GDE Monitoring Wells / B50001.06				
Location:					
Formation/Depth:					
Sampling Point:					
Date Sampled:	7/01/2021 12:55	Date Received:	7/09/2021	Date Reported:	7/14/2021

δD of water	---------------	-61.2 ‰ relative to VSMOW
$\delta^{18}O$ of water	---------------	-8.82 ‰ relative to VSMOW
Tritium content of water	---------------	na
$\delta^{13}C$ of DIC	---------------	na
^{14}C content of DIC	---------------	na
$\delta^{15}N$ of nitrate	---------------	na
$\delta^{18}O$ of nitrate	---------------	na
$\delta^{34}S$ of sulfate	---------------	na
$\delta^{18}O$ of sulfate	---------------	na
Vacuum Distilled? *	---------------	No

Remarks:

nd = not detected. na = not analyzed.
*Indicates if vacuum distillation was utilized for hydrogen and oxygen isotopic analysis of water

ISOTECH
a Stratum Reservoir brand
www.isotechlabs.com

Lab #:	797218	Job #:	48155	IS-99843	Co. Job#:		
Sample Name:	Citrus Shop Well				Co. Lab#:		
Company:	EKI Environment & Water, Inc.						
API/Well:							
Container:	VOA Vial						
Field/Site Name:	White Wolf Basin GDE Monitoring Wells / B50001.06						
Location:							
Formation/Depth:							
Sampling Point:							
Date Sampled:	7/01/2021 12:20	Date Received:	7/09/2021		Date Reported:	7/14/2021	

δD of water	---------------	-58.7 ‰ relative to VSMOW
$\delta^{18}O$ of water	---------------	-7.94 ‰ relative to VSMOW
Tritium content of water	---------------	na
$\delta^{13}C$ of DIC	---------------	na
^{14}C content of DIC	---------------	na
$\delta^{15}N$ of nitrate	---------------	na
$\delta^{18}O$ of nitrate	---------------	na
$\delta^{34}S$ of sulfate	---------------	na
$\delta^{18}O$ of sulfate	---------------	na
Vacuum Distilled? *	---------------	No

Remarks:

nd = not detected. na = not analyzed.
*Indicates if vacuum distillation was utilized for hydrogen and oxygen isotopic analysis of water

ISOTECH
a Stratum Reservoir brand
www.isotechlabs.com

Lab #:	797219	Job #: 48155	IS-99843	Co. Job#:	
Sample Name:	South Artesian Well			Co. Lab#:	
Company:	EKI Environment & Water, Inc.				
API/Well:					
Container:	VOA Vial				
Field/Site Name:	White Wolf Basin GDE Monitoring Wells / B50001.06				
Location:					
Formation/Depth:					
Sampling Point:					
Date Sampled:	7/01/2021 13:50	Date Received:	7/09/2021	Date Reported:	7/14/2021

δD of water	---------------	-66.6 ‰ relative to VSMOW
$\delta^{18}O$ of water	---------------	-9.26 ‰ relative to VSMOW
Tritium content of water	---------------	na
$\delta^{13}C$ of DIC	---------------	na
^{14}C content of DIC	---------------	na
$\delta^{15}N$ of nitrate	---------------	na
$\delta^{18}O$ of nitrate	---------------	na
$\delta^{34}S$ of sulfate	---------------	na
$\delta^{18}O$ of sulfate	---------------	na
Vacuum Distilled? *	---------------	No

Remarks:

nd = not detected. na = not analyzed.
*Indicates if vacuum distillation was utilized for hydrogen and oxygen isotopic analysis of water

EKI Environment & Water, Inc.

CONSULTING ENGINEERS AND SCIENTISTS

CHAIN OF CUSTODY RECORD

PAGE 1 OF 1

2001 Junipero Serra Blvd, Suite 300, Daly City, CA 94014 PHONE: 650-292-9100 http://www.ekiconsult.com

Project Name: White Wolf Monitoring Network

Project No.: B50001.06

EKI COC No.: (YYYYMMDD-#) 20210701-A

Location: Kern County, CA

Sampled By: J. Shaw

Reporting:

Electronic Format: Hard Copy Format: PDF

EPA Data Report Level:

Please report results to the following people:

(1) Data Archive: labs@ekiconsult.com

(2) Christina Lucero: clucero@ekiconsult.com

(3) Jeff Shaw: jshaw@ekiconsult.com

(4) Meghan Engh: mengh@ekiconsult.com

Laboratory:

Isotech Laboratories
1308 Parkland Court
Champaign, IL 61821-1826
(217) 398-3490

ANALYSES REQUESTED

Method No.: Cavity Ring-Down Spectroscopy
Analyte / Group: $\delta^{18}O$ & δD

Revision: ________ (A, B, C, D, etc.)

Date: By:

Field Sample ID	Lab Sample No.	Date	Time	Matrix	Container Count & Type	Cavity Ring-Down Spectroscopy: $\delta^{18}O$ & δD											Extract and HOLD	HOLD	EXPECTED TURNAROUND TIME	Remarks
Vista Orchards PW		30 Jun 2021	0835	H_2O	1x 40mL VOA	X													STD	
Tejon Ck.			1230			X														Near BMW-15W03
Butcher Pasture			1258			X														
OHQ Well West			1328			X														
OHQ Well East			1335			X														
Vaquero Well		1 Jul 2021	~~1115~~ (1)			X														Resamp @ wellhead
Citrus Shop Well			1220			X														
South Artesian Well			1350			X														Near BMW-15W01

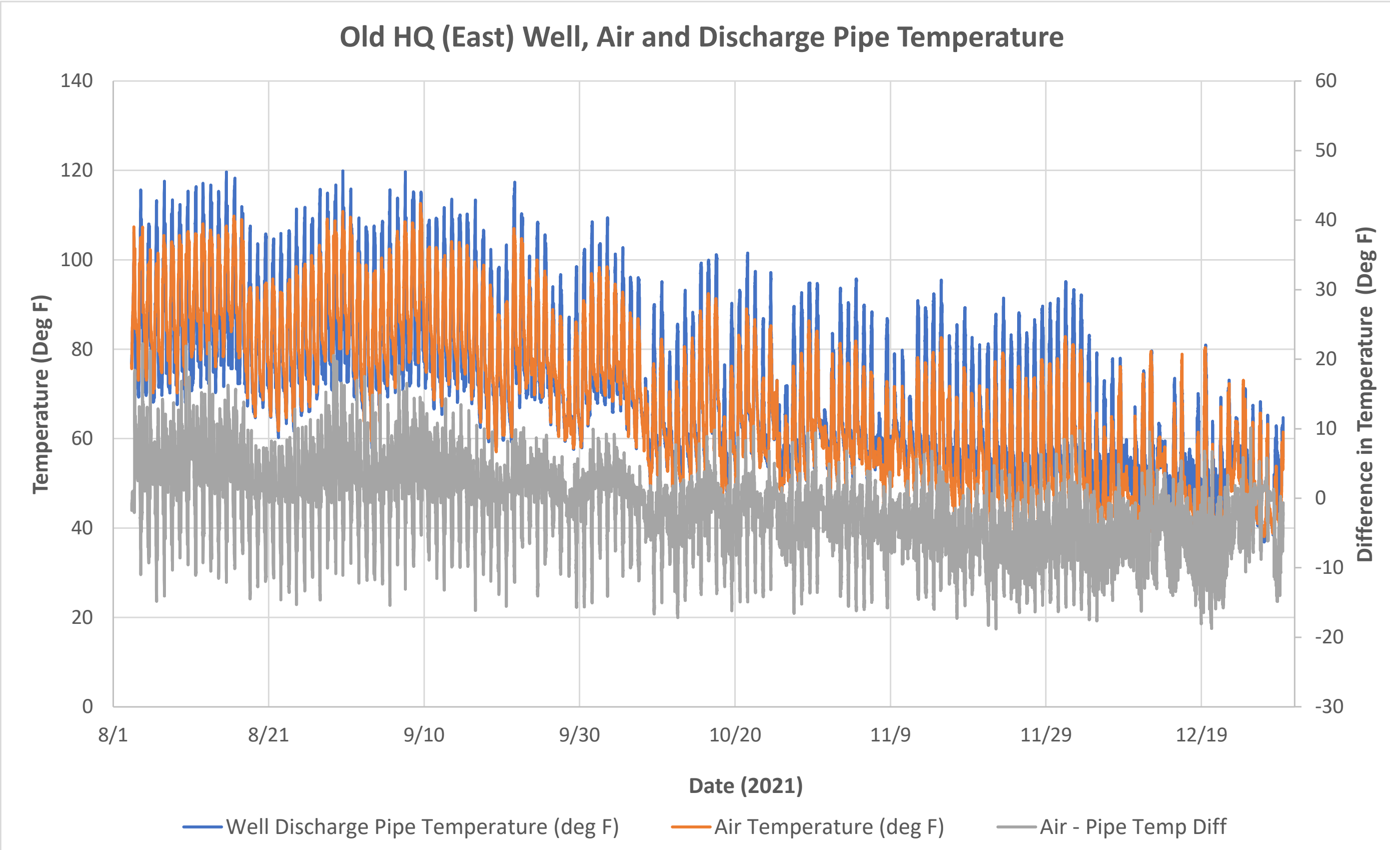
Special Instructions: (1) Resampled. New sample time 1255 * Note: All VOAs unpreserved

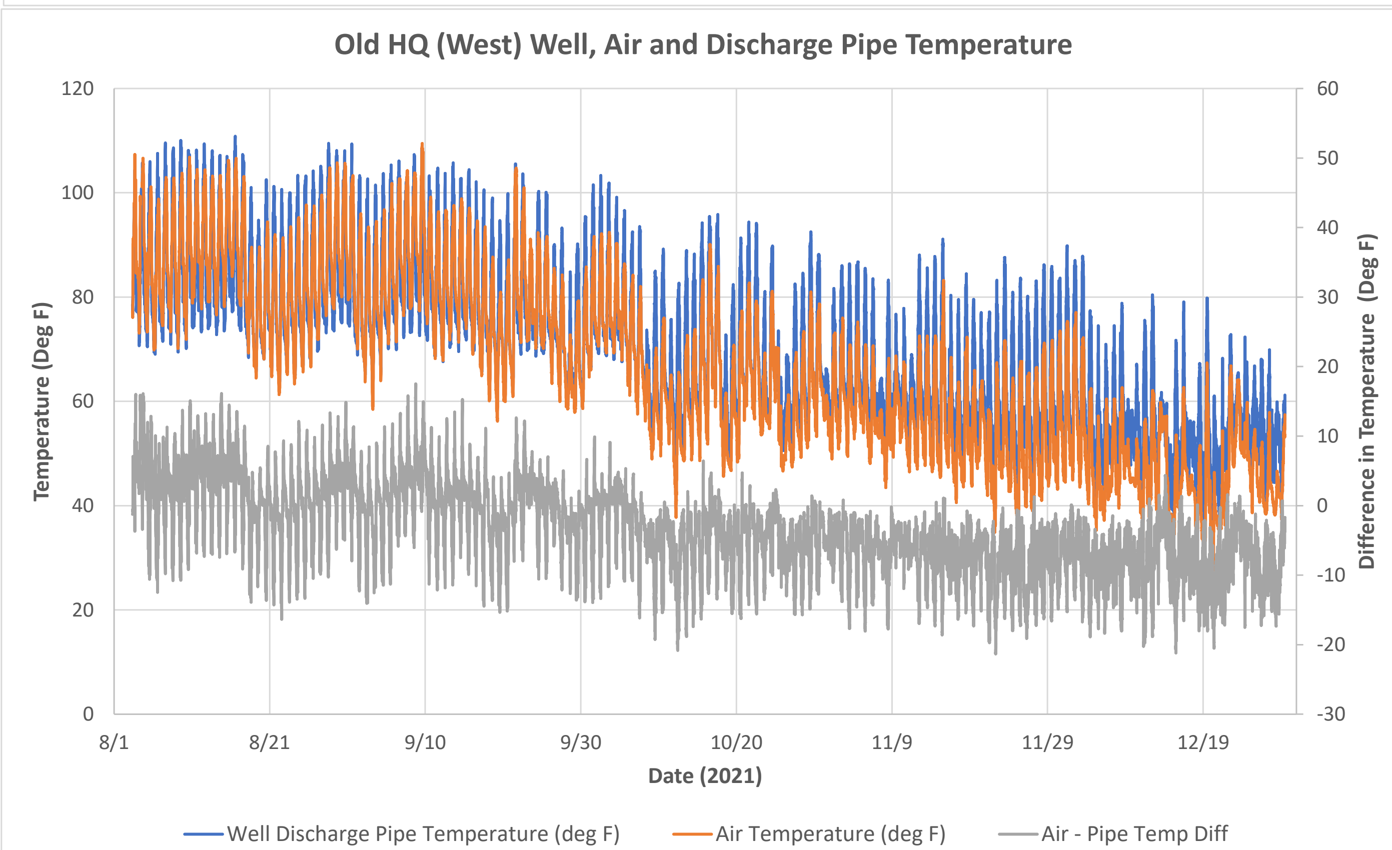
Relinquished by: (Signature/Affiliation)	Date & Time	Received by: (Signature/Affiliation or Carrier/Air Bill No.)
[signature] EKI	2 Jul 2021, 1225	Fedex #7741 6807 1161
Relinquished by: (Signature/Affiliation)	**Date & Time**	**Received by: (Signature/Affiliation)**
	JUL 09 2021 10:00	Abby Skube/SR Isotech
Relinquished by: (Signature/Affiliation)	**Date & Time**	**Received by: (Signature/Affiliation)**

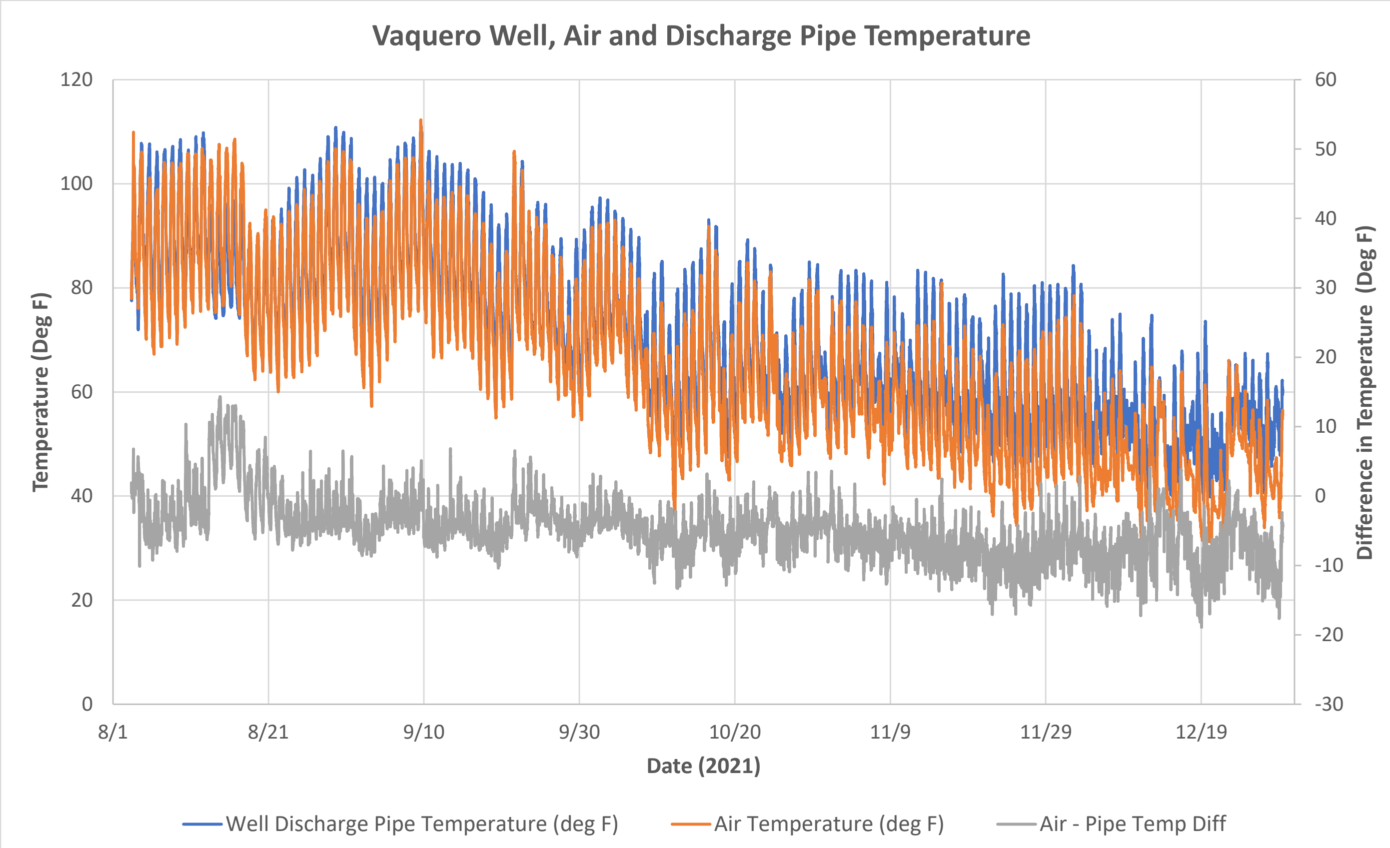
=FieldDataForms-2021-03.xlsx

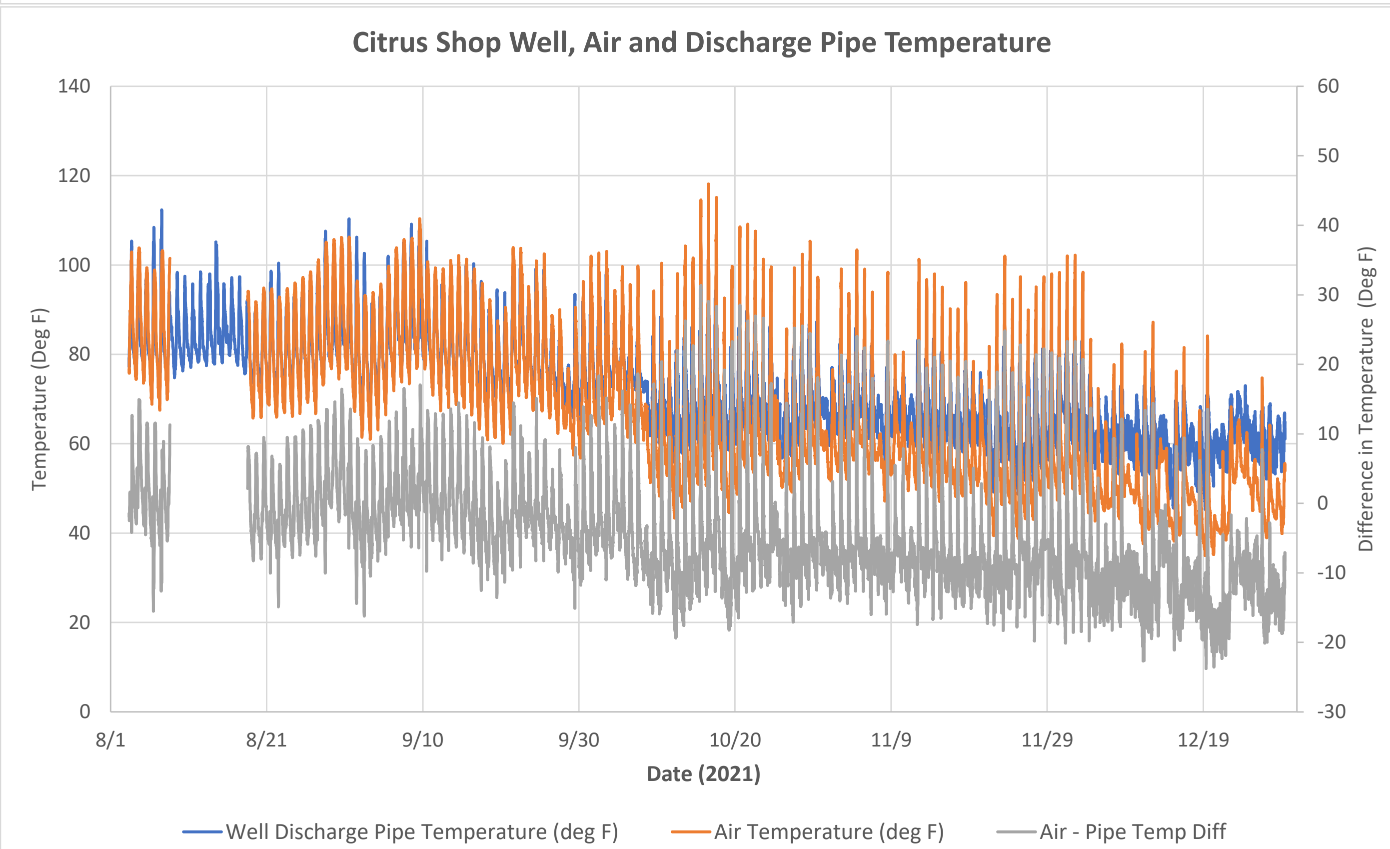
Attachment 6

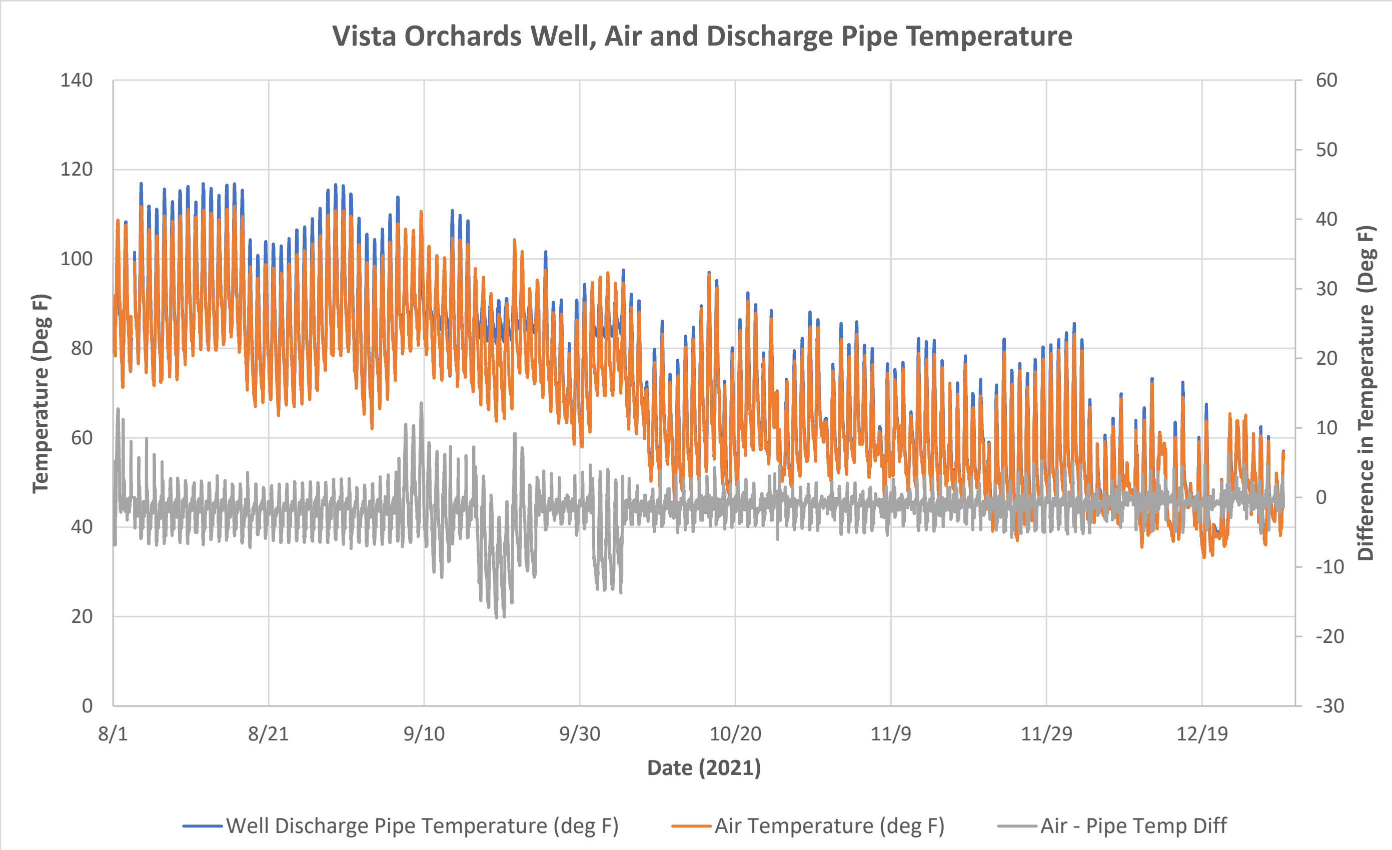
Time-Series Plots of Supply Well Discharge Pipe and Air Temperature Data


Old HQ (East) Well, Air and Discharge Pipe Temperature
Temperature (Deg F)
Difference in Temperature (Deg F)
Date (2021)
8/1
8/21
9/10
9/30
10/20
11/9
11/29
12/19
Well Discharge Pipe Temperature (deg F)
Air Temperature (deg F)
Air - Pipe Temp Diff


Old HQ (West) Well, Air and Discharge Pipe Temperature
Temperature (Deg F)
Difference in Temperature (Deg F)
Date (2021)
8/1
8/21
9/10
9/30
10/20
11/9
11/29
12/19
Well Discharge Pipe Temperature (deg F)
Air Temperature (deg F)
Air - Pipe Temp Diff


Vaquero Well, Air and Discharge Pipe Temperature
120
100
80
60
40
20
0
Temperature (Deg F)
60
50
40
30
20
10
0
-10
-20
-30
Difference in Temperature (Deg F)
8/1
8/21
9/10
9/30
10/20
11/9
11/29
12/19
Date (2021)
Well Discharge Pipe Temperature (deg F)
Air Temperature (deg F)
Air - Pipe Temp Diff


Citrus Shop Well, Air and Discharge Pipe Temperature
140
120
100
80
60
40
20
0
Temperature (Deg F)
60
50
40
30
20
10
0
-10
-20
-30
Difference in Temperature (Deg F)
8/1
8/21
9/10
9/30
10/20
11/9
11/29
12/19
Date (2021)
Well Discharge Pipe Temperature (deg F)
Air Temperature (deg F)
Air - Pipe Temp Diff


Vista Orchards Well, Air and Discharge Pipe Temperature
Temperature (Deg F)
140
120
100
80
60
40
20
0
Difference in Temperature (Deg F)
60
50
40
30
20
10
0
-10
-20
-30
8/1
8/21
9/10
9/30
10/20
11/9
11/29
12/19
Date (2021)
Well Discharge Pipe Temperature (deg F)
Air Temperature (deg F)
Air - Pipe Temp Diff

Appendix E

Summary of Water Quality Data Sources

Summary of Water Quality Data Sources

Table of Contents

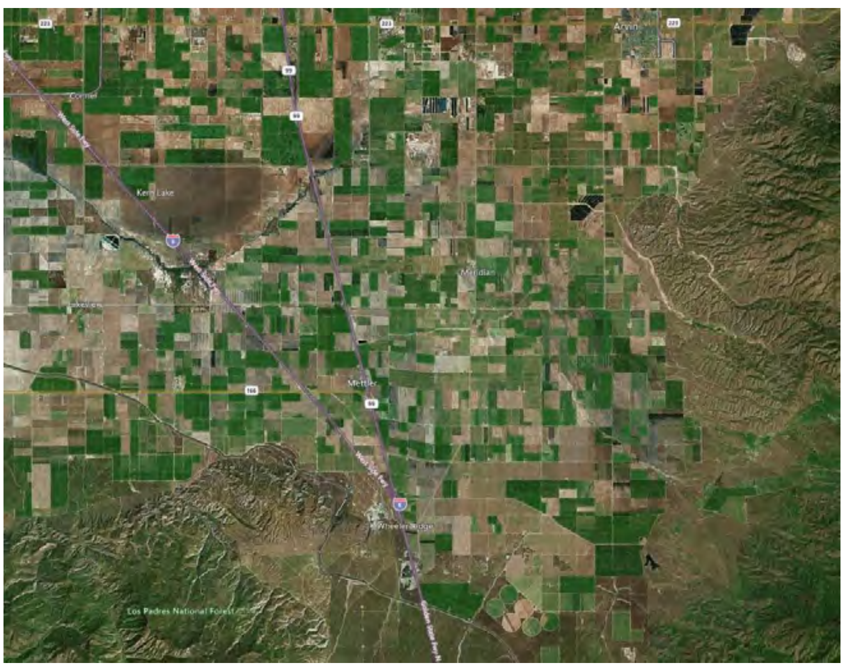
1. California EPA – Information on Hazardous Waste in Groundwater

1.1. Regulated Site Portal

https://siteportal.calepa.ca.gov/nsite

- Lists many environmentally regulated sites and facilities, including: hazardous waste and materials, hazardous waste facilities and sites, and storm water management sites.
- Data sources include California Occupational Safety and Health Administration (Cal/OSHA), California Environmental Reporting System (CERS), California Integrated Water Quality System (CIWQS), US EPA's Emission Inventory System (EIS), the California Department of Toxic Substances Control's (DTSC) EnviroStor site, the State Water Resources Control Board's (SWRCB) GeoTracker site, the SWRCB's Stormwater Multiple Application and Report Tracking System (SMARTS), the Solid Waste Information System (SWIS), and the federal Toxic Release Inventory (TRI) database.
- Contains downloadable data (e.g., quantity of chemical release), and other regulatory documents.
- No available spatial or temporal concentration data.

No available data in White Wolf Subbasin (WWB) in this source.



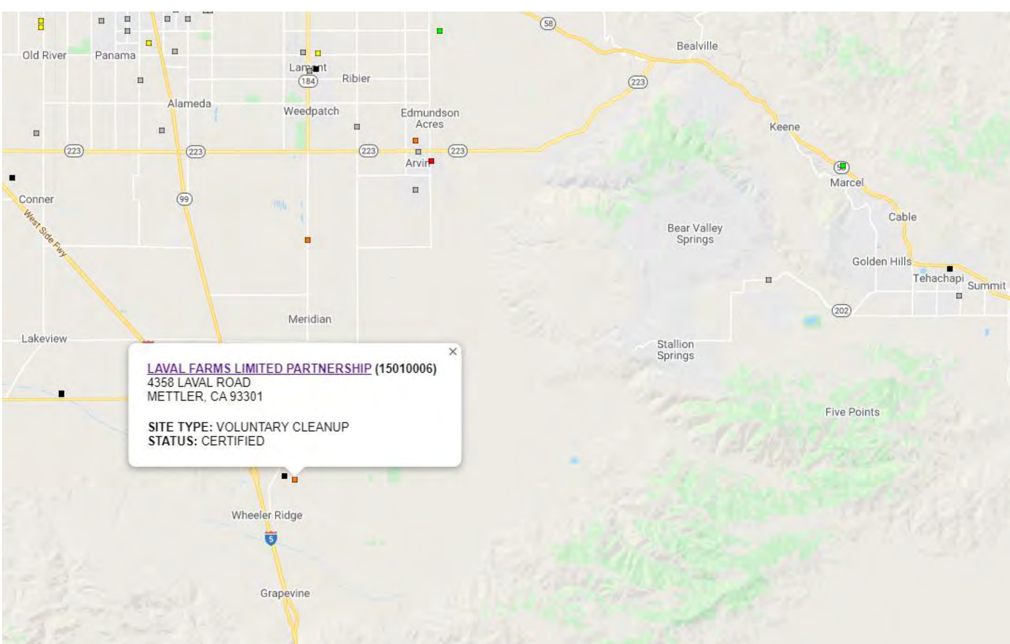
1.2. Cortese List

https://calepa.ca.gov/sitecleanup/corteselist/

- A list released by CalEPA annually, including hazardous waste and substance sites (DSTC), leaking USTs, solid waste disposal sites, "active" CDO and CAO sites.
- Data sources from DTSC, SWRCB, and local enforcement agencies.
- No available spatial or temporal concentration data.

No chemical data available, but contaminated sites are identified, with links to other websites (i.e., GeoTracker and ENVIROSTOR).

GeoTracker: [*https://geotracker.waterboards.ca.gov/map/?global_id=T0606769013*](https://geotracker.waterboards.ca.gov/map/?global_id=T0606769013)



ENVIROSTOR: *https://www.envirostor.dtsc.ca.gov/public/map/?global_id=15280011*

1.3. Managing Hazardous Waste website

https://dtsc.ca.gov/managing-hazardous-waste/

- Hazardous waste sites updates/status/current regulation.

No chemical data available.

1.4. GeoTracker

https://geotracker.waterboards.ca.gov/map/?global_id=T10000006808

- Lists relevant information about the hazardous sites, including location, substance of spill, clean up timeline, monitoring reports, site investigation reports, regulatory correspondence, etc.
- Chemical data available for each county (as txt file, can be opened with Access or Excel). https://geotracker.waterboards.ca.gov/data_download_by_county
- Temporal and spatial chemical concentration data.

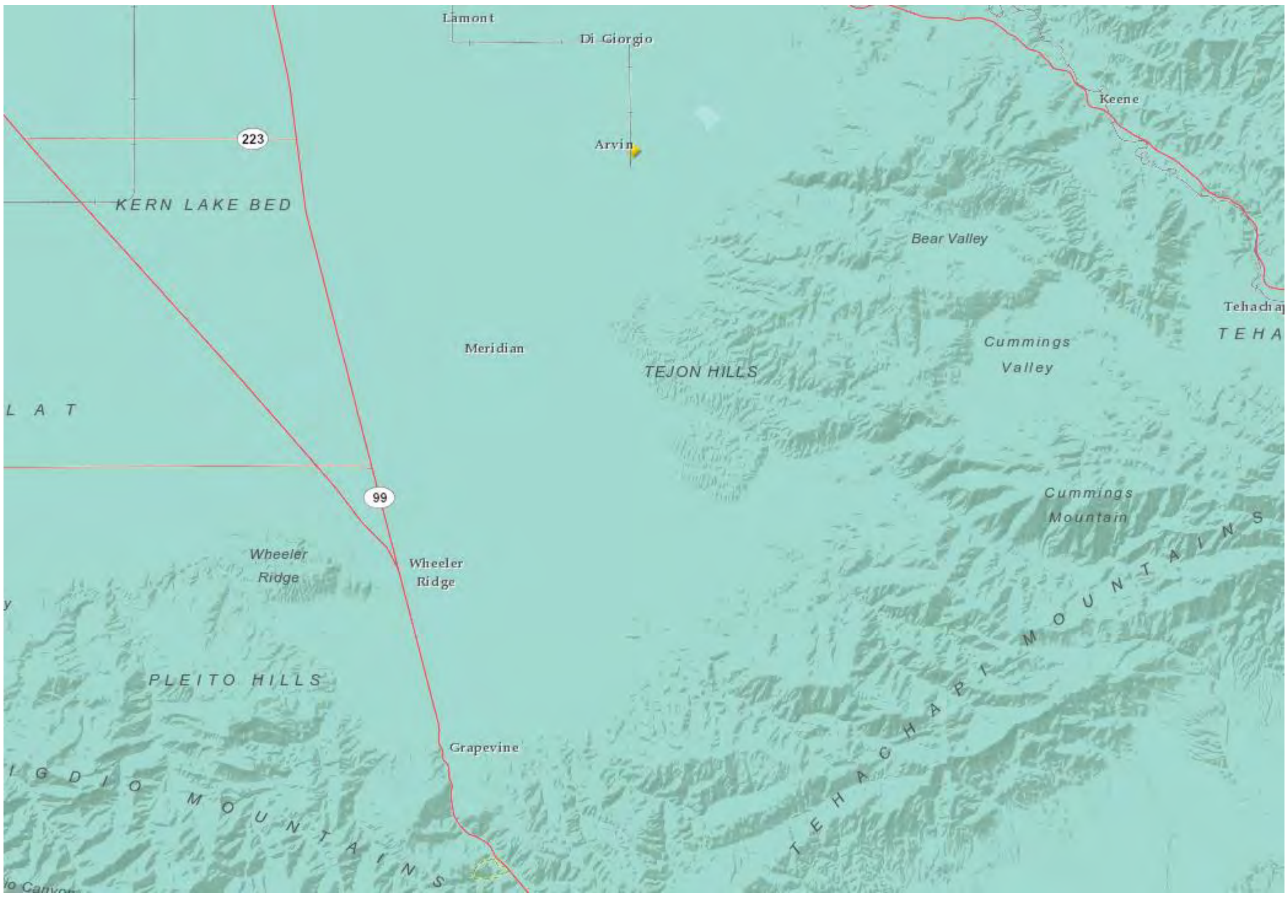
No active sites in WWB.

2. USEPA Superfund: National Priorities List (NPL)

https://www.epa.gov/superfund/superfund-national-priorities-list-npl

- USEPA Lists all current, proposed or deleted sites of national priority resulting from known orthreatened releases of hazardous substances, pollutants or contaminants.
- No downloadable data.
- Graphical display and lists all current and proposed NPL sites, sortable by state, regions, etc.
- Site descriptions include summary reports.

No superfund sites in WWB.



3. California EPA – Information on Drinking Water Quality

3.1. Water Quality Analysis Database Files

https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/EDTlibrary.html

- Electronic Data Transfer (EDT) Library, a link to Schedules for Upcoming Water Quality Monitoring, files for the Division of Drinking Water's (DDW's) water quality analyses database, and county small water system water quality data files.
- Statewide current and historical chemical data from water suppliers.
- Downloadable data, including temporal data.
- Chemical data from April 1947 to current; data format: dbf, can be opened in Access; supporting database files are needed to interpret the data.

Downloaded and added to the Data Management System (DMS). Identified source as "Public Water System WQ"

3.2. Drinking Water Watch

https://sdwis.waterboards.ca.gov/PDWW/

- This website provides a variety of chemical data (including many uncommon chemicals) for wells and distribution systems. Includes historical data (at least dated back in the 1980s).
- Data are available in the pdf form (convertible to Excel).
- With well locations and temporal changes in chemical concentrations, a trendline analysis is feasible.

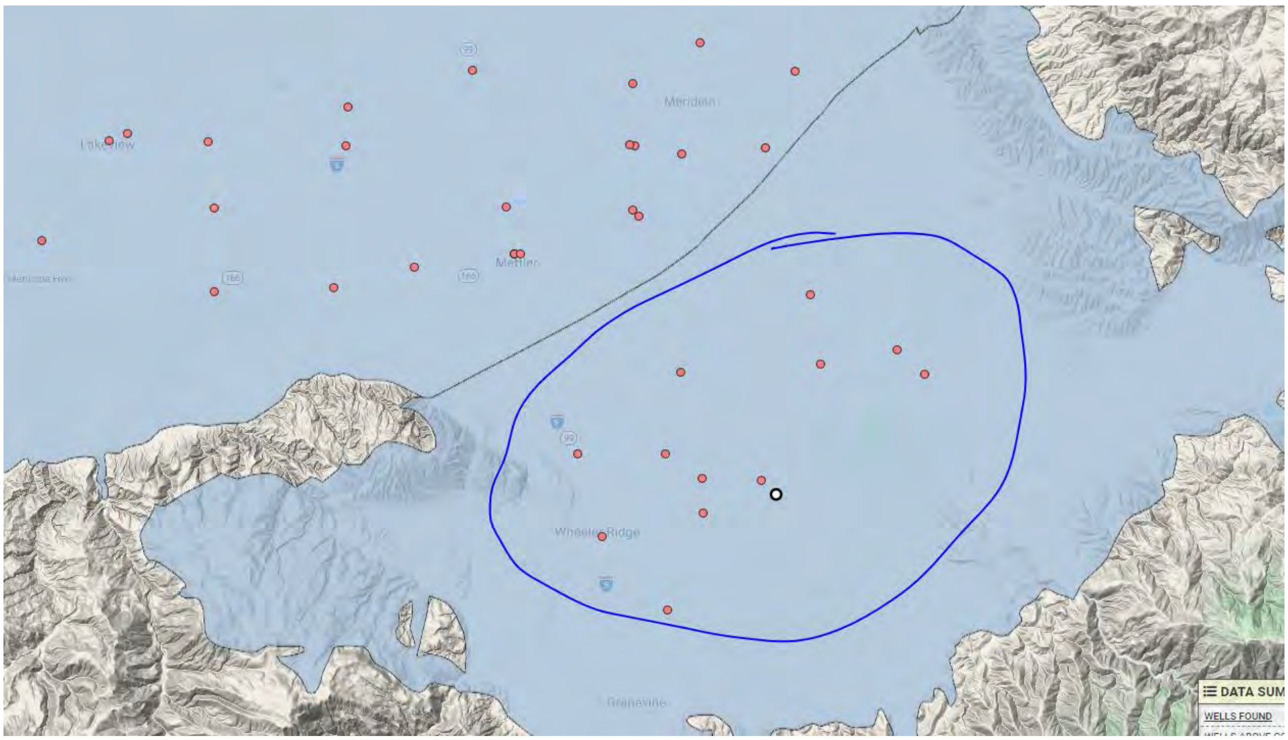
Data were identical to the EDT database above.

3.3. GAMA-PBP Groundwater-Quality Results: Assessment and Trends

https://ca.water.usgs.gov/projects/gama/water-quality-results/

- From USGS California Water Science Center, Groundwater Ambient Monitoring and Assessment (GAMA) Priority Basin Project (PBP)
- Map viewer showing concentrations and trends of many constituents, such as metal ions, nutrients, TDS, pesticides, VOCs, age-dating tracers, radioactivity, etc.
- Concentrations are provided and categorized as different ranges, with color code. No date is associated with the measurements.

Downloaded and added to the DMS. Identified source as "GAMA WW WQ".



4. Information on Pesticide Use pertaining to groundwater quality

4.1. California Pesticide Information Portal (CalPIP)

https://calpip.cdpr.ca.gov/main.cfm

- From Department of Pesticide Regulation (DPR).
- Pesticide use reporting (PUR) data, and Groundwater Protection Areas (GWPAs).
- Downloadable data in text files, shapefiles, maps, and KML files.
- Data can be sorted by locations, chemicals, years, counties.
- Trendline analysis can be done on usage of pesticides, but not on groundwater elevation or chemical concentrations.
- Data archives are available for download. ftp://transfer.cdpr.ca.gov/pub/outgoing/pur_archives/
    - List the locations and quantities of pesticide uses for that year.
- Pesticide use reporting (PUR) https://www.cdpr.ca.gov/docs/pur/purmain.htm
    - Choose location of interests and generate a report.

No groundwater chemical data available.

4.2. Locations of Ground Water Protection Areas (GWPA)

https://www.cdpr.ca.gov/docs/emon/grndwtr/gwpa_locations.htm

- GWPA maps and county lists.
- Downloadable maps, shapefiles, KML files.
- Contains locations of regulated sites, but no data.
- Choose a township and check whether it contains GW Protection Areas. https://calpip.cdpr.ca.gov/county.cfm?ds=GWPA
- Ground Water Protection Area Lists https://www.cdpr.ca.gov/docs/emon/grndwtr/gwpa_lists.htm

No groundwater chemical data available.

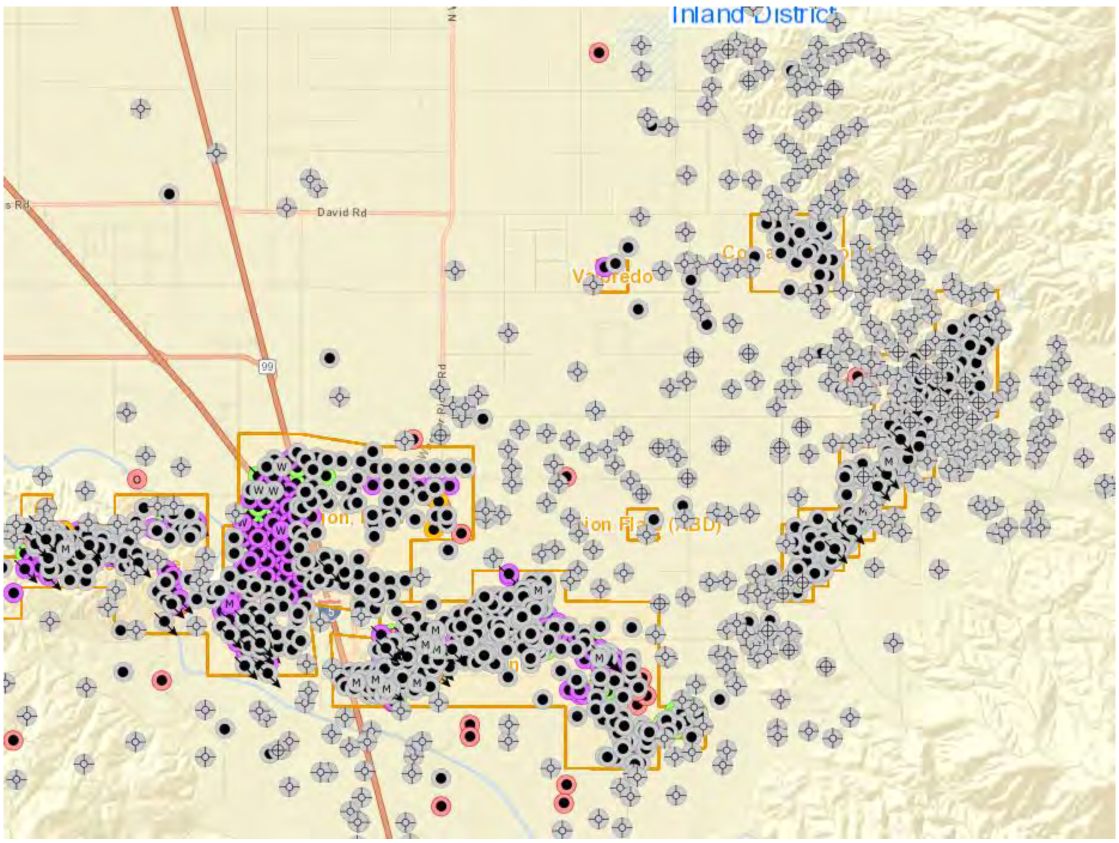
5. Information on Groundwater Quality in Areas of Oil and Gas Production

5.1. WellFinder

https://www.conservation.ca.gov/calgem/Pages/WellFinder.aspx

- From California Geologic Energy Management Division (CalGEM), formerly California Division of Oil, Gas, and Geothermal Resources (DOGGR).
- Oil and gas well locations, information and records; Information about other oil and gas facilities.
- Data through third party reporting.
- Well locations as Excel; well data and reports as pdf or tif files.

No groundwater chemical data available. Contains information on the location of oil and gas production wells.



5.2. CalStim'D – Well Stimulation Permits and Sites

https://maps.conservation.ca.gov/doggr/calstimd/#close

- Data from DOGGR.
- Map viewer of well stimulation sites.
- No downloadable data.
- Searched by permits or American Petroleum Institute (API) number.
- Well Stimulation Treatment (WST) Disclosure; includes WST disclosures from Jan. 1, 2014 to present.

No groundwater chemical data available.

5.3. Well Stimulation Treatment Disclosure Search

https://www.conservation.ca.gov/calgem/Online_Data/Pages/Index.aspx

- Well stimulation sites and permits can be searched by date or chemical constituent.
- No downloadable data.

No groundwater chemical data available.

5.3. Water Quality in Areas of Oil and Gas Production – Regional Groundwater Monitoring Program

https://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/regional_monitoring/index.html#overview

- Salinity mapping.
- Produced water characterization.
- Groundwater potential risk zone analysis.
- Data from USGS, DOGGR, and other state and regional boards.
- Chemical data are available to download. Trendline analysis is feasible.
- Data releases: https://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/regional_monitoring/index.html#datareleases

No groundwater chemical data available. Contains information on the location of oil and gas production wells.

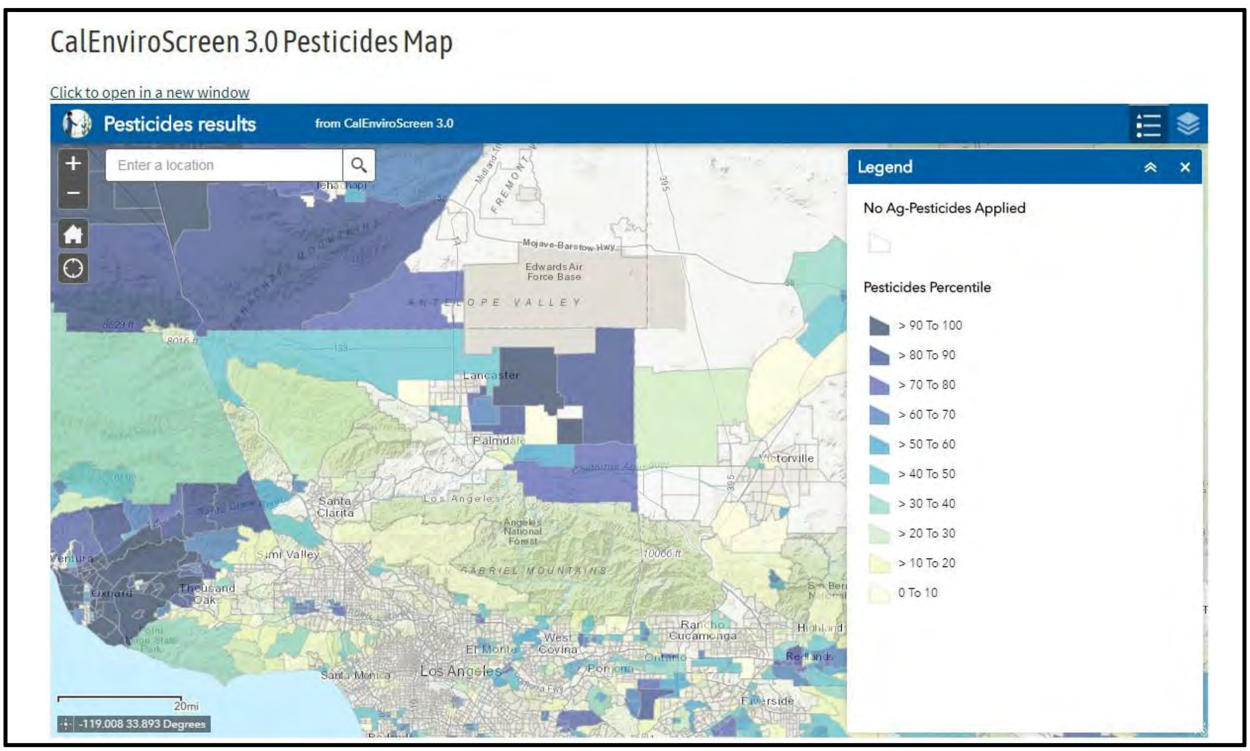
6. Information on Vulnerability Assessment Tools Pertaining to Groundwater

6.1. CalEnviroScreen 3.0 Maps

https://oehha.ca.gov/calenviroscreen

- Scores for pollution burden, including groundwater threats, drinking water contamination, clean ups, pesticides, and other indicators of pollution burden, and population characteristics by census tract.
- From various sources.
- Downloadable data in various formats (no chemical concentration measurements or groundwater elevations).
- Screening tool to help identify communities burdened by or susceptible to multiple sources of pollution.
- Maps – Cal EnviroScreen, Pesticides, Pollution Map, Disadvantaged Communities, etc. https://oehha.ca.gov/calenviroscreen/maps-data
    - Most results are expressed as scores; applicable for regulatory purposes.
- Chemicals databases – toxicity reports: https://oehha.ca.gov/node/11208

No groundwater data available.



OEHHA Environmental Topics About Proposition 65 News and Events Library

7440-38-2

As
Arsenic
74.9216

Synonym(s)

Arsenic, inorganic; Arsenic black; Arsenic-75; Colloidal arsenic; Gray arsenic; Inorganic arsenic compounds; Metallic arsenic

Occurence(s)/Use(s)

Wood preservative, herbicide, nonferrous alloys, medicine (leukemia treatment); component of tobacco smoke. Formerly used in optical glass.

More information about Arsenic

California Public Health Goals Data

Health Risk Category:	Carcinogenicity
Public Health Goal (mg/L):	0.000004
Public Health Goal - Download:	Arsenic Public Health Goal Technical Support Document
Downloads:	Response to comments on PHG for arsenic Fact Sheet: Public Health Goal for Arsenic
Cancer Risk at PHG:	0.000001
MCL value (mg/L):	0.01
Cancer Risk at MCL:	0.0025
Last PHG Revision :	2004
California PHG Comments:	Solubility of arsenic compounds vary.
Update Date:	04/01/2004

Maps

Indicator Maps (CalEnviroScreen)

View maps on pollution burden, ozone, PM2.5, Diesel PM, Drinking Water, Pesticides, Toxic Releases, Traffic, Cleanups, Groundwater, Hazardous Waste, Impaired Waters and Solid Waste

Fish Advisory Map

Searchable map by waterways to find safe fish to eat

Pesticides (CalEnviroScreen)

Map information about agriculture use of Pesticides in your region.

Disadvantaged Communities (CalEnviroScreen)

This map shows the disadvantaged communities designated by CalEPA for the purpose of SB 535.

Pollution Map (CalEnviroScreen)

This map shows Pollution concentrations.

Medical Supervisor Registration

California's Medical Supervision Program is a biomonitoring program that measures cholinesterase activity in blood samples collected from agricultural workers who regularly handle category I and II organophosphate and carbamate pesticides.

7. Surface Water Water Quality

7.1 CEDEN

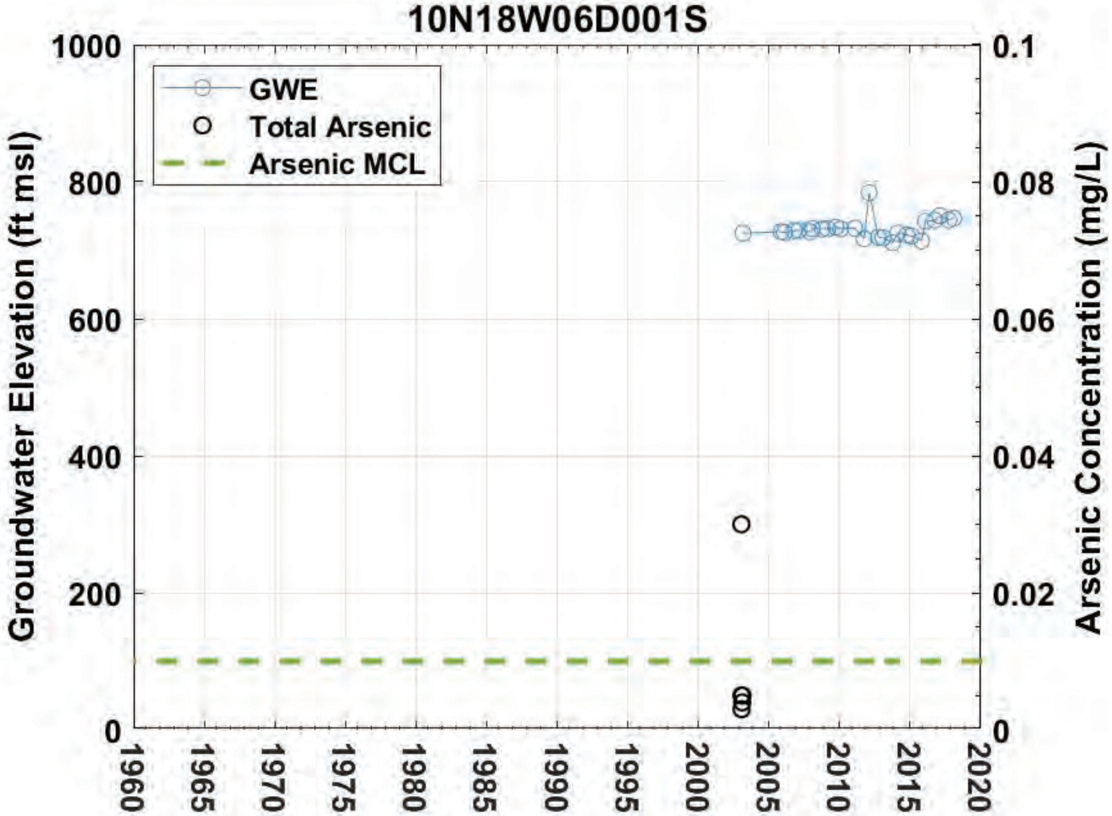
https://ceden.waterboards.ca.gov/AdvancedQueryTool.php

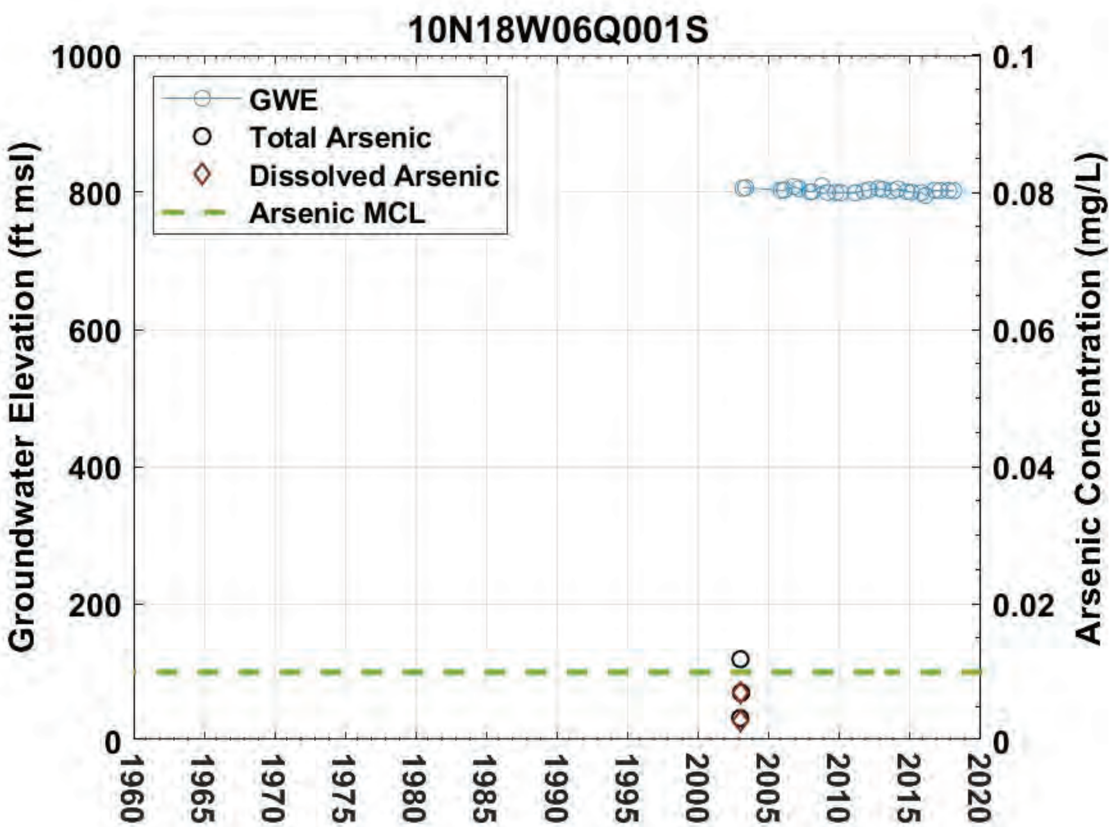
- Surface water quality data

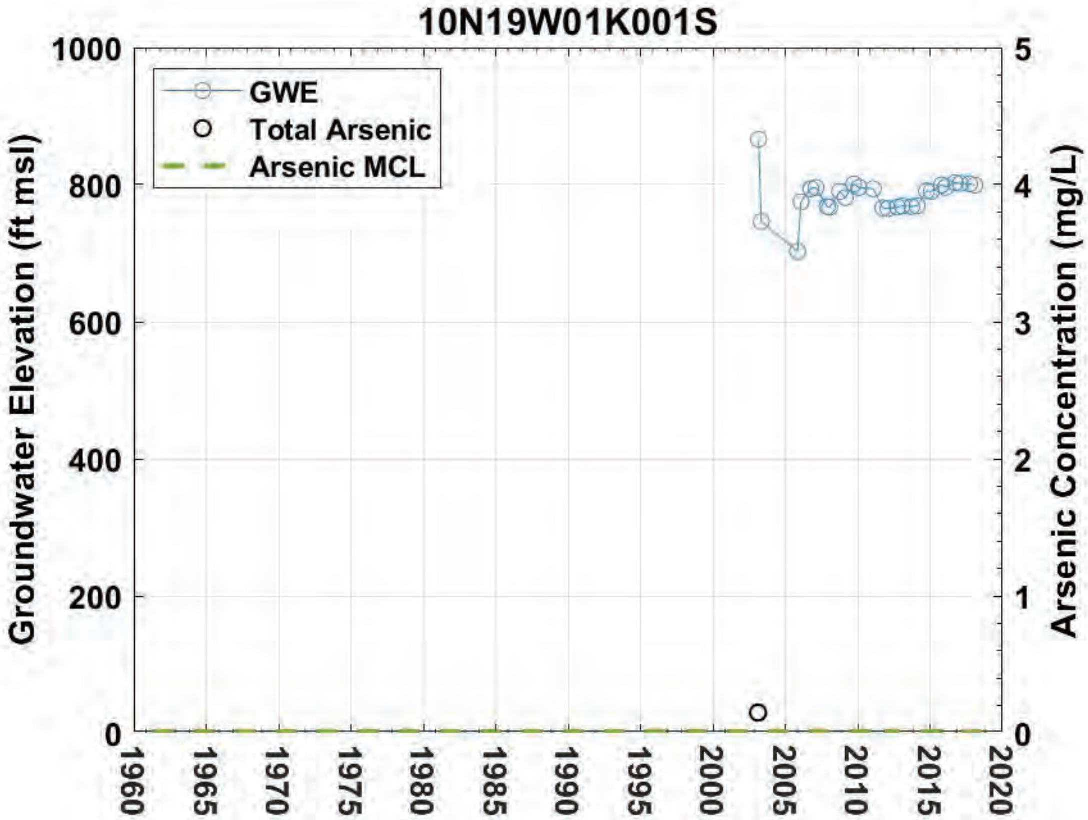
No groundwater chemical data available in WWB.

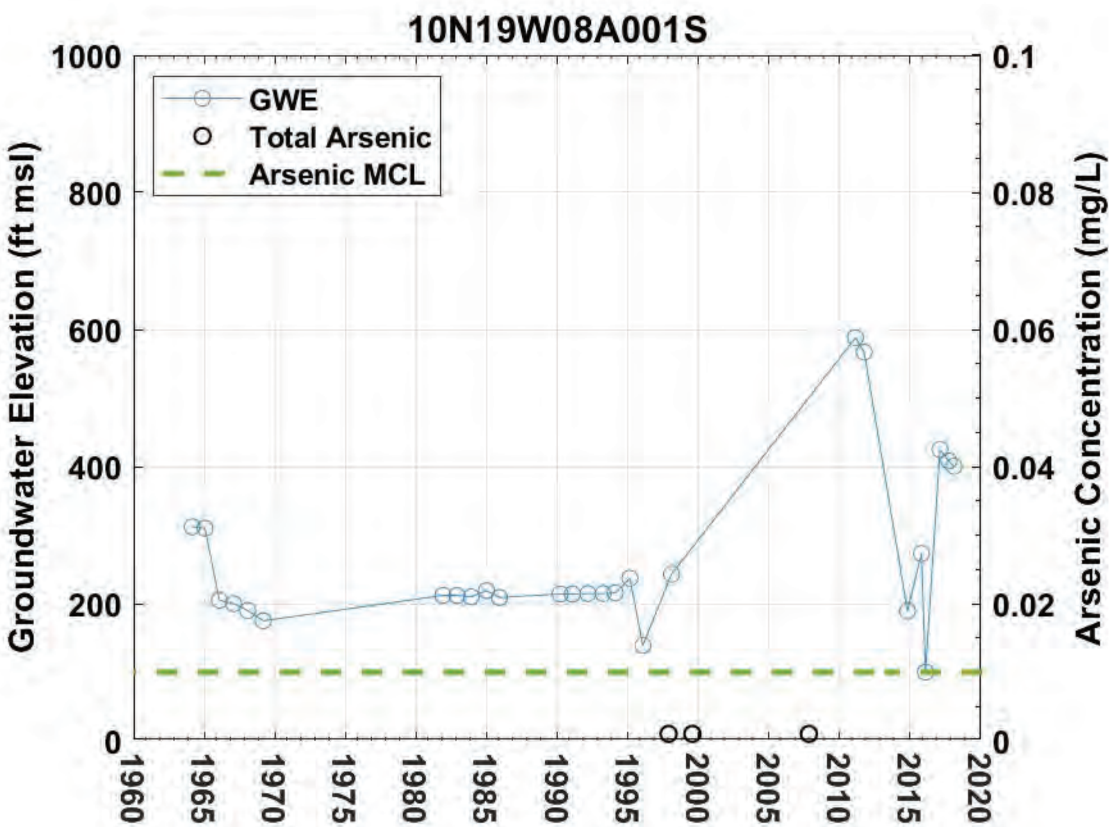
Appendix F

Temporal Characteristics of Available Groundwater Data

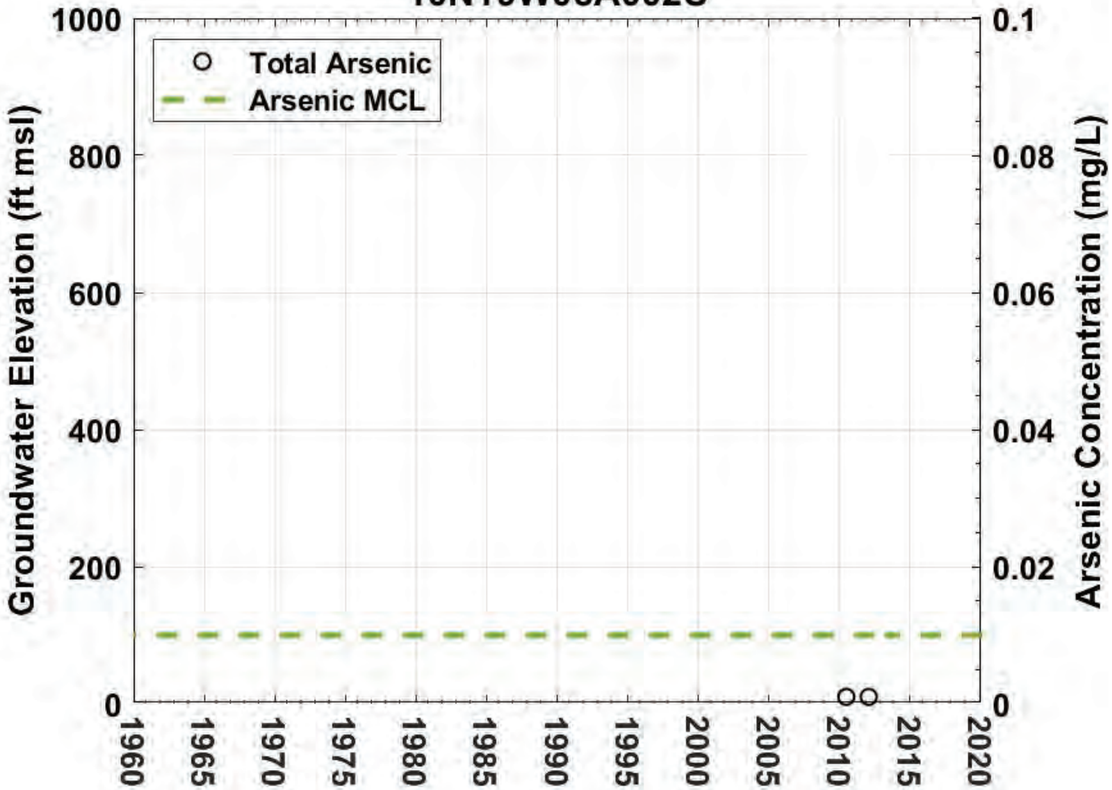

10N18W06D001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


10N18W06Q001S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

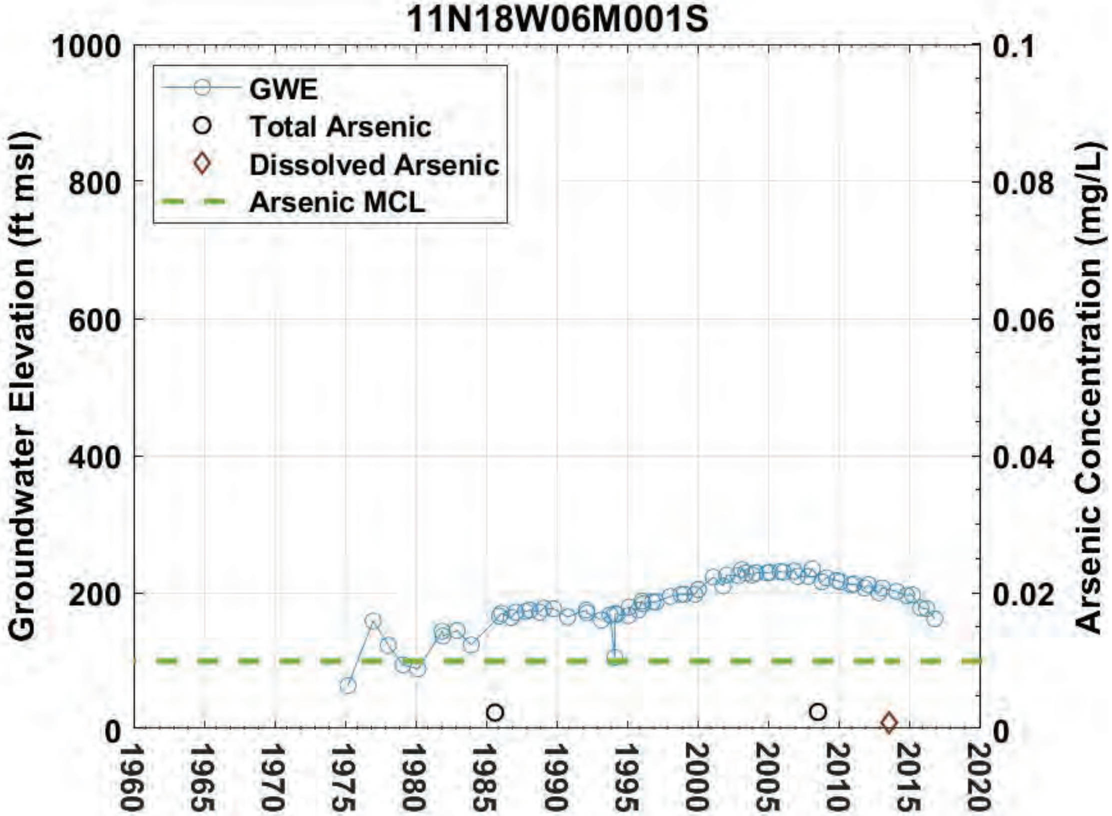

10N19W01K001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
5
4
3
2
1
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

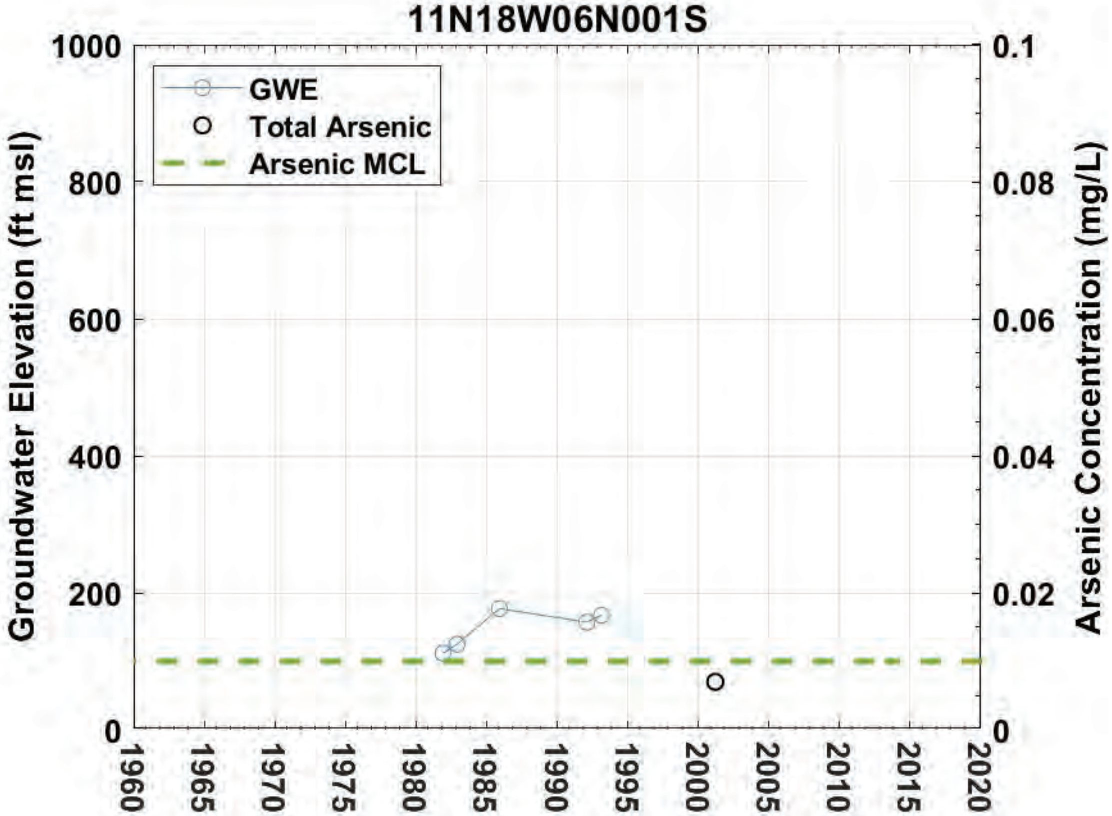

10N19W08A001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

10N19W08A002S

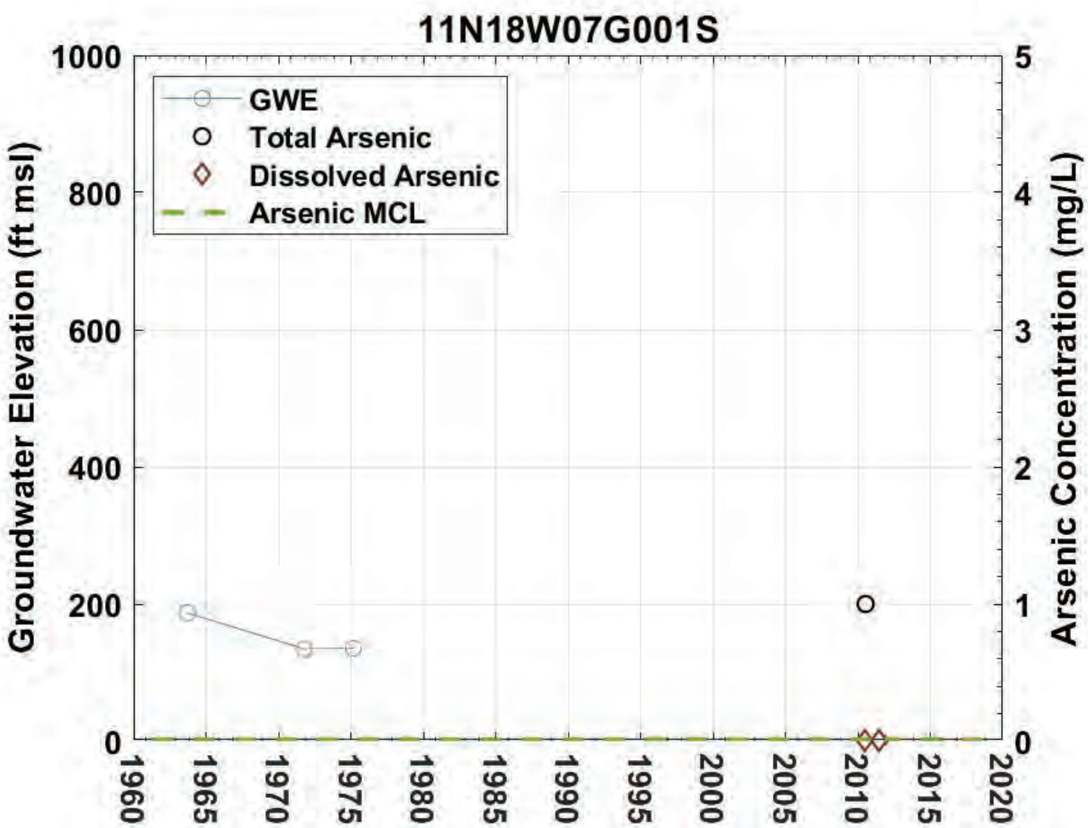


11N18W06M001S

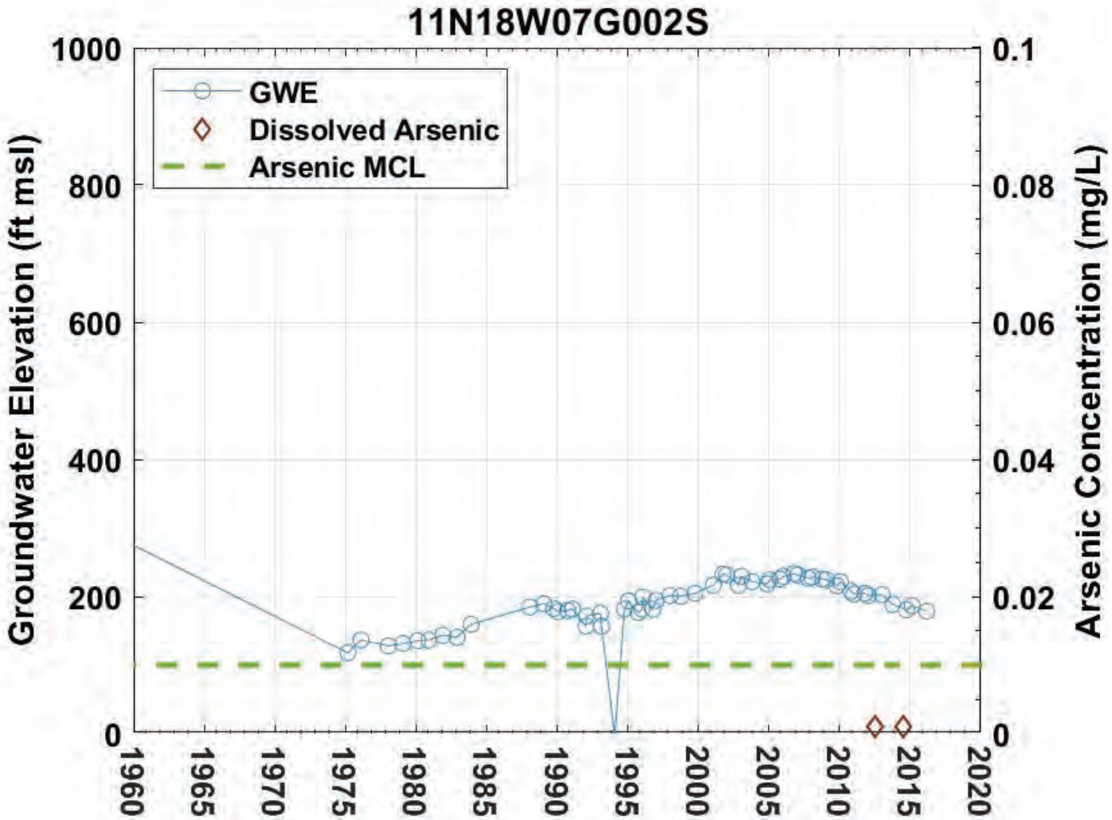


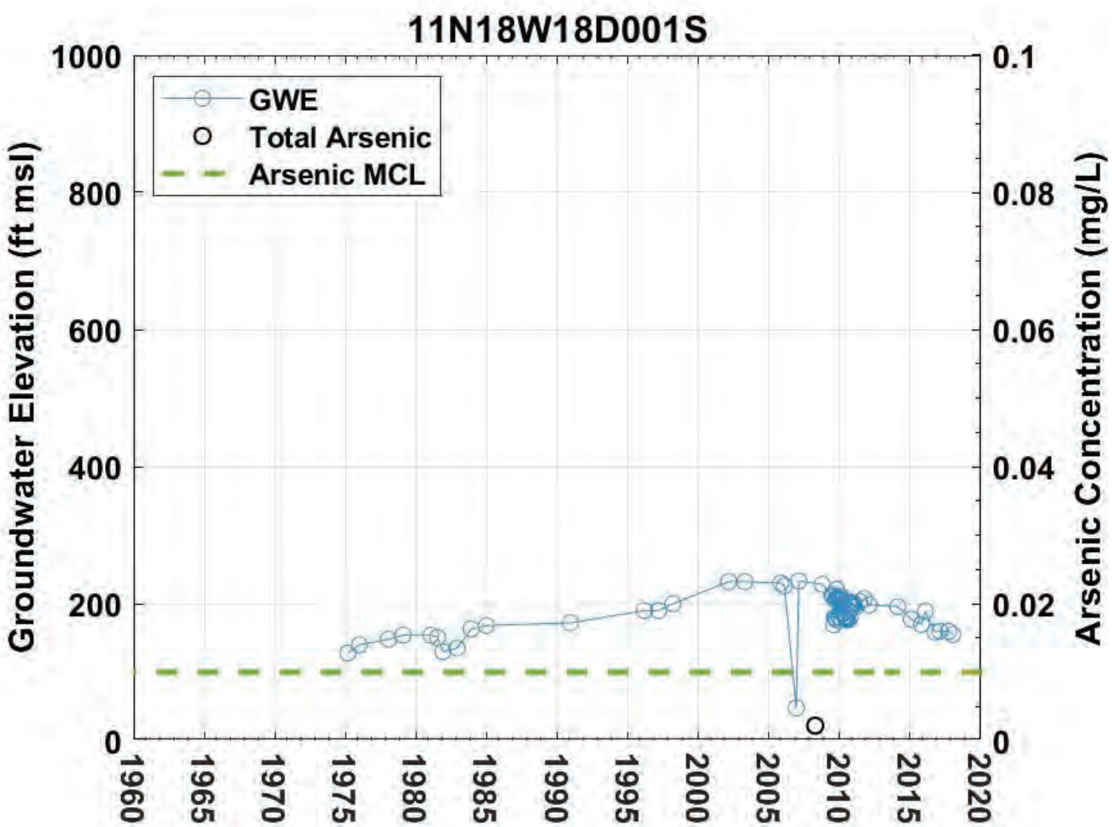


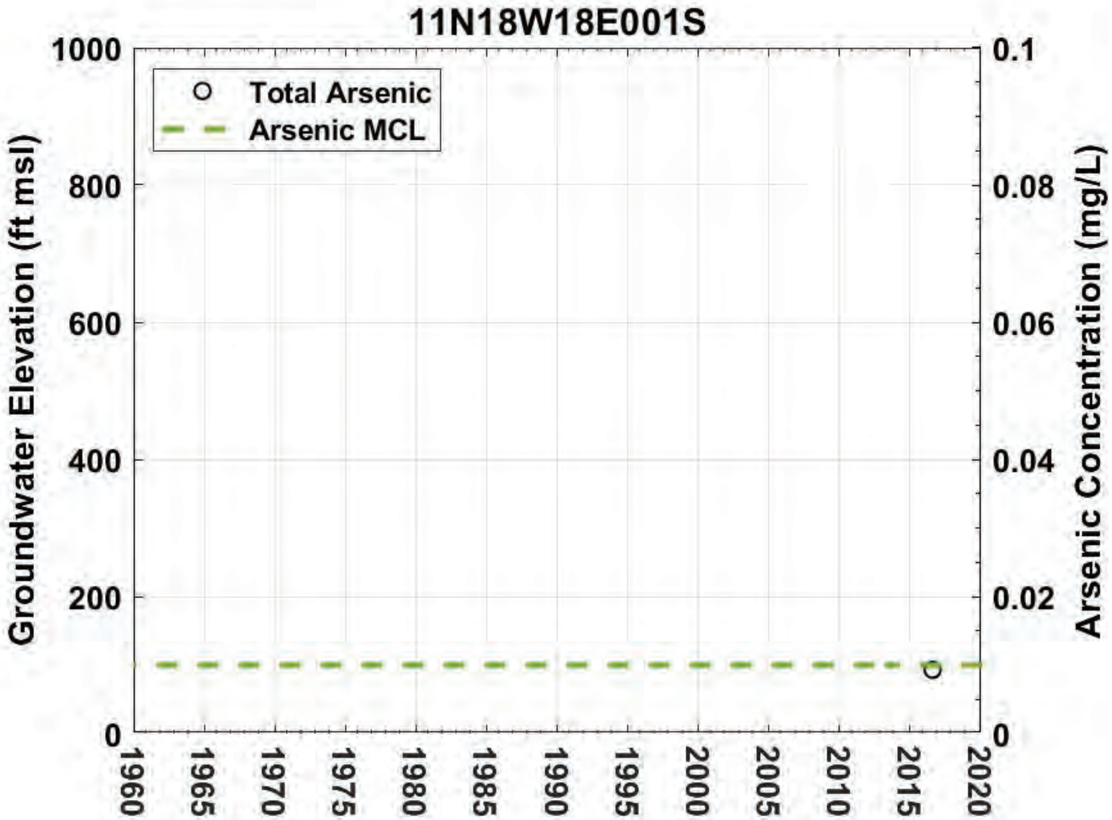
11N18W06N001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

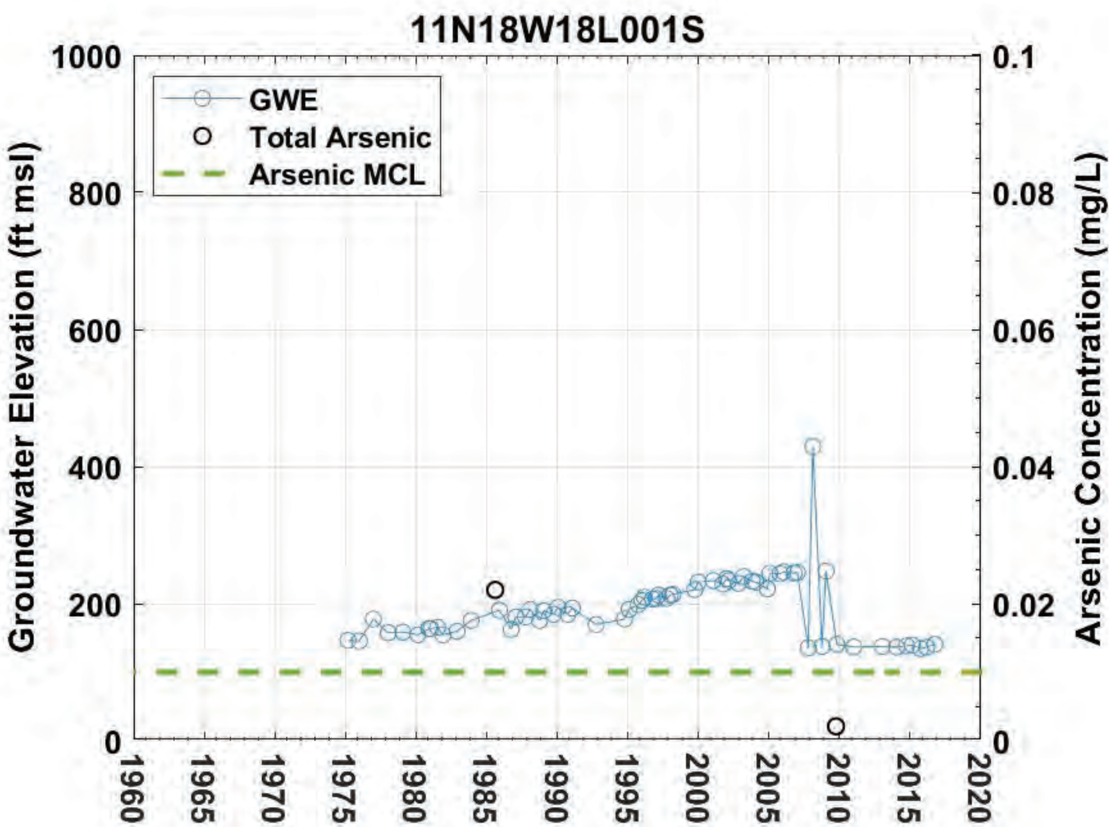


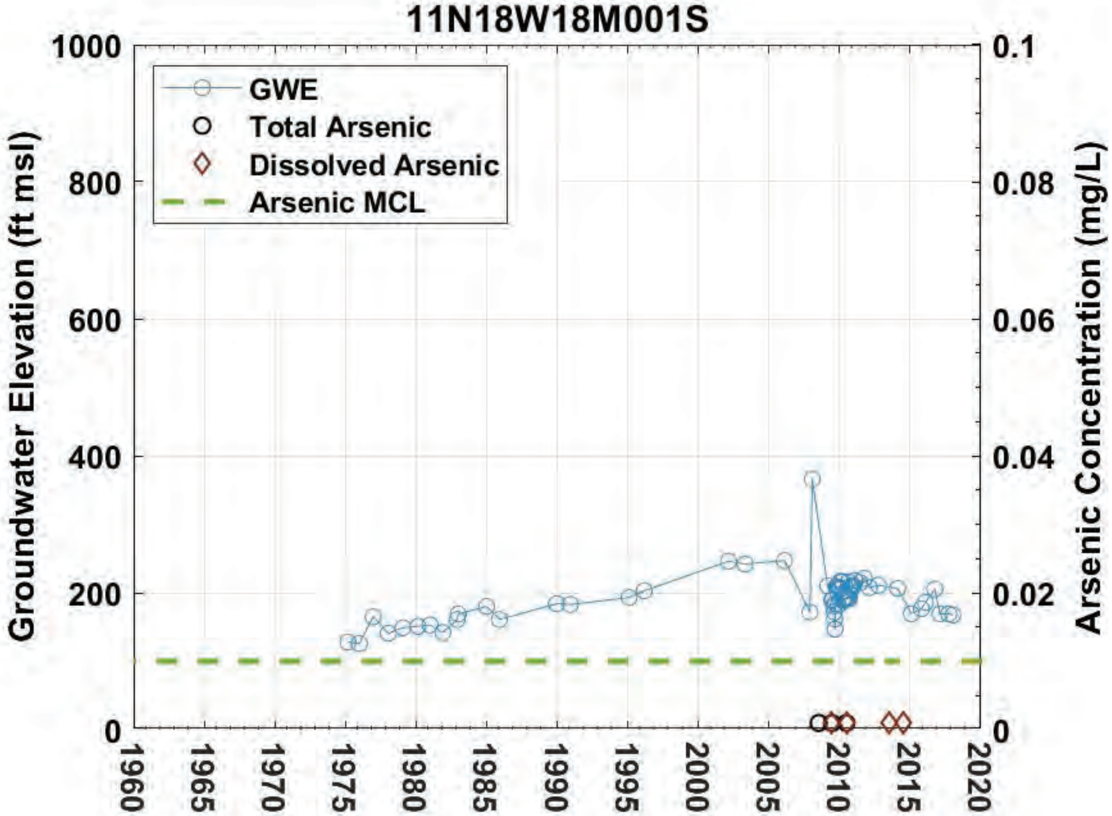
11N18W07G001S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
5
4
3
2
1
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

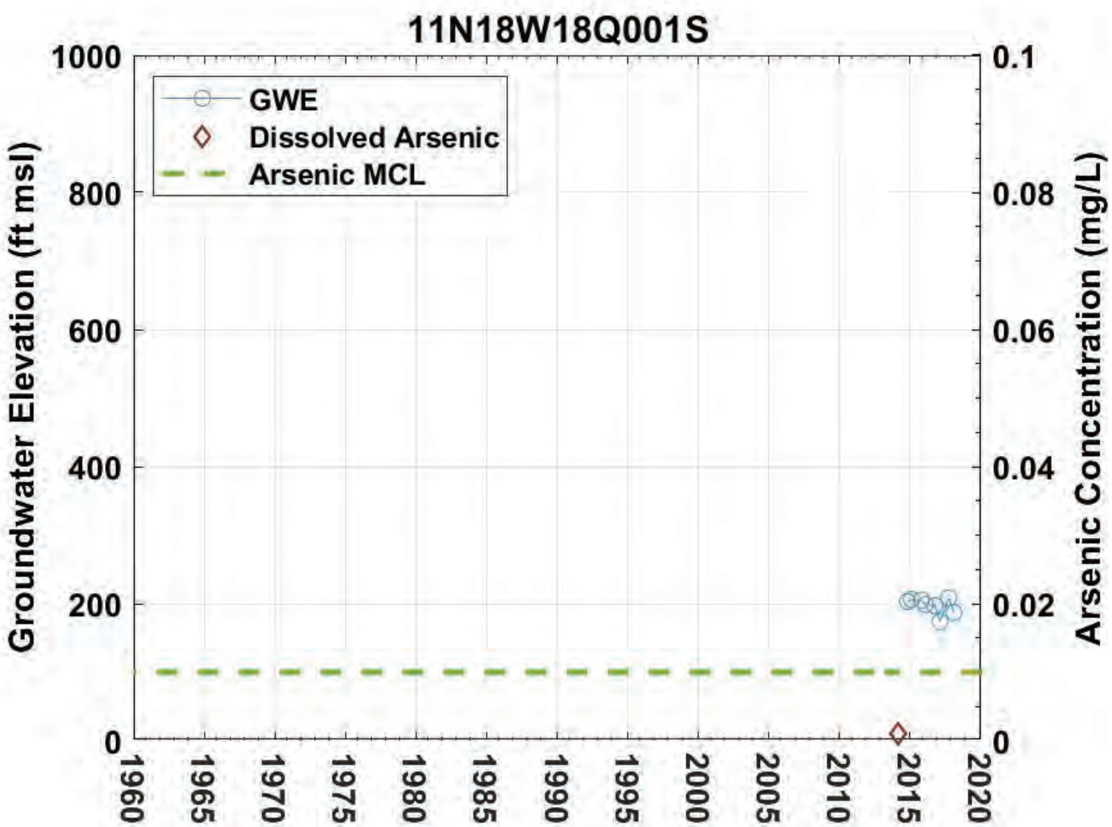

11N18W07G002S
GWE
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

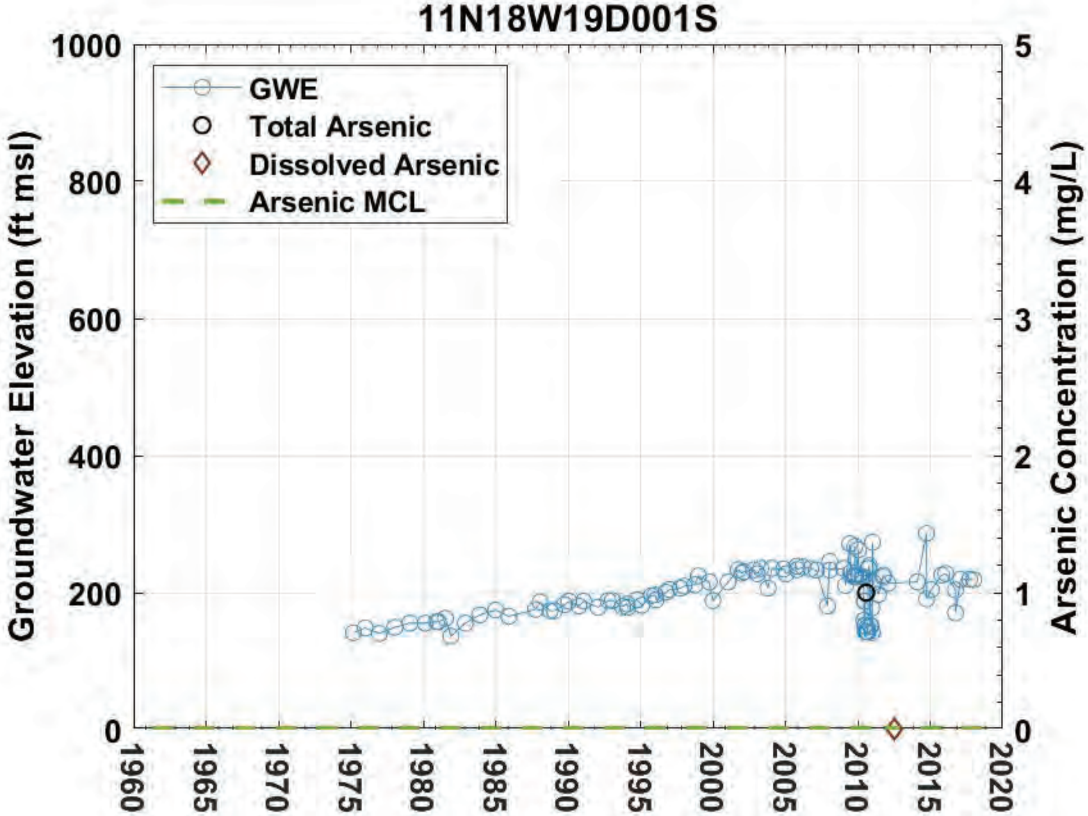

11N18W18D001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

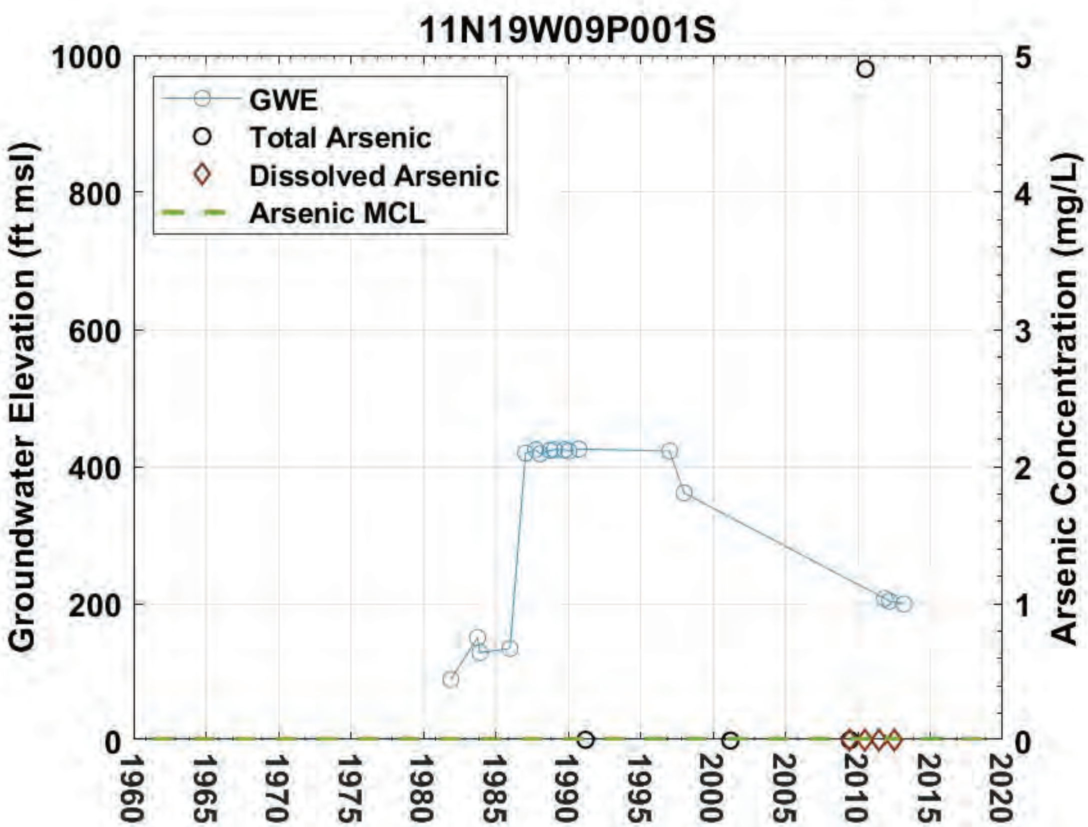

11N18W18E001S
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

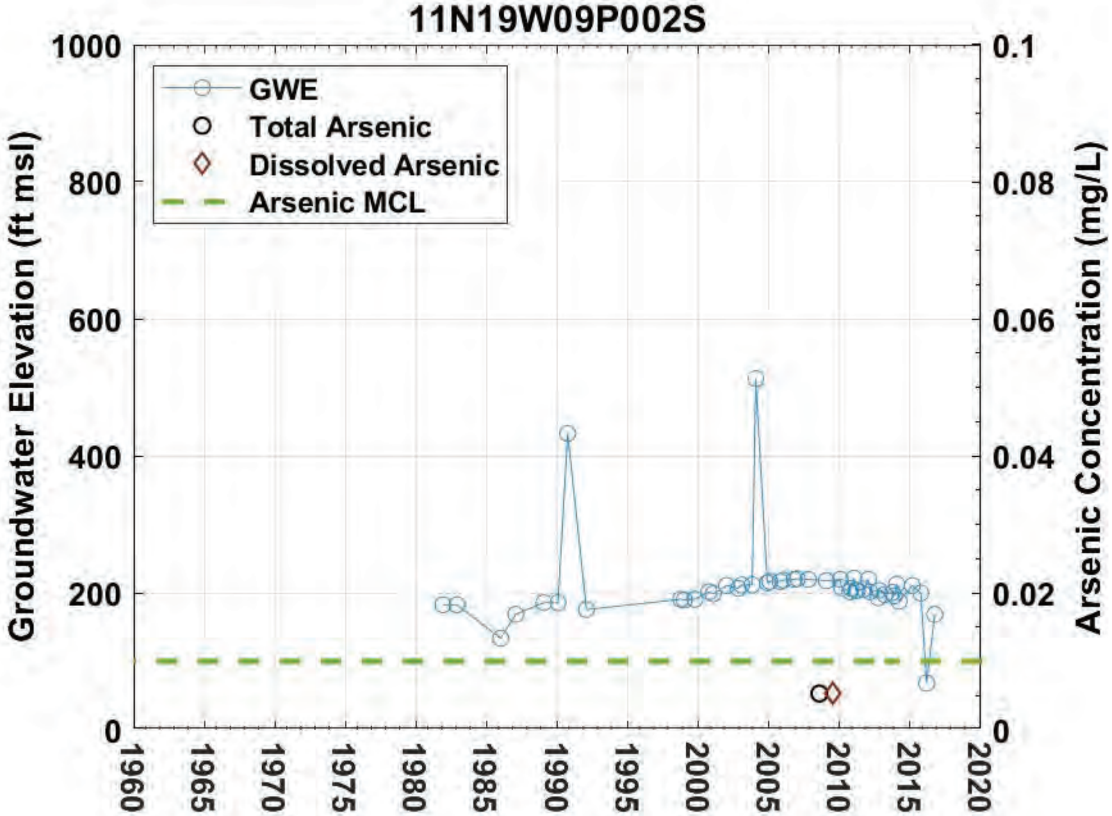

11N18W18L001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

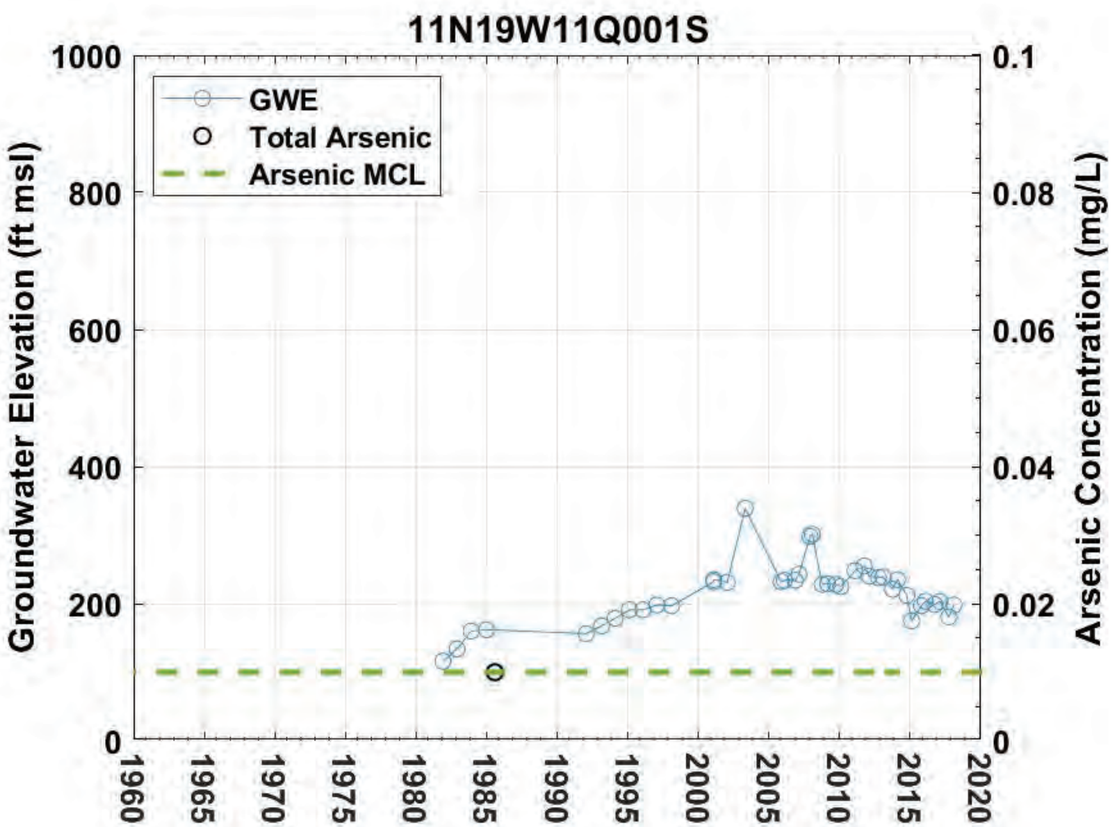

11N18W18M001S
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

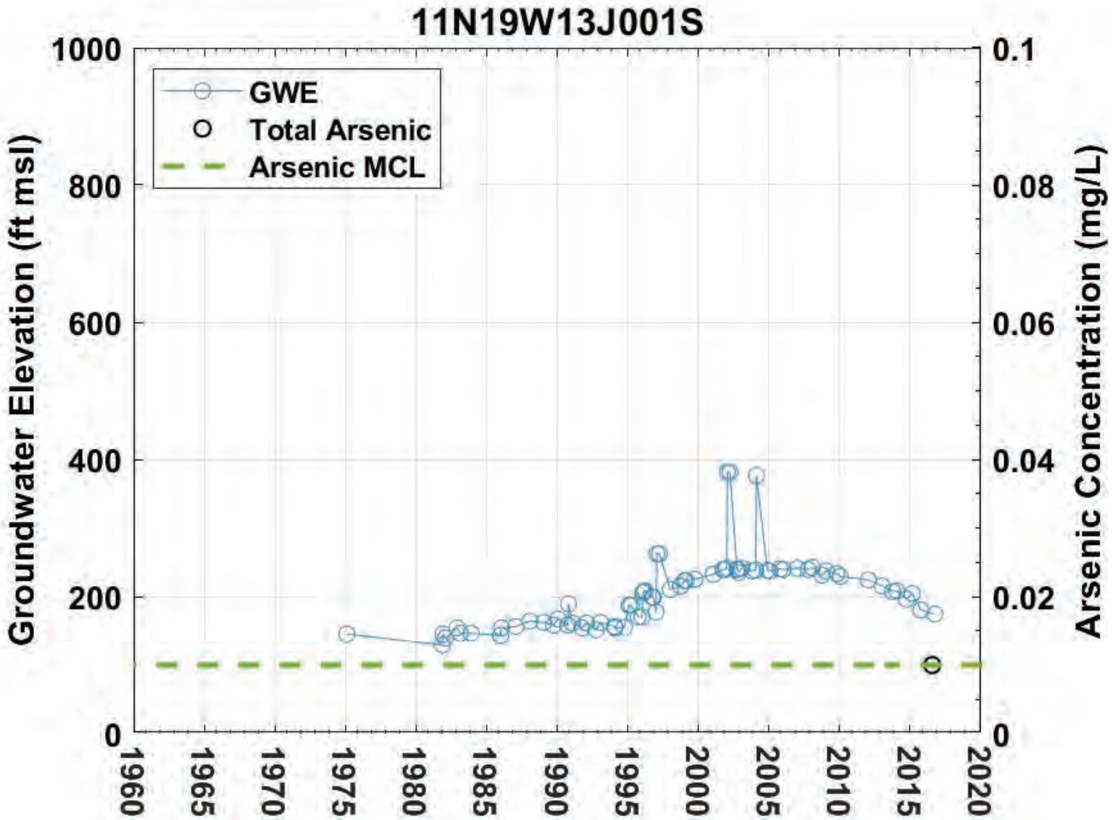

11N18W18Q001S
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
GWE
Dissolved Arsenic
Arsenic MCL
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N18W19D001S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
0
200
400
600
800
1000
0
1
2
3
4
5
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

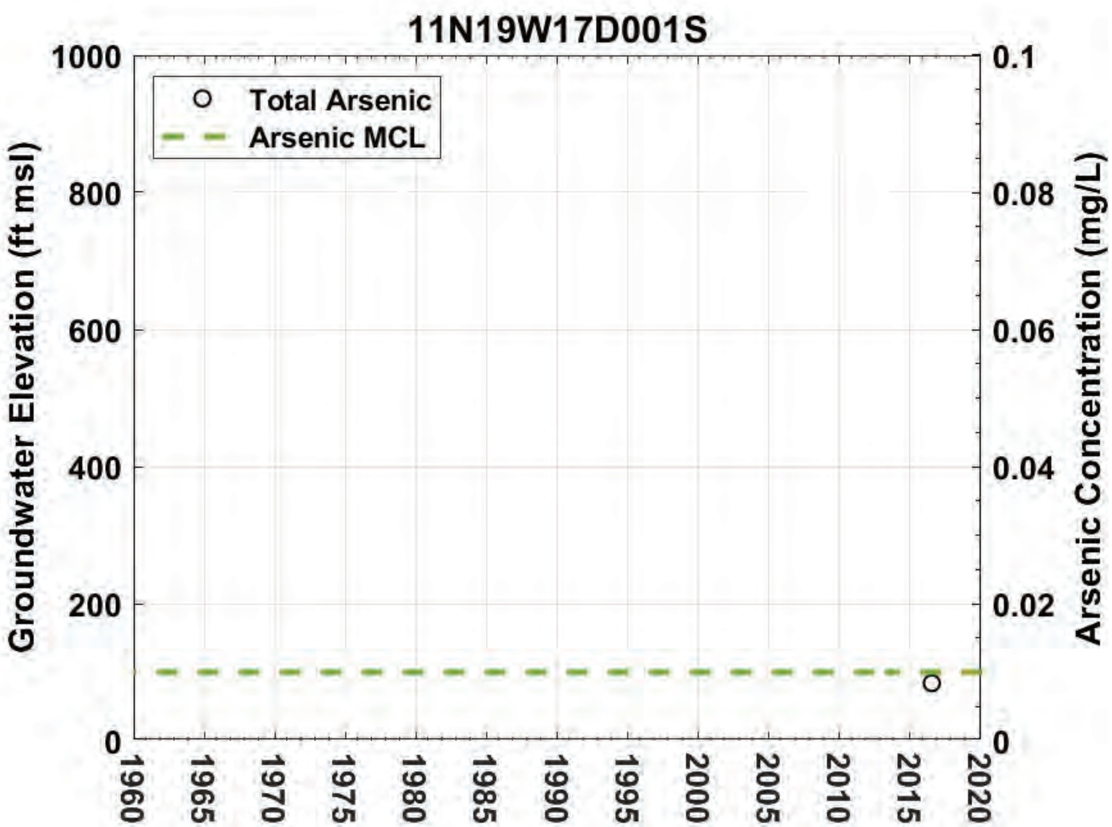

11N19W09P001S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
0
200
400
600
800
1000
0
1
2
3
4
5
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W09P002S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

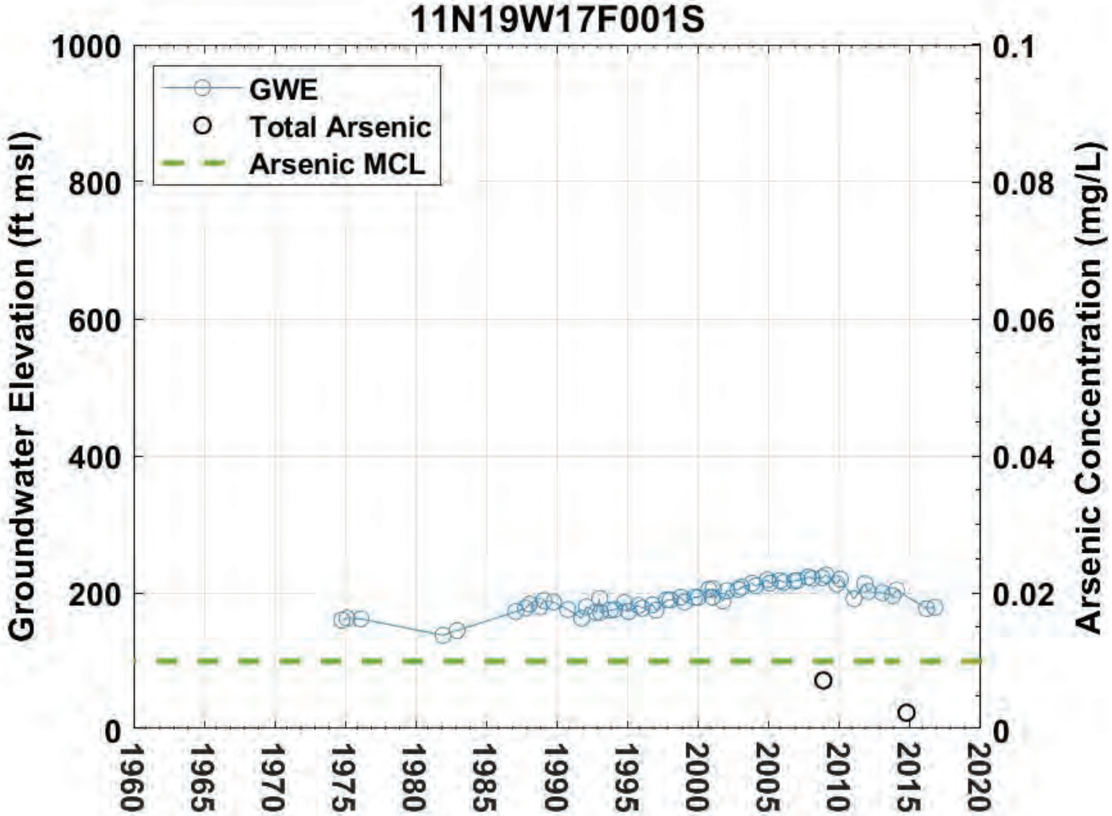

11N19W11Q001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

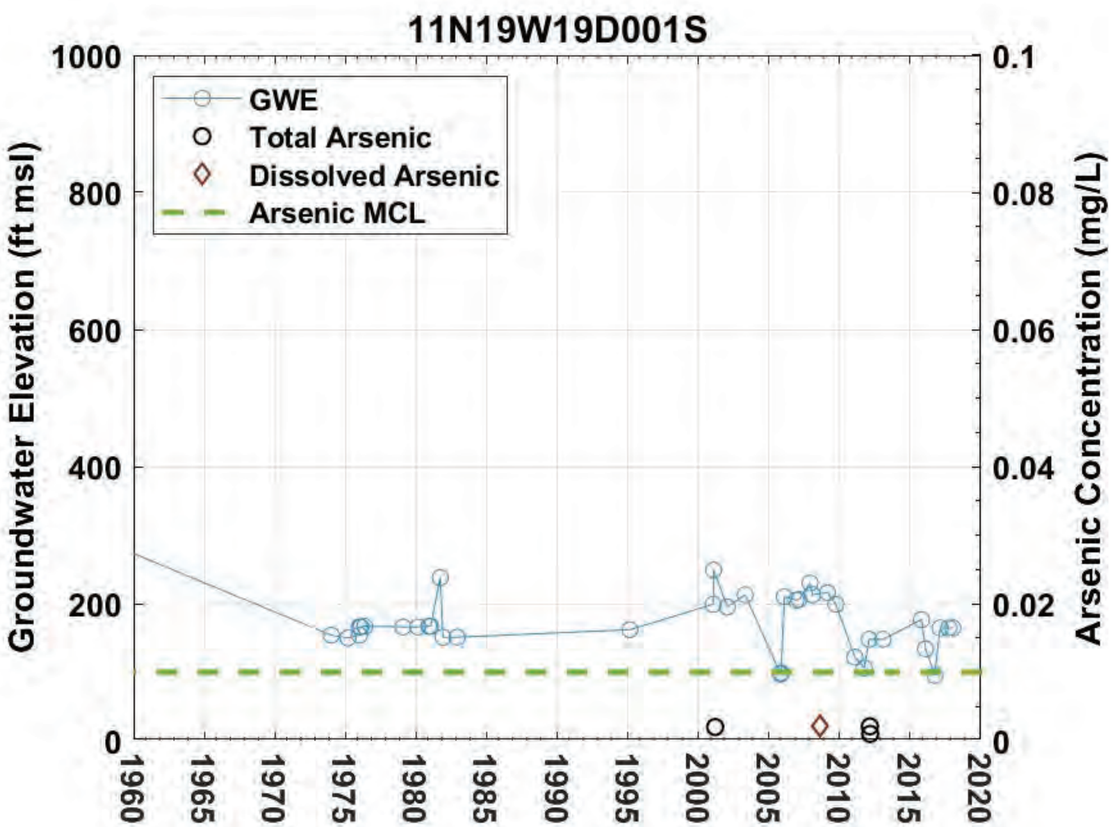


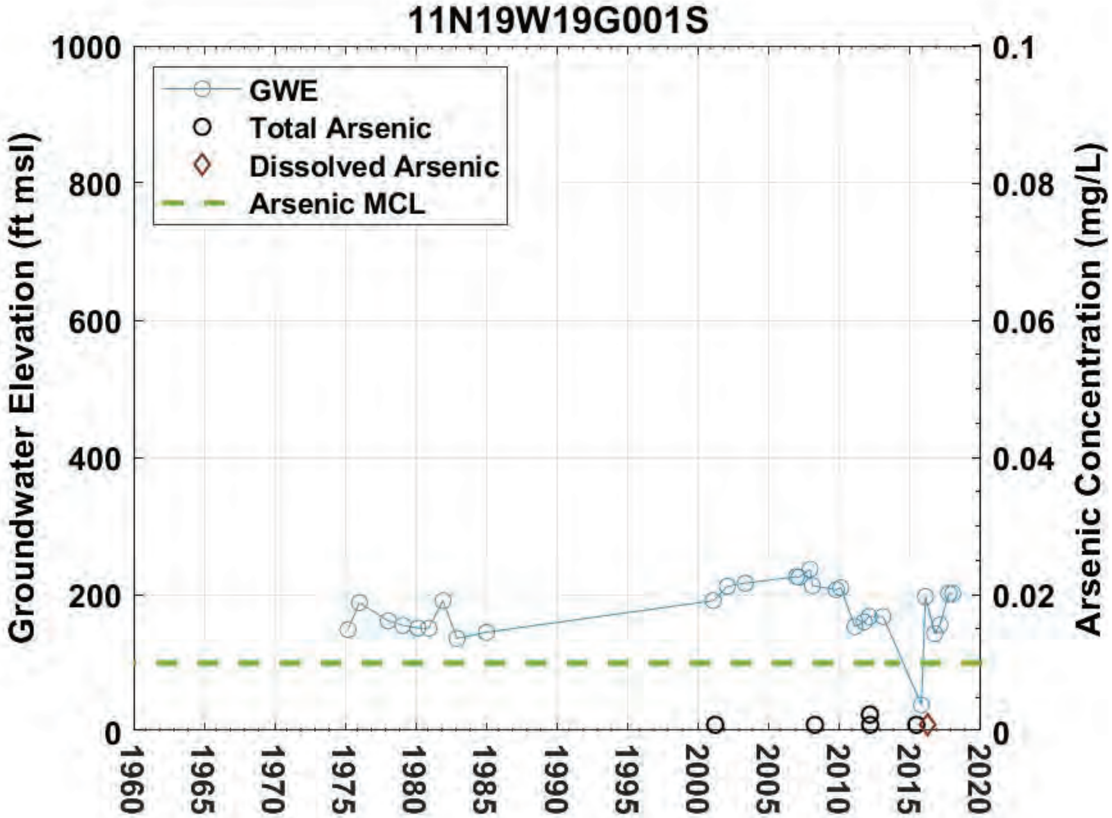
11N19W13J001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

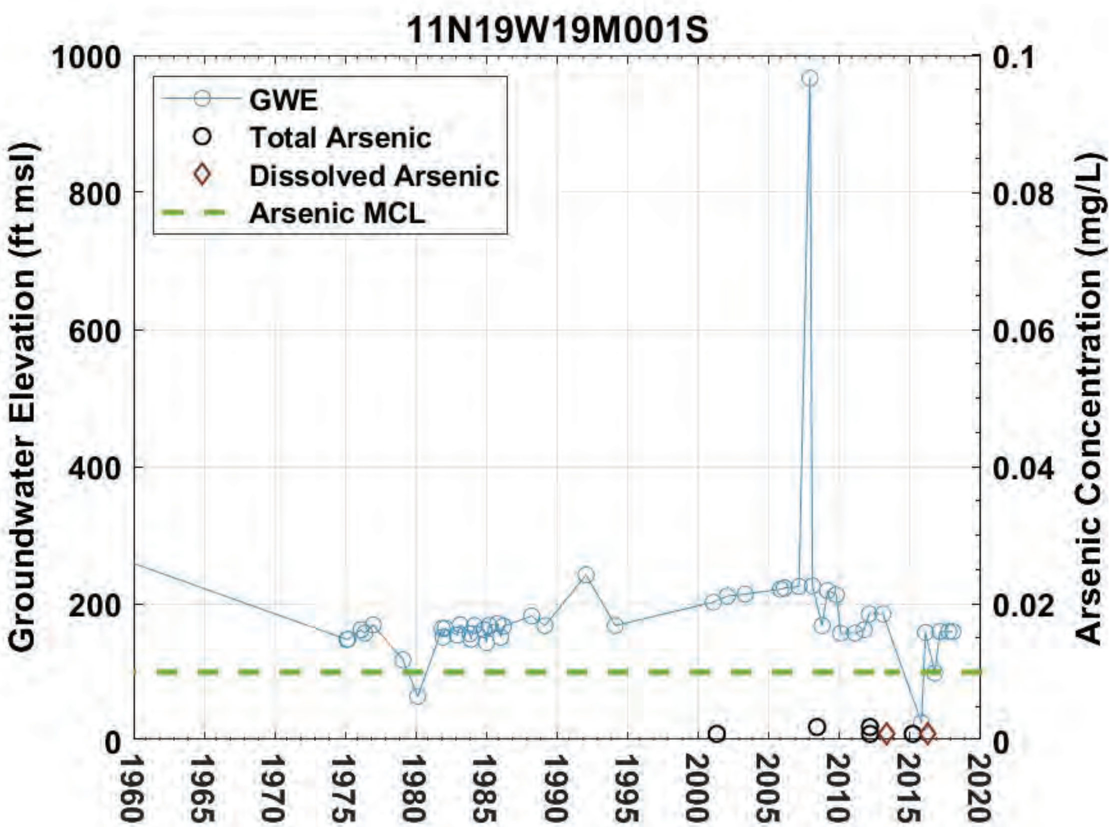


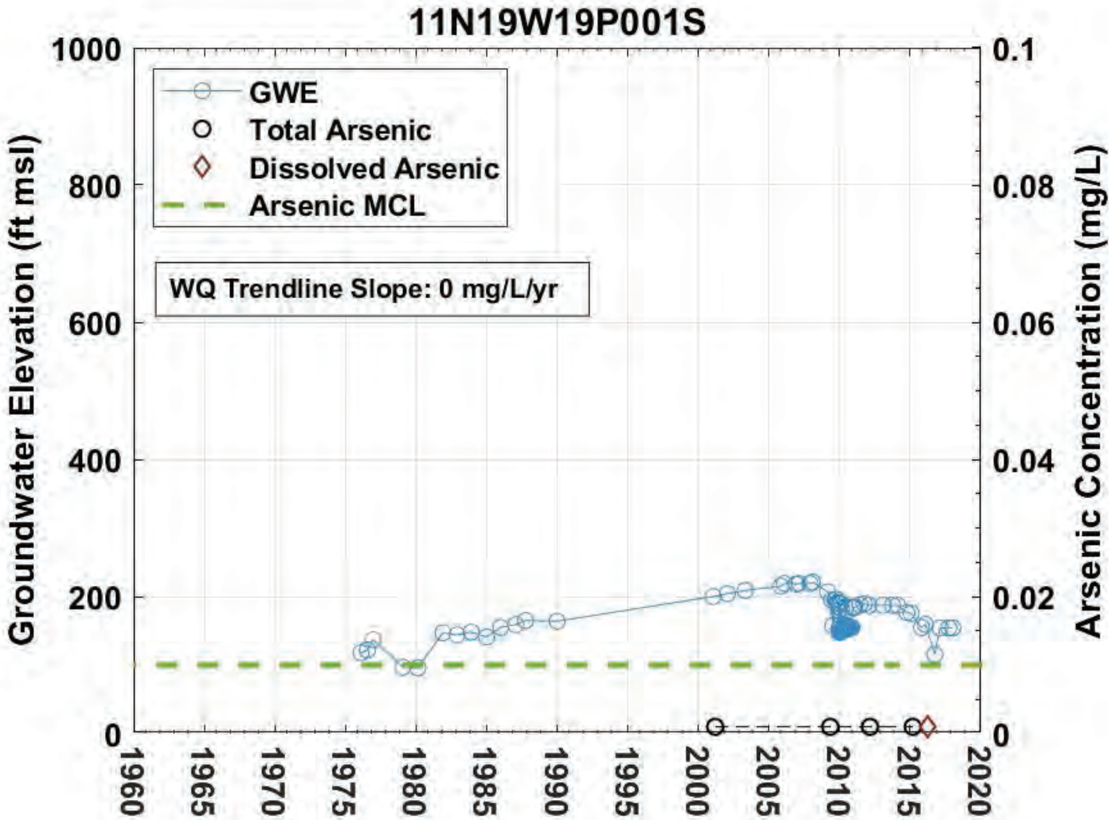
11N19W17D001S
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

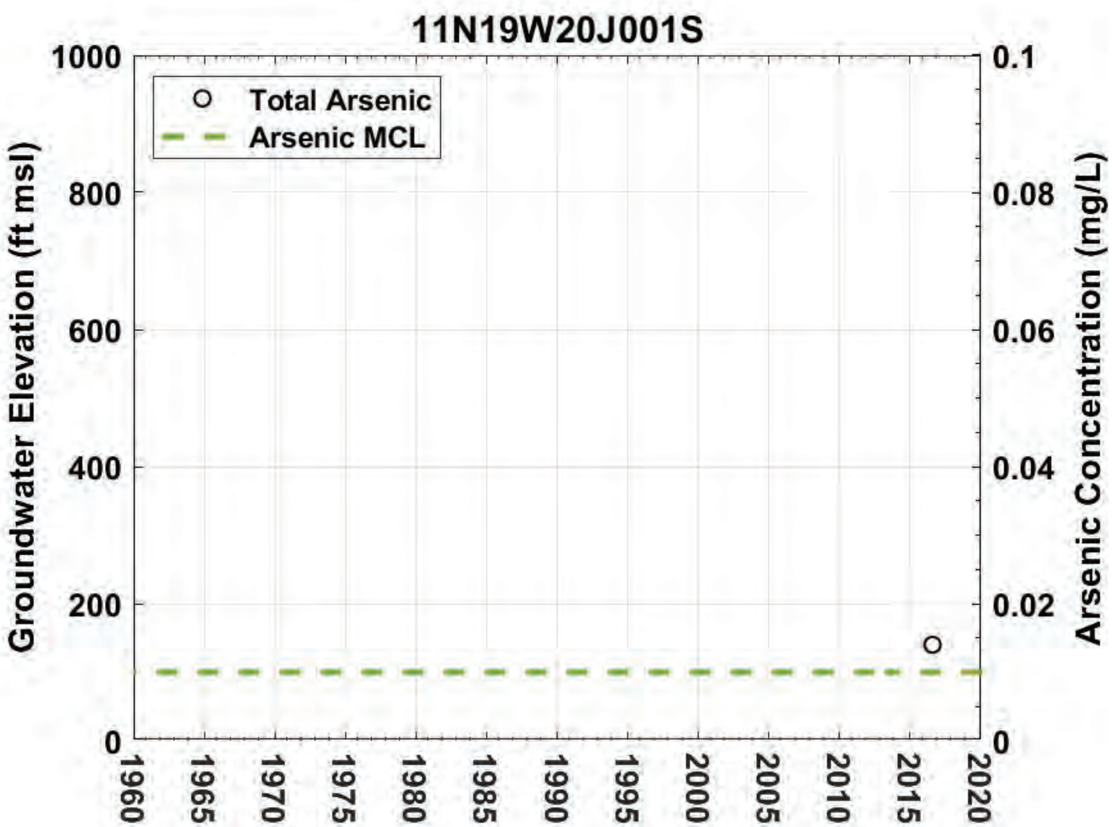

11N19W17F001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
0
200
400
600
800
1000
0
0.02
0.04
0.06
0.08
0.1
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

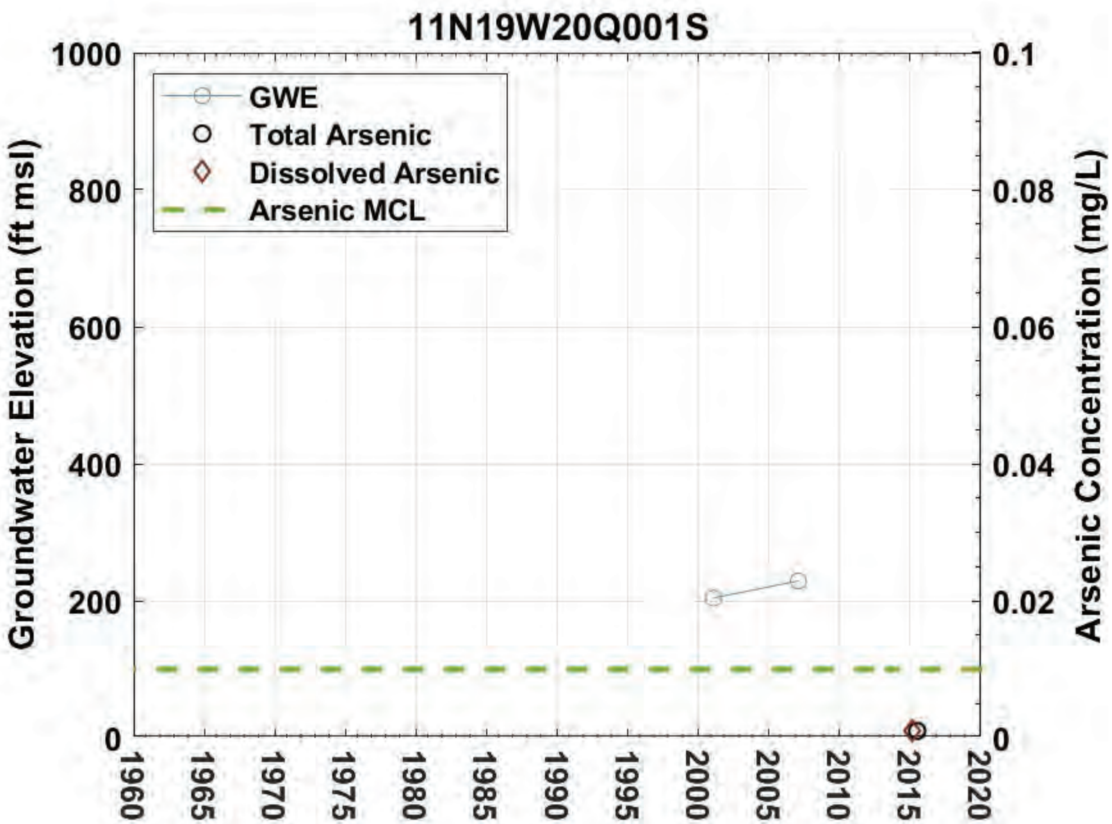

11N19W19D001S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
0
200
400
600
800
1000
0
0.02
0.04
0.06
0.08
0.1
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

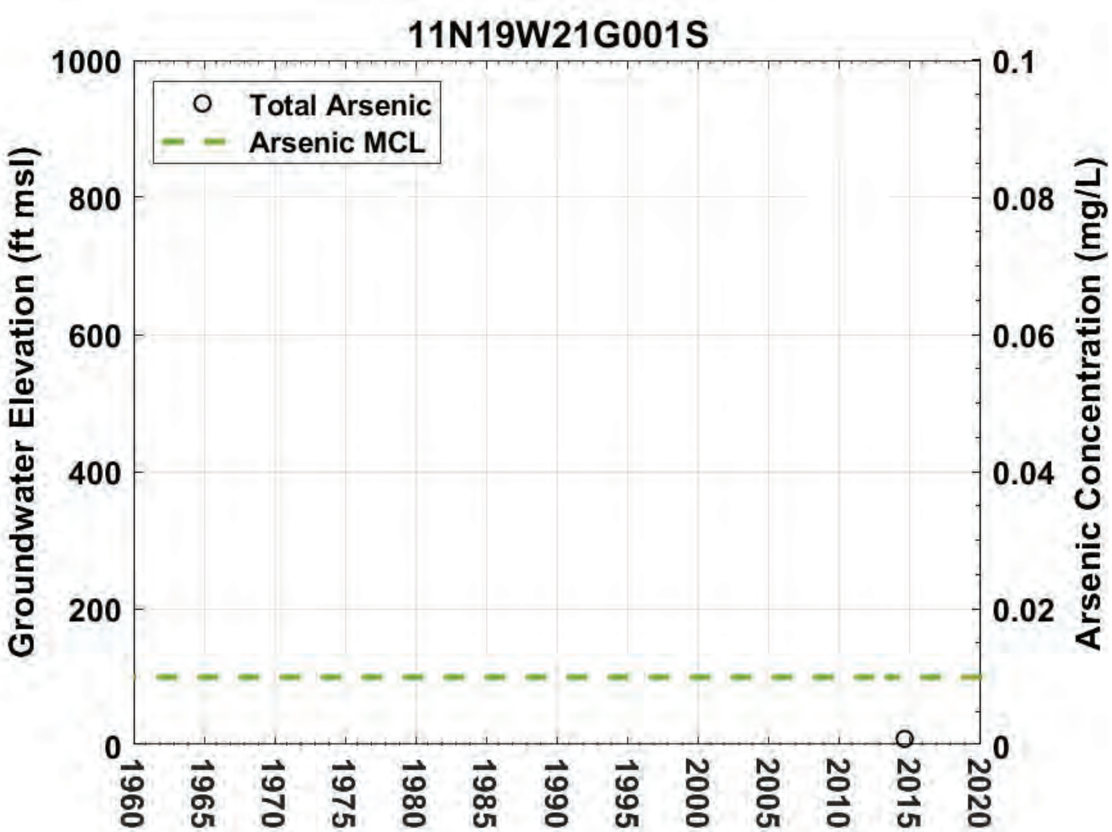

11N19W19G001S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
0
200
400
600
800
1000
0
0.02
0.04
0.06
0.08
0.1
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

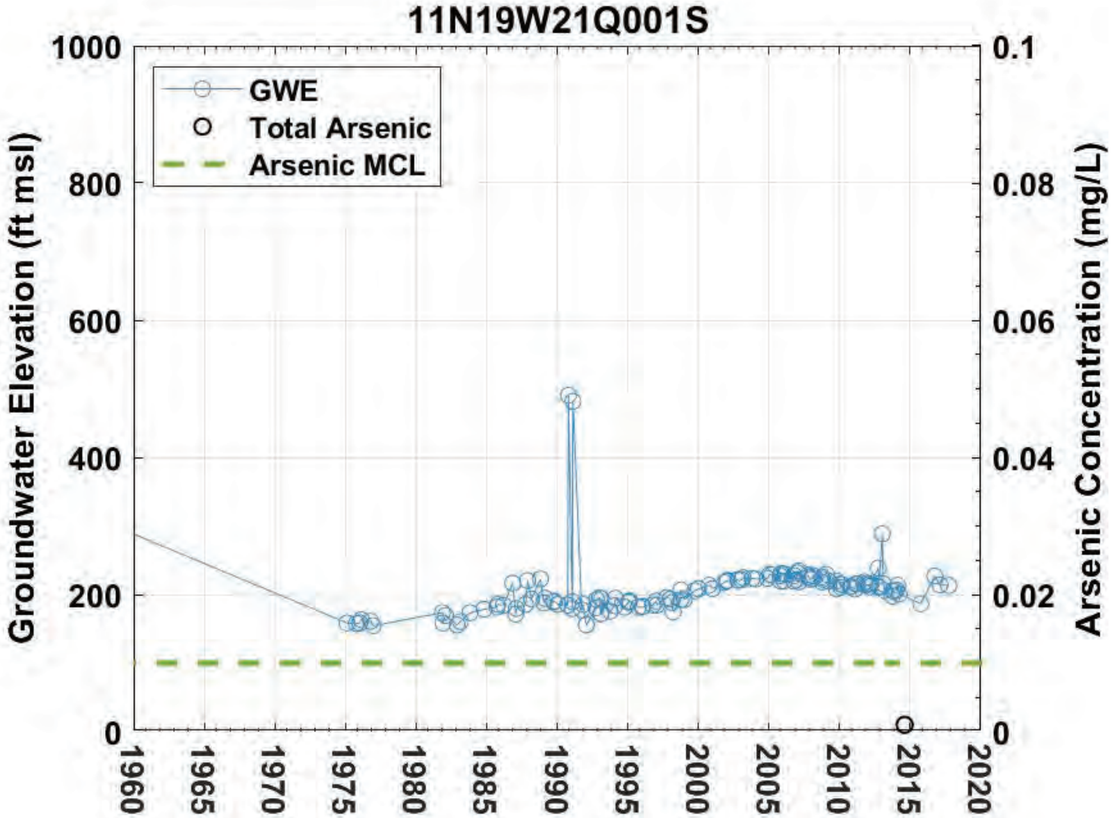

11N19W19M001S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
0
200
400
600
800
1000
0
0.02
0.04
0.06
0.08
0.1
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

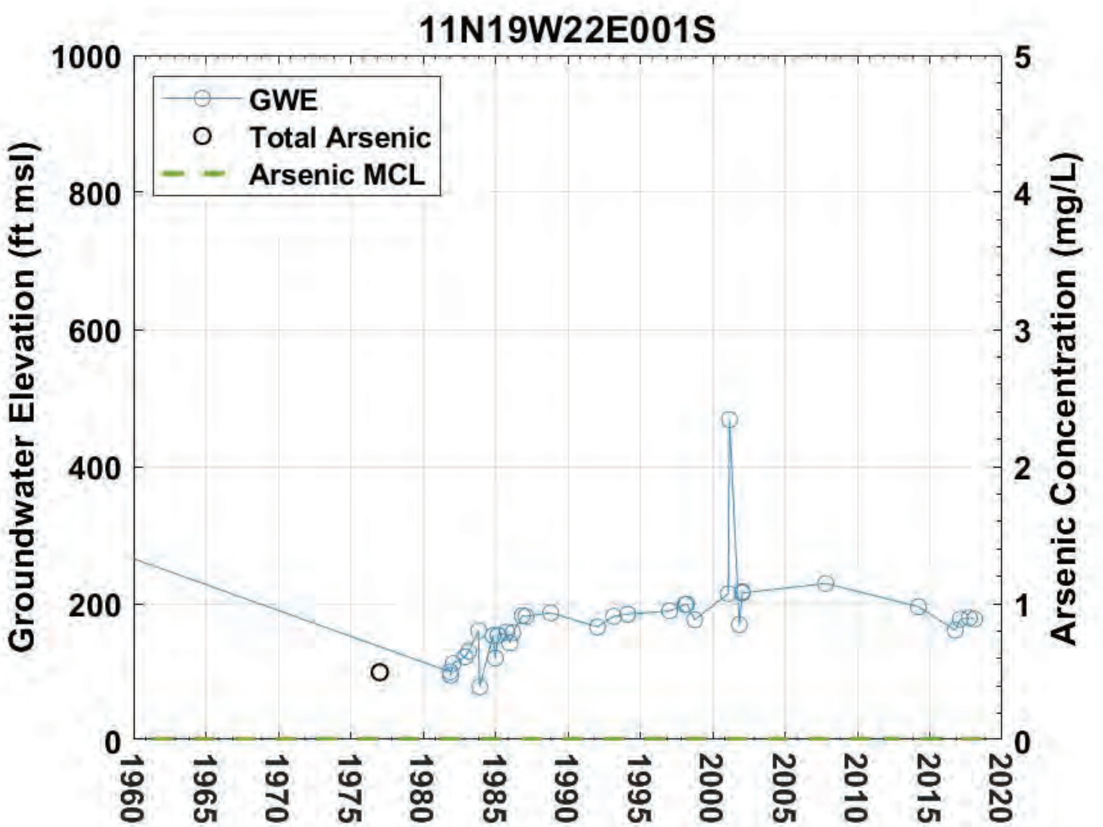

11N19W19P001S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
WQ Trendline Slope: 0 mg/L/yr
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)

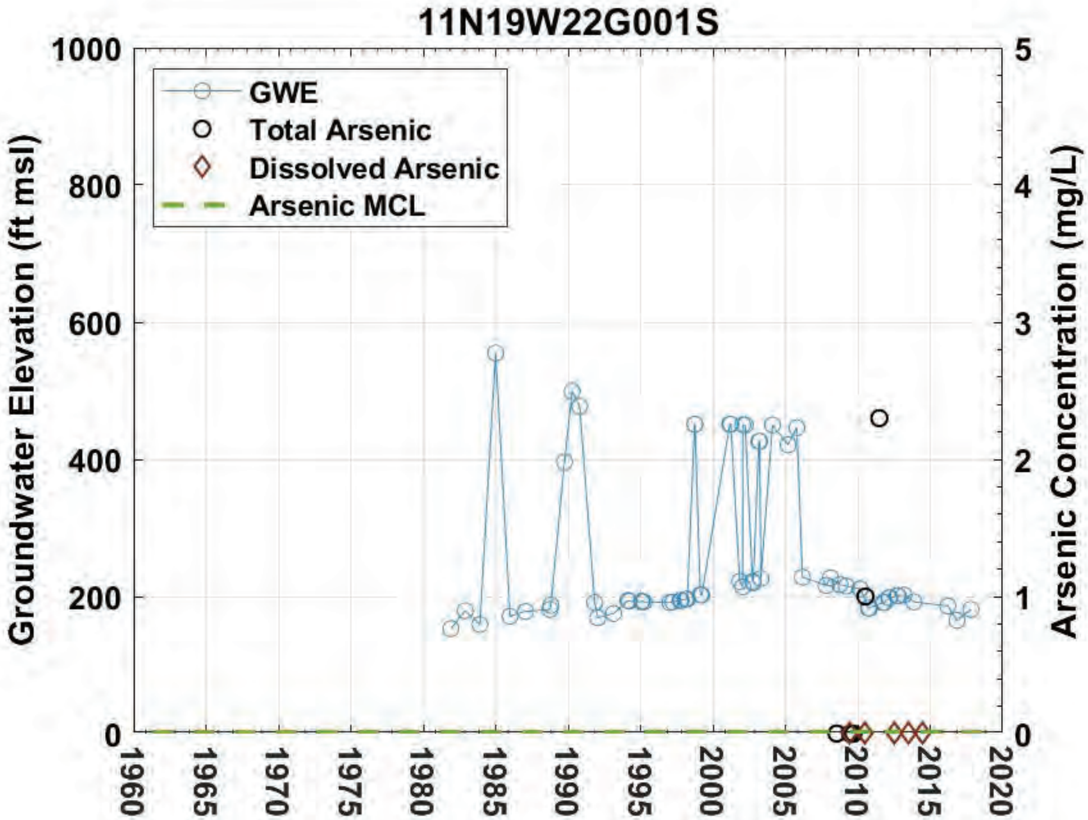

11N19W20J001S
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)

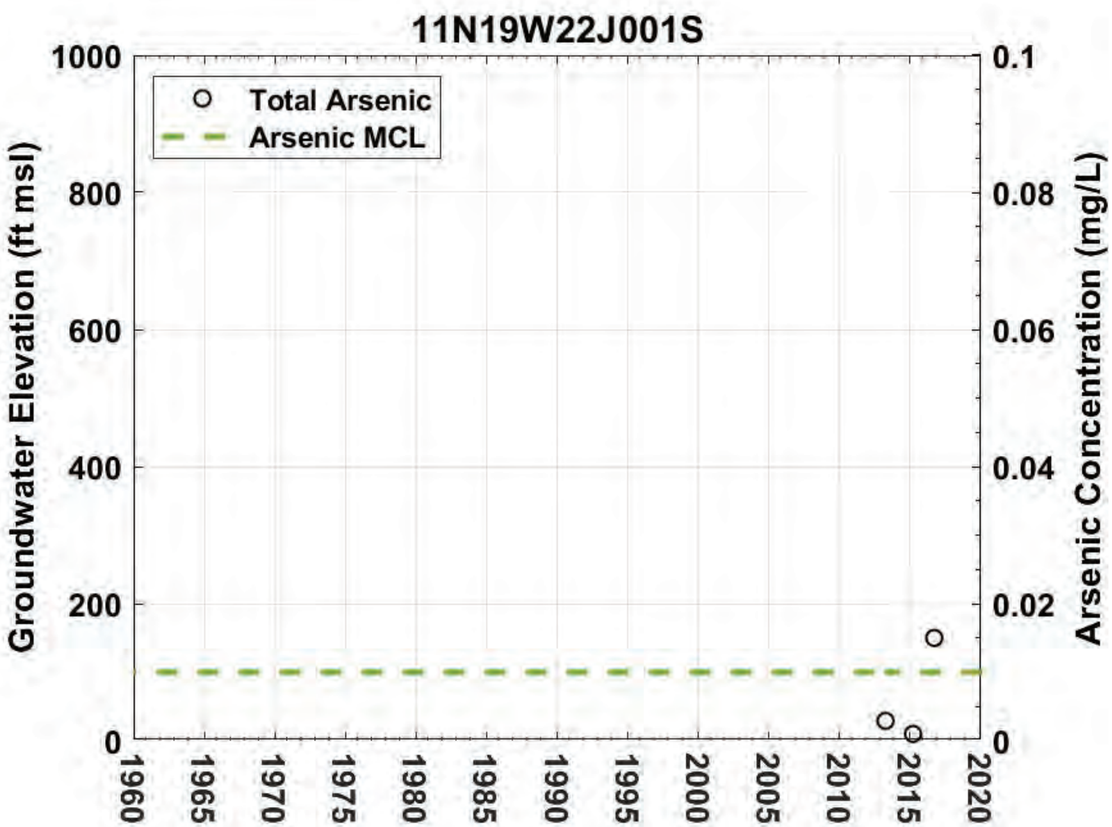

11N19W20Q001S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

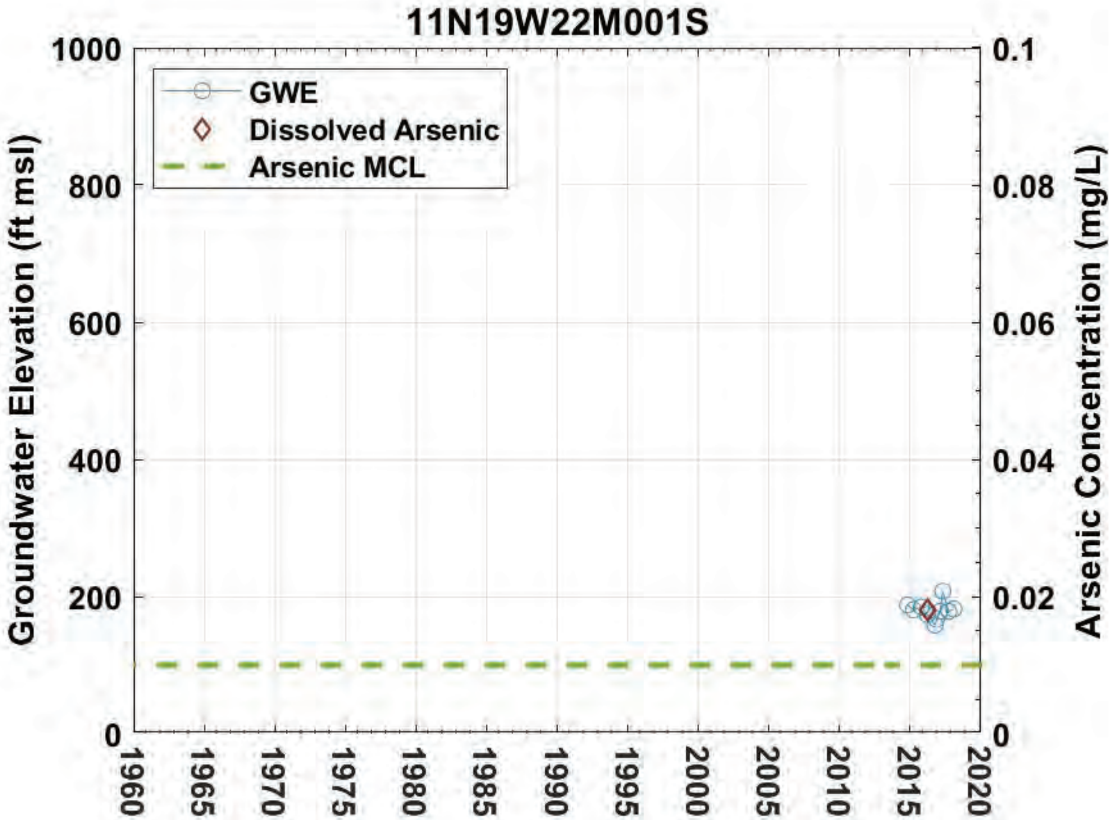

11N19W21G001S
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

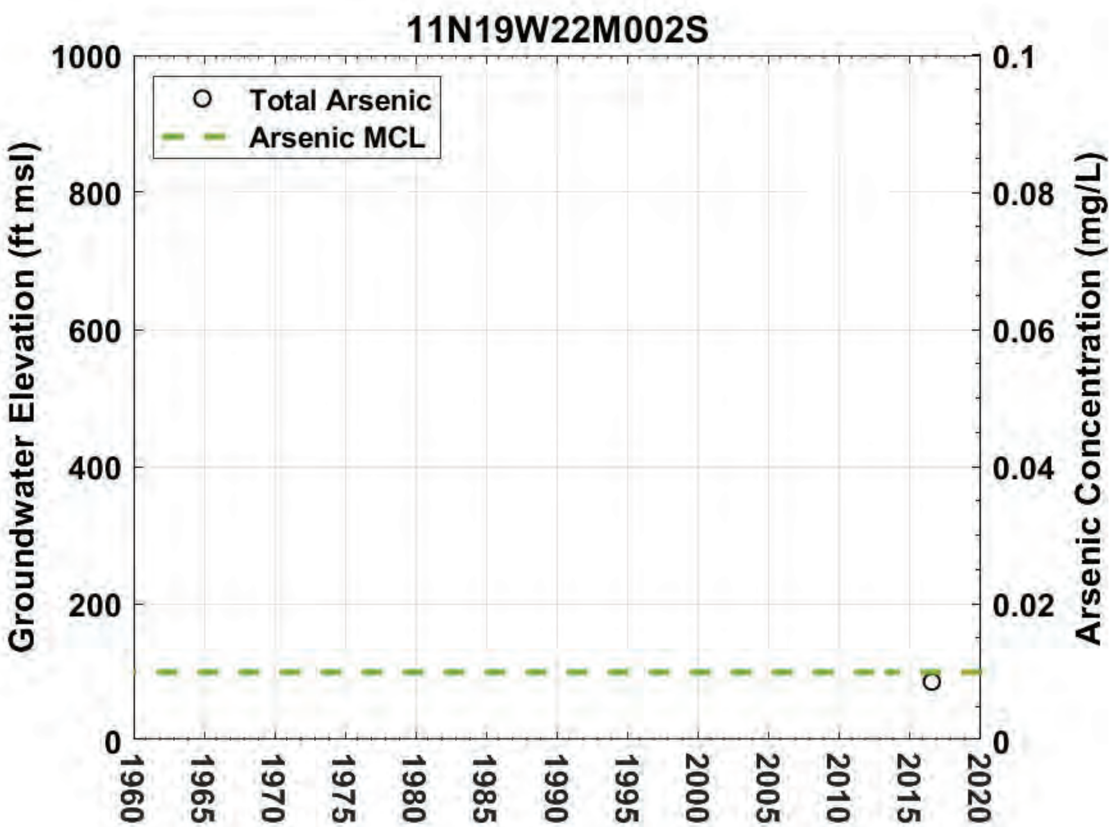

11N19W21Q001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
0
200
400
600
800
1000
0
0.02
0.04
0.06
0.08
0.1
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

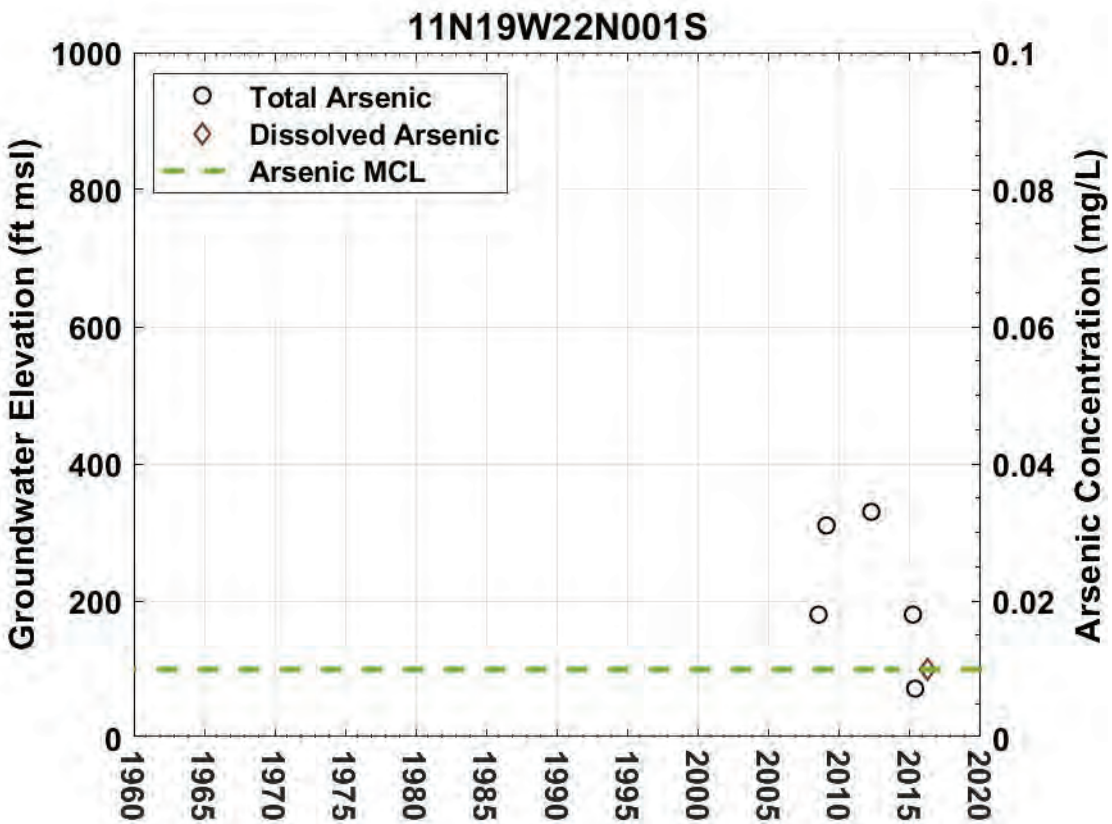

11N19W22E001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
0
200
400
600
800
1000
0
1
2
3
4
5
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

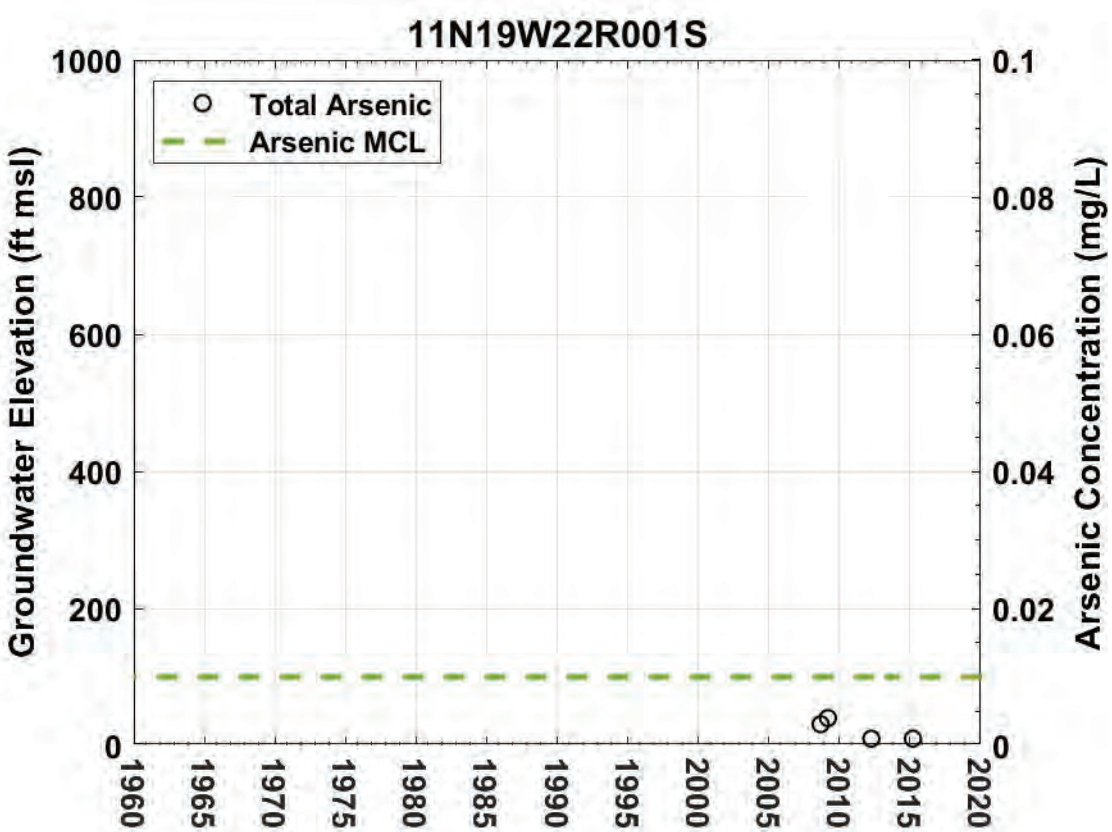

11N19W22G001S
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
1000
800
600
400
200
0
5
4
3
2
1
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

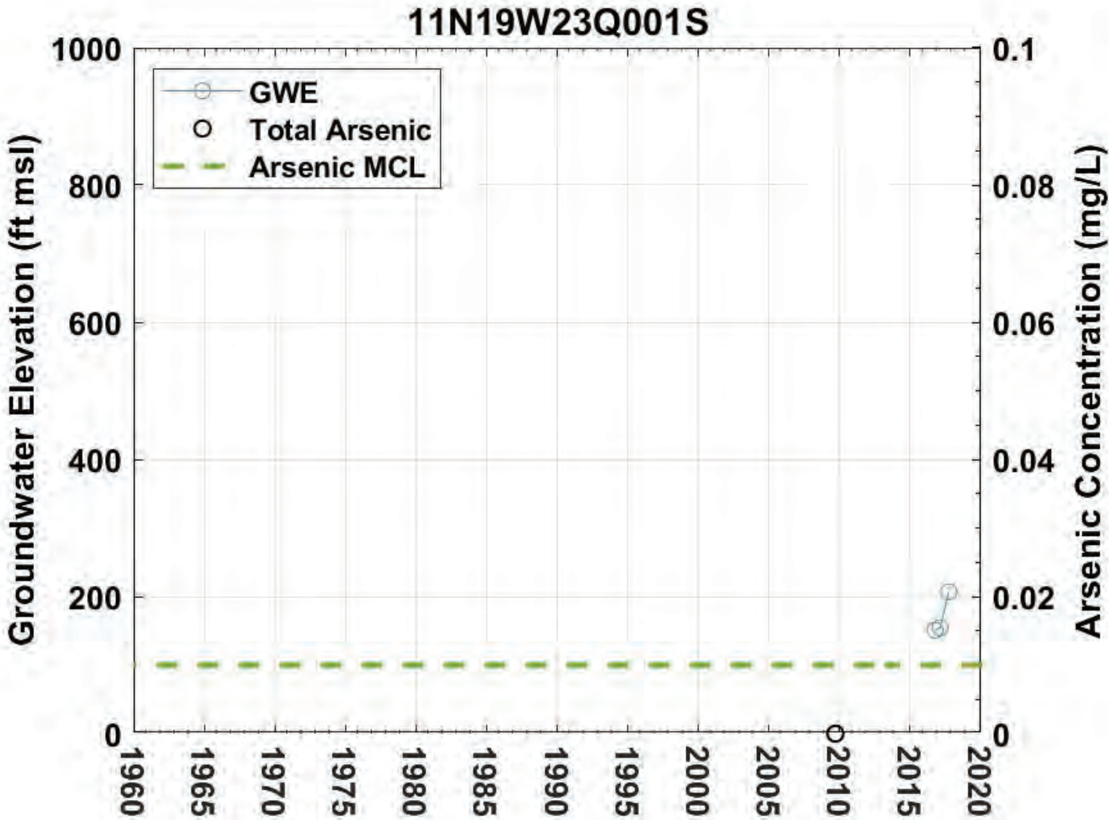

11N19W22J001S
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
Total Arsenic
Arsenic MCL
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

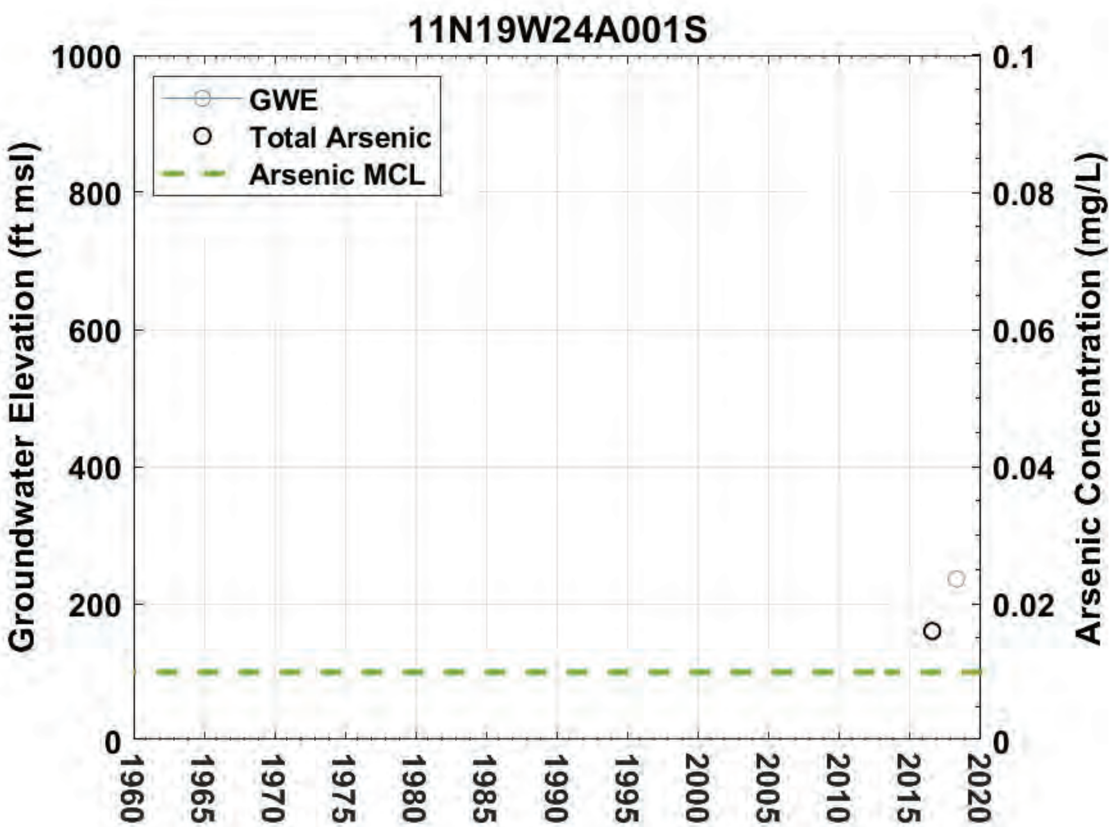

11N19W22M001S
GWE
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
0
200
400
600
800
1000
0
0.02
0.04
0.06
0.08
0.1
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

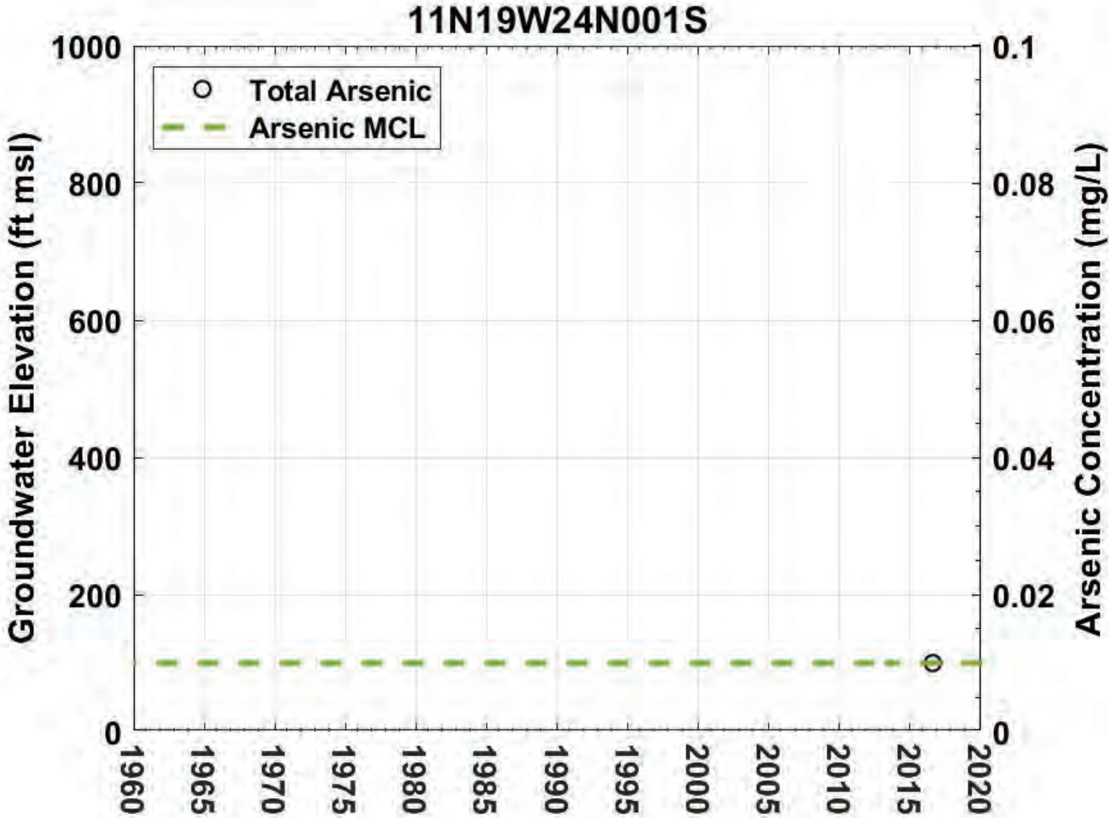

11N19W22M002S
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
0
200
400
600
800
1000
0
0.02
0.04
0.06
0.08
0.1
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

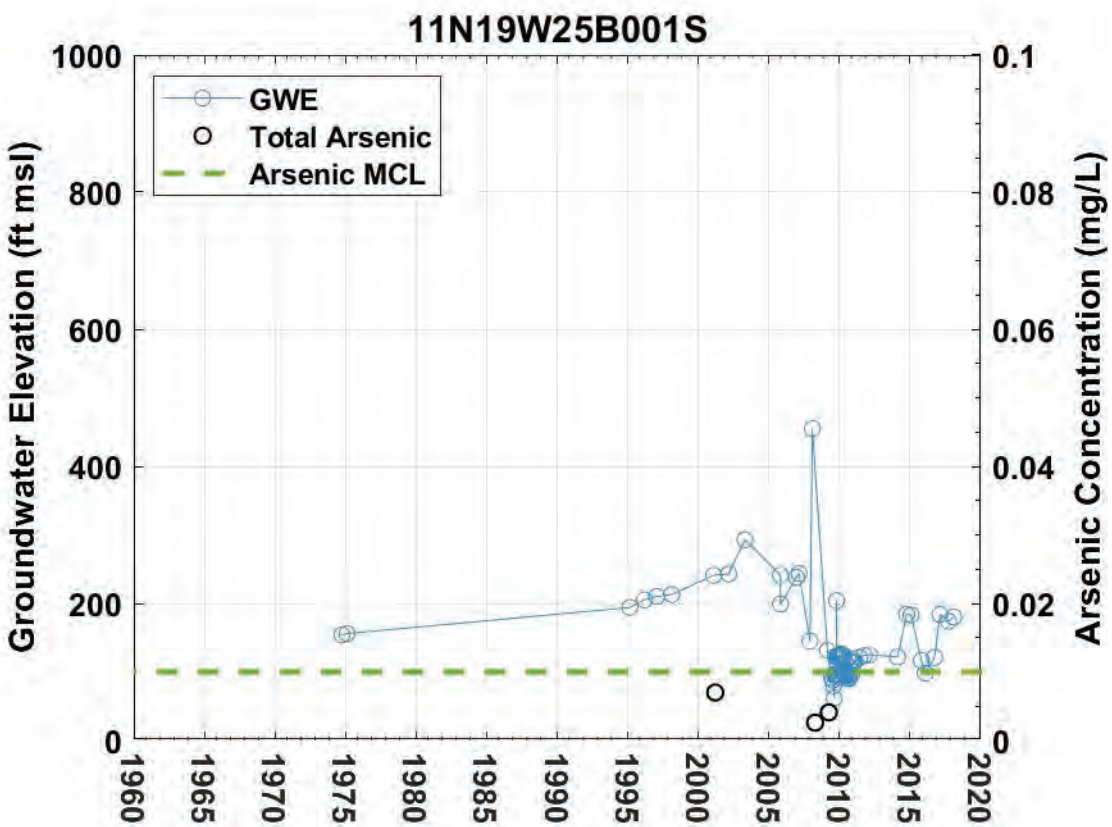

11N19W22N001S
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

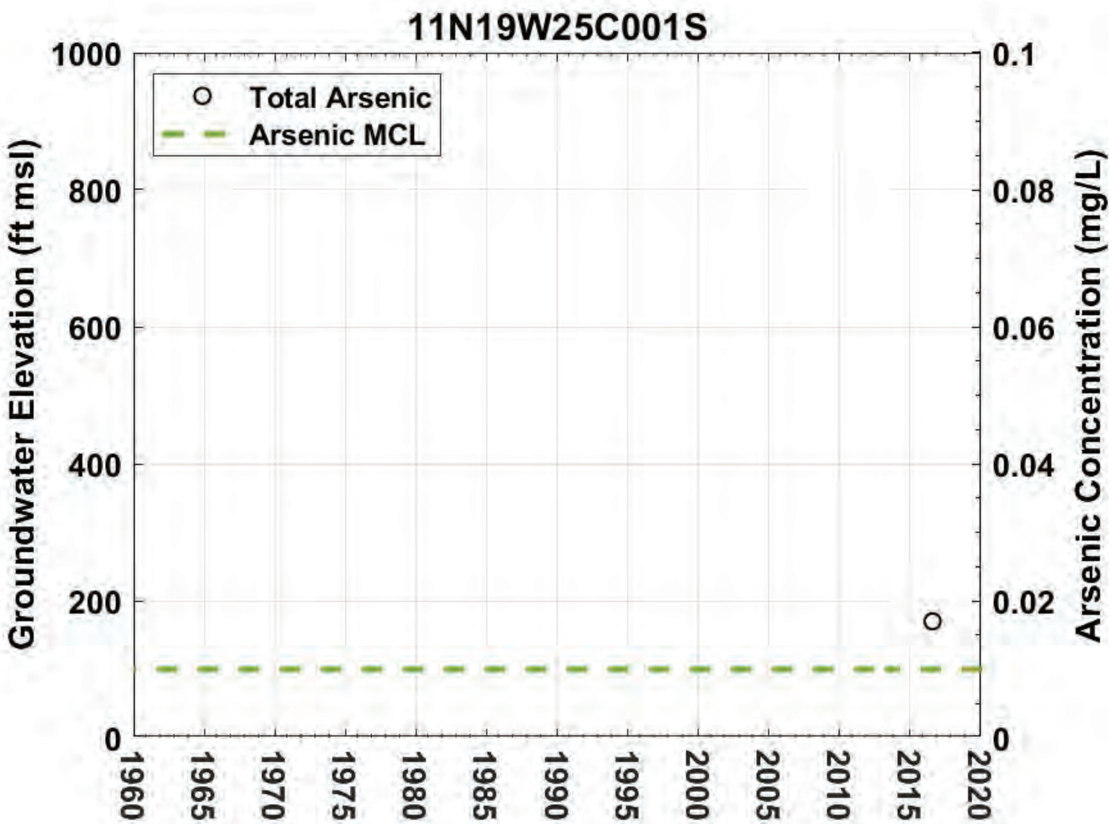

11N19W22R001S
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

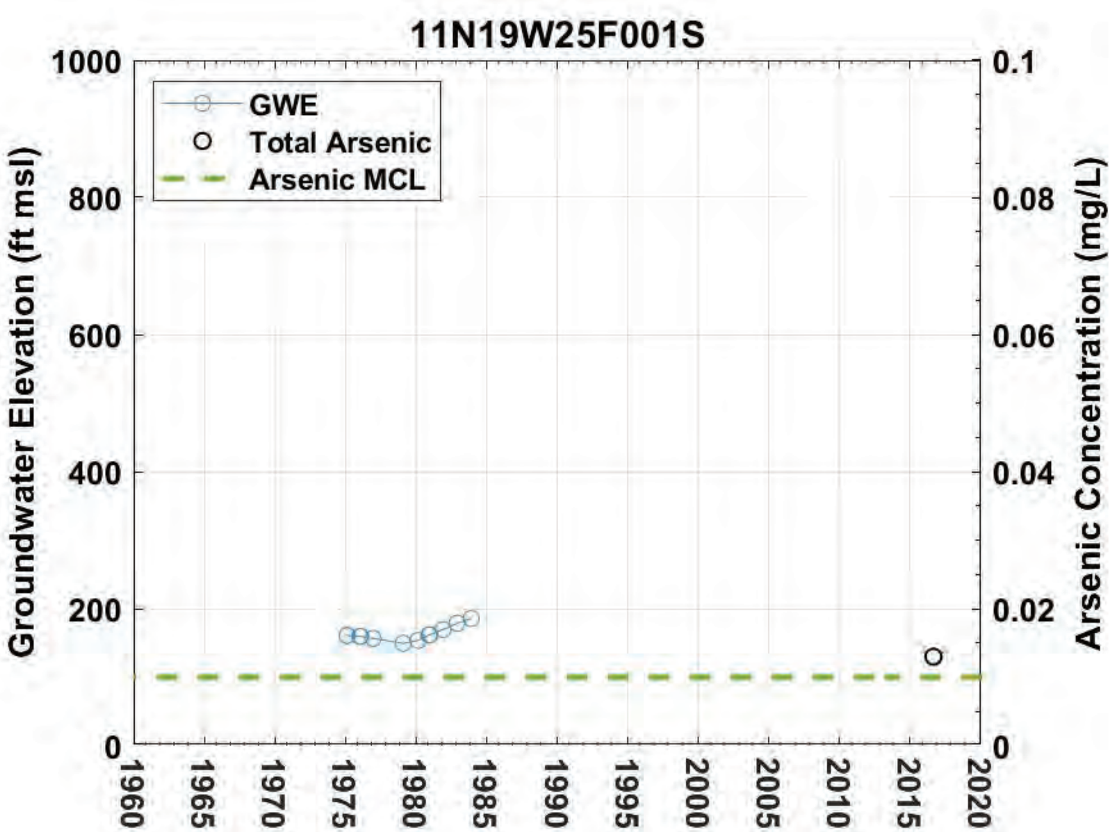

11N19W23Q001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

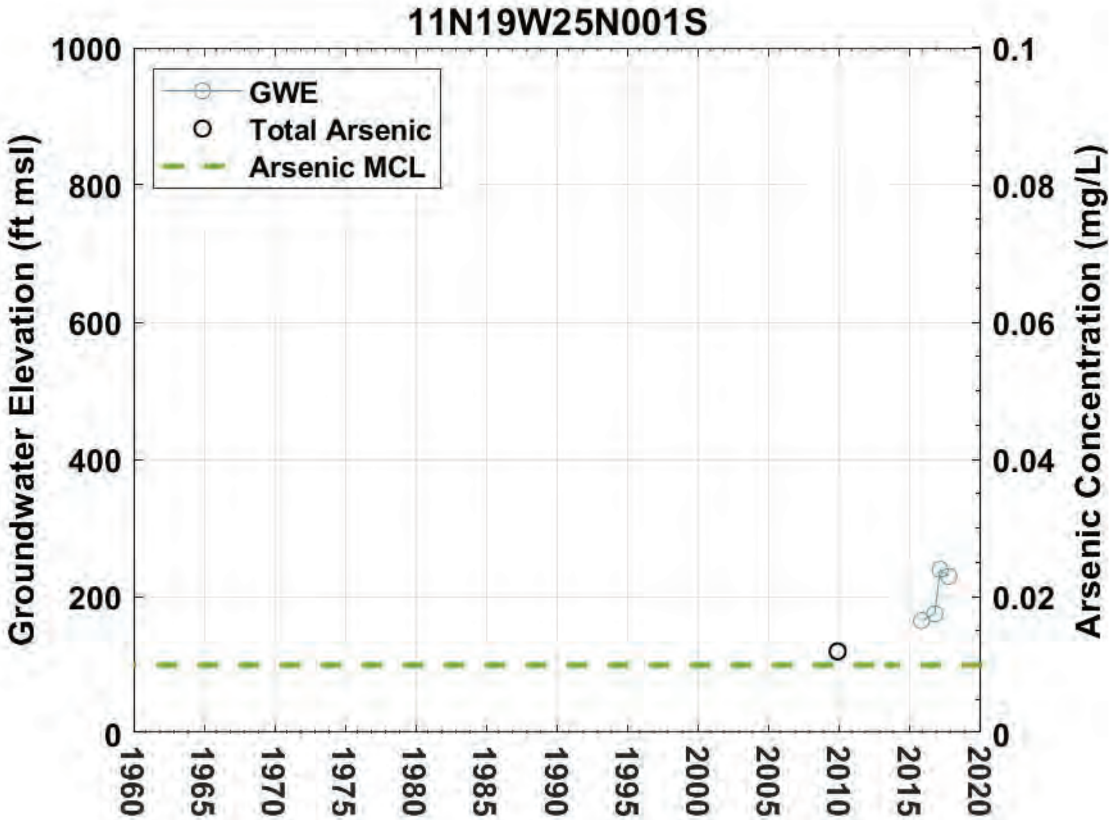

11N19W24A001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

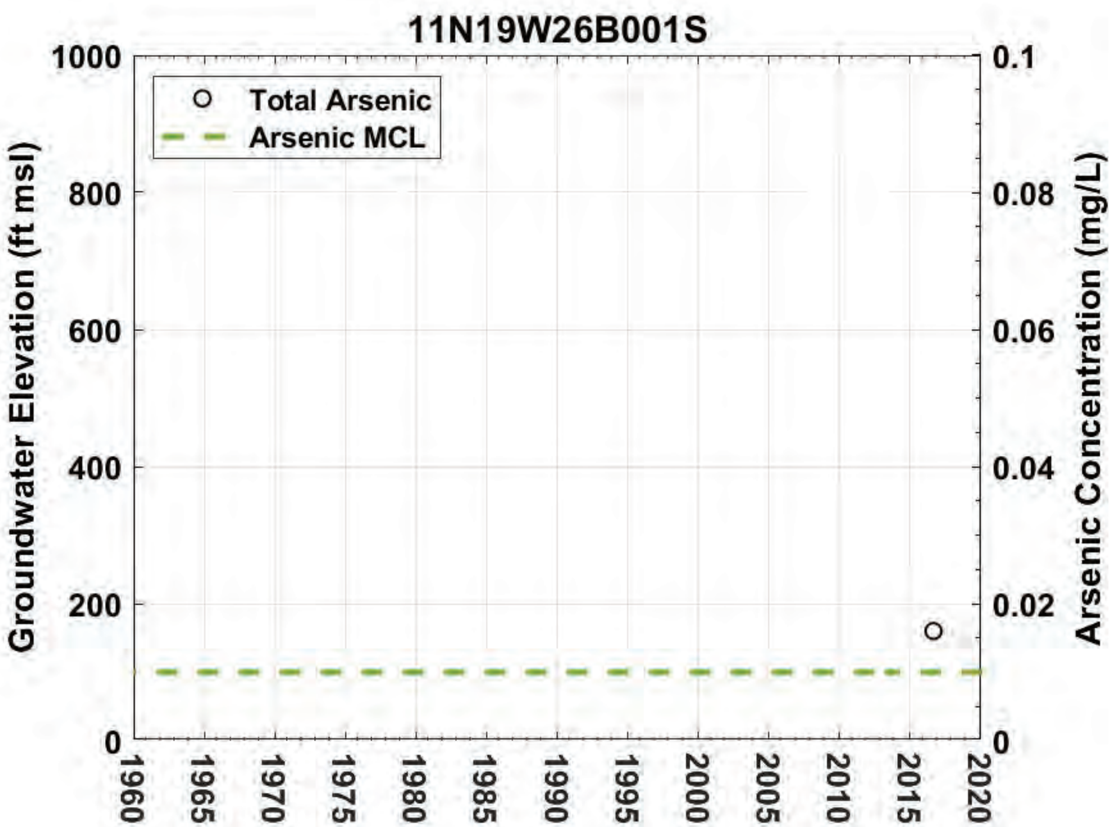

11N19W24N001S
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

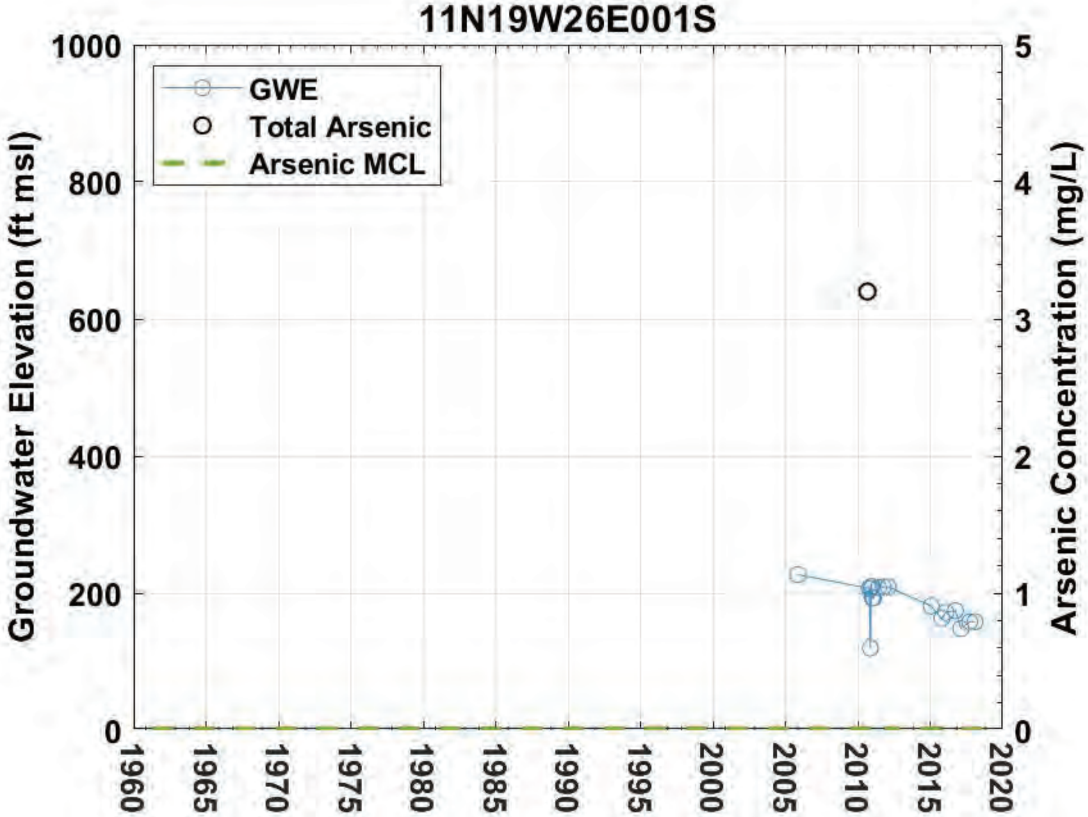

11N19W25B001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

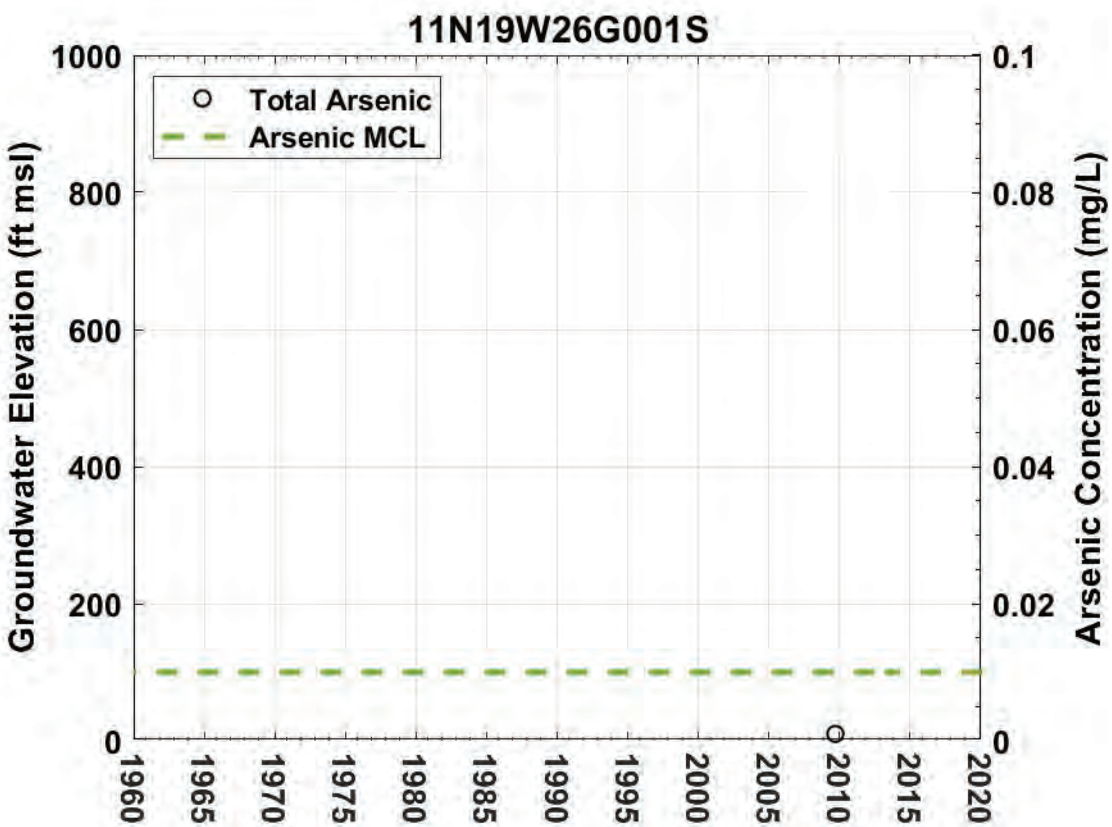

11N19W25C001S
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

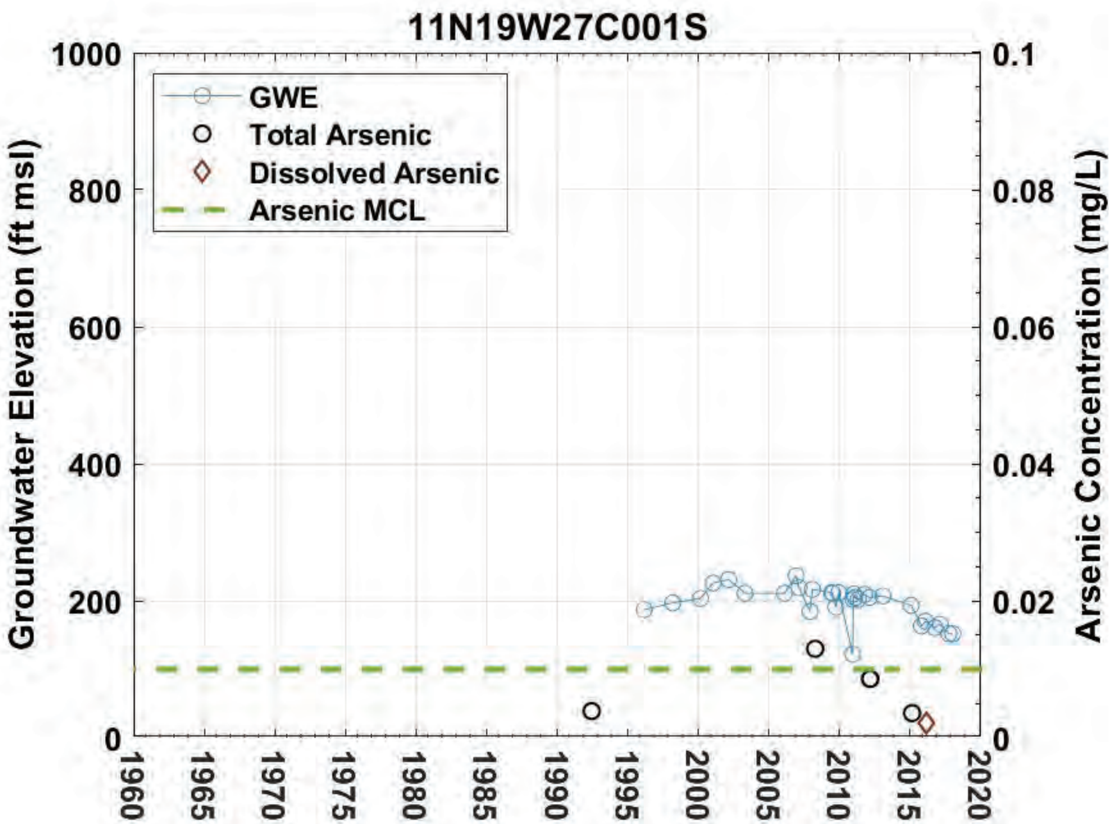

11N19W25F001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

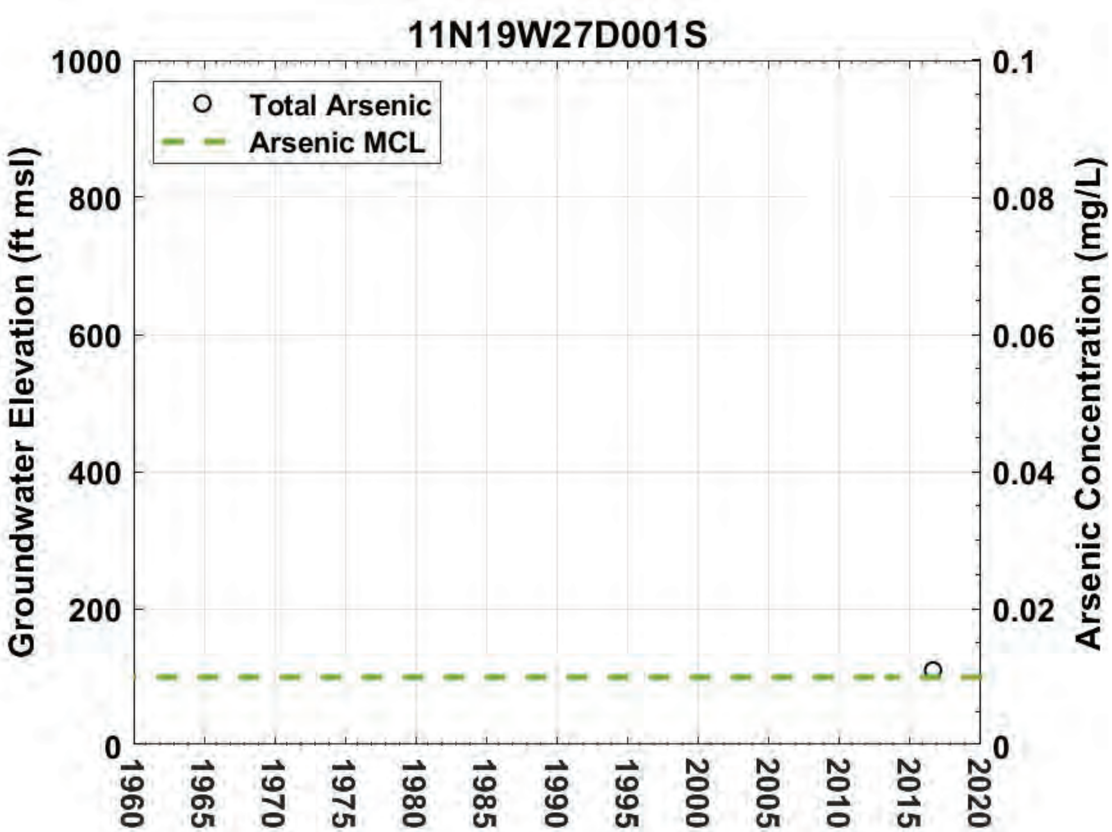

11N19W25N001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

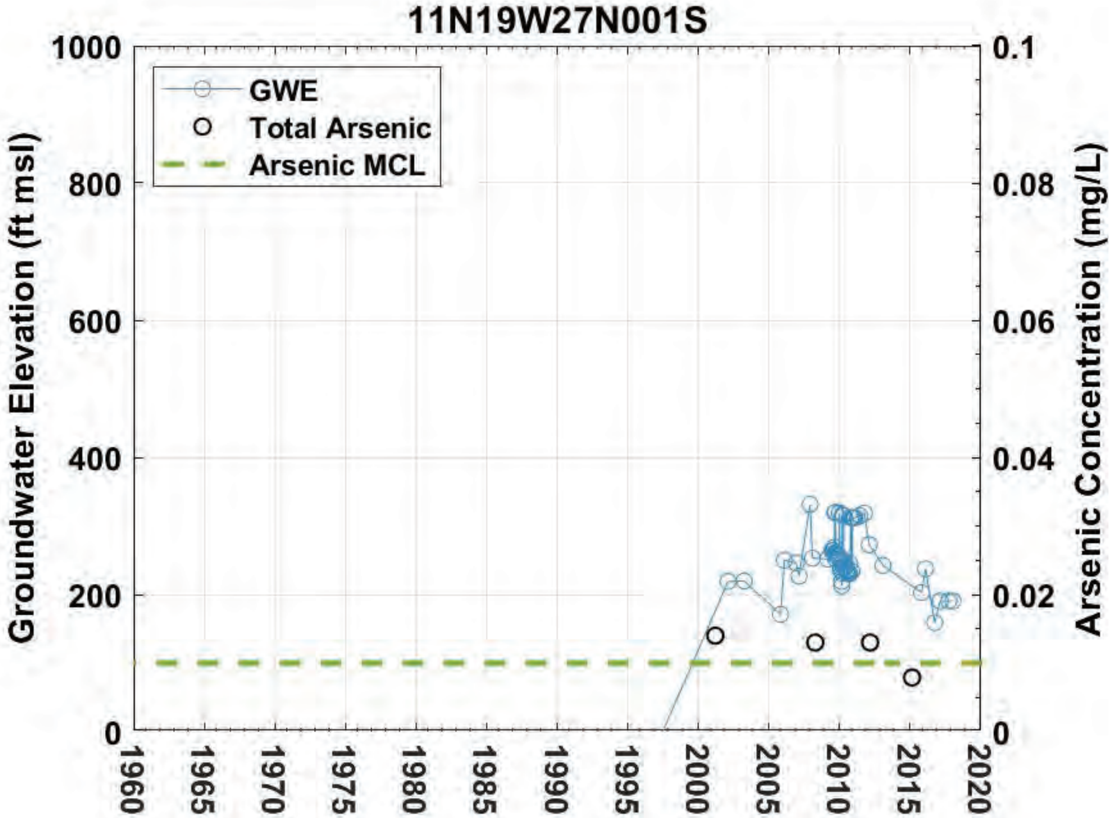

11N19W26B001S
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

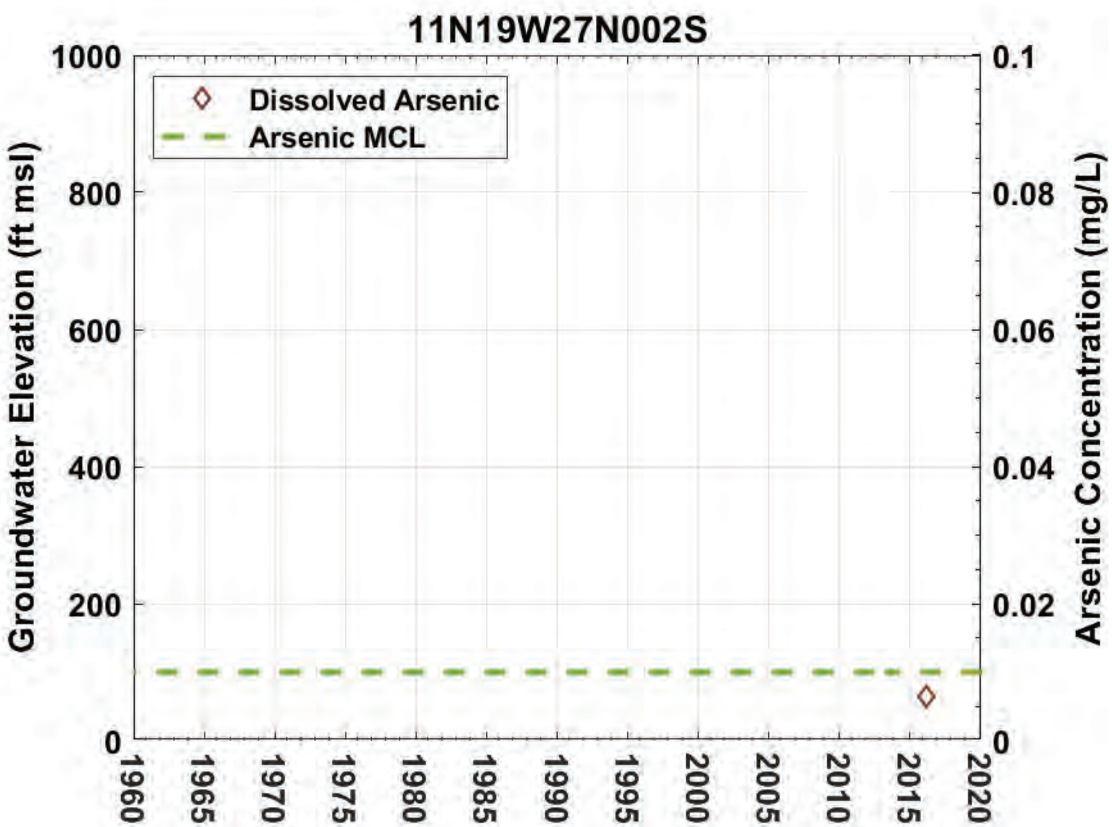

11N19W26E001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
5
4
3
2
1
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

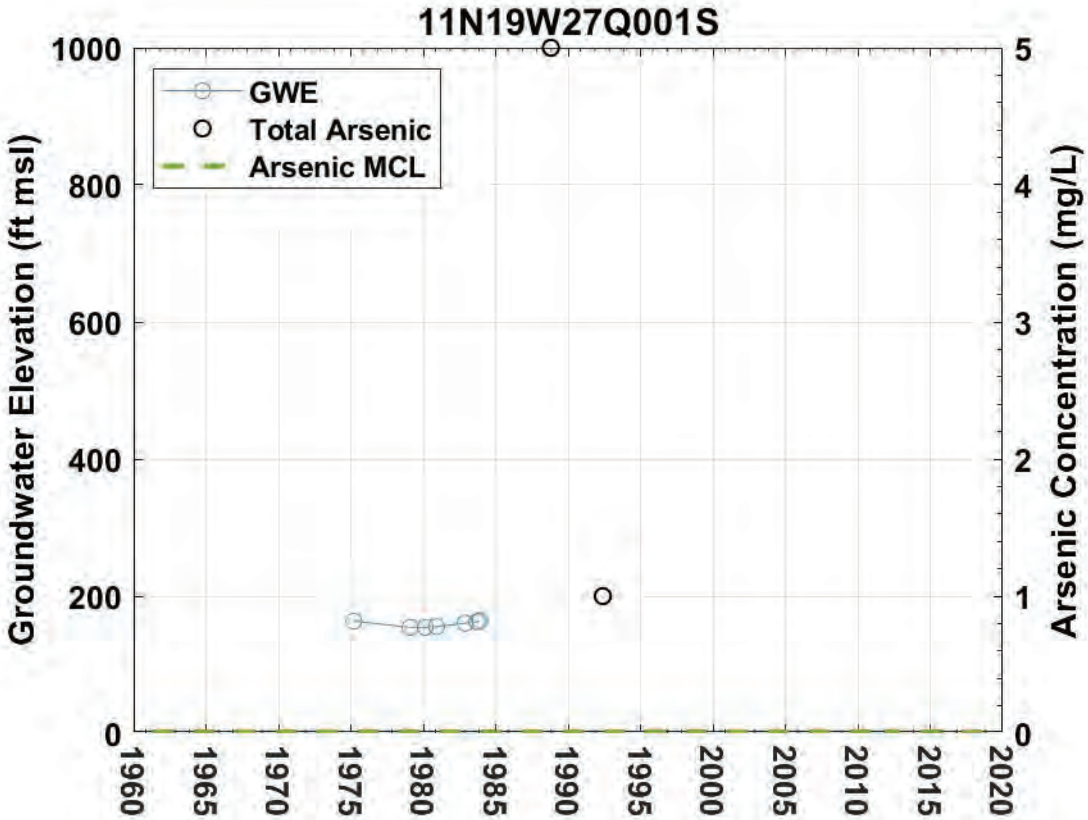

11N19W26G001S
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W27C001S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

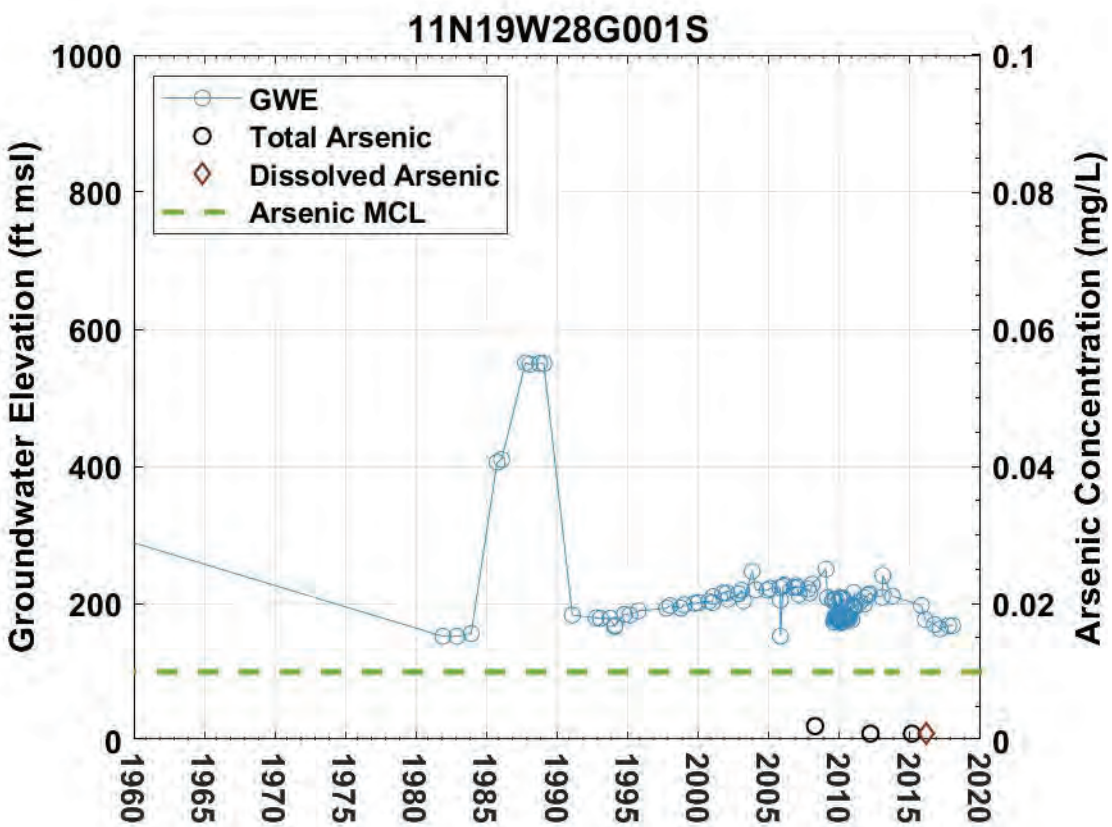

11N19W27D001S
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W27N001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

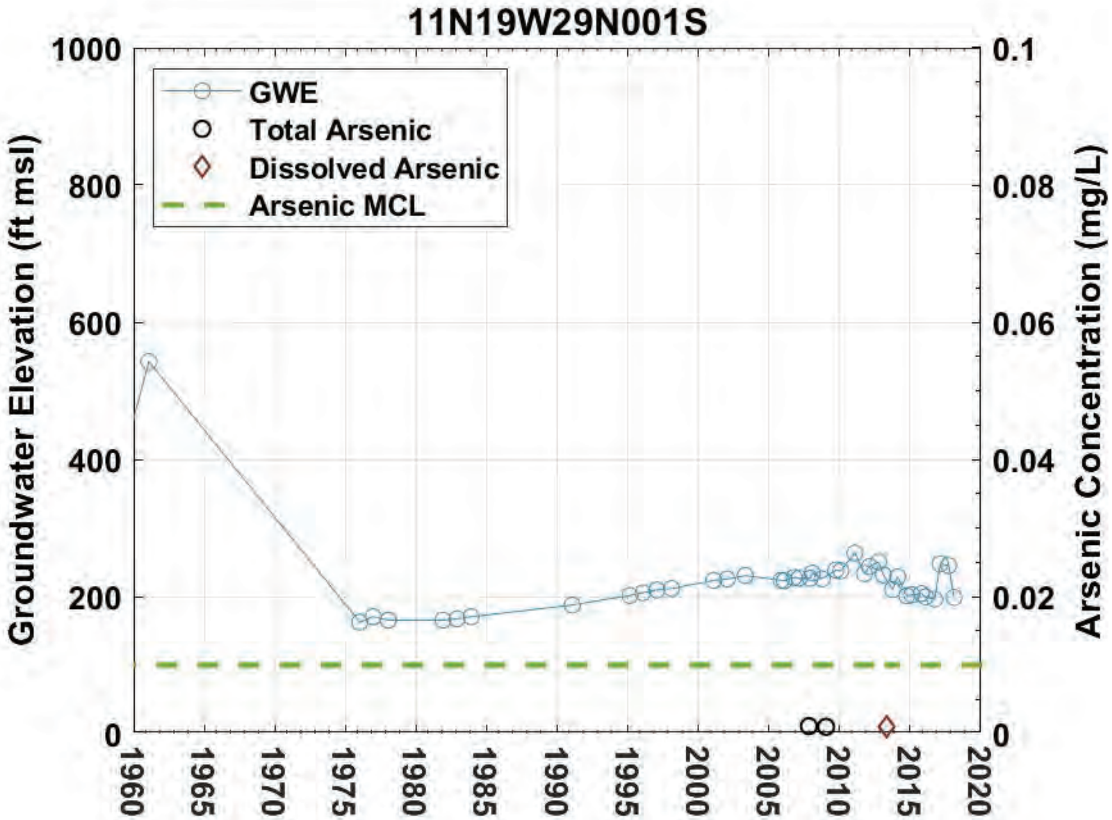

11N19W27N002S
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

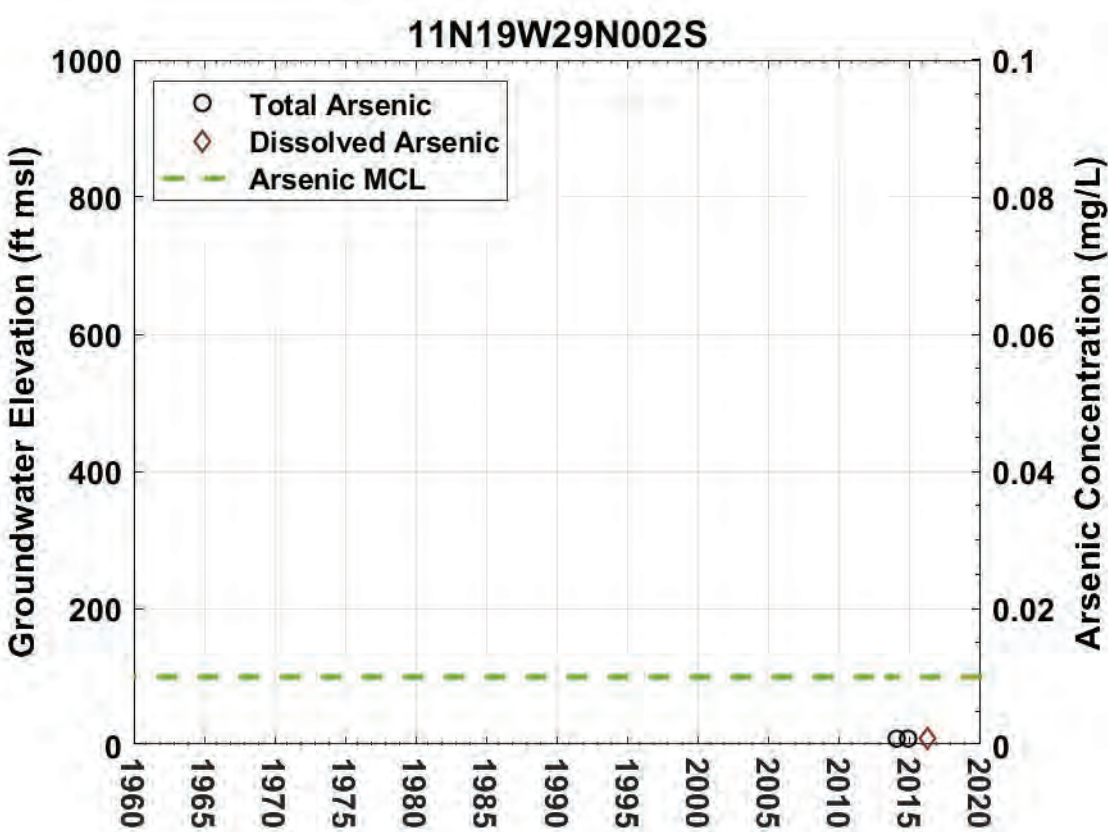


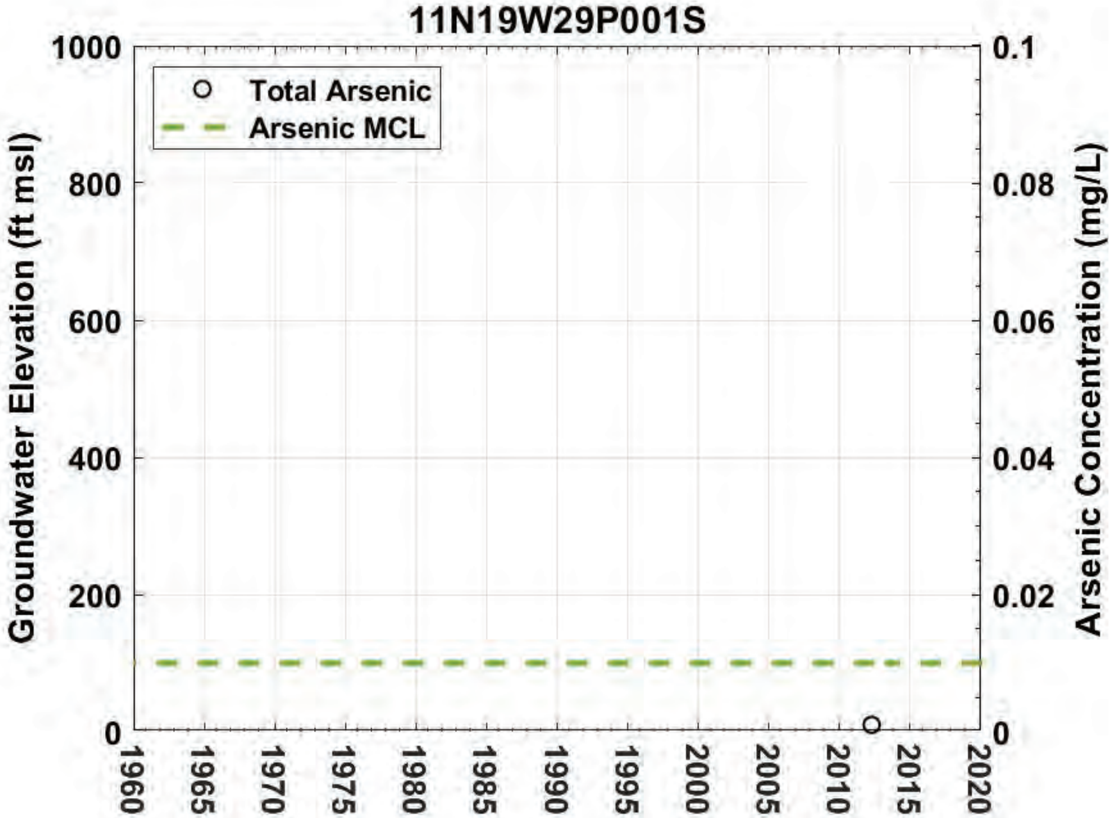
11N19W27Q001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
0
200
400
600
800
1000
0
1
2
3
4
5
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



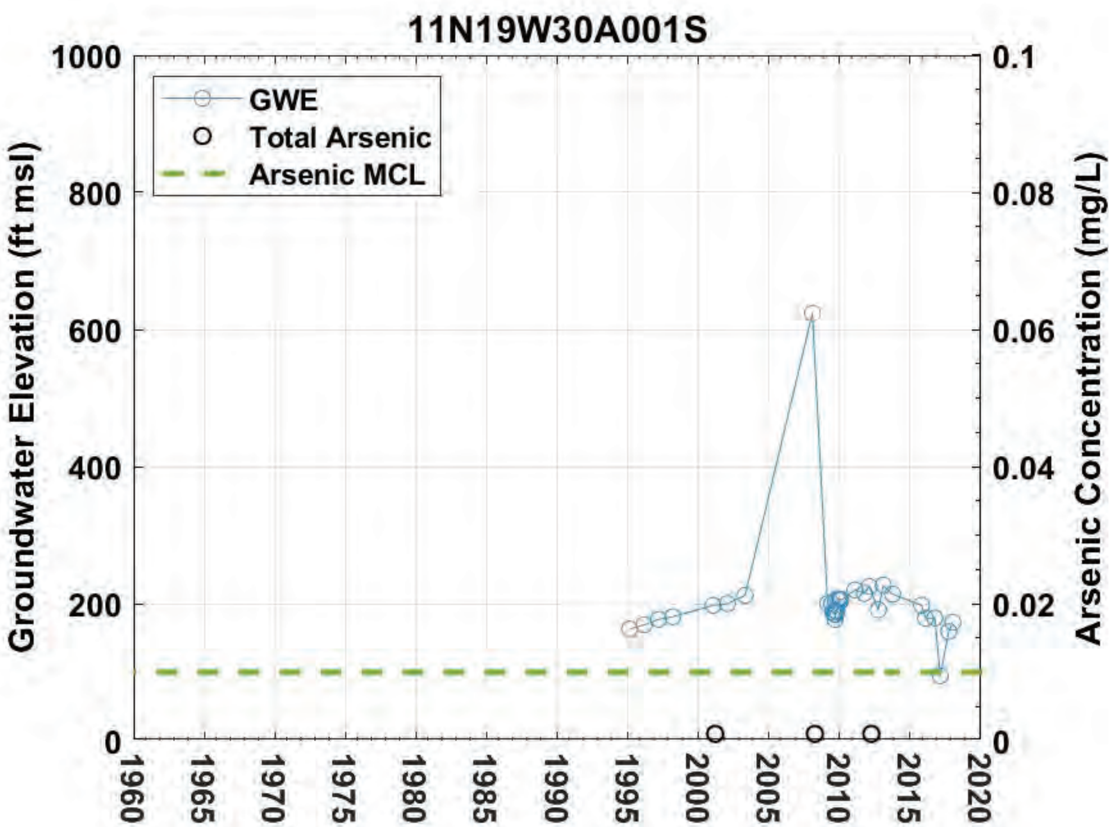
11N19W28G001S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
0
200
400
600
800
1000
0
0.02
0.04
0.06
0.08
0.1
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W29N001S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

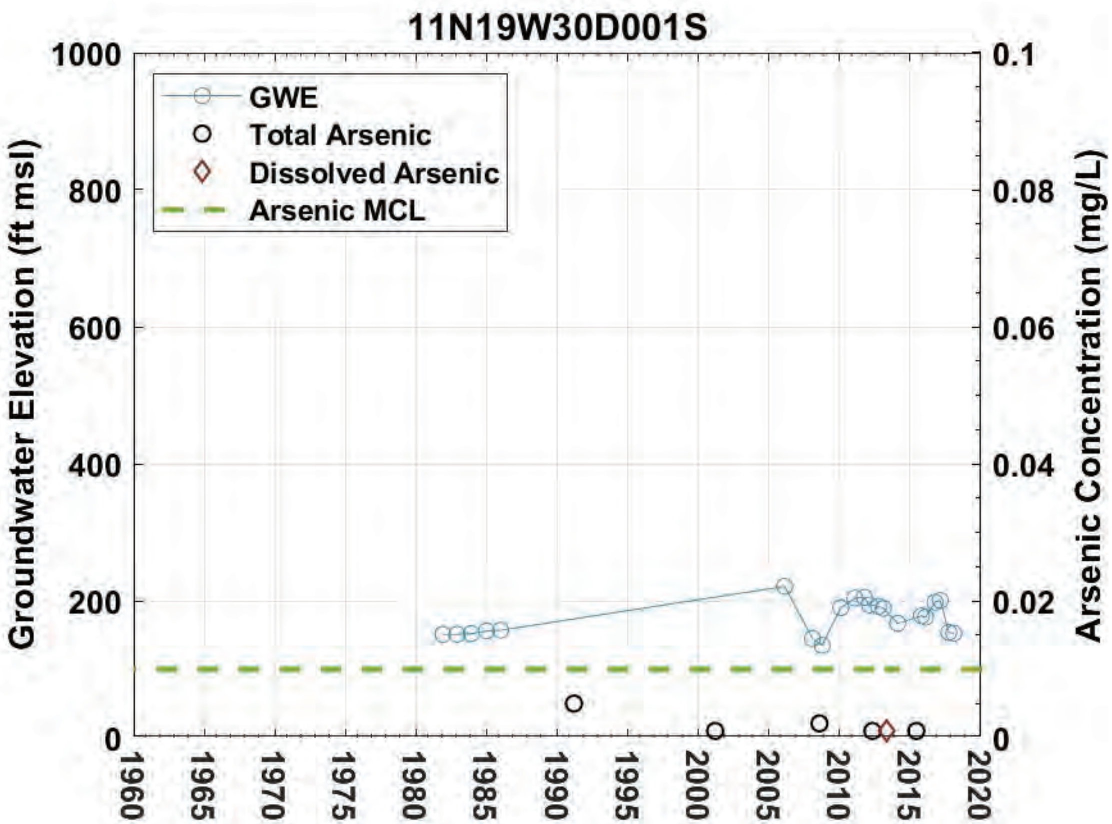

11N19W29N002S
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



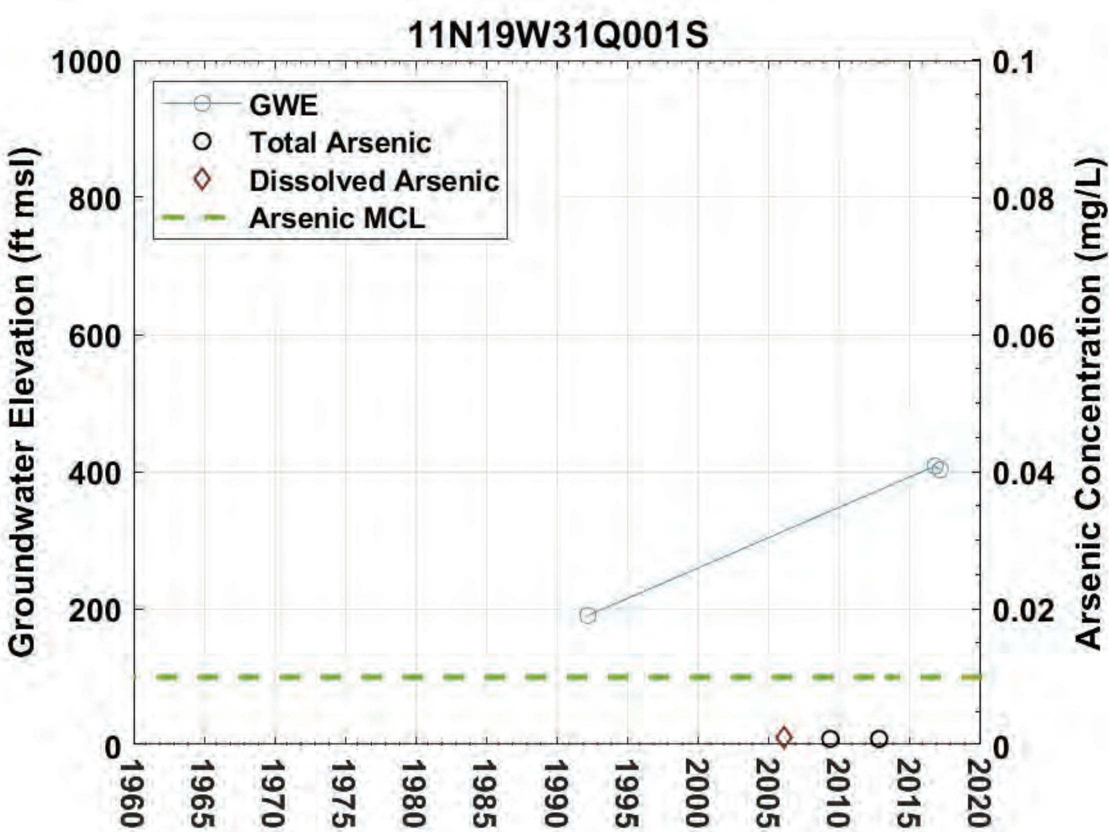
11N19W29P001S
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



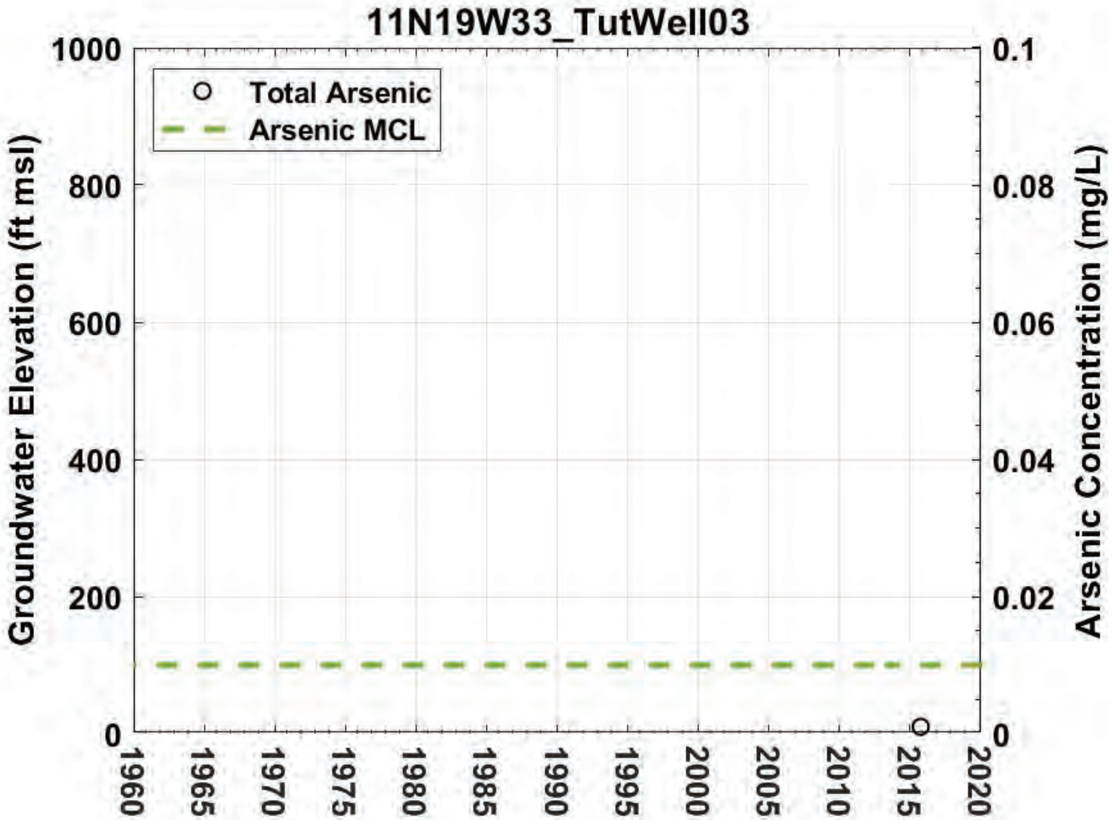
11N19W30A001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

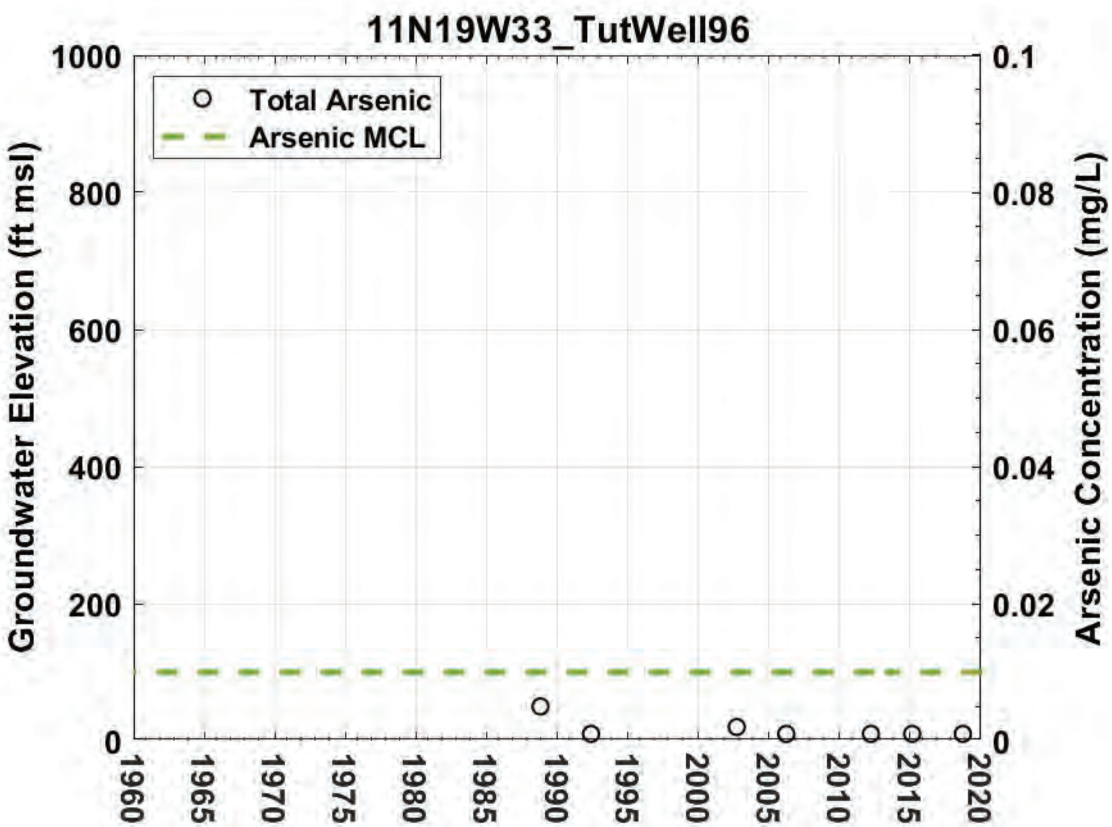


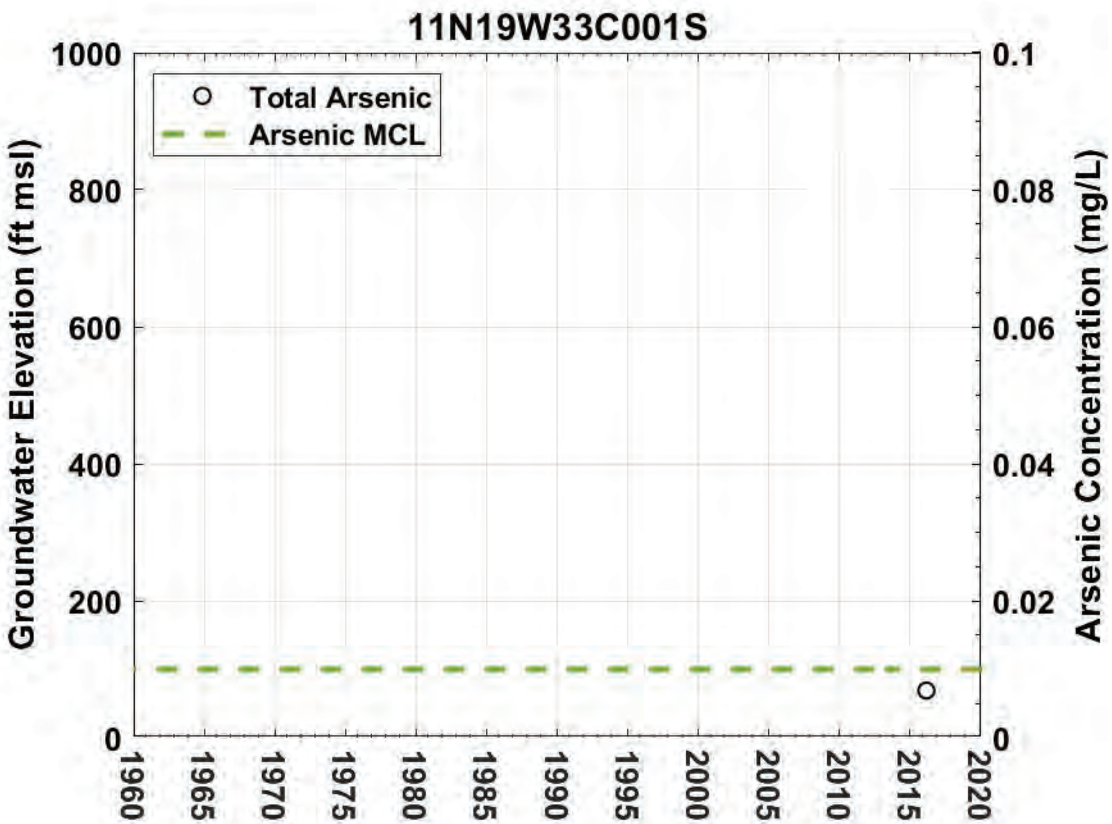
11N19W30D001S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

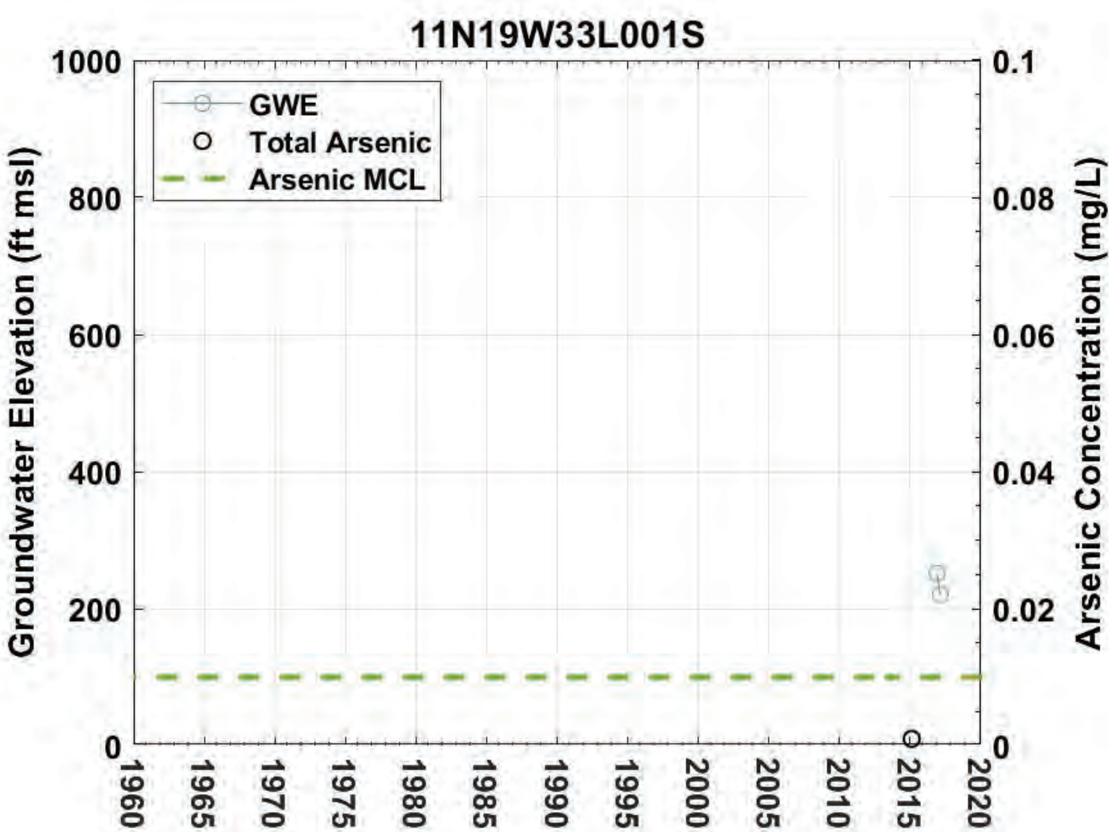


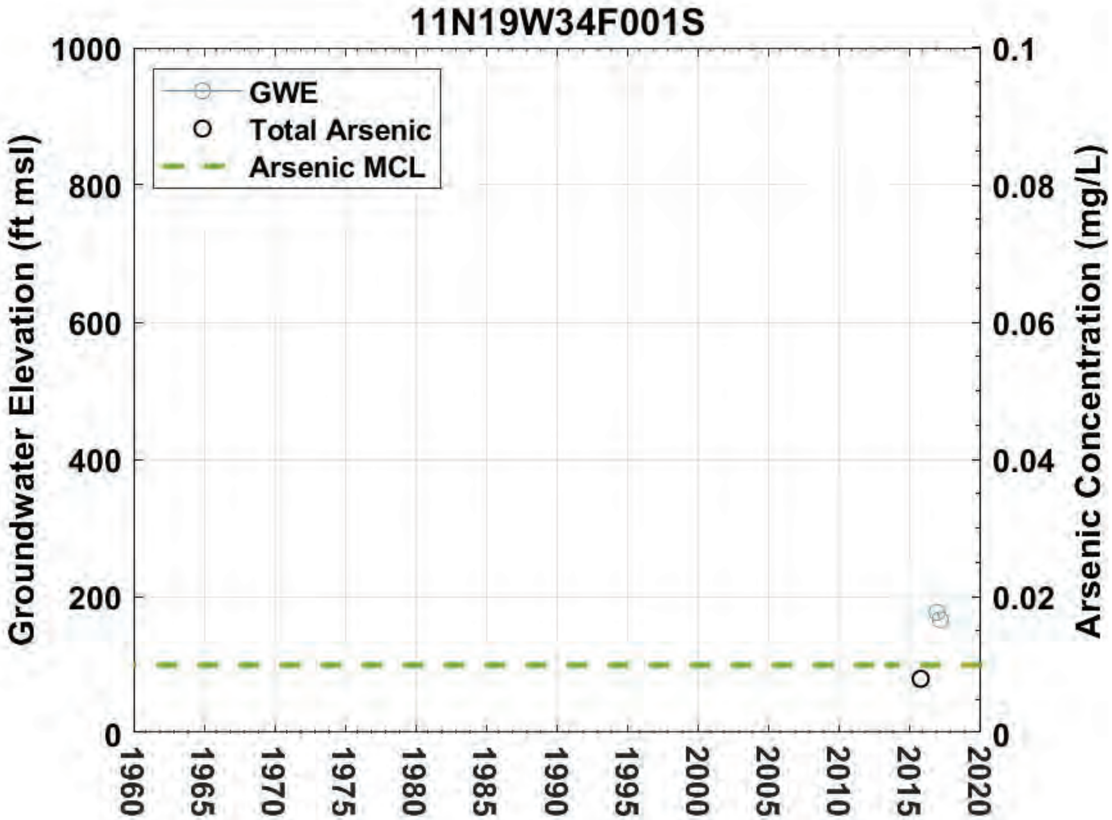
11N19W31Q001S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

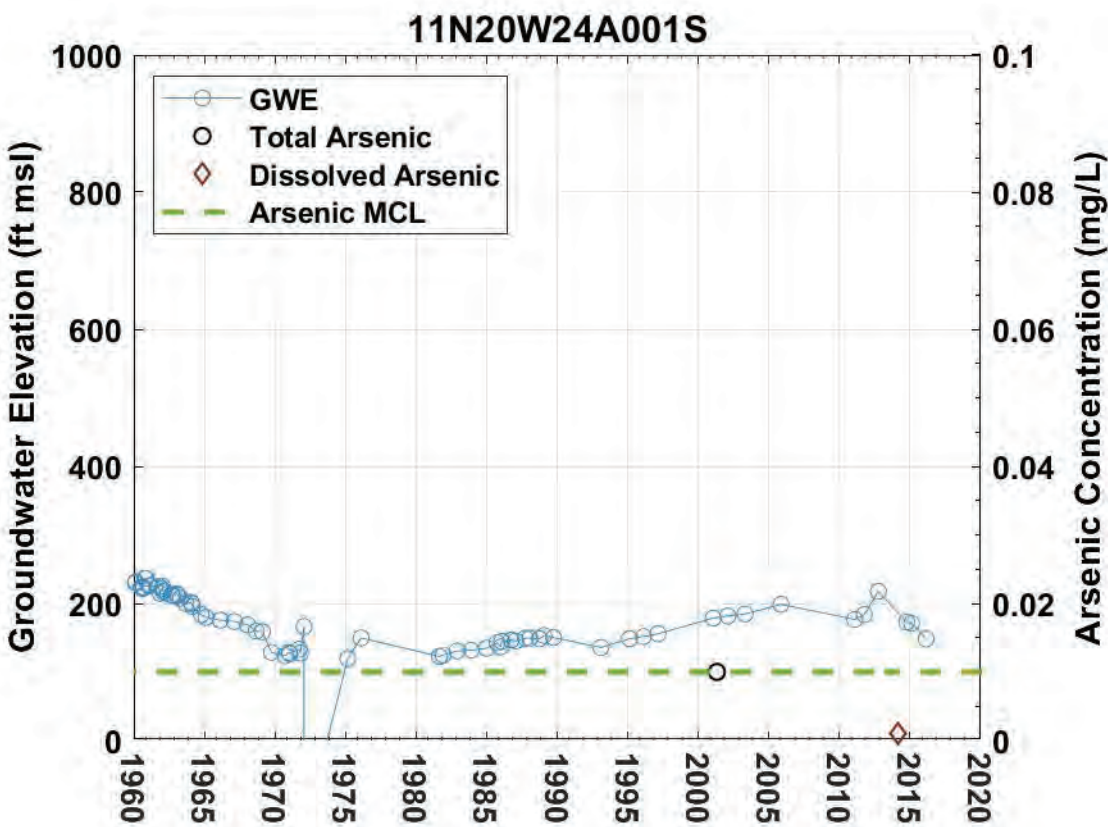

11N19W33_TutWell03
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

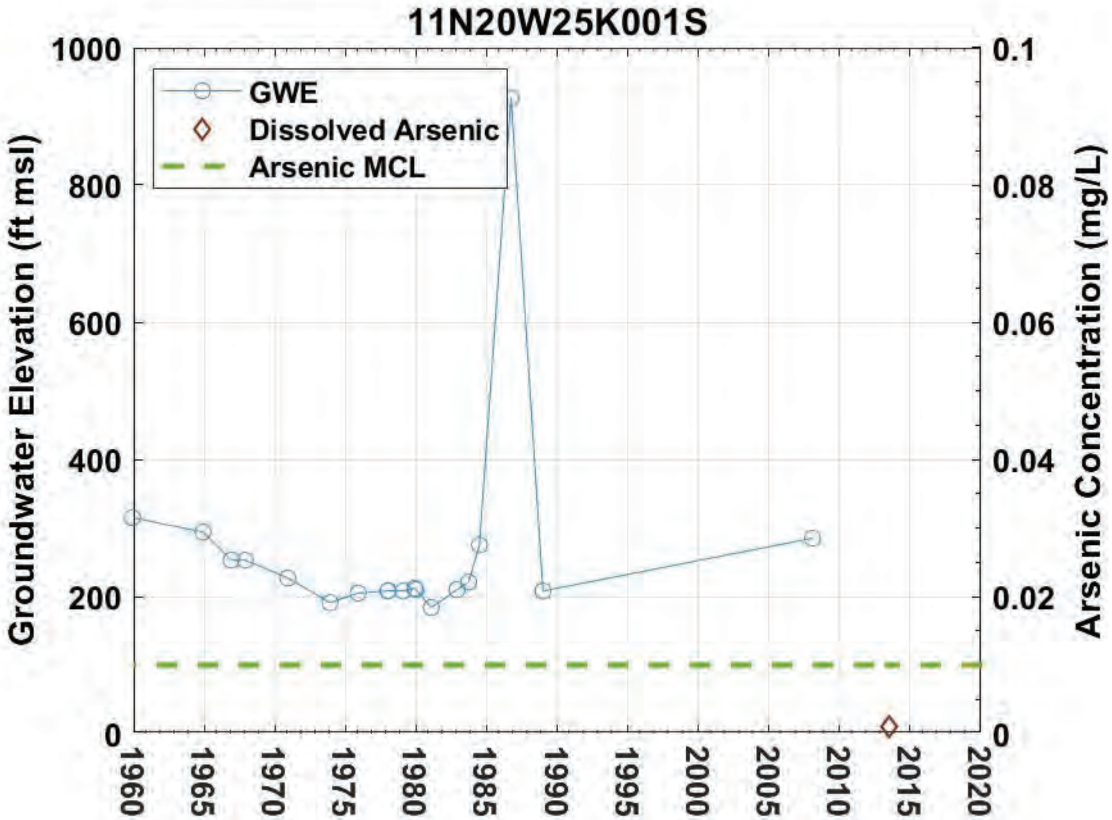

11N19W33_TutWell96
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

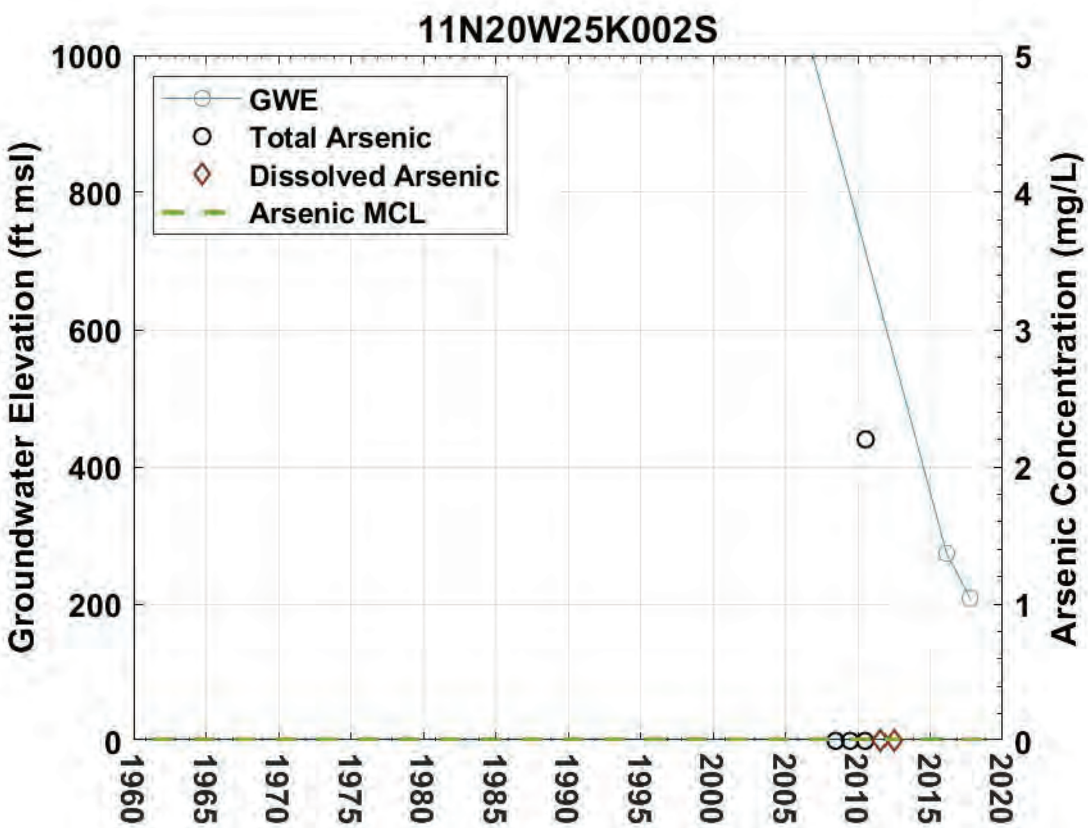

11N19W33C001S
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

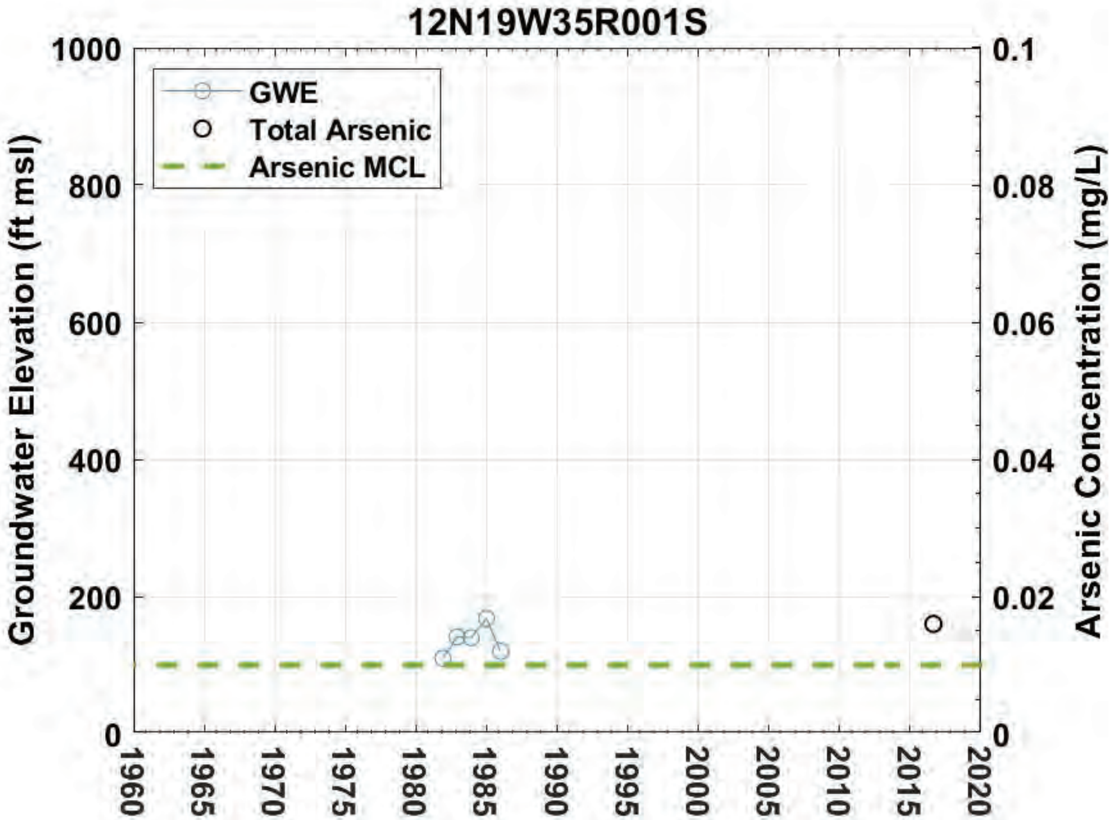

11N19W33L001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

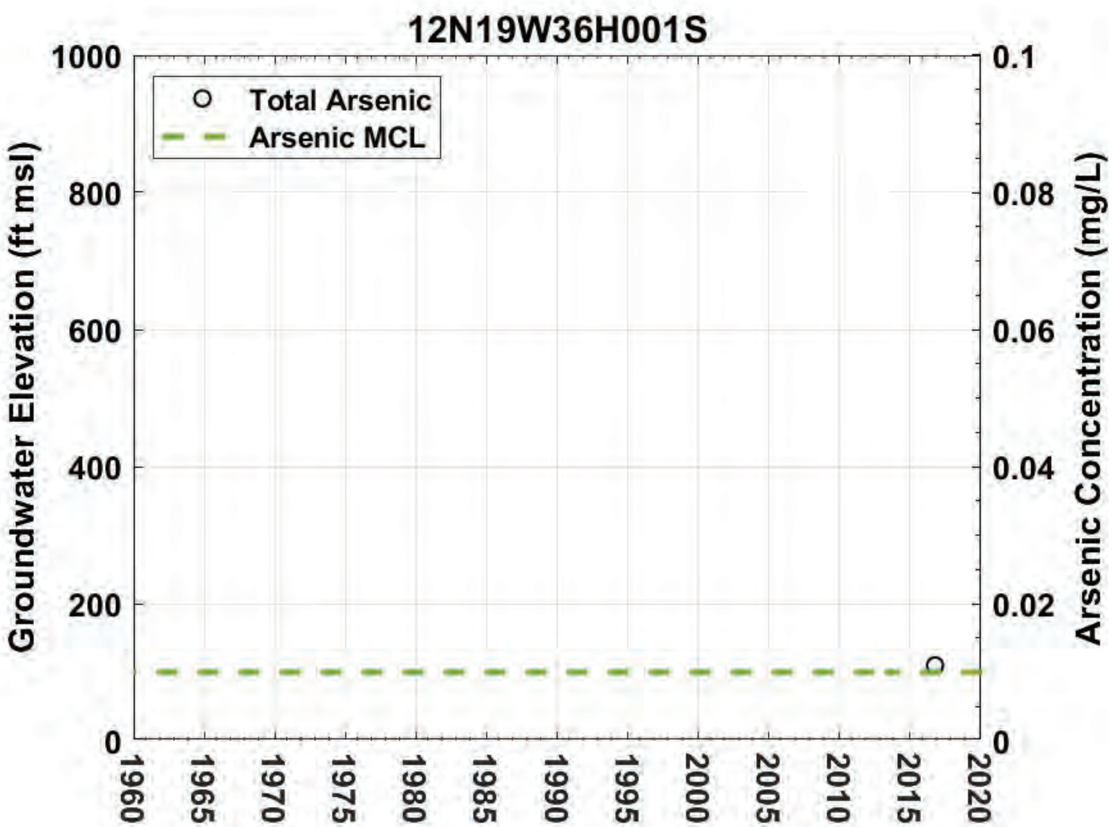

11N19W34F001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

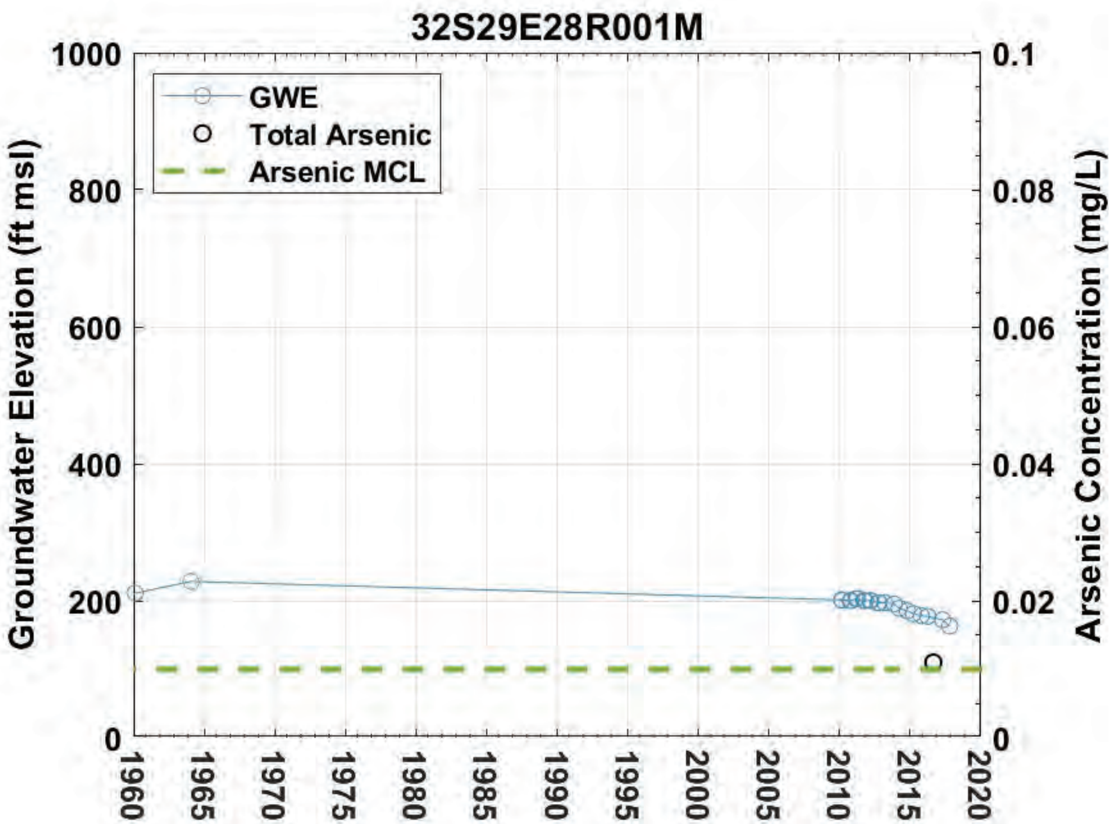

11N20W24A001S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N20W25K001S
GWE
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

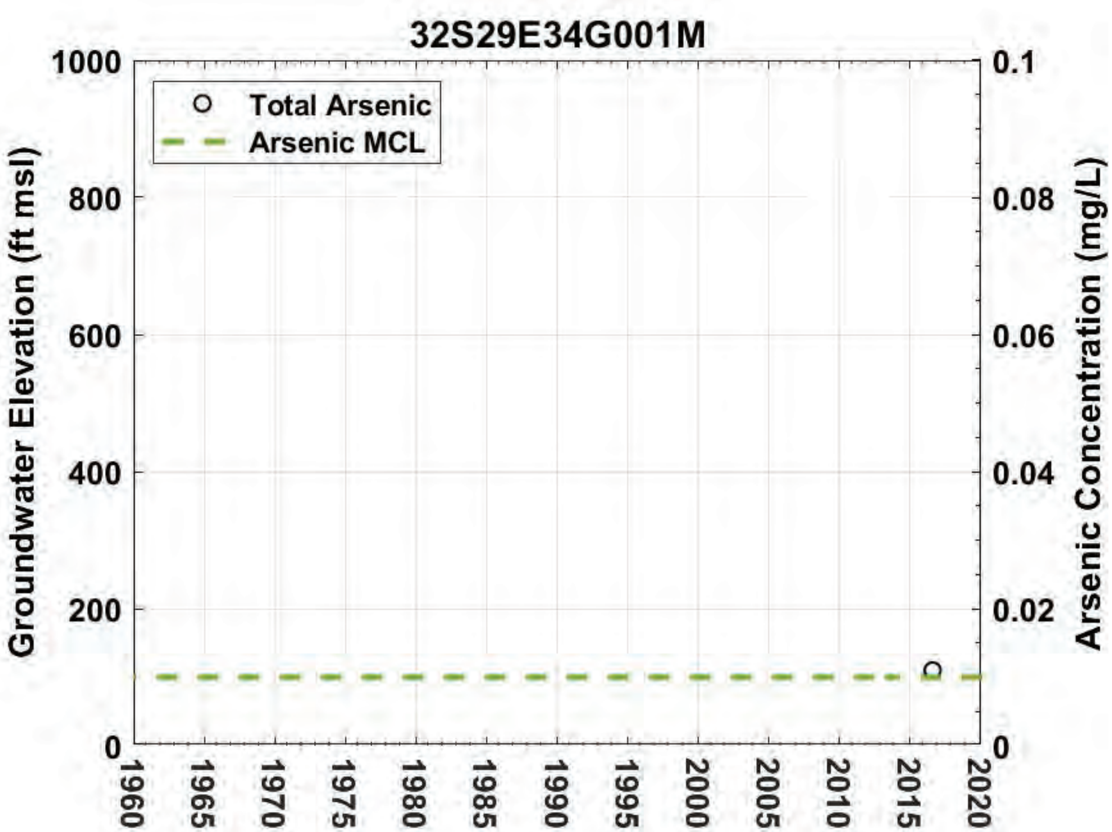

11N20W25K002S
GWE
Total Arsenic
Dissolved Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
5
4
3
2
1
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


12N19W35R001S
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

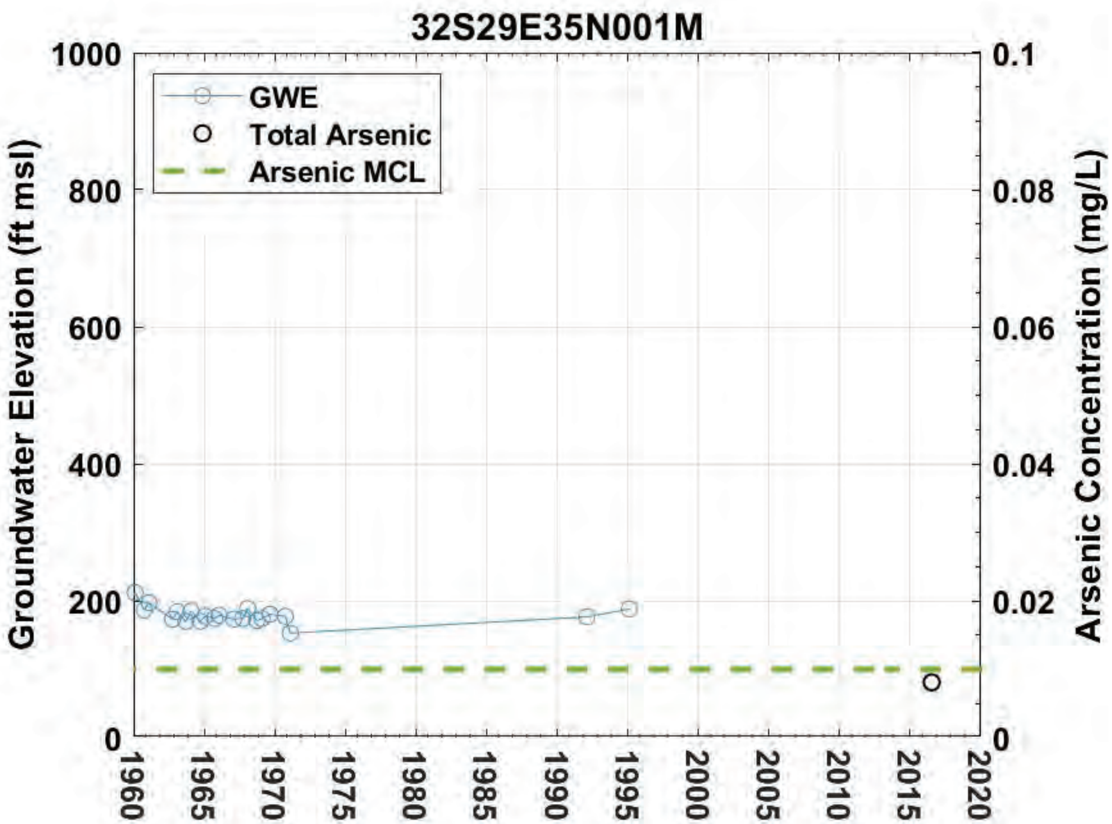

12N19W36H001S
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

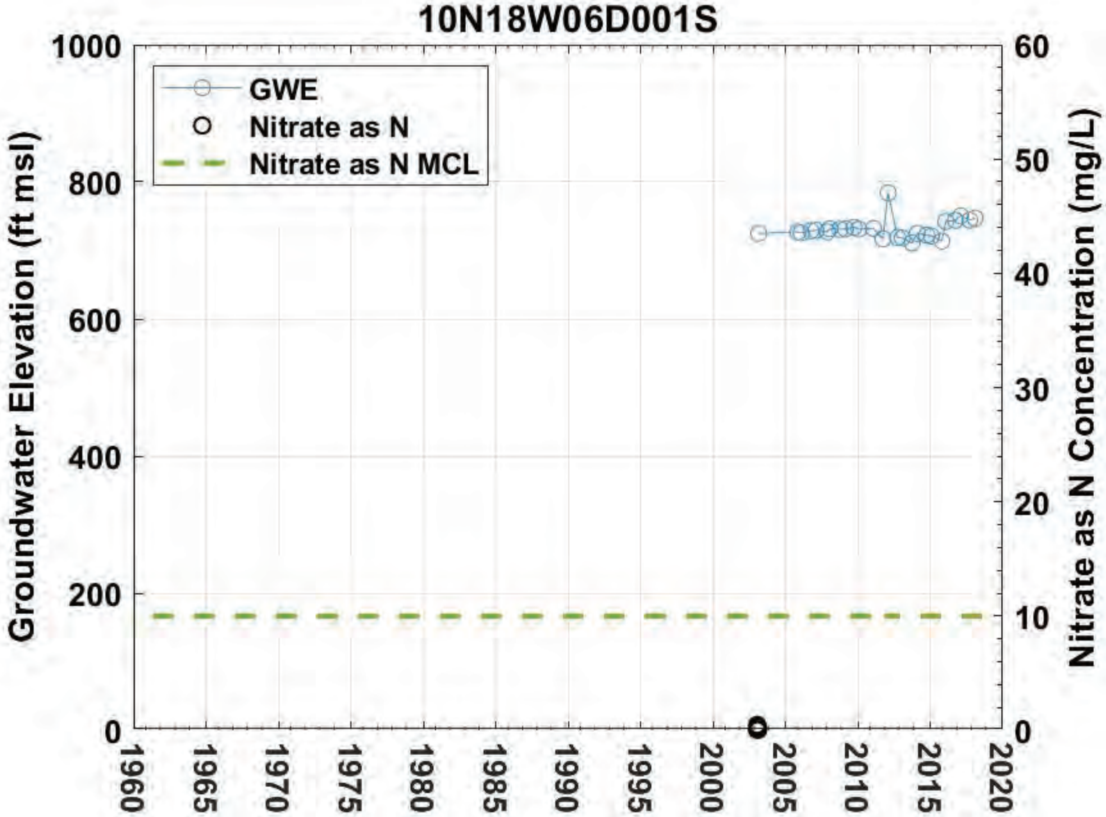


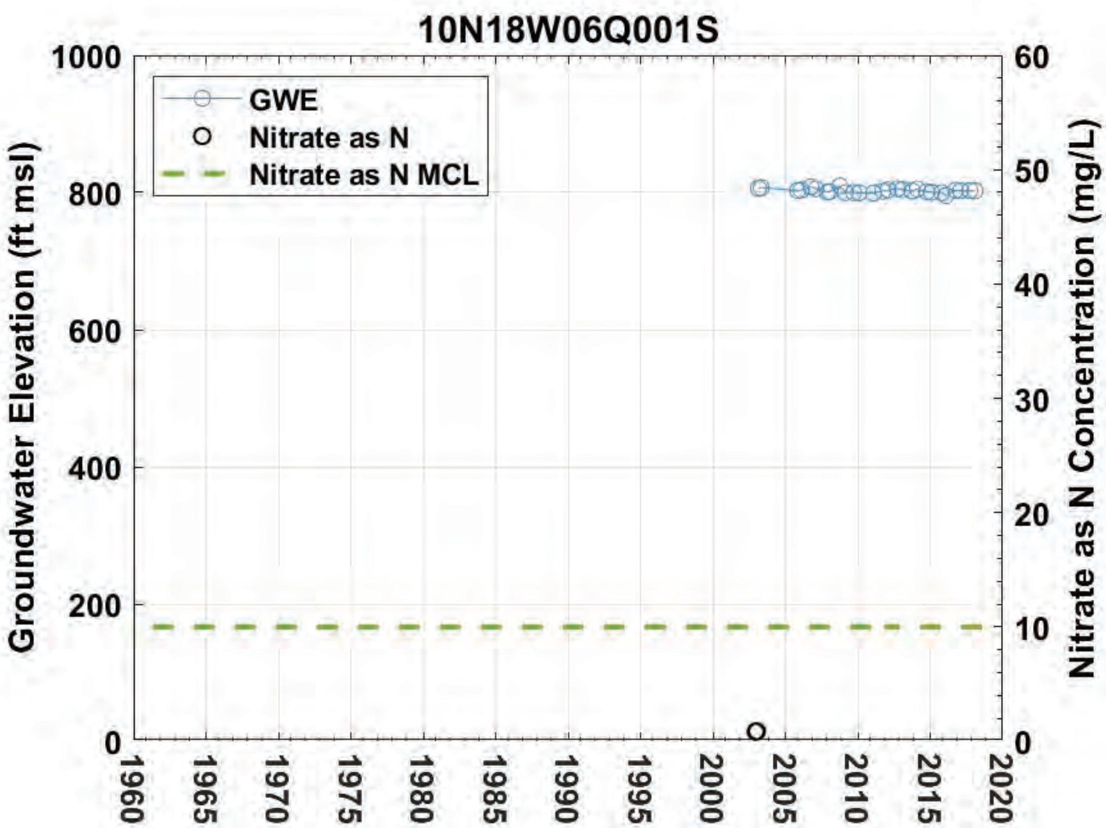
32S29E28R001M
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

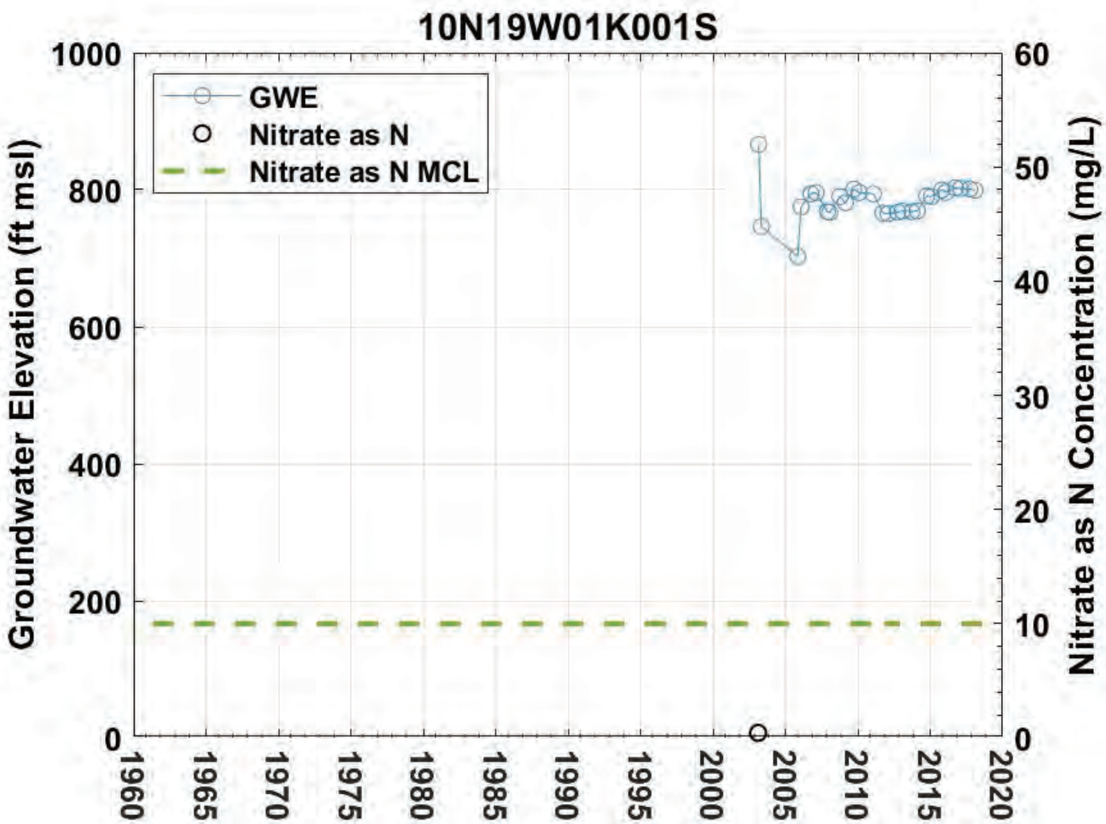


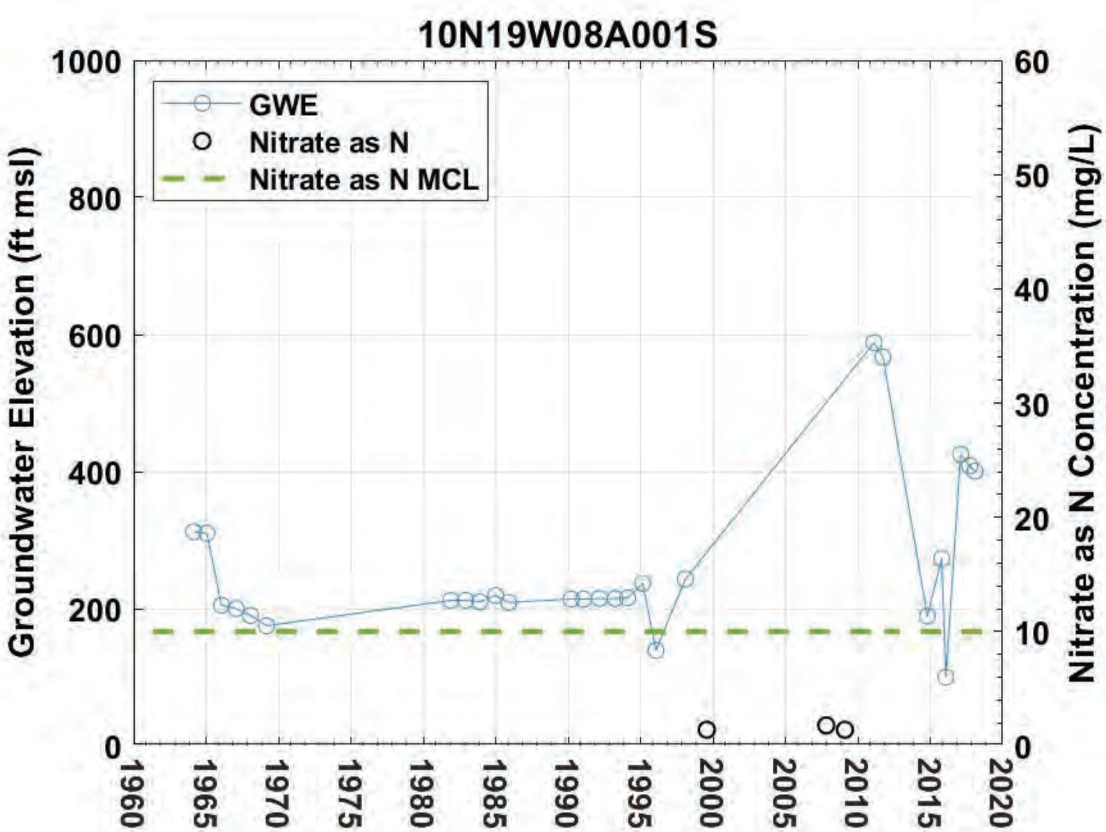
32S29E34G001M
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

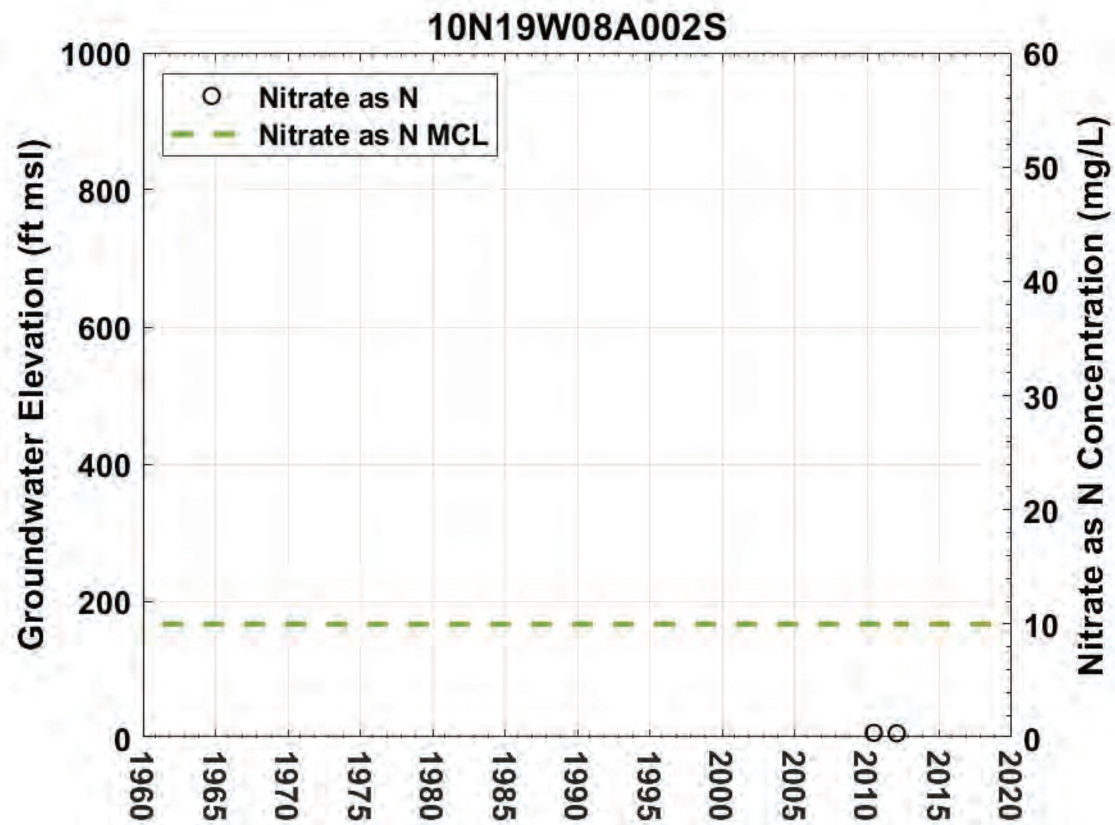

32S29E35N001M
GWE
Total Arsenic
Arsenic MCL
Groundwater Elevation (ft msl)
Arsenic Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

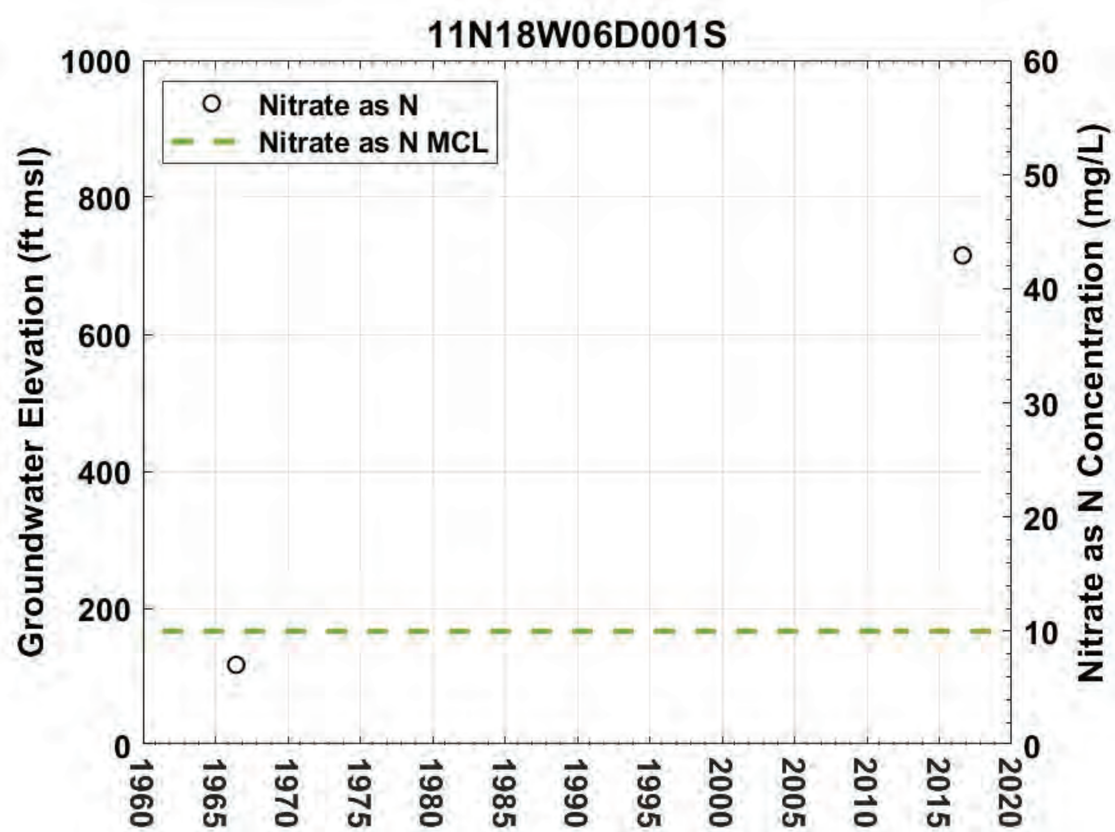

10N18W06D001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

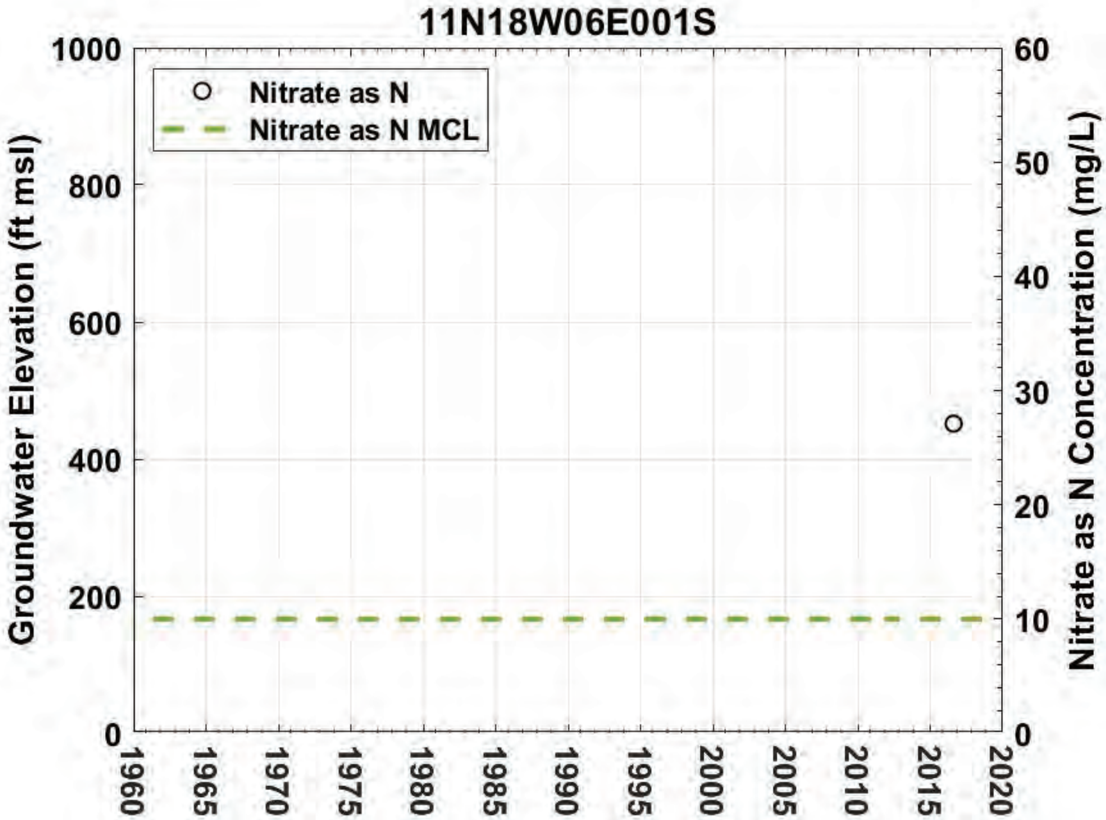

10N18W06Q001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

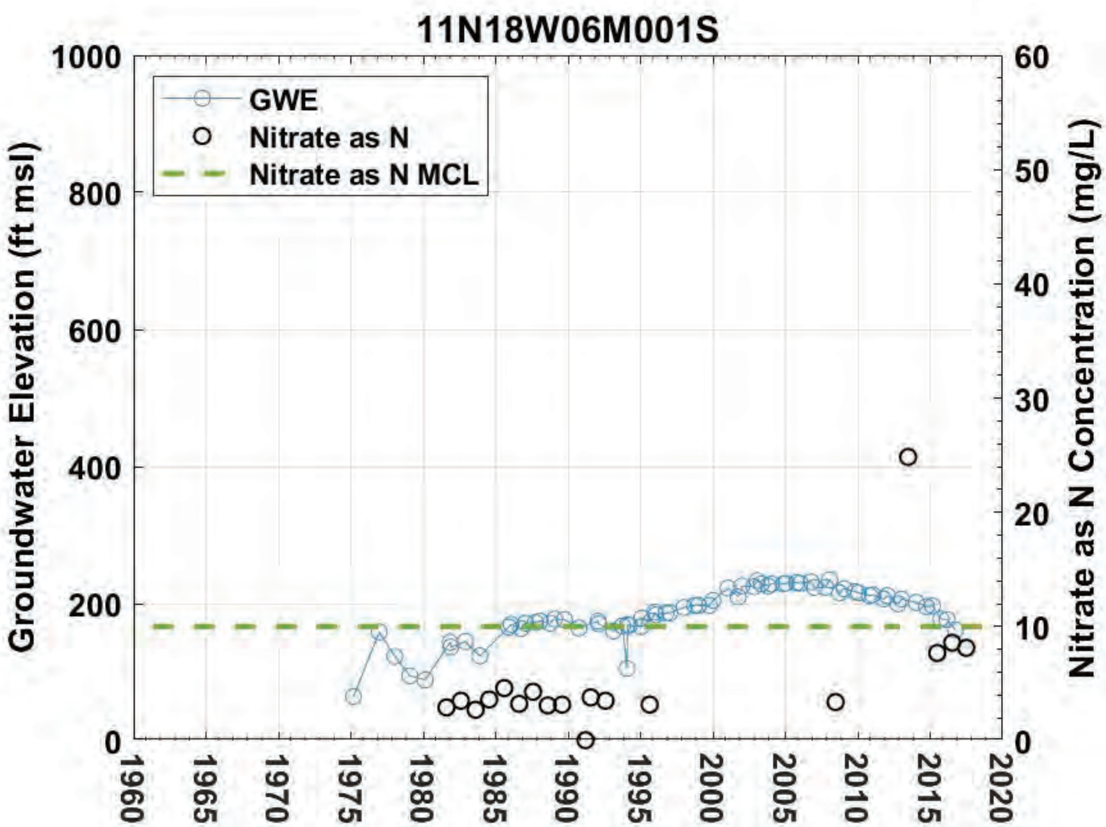

10N19W01K001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

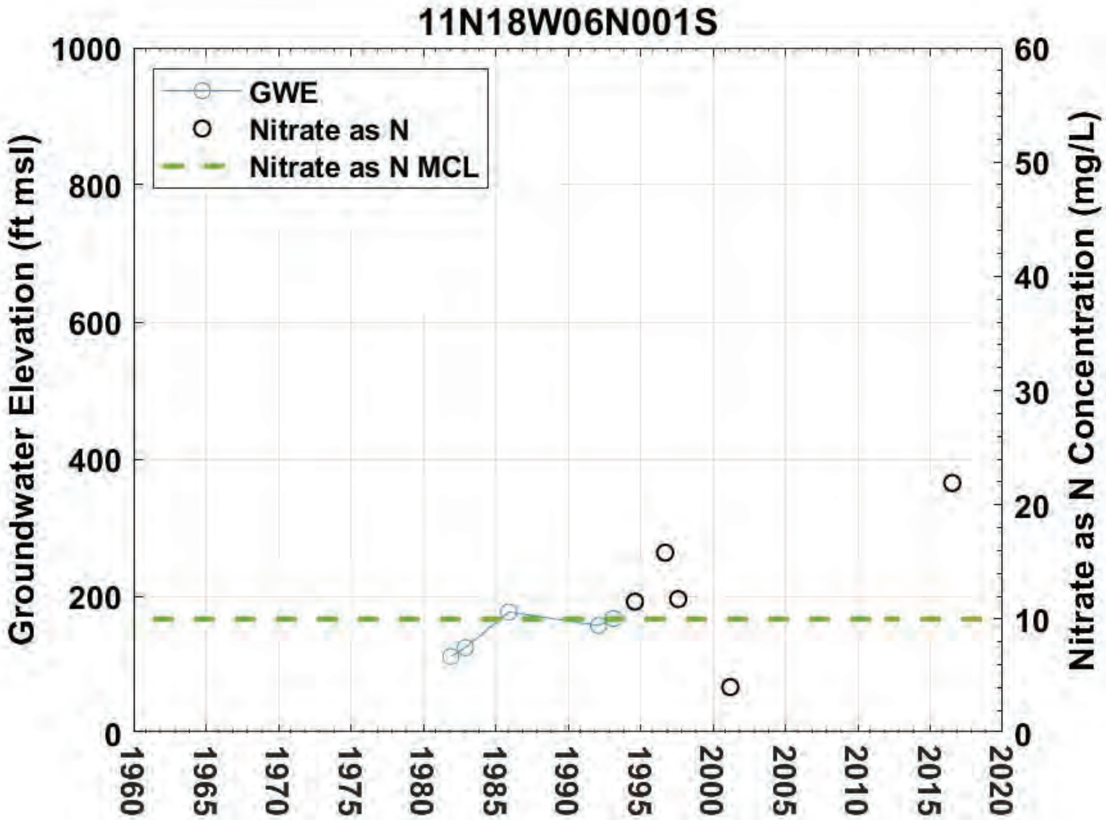

10N19W08A001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

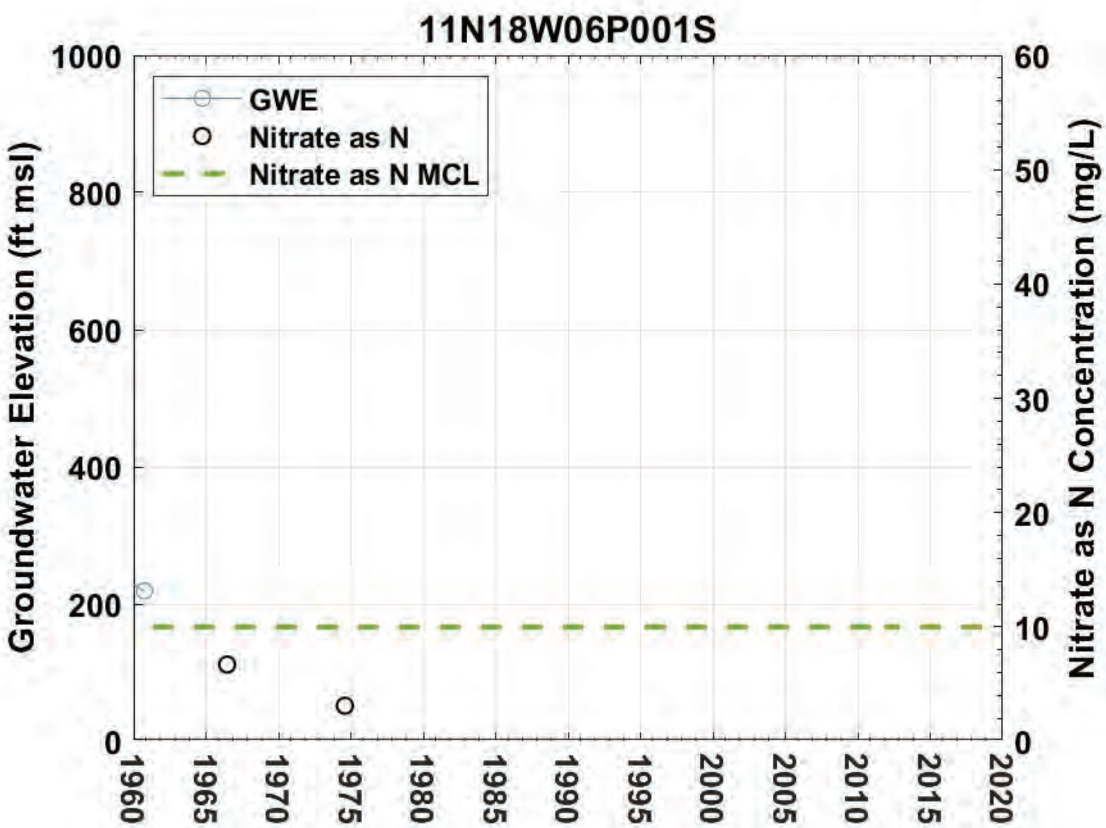

10N19W08A002S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

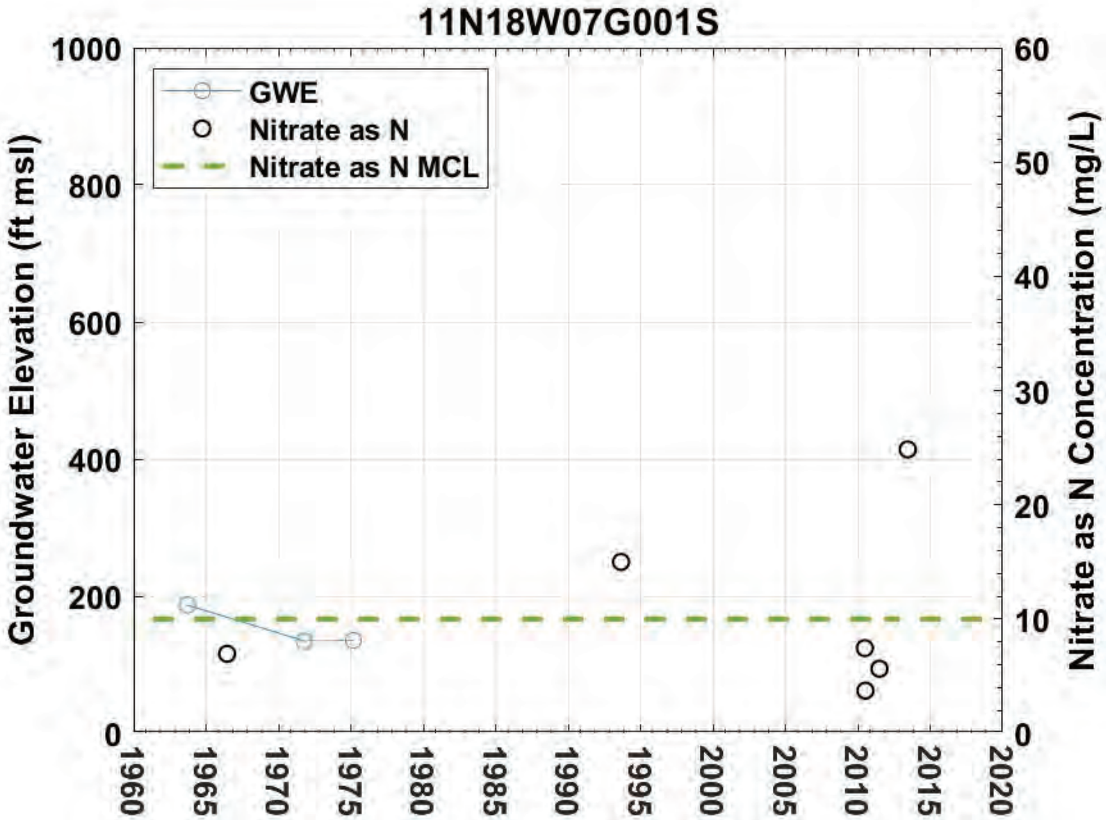

11N18W06D001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

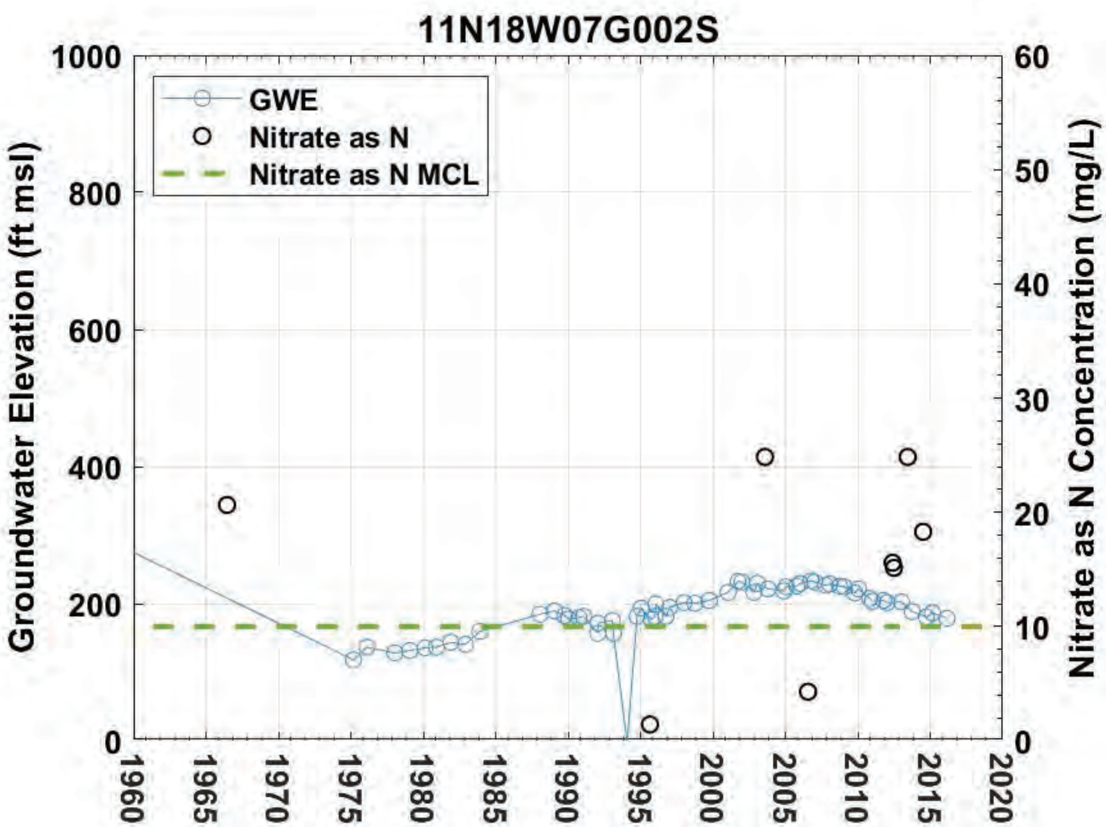

11N18W06E001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
Nitrate as N
Nitrate as N MCL
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

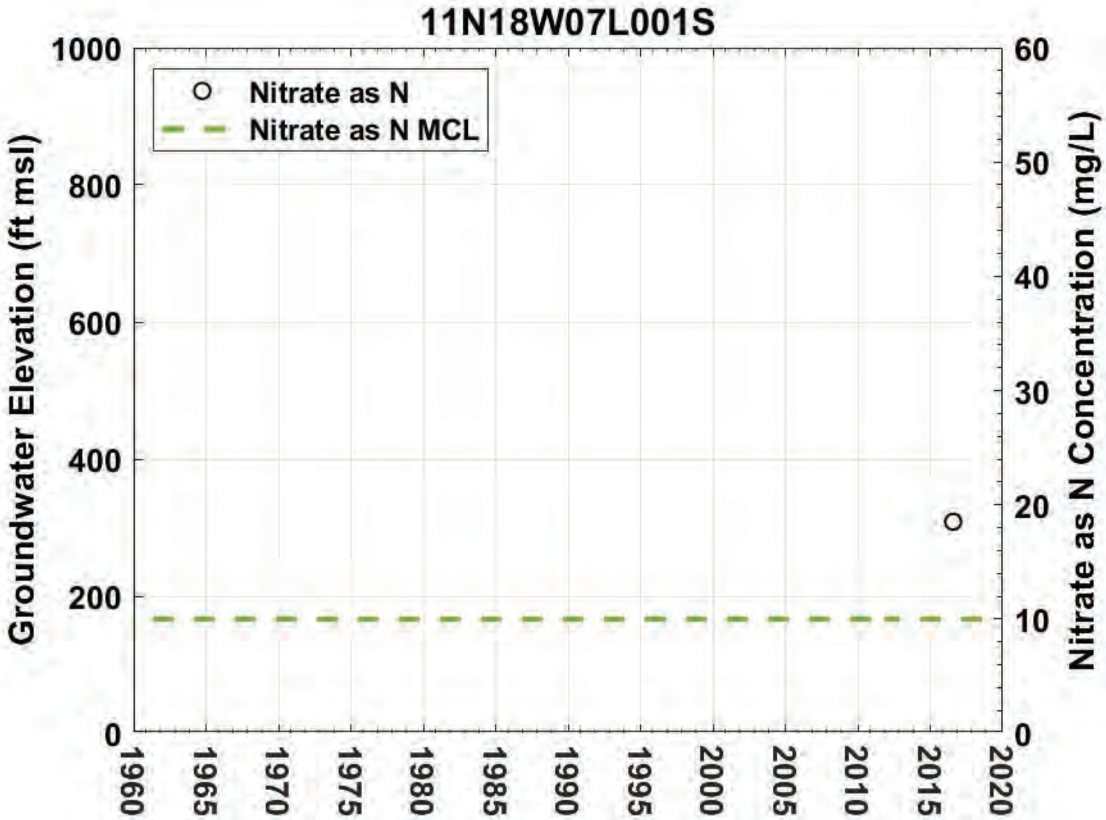

11N18W06M001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
GWE
Nitrate as N
Nitrate as N MCL
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

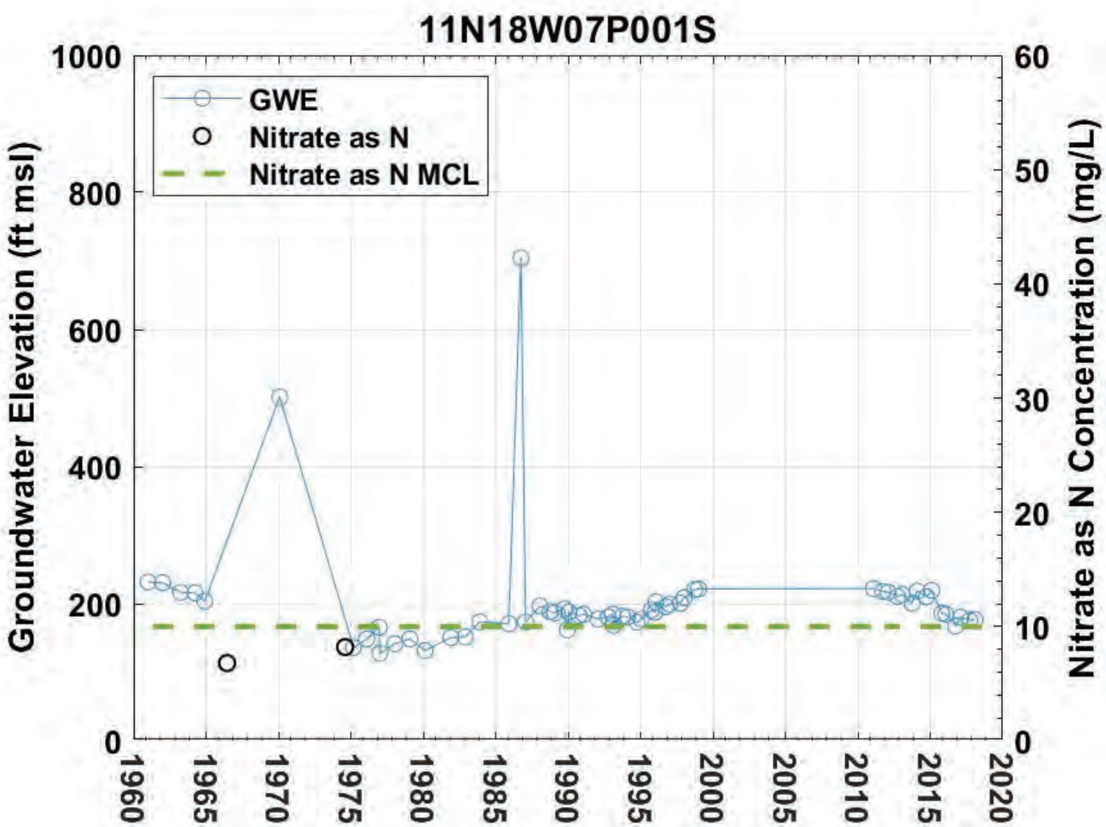

11N18W06N001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

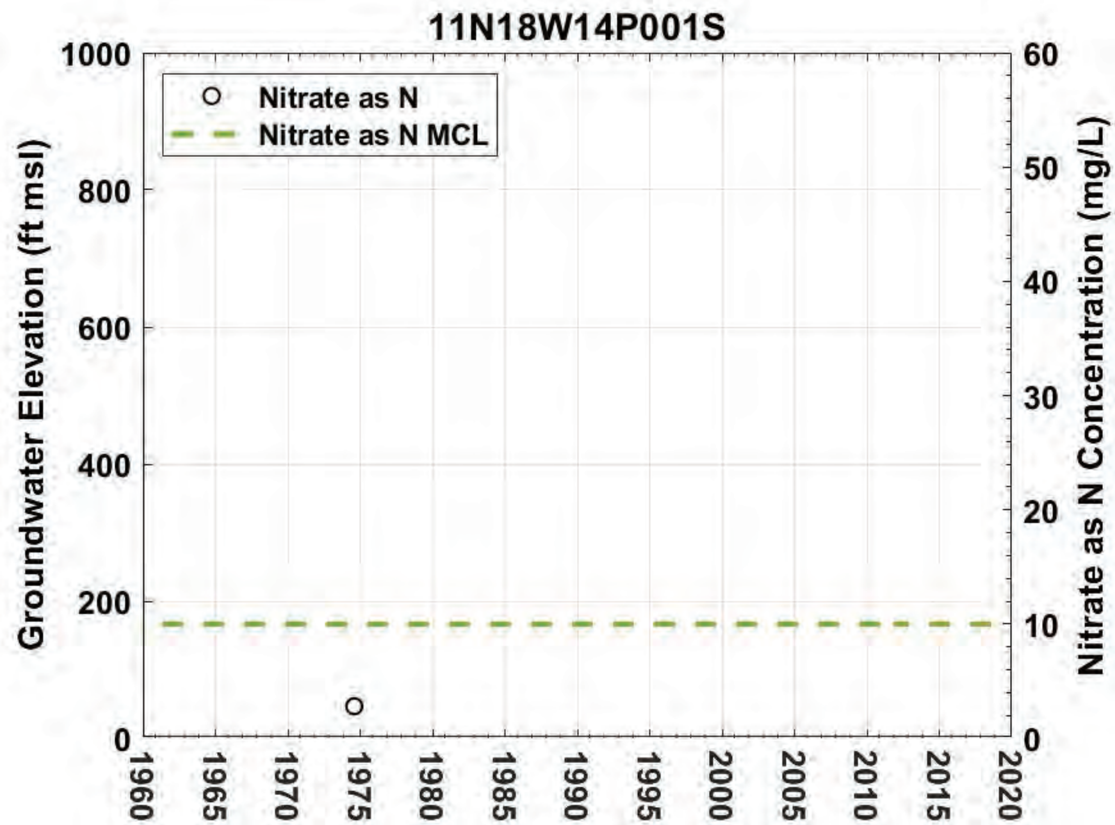

11N18W06P001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

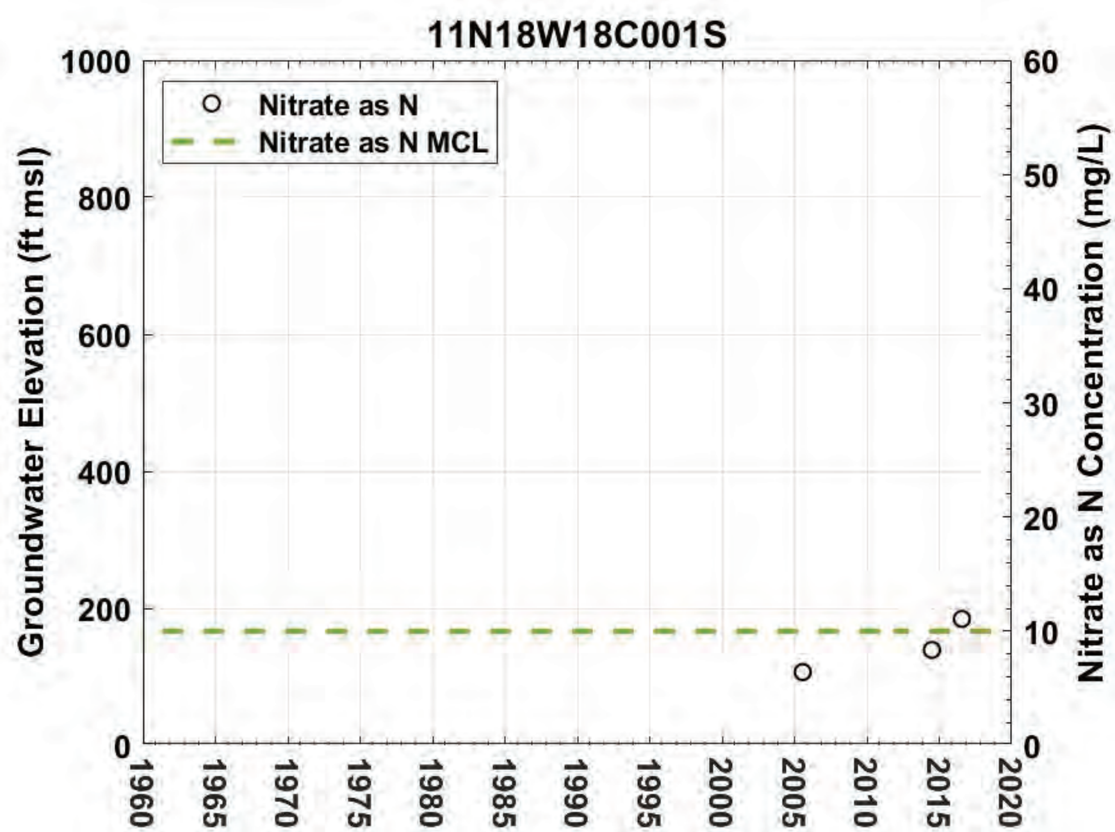

11N18W07G001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

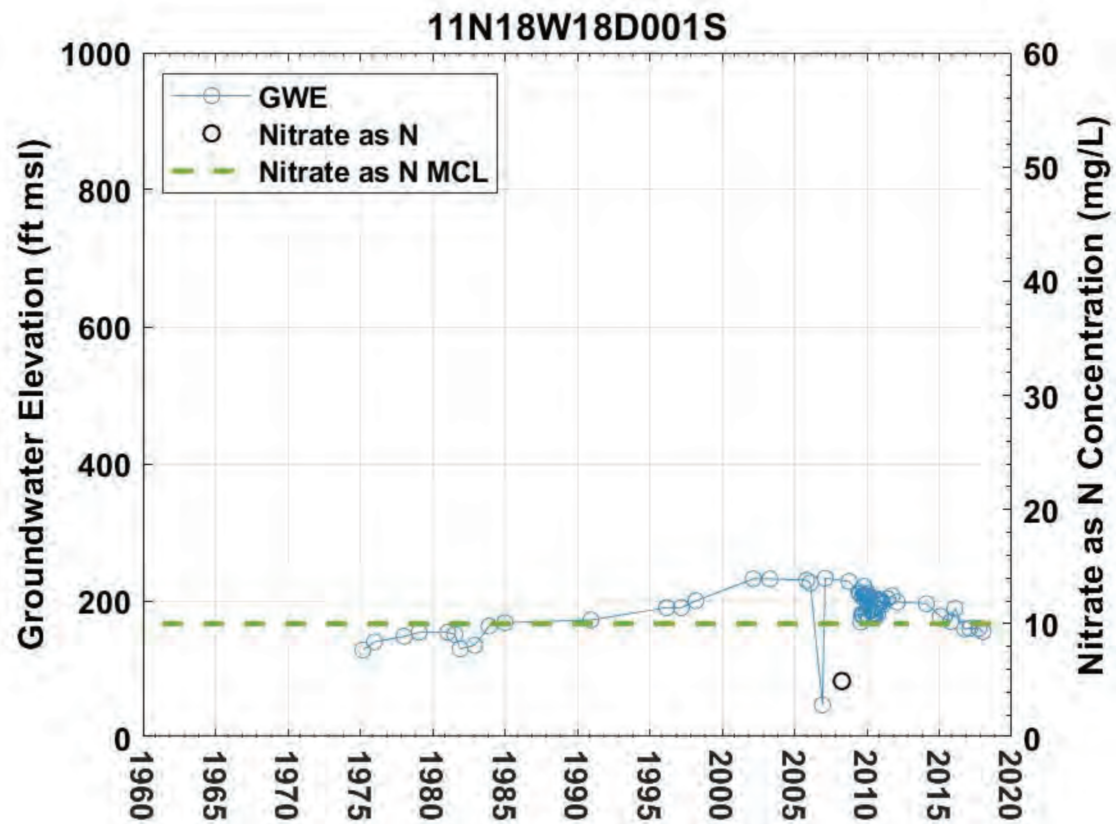

11N18W07G002S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

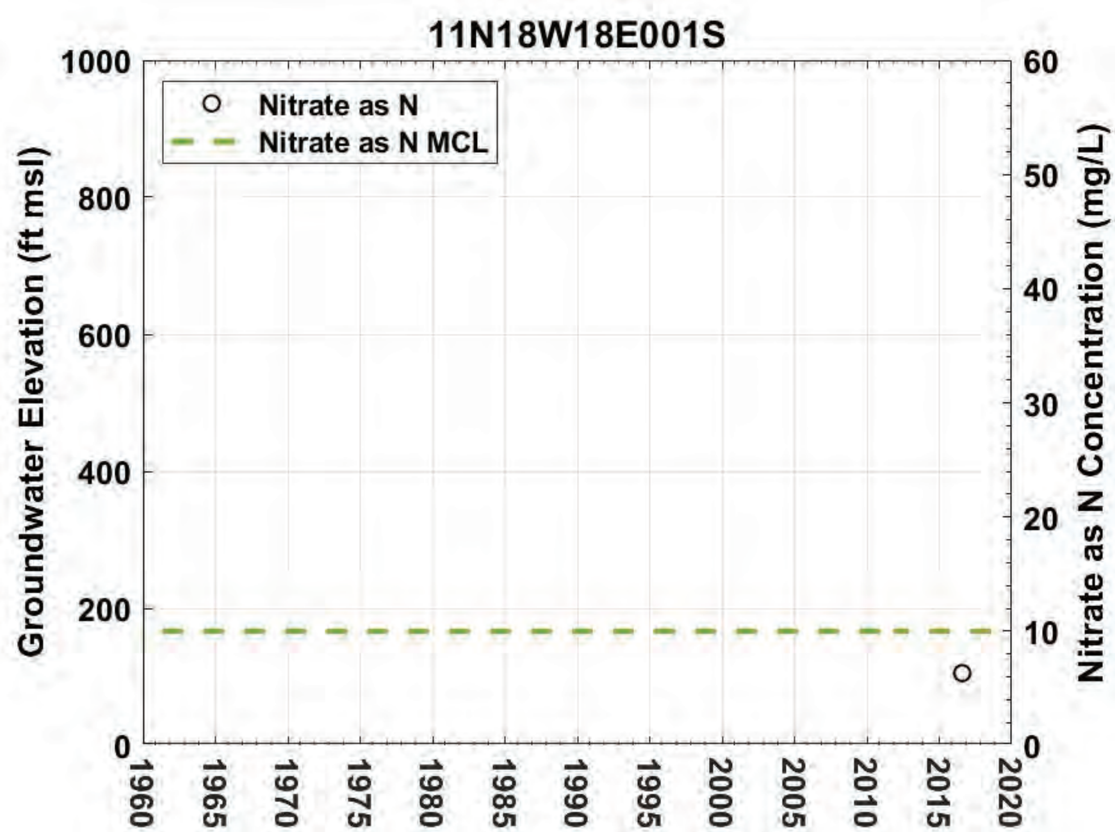

11N18W07L001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

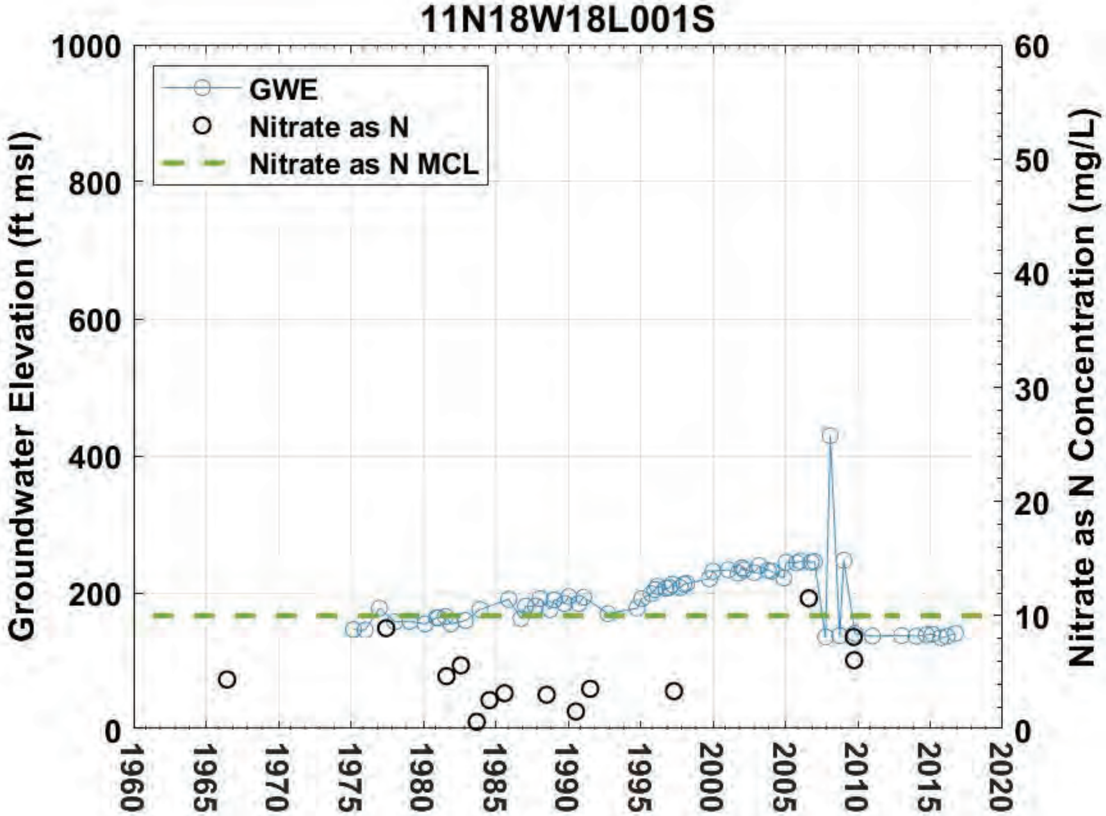

11N18W07P001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

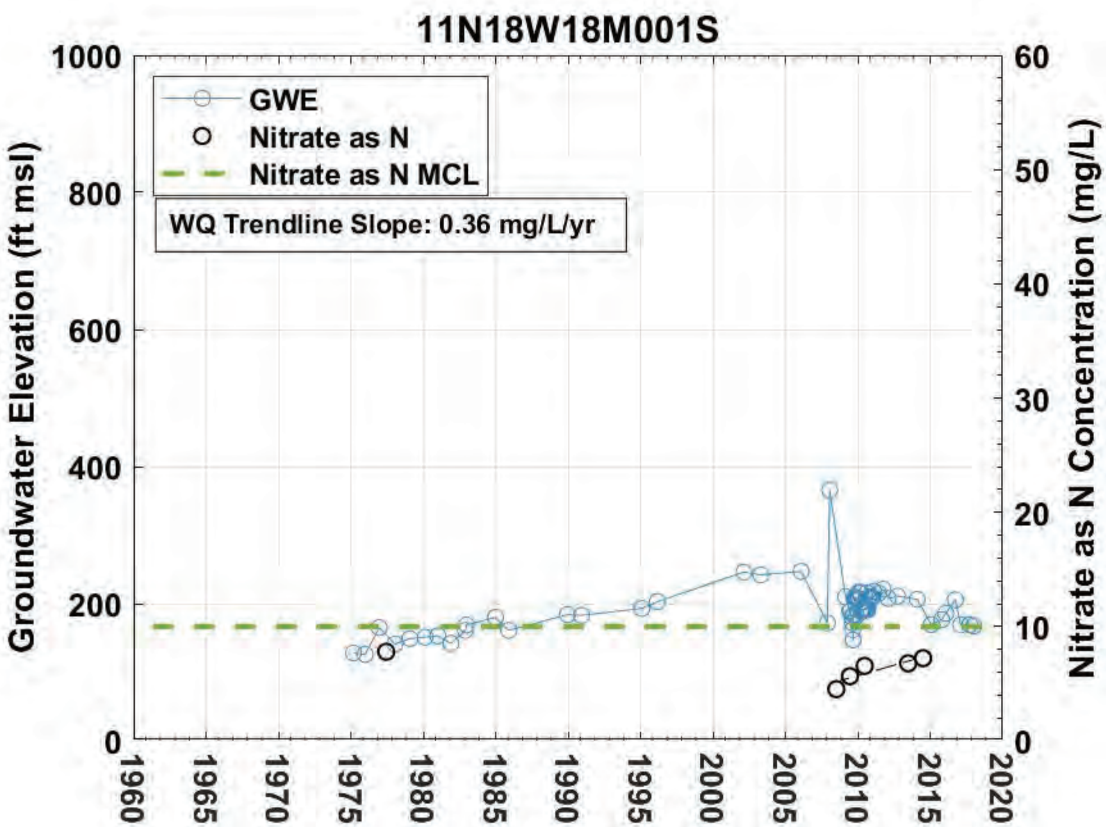

11N18W14P001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

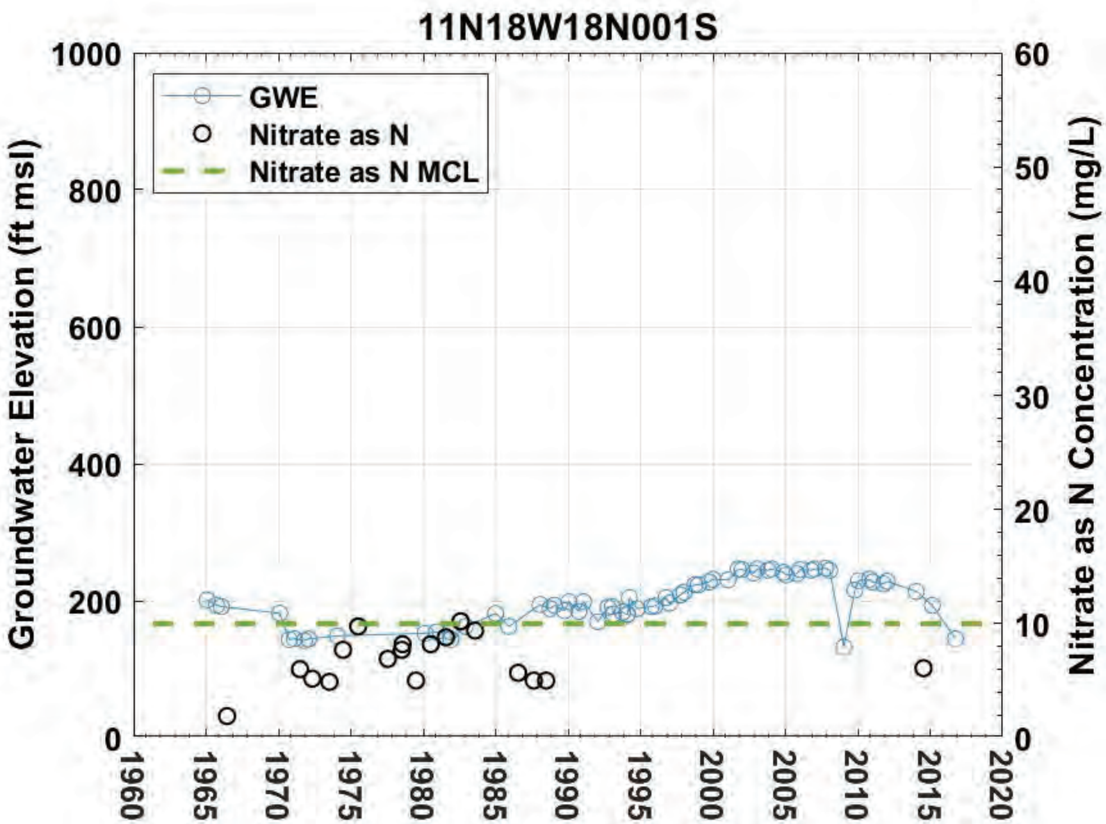

11N18W18C001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N18W18D001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

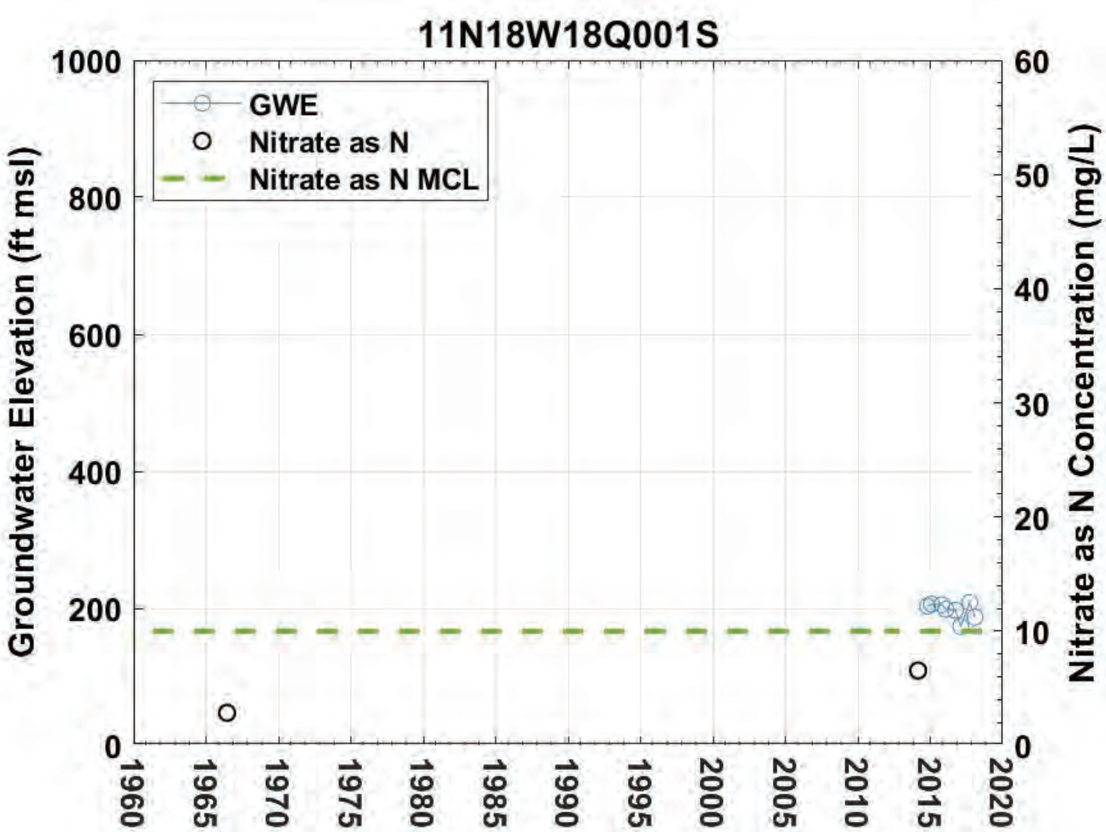

11N18W18E001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N18W18L001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

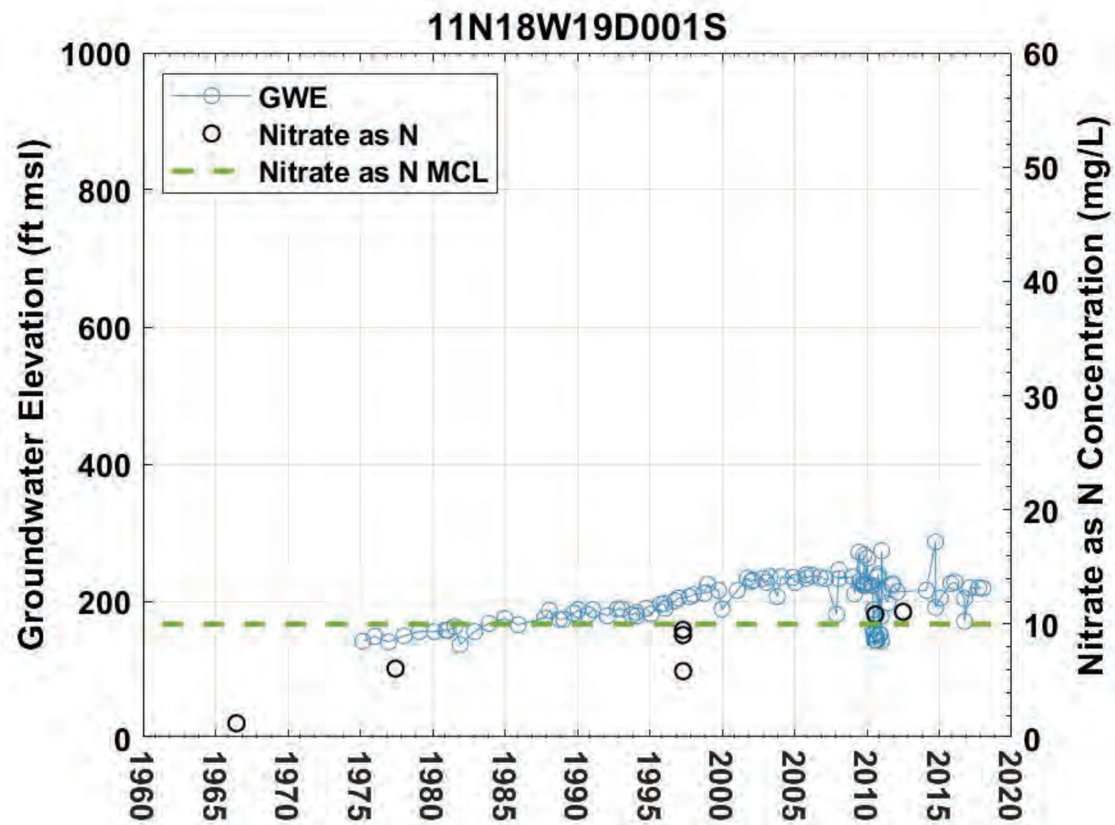

11N18W18M001S
GWE
Nitrate as N
Nitrate as N MCL
WQ Trendline Slope: 0.36 mg/L/yr
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



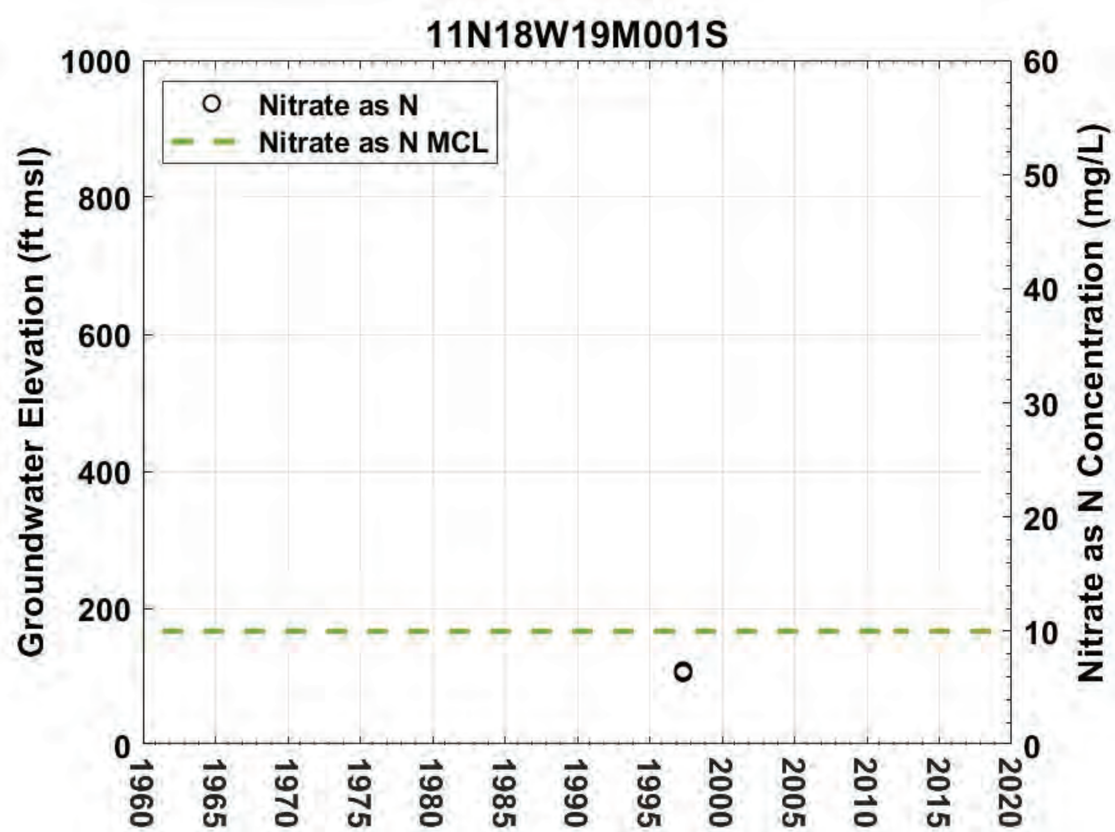
11N18W18N001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
GWE
Nitrate as N
Nitrate as N MCL



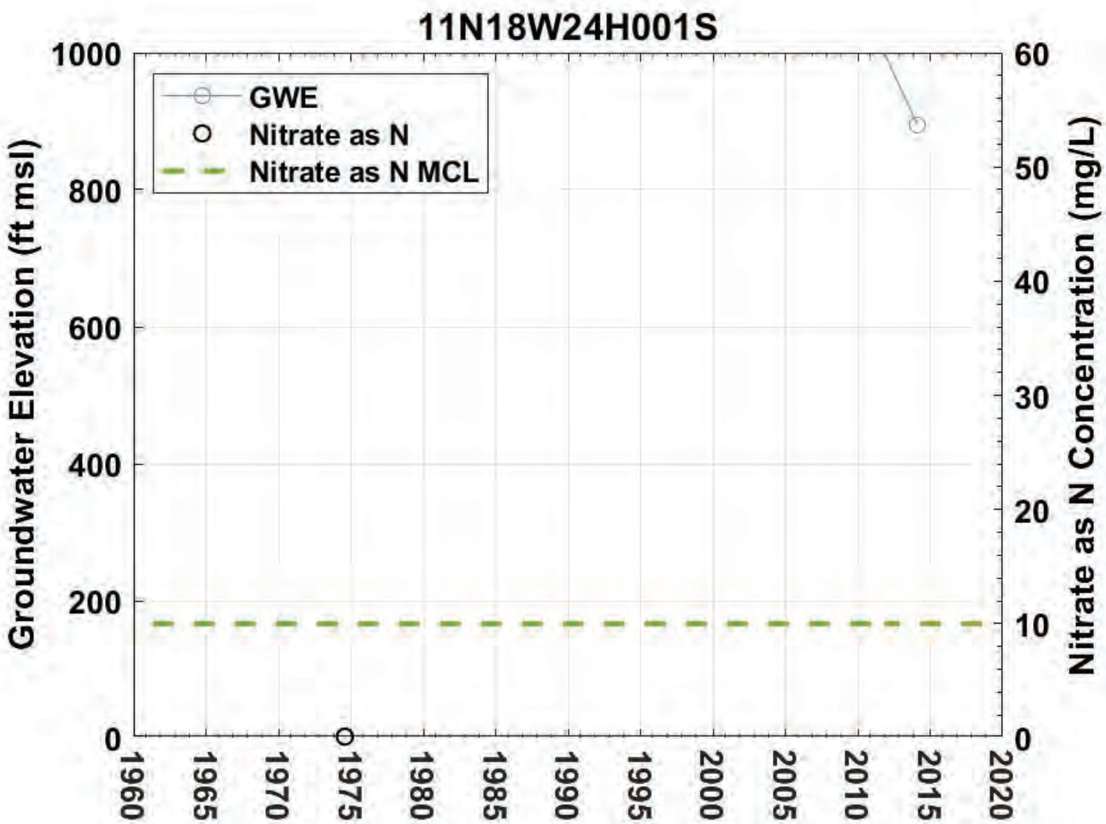
11N18W18Q001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
GWE
Nitrate as N
Nitrate as N MCL



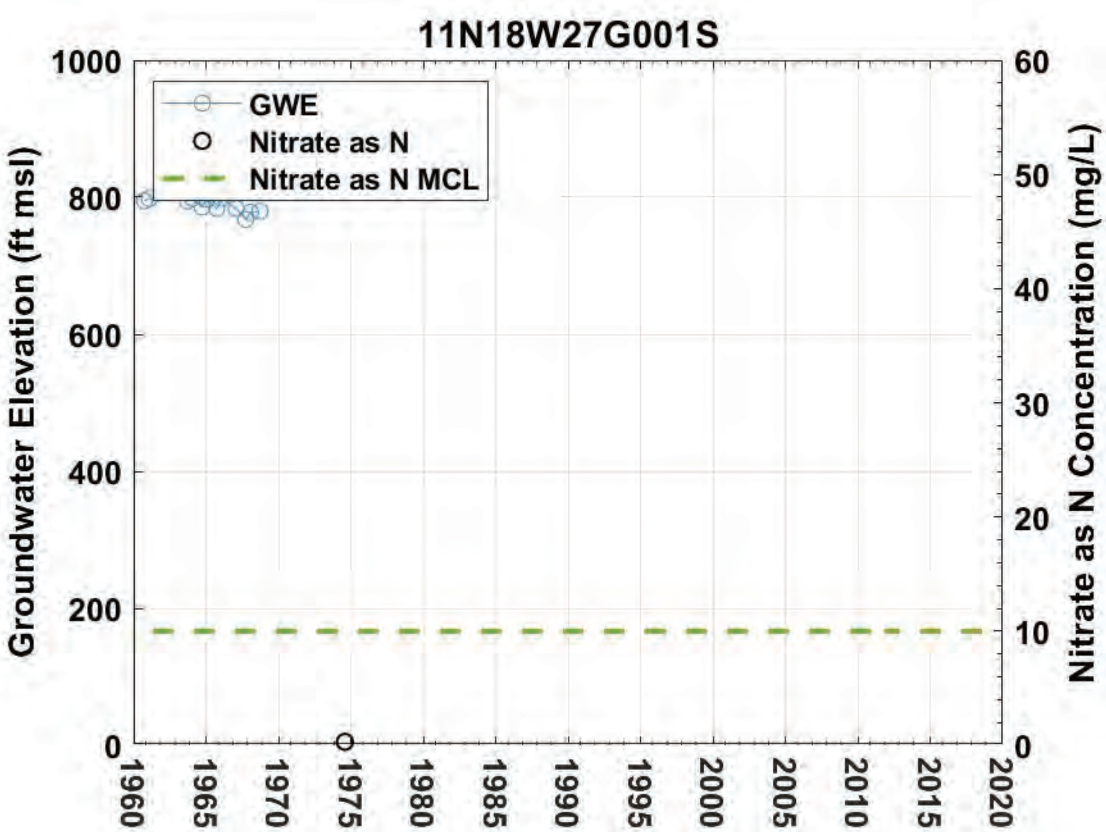
11N18W19D001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
GWE
Nitrate as N
Nitrate as N MCL
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



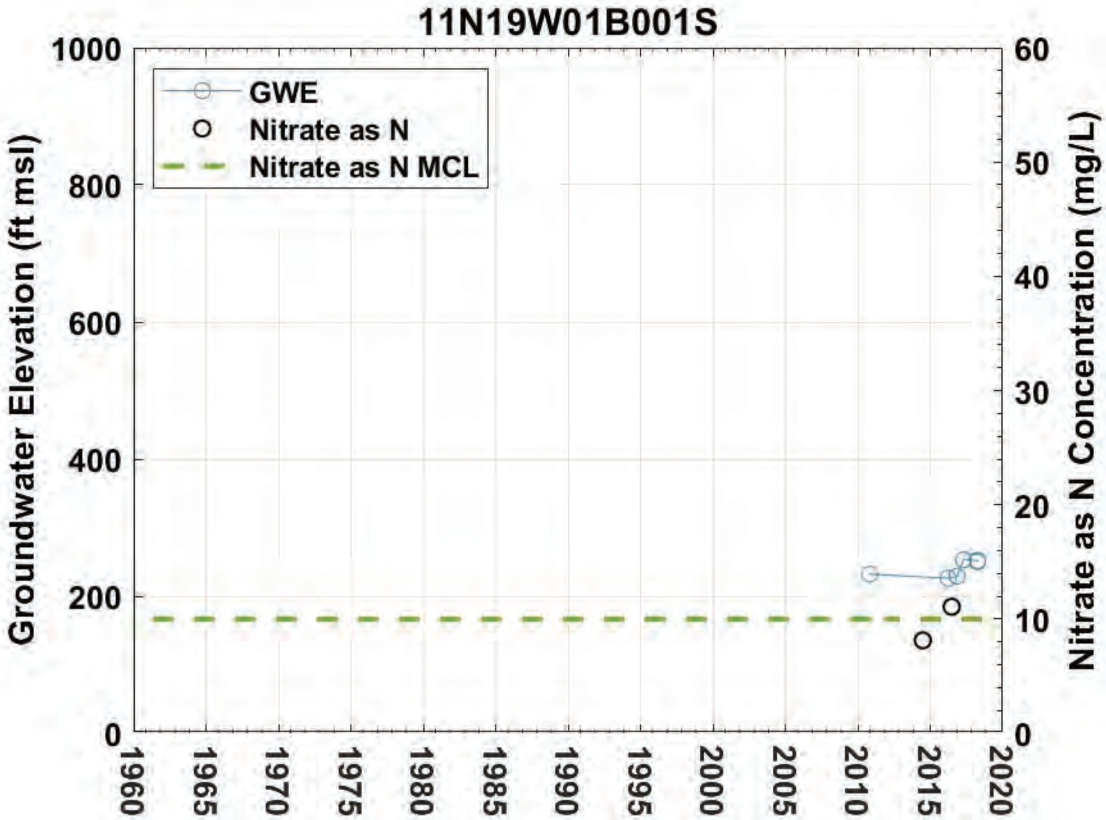
11N18W19M001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
Nitrate as N
Nitrate as N MCL
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

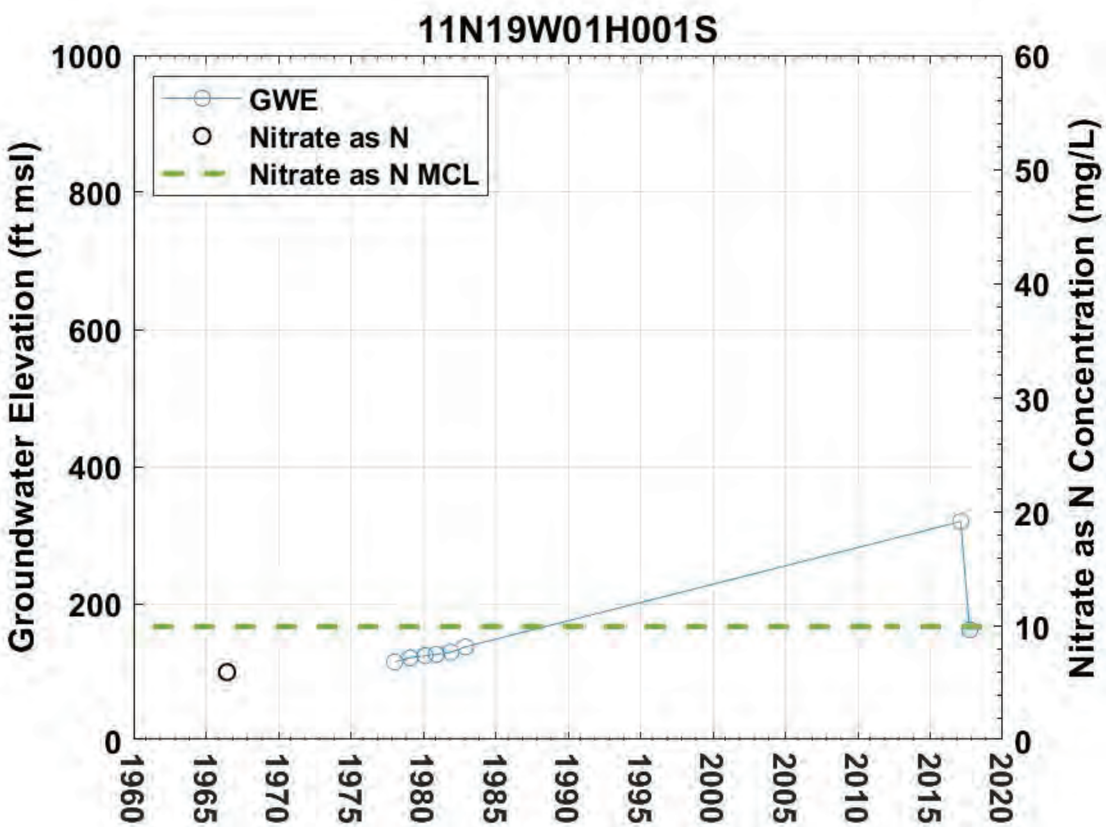


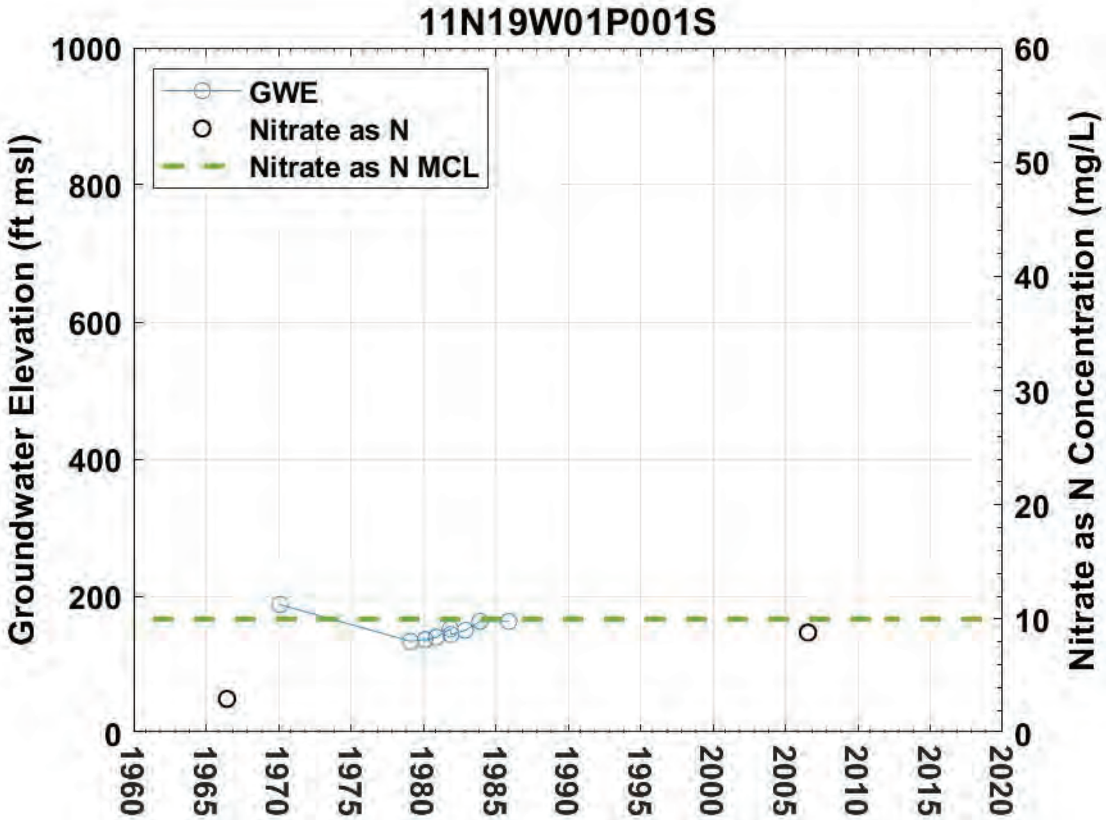
11N18W24H001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

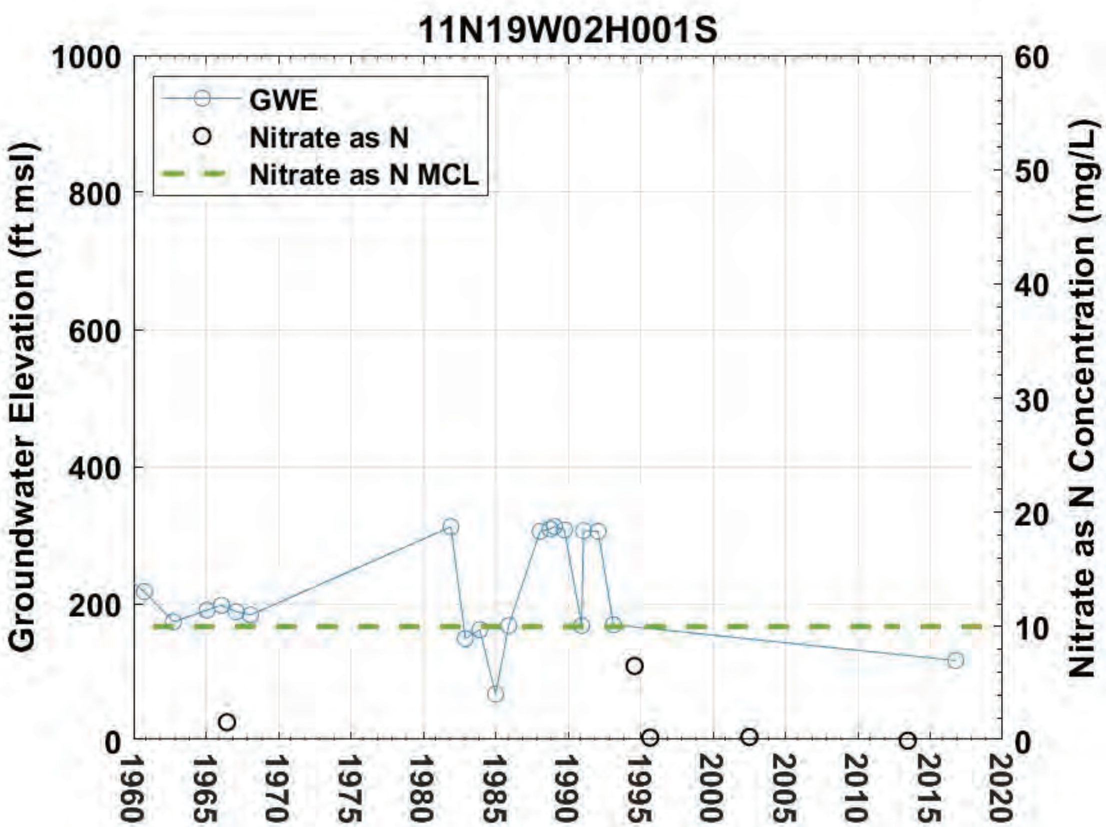


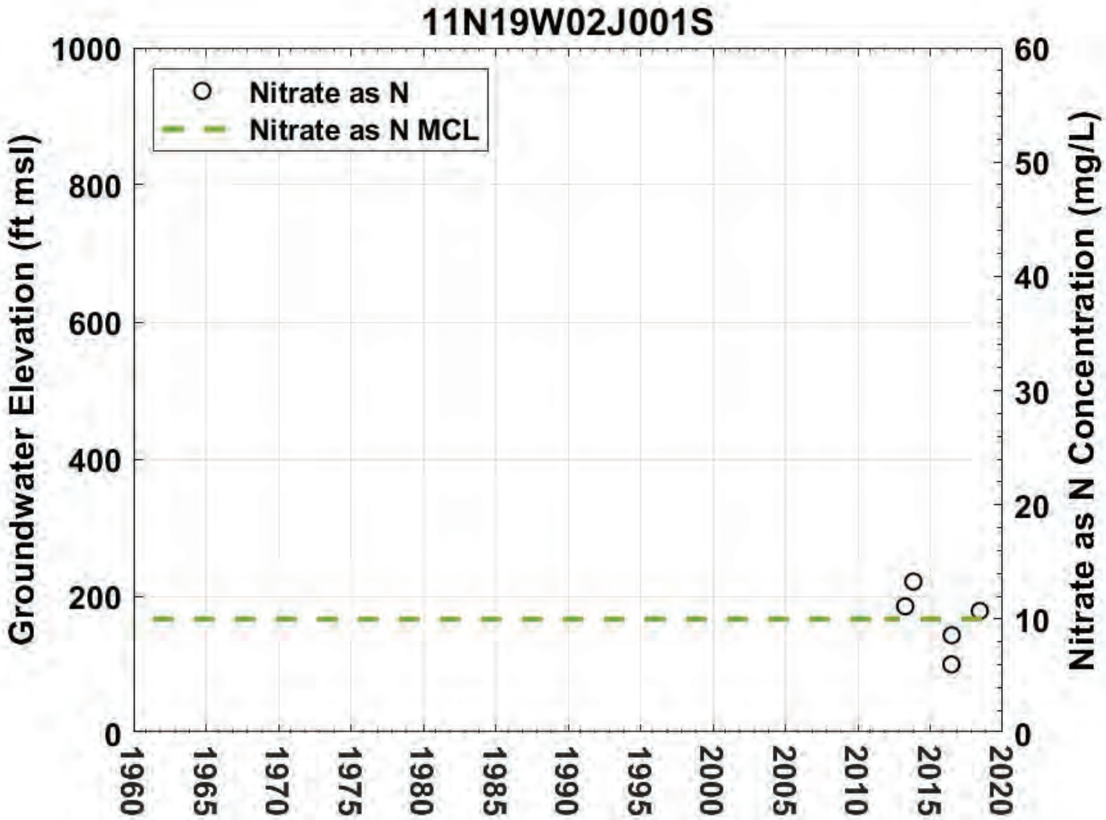
11N18W27G001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

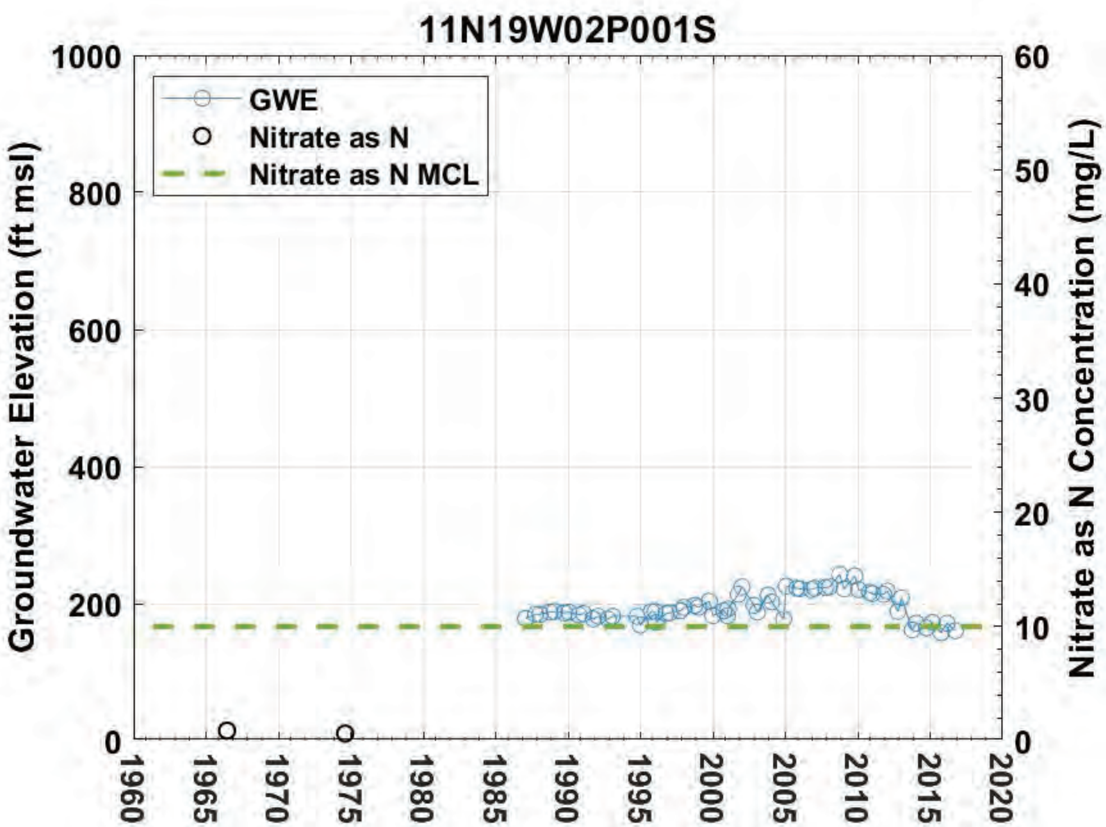

11N19W01B001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

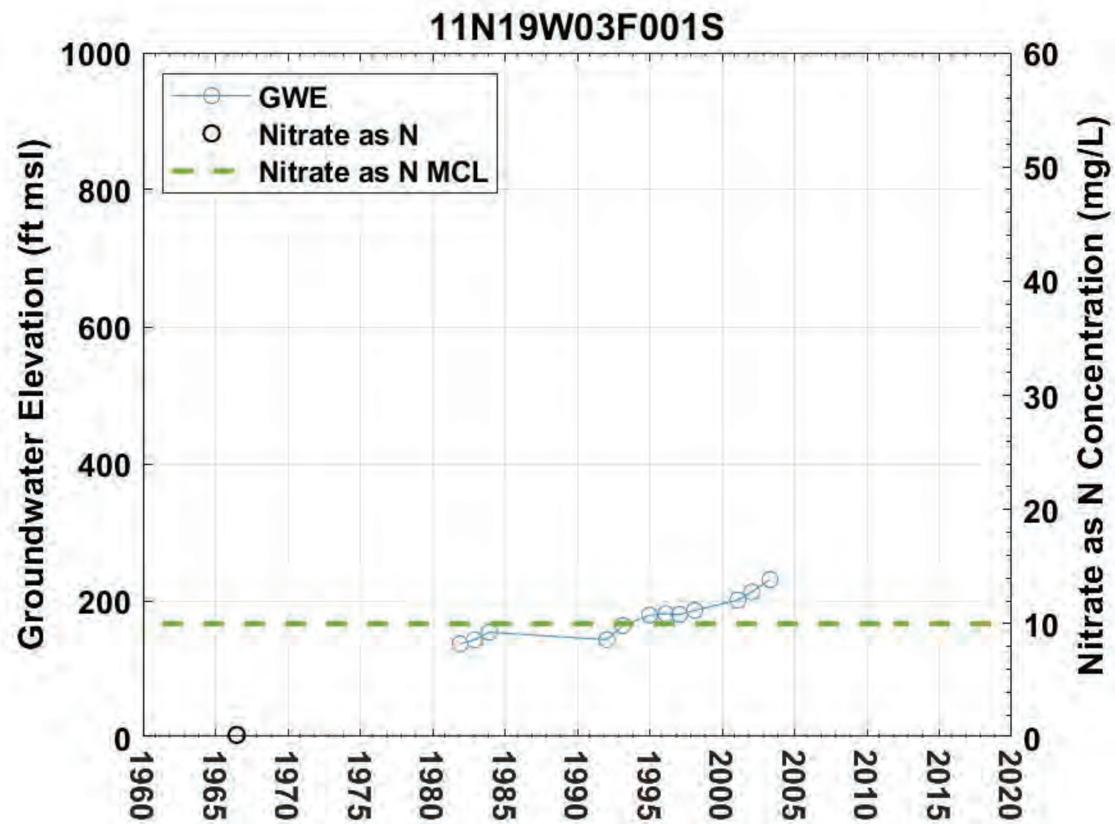

11N19W01H001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

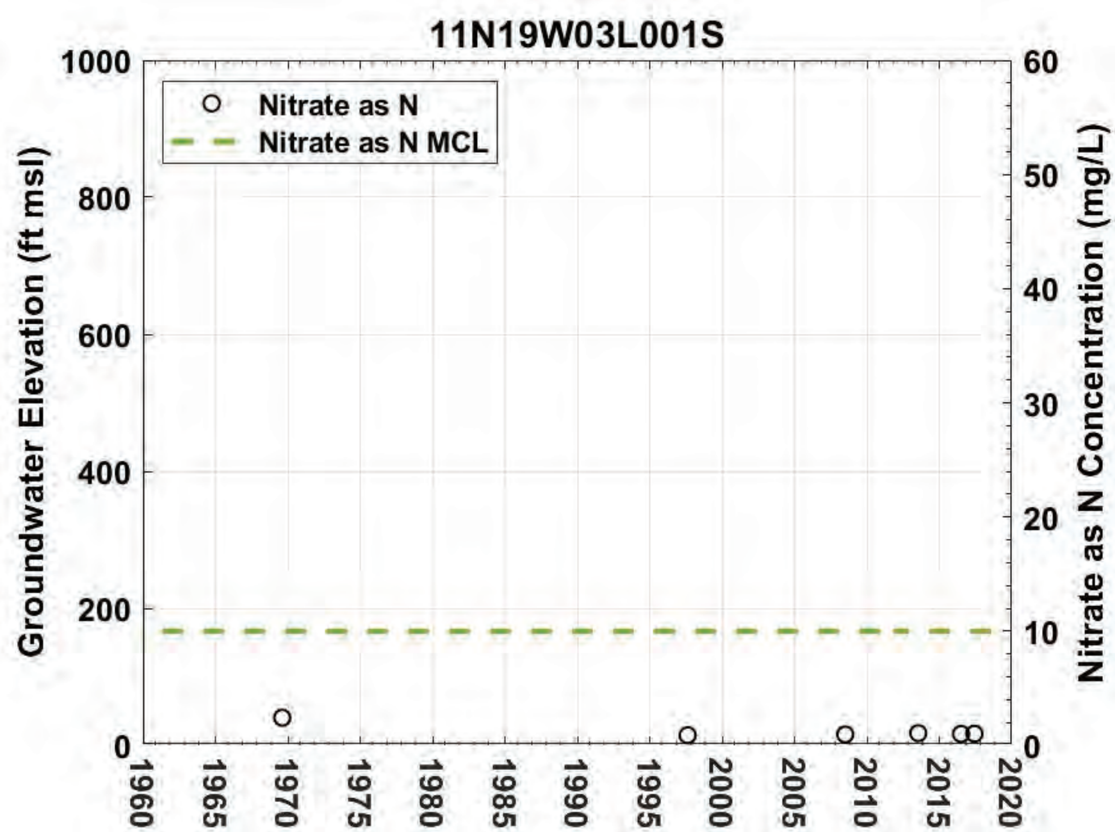

11N19W01P001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

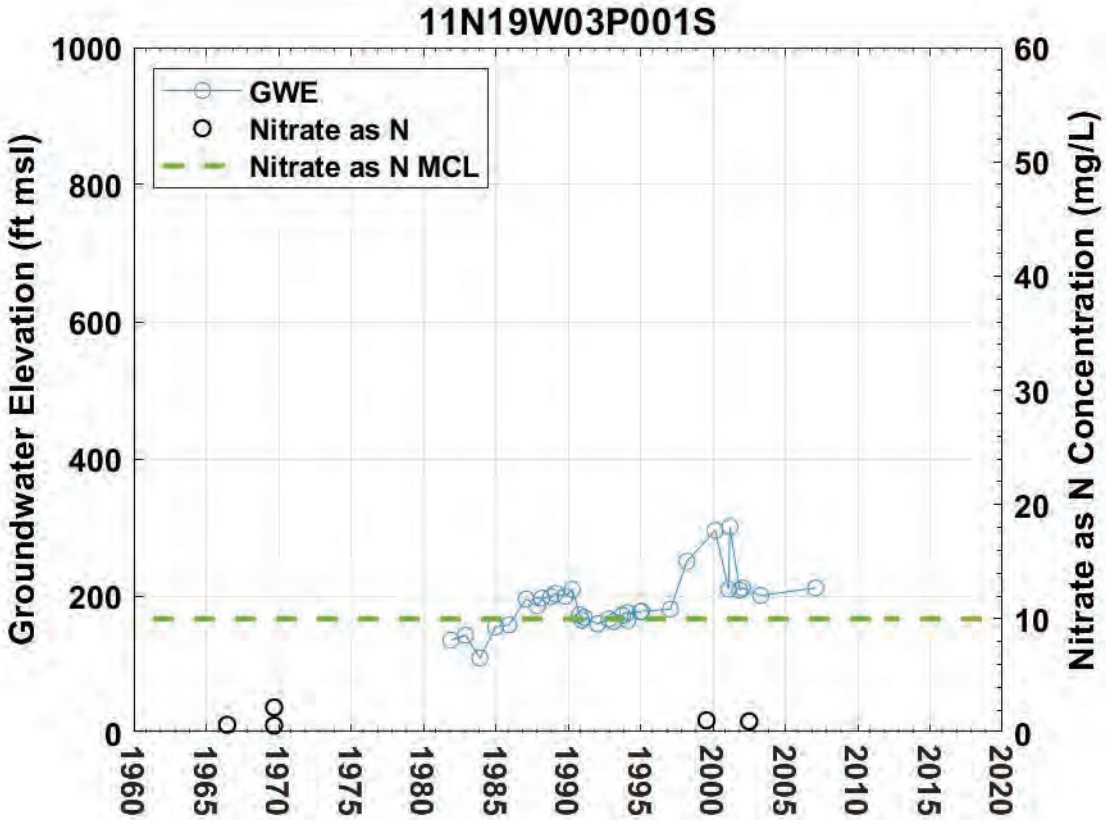

11N19W02H001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W02J001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

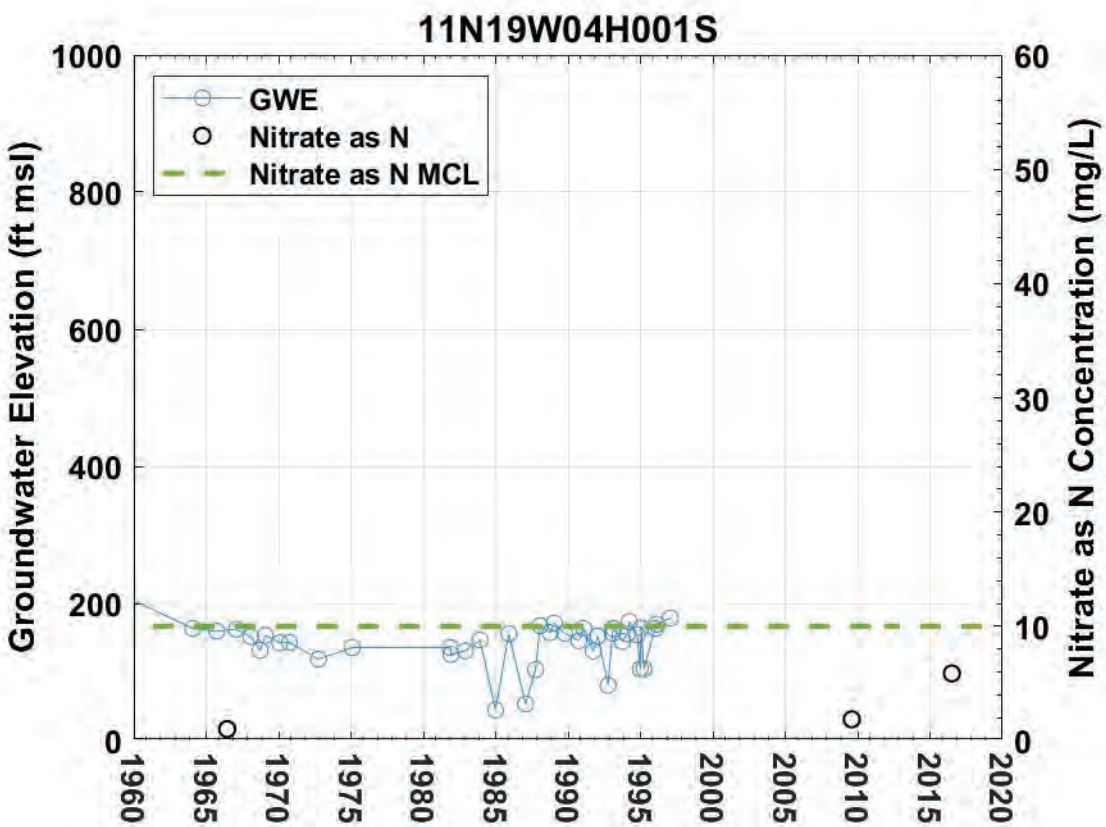

11N19W02P001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W03F001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

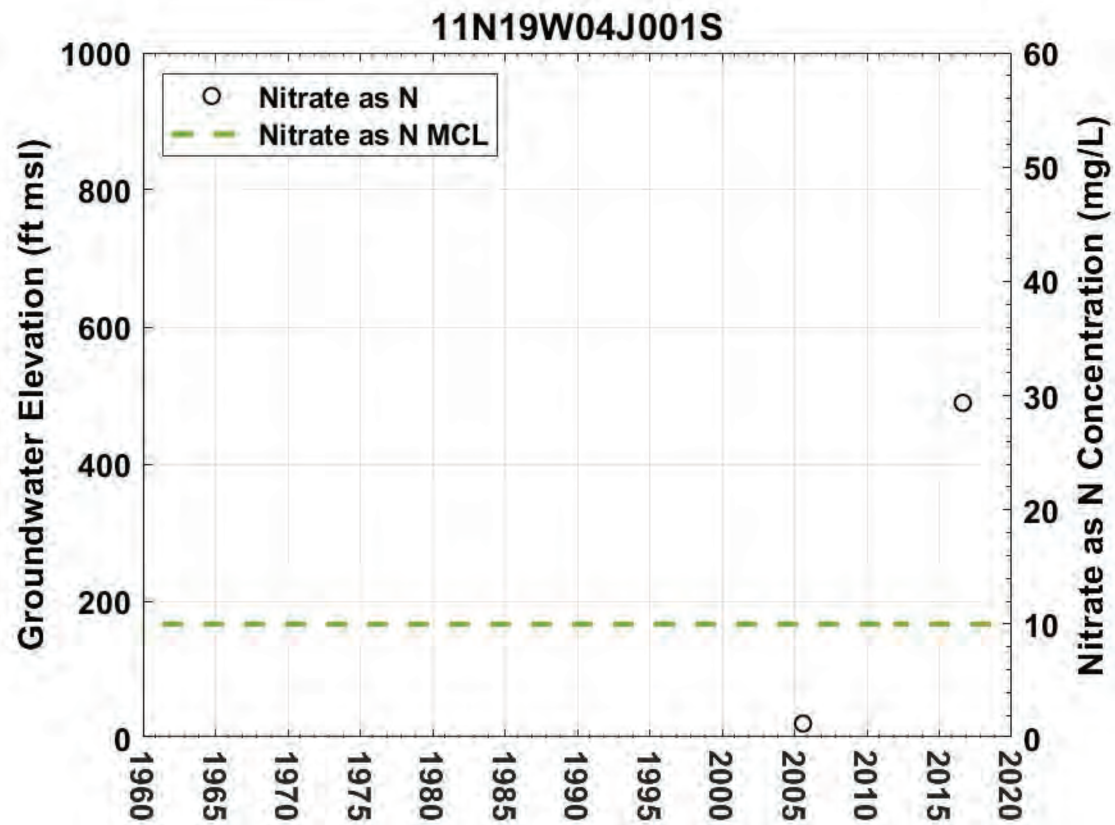

11N19W03L001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

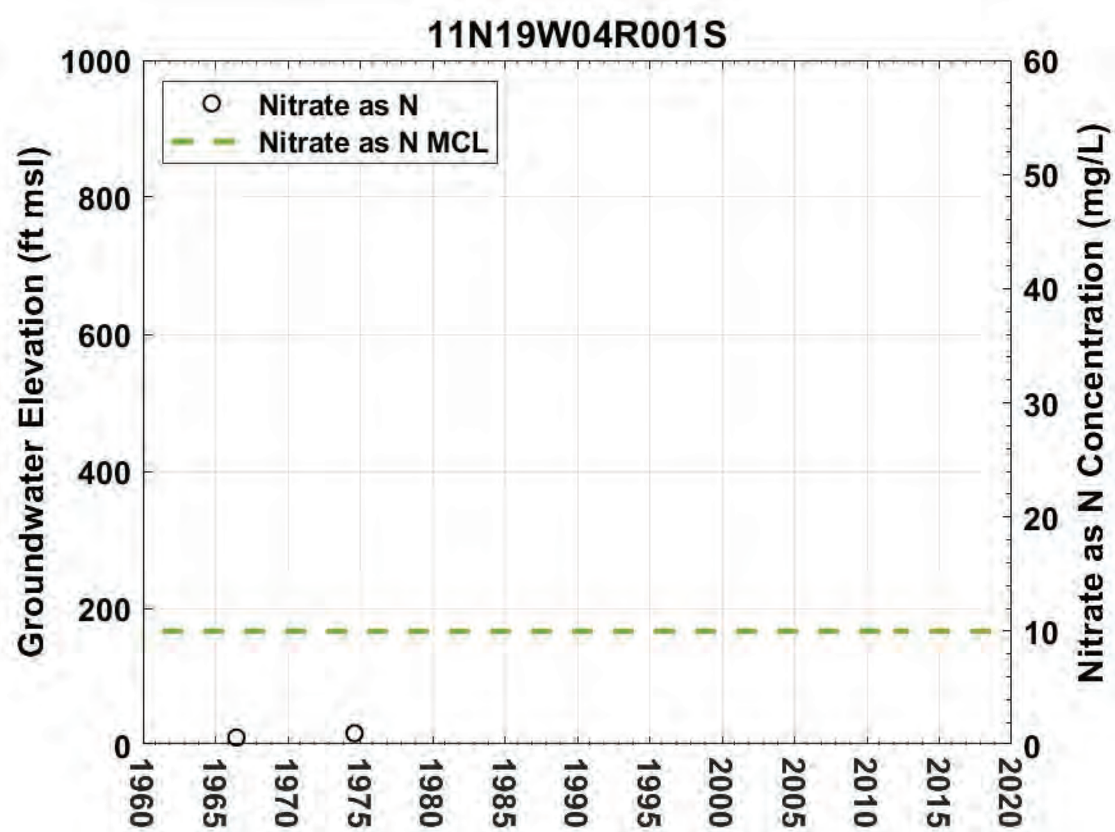


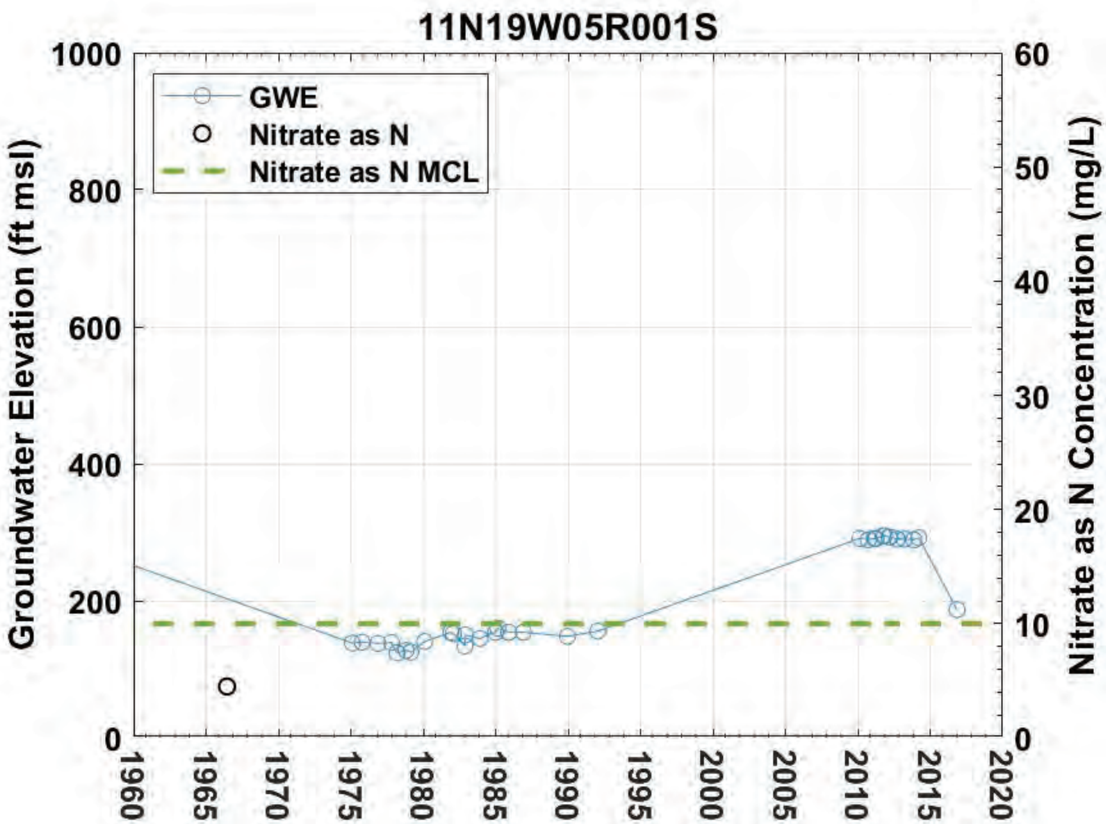
11N19W03P001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)

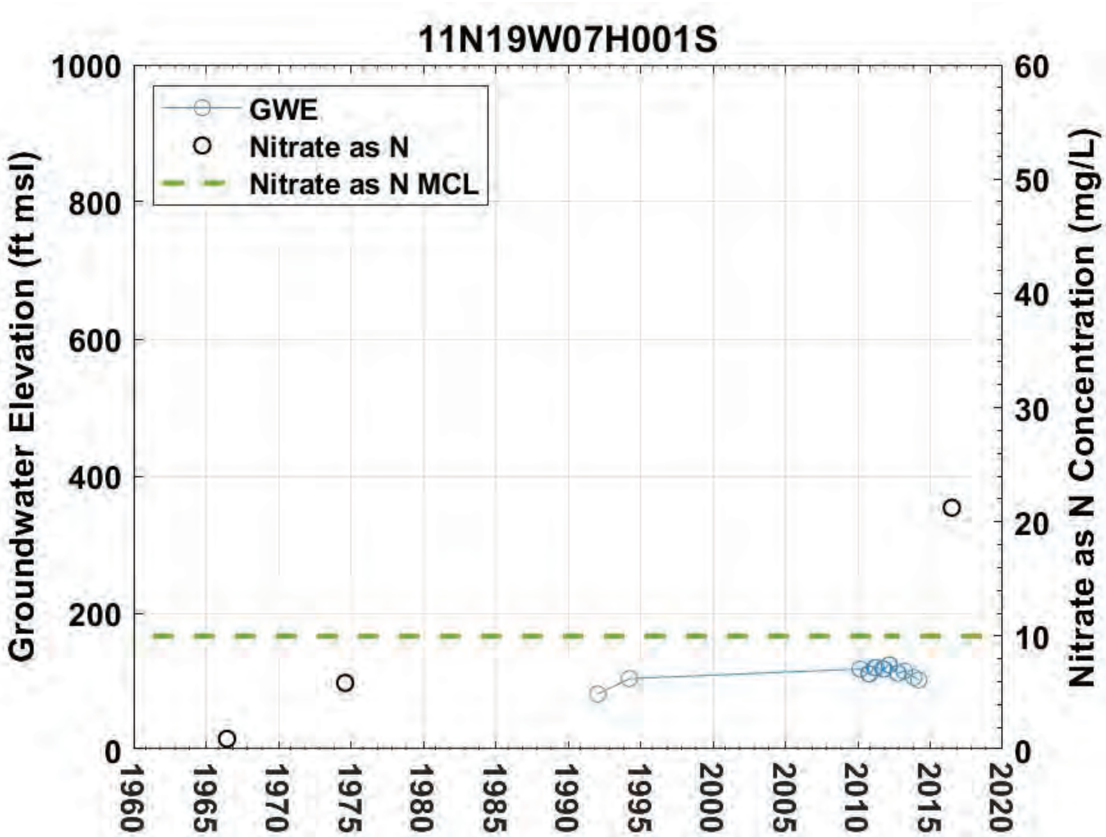


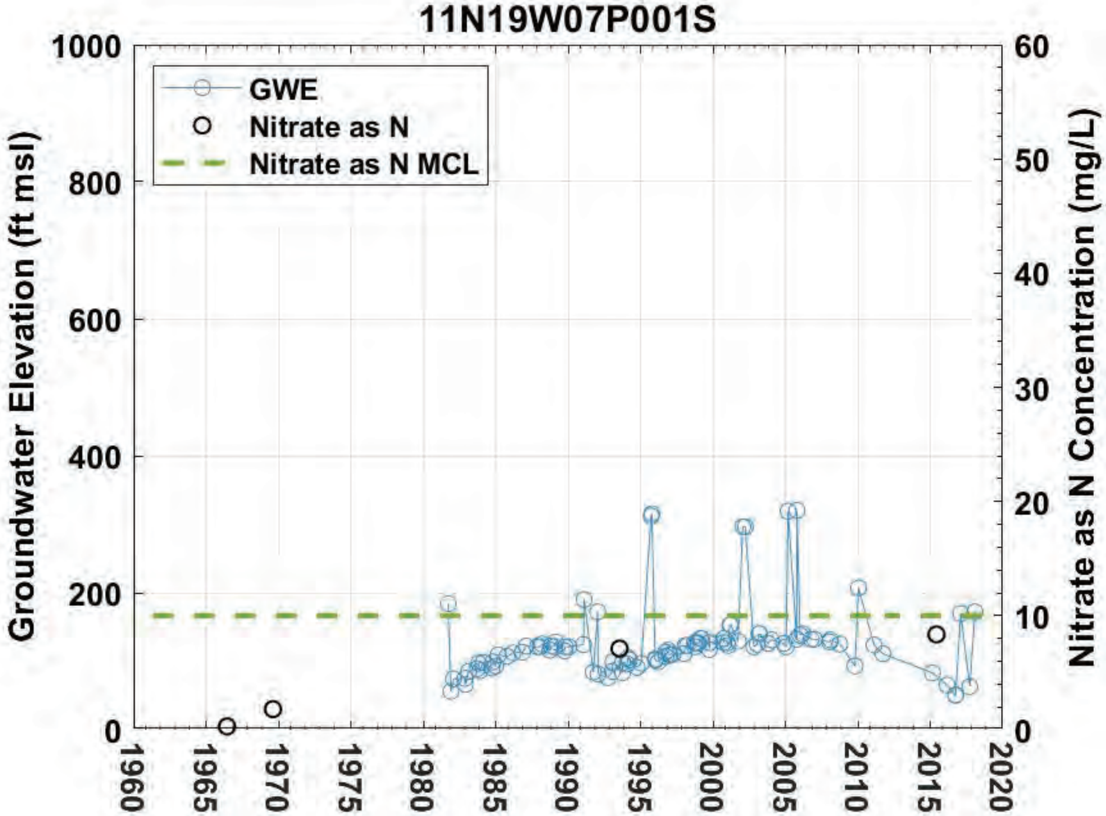
11N19W04H001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)

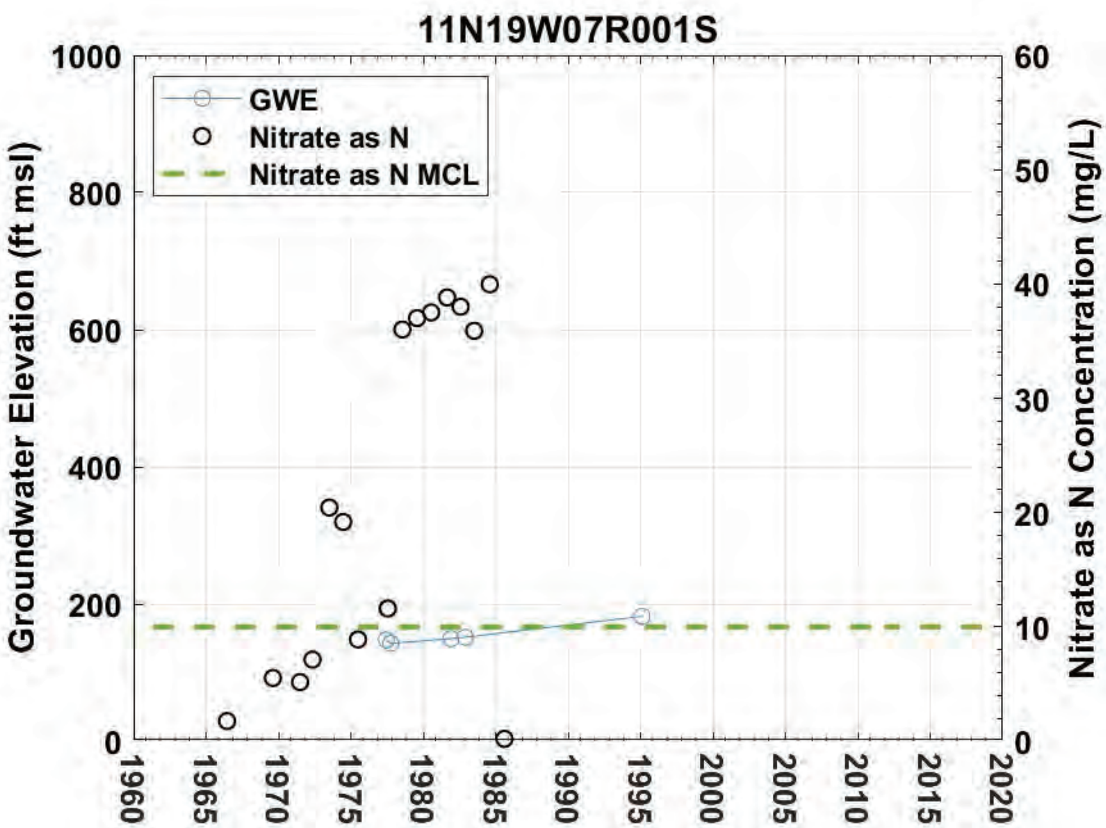

11N19W04J001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

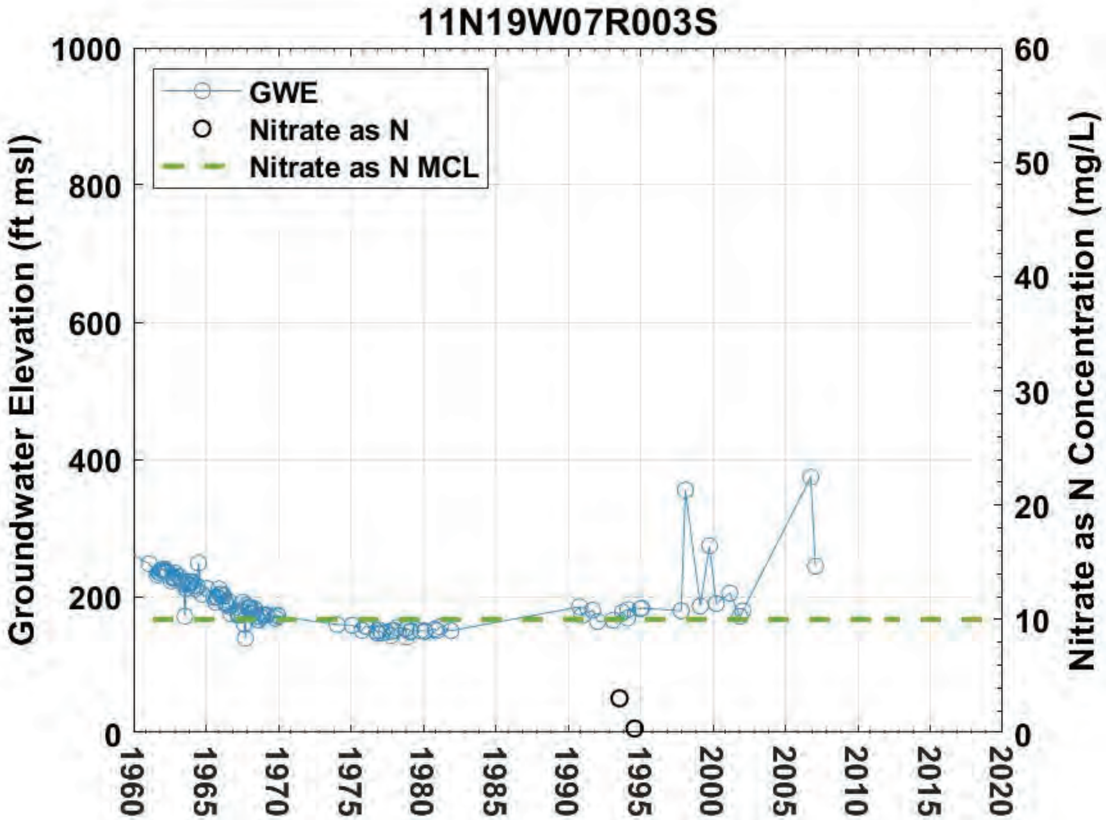

11N19W04R001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

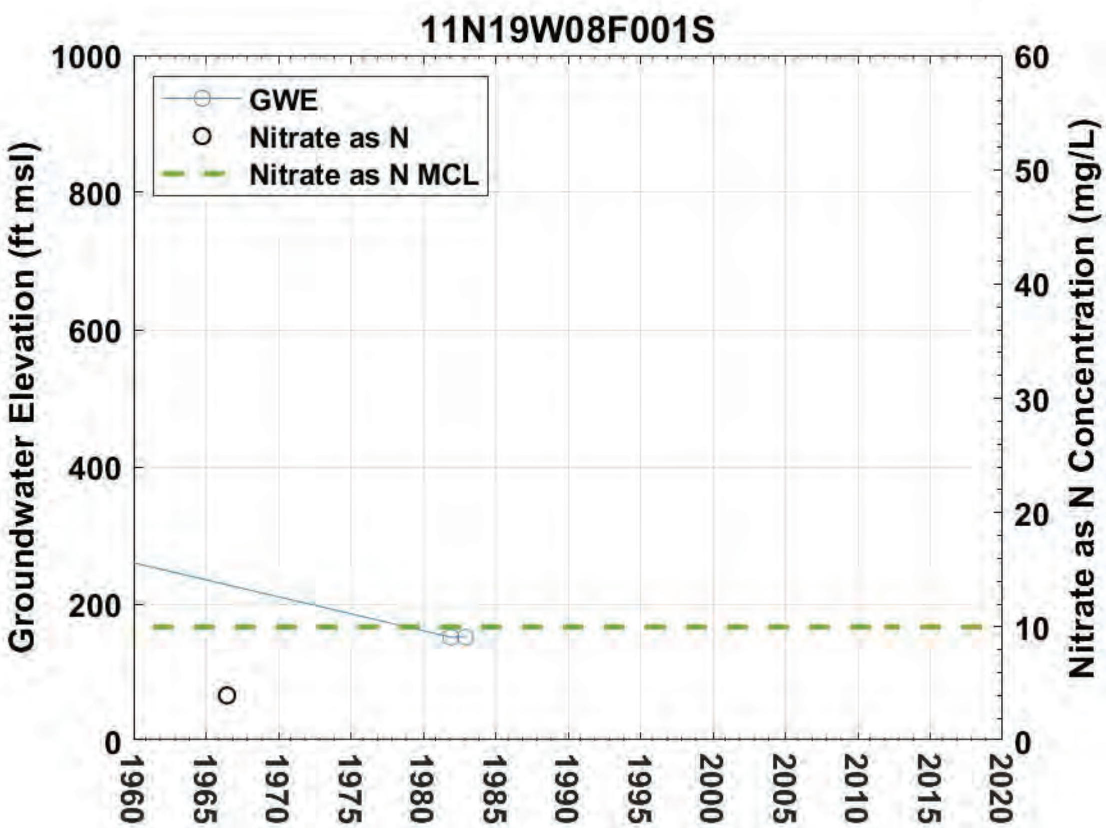

11N19W05R001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

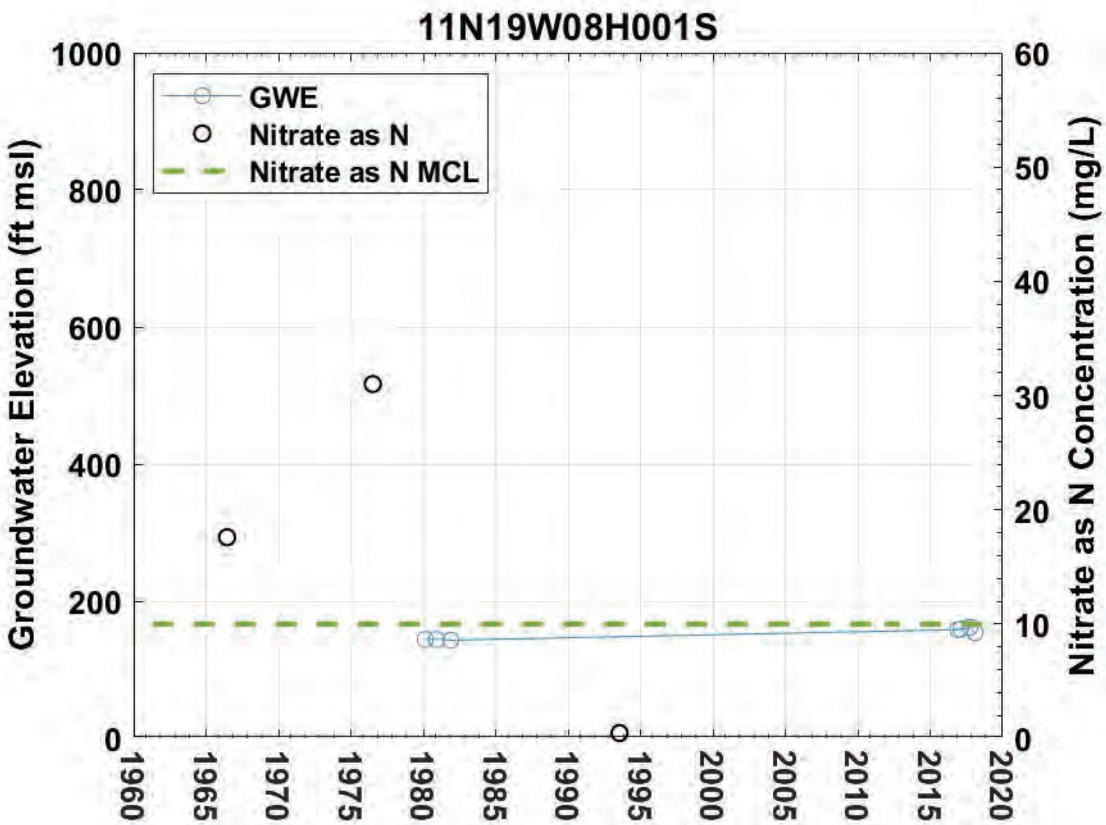

11N19W07H001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W07P001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

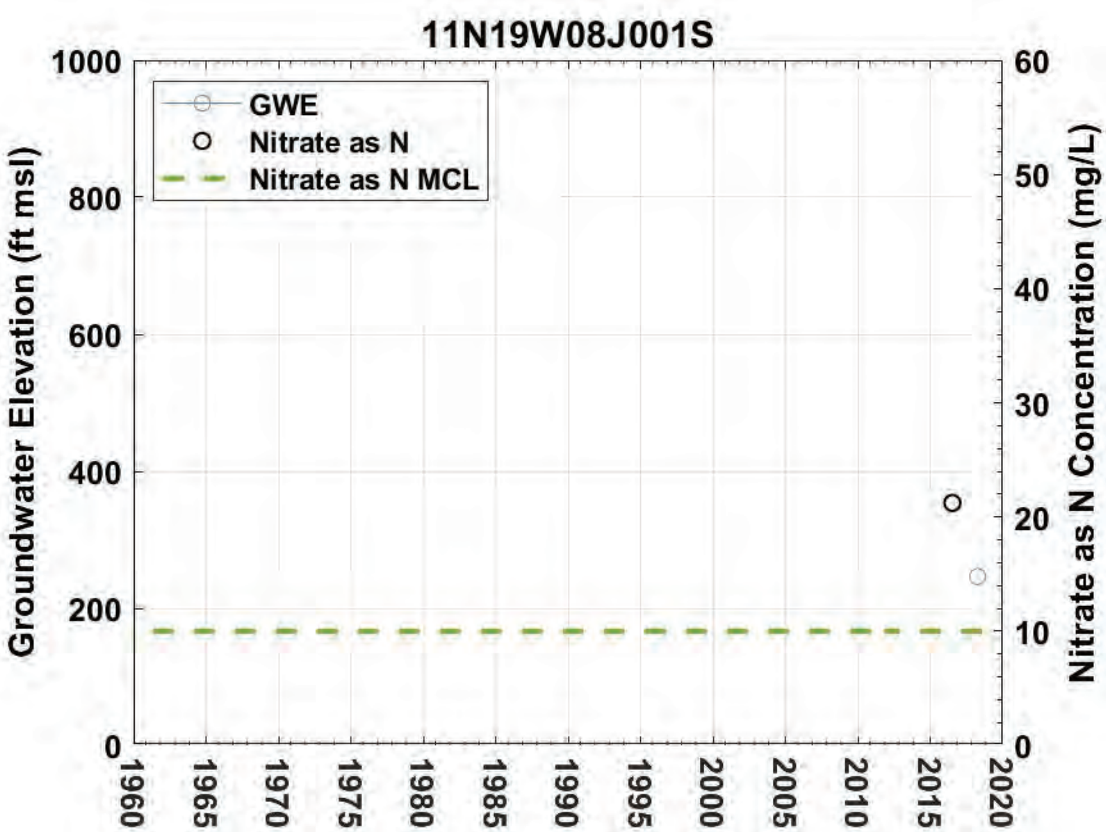

11N19W07R001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W07R003S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

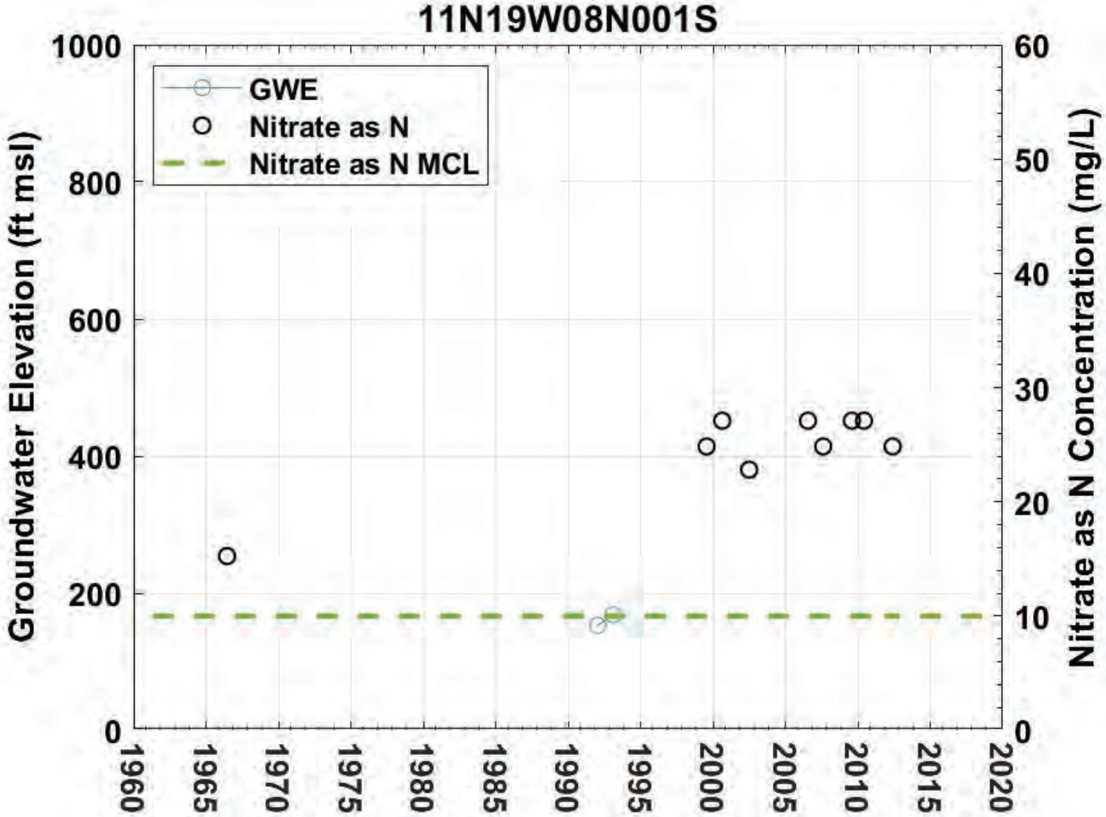

11N19W08F001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

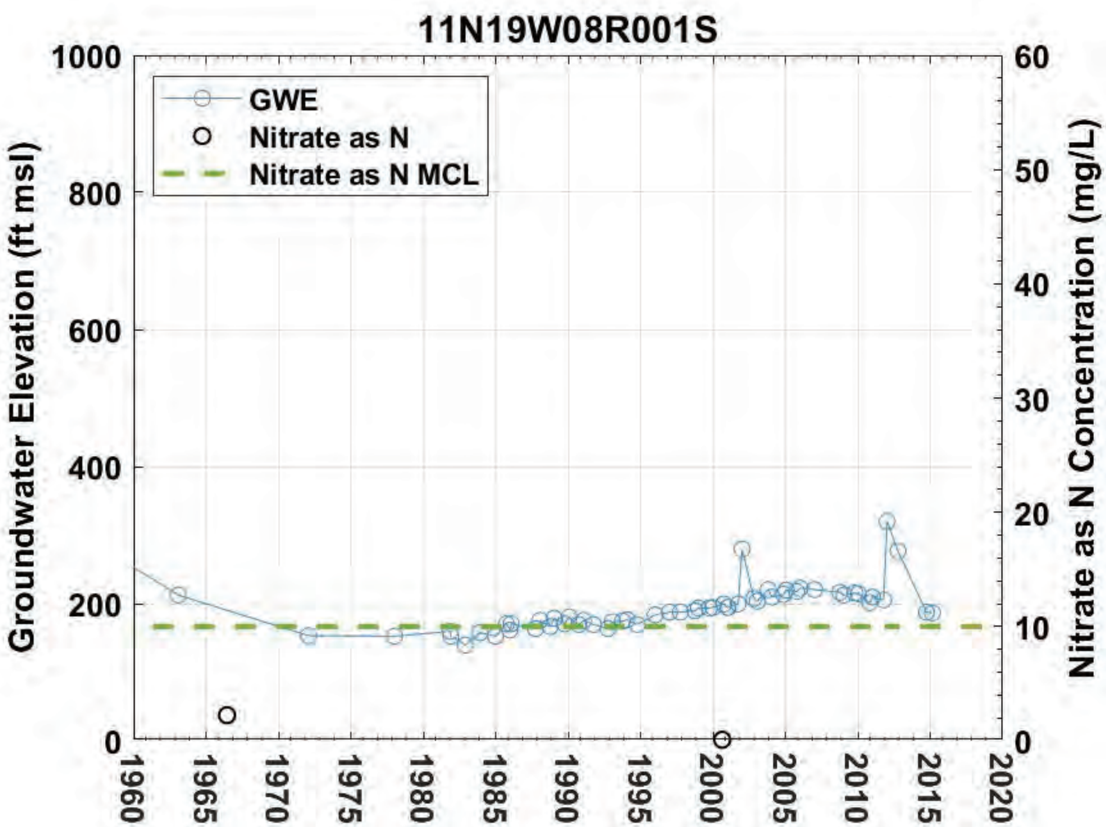


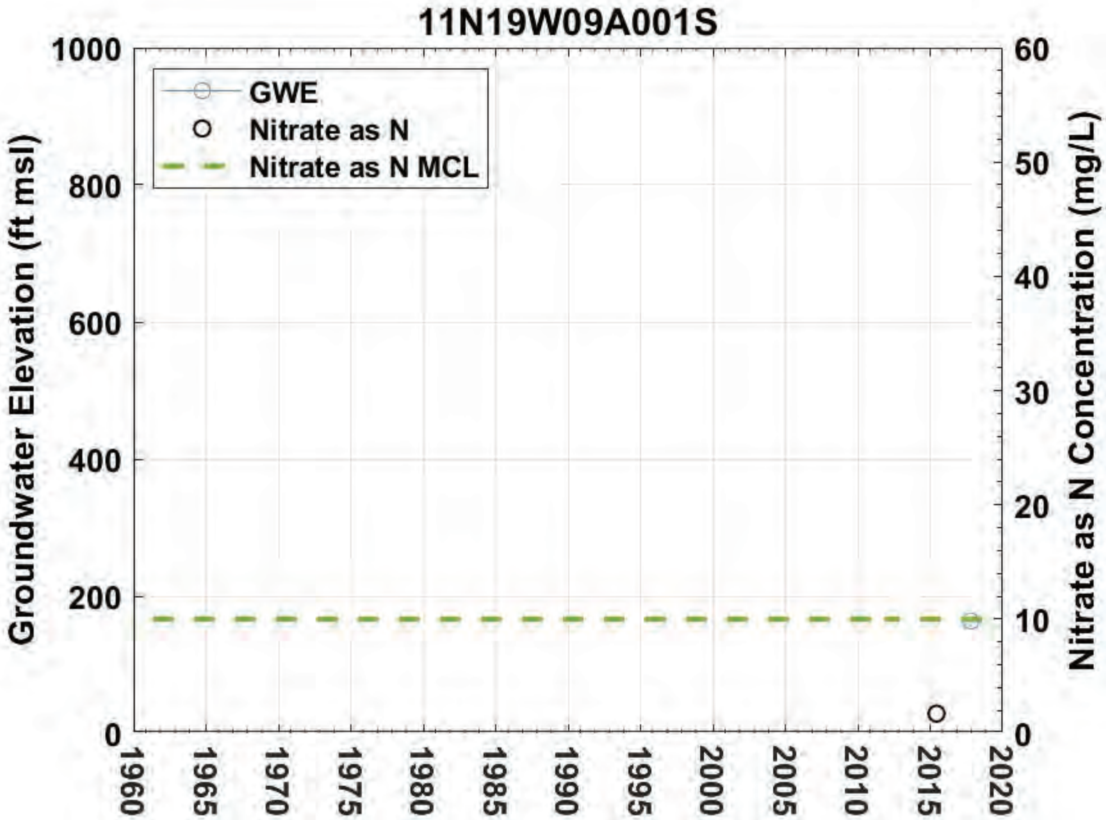
11N19W08H001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

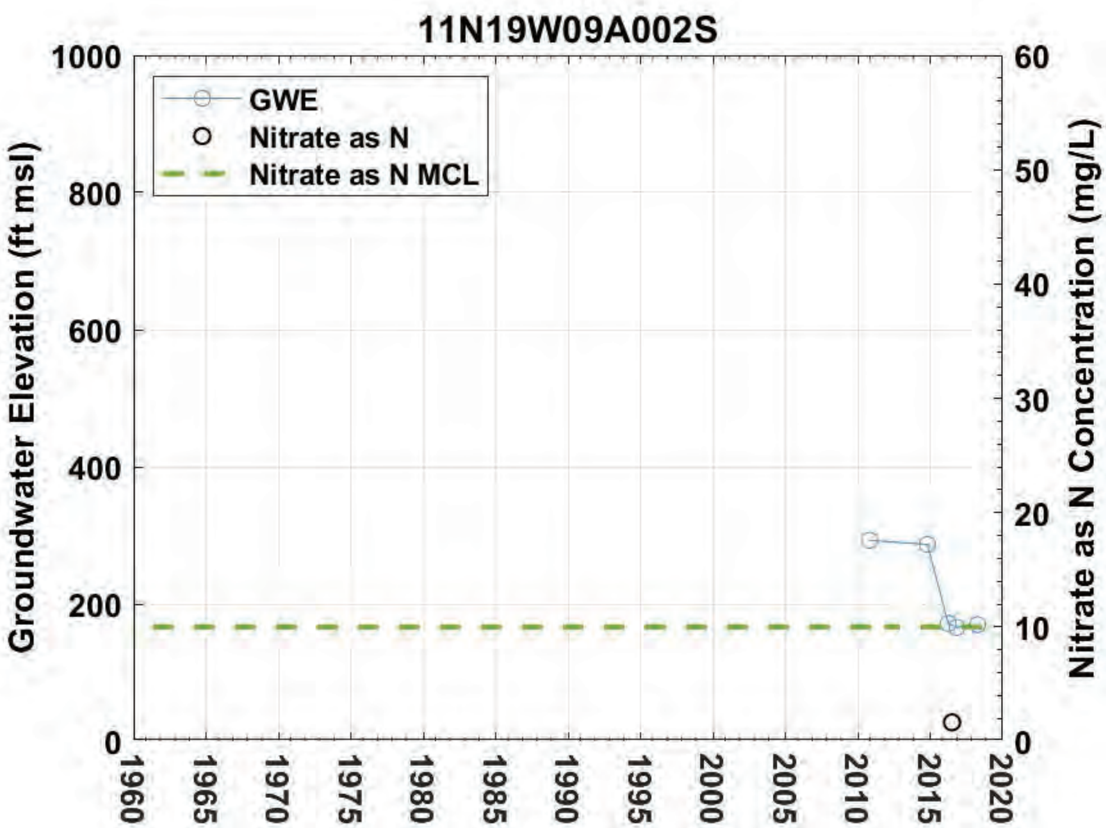


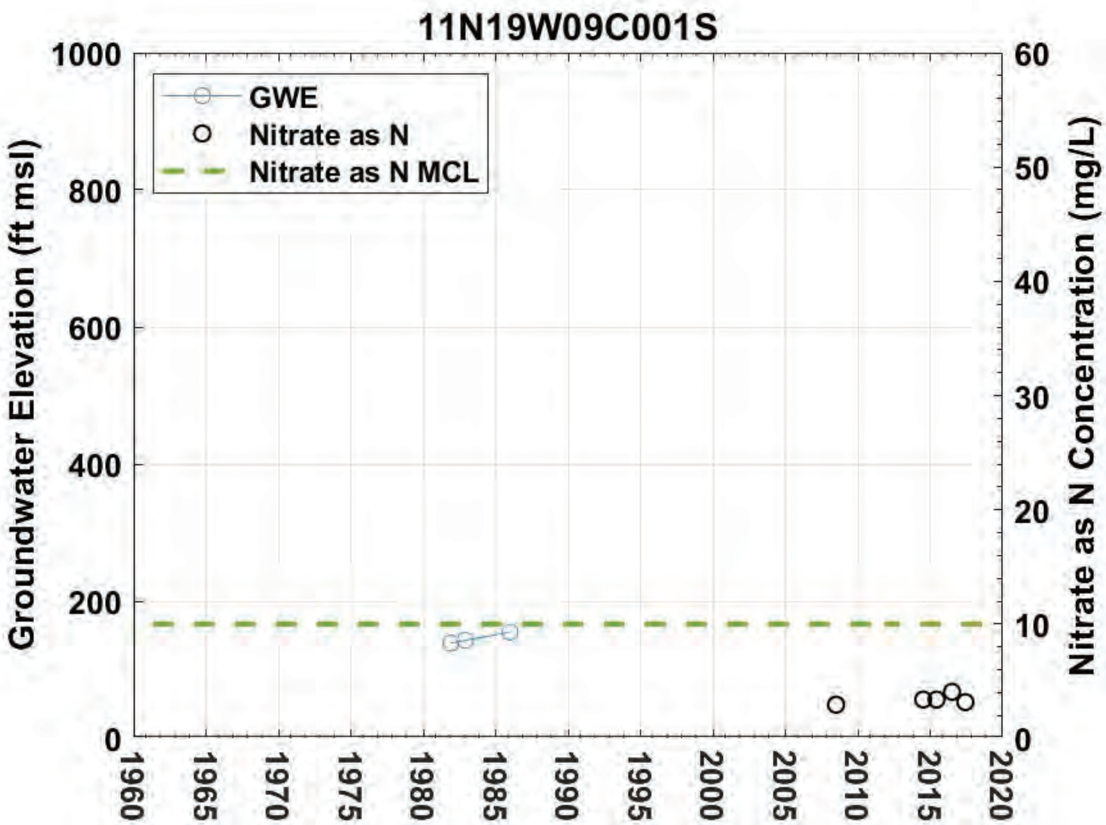
11N19W08J001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W08N001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
GWE
Nitrate as N
Nitrate as N MCL
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

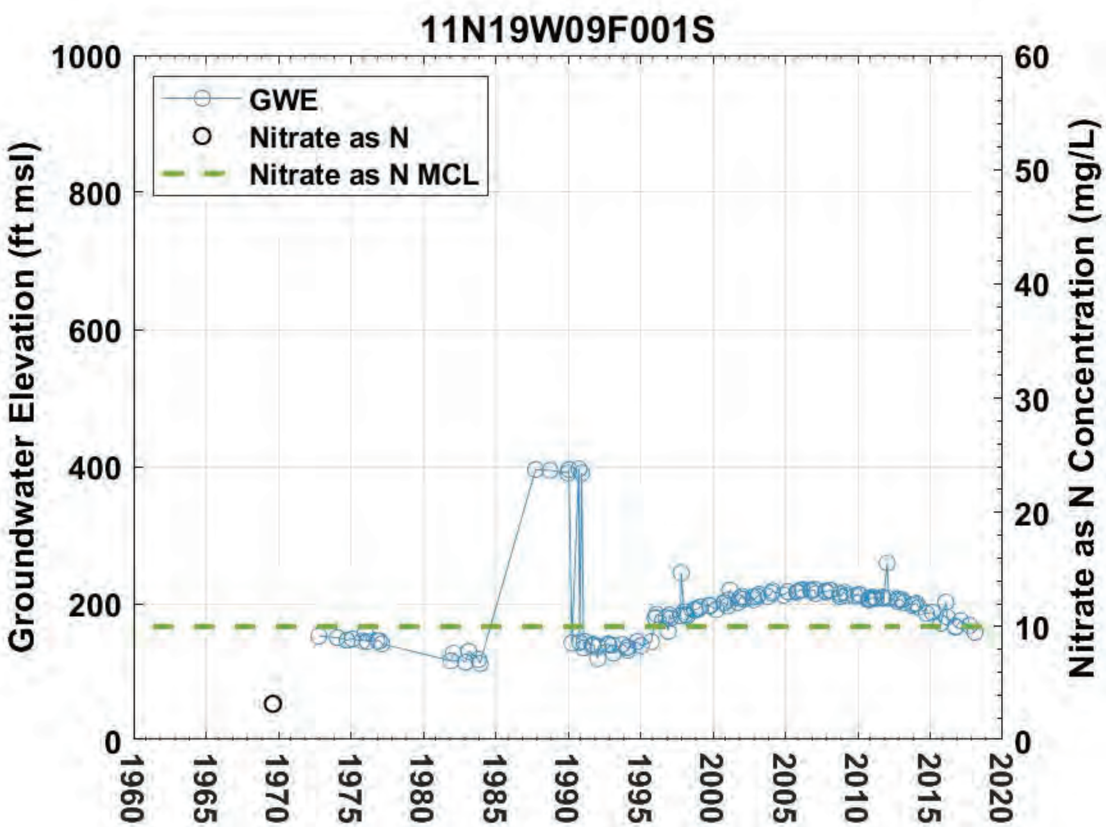

11N19W08R001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
GWE
Nitrate as N
Nitrate as N MCL
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W09A001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

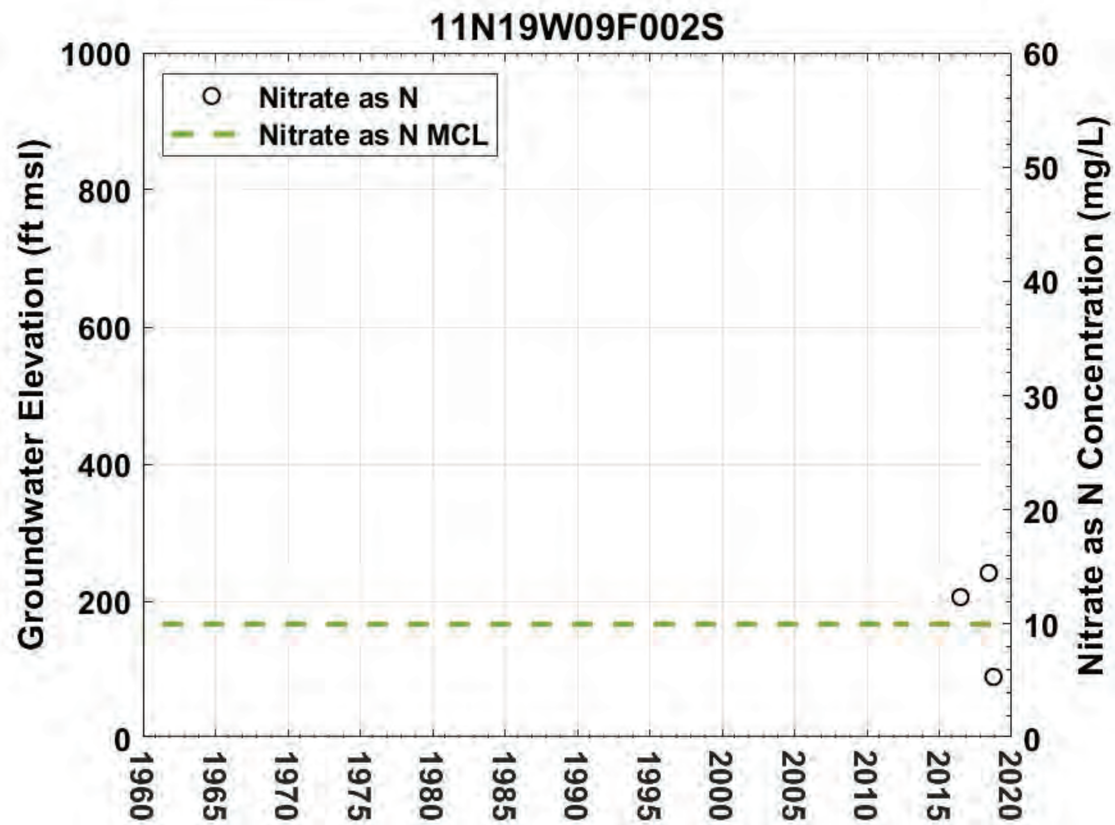

11N19W09A002S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

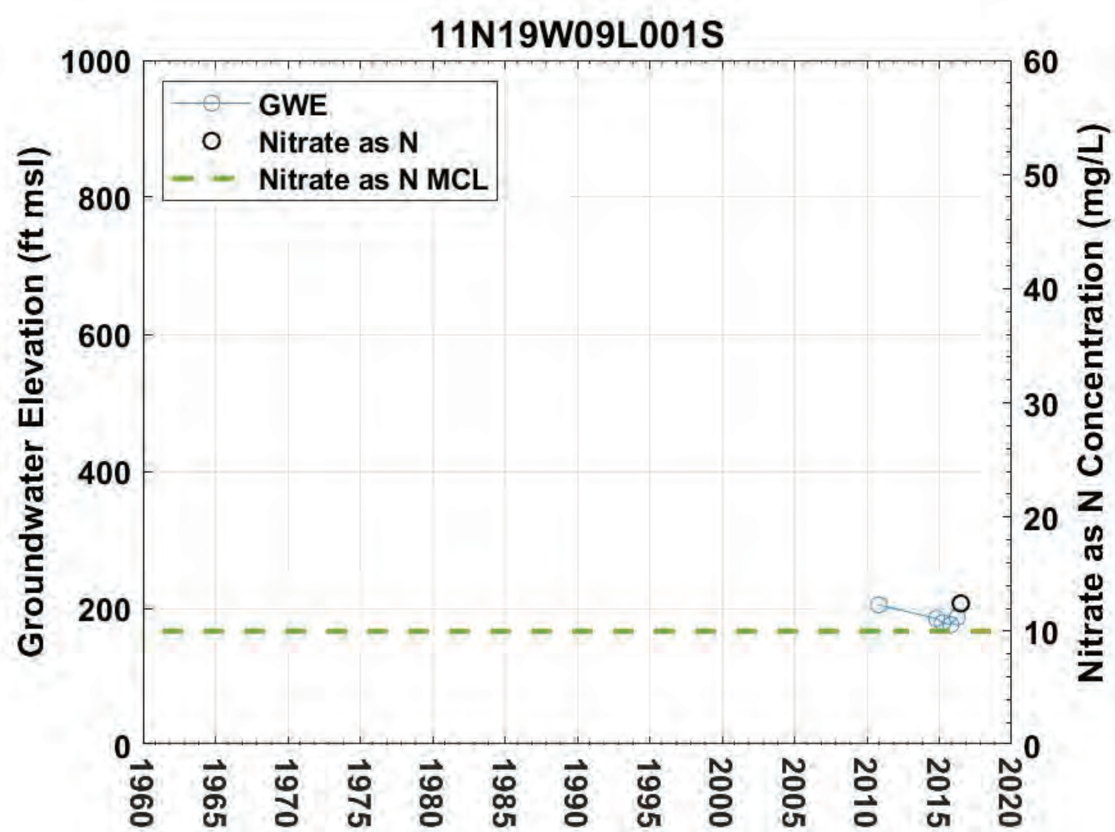


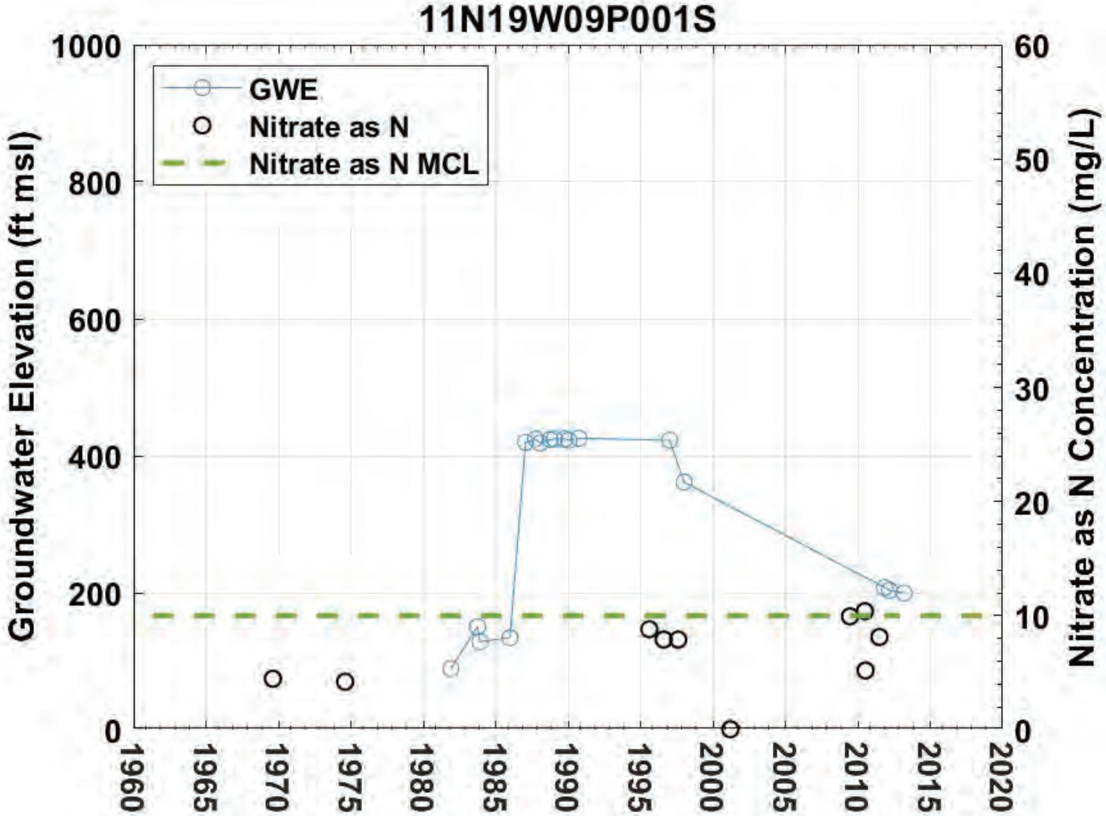
11N19W09C001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

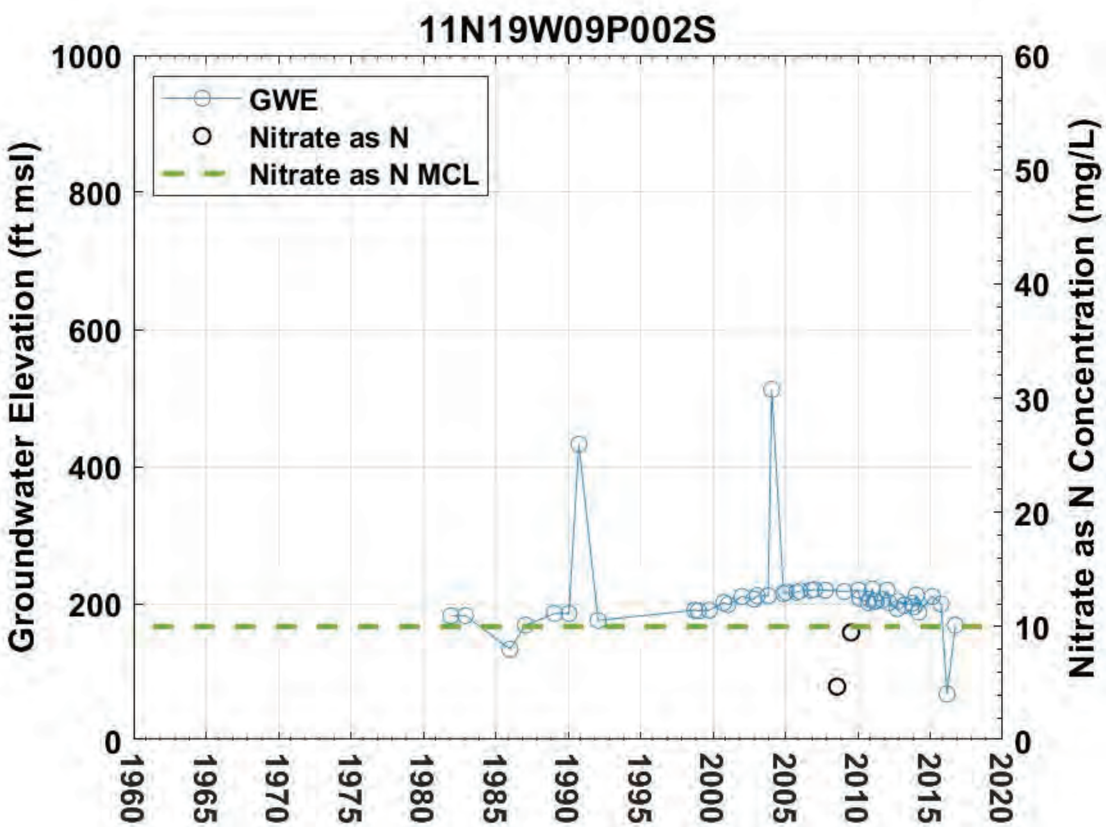


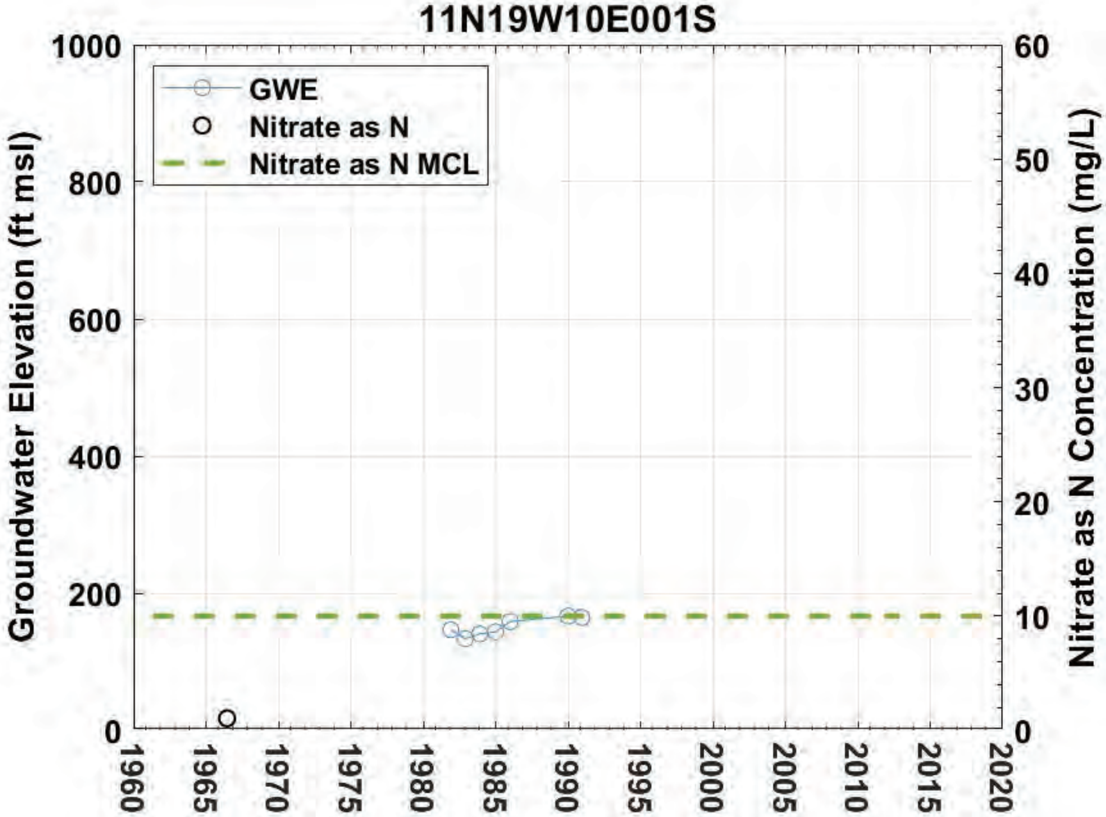
11N19W09F001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W09F002S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

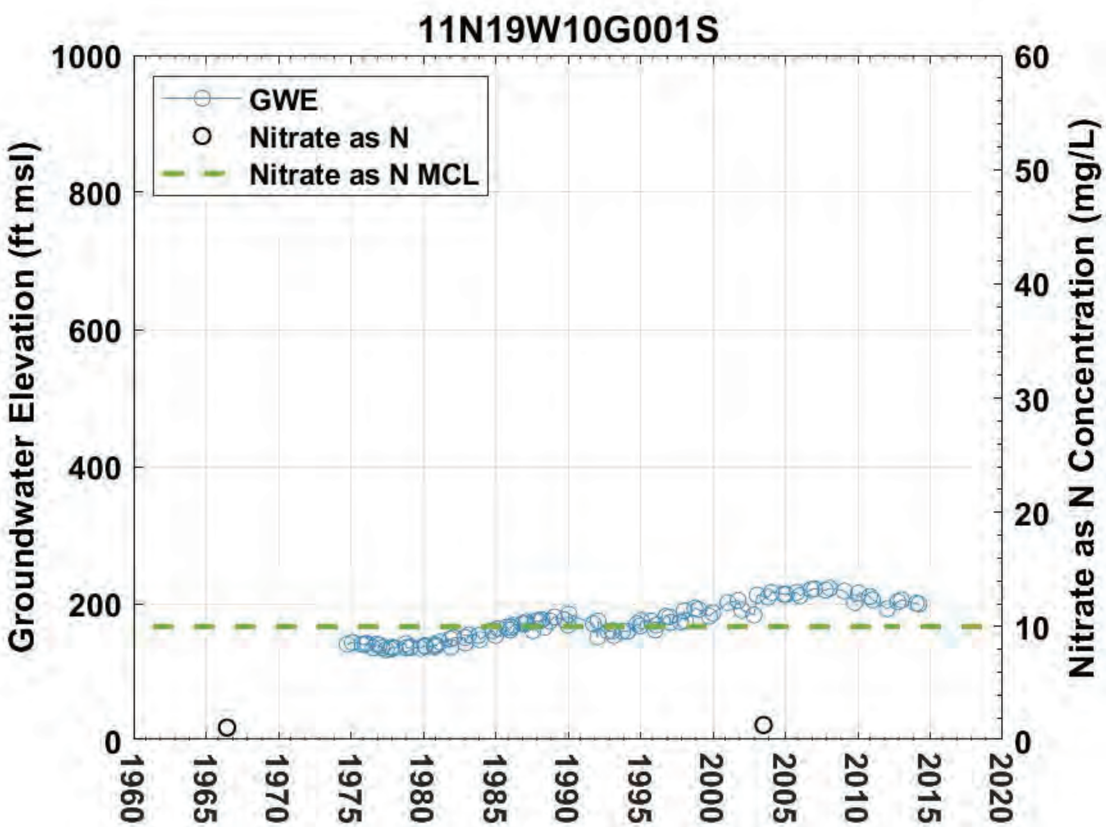

11N19W09L001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W09P001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

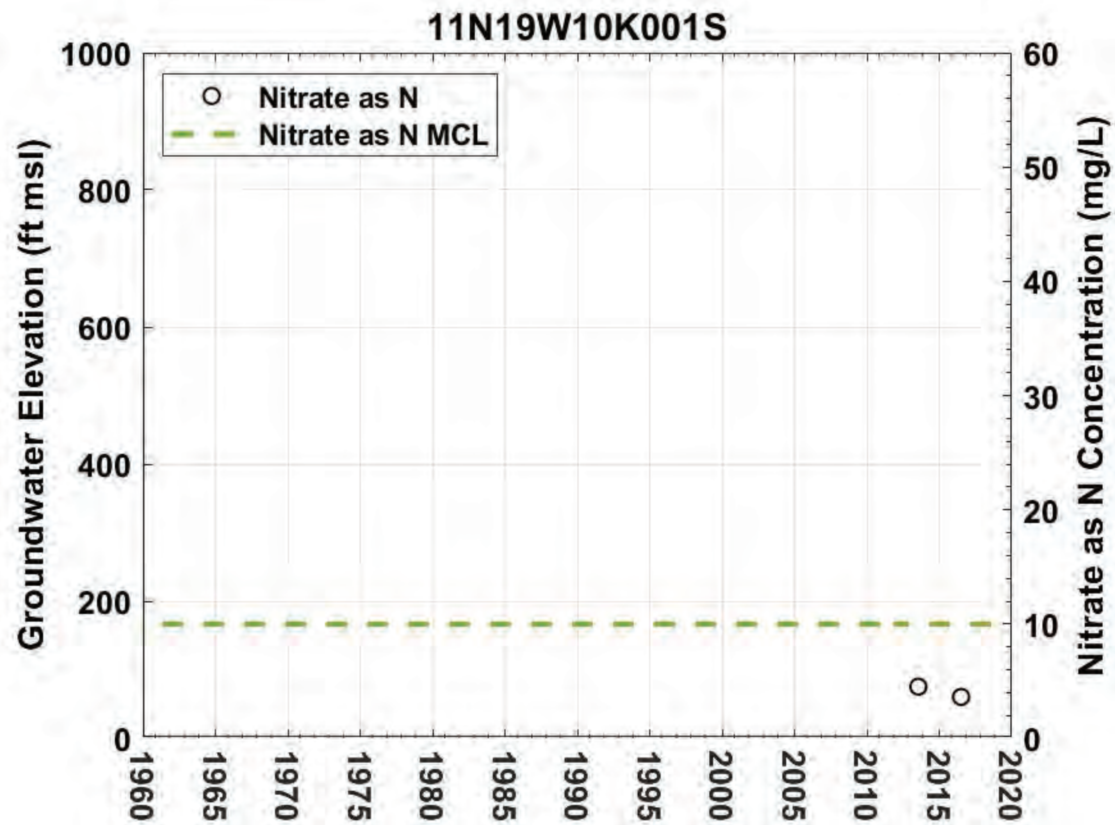

11N19W09P002S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

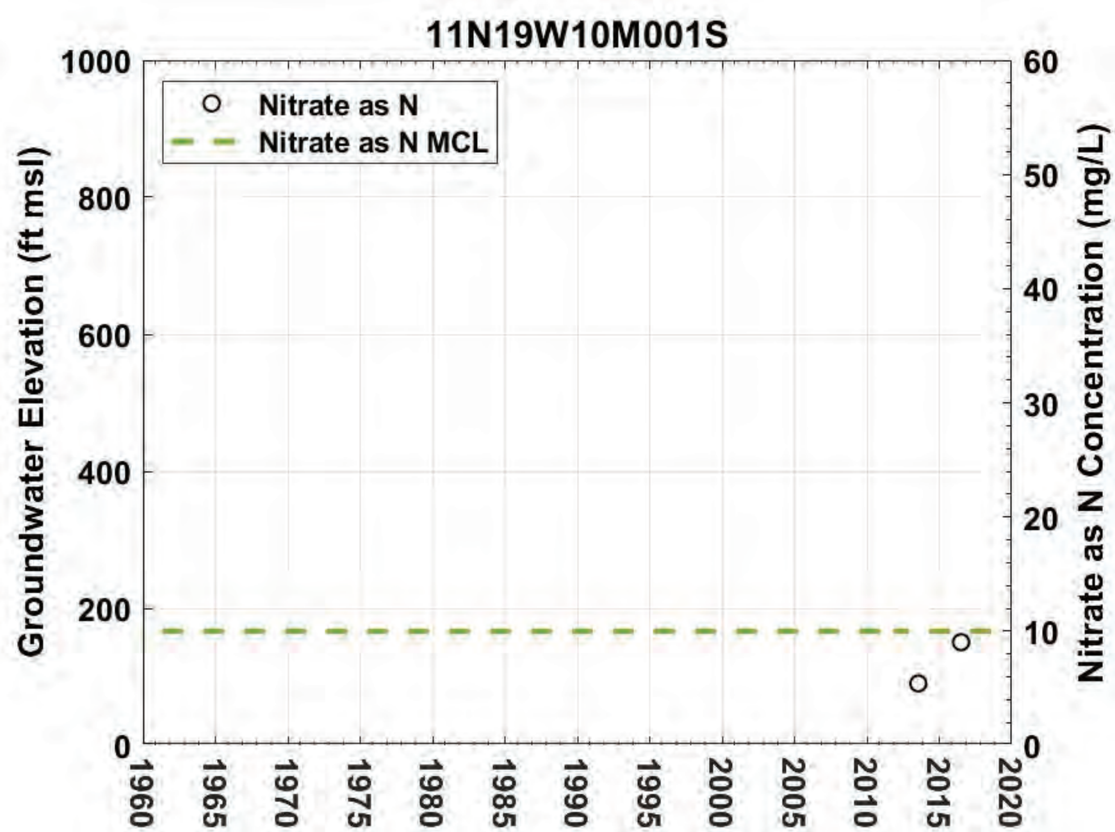


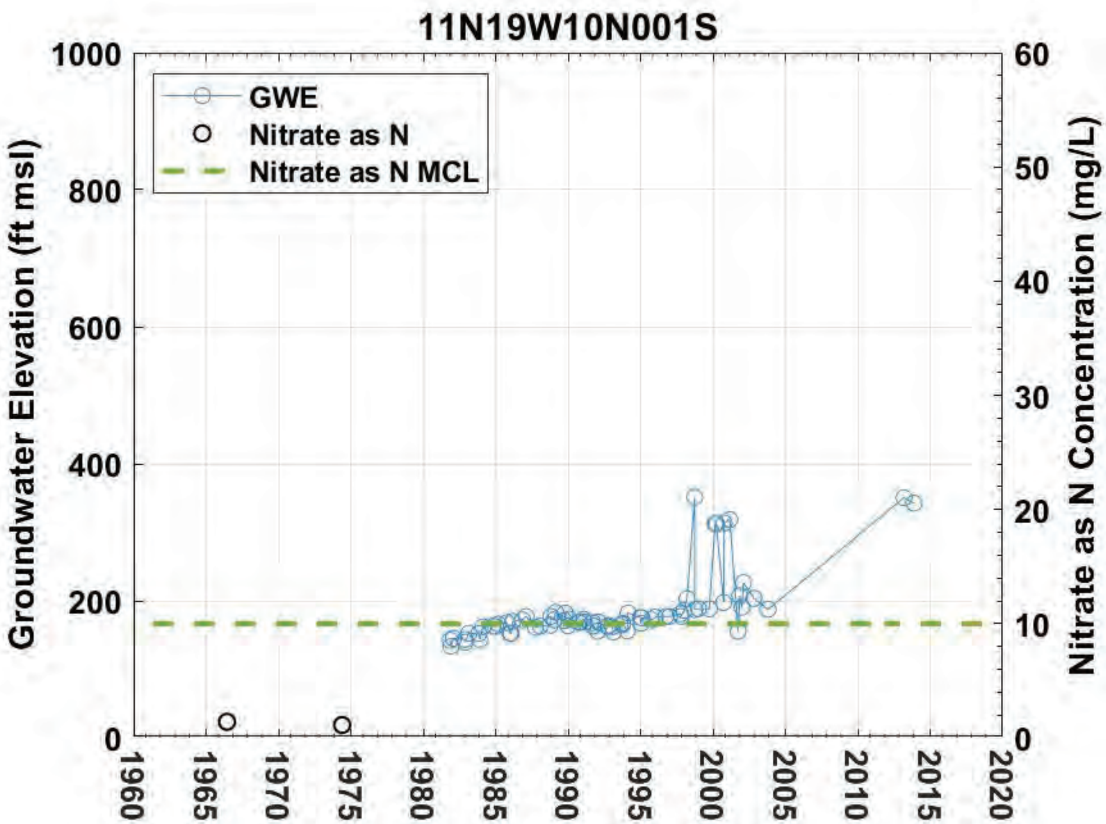
11N19W10E001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

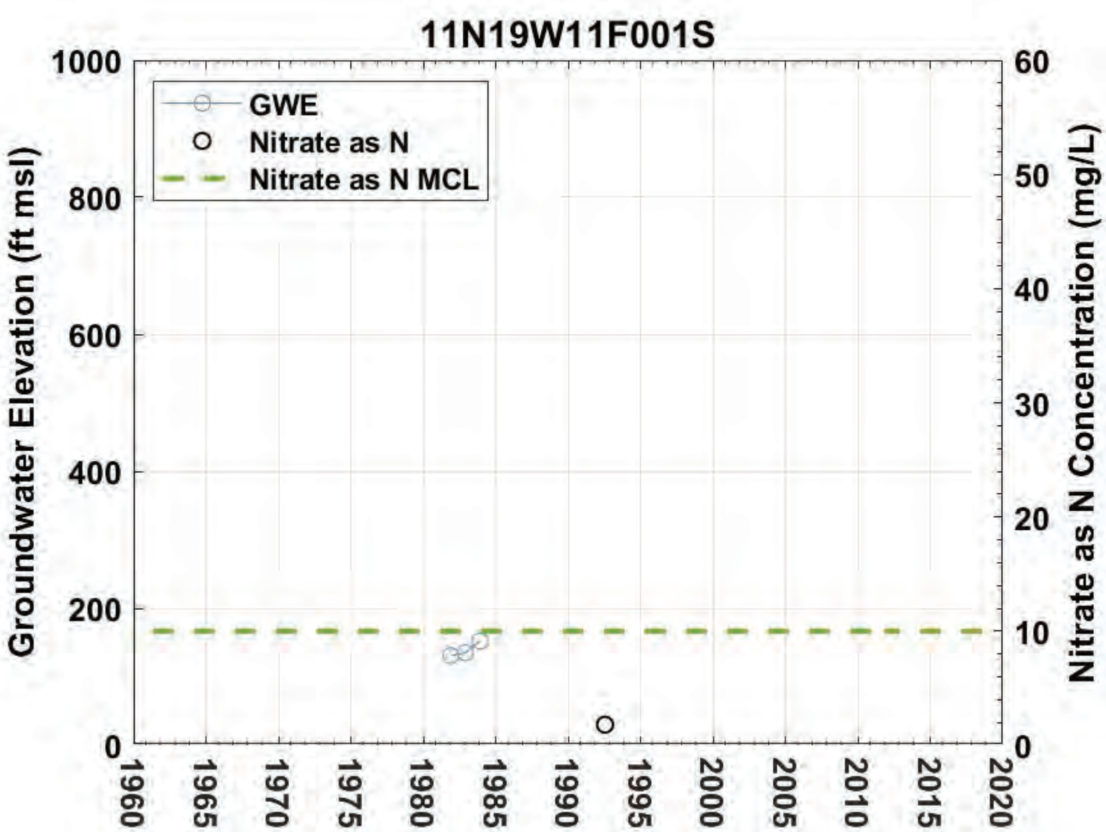


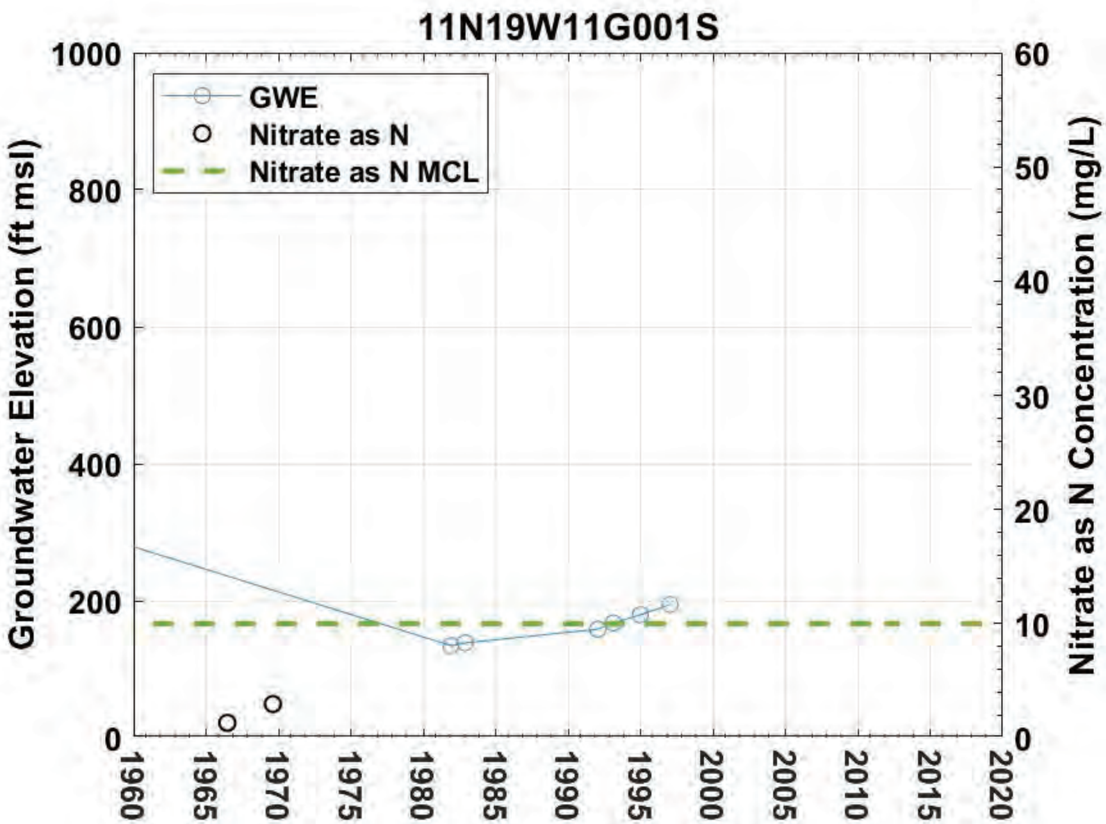
11N19W10G001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

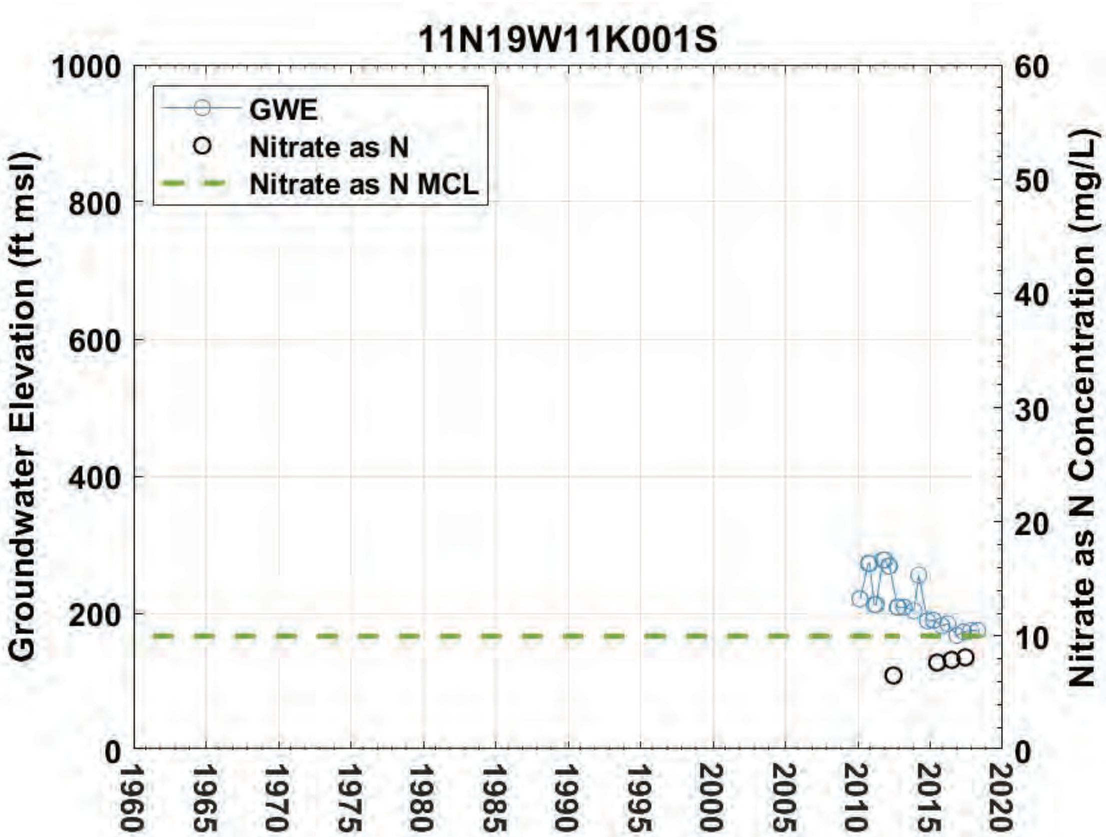

11N19W10K001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

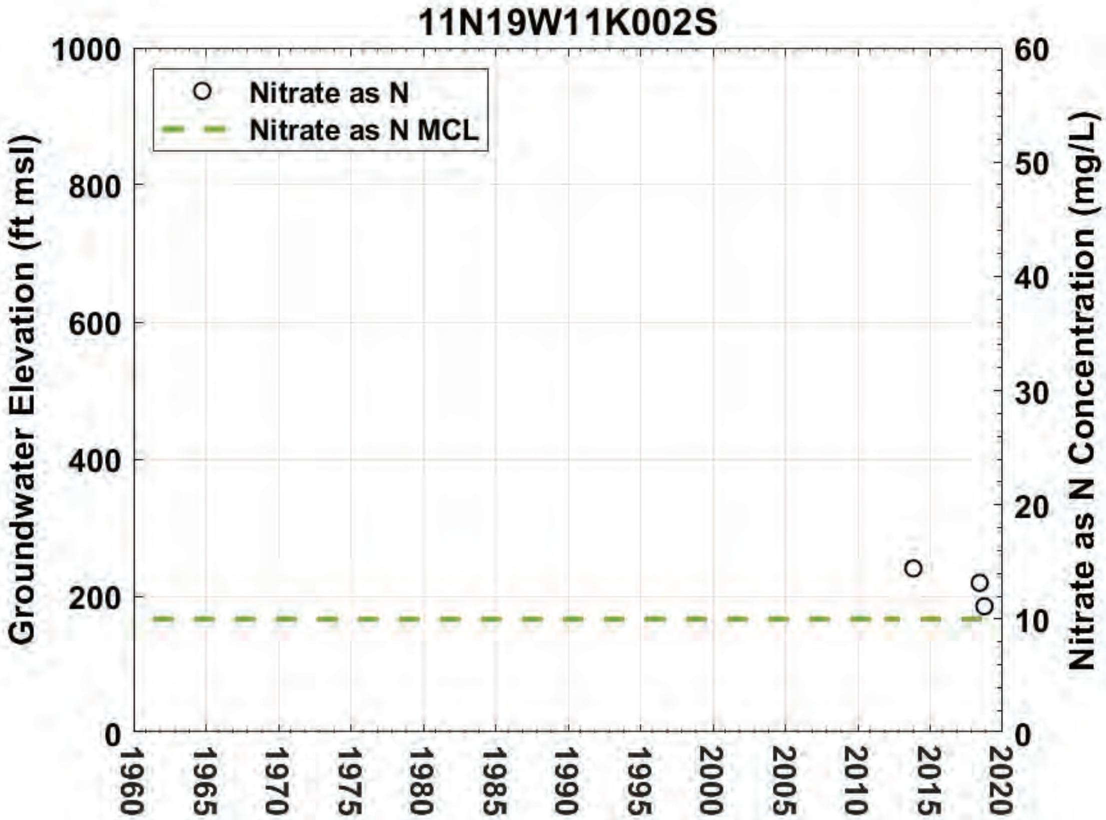

11N19W10M001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

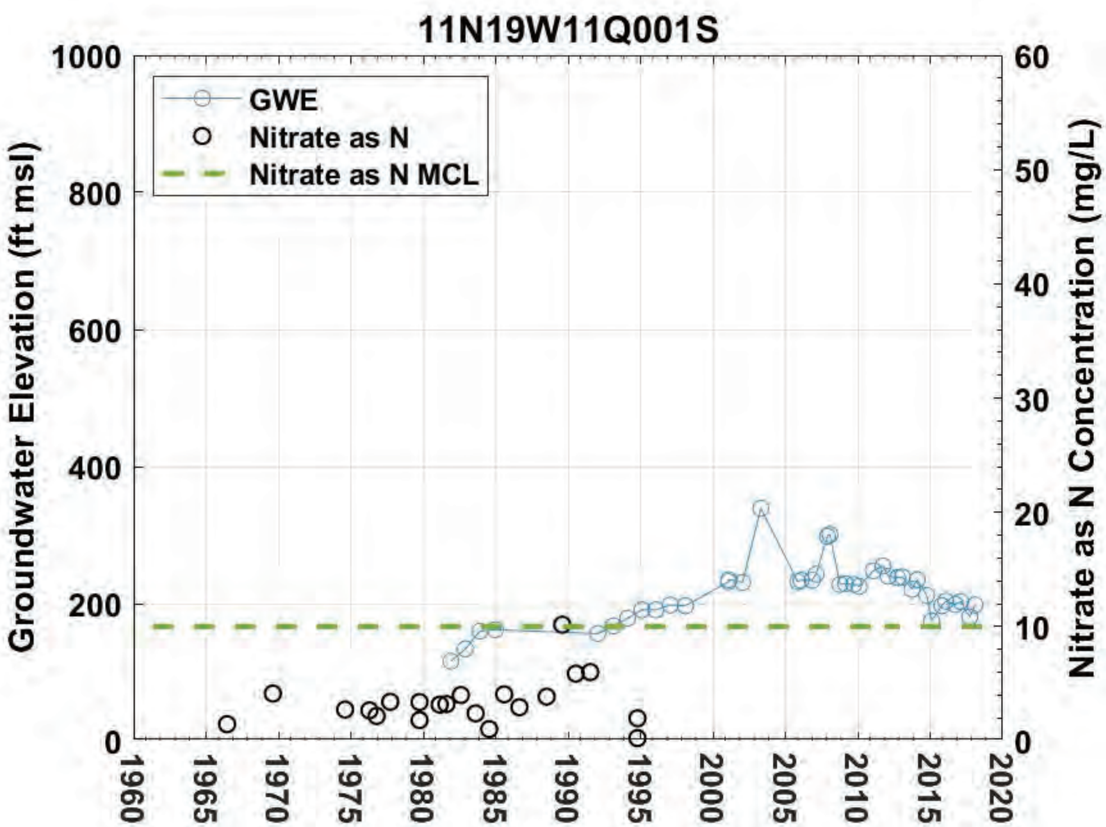

11N19W10N001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

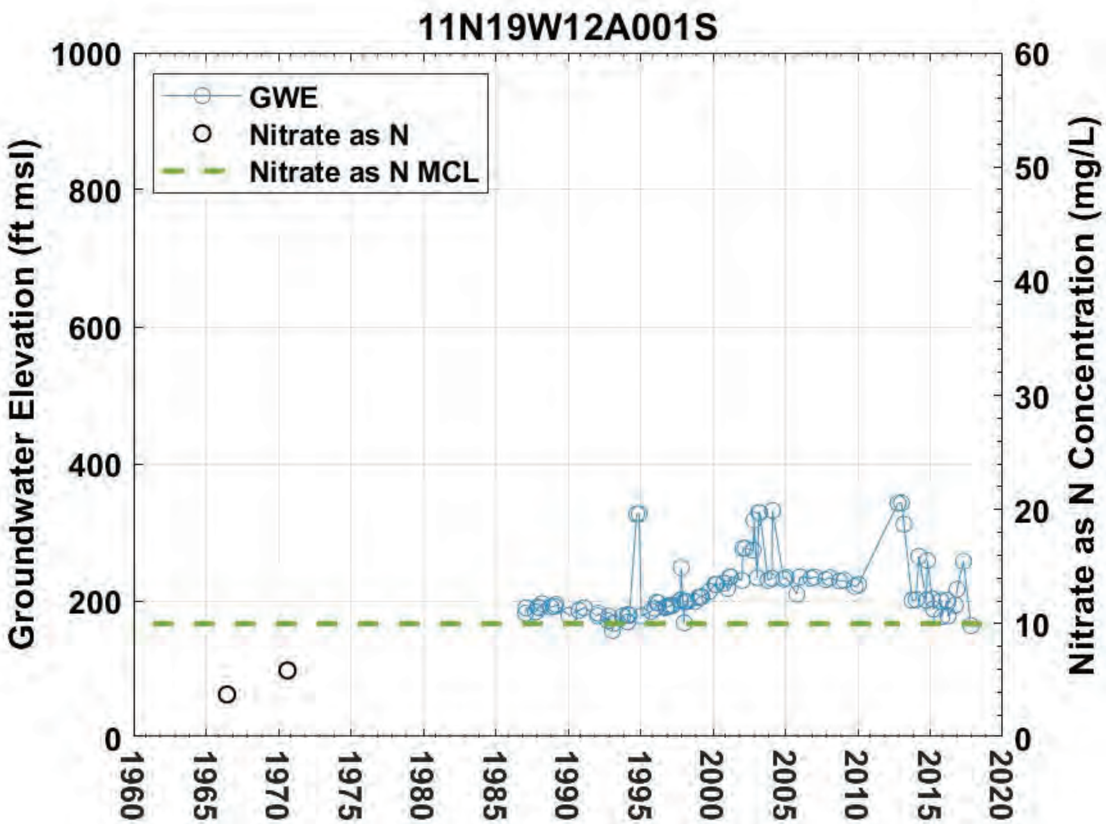

11N19W11F001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

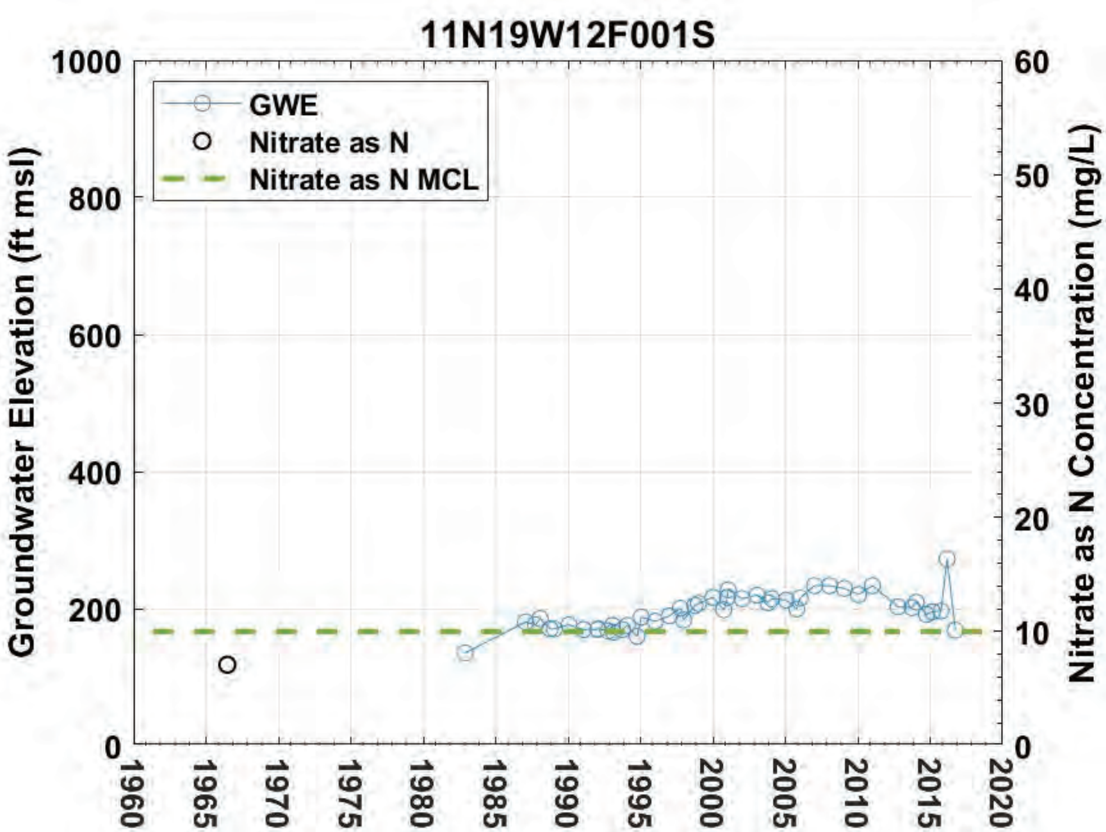

11N19W11G001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

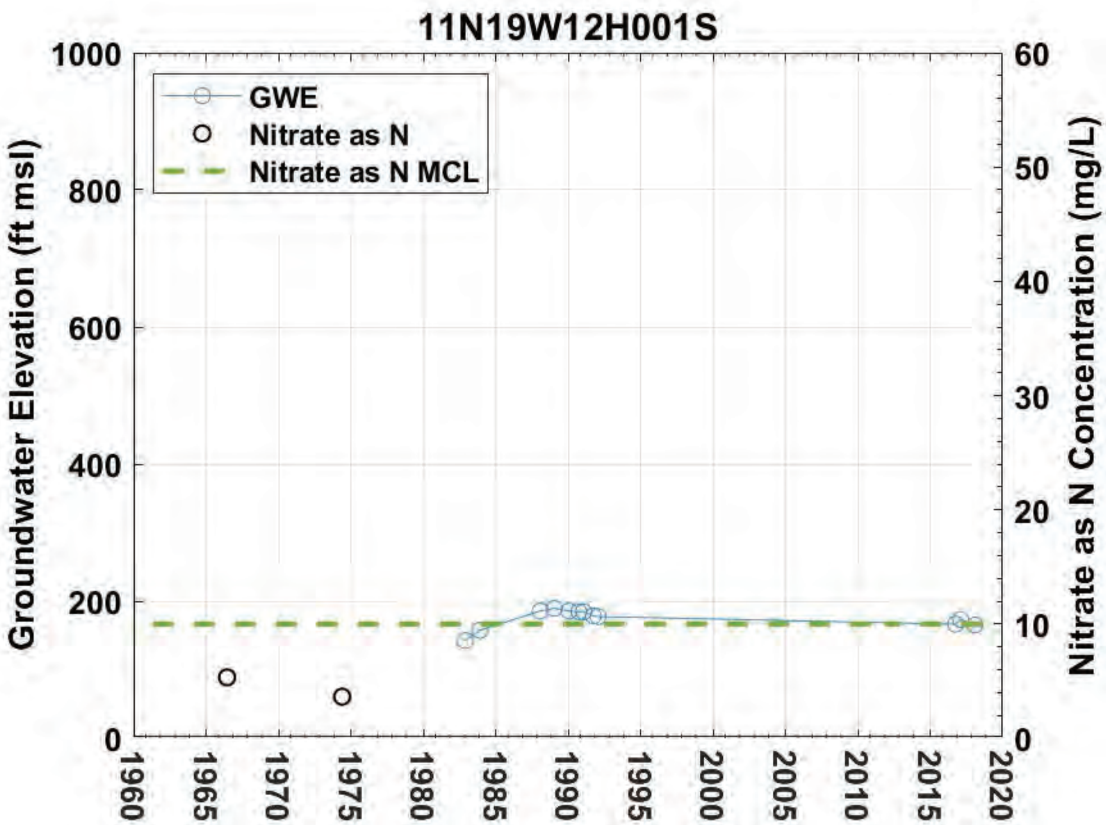

11N19W11K001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

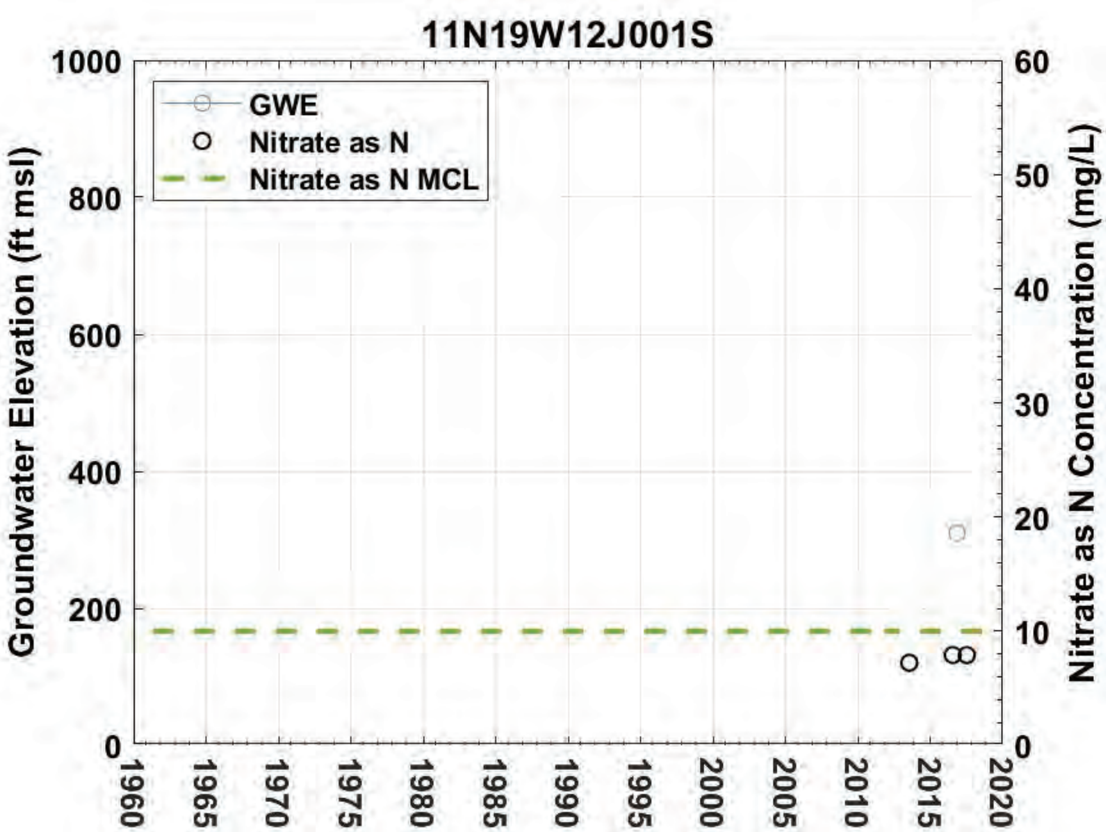

11N19W11K002S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

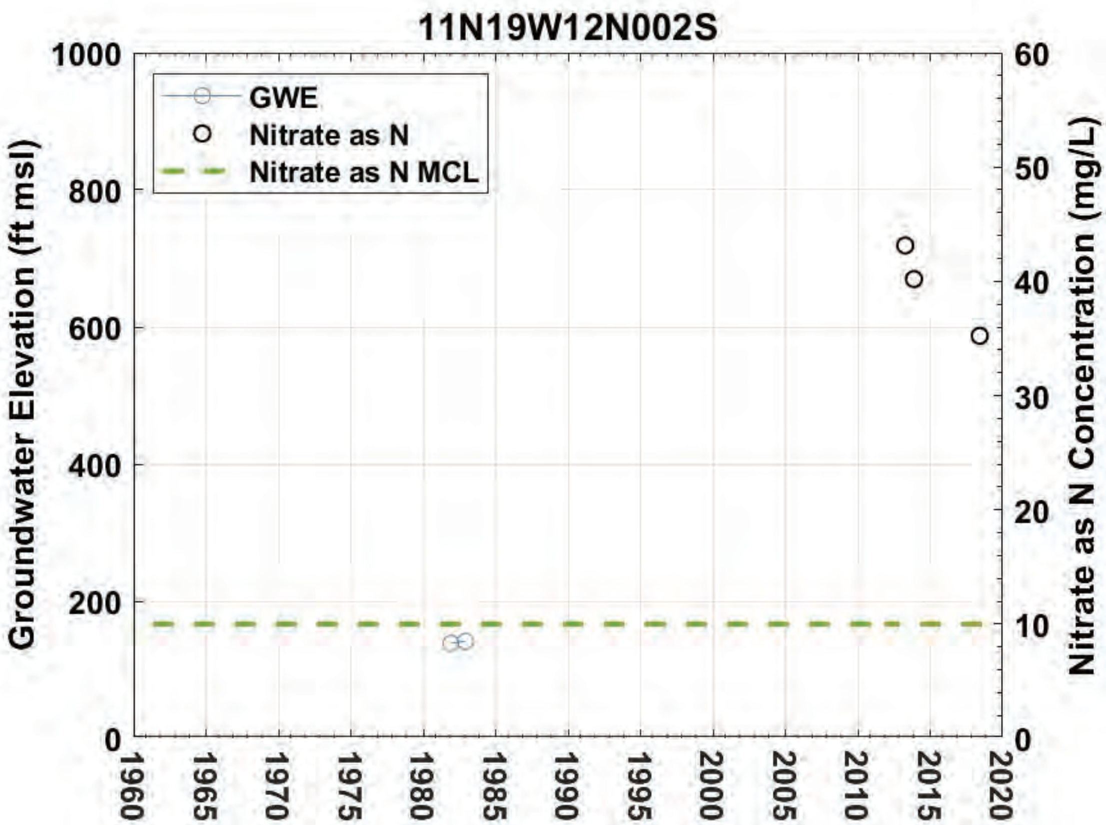

11N19W11Q001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

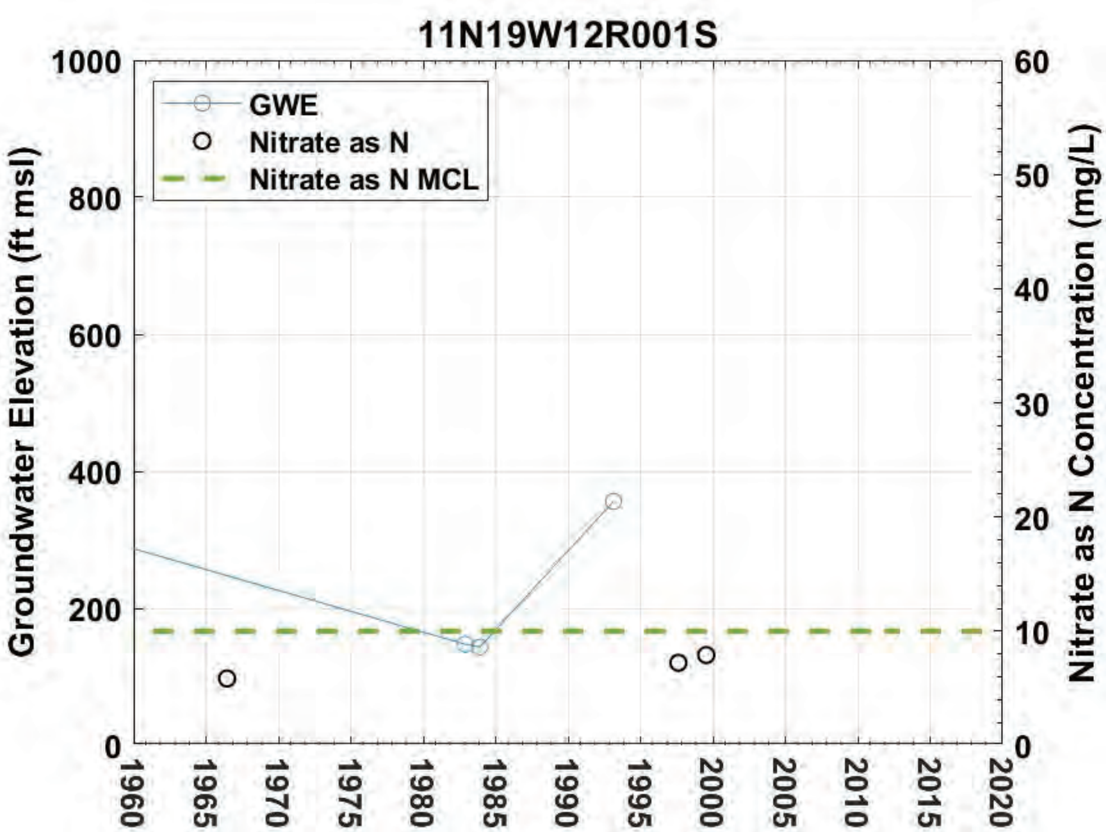

11N19W12A001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

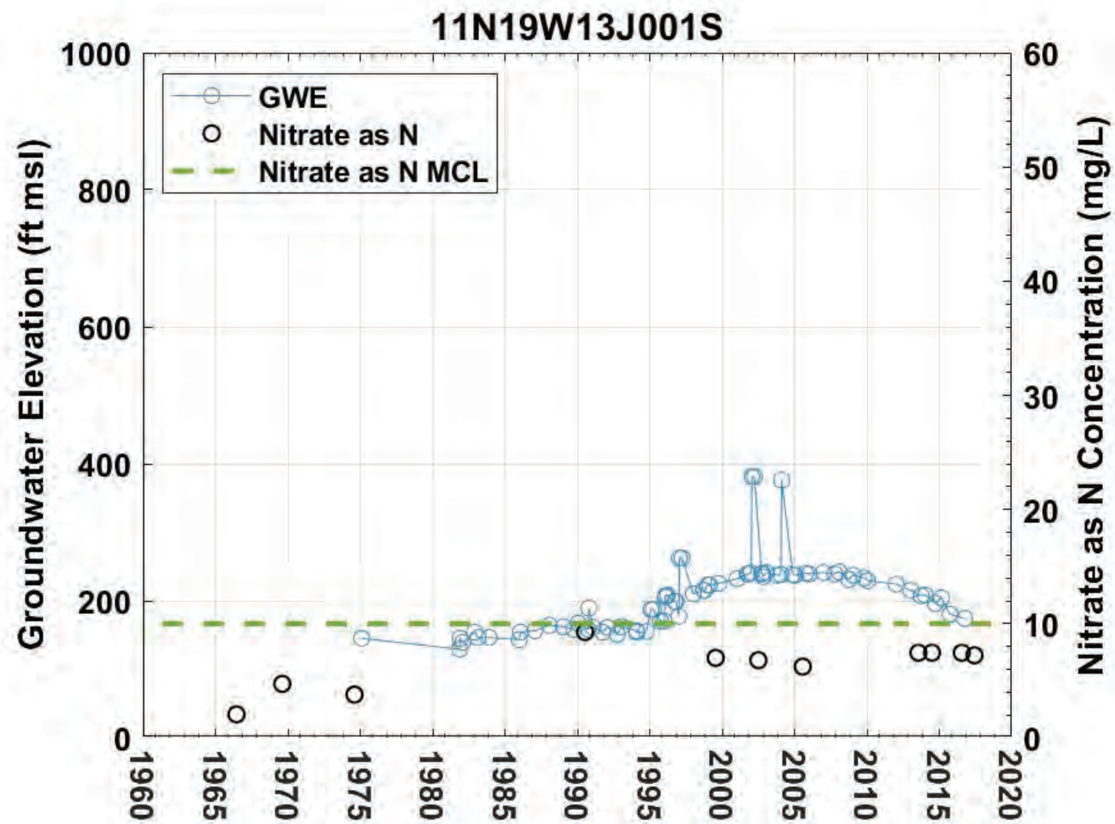

11N19W12F001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

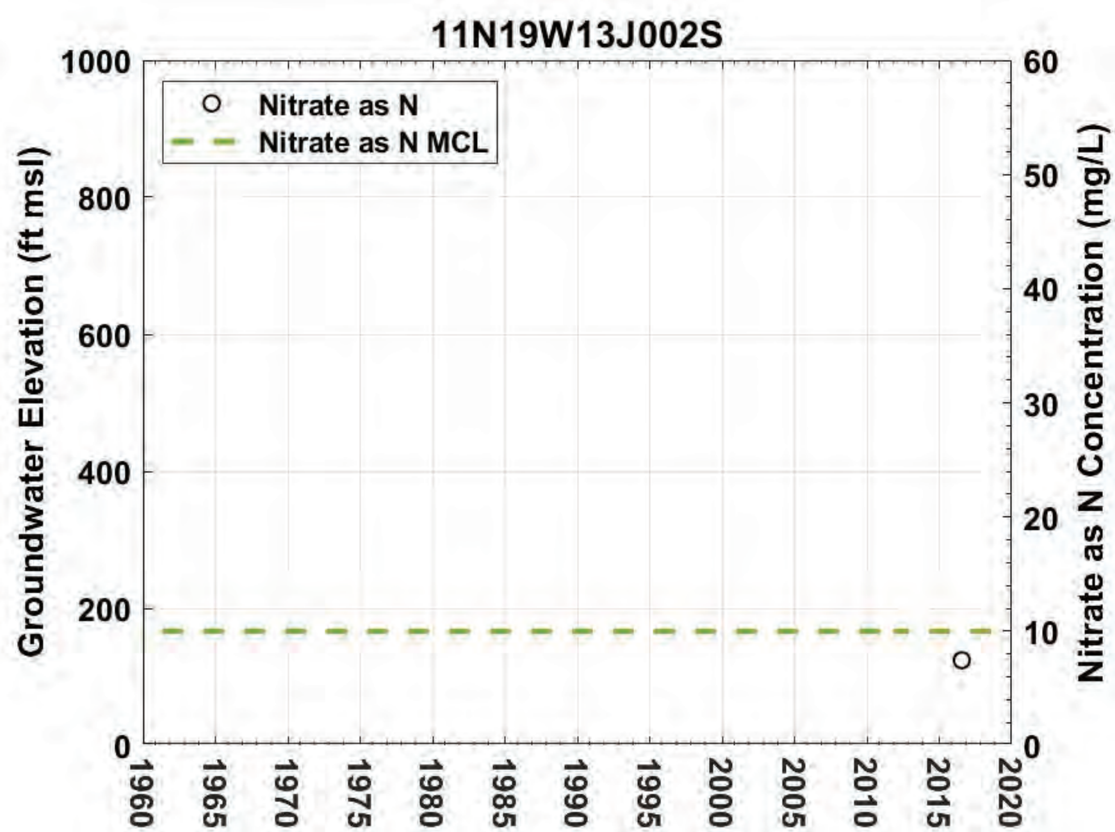

11N19W12H001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
GWE
Nitrate as N
Nitrate as N MCL
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

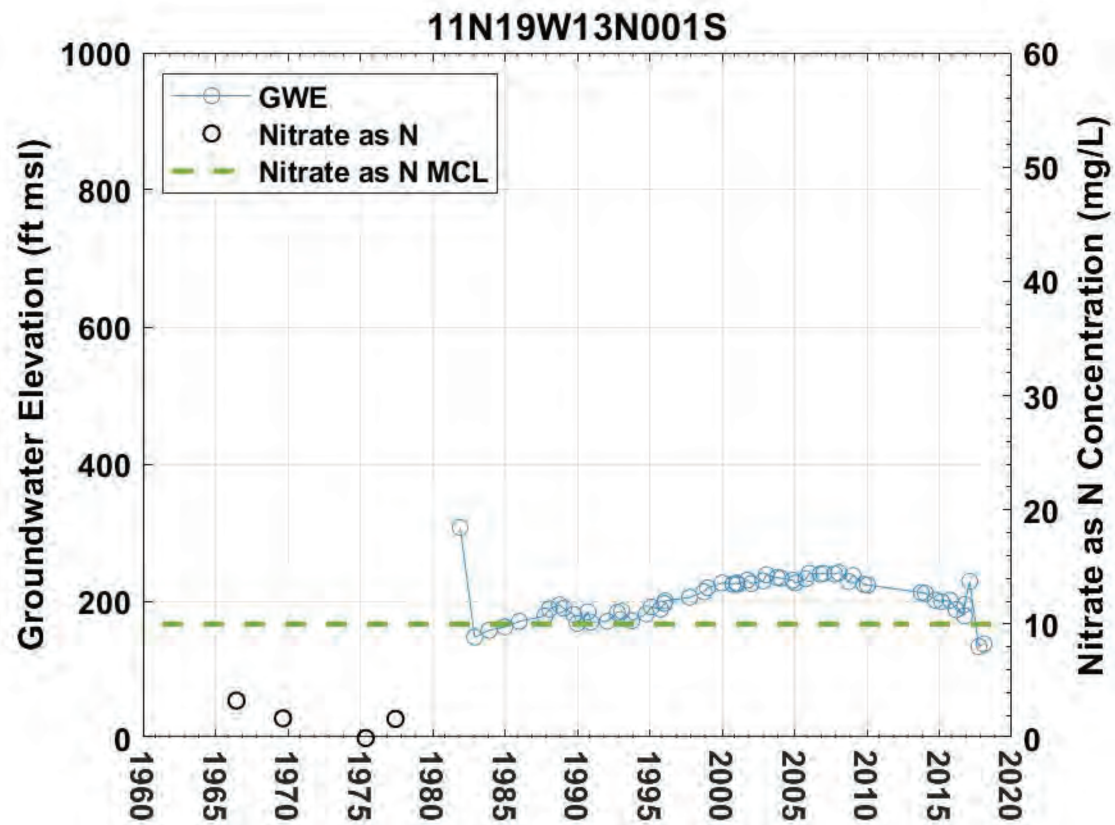

11N19W12J001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
GWE
Nitrate as N
Nitrate as N MCL
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

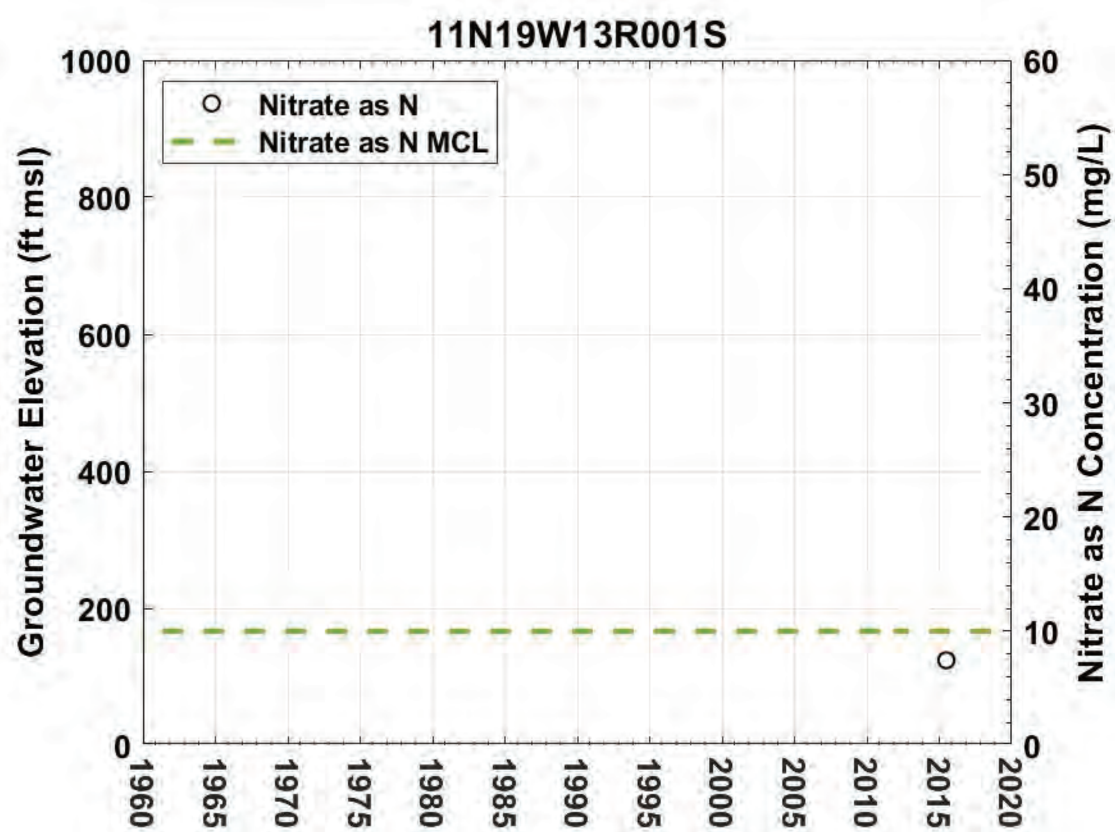

11N19W12N002S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

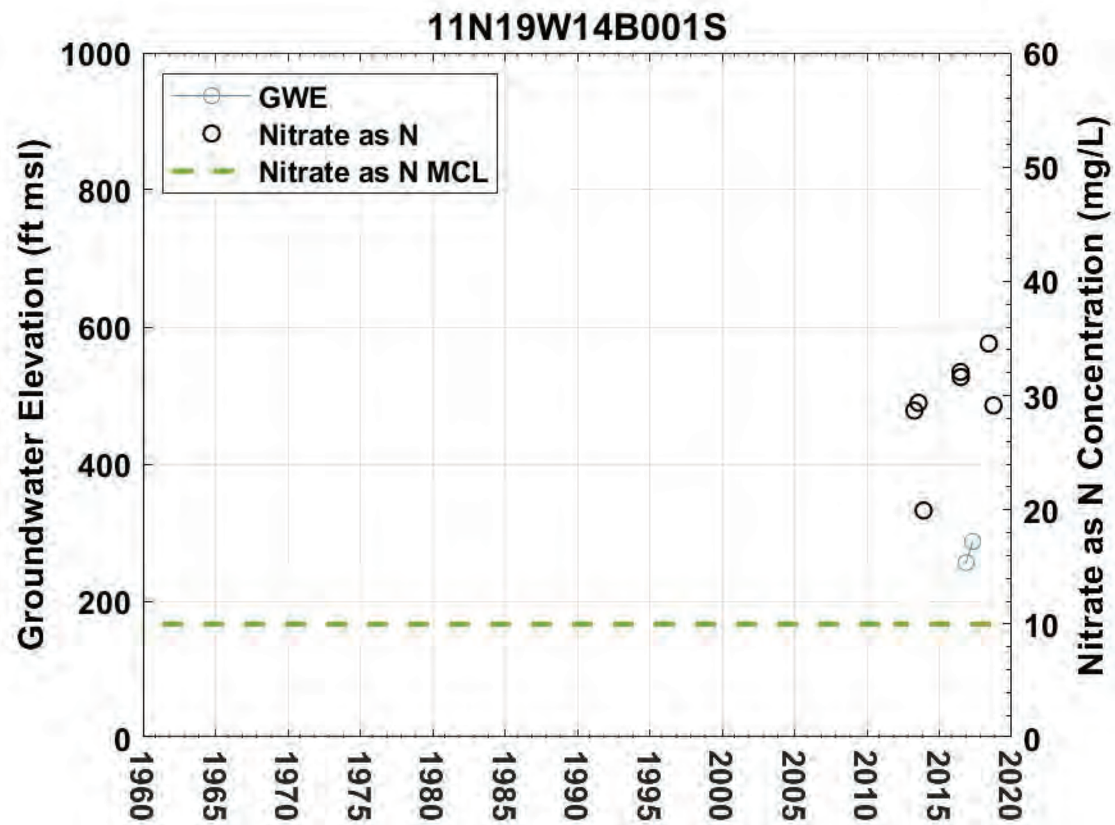

11N19W12R001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

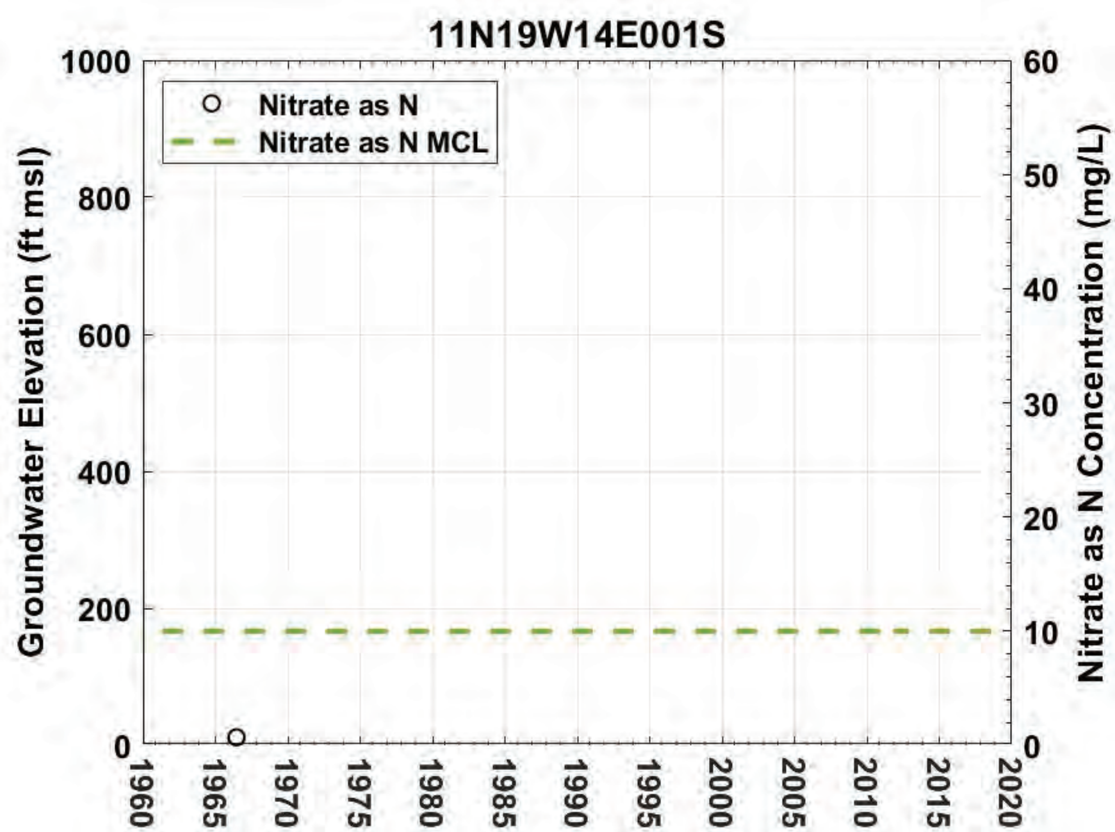

11N19W13J001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

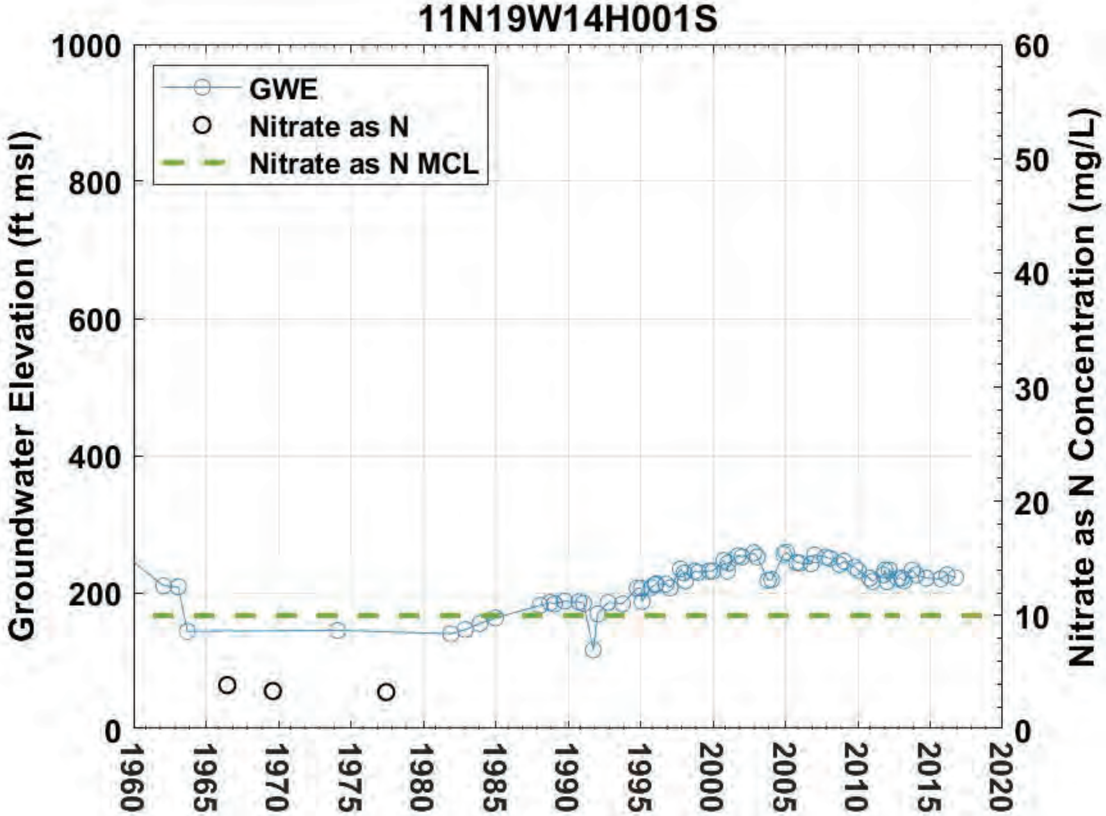

11N19W13J002S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

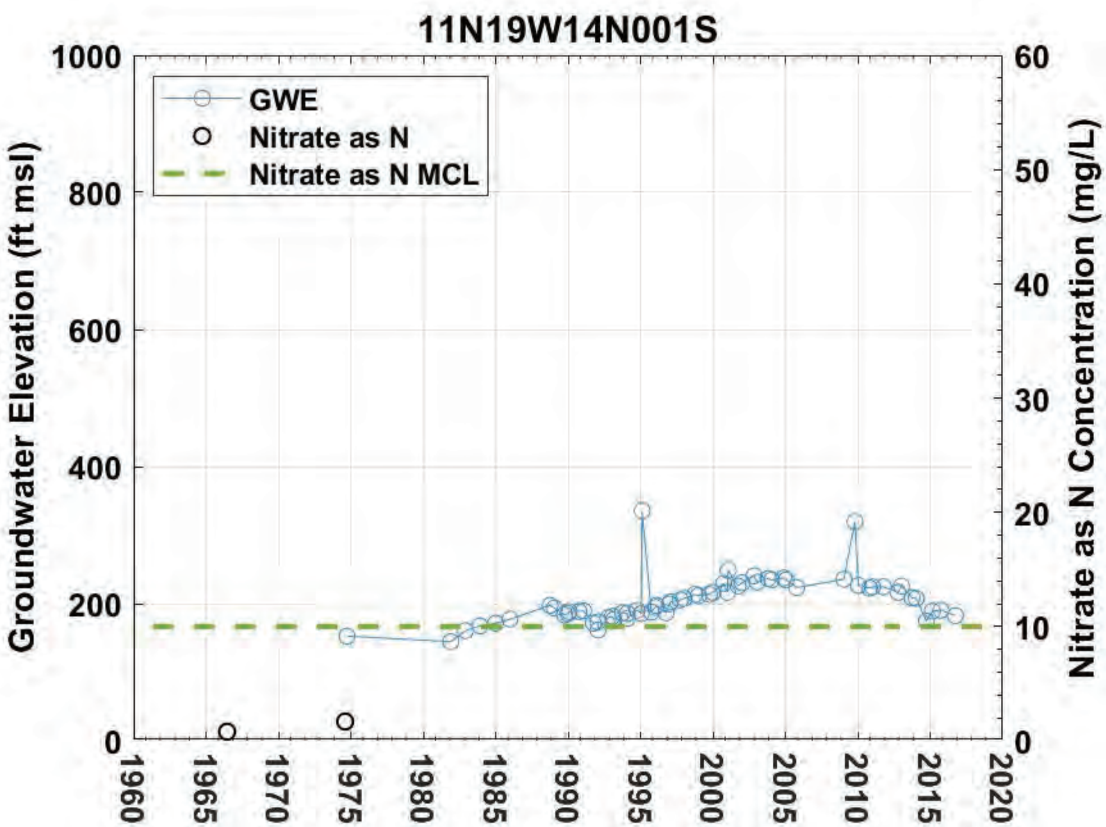

11N19W13N001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)

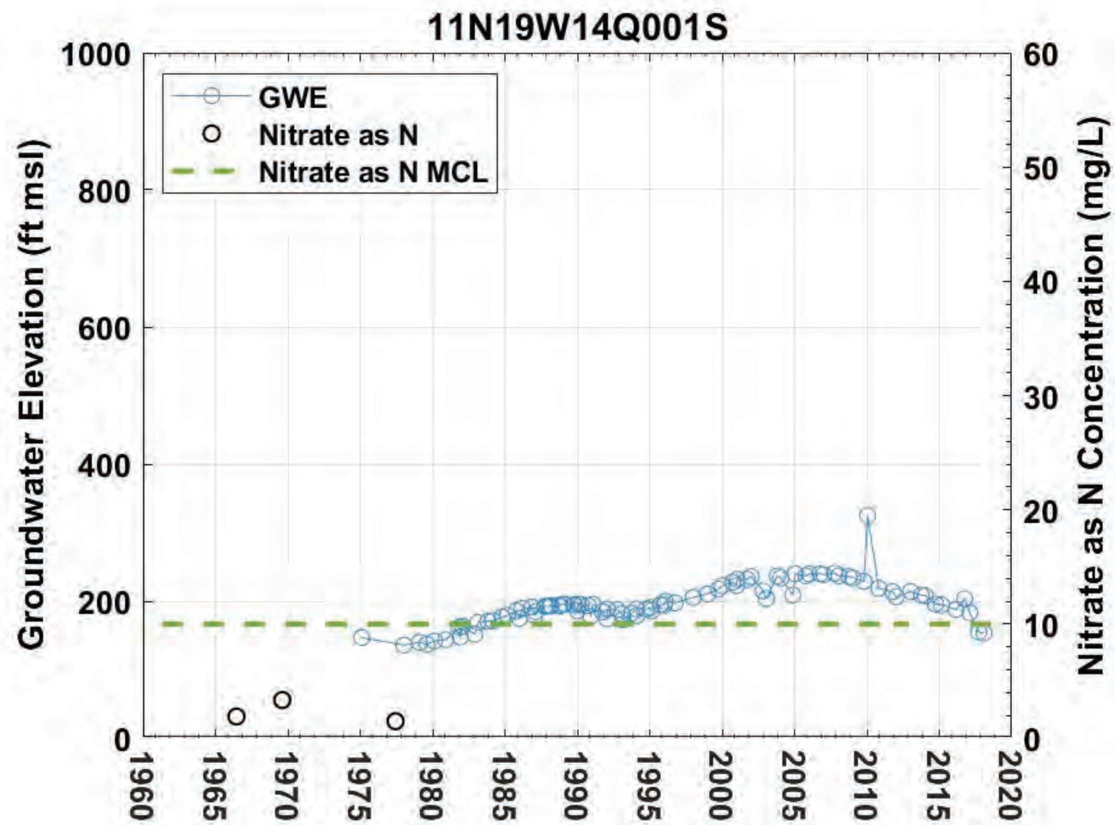

11N19W13R001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)


11N19W14B001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

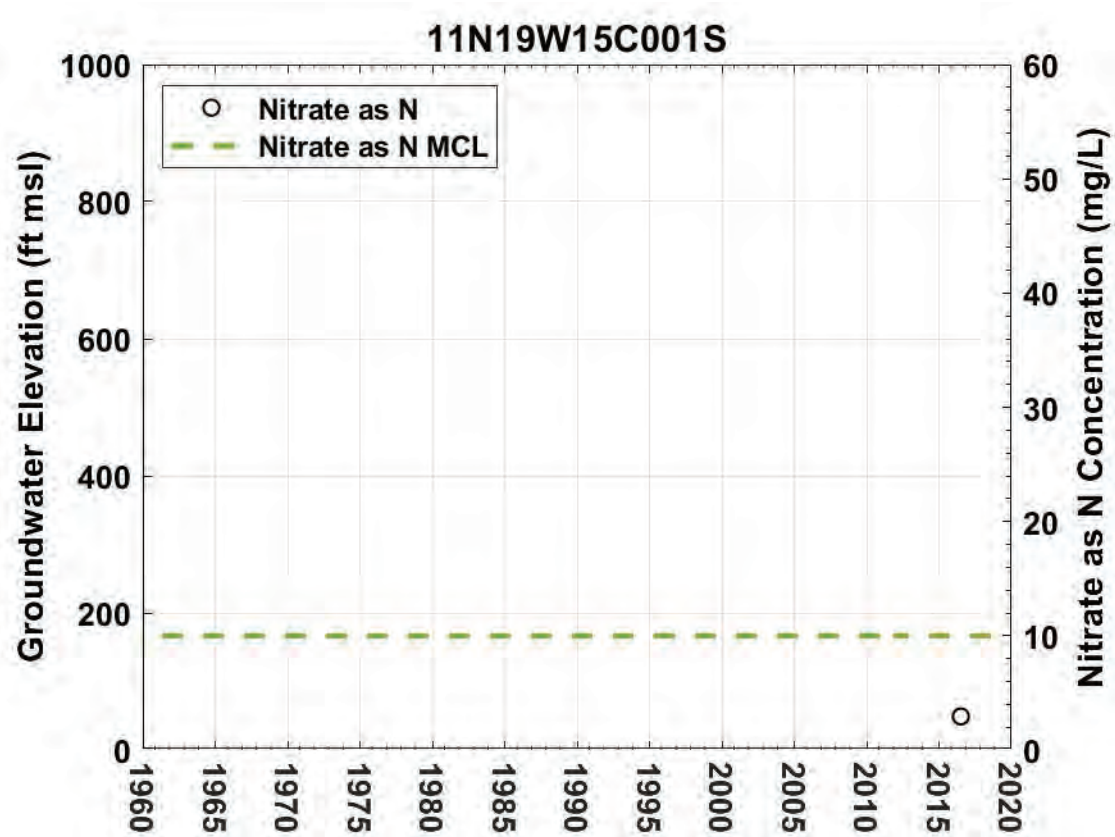

11N19W14E001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W14H001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

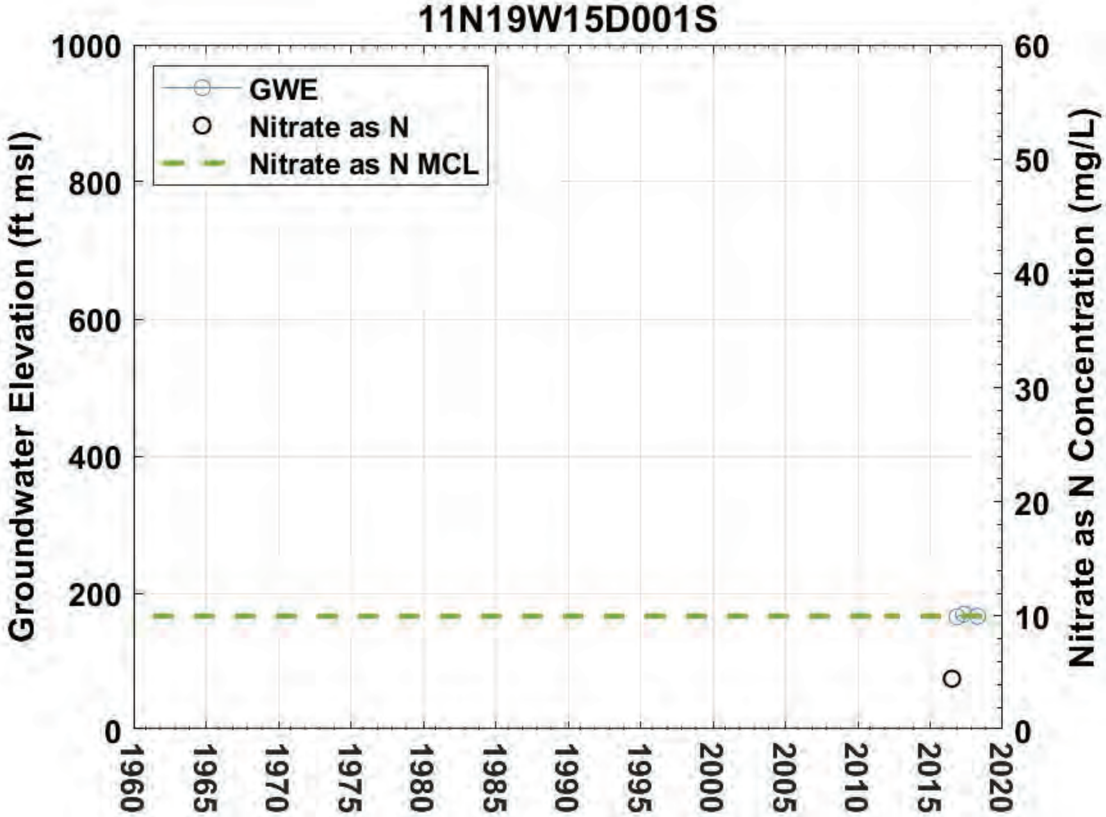

11N19W14N001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

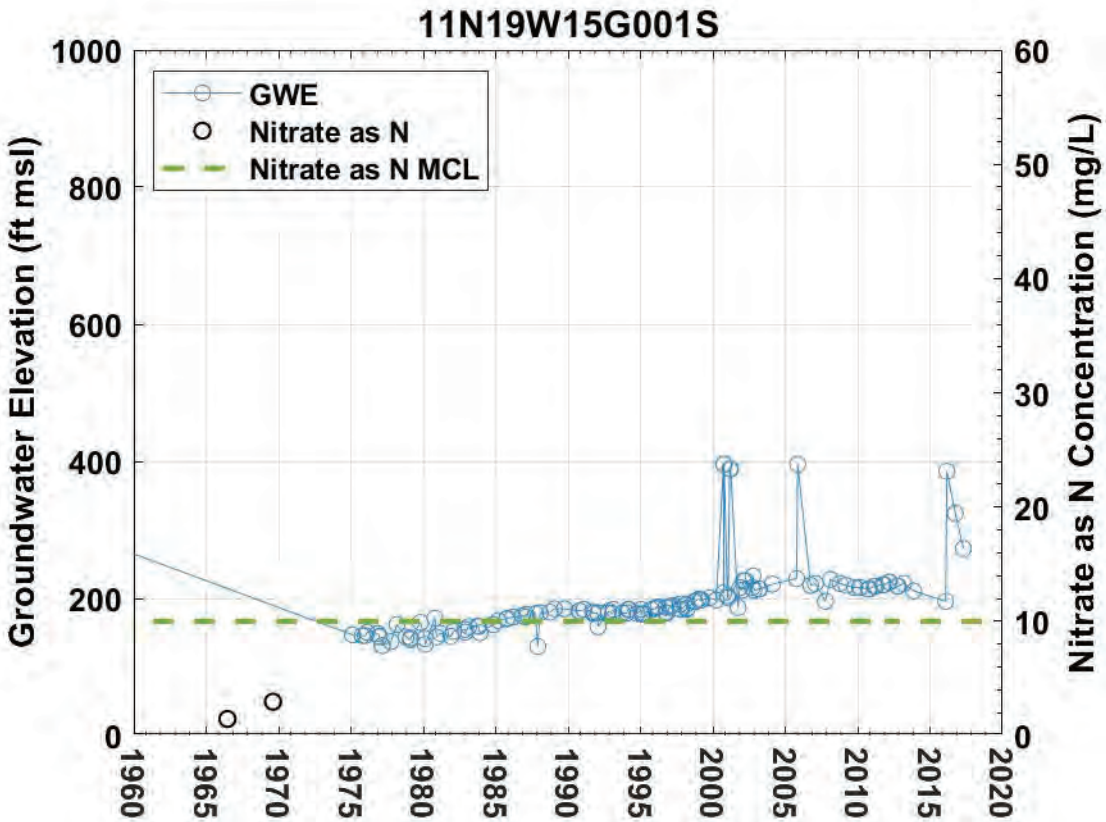


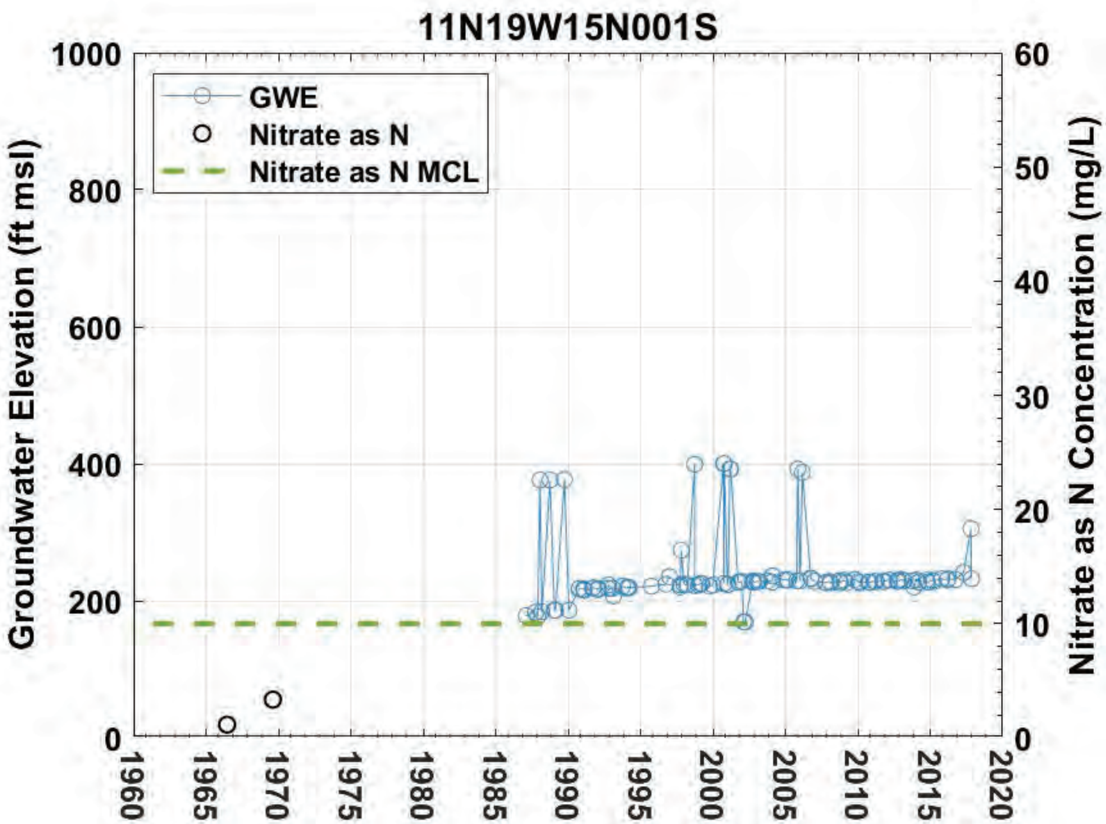
11N19W14Q001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

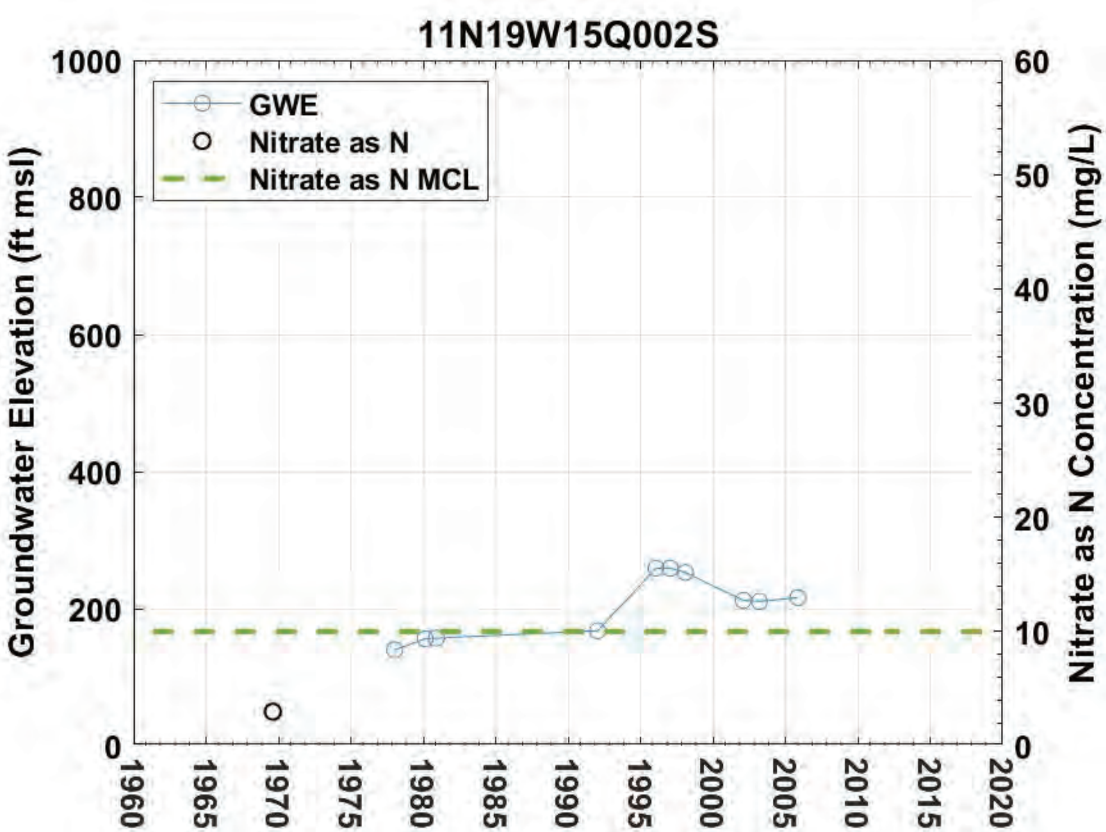


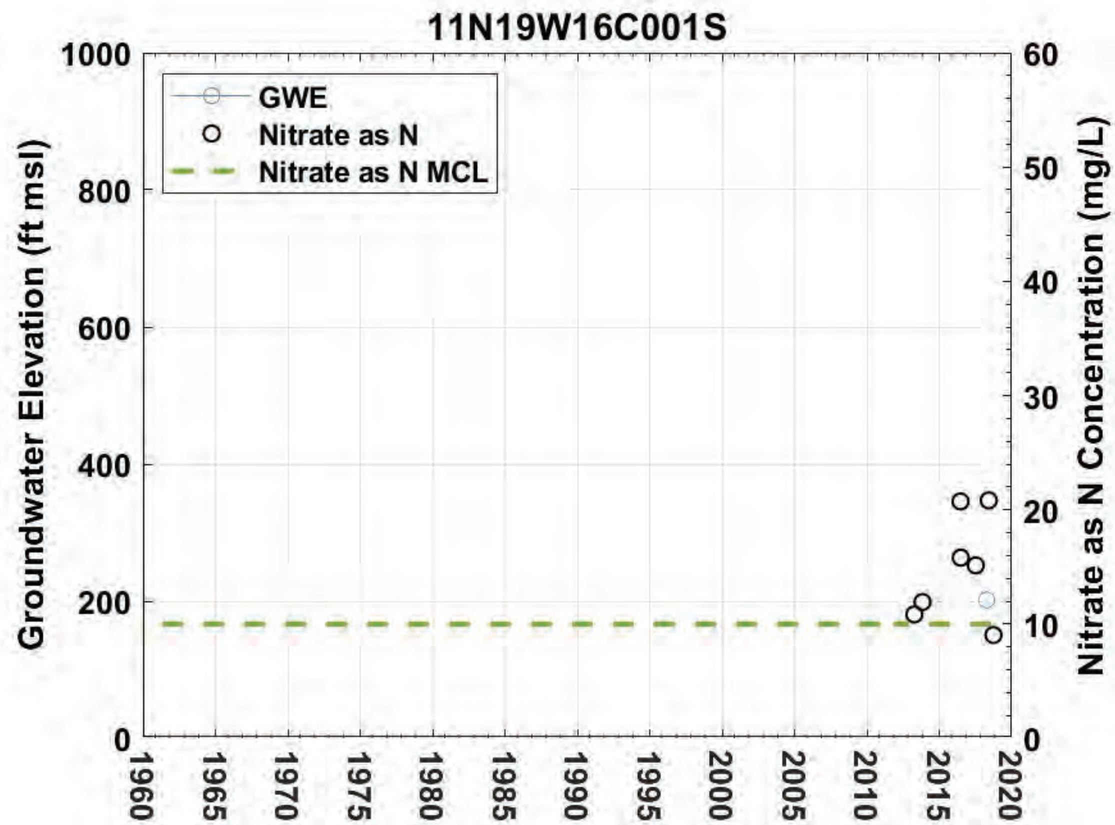
11N19W15C001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

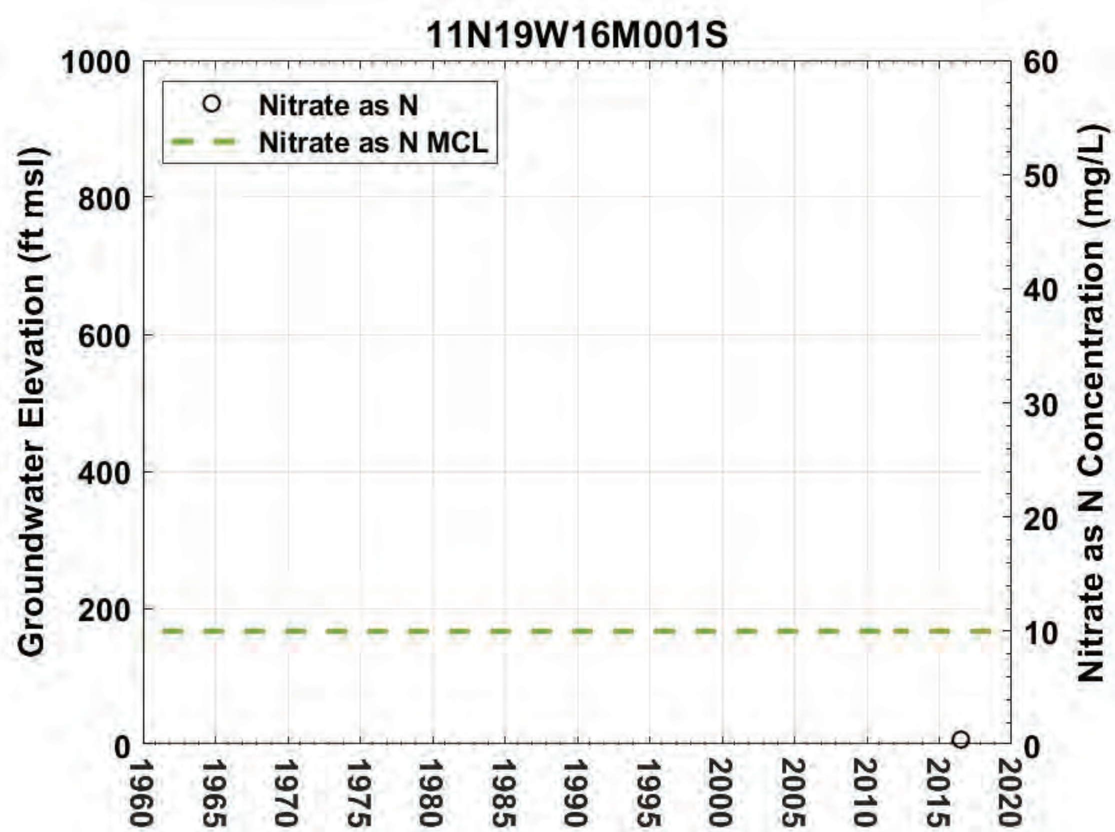

11N19W15D001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

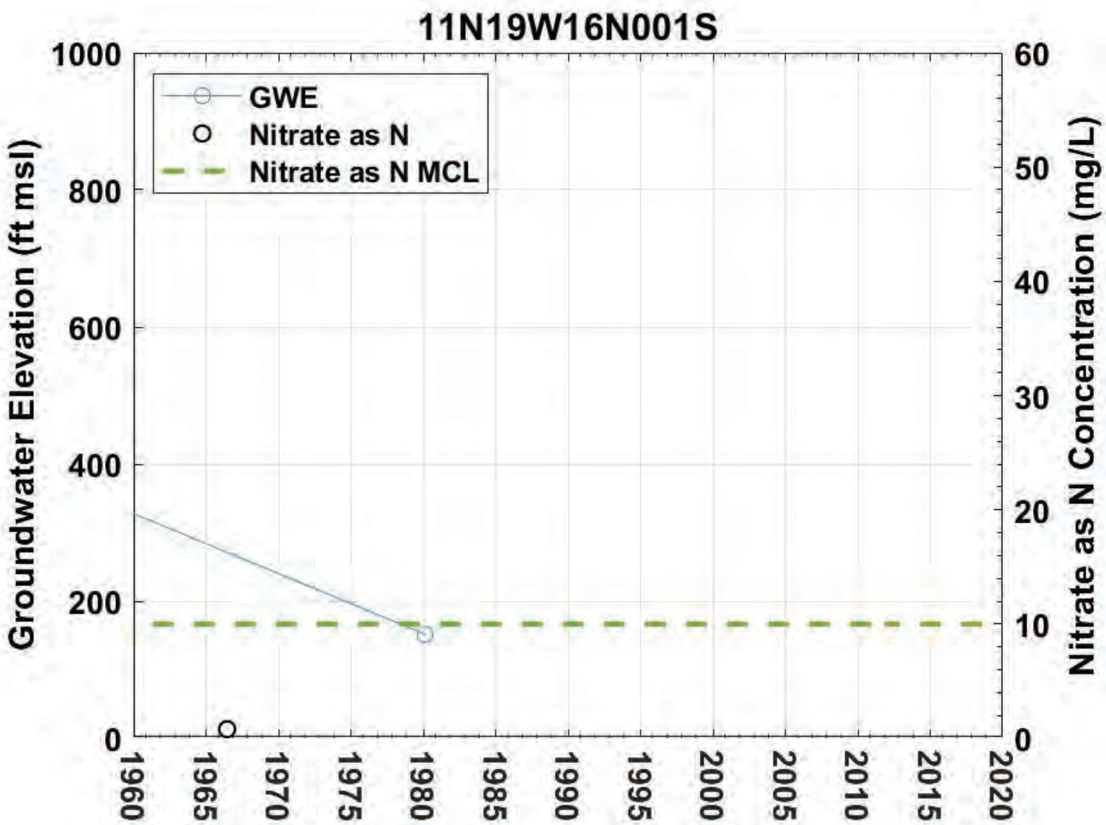

11N19W15G001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

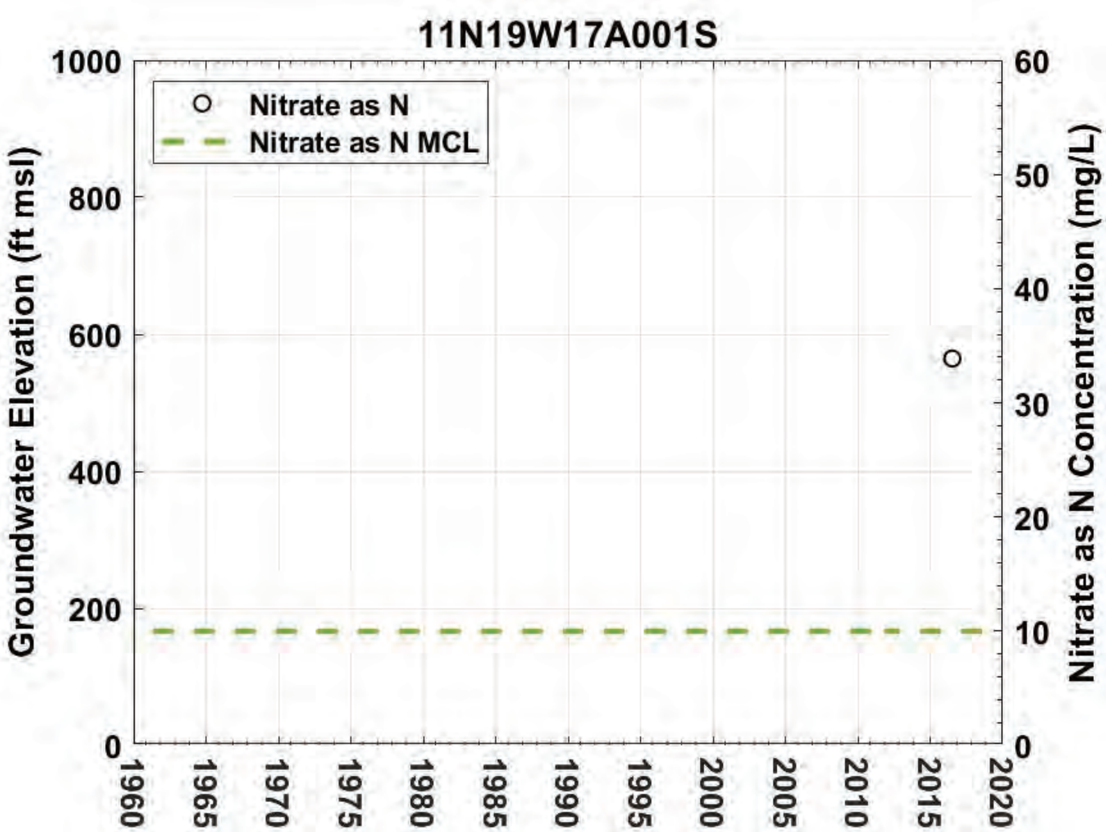

11N19W15N001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

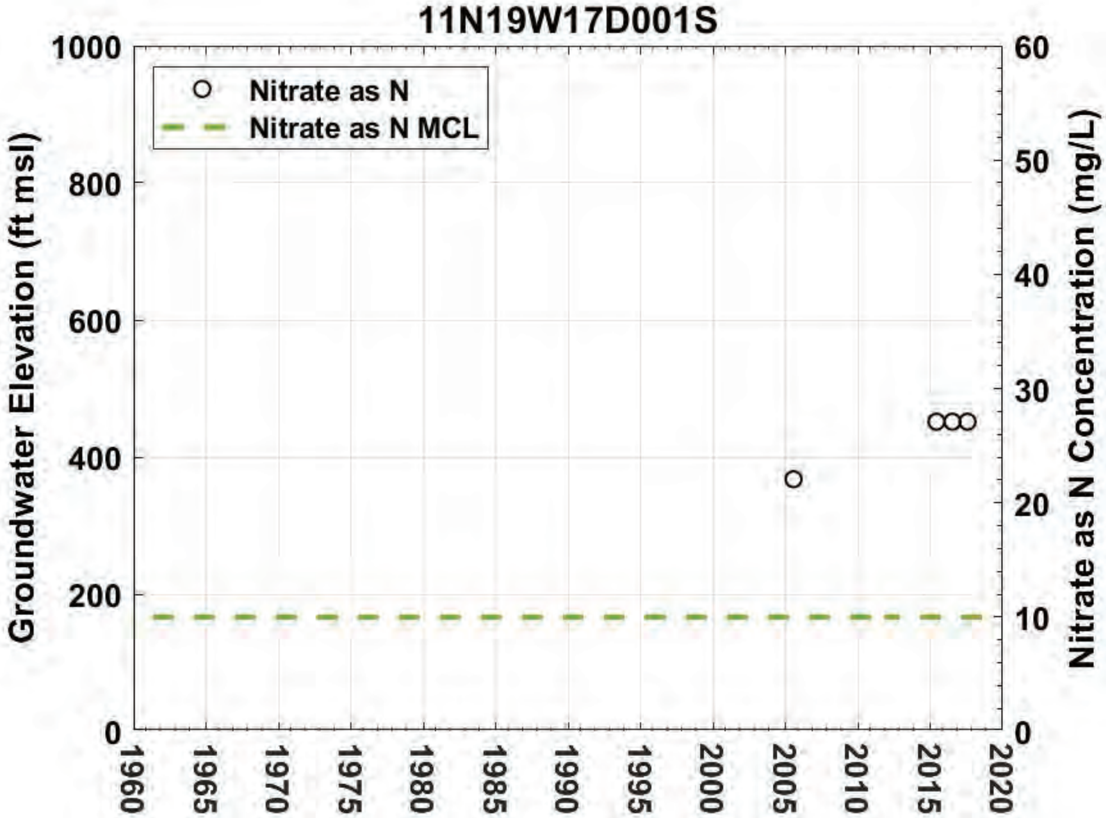

11N19W15Q002S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

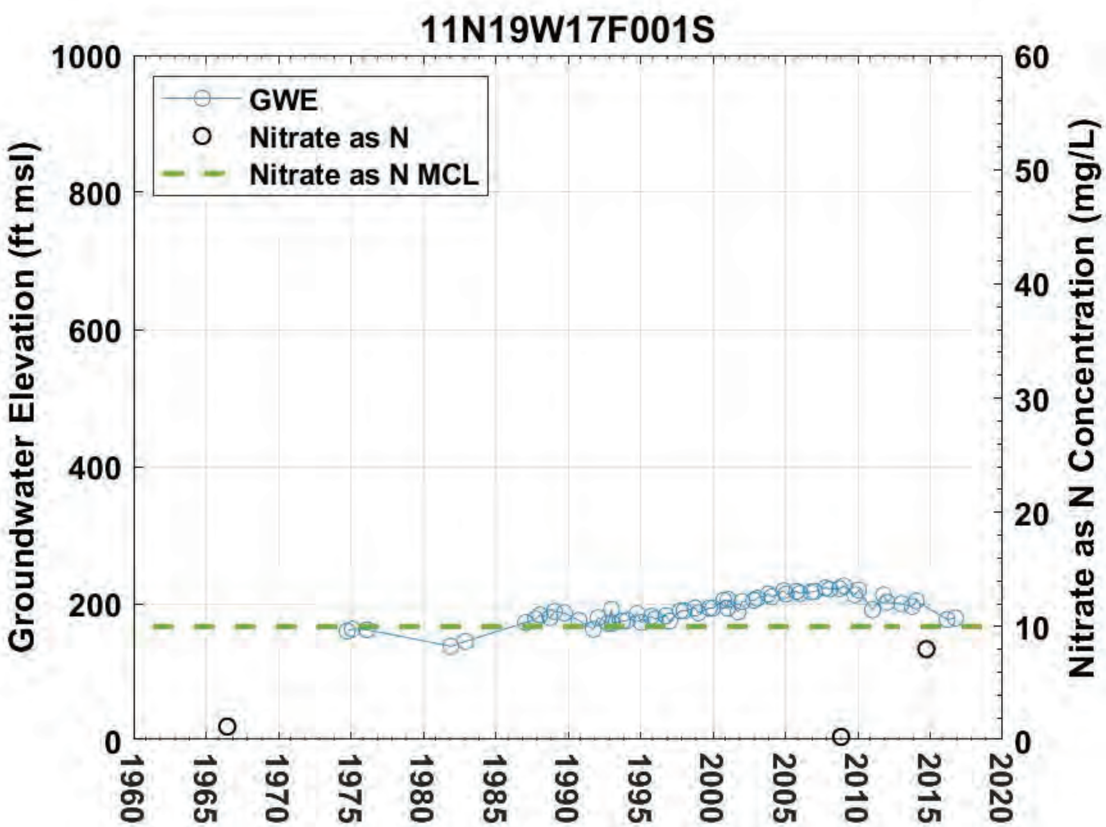

11N19W16C001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

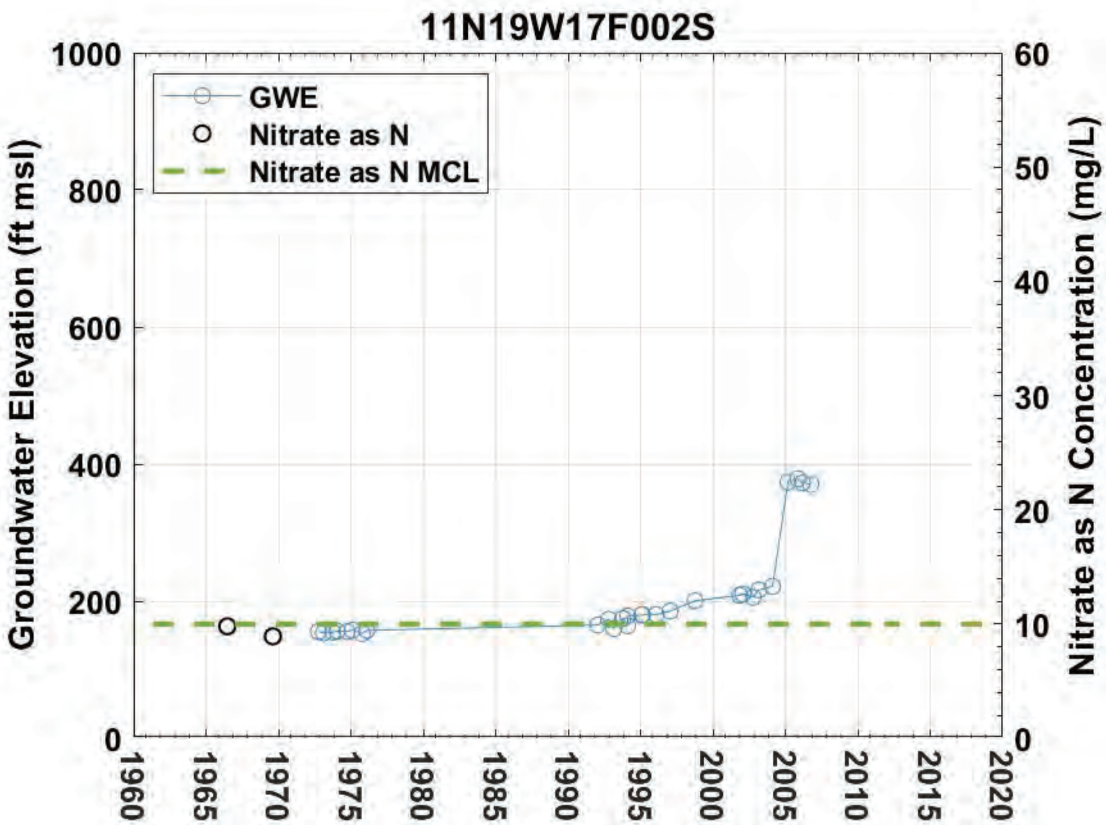

11N19W16M001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

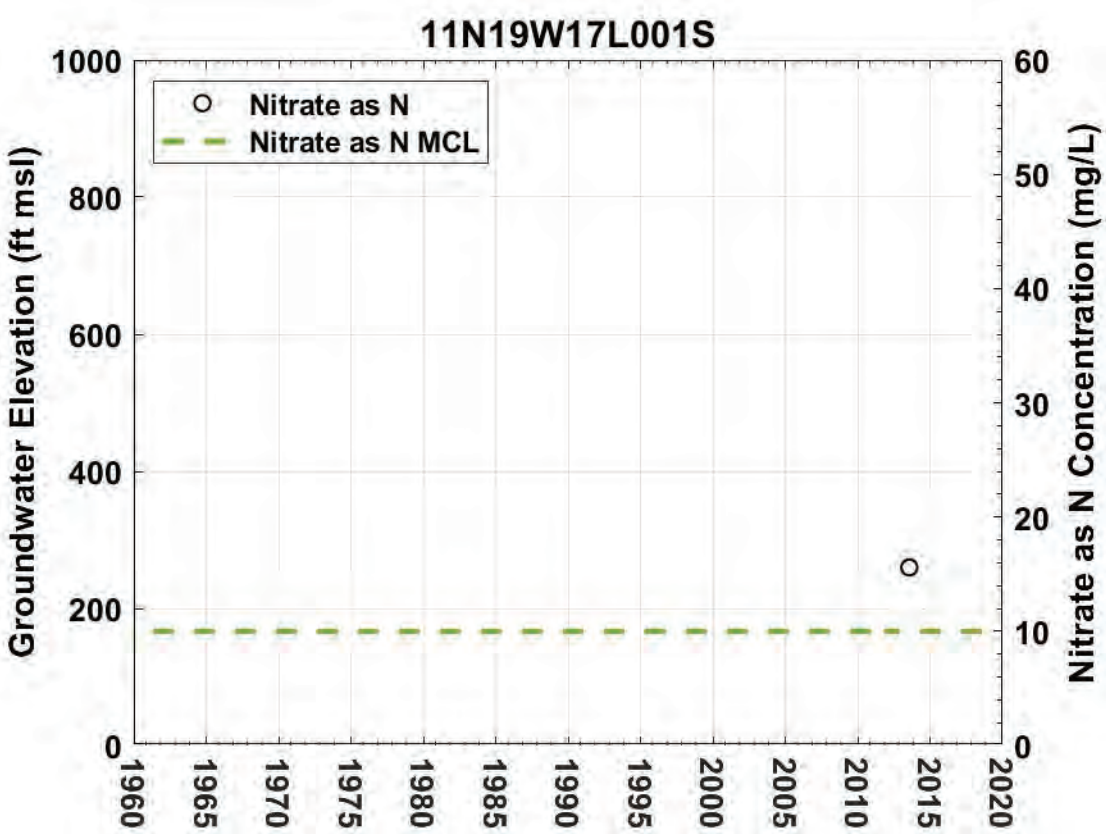

11N19W16N001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

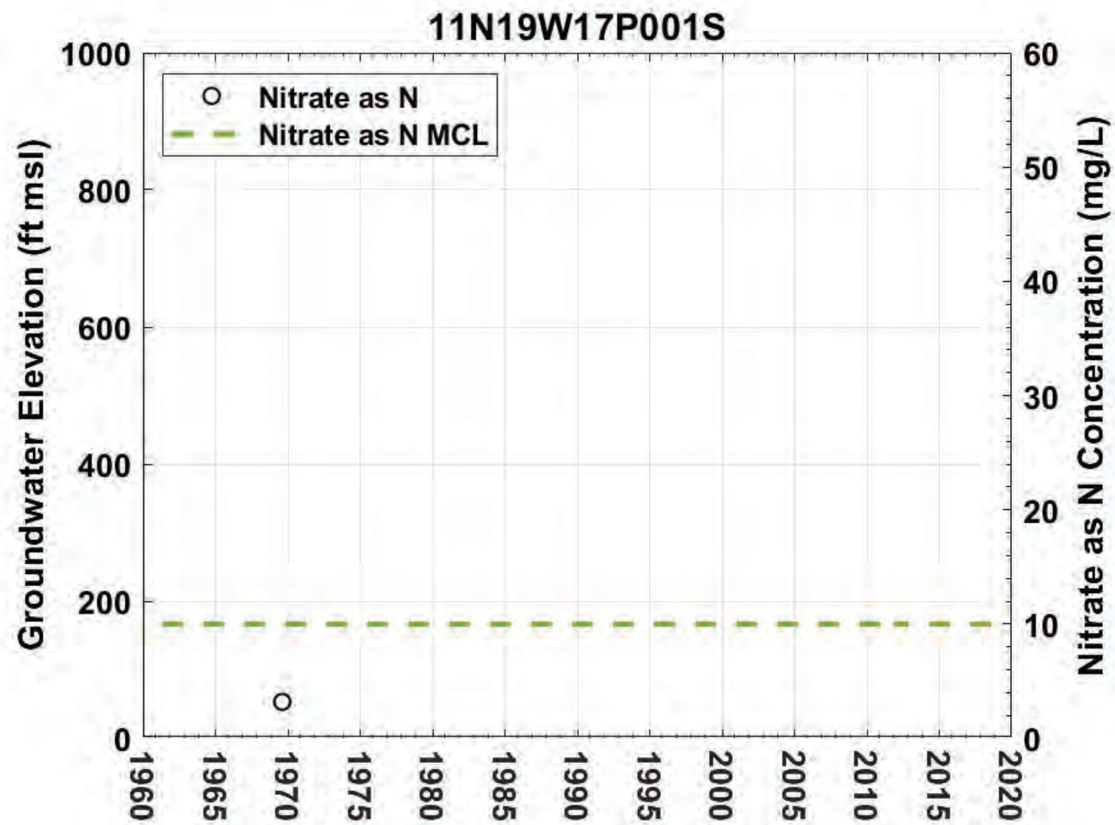

11N19W17A001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

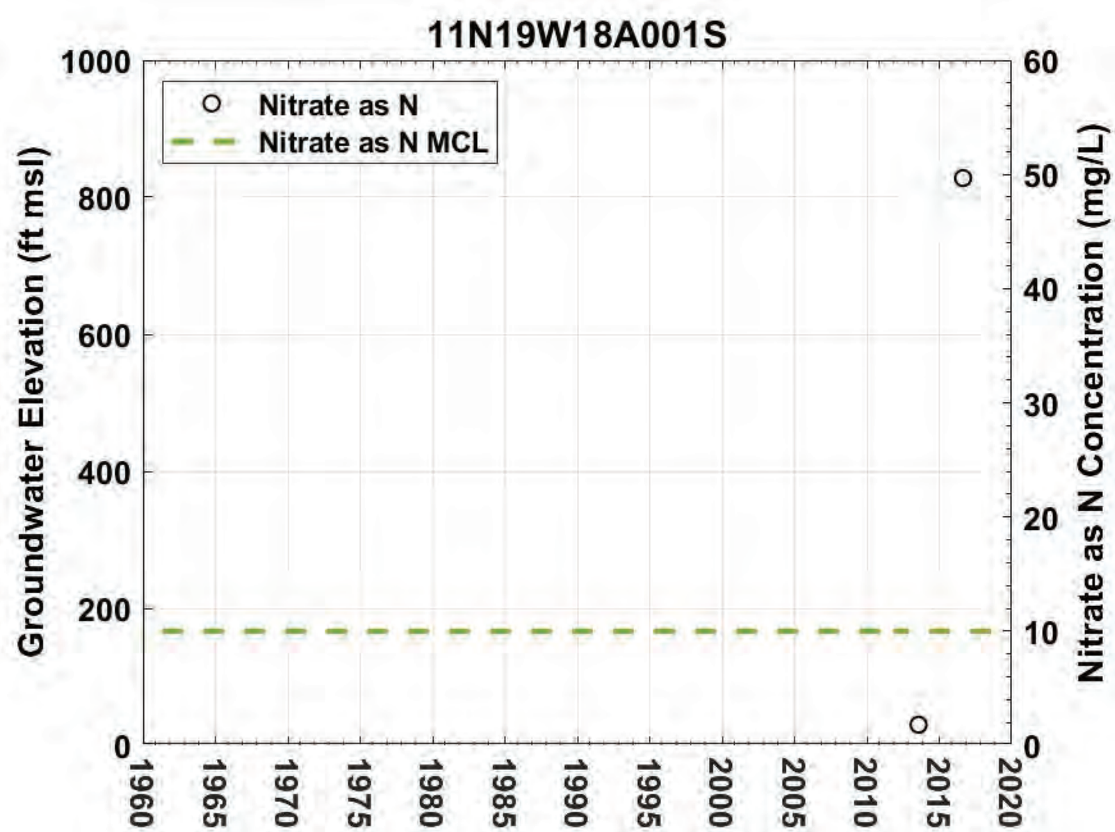

11N19W17D001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

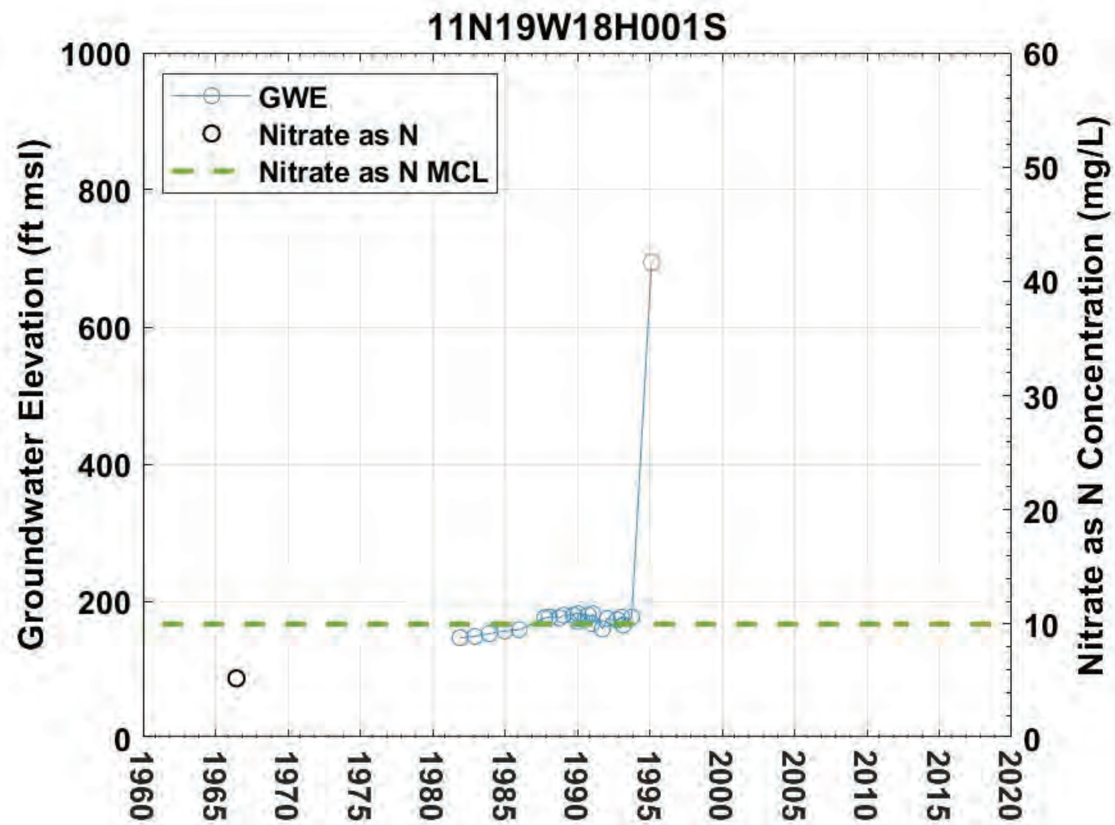

11N19W17F001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

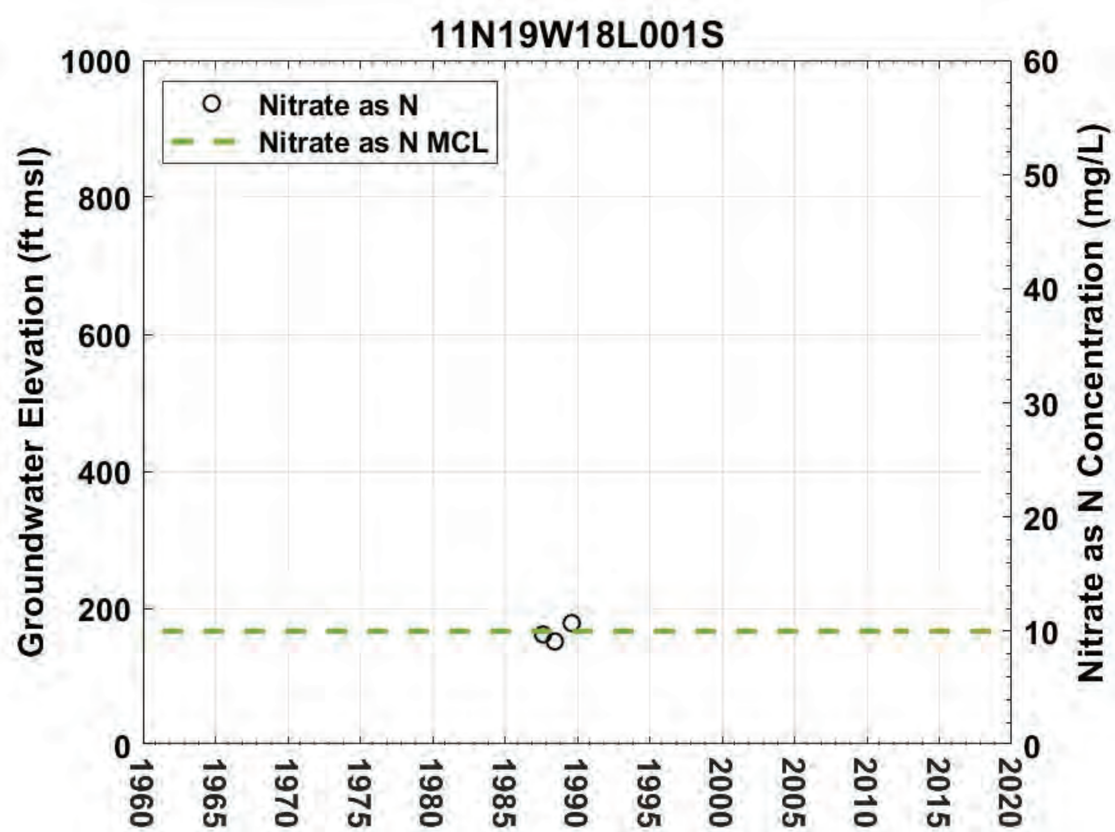

11N19W17F002S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

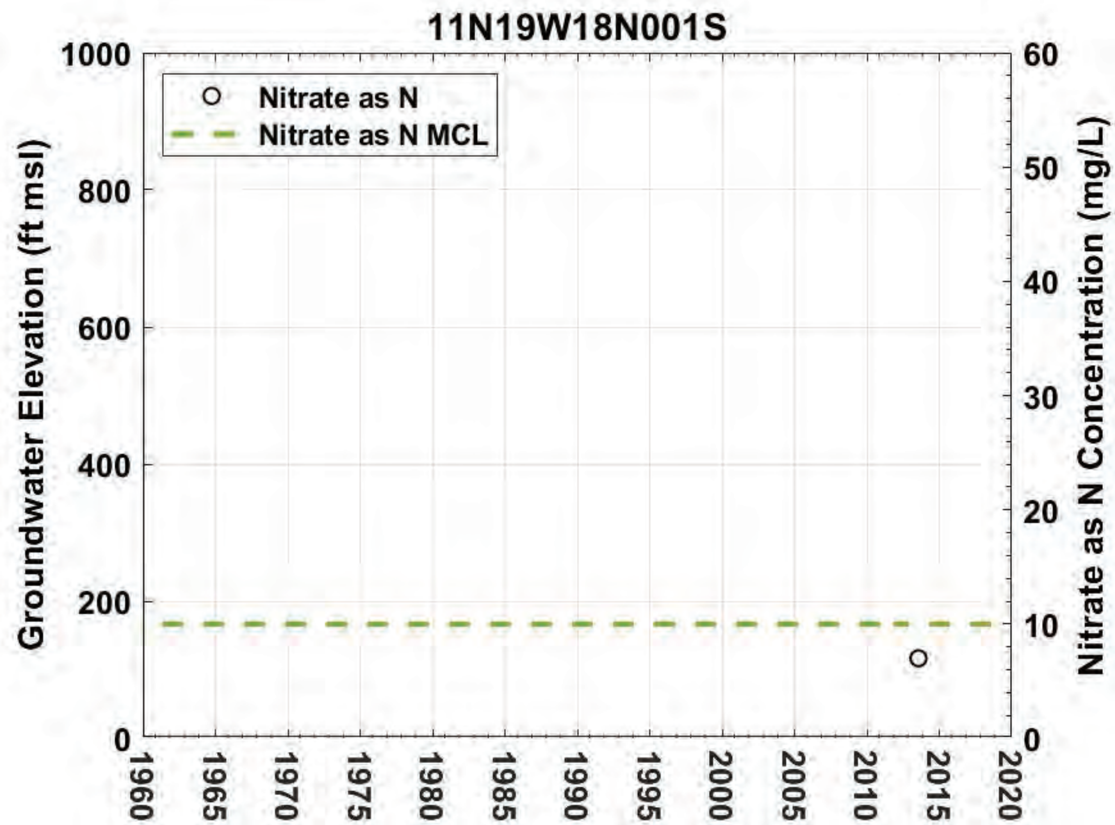

11N19W17L001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

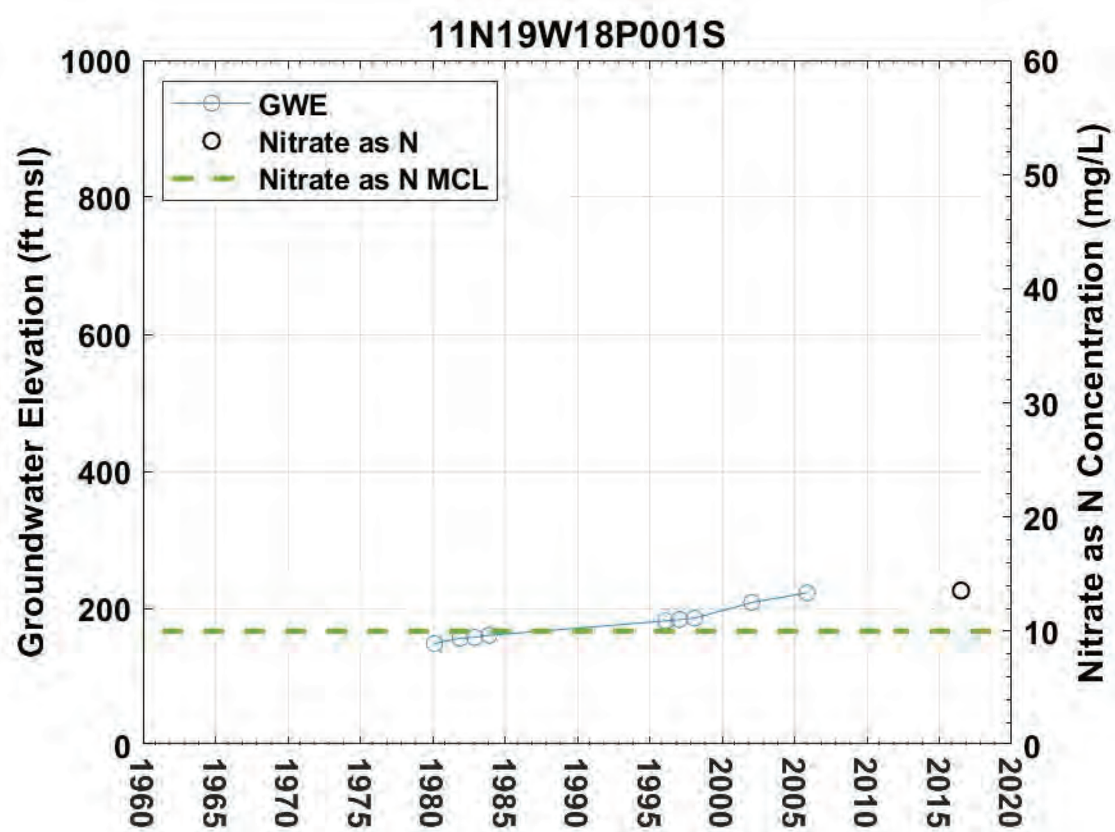

11N19W17P001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

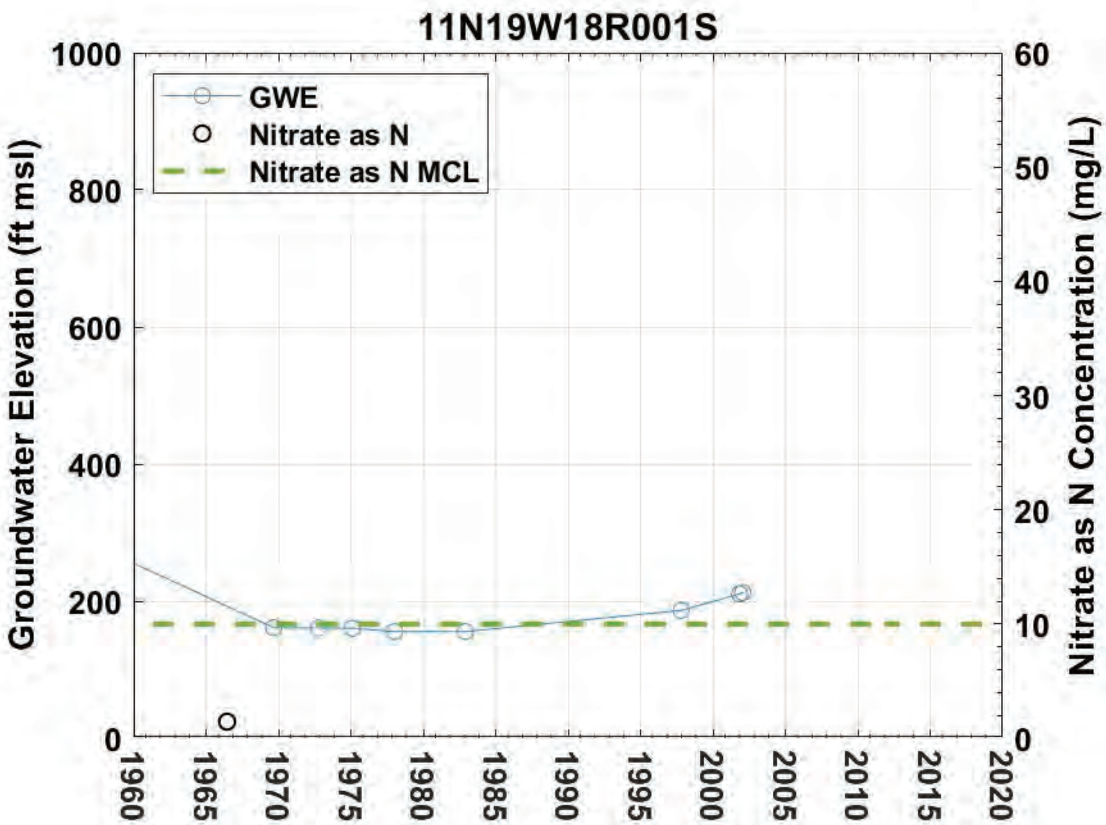

11N19W18A001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

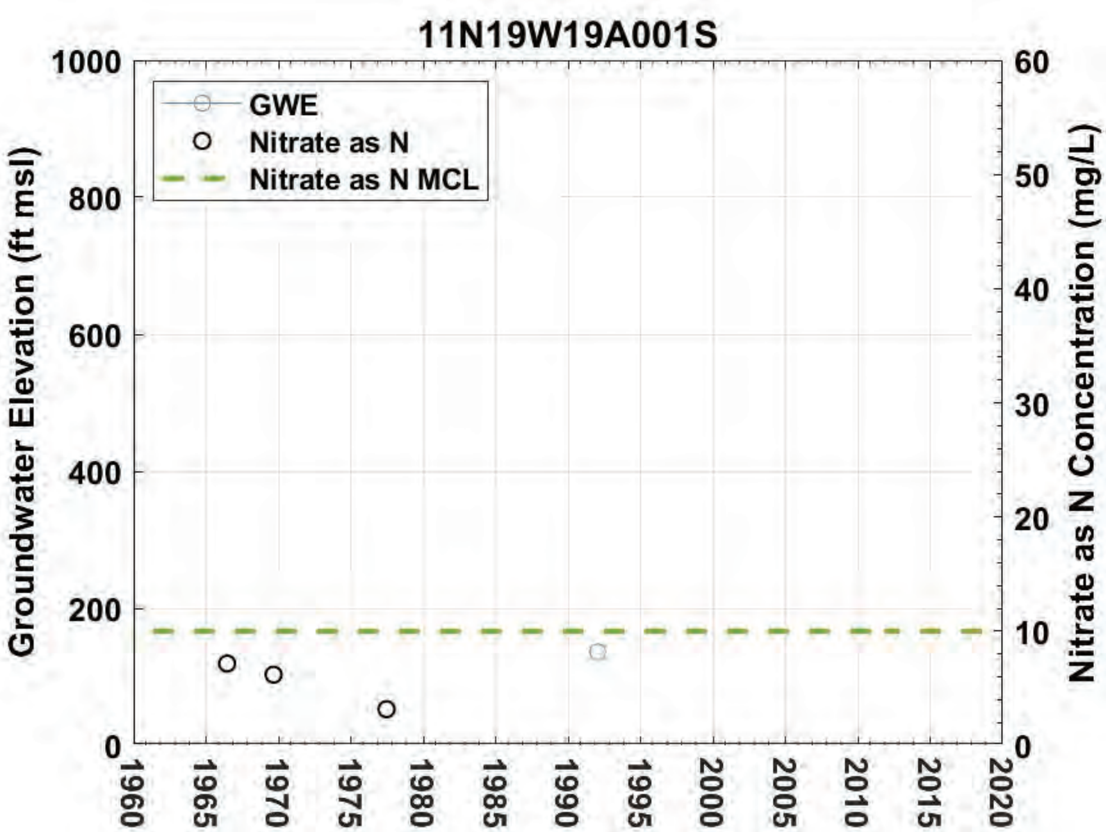

11N19W18H001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

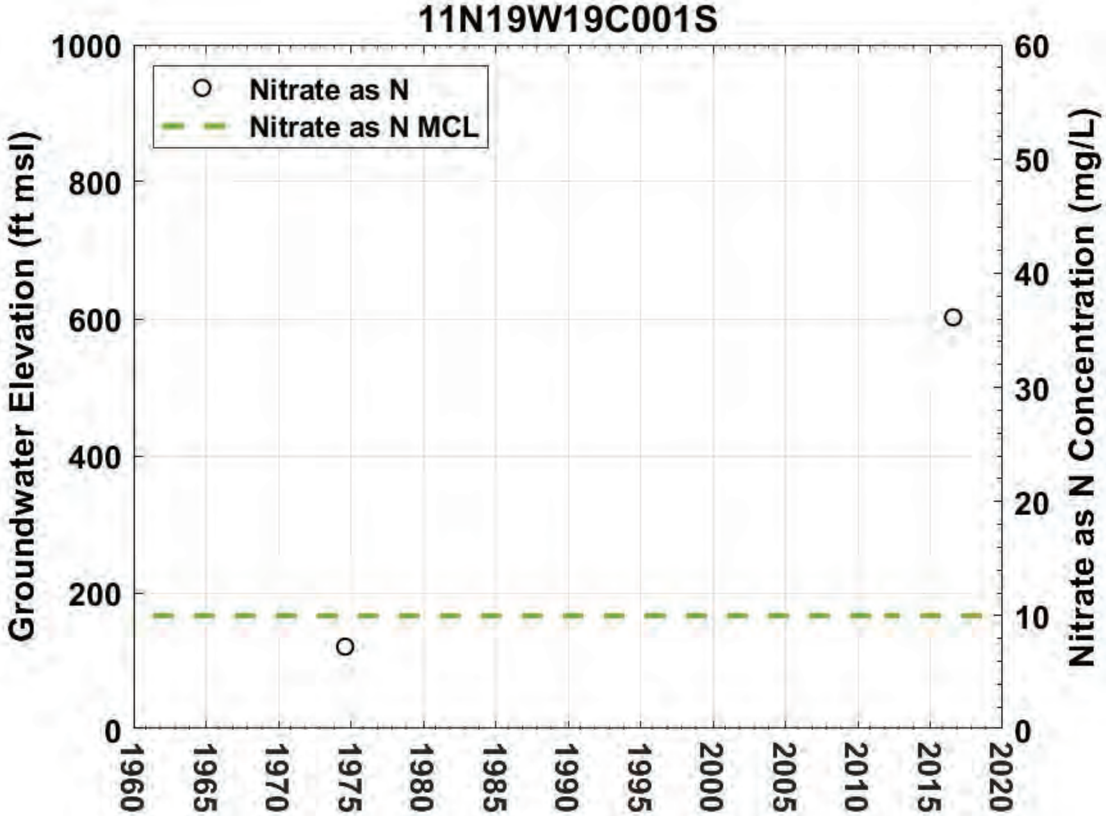

11N19W18L001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

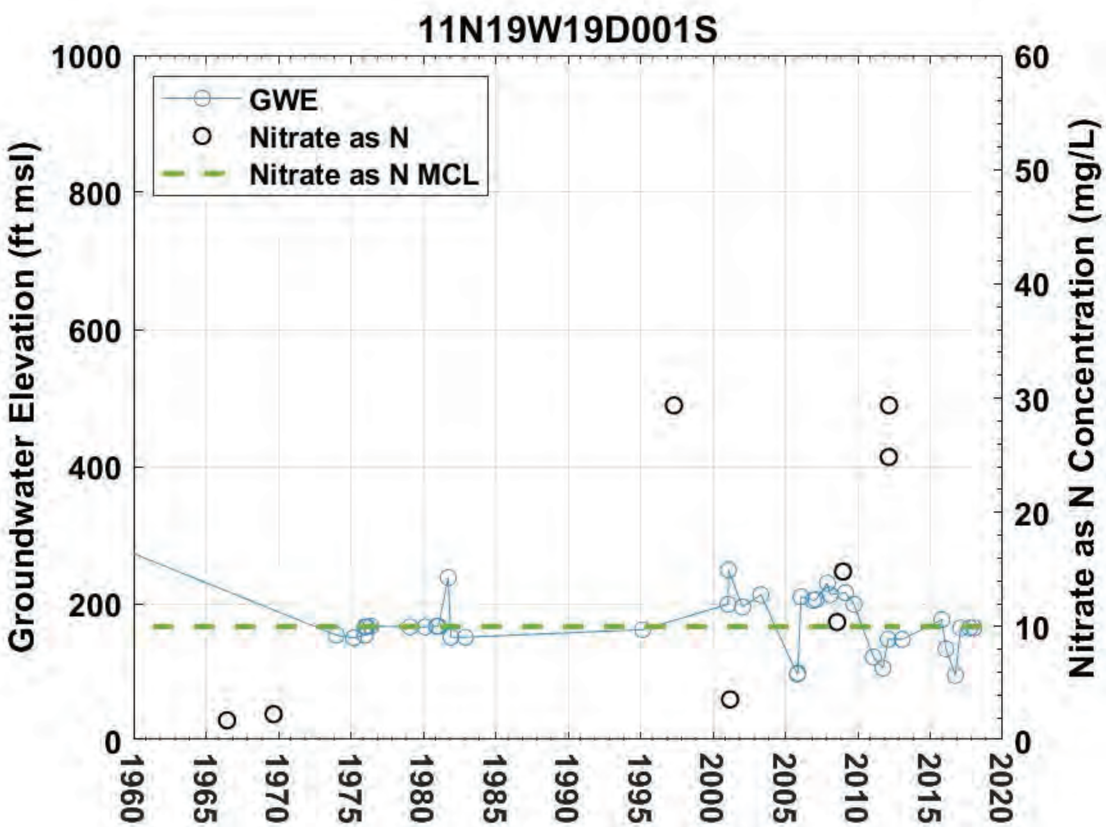

11N19W18N001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

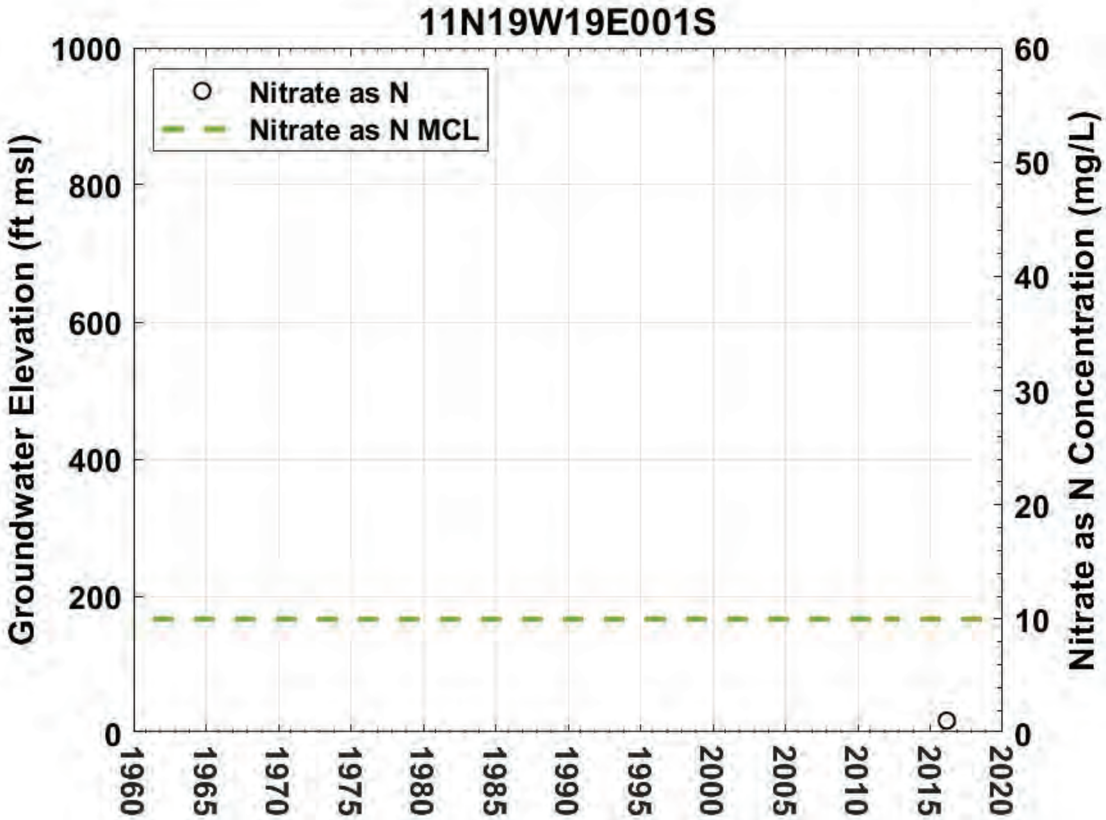

11N19W18P001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

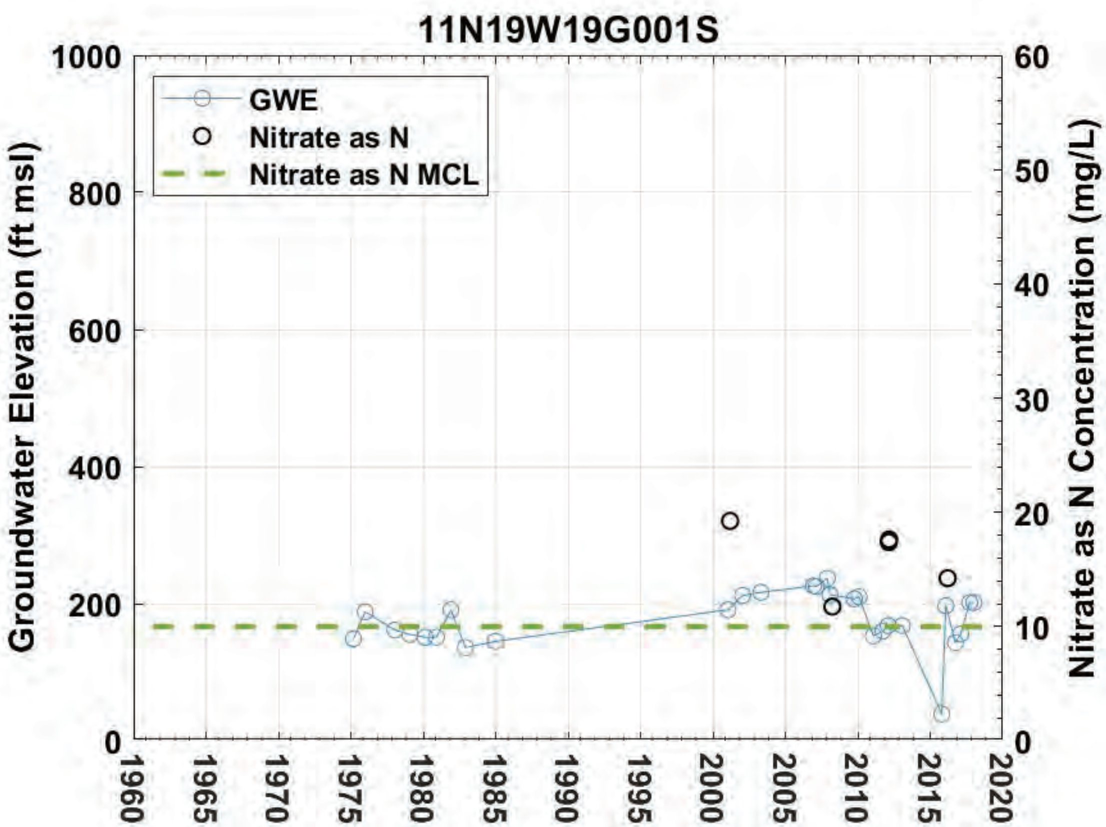

11N19W18R001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

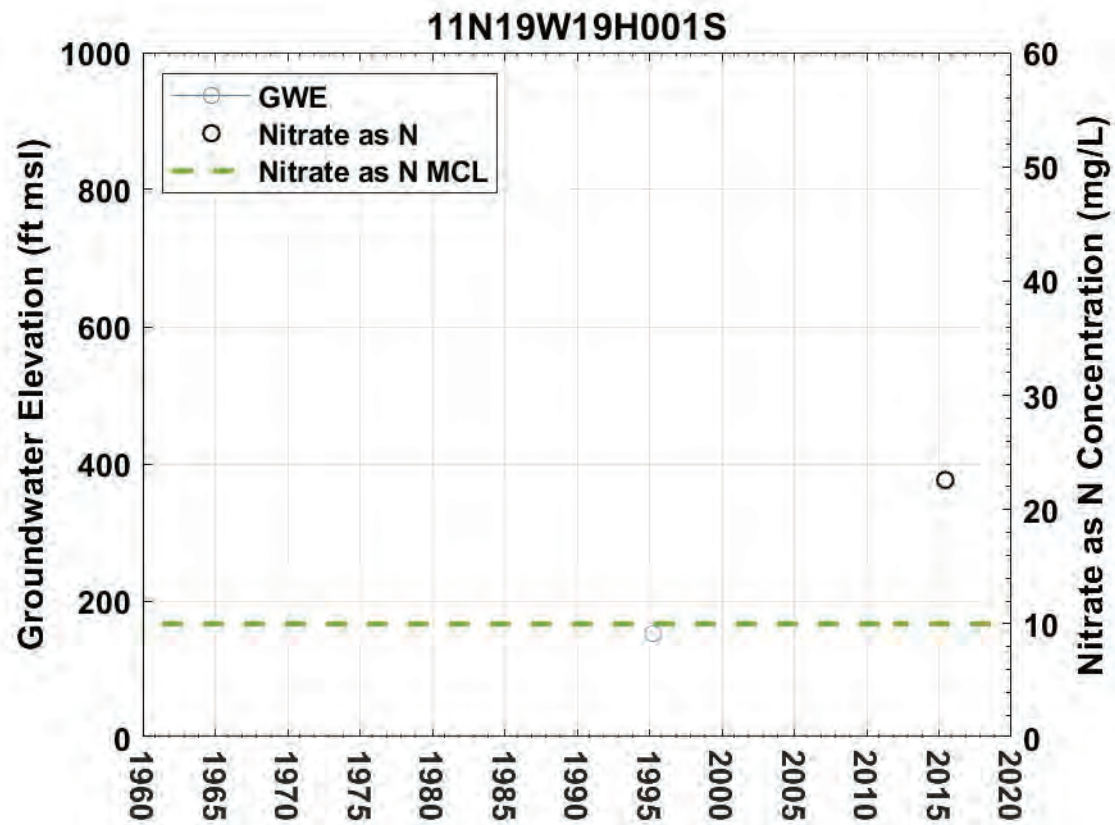

11N19W19A001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

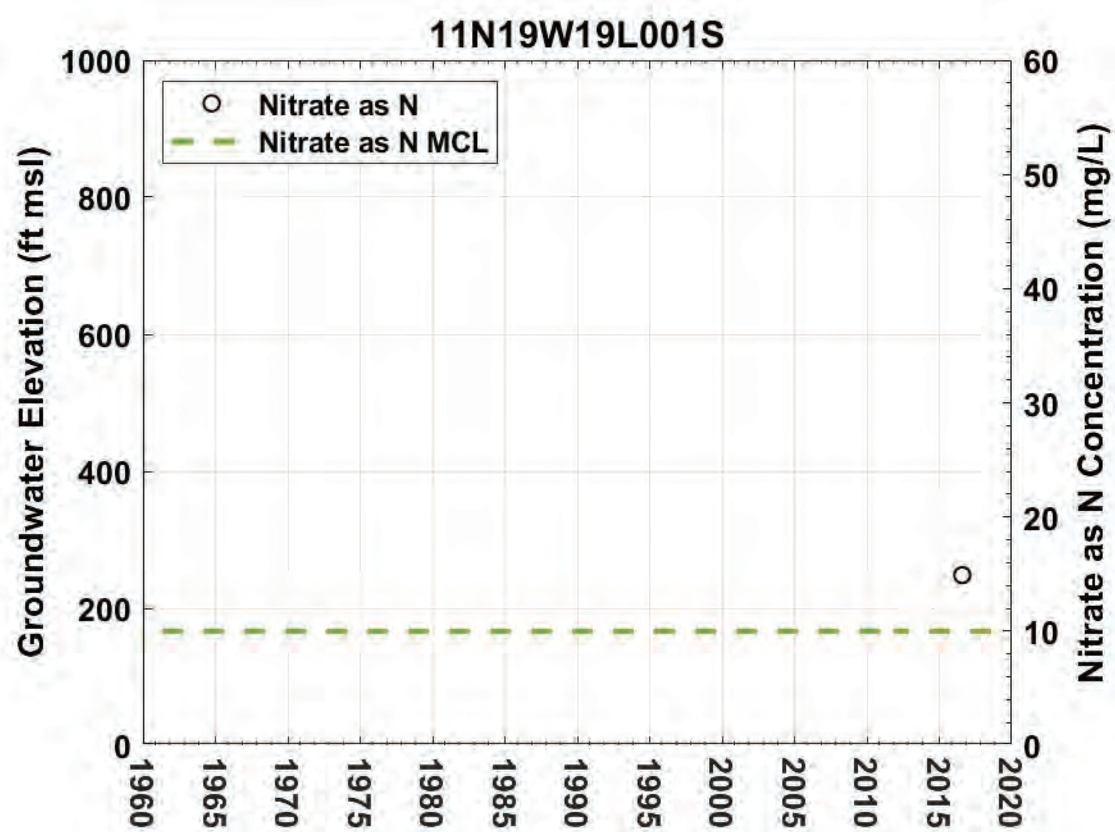

11N19W19C001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

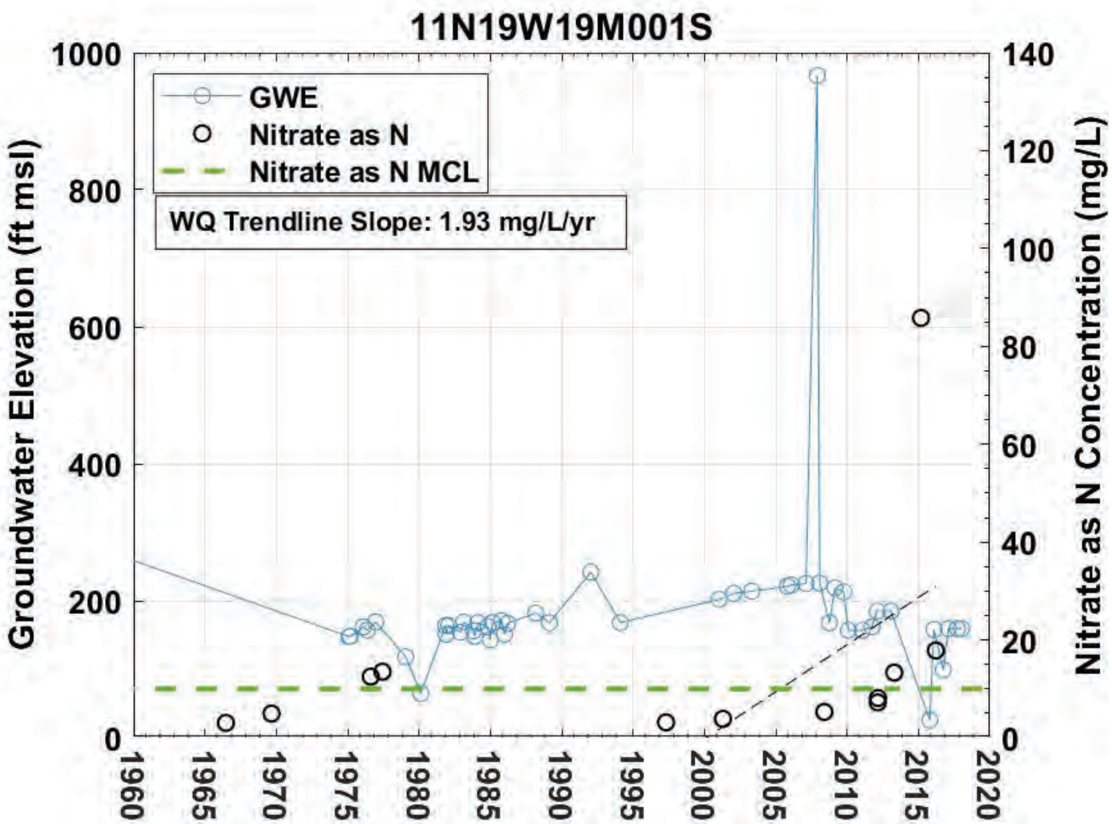

11N19W19D001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

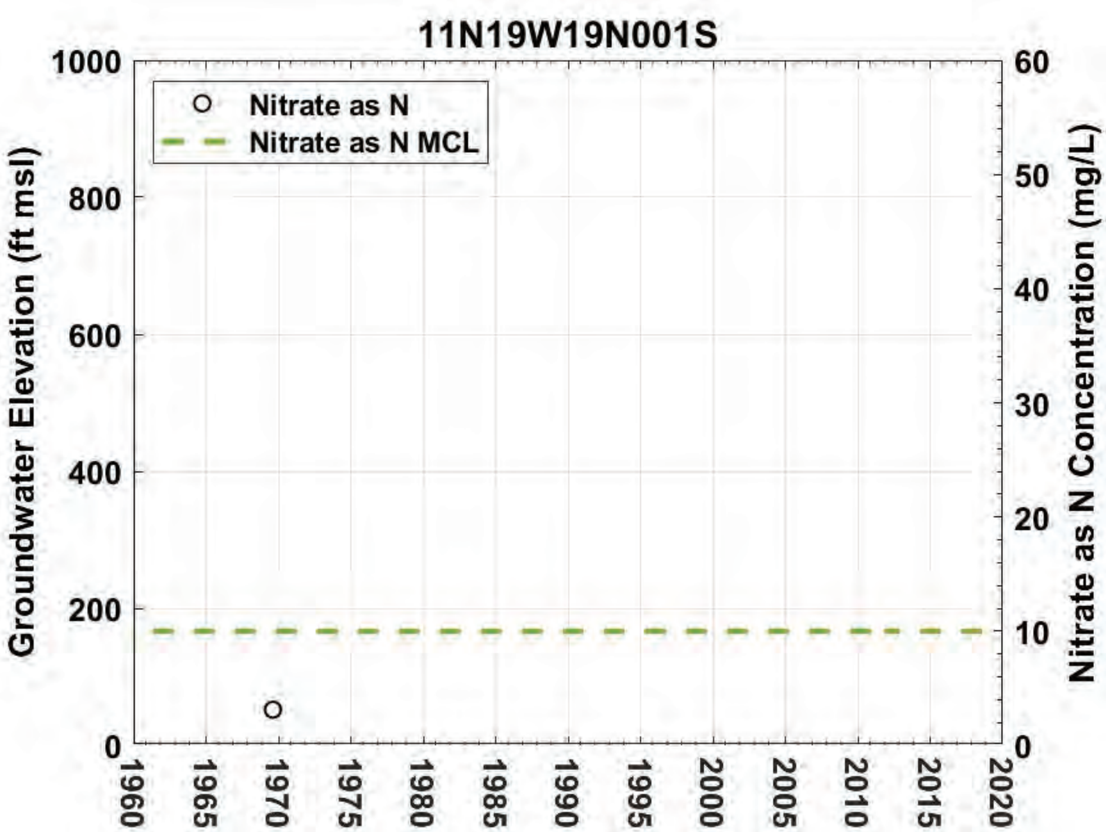

11N19W19E001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
Nitrate as N
Nitrate as N MCL
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

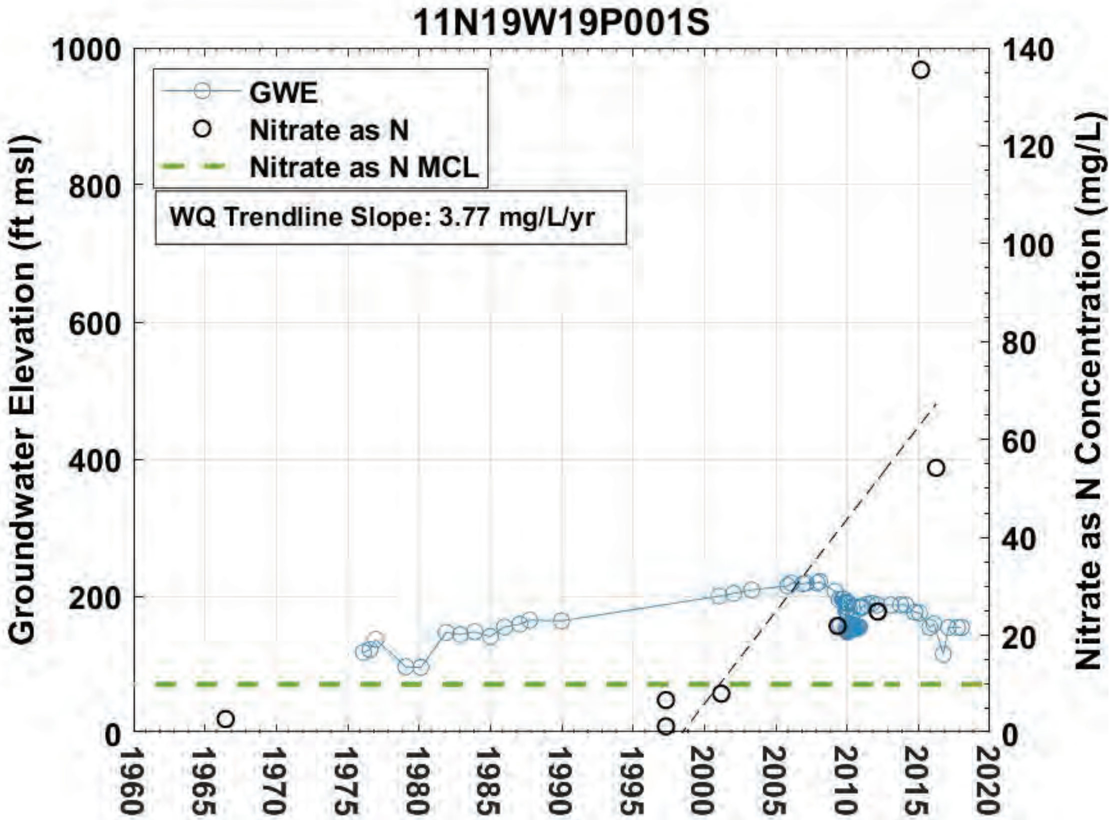

11N19W19G001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
GWE
Nitrate as N
Nitrate as N MCL
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

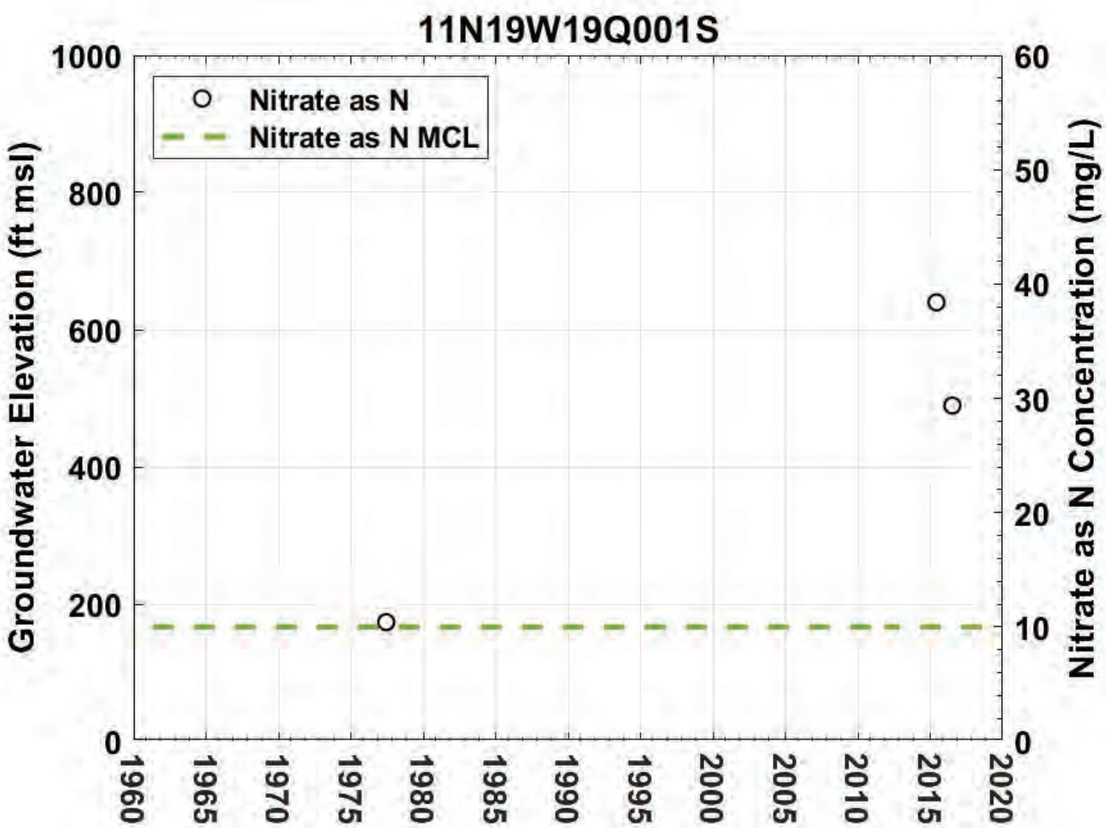

11N19W19H001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
GWE
Nitrate as N
Nitrate as N MCL
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

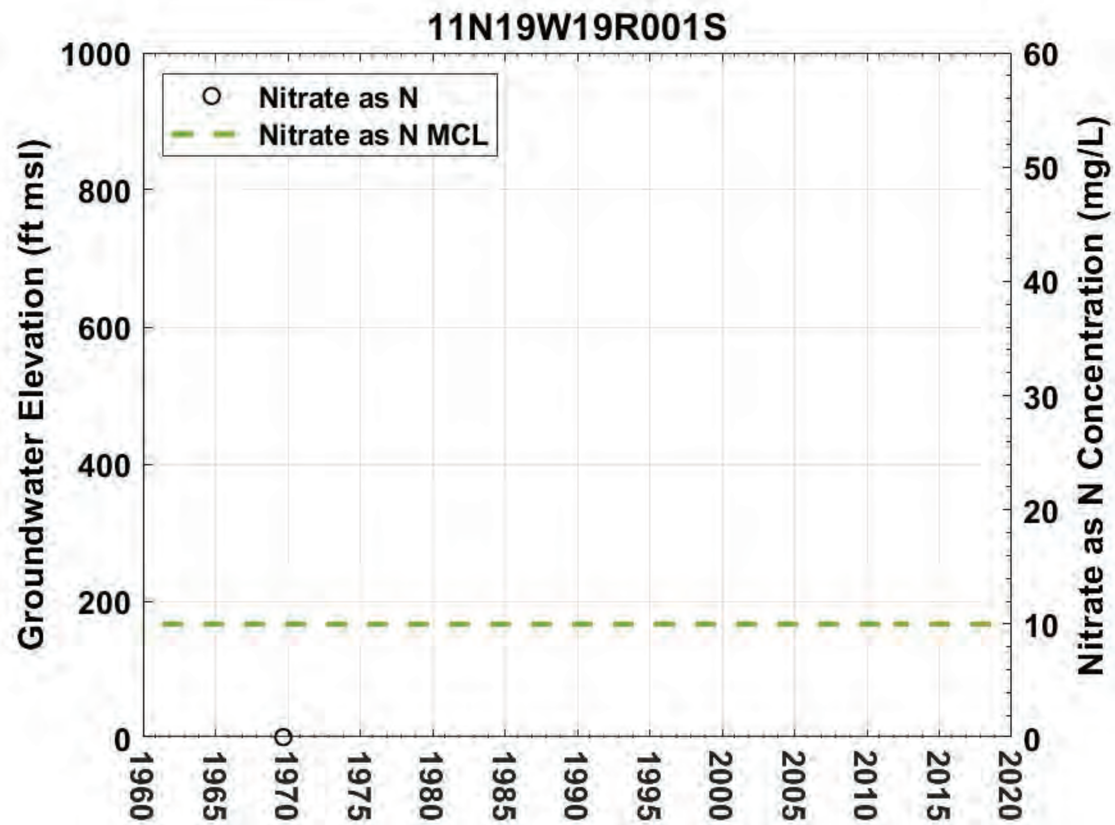

11N19W19L001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
Nitrate as N
Nitrate as N MCL
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

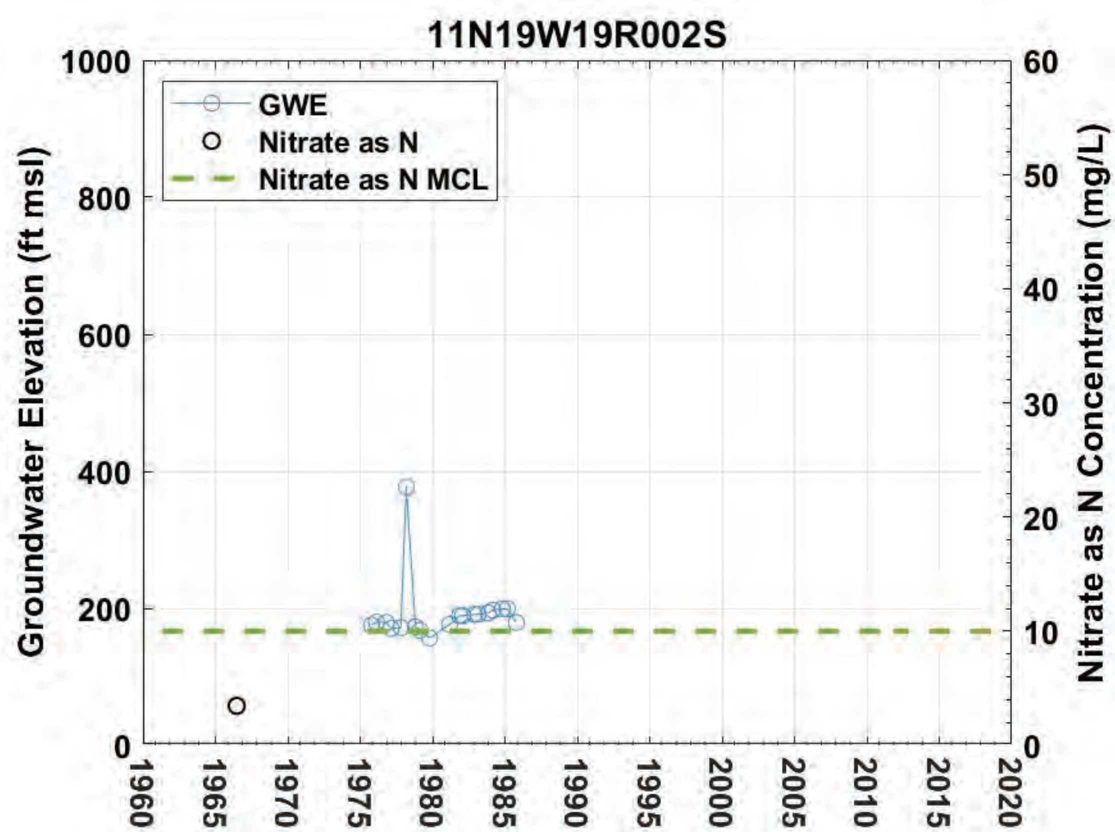

11N19W19M001S
GWE
Nitrate as N
Nitrate as N MCL
WQ Trendline Slope: 1.93 mg/L/yr
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
20
40
60
80
100
120
140
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

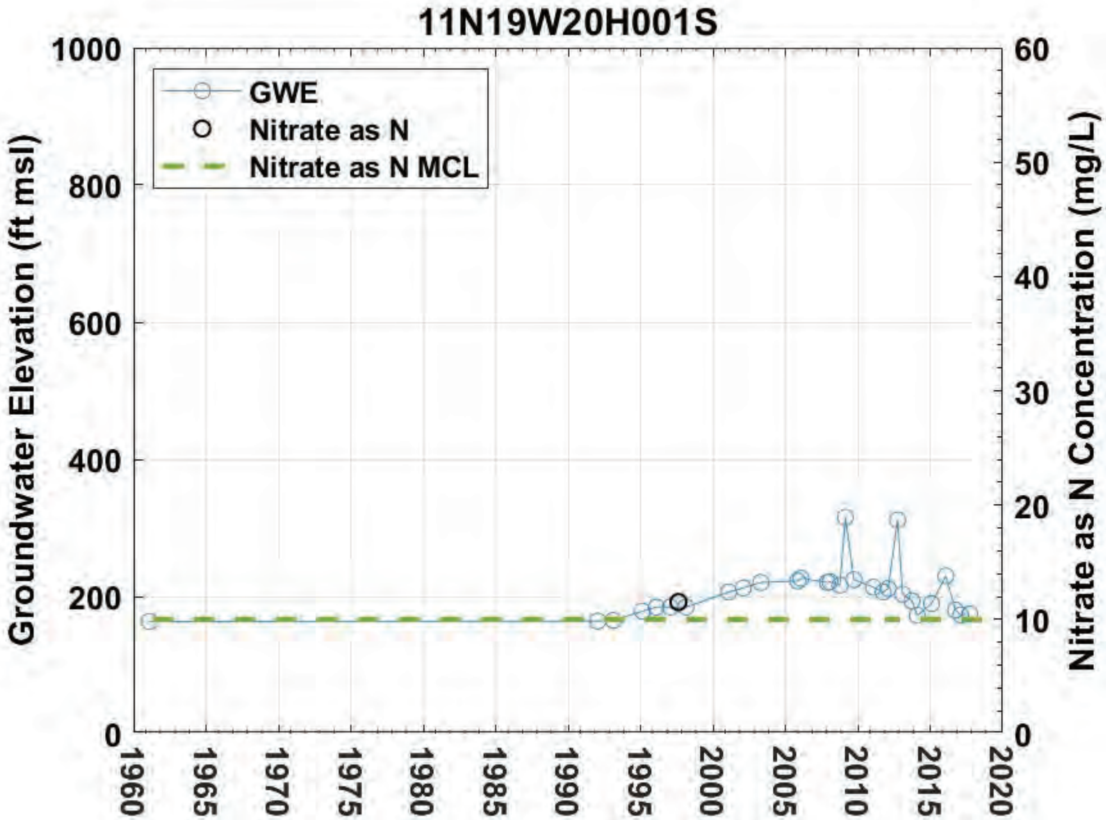

11N19W19N001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W19P001S
GWE
Nitrate as N
Nitrate as N MCL
WQ Trendline Slope: 3.77 mg/L/yr
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)

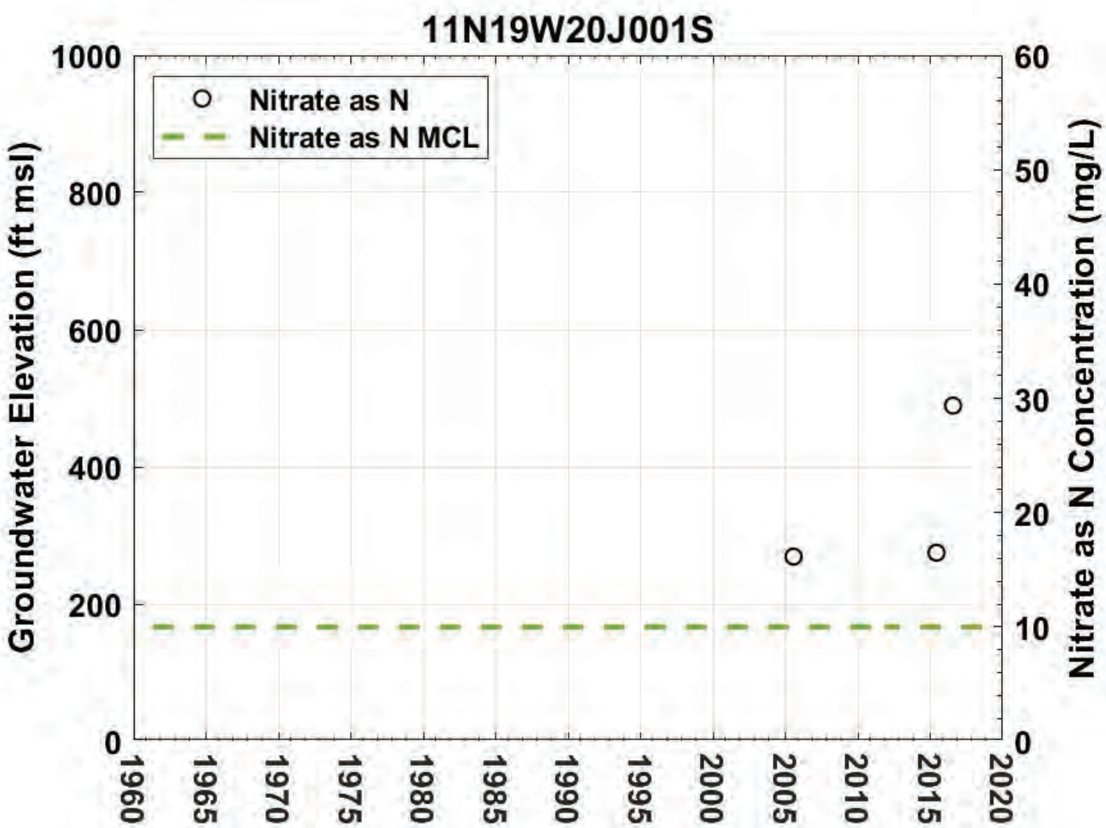

11N19W19Q001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)


11N19W19R001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

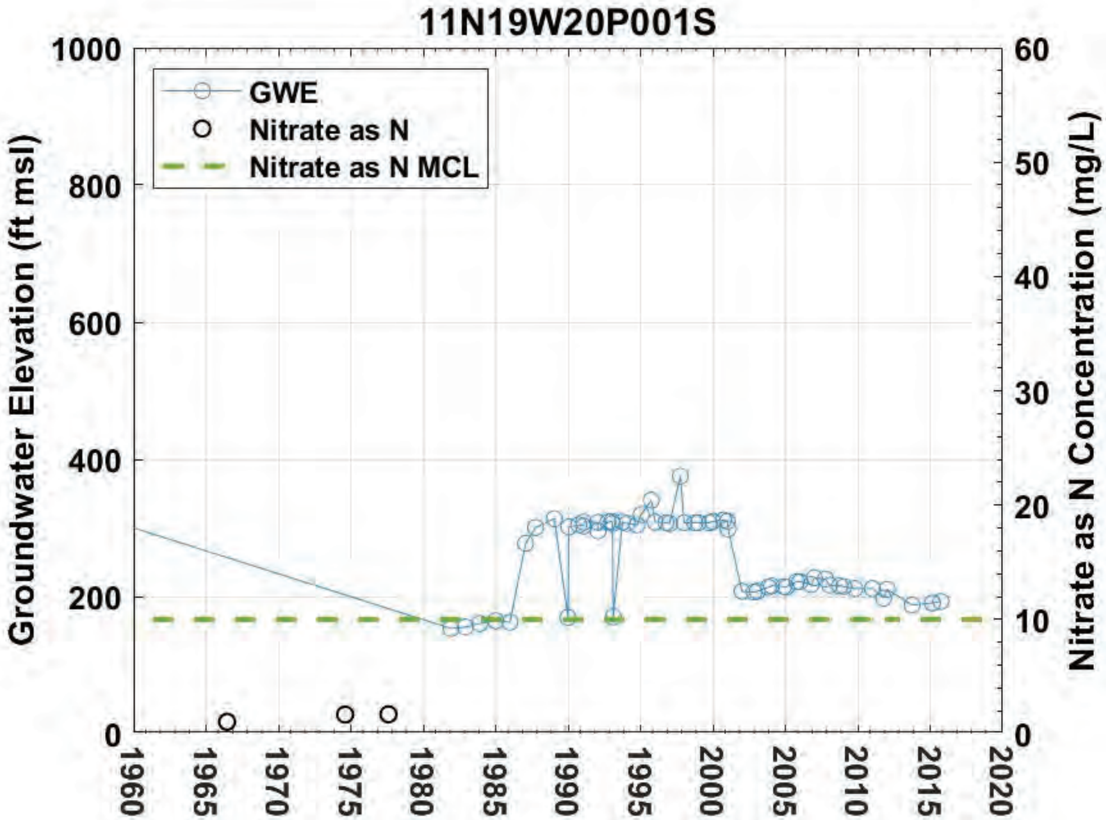

11N19W19R002S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

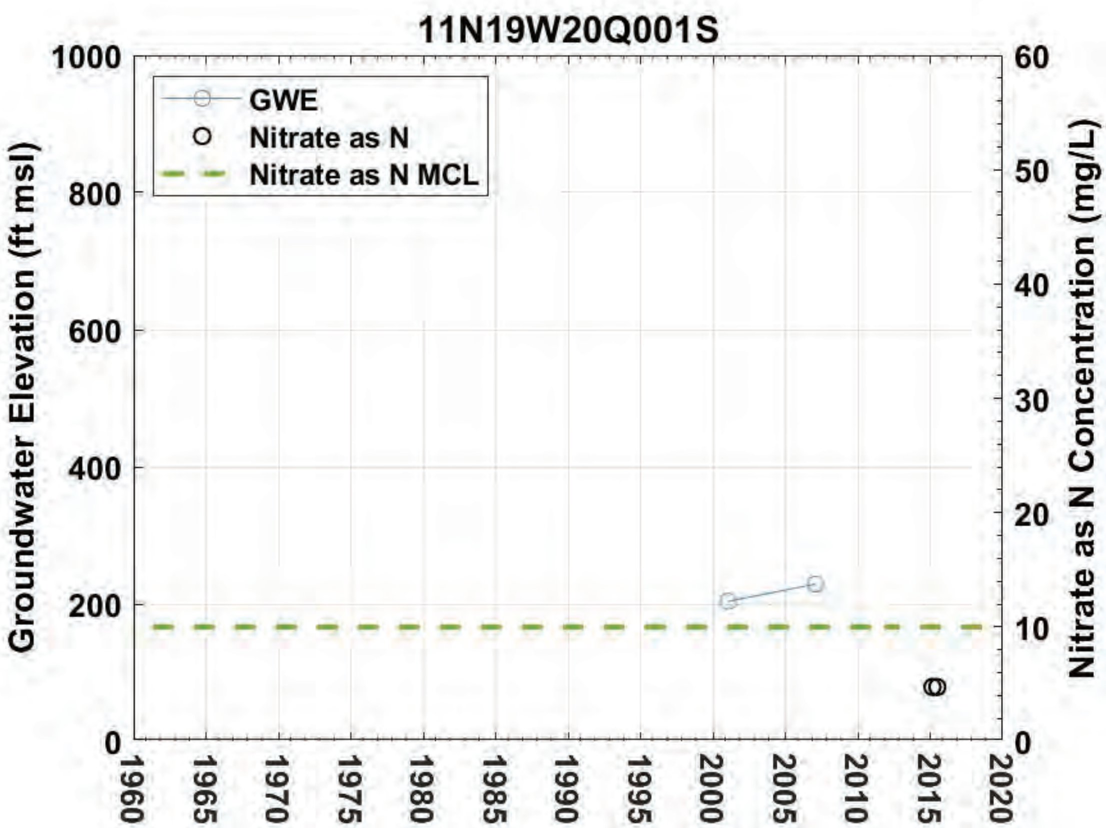


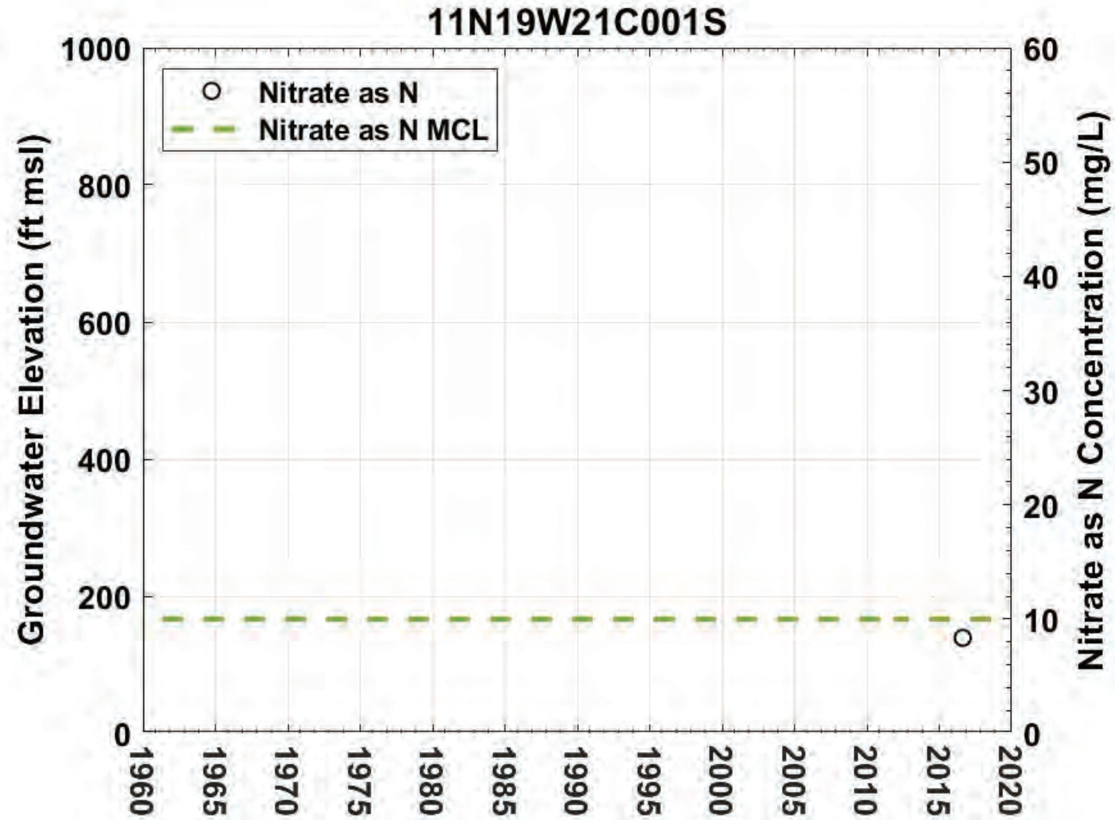
11N19W20H001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

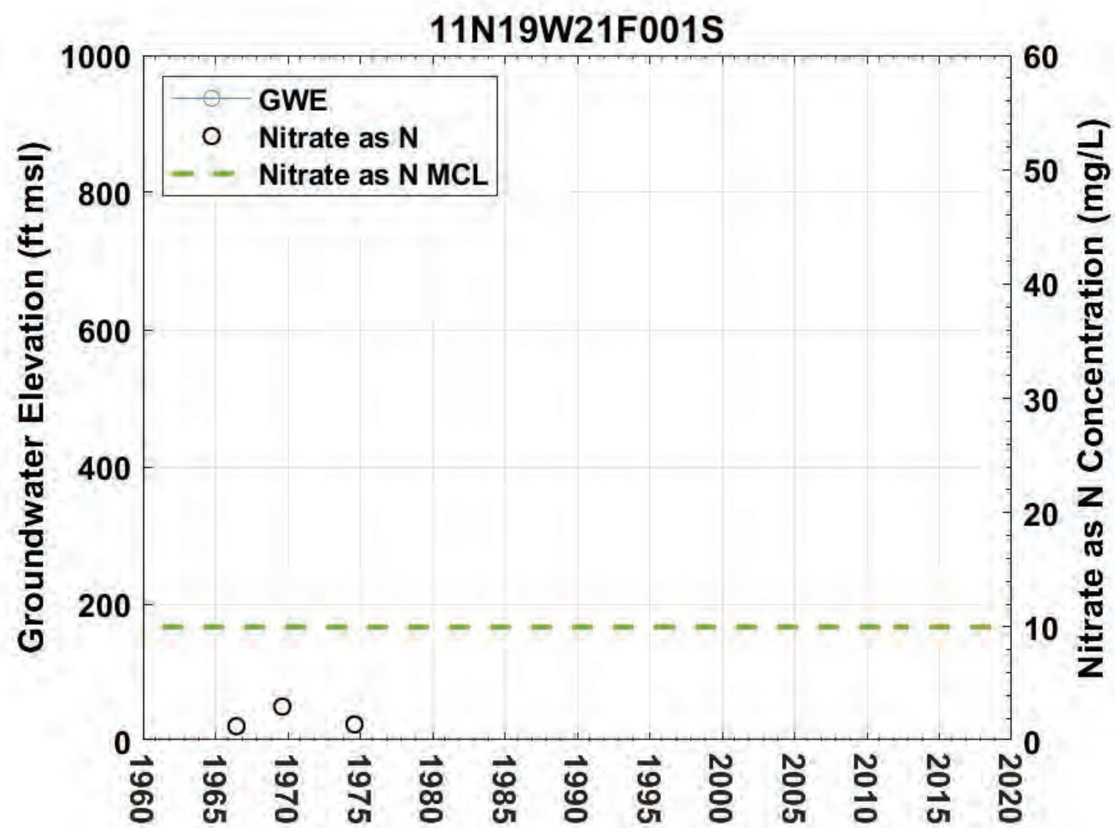


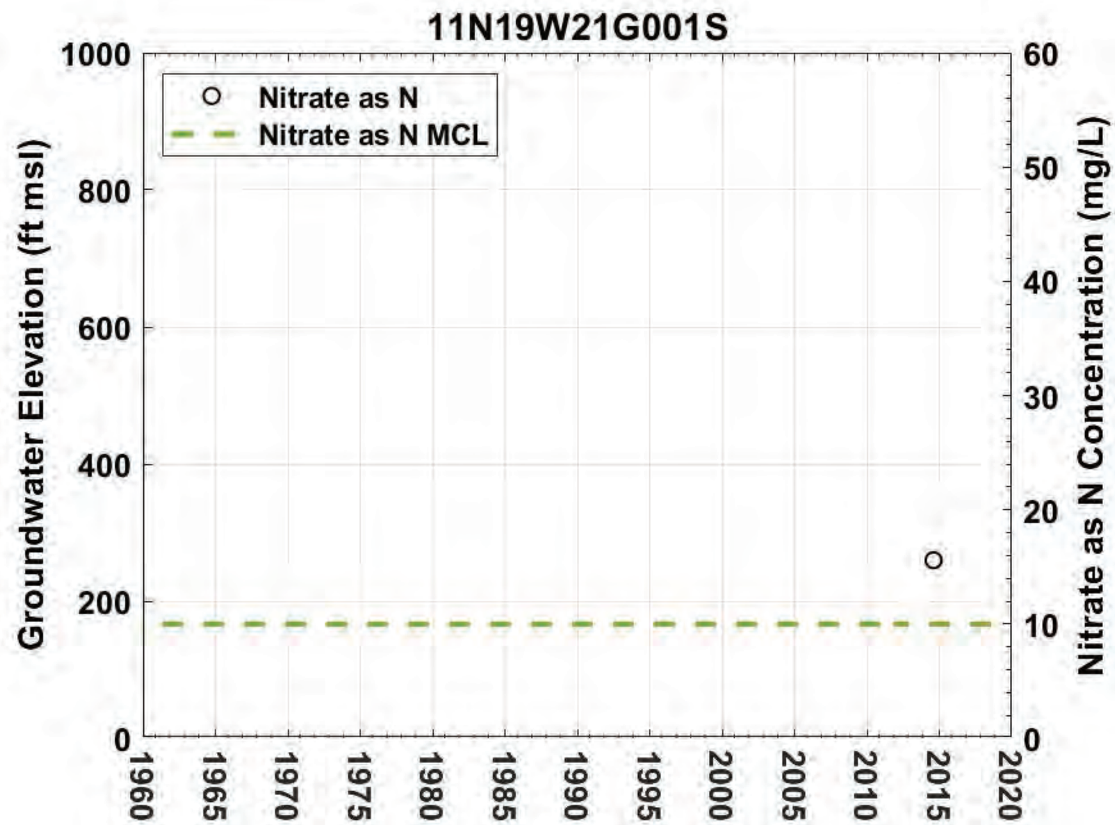
11N19W20J001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

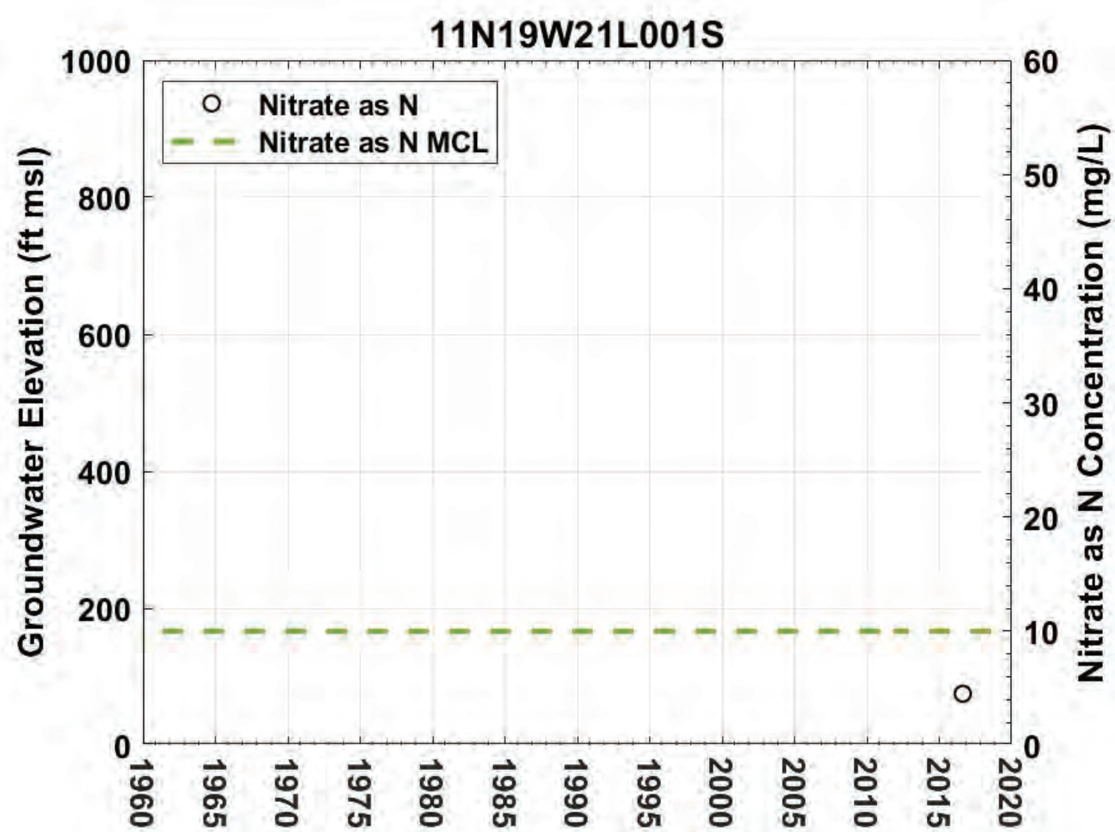

11N19W20P001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

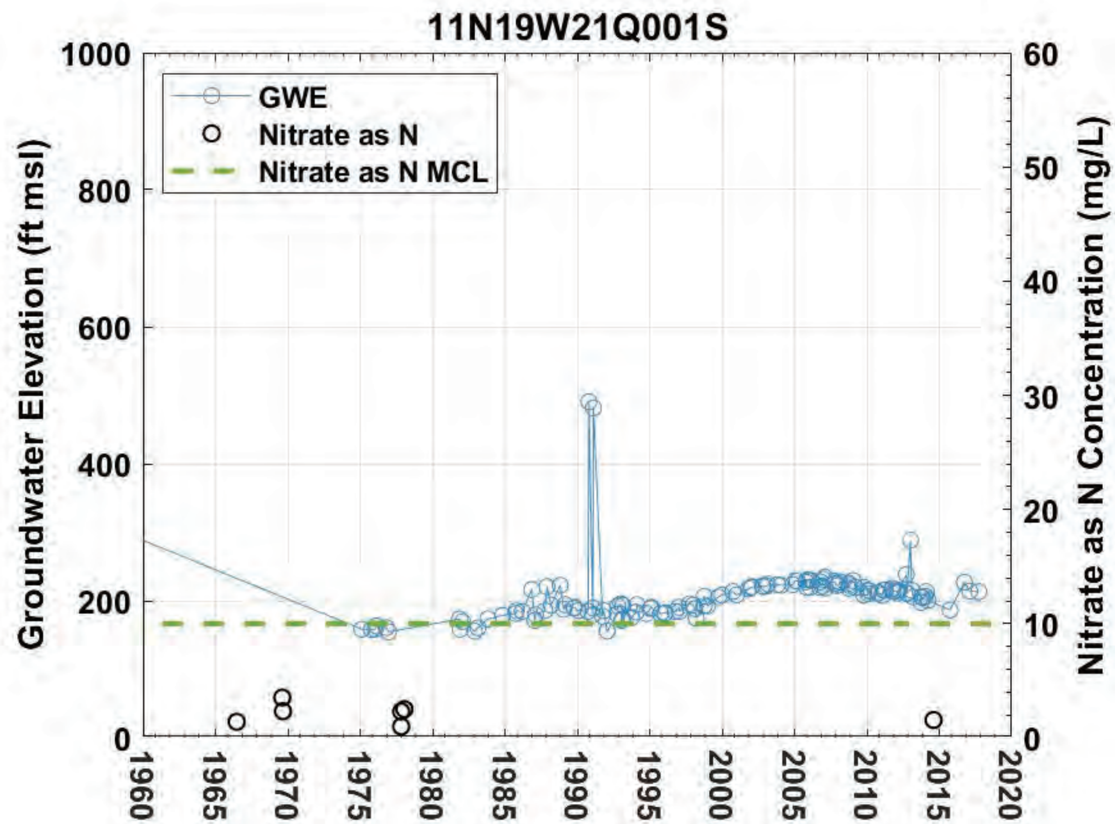

11N19W20Q001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

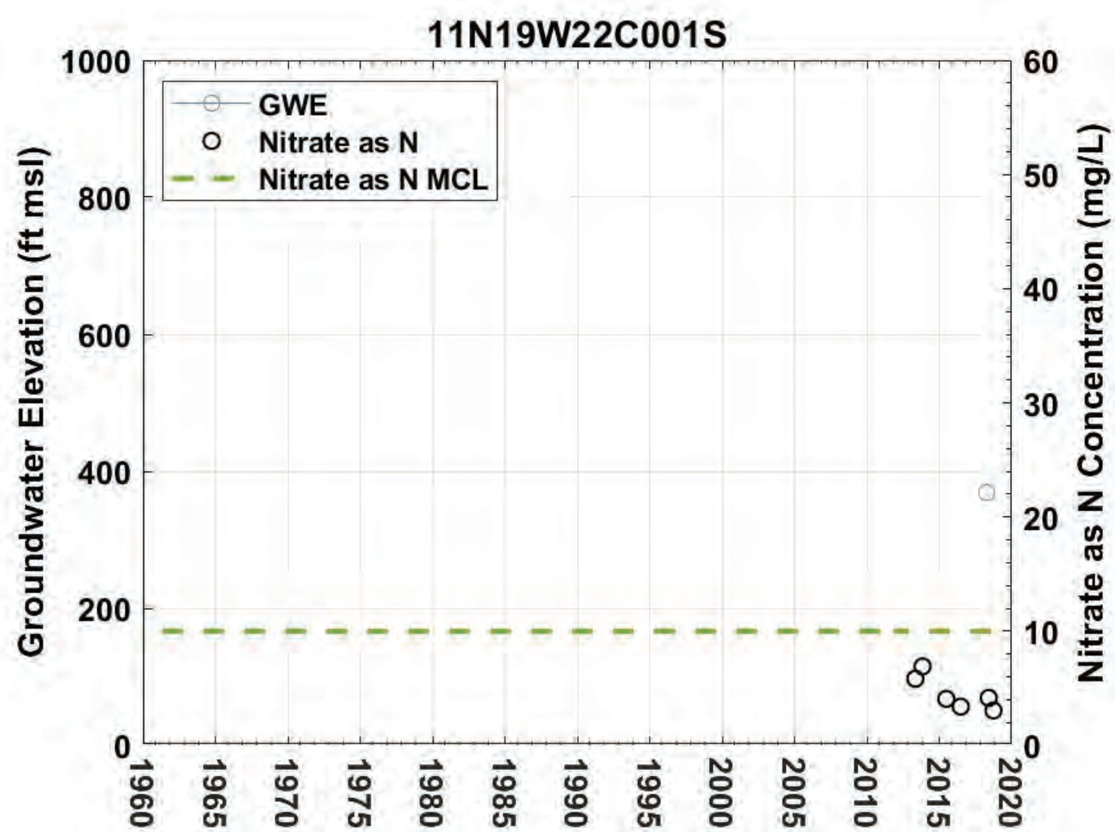

11N19W21C001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

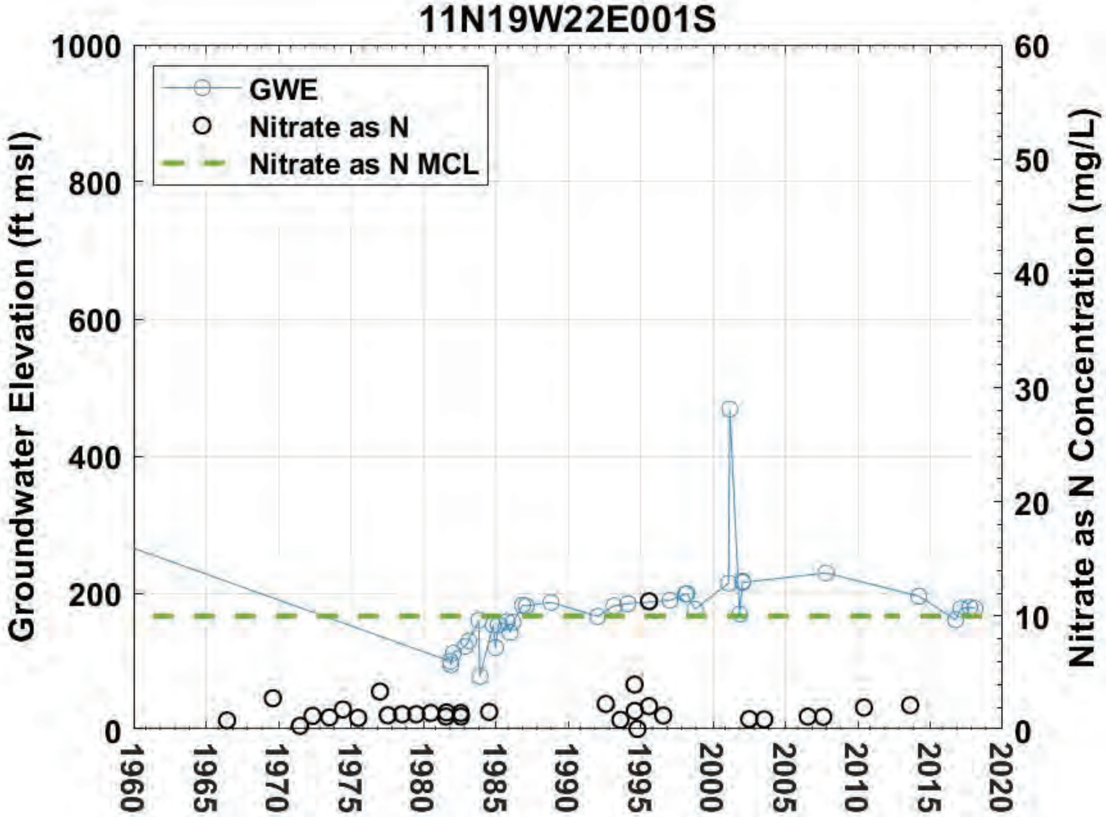

11N19W21F001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W21G001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

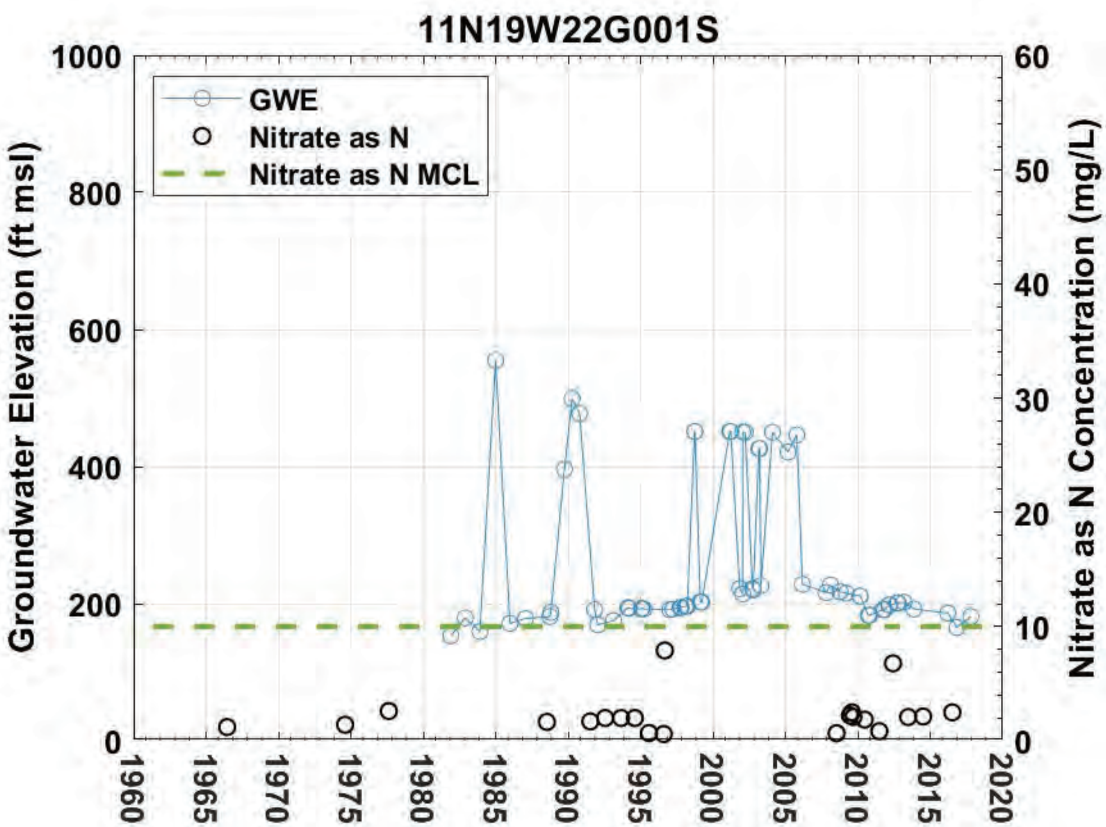

11N19W21L001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W21Q001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

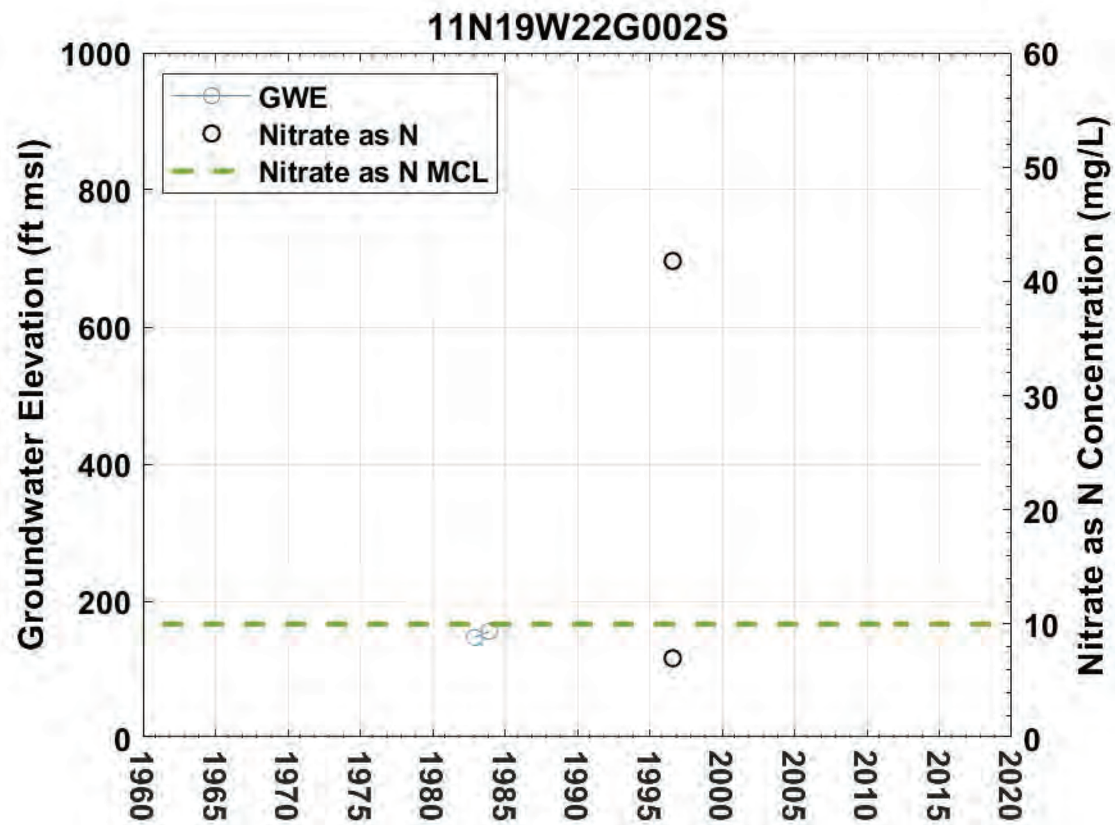

11N19W22C001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

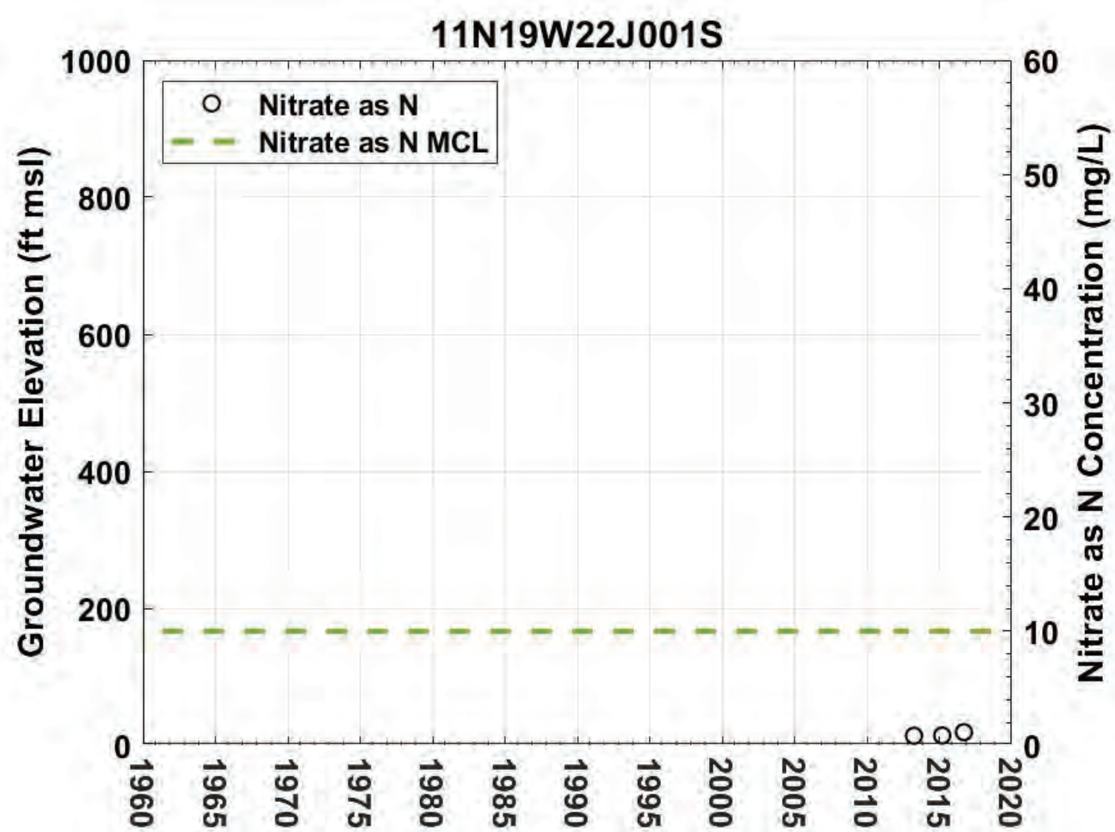


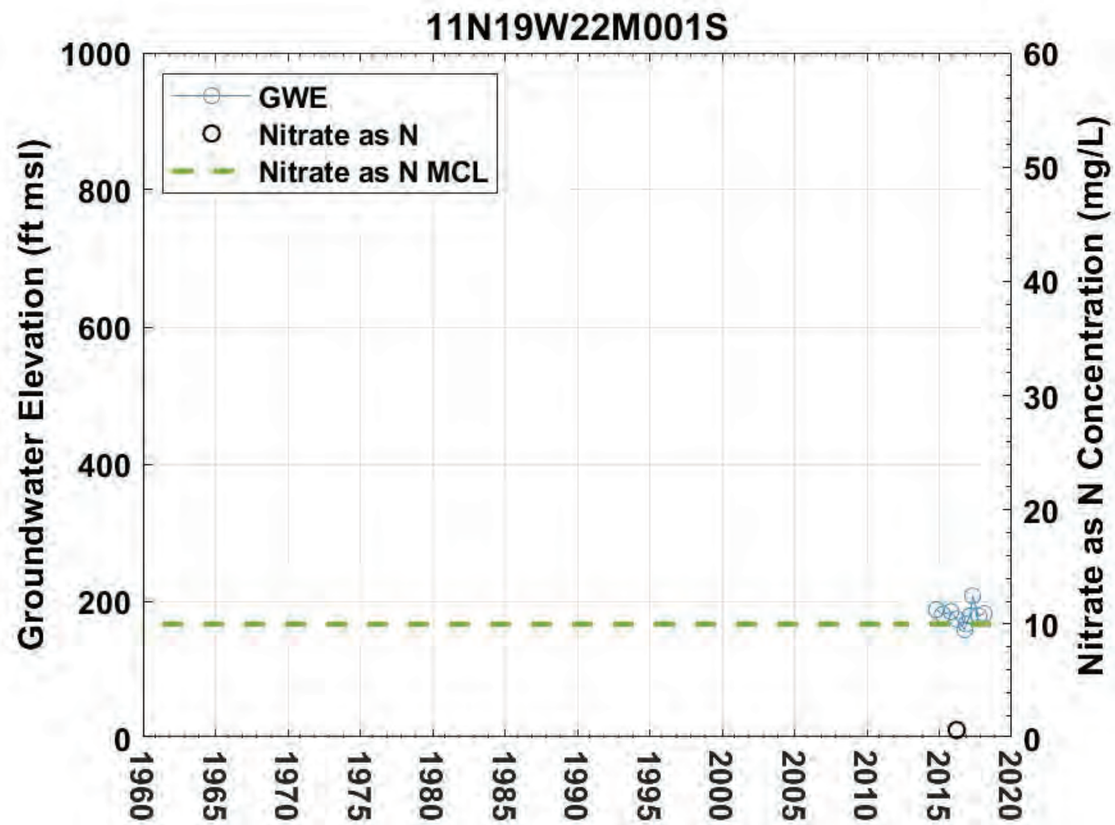
11N19W22E001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



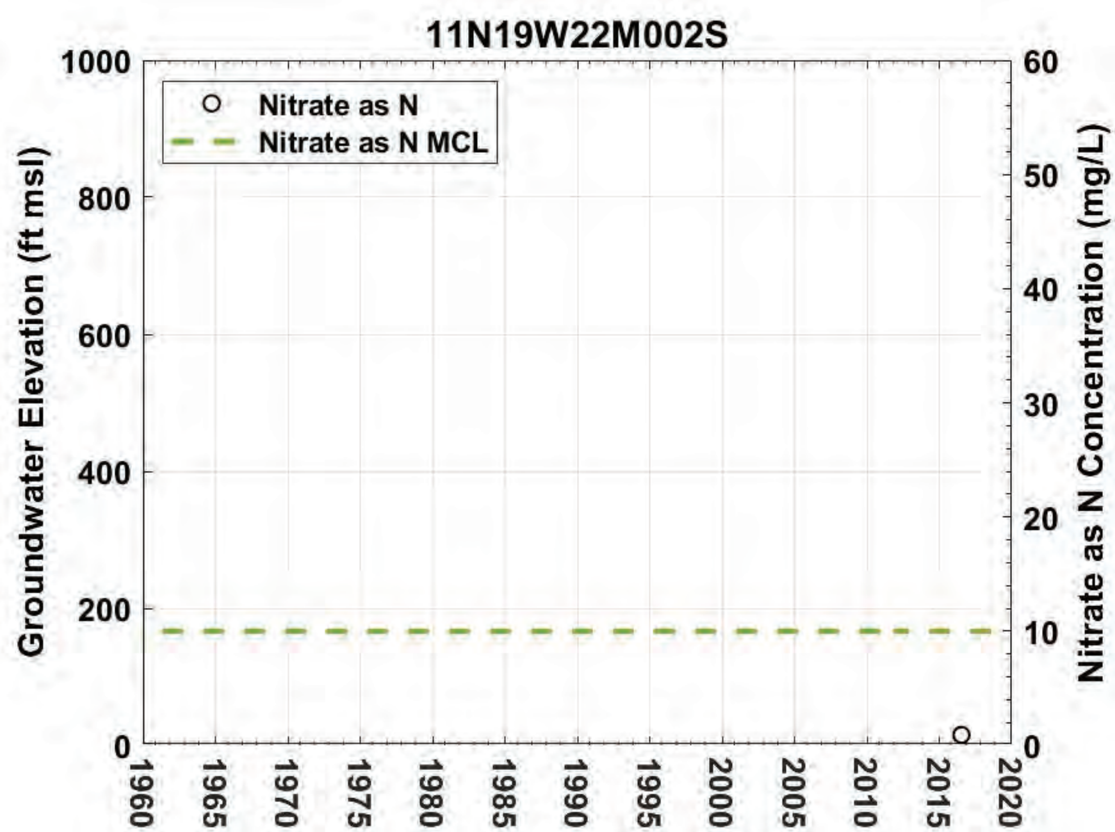
11N19W22G001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W22G002S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

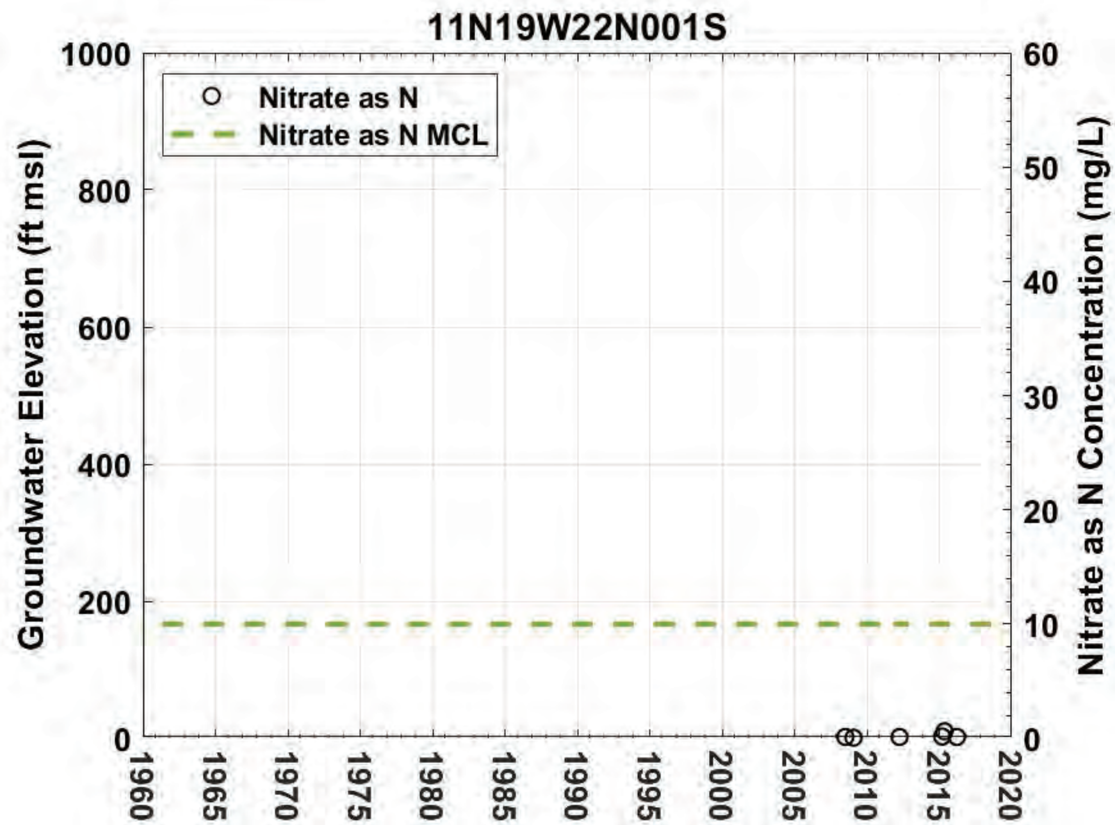

11N19W22J001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

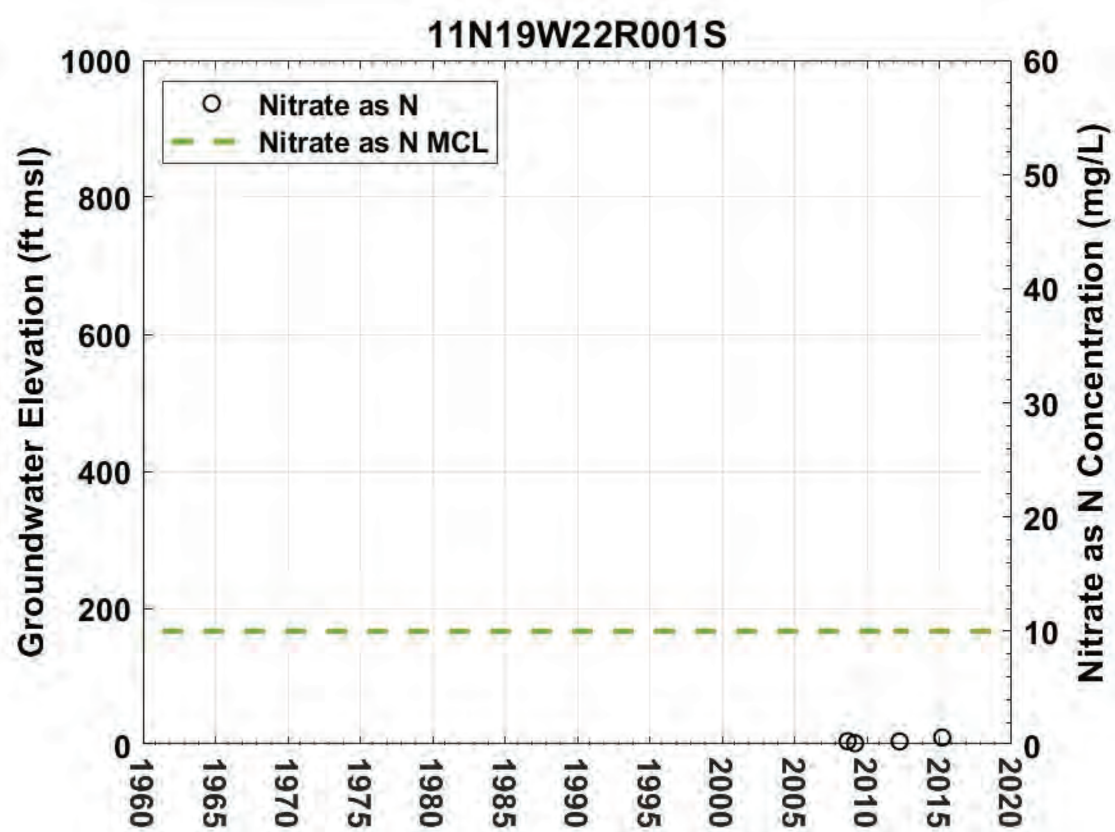


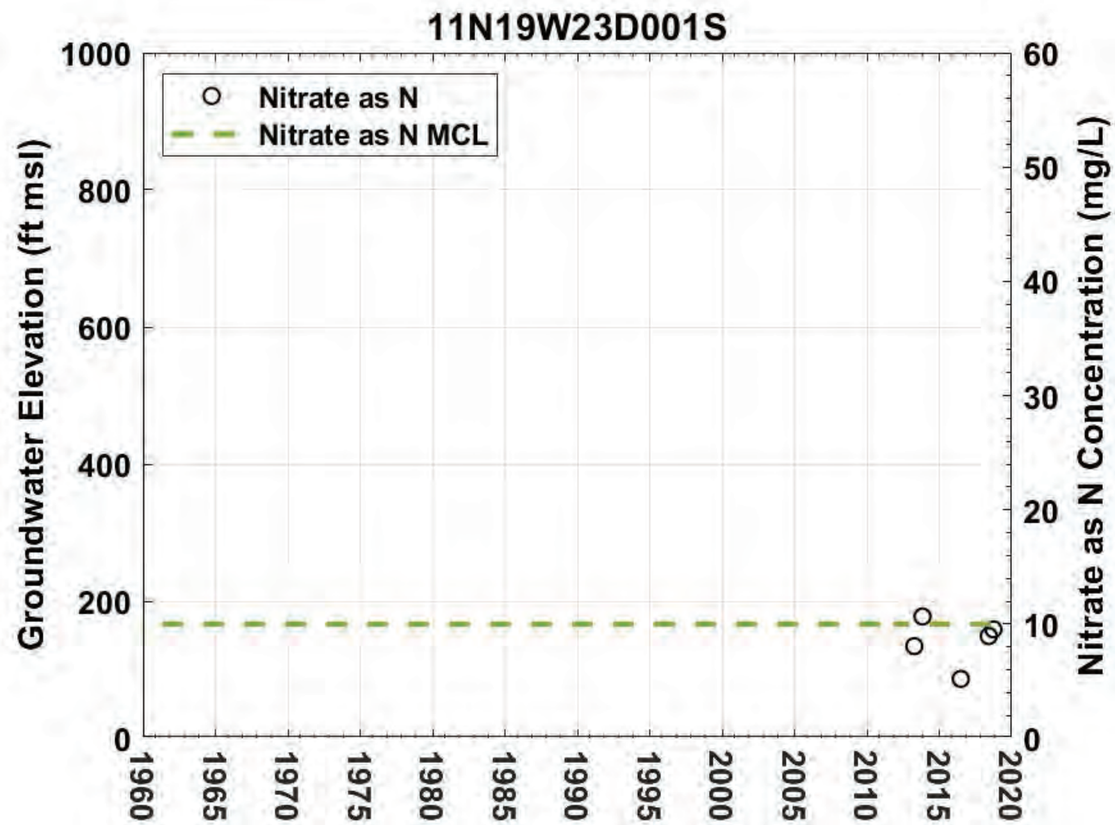
11N19W22M001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



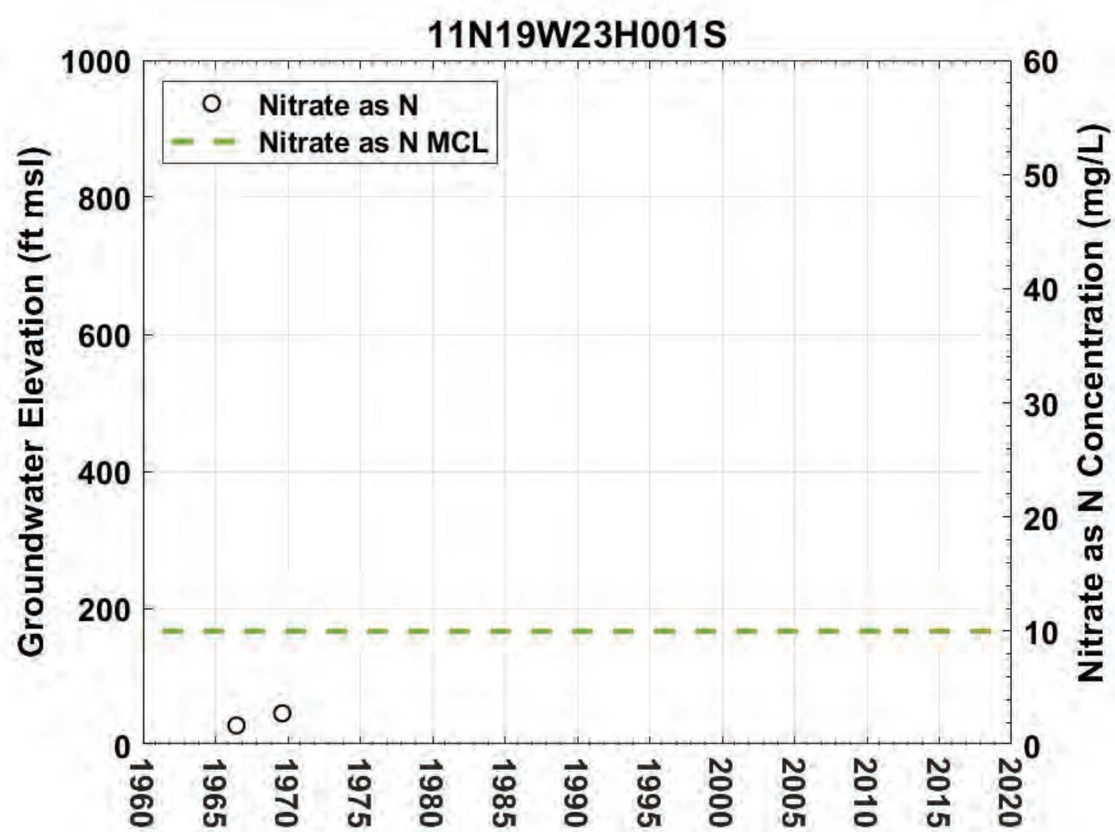
11N19W22M002S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W22N001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

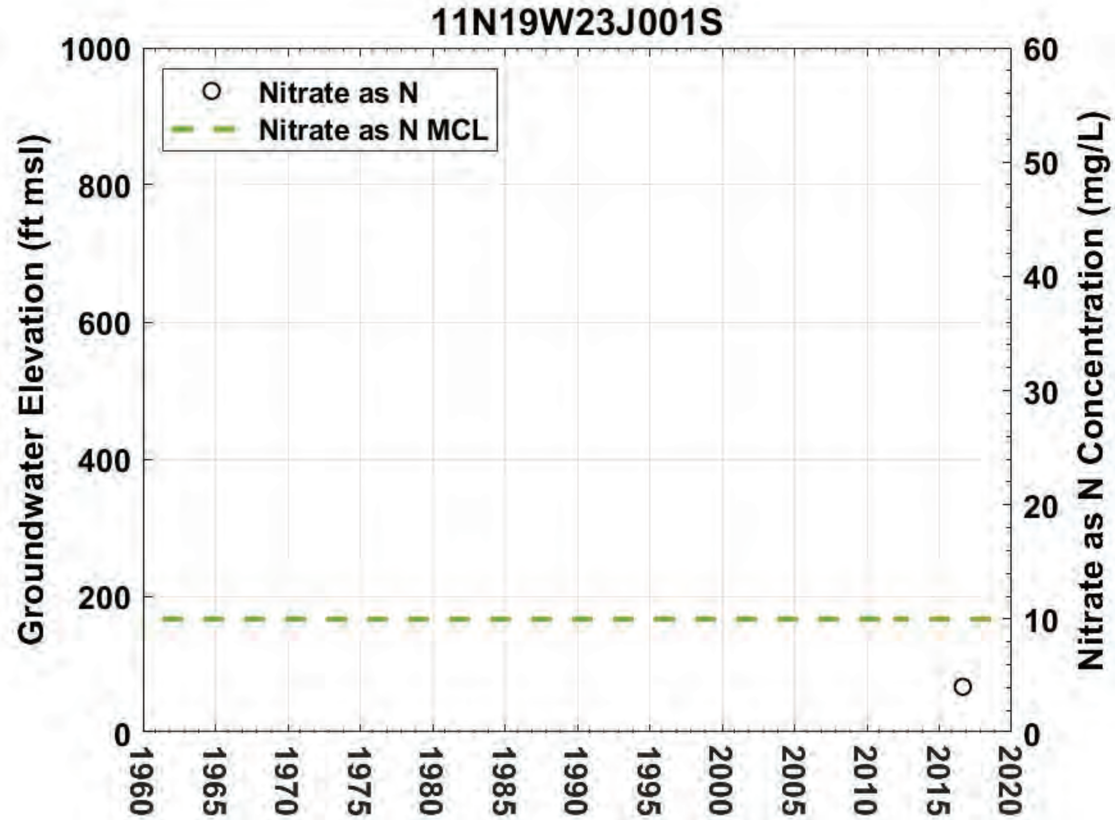

11N19W22R001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

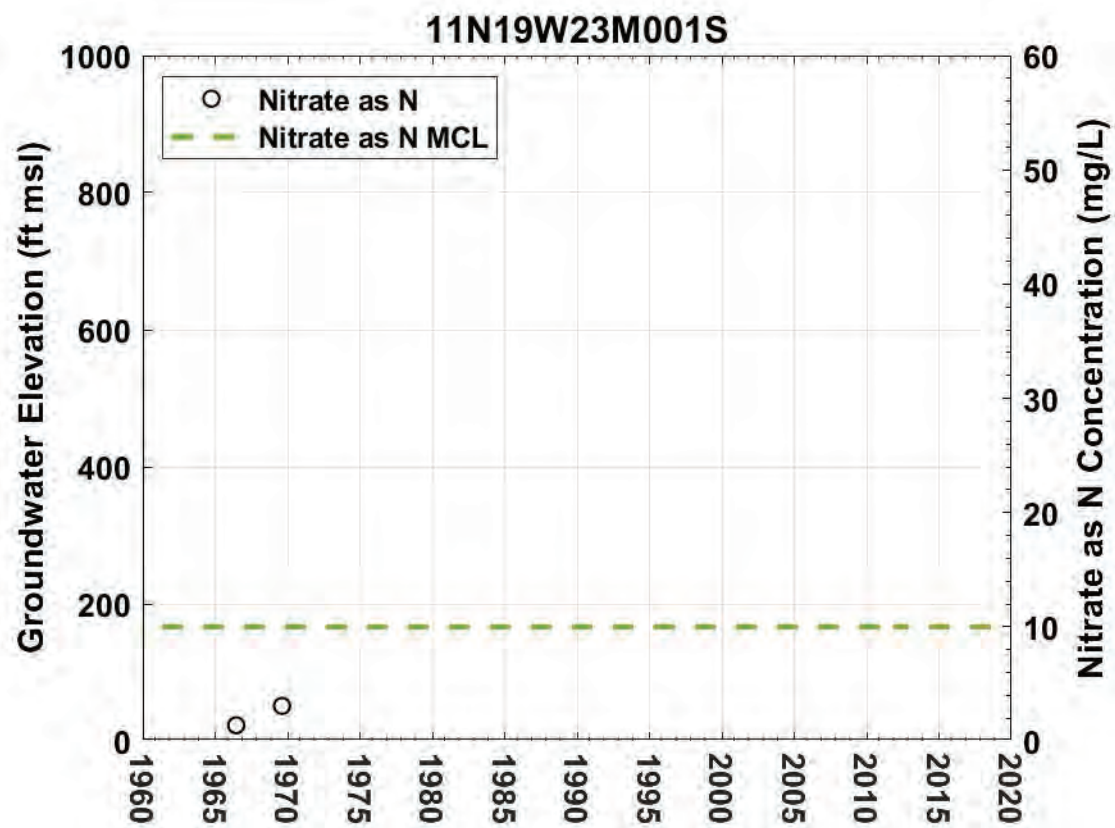


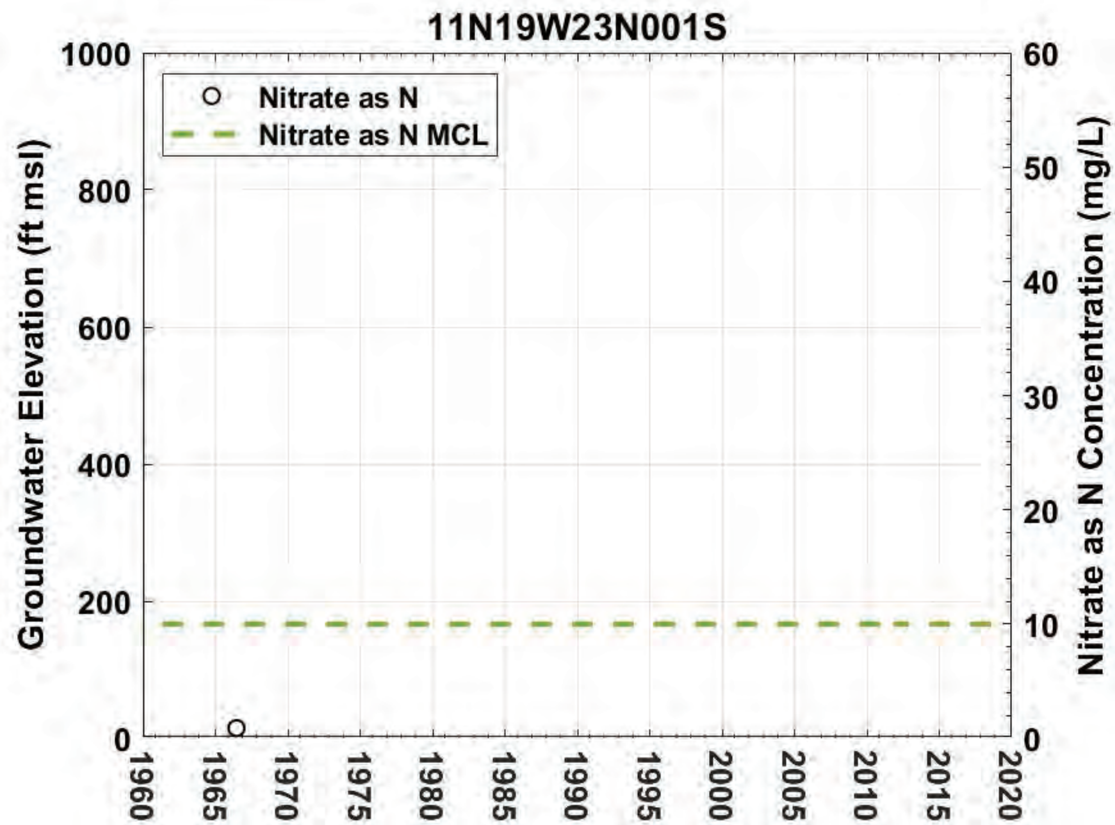
11N19W23D001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



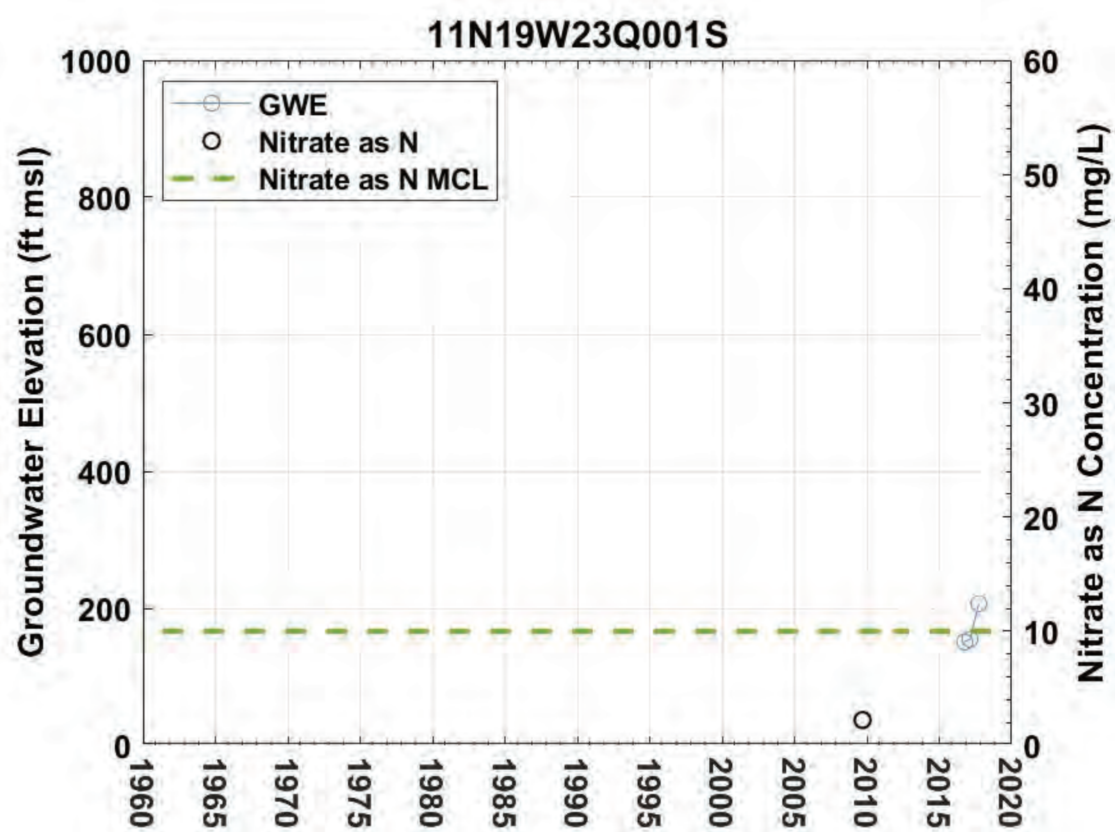
11N19W23H001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W23J001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

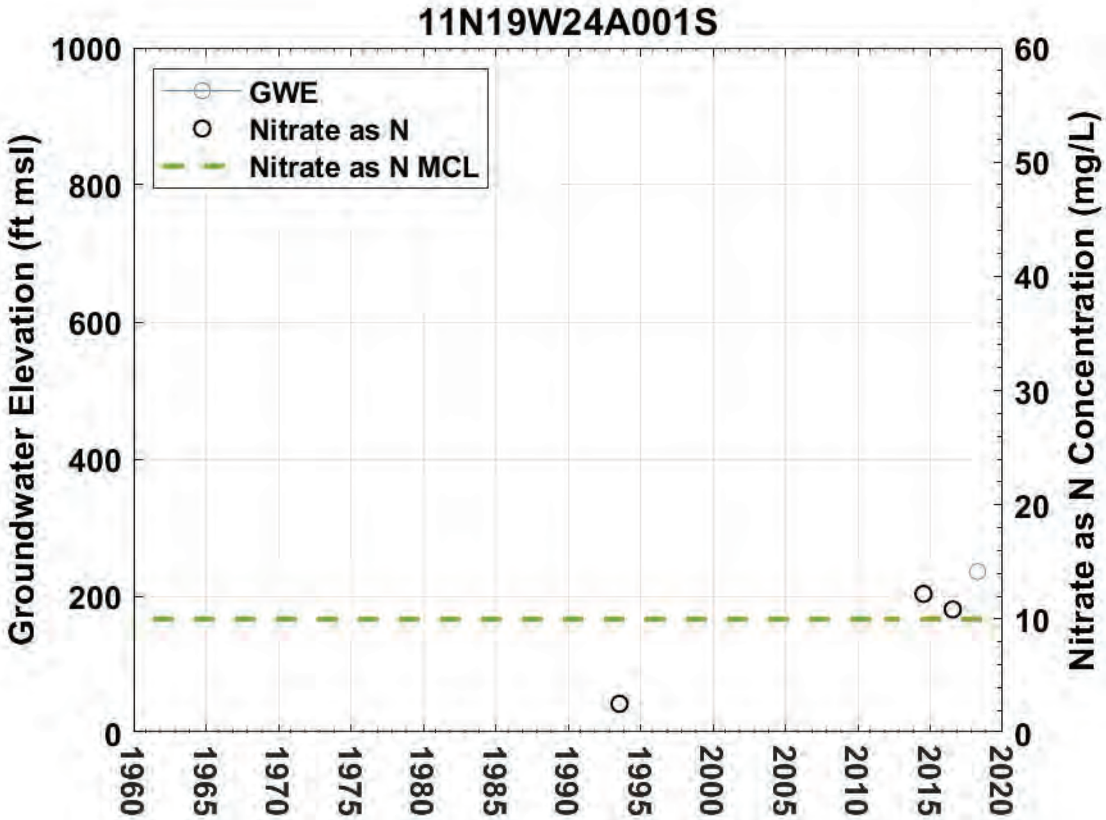

11N19W23M001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

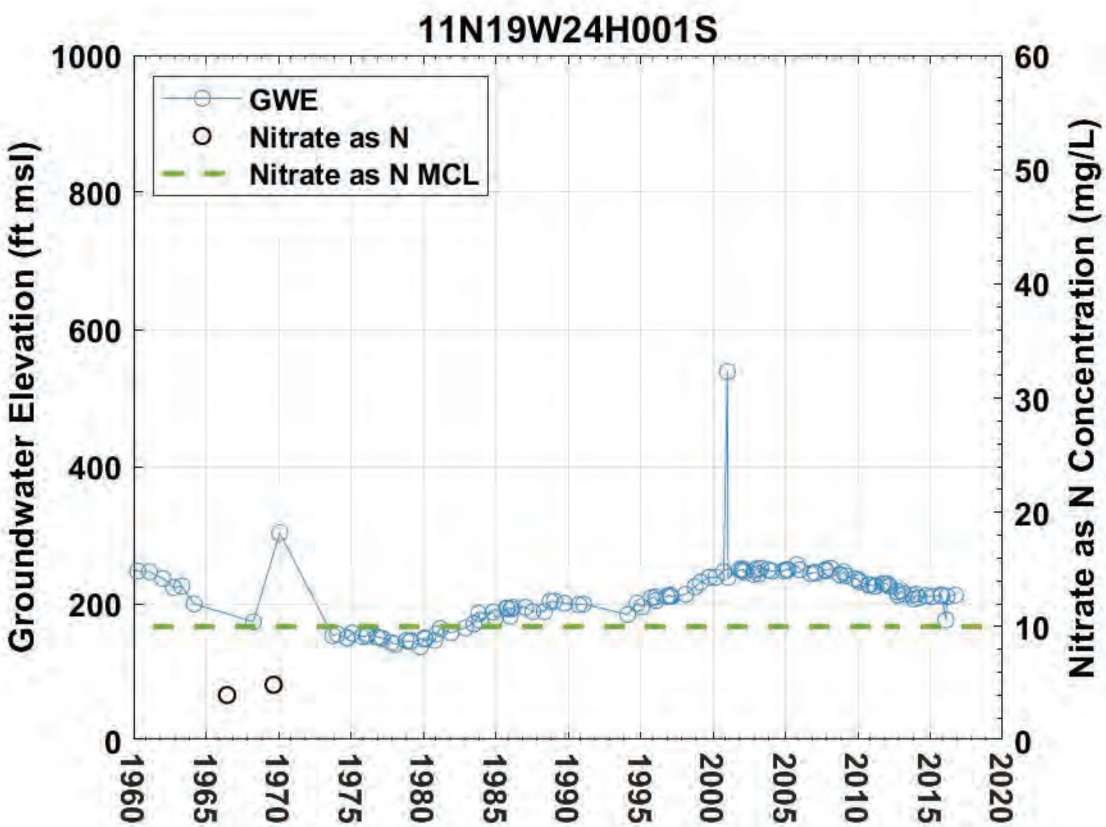


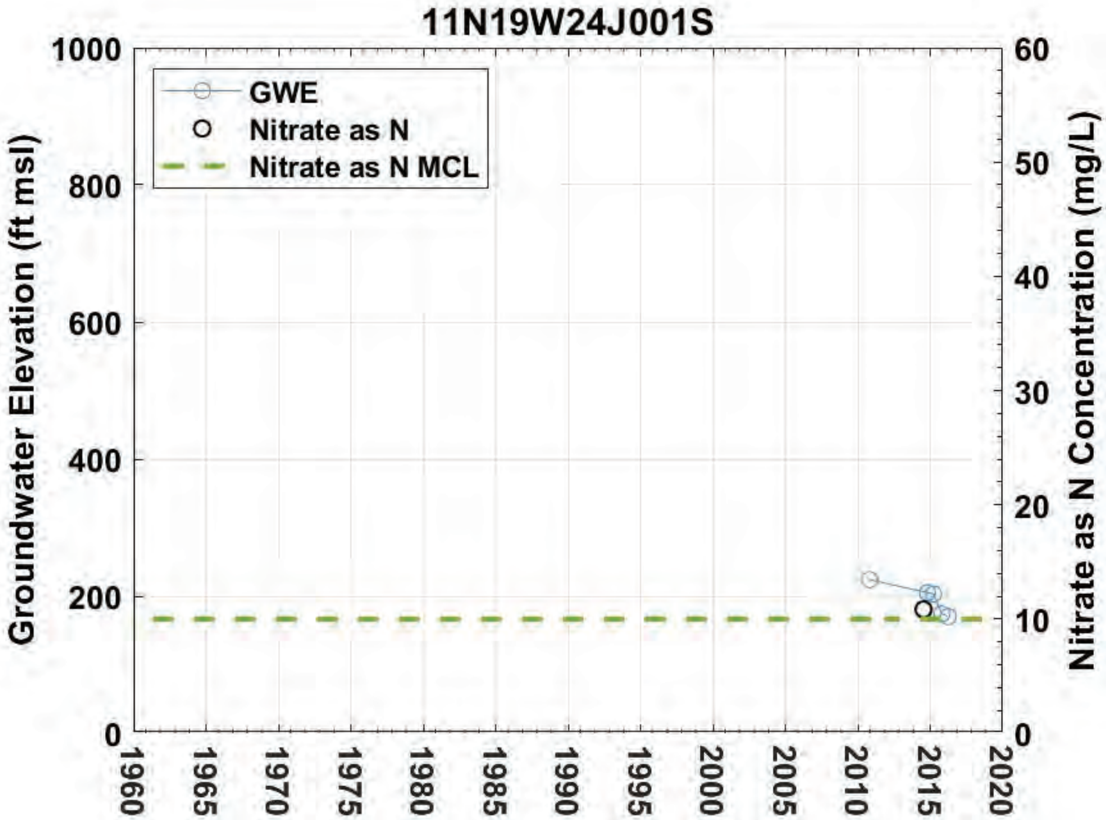
11N19W23N001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



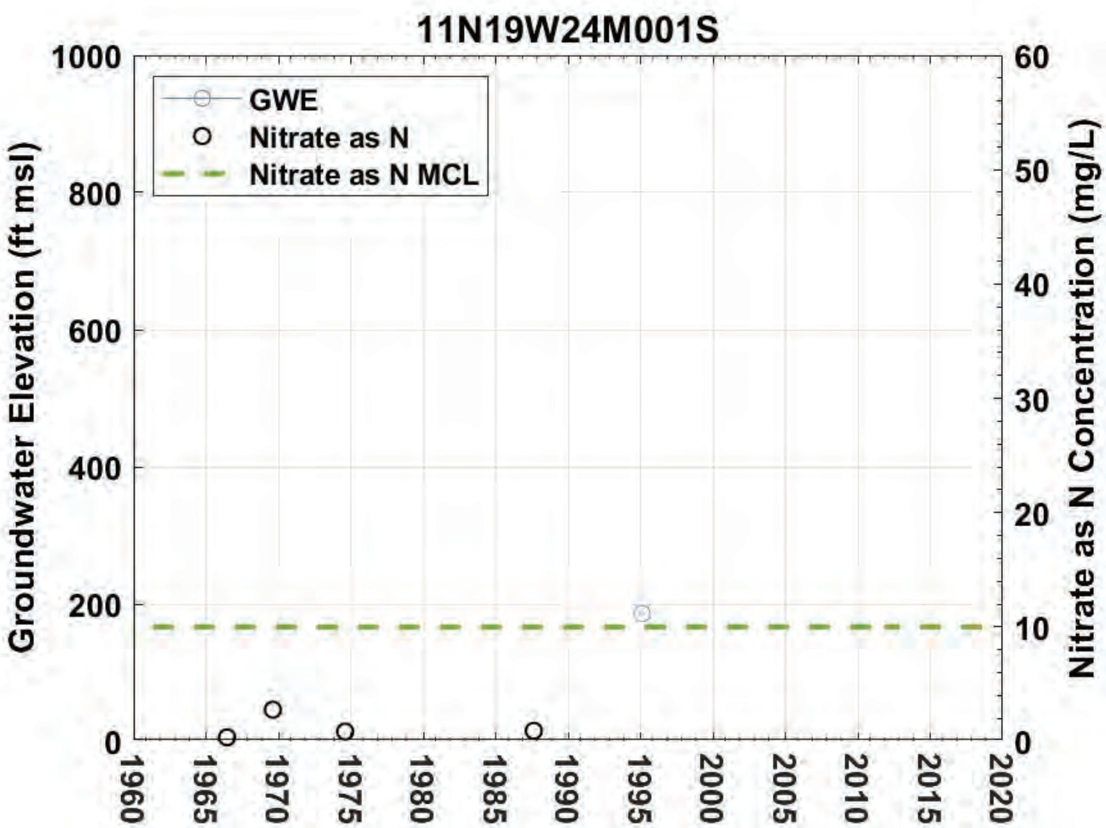
11N19W23Q001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W24A001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
GWE
Nitrate as N
Nitrate as N MCL
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

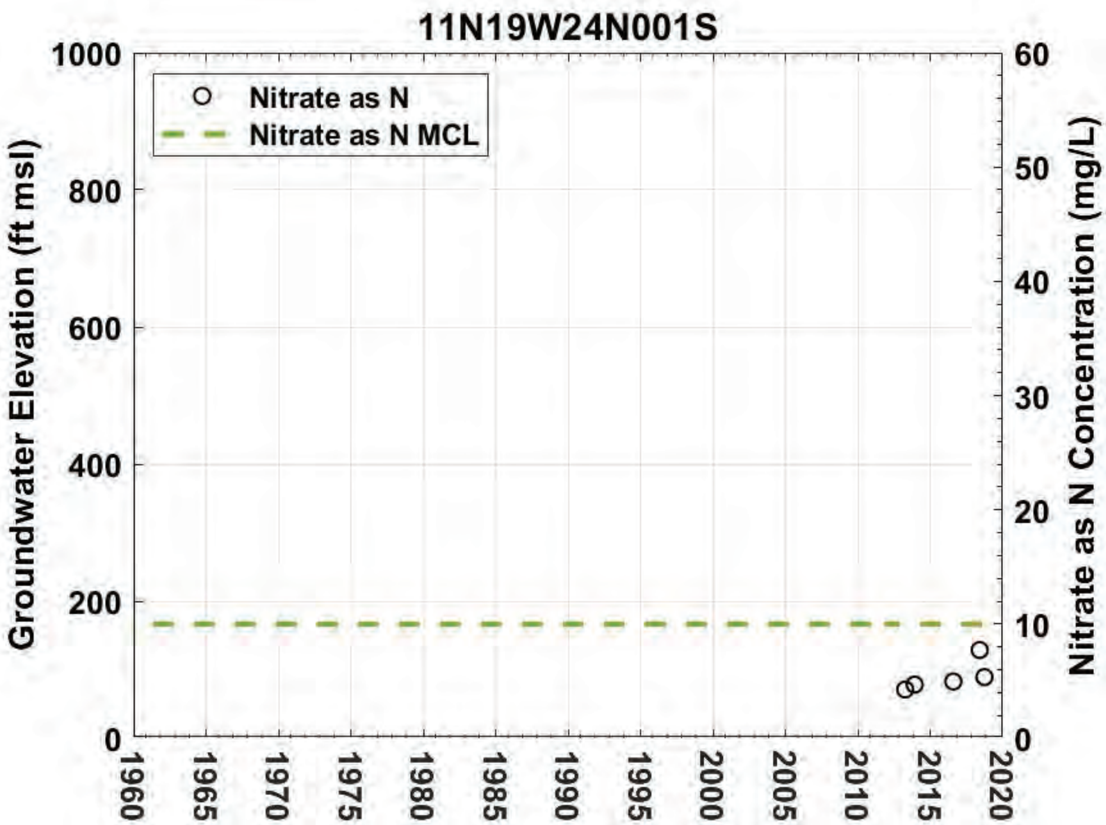

11N19W24H001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
GWE
Nitrate as N
Nitrate as N MCL
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



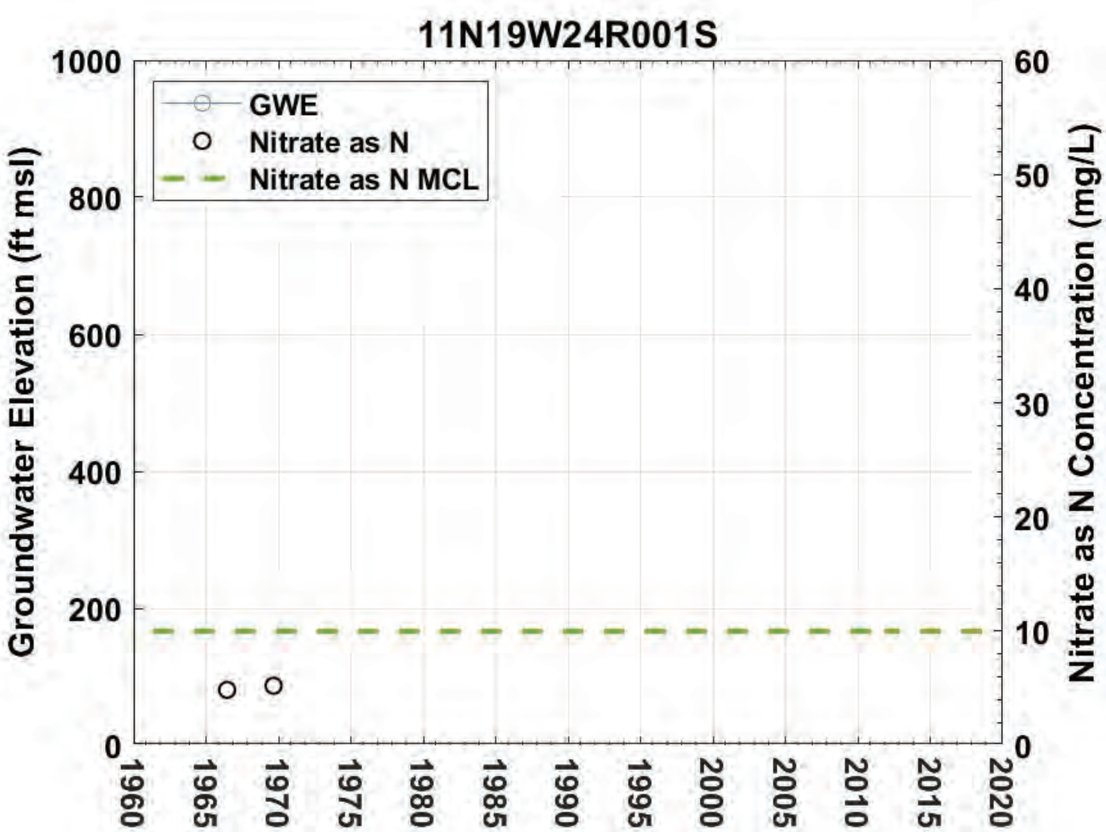
11N19W24J001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



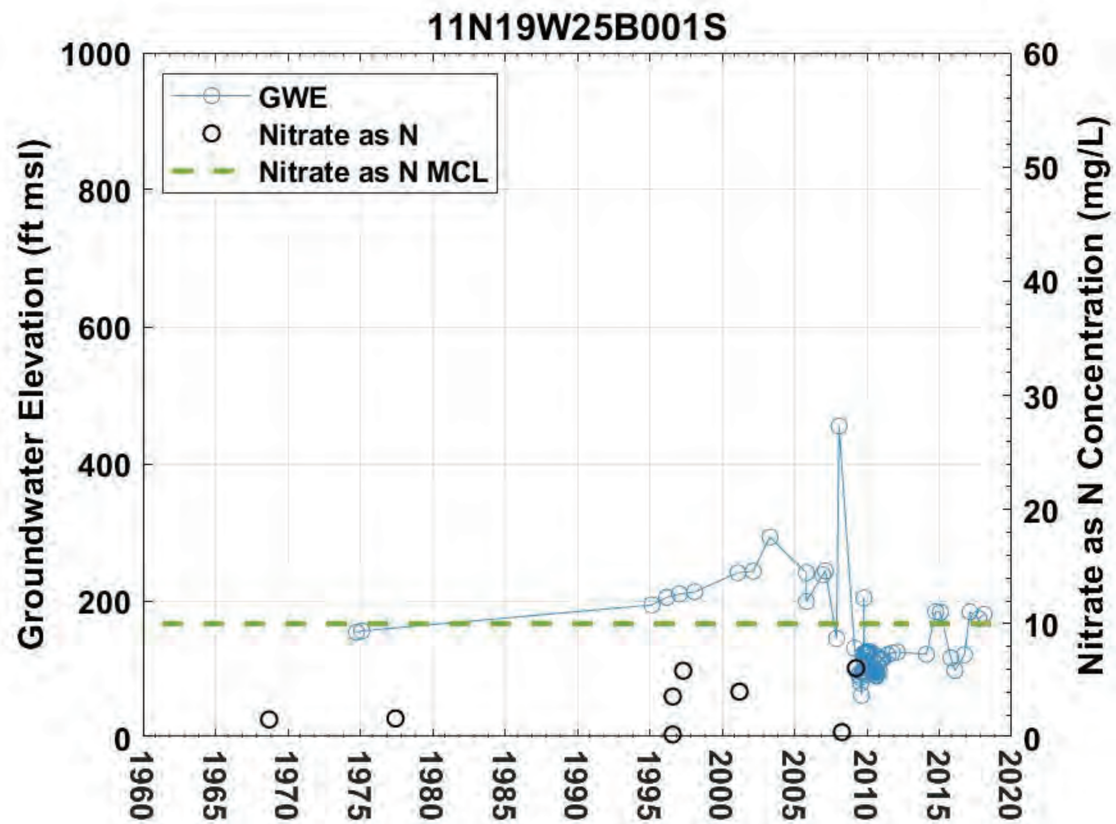
11N19W24M001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

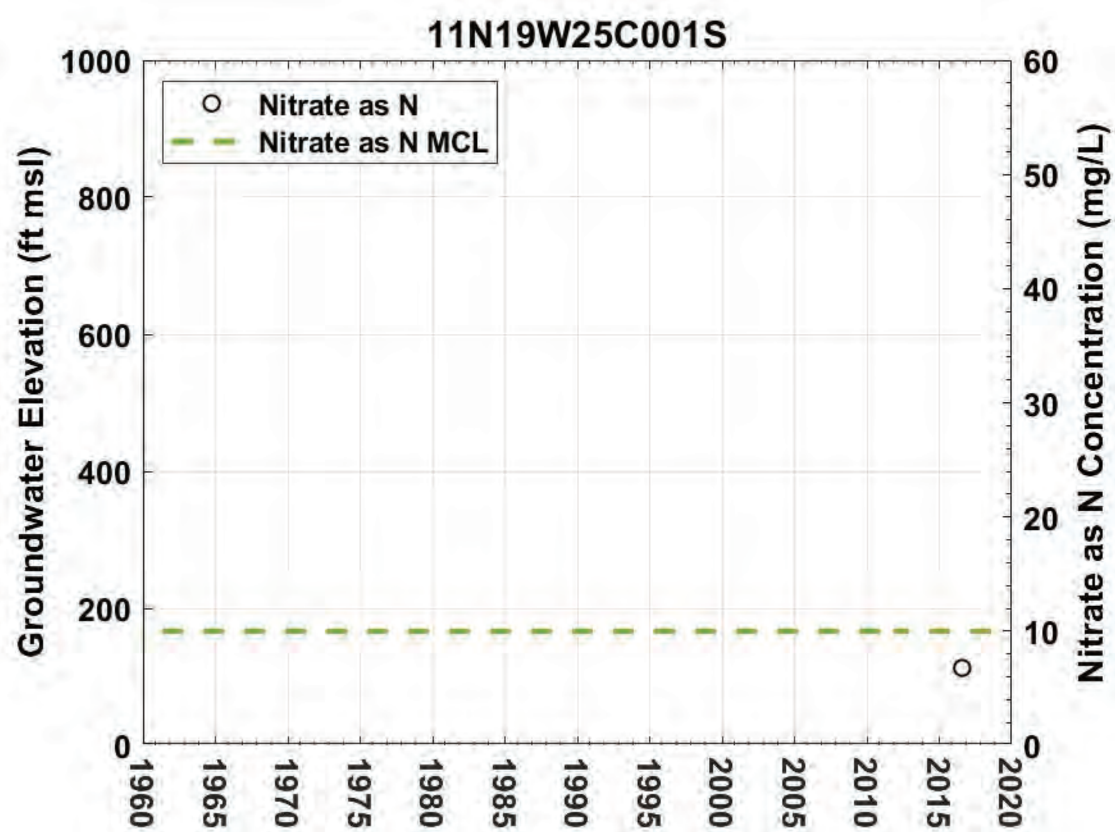


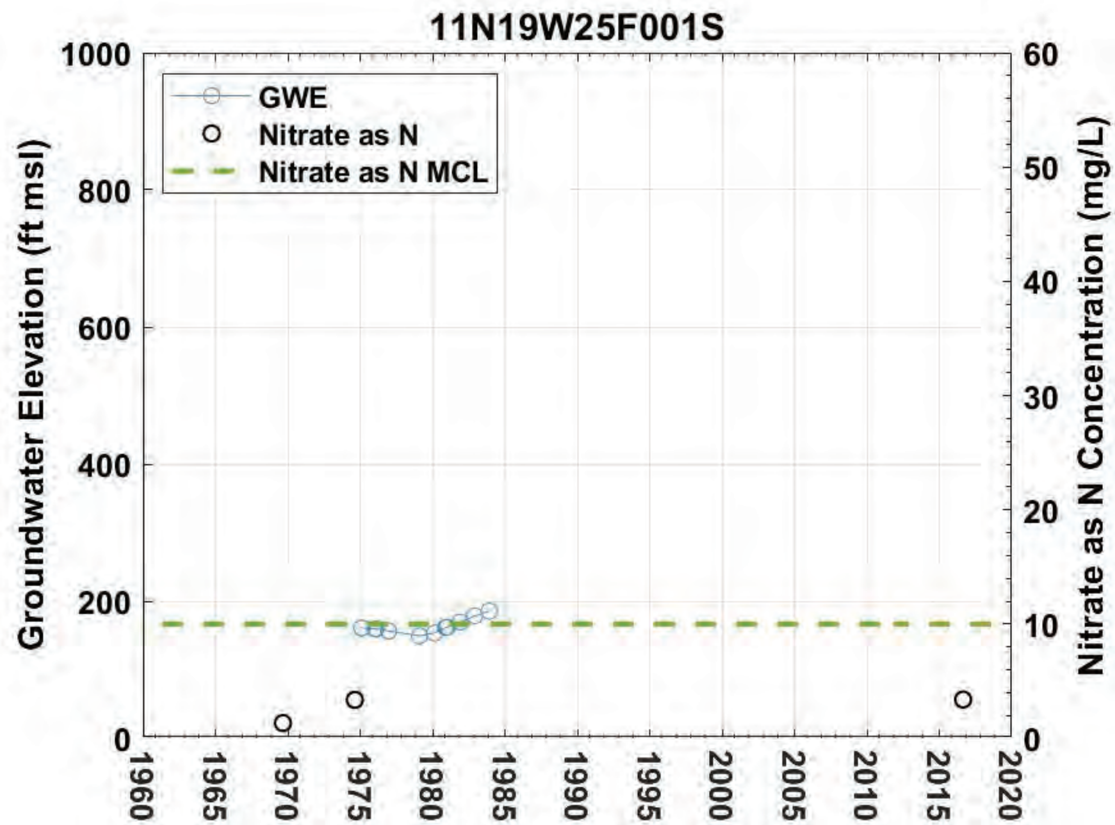
11N19W24N001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

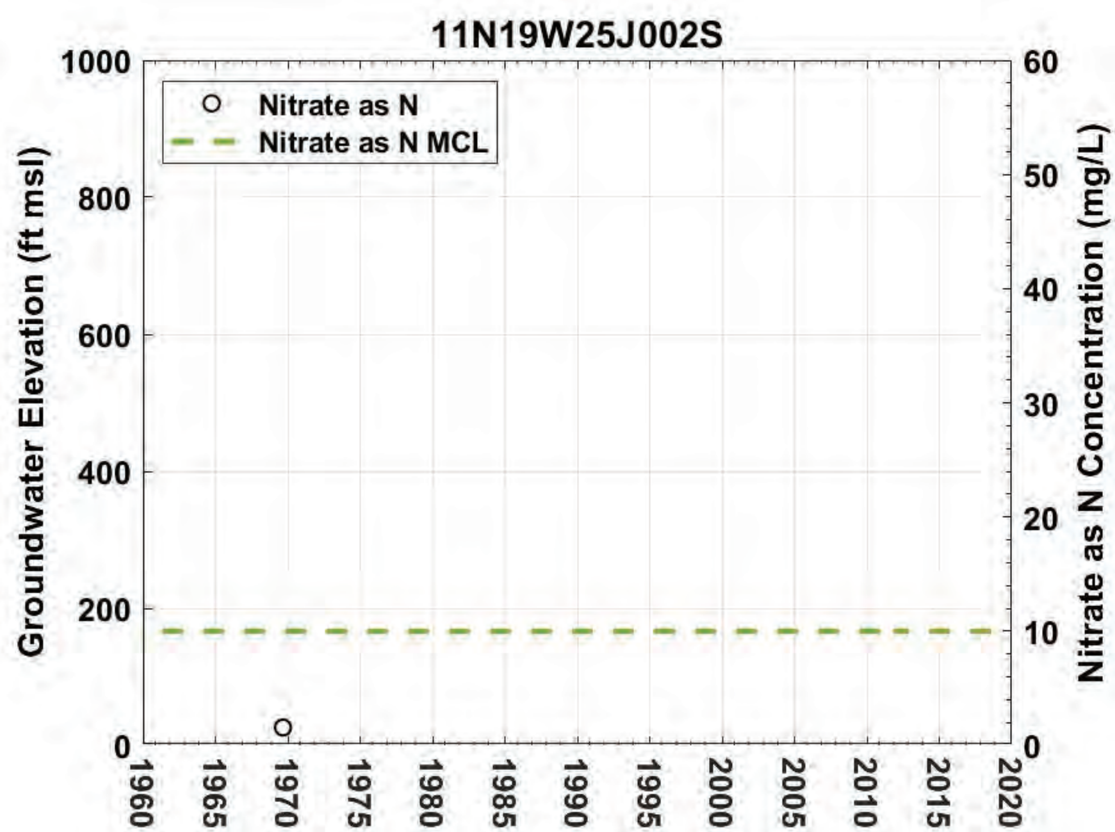


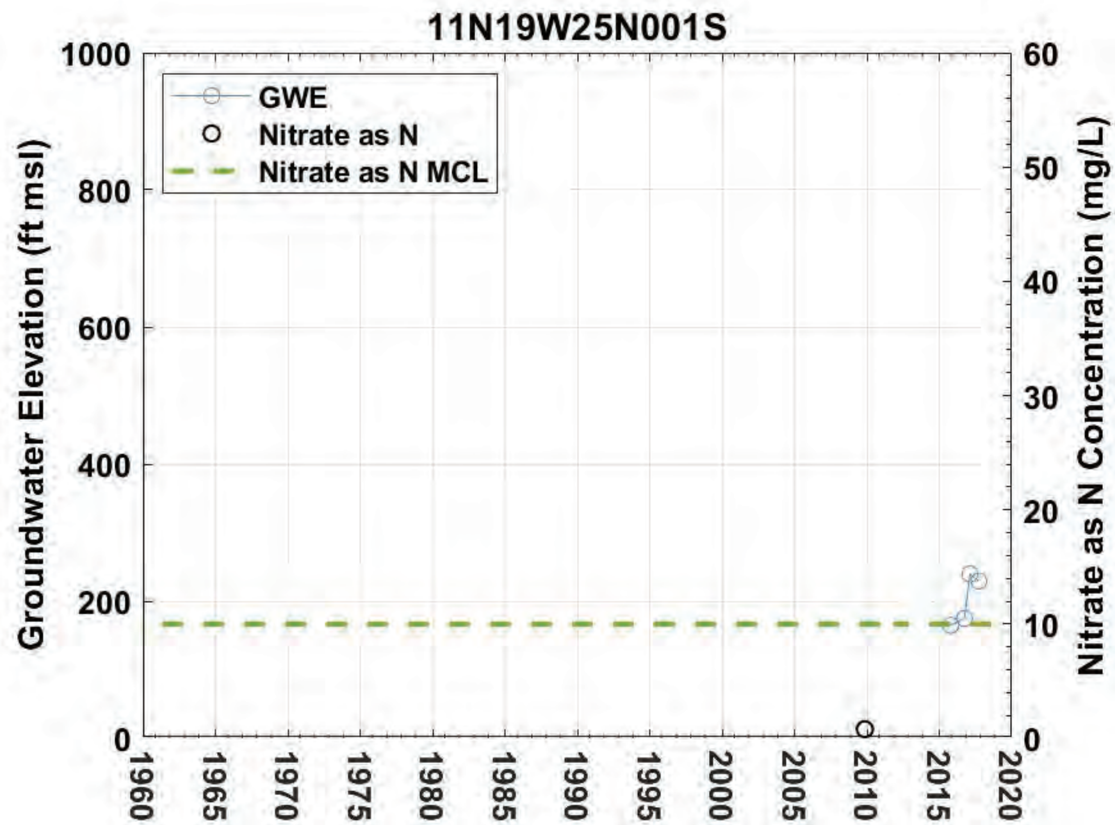
11N19W24R001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

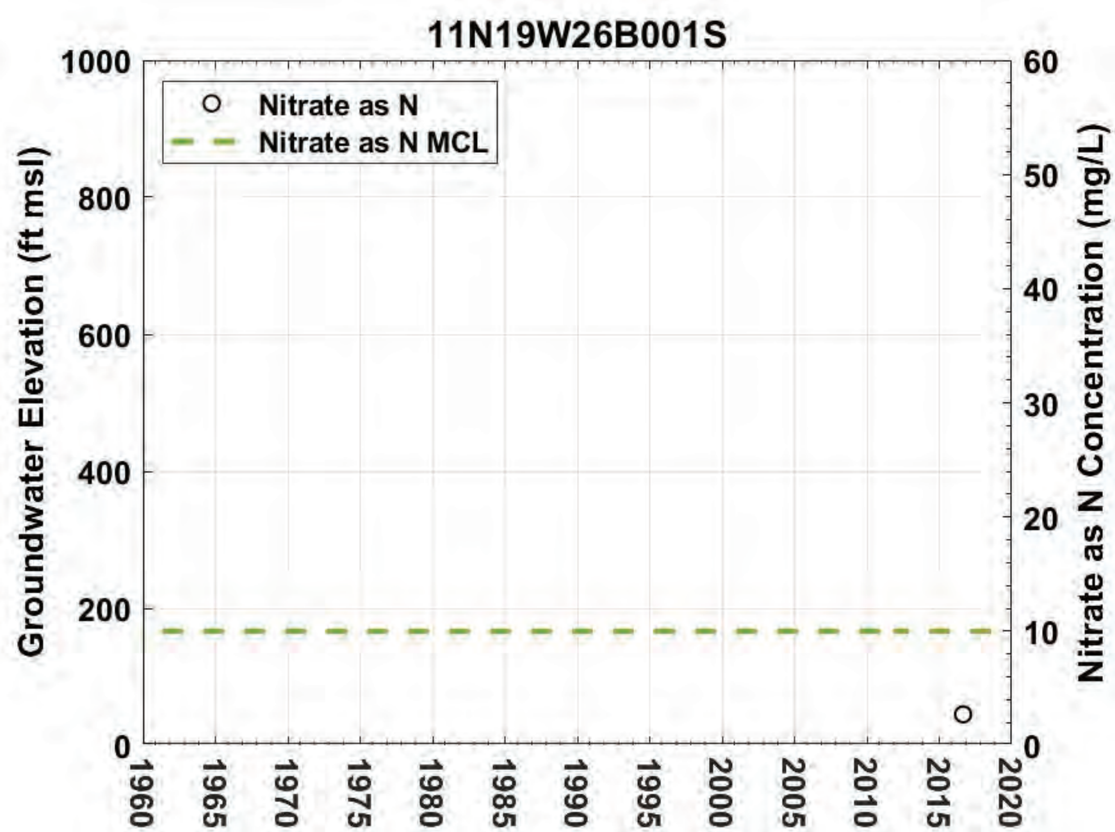

11N19W25B001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

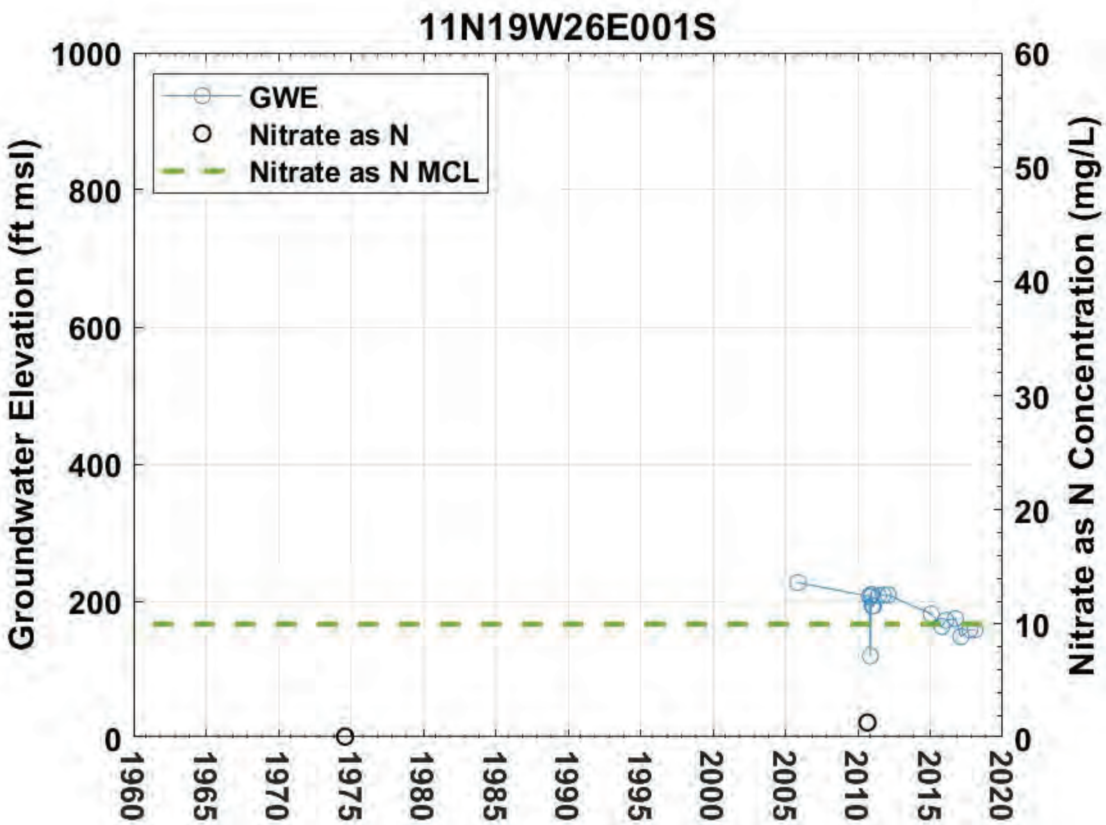

11N19W25C001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

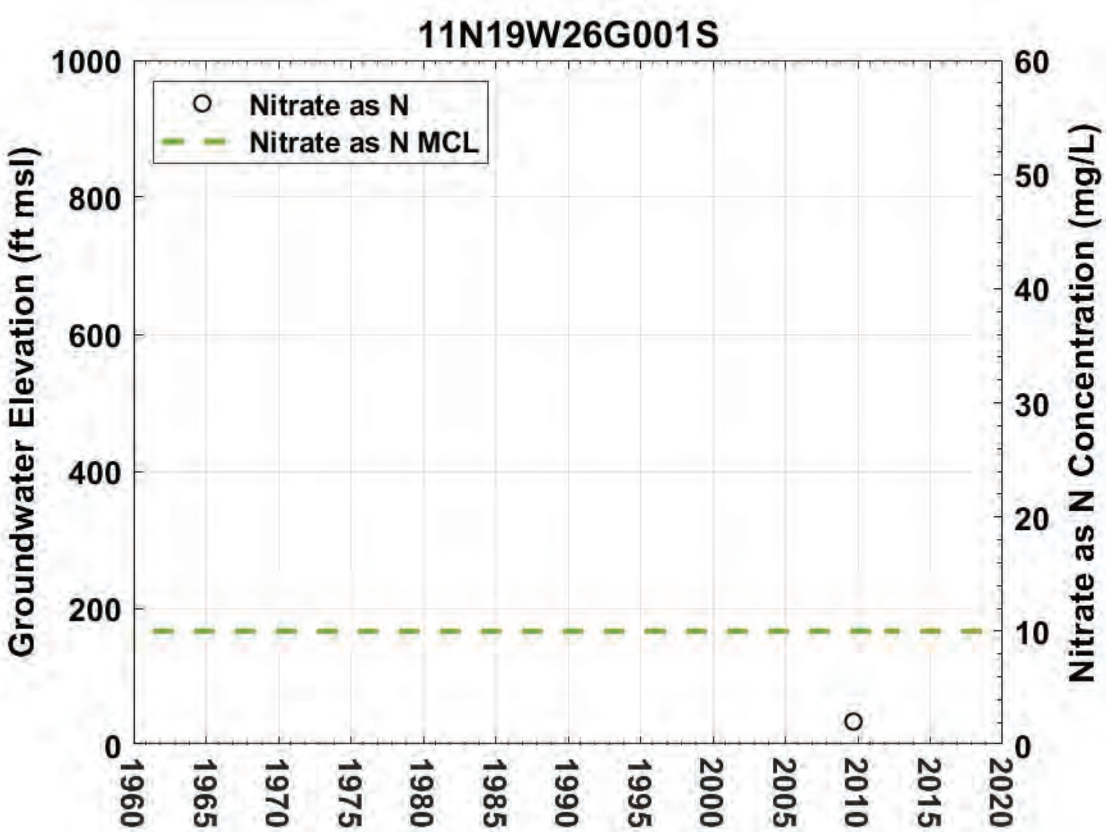

11N19W25F001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

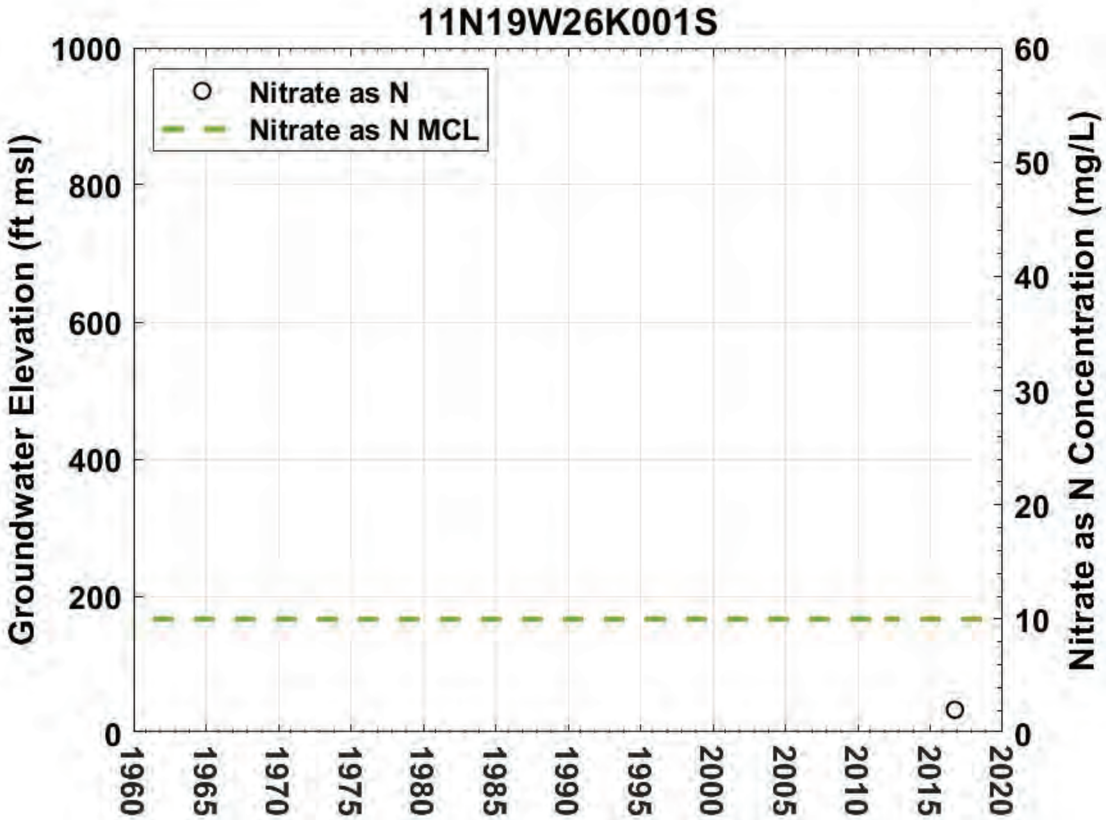

11N19W25J002S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

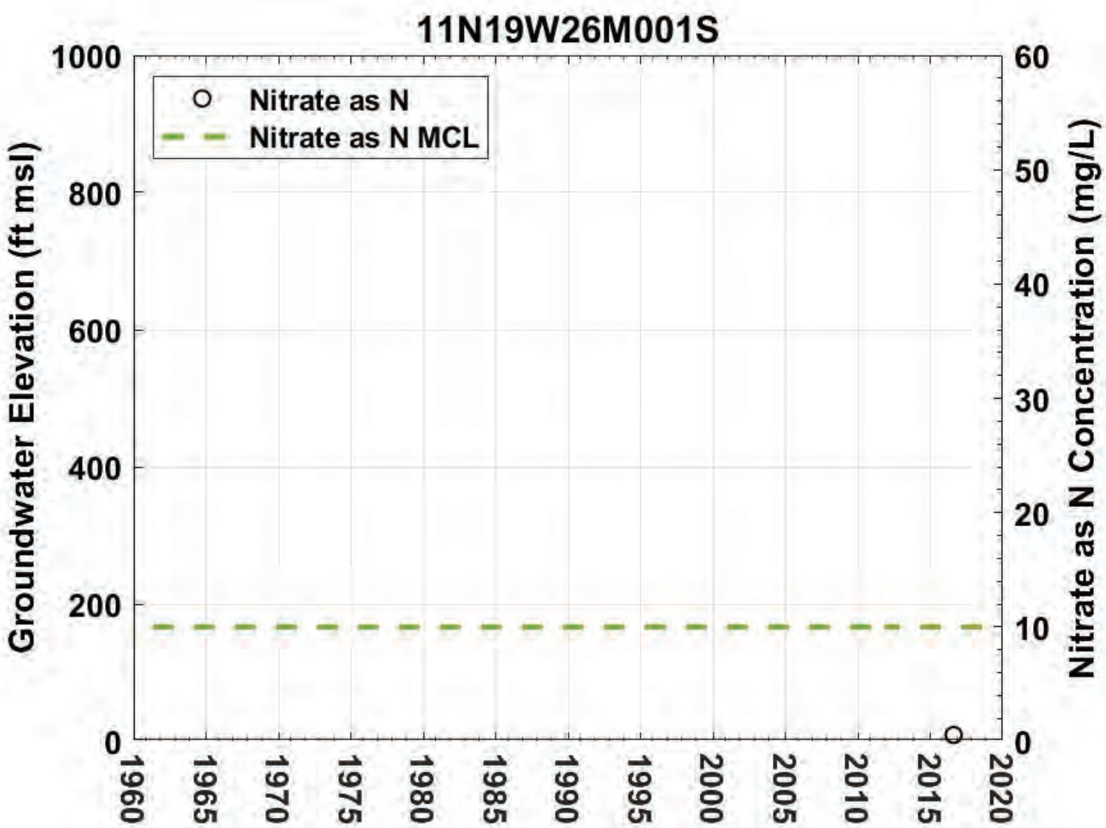

11N19W25N001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

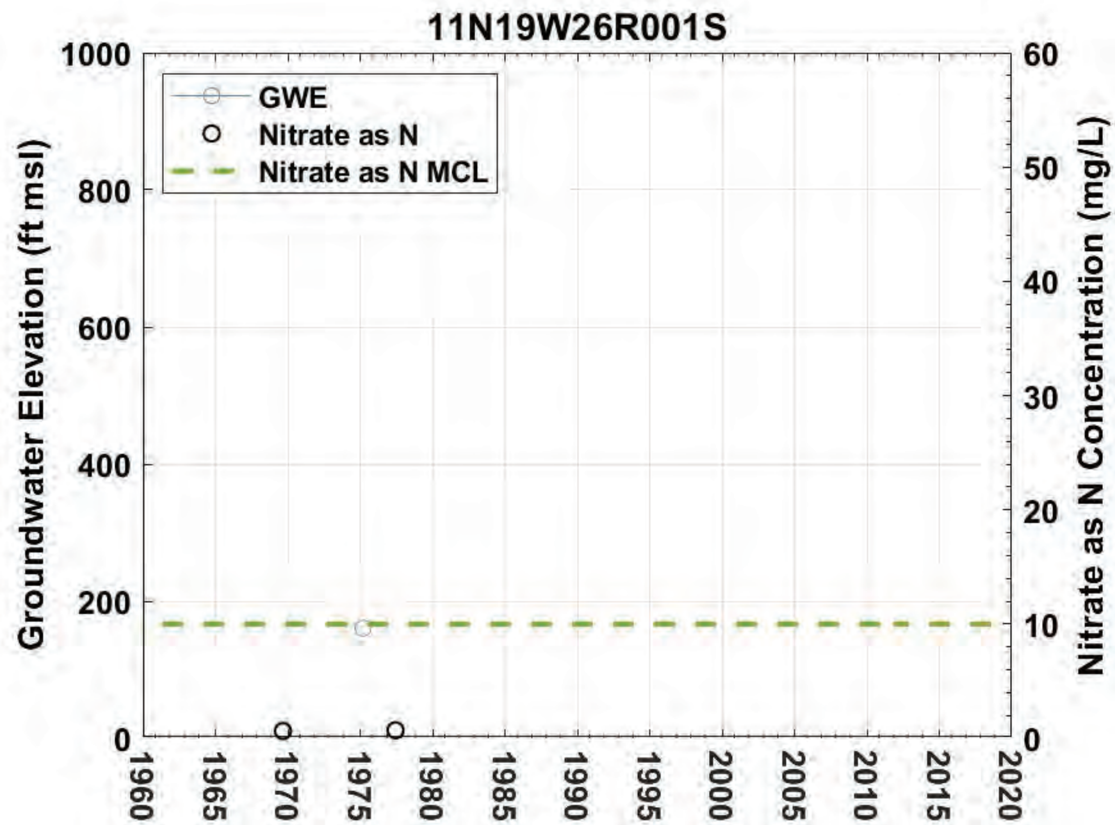

11N19W26B001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

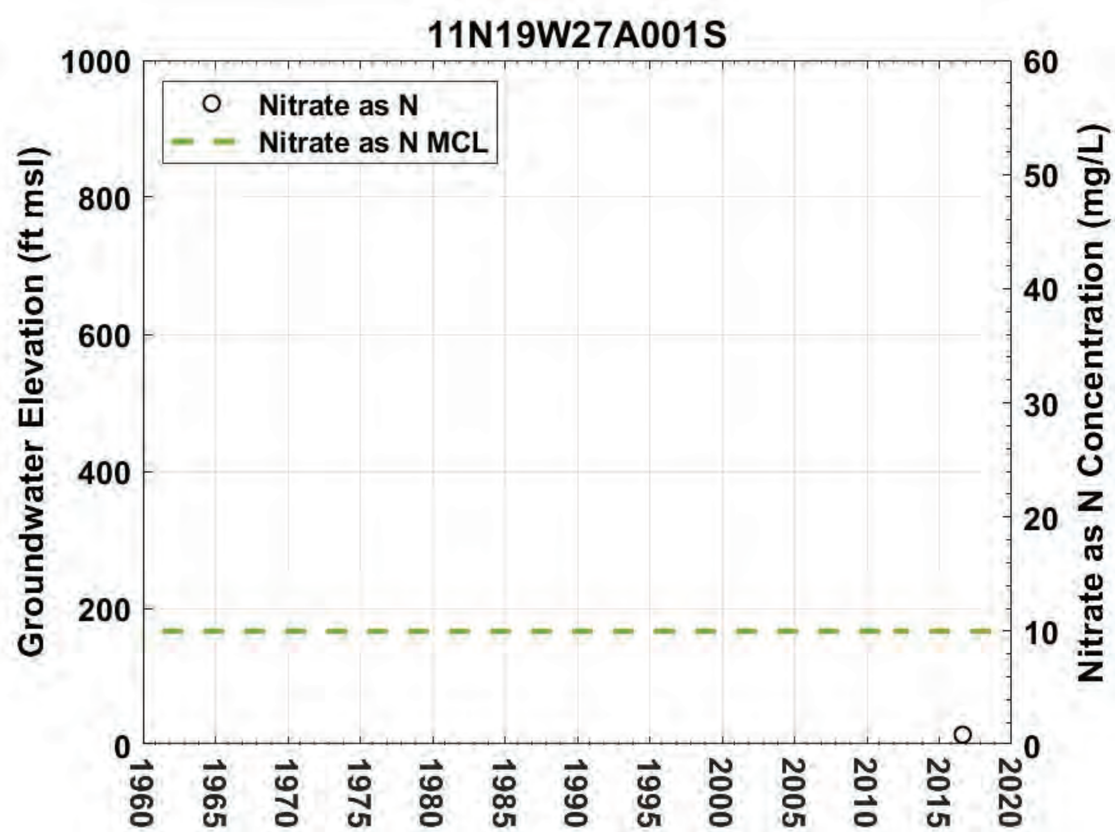

11N19W26E001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
GWE
Nitrate as N
Nitrate as N MCL
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

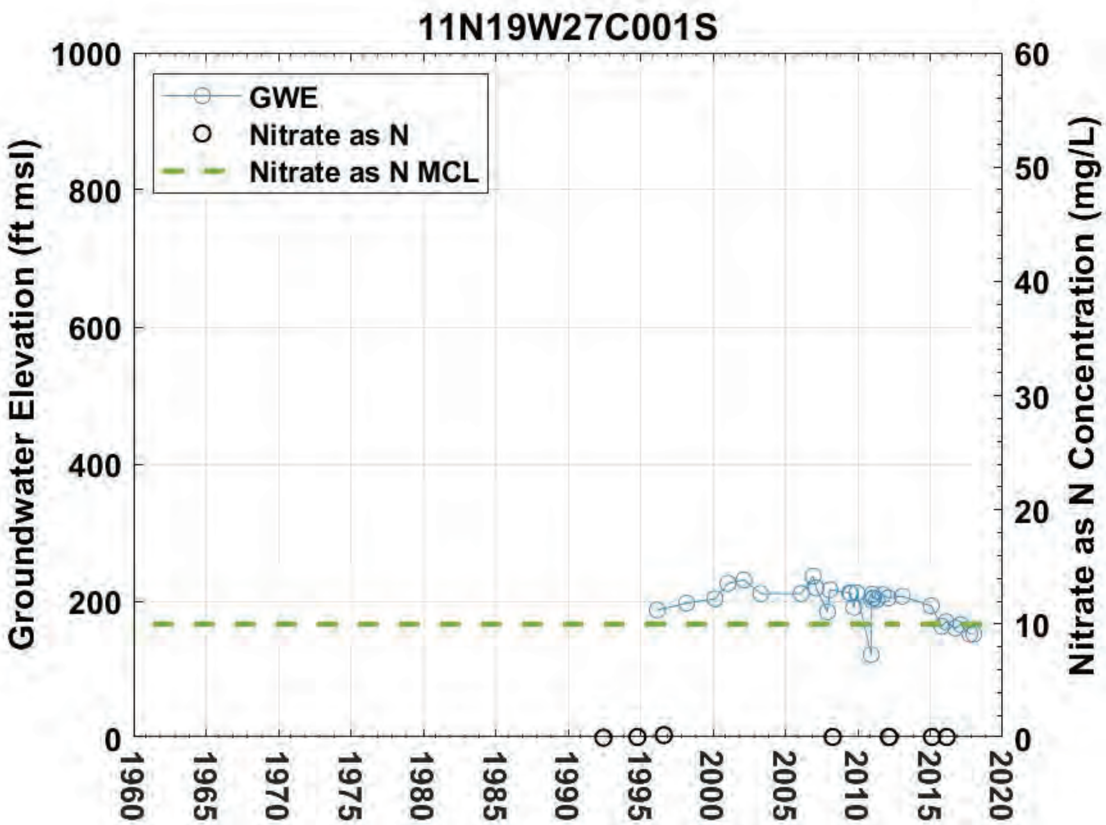

11N19W26G001S
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
Nitrate as N
Nitrate as N MCL
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

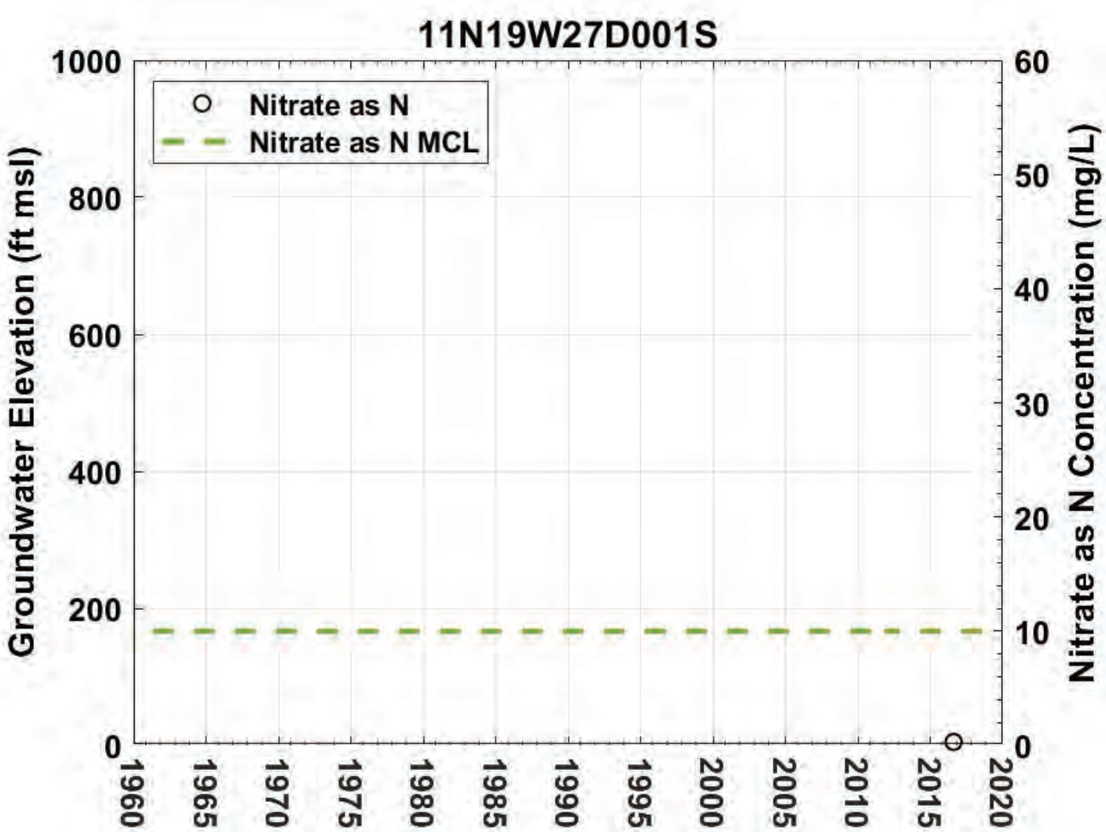

11N19W26K001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

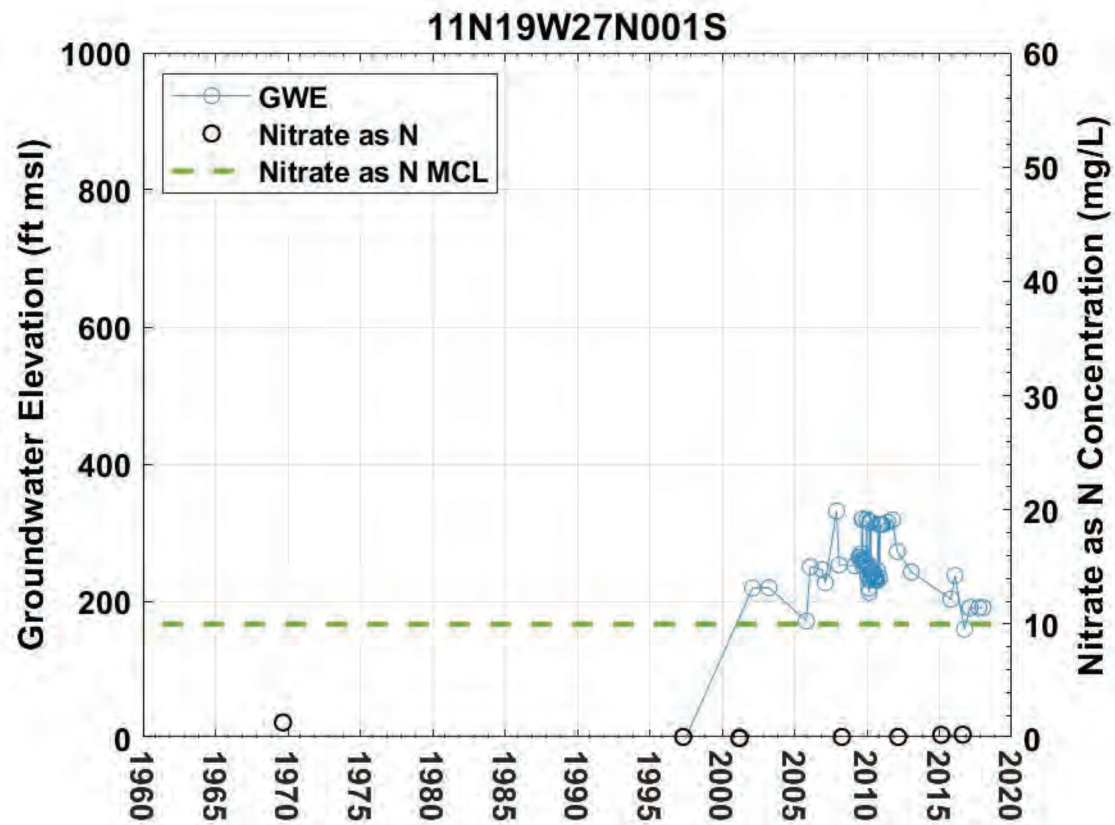

11N19W26M001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W26R001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

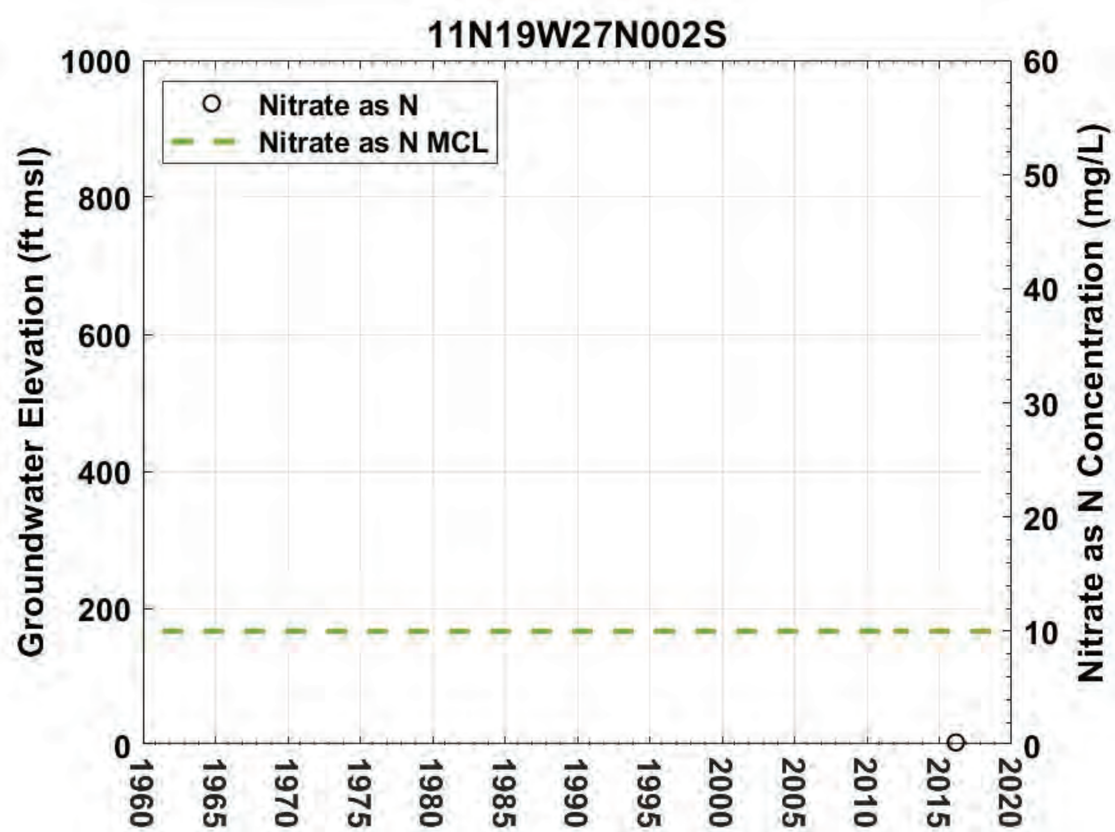

11N19W27A001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W27C001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

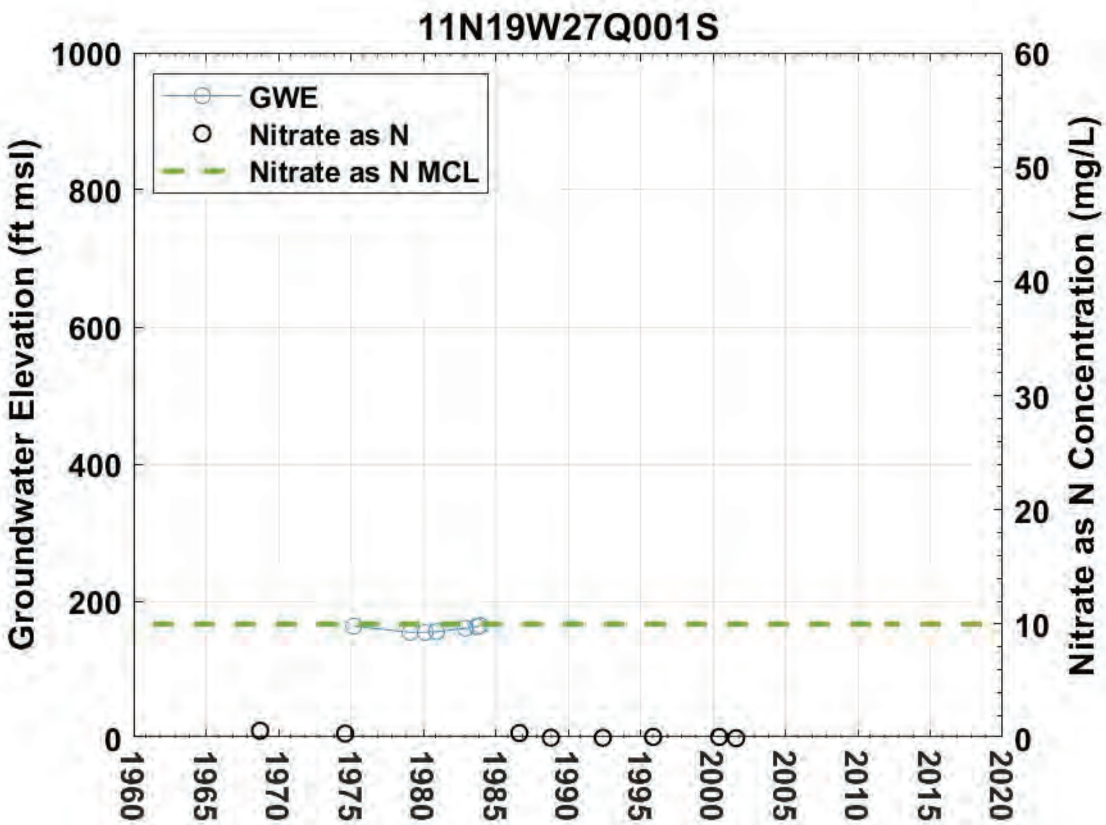

11N19W27D001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

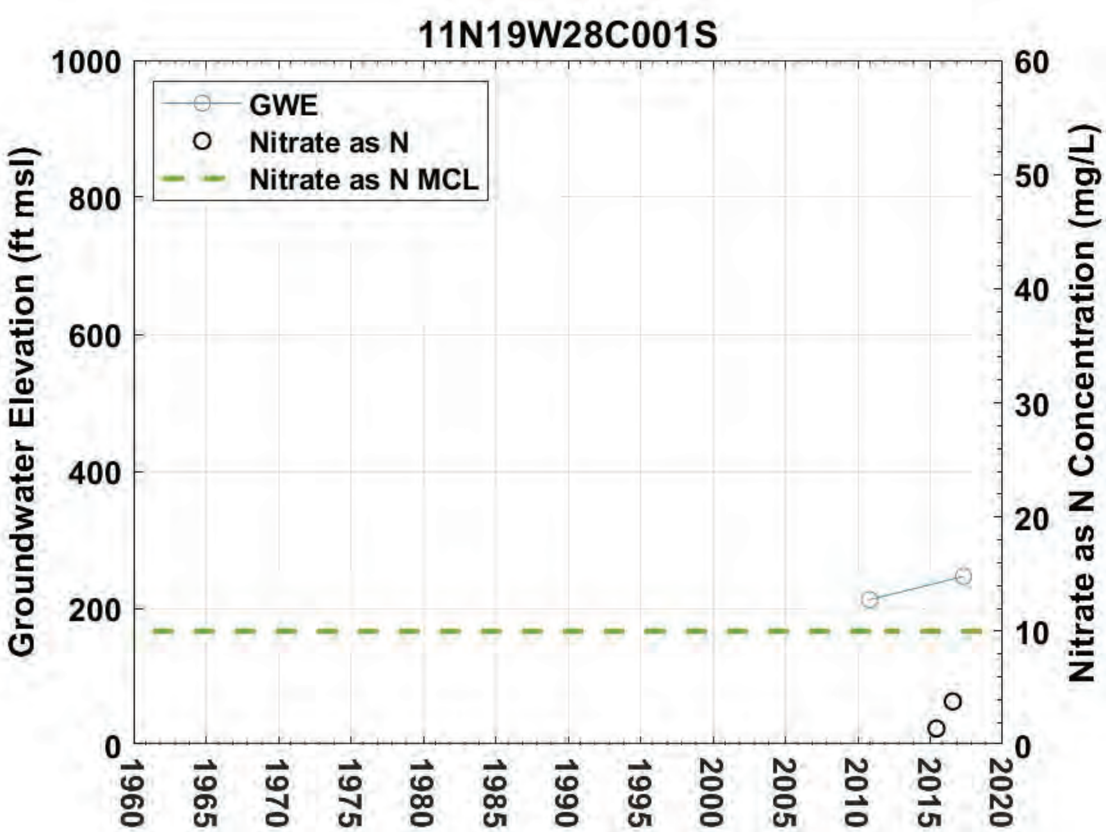


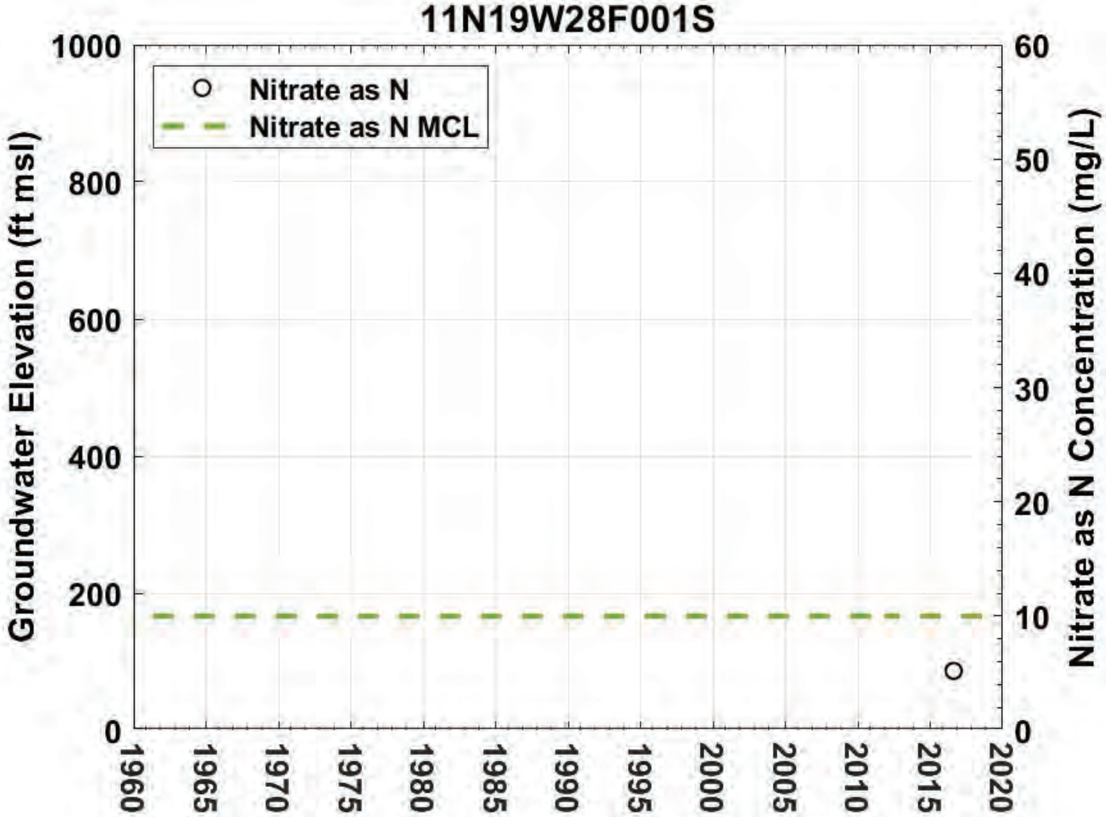
11N19W27N001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

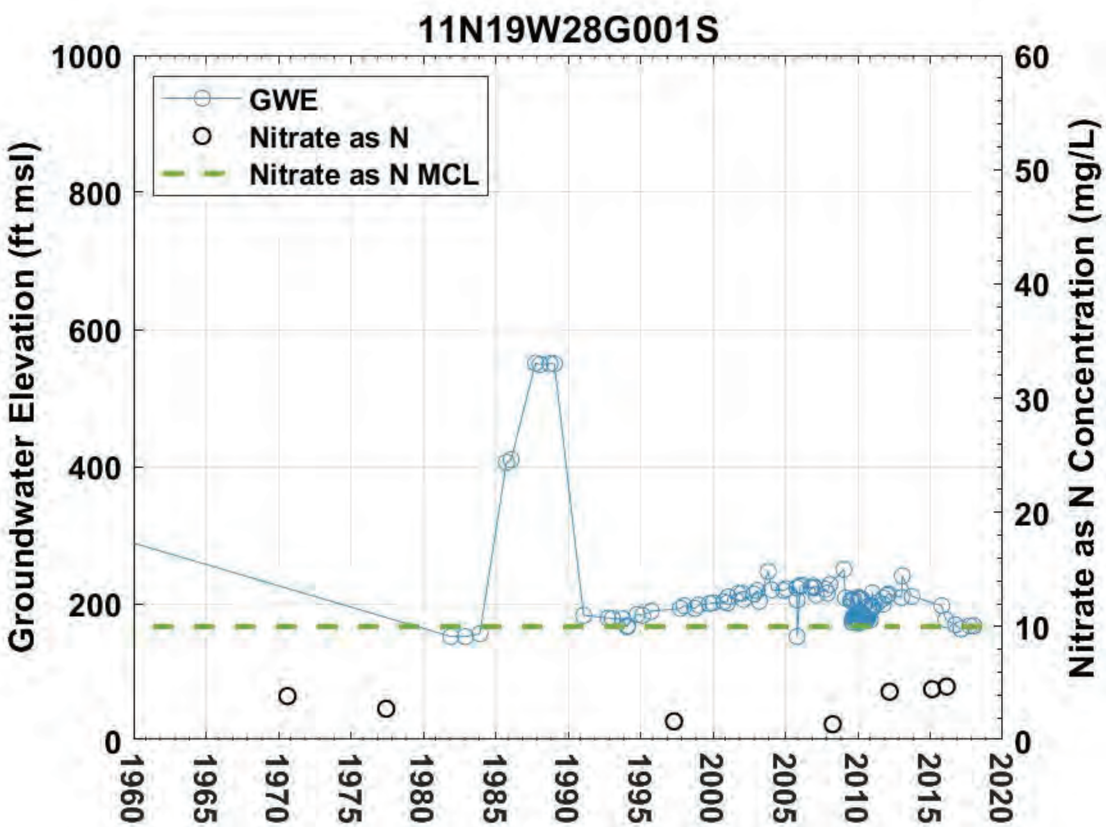


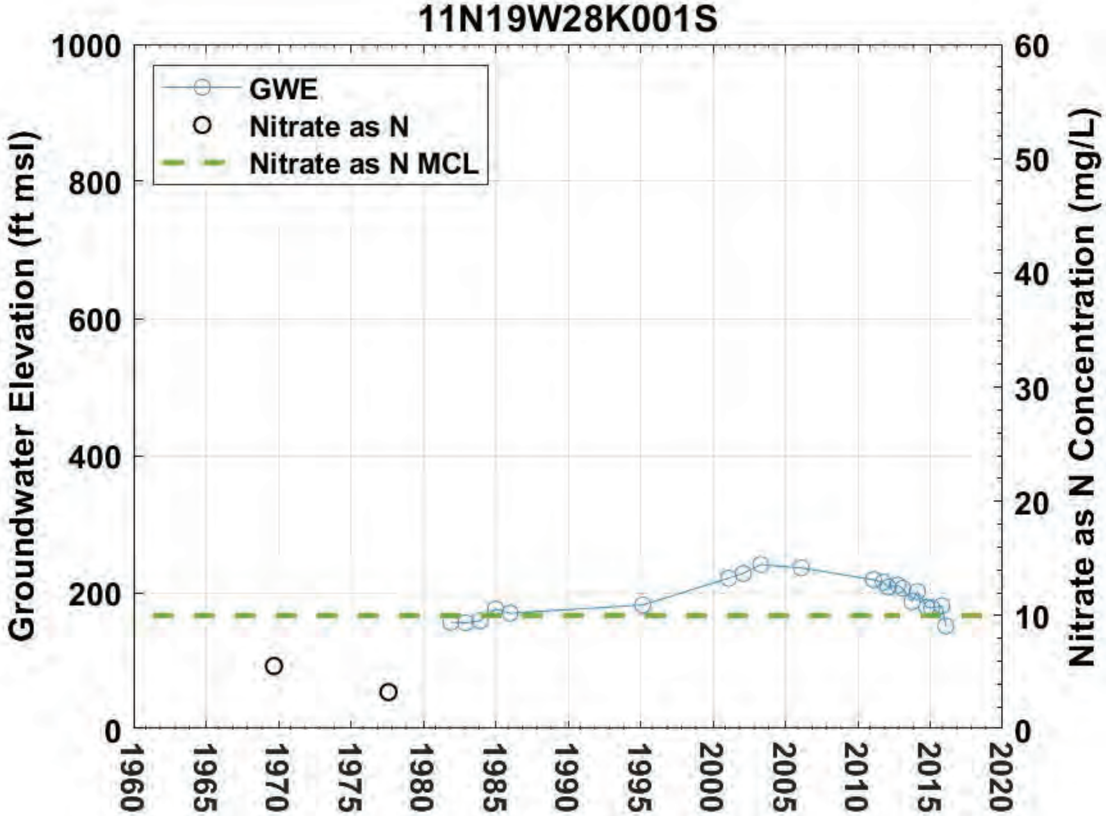
11N19W27N002S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

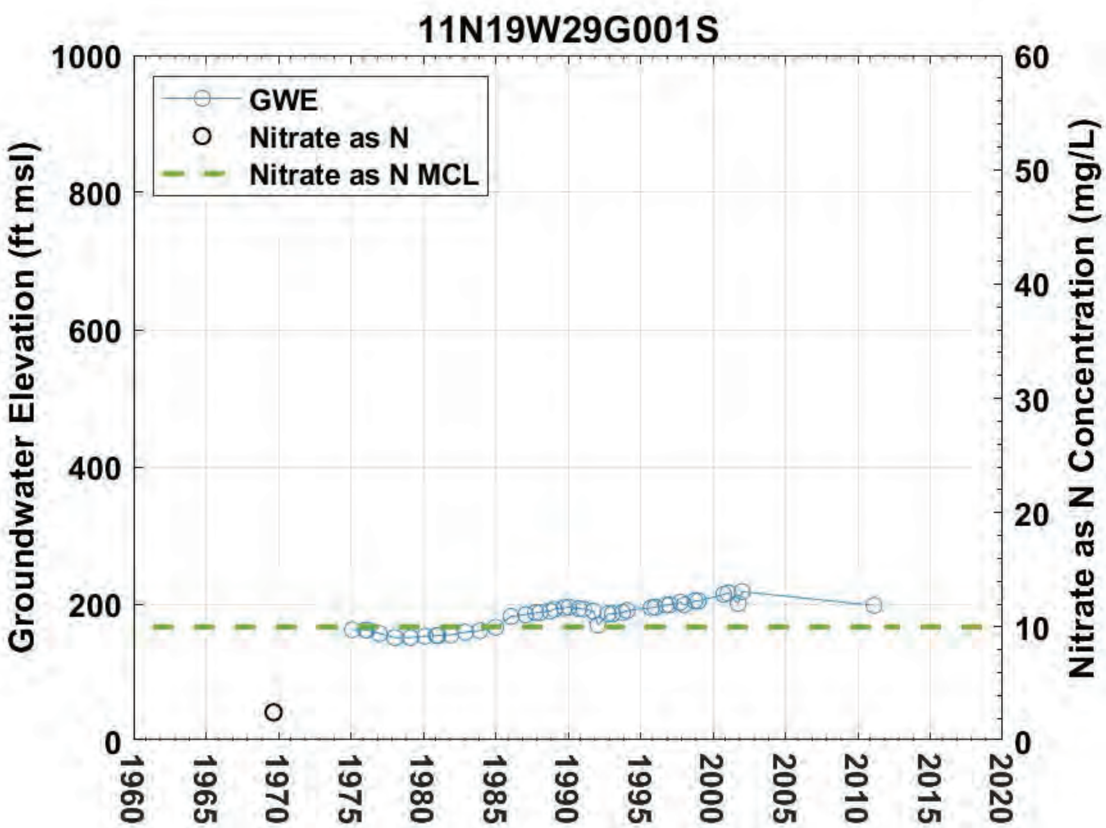

11N19W27Q001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

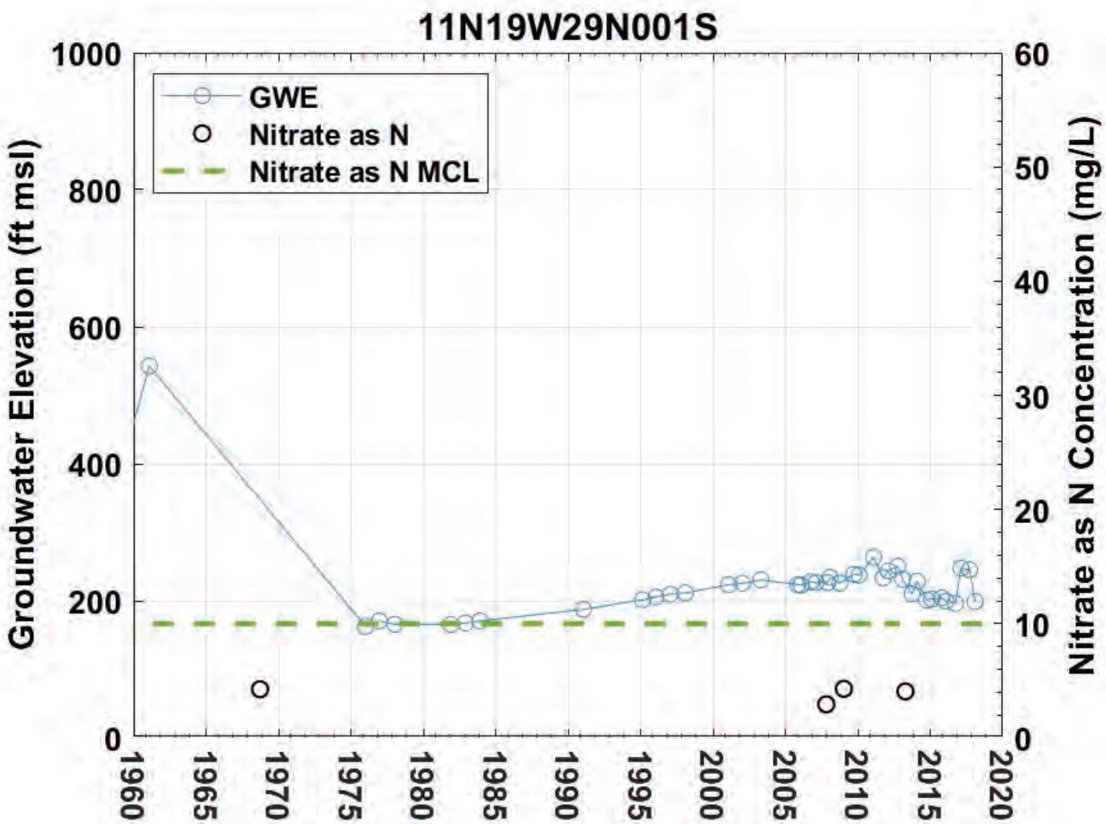

11N19W28C001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

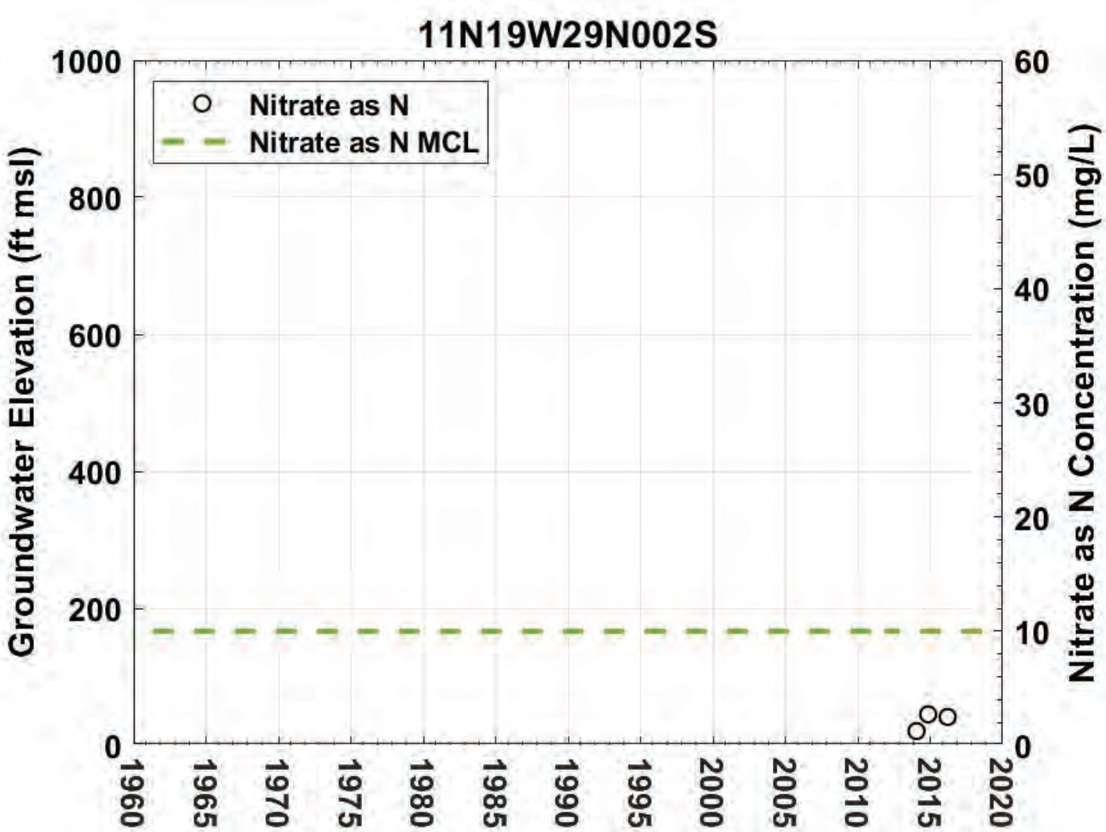

11N19W28F001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

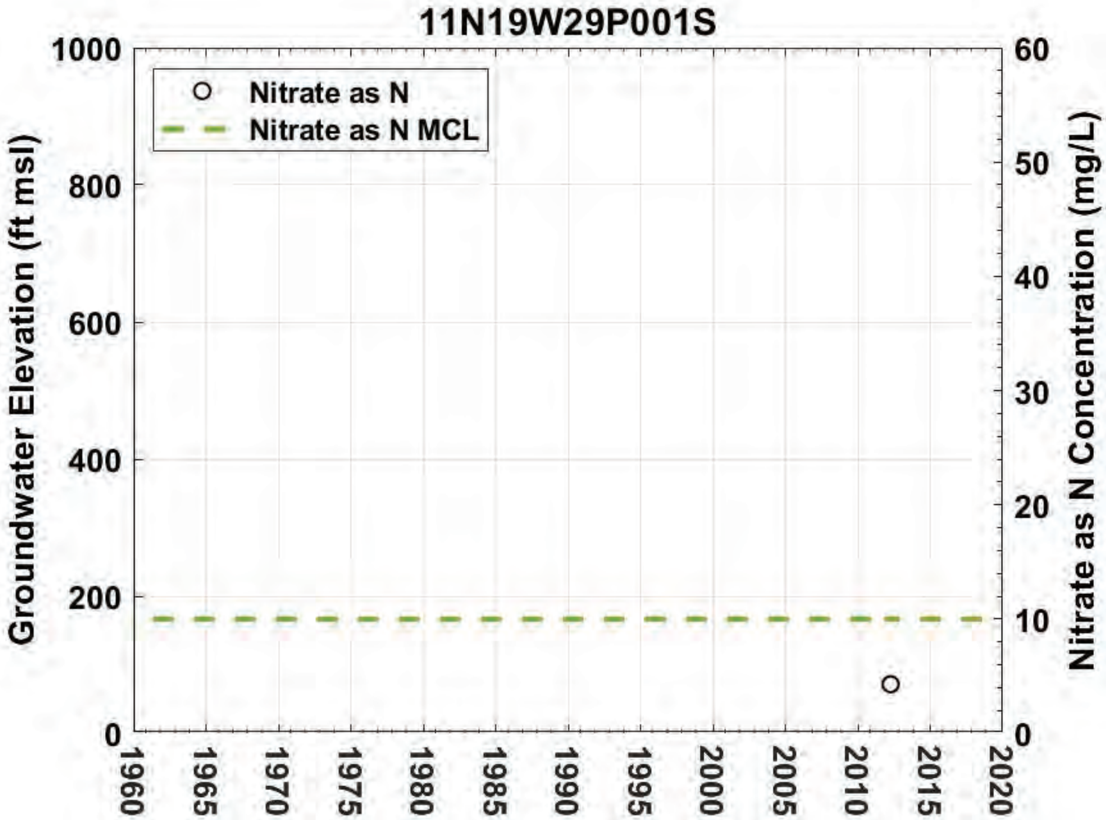

11N19W28G001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

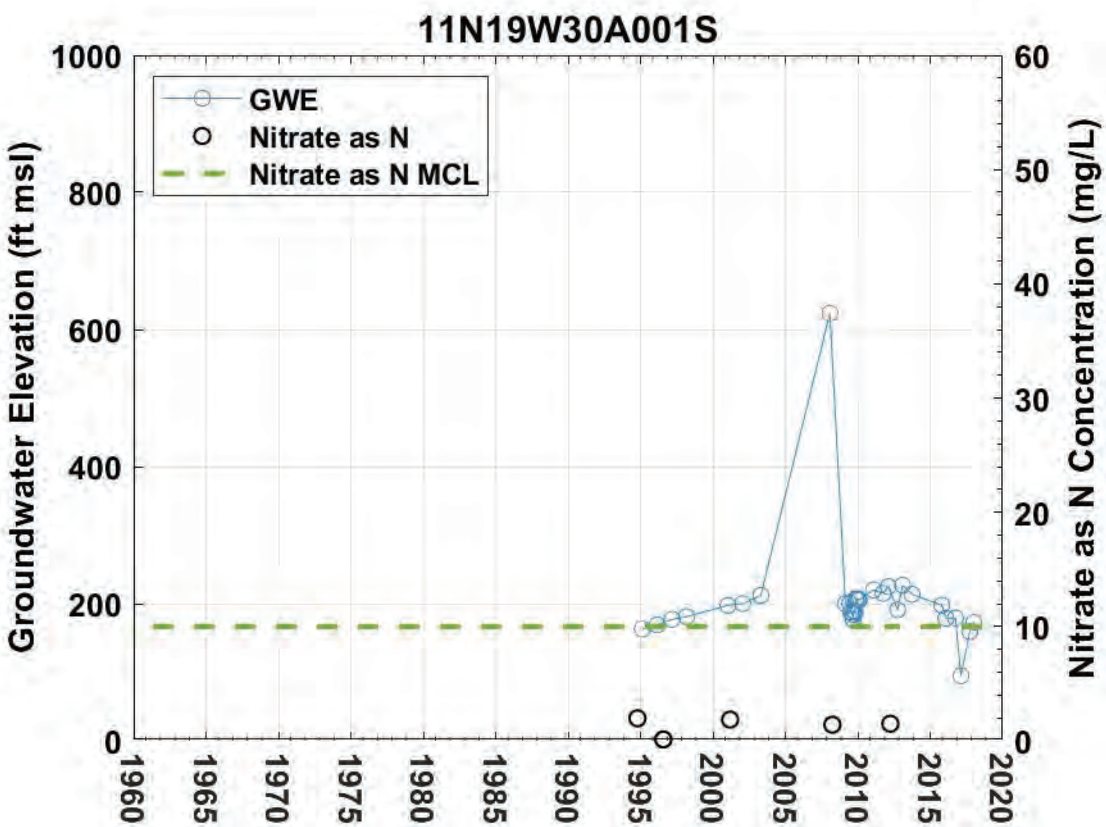

11N19W28K001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

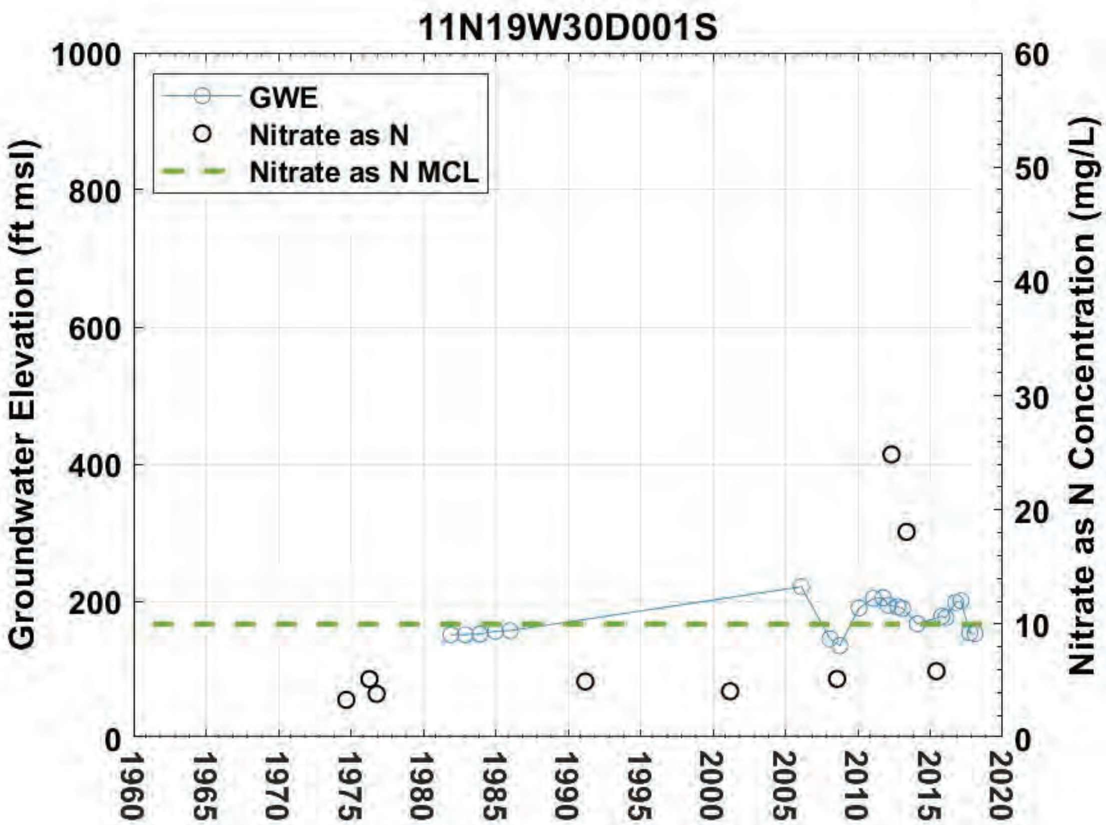

11N19W29G001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

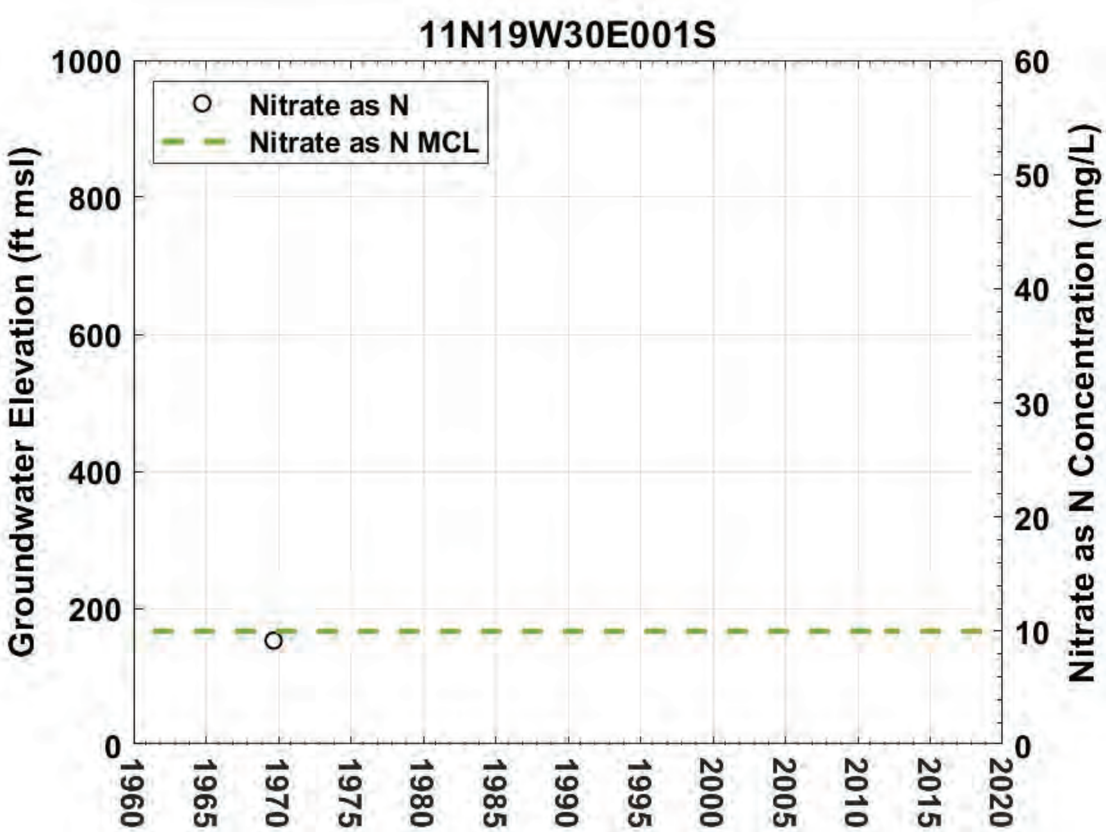

11N19W29N001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

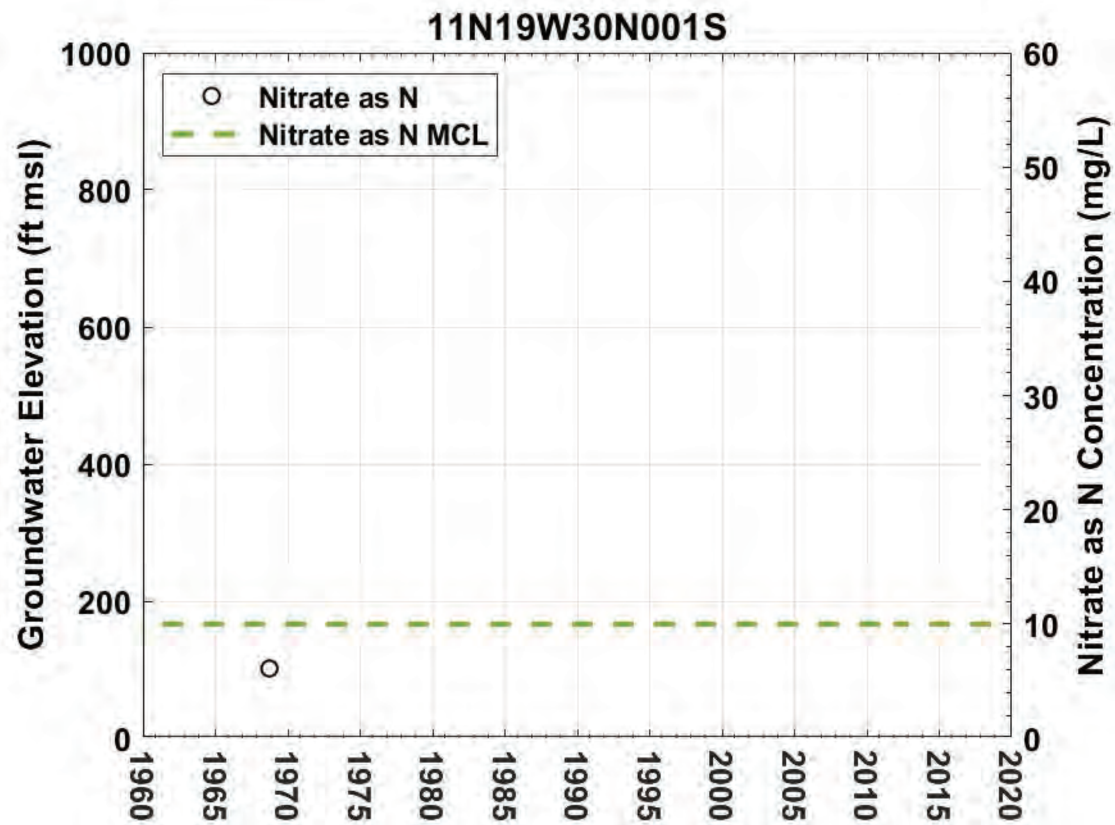

11N19W29N002S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W29P001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

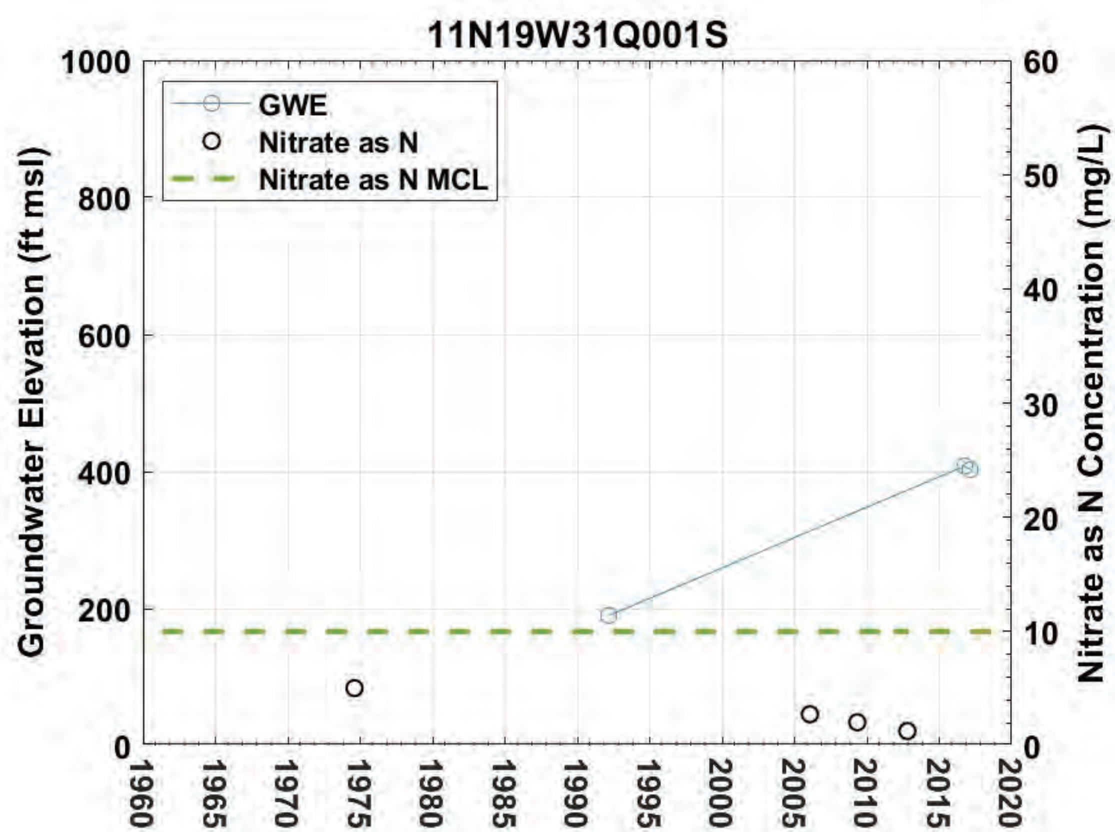

11N19W30A001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W30D001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

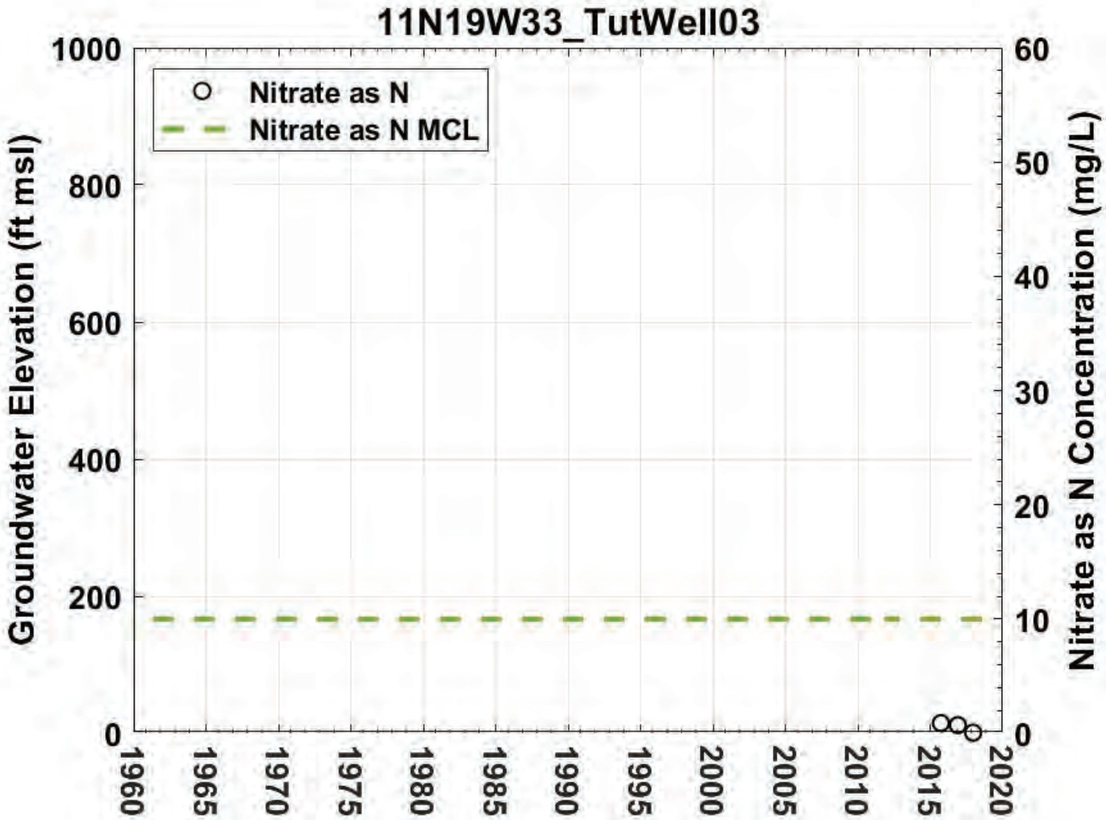

11N19W30E001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



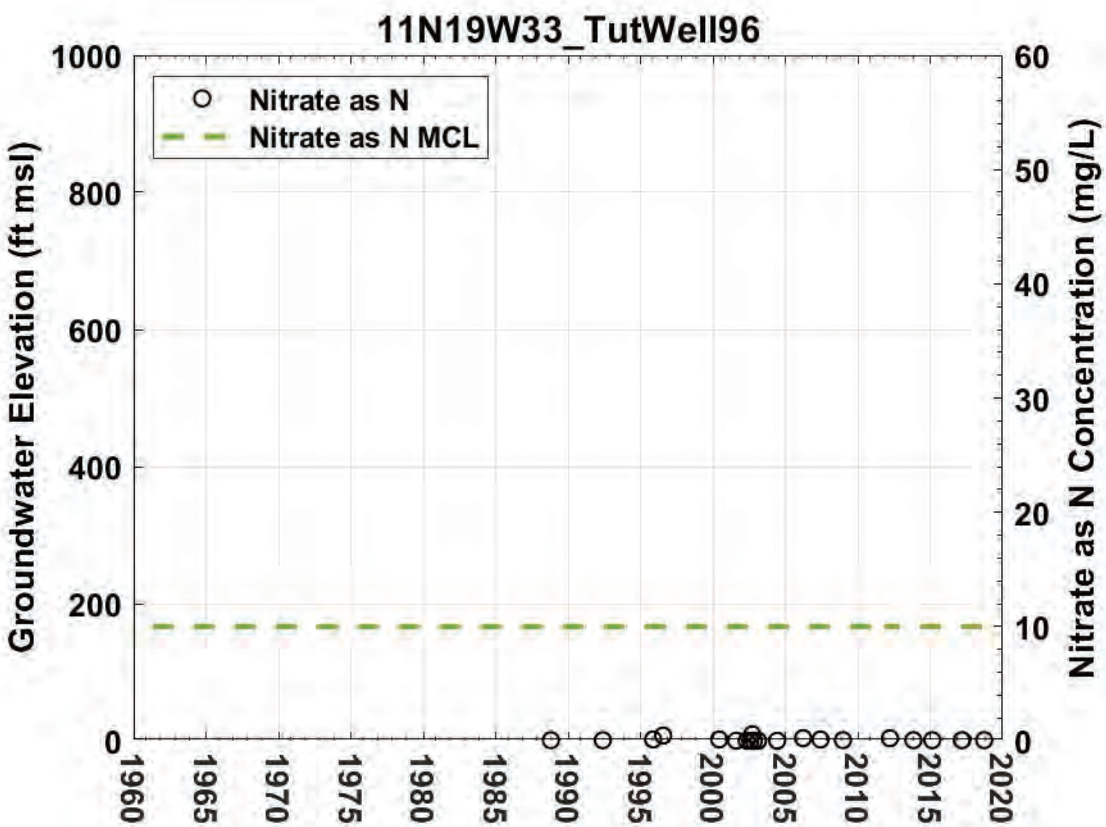
11N19W30N001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



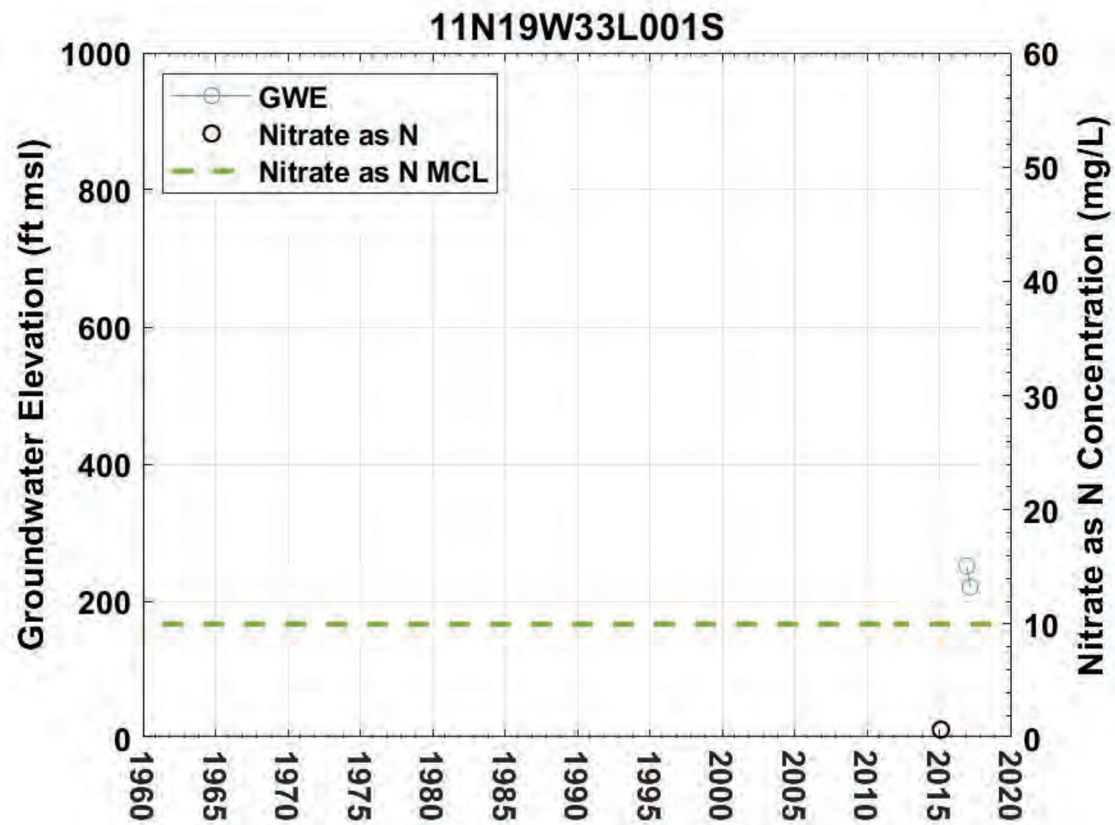
11N19W31Q001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

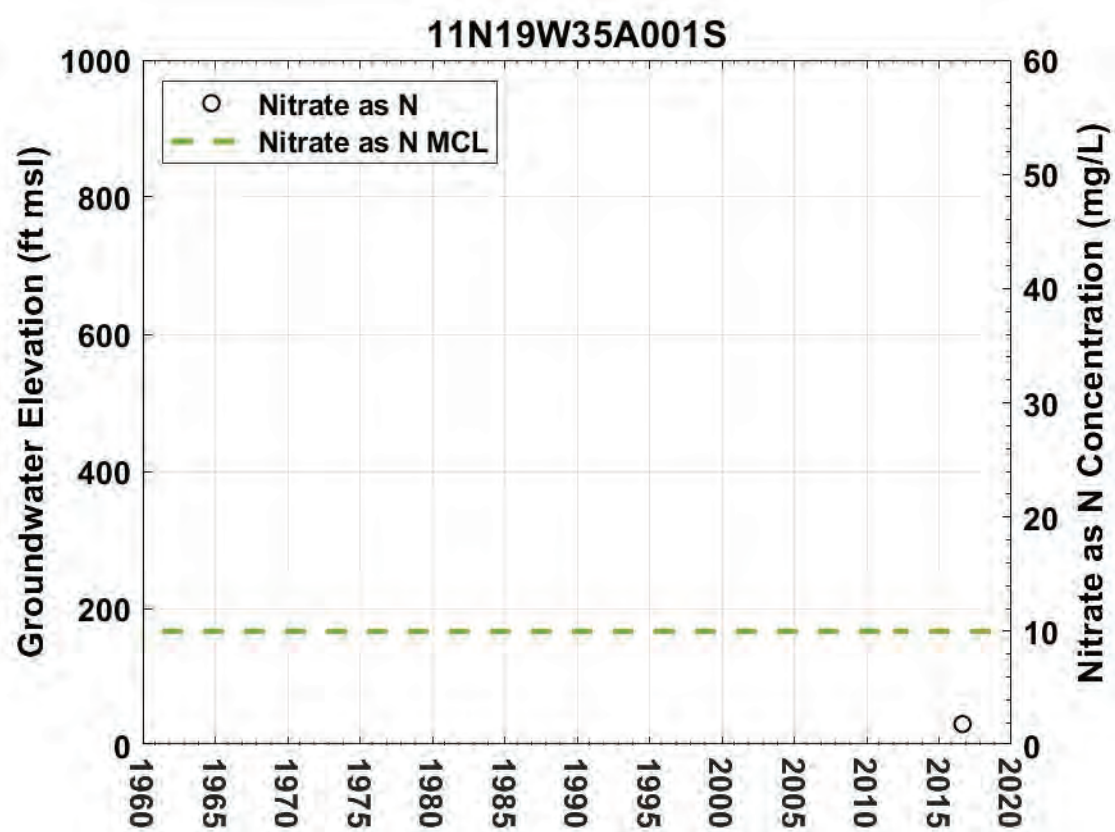


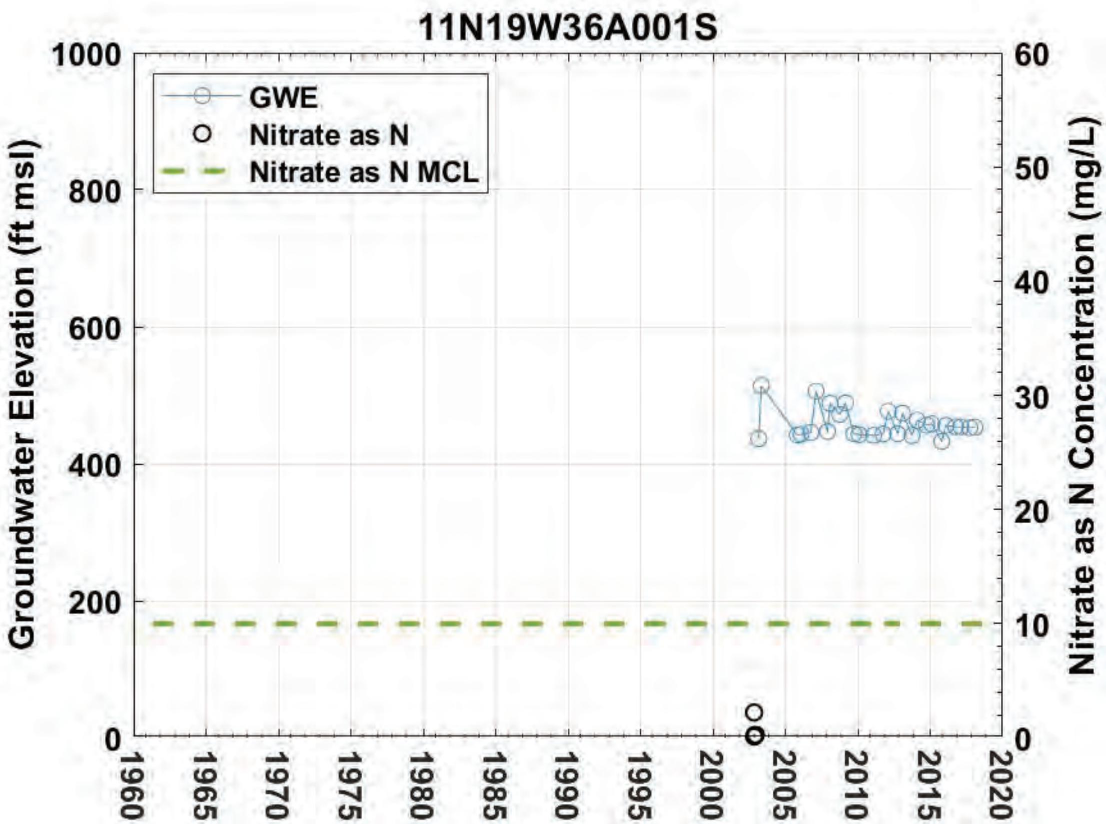
11N19W33_TutWell03
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



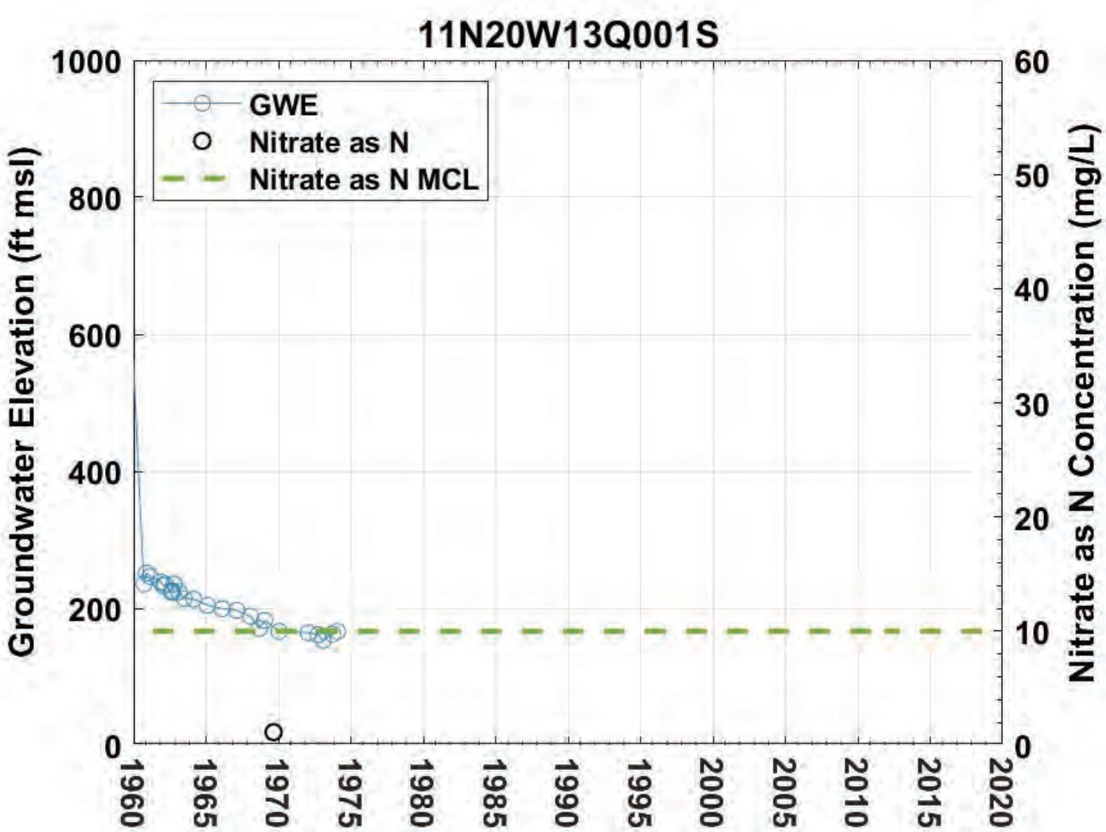
11N19W33_TutWell96
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W33L001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

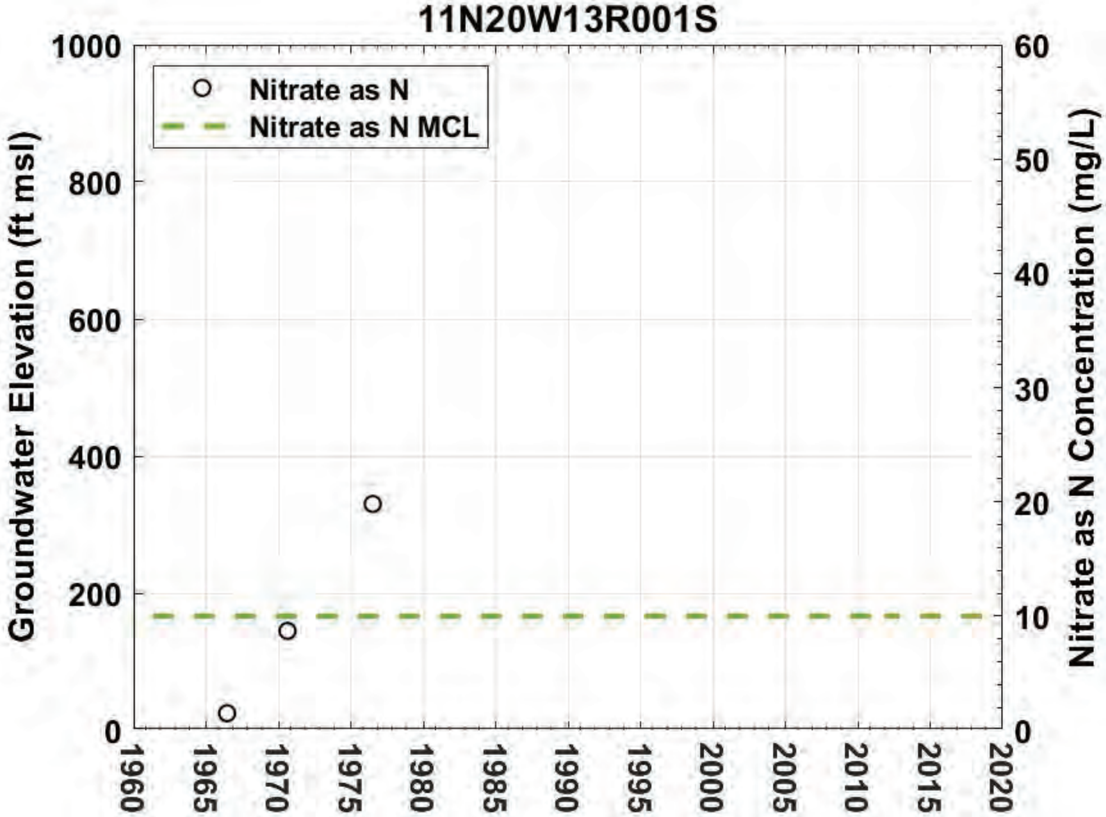

11N19W35A001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

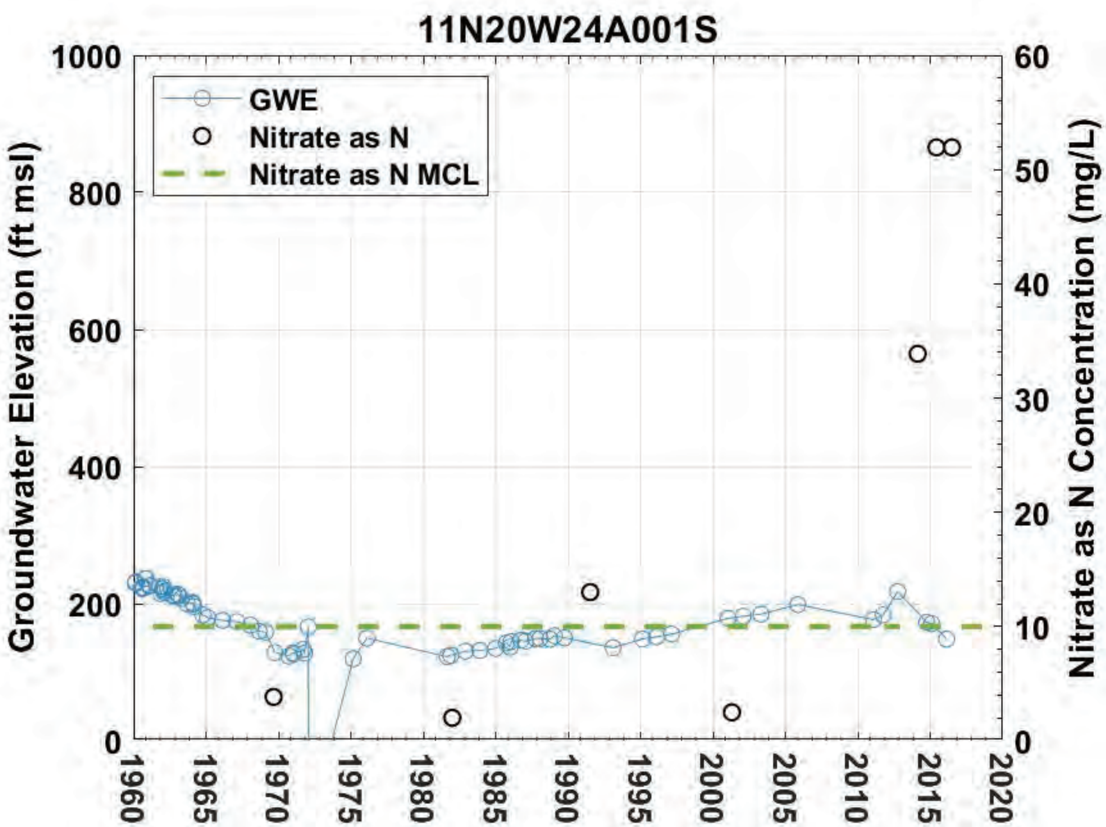


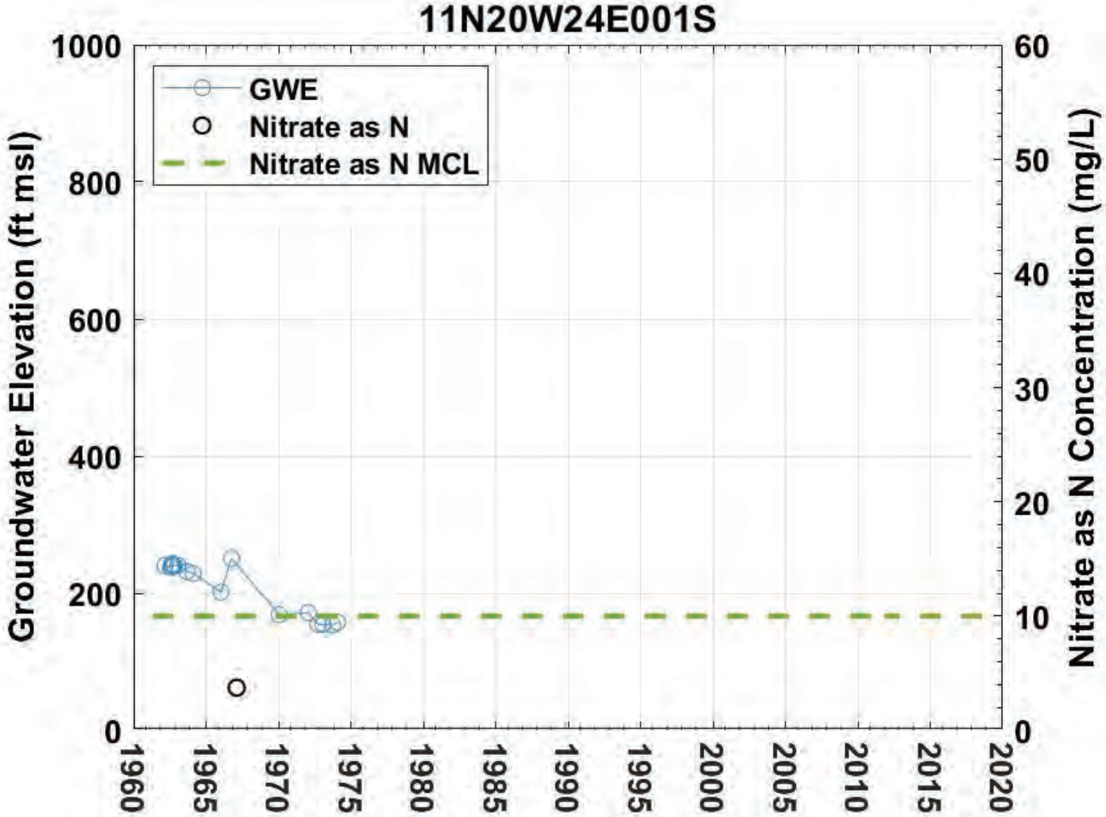
11N19W36A001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

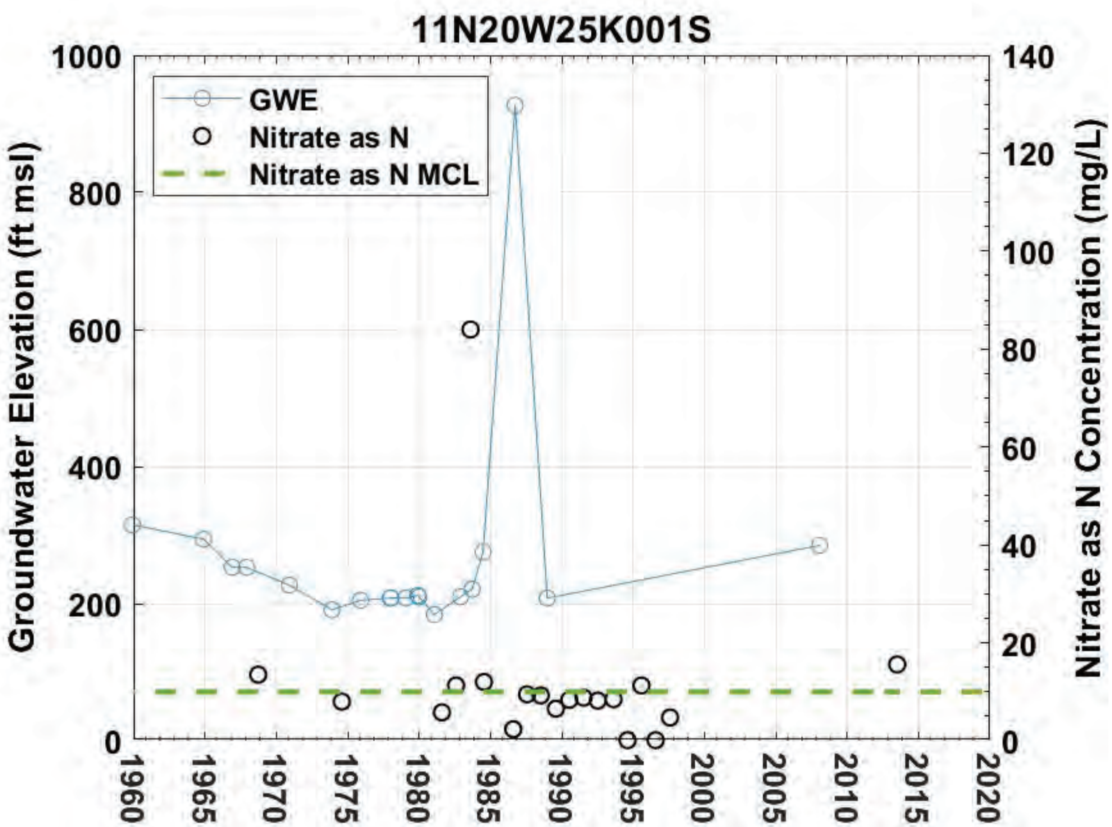


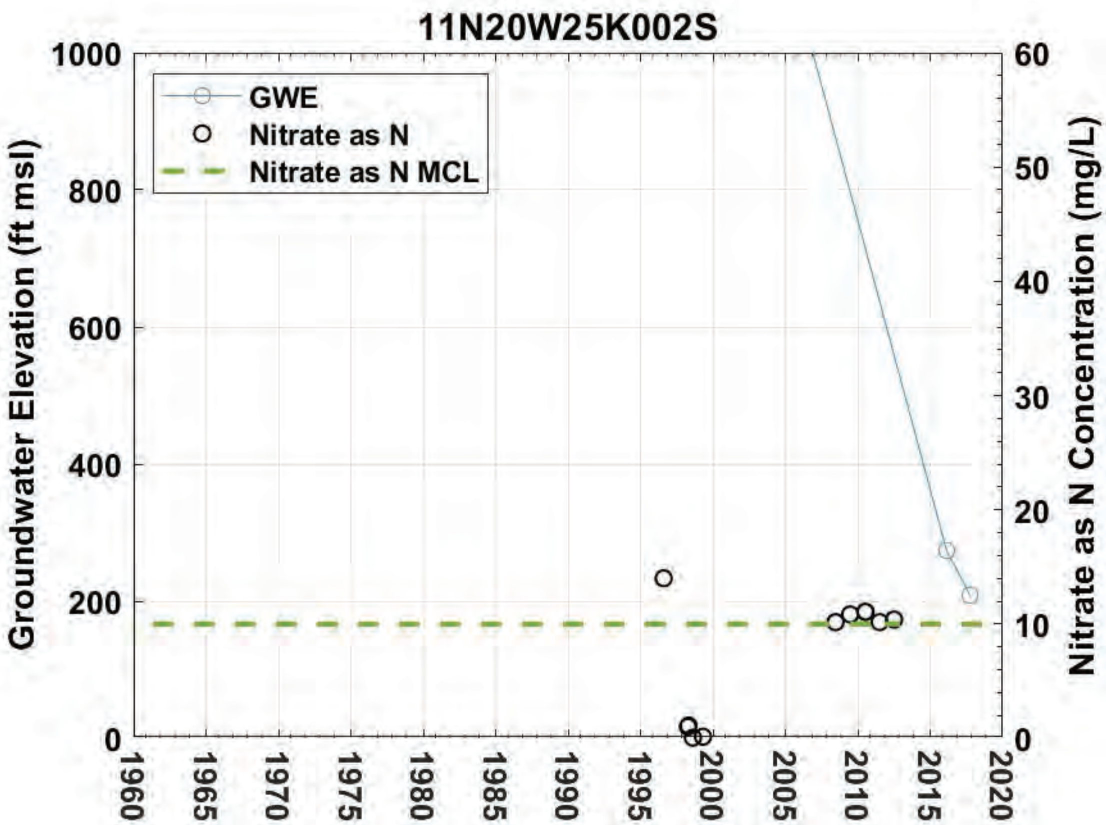
11N20W13Q001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N20W13R001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

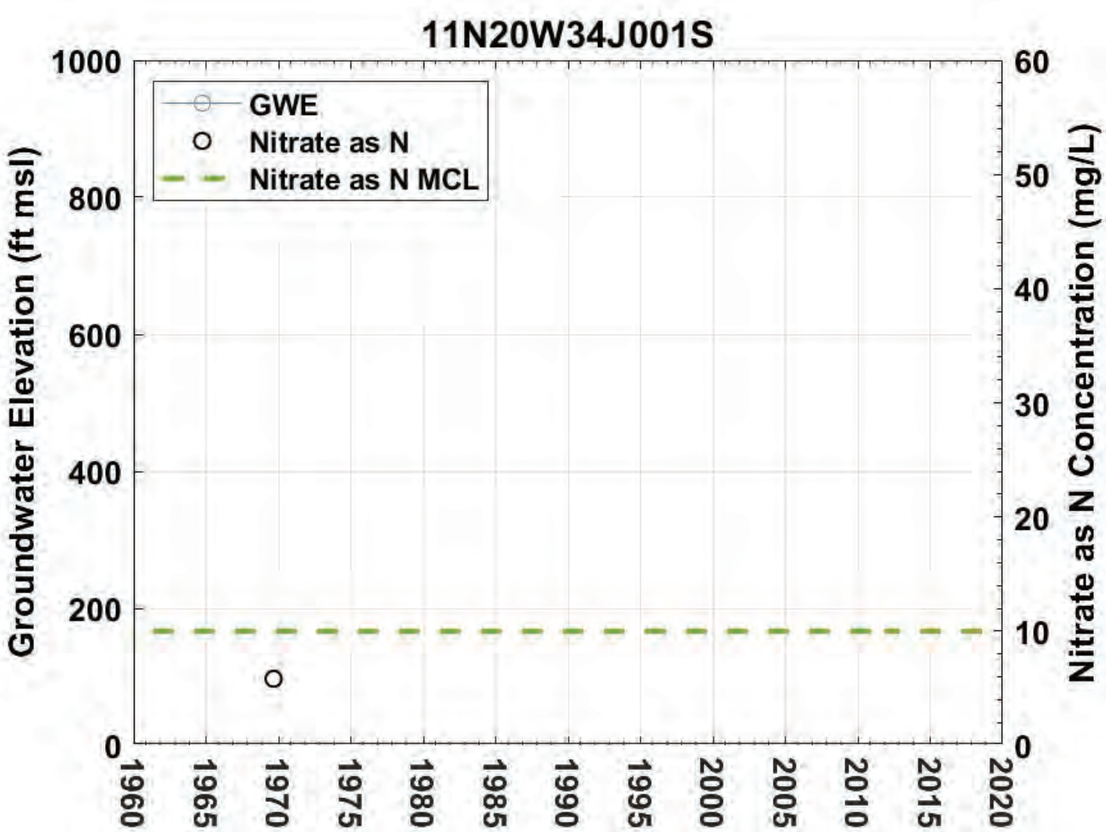

11N20W24A001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N20W24E001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

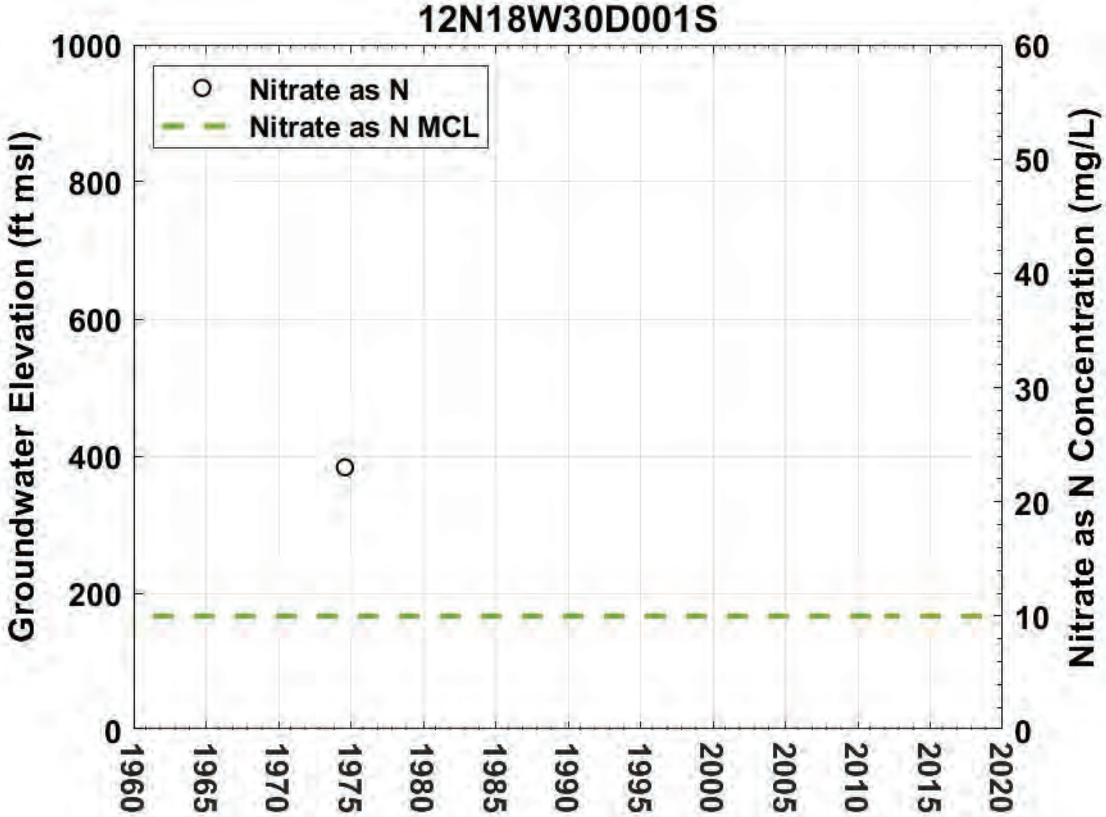

11N20W25K001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
140
120
100
80
60
40
20
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



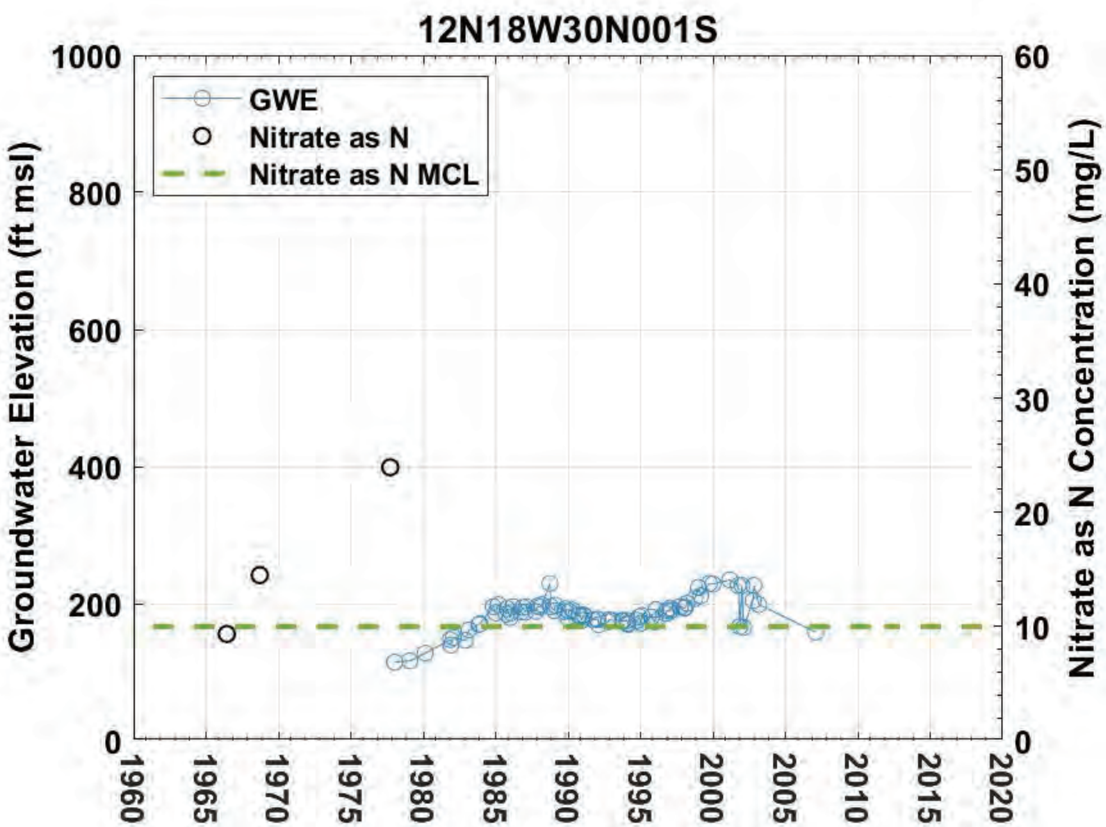
11N20W25K002S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)



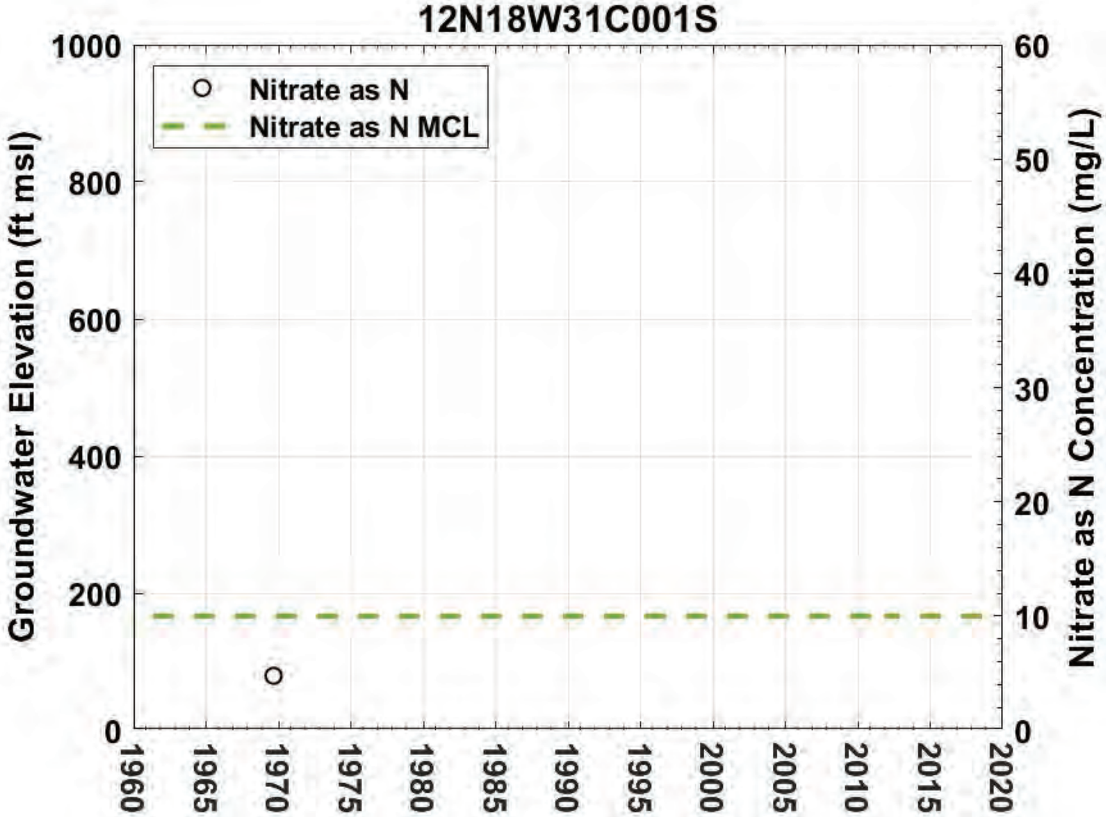
11N20W34J001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)



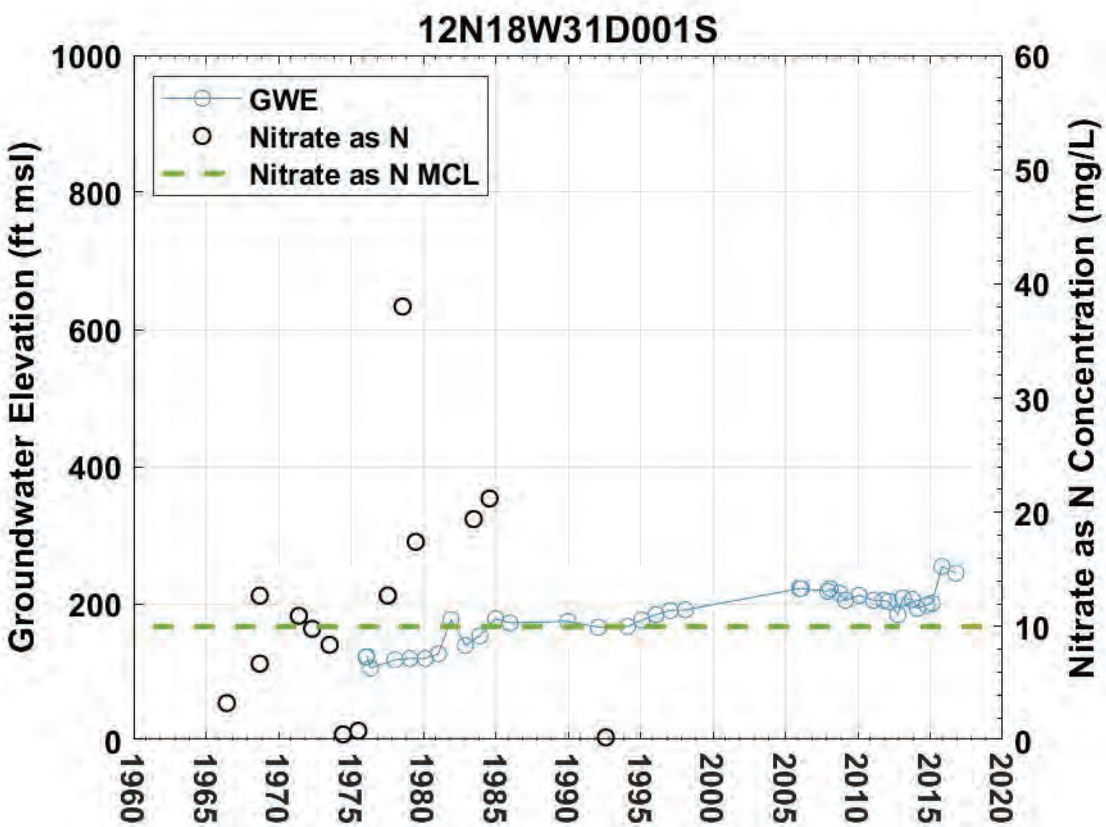
12N18W30D001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



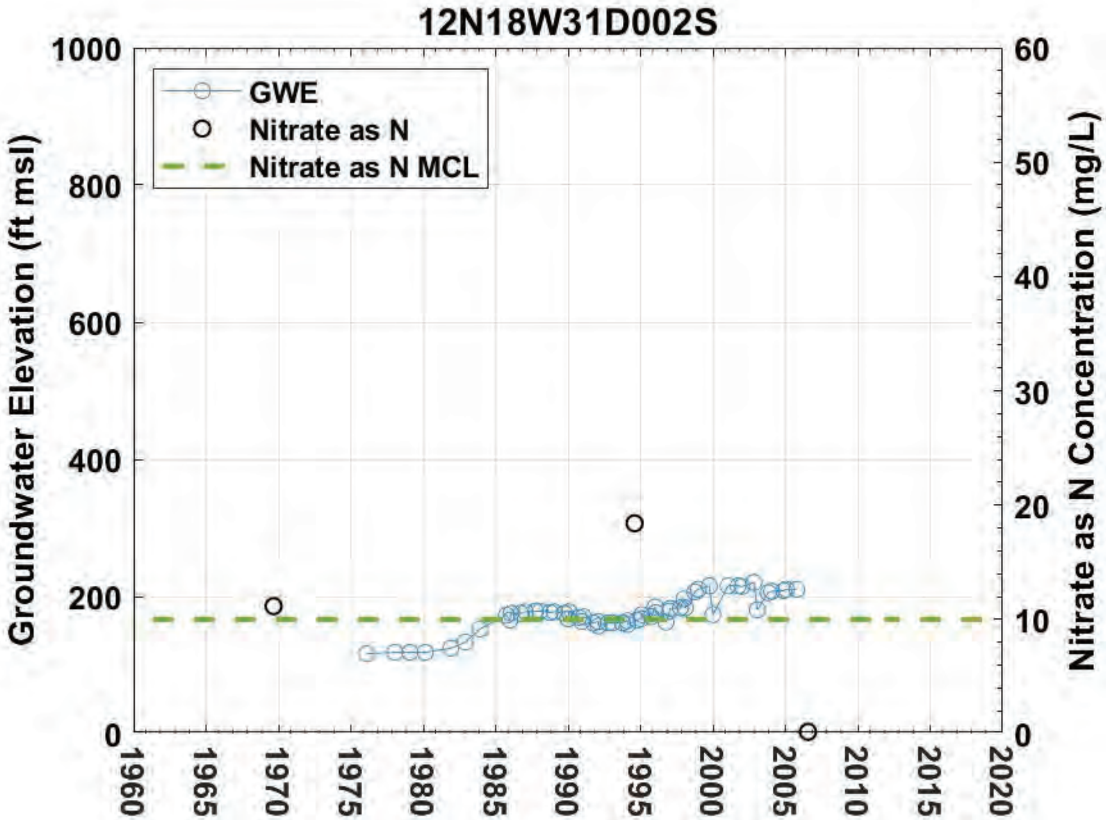
12N18W30N001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



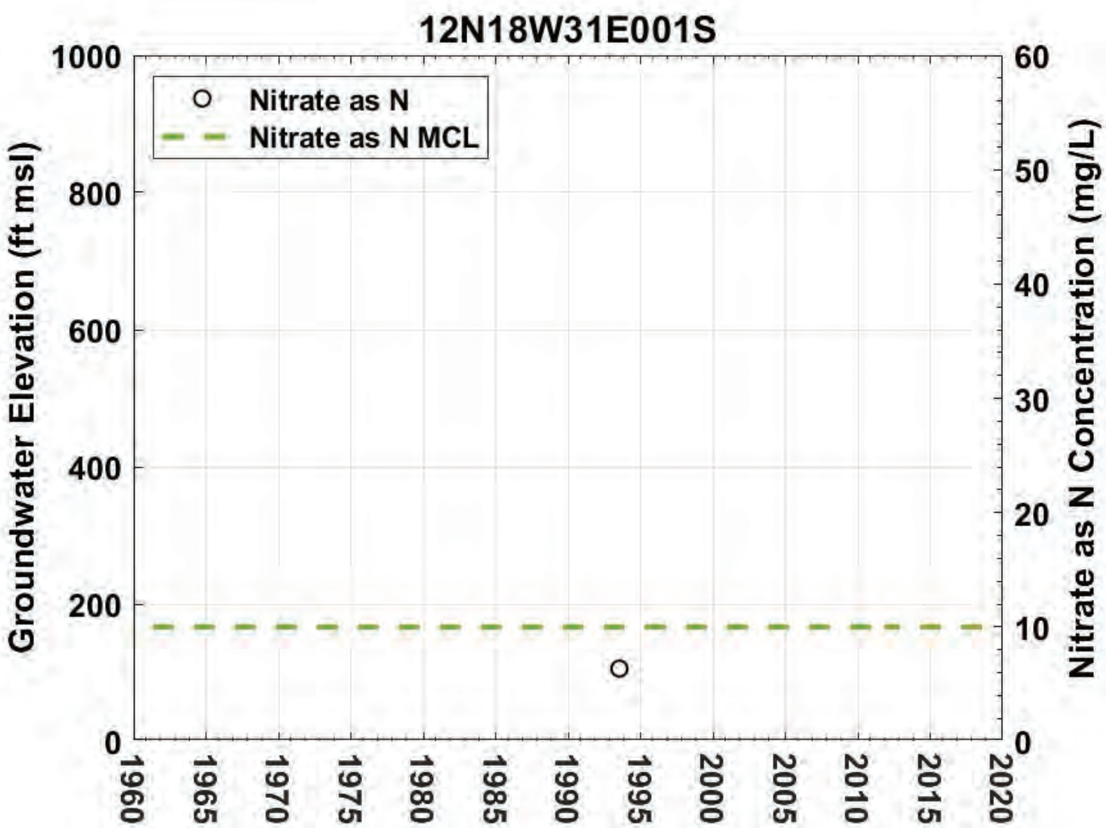
12N18W31C001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)



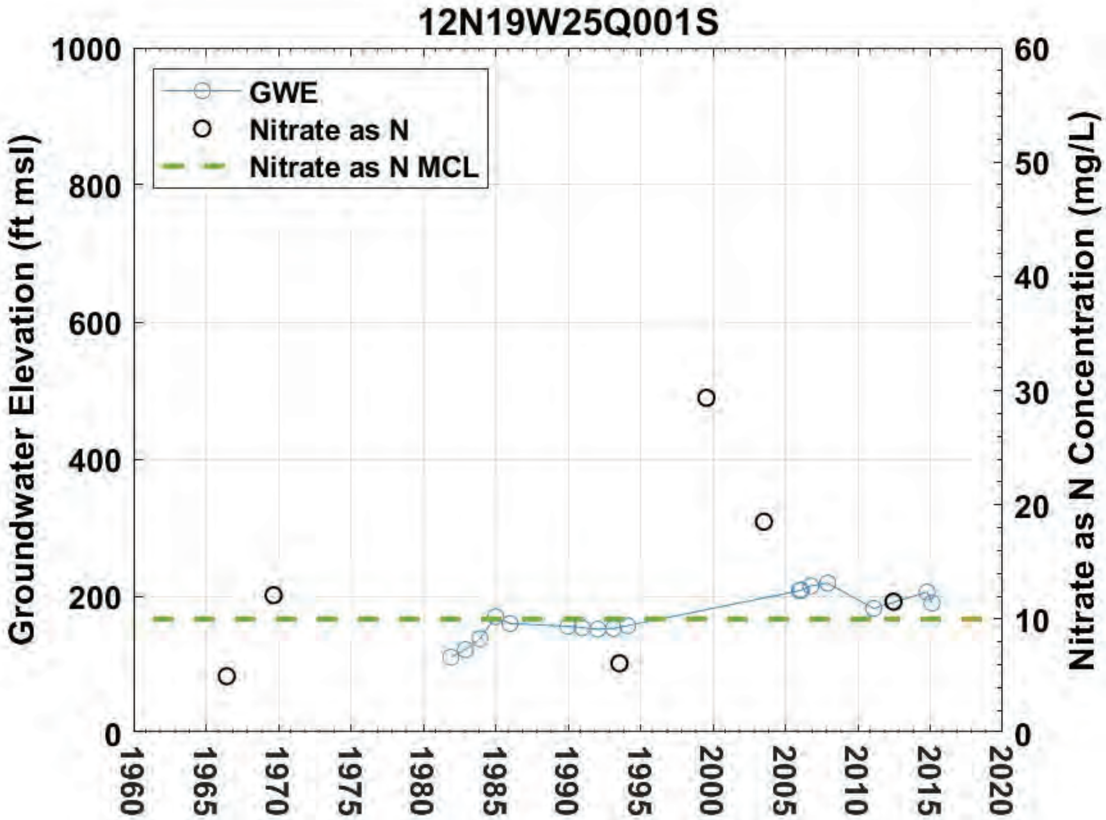
12N18W31D001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)

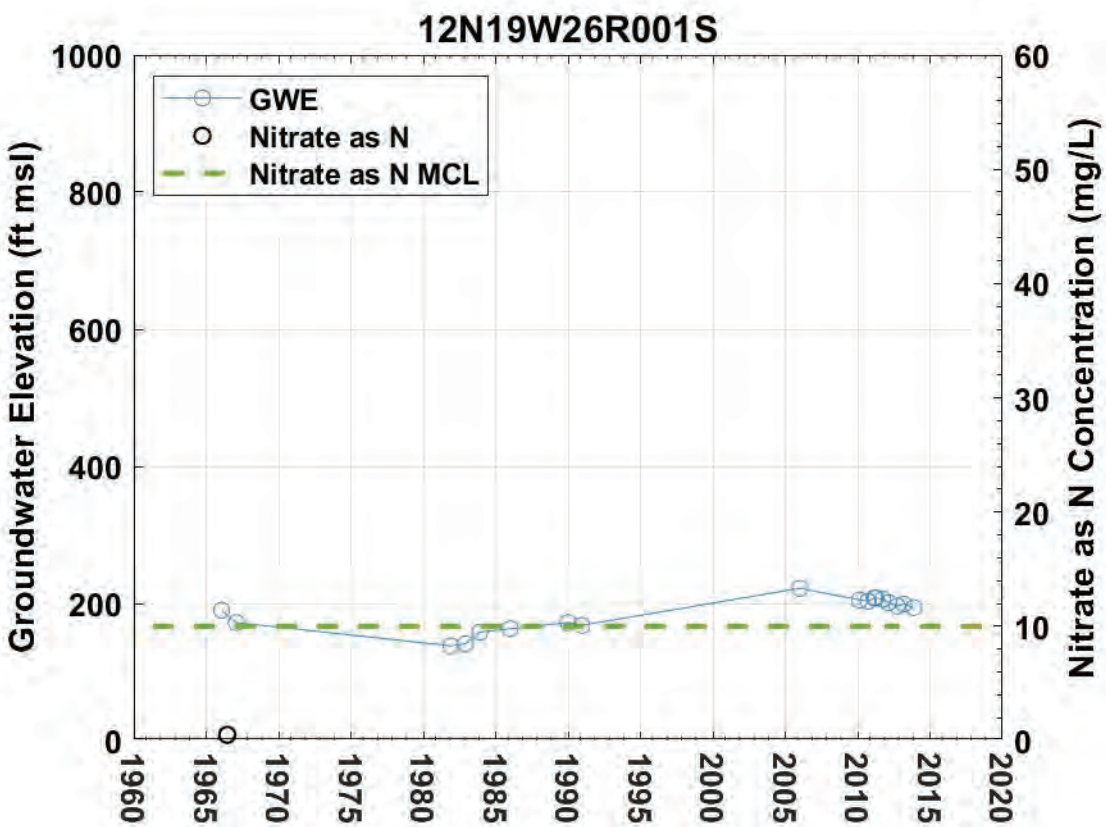


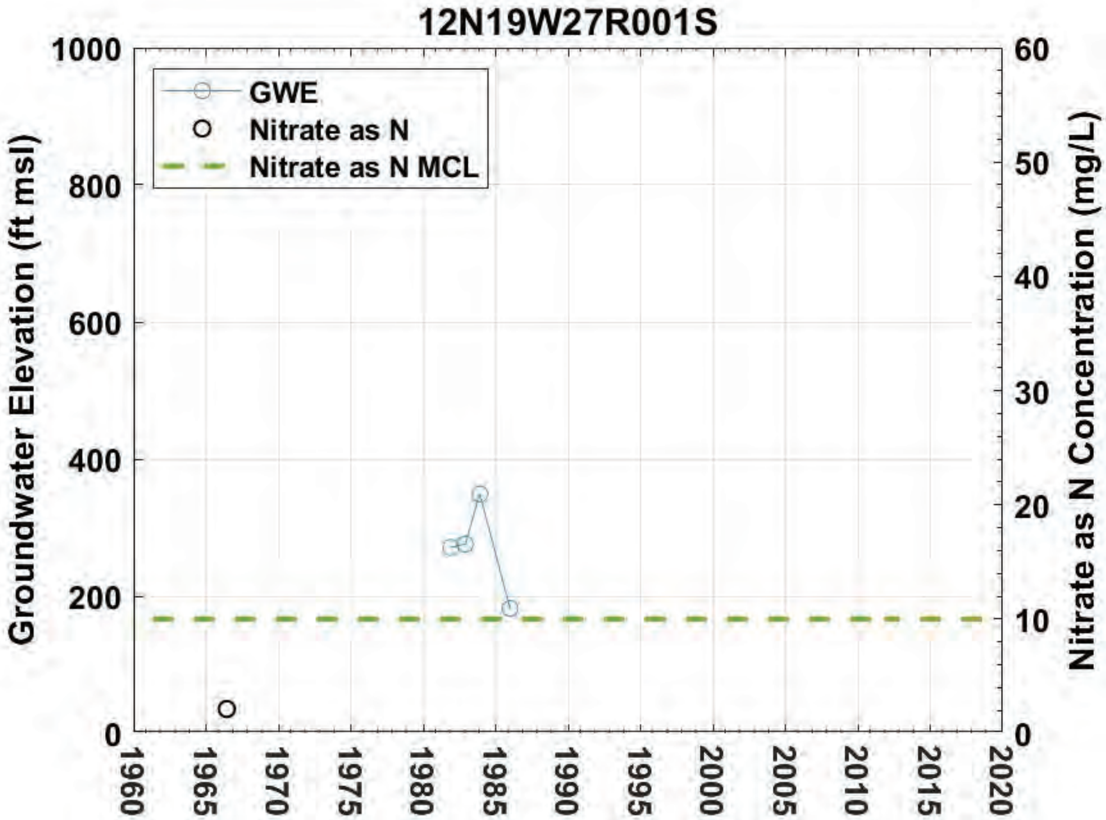
12N18W31D002S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



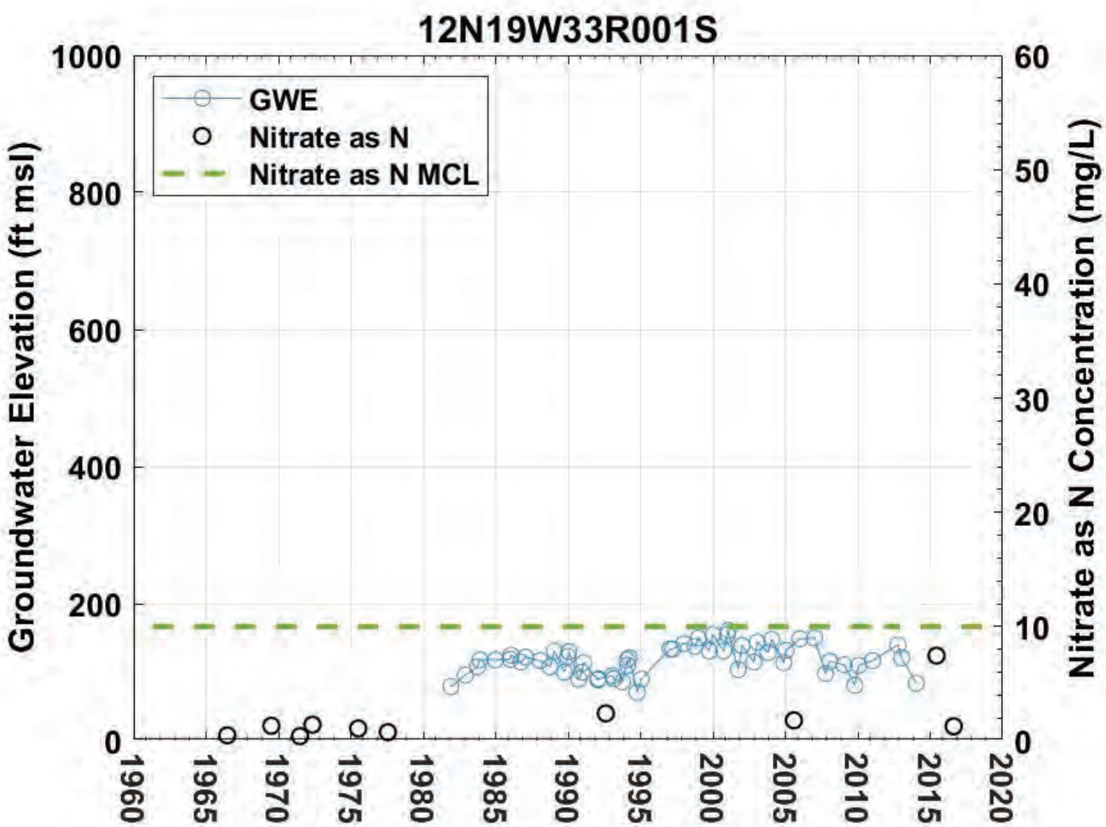
12N18W31E001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


12N19W25Q001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

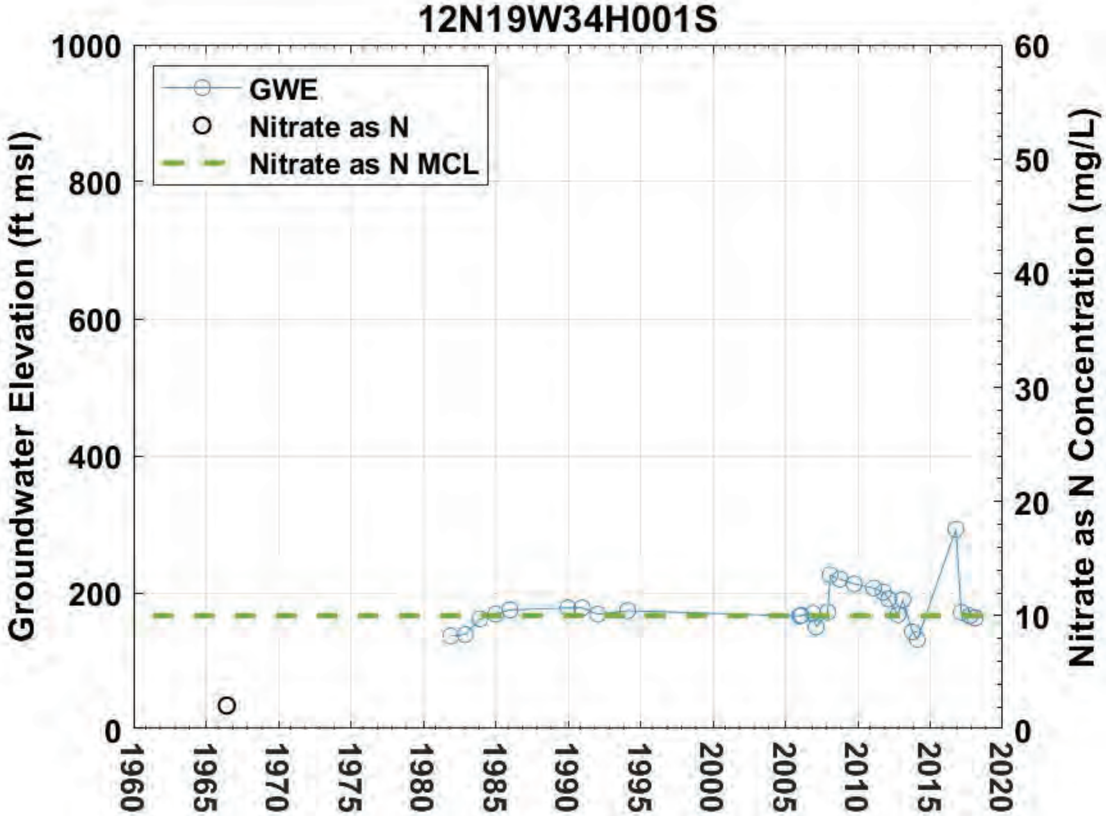

12N19W26R001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

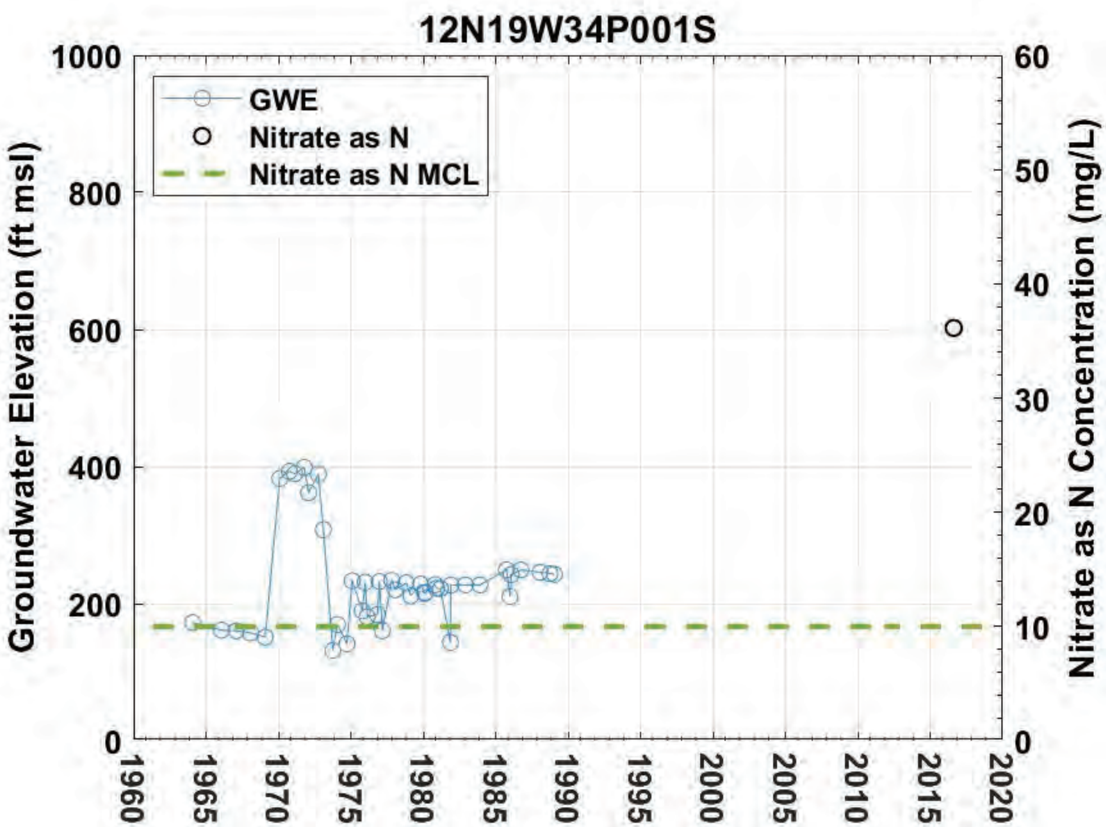


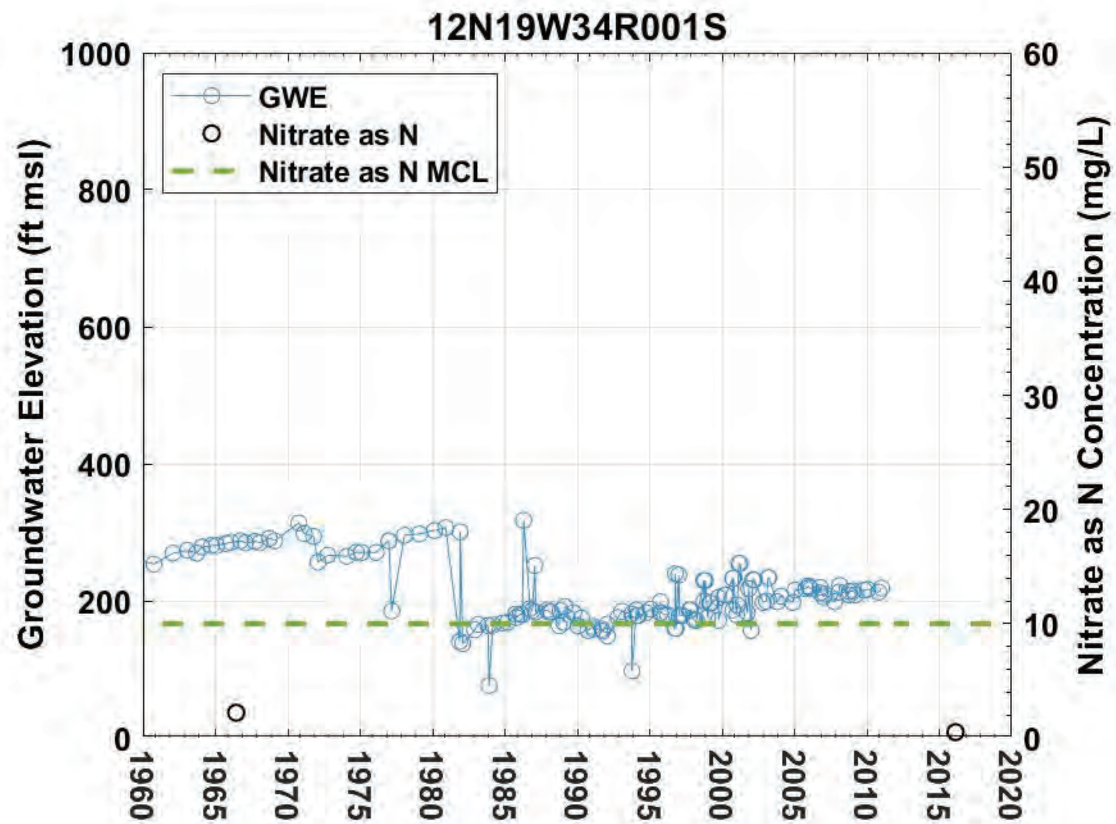
12N19W27R001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

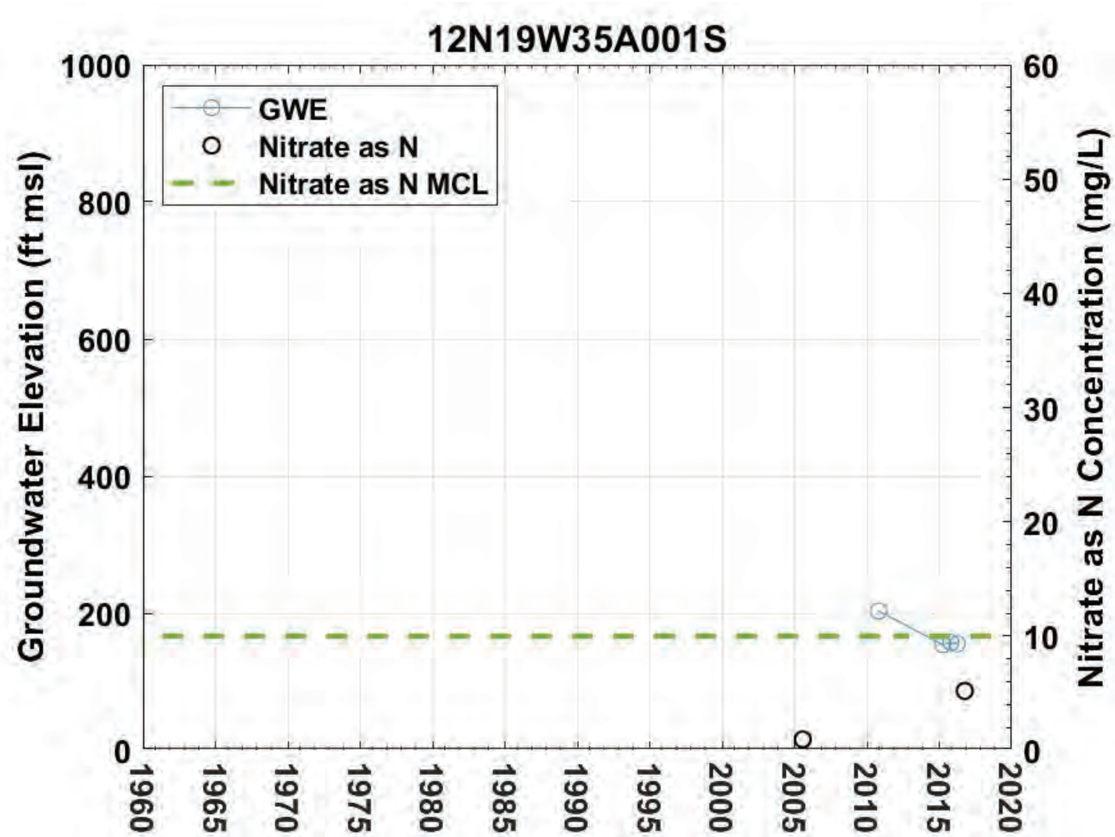


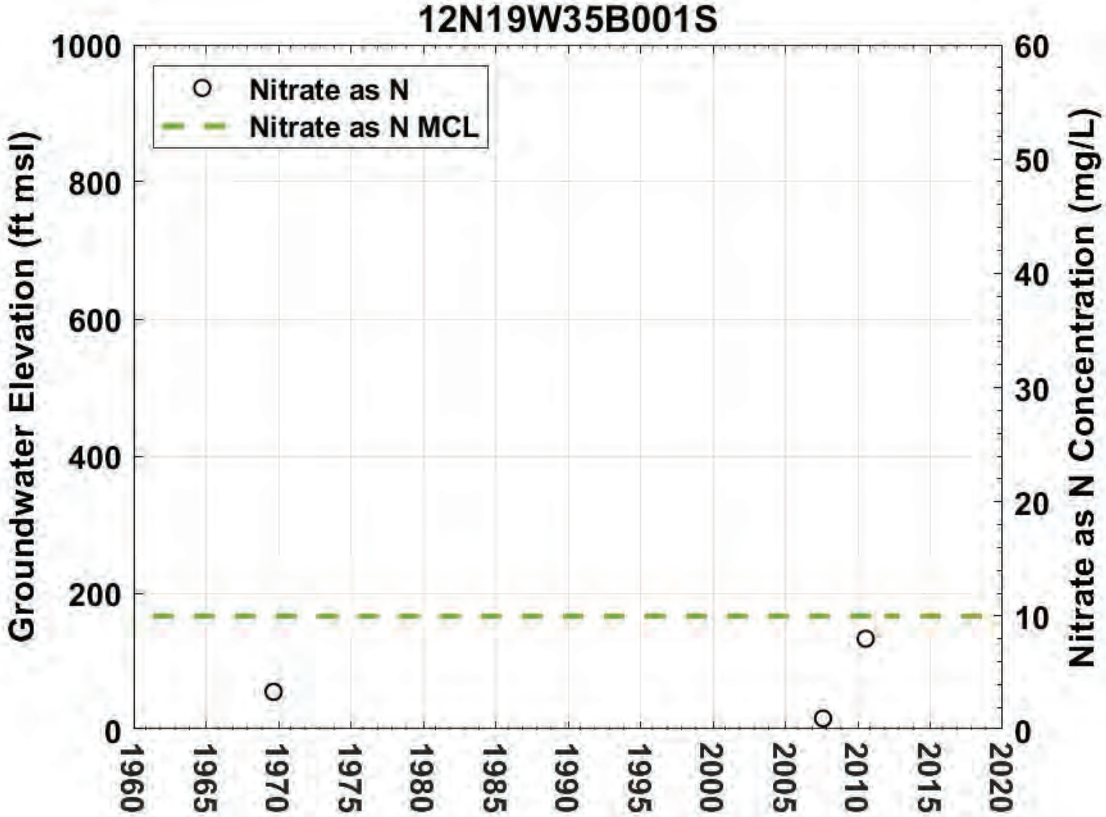
12N19W33R001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

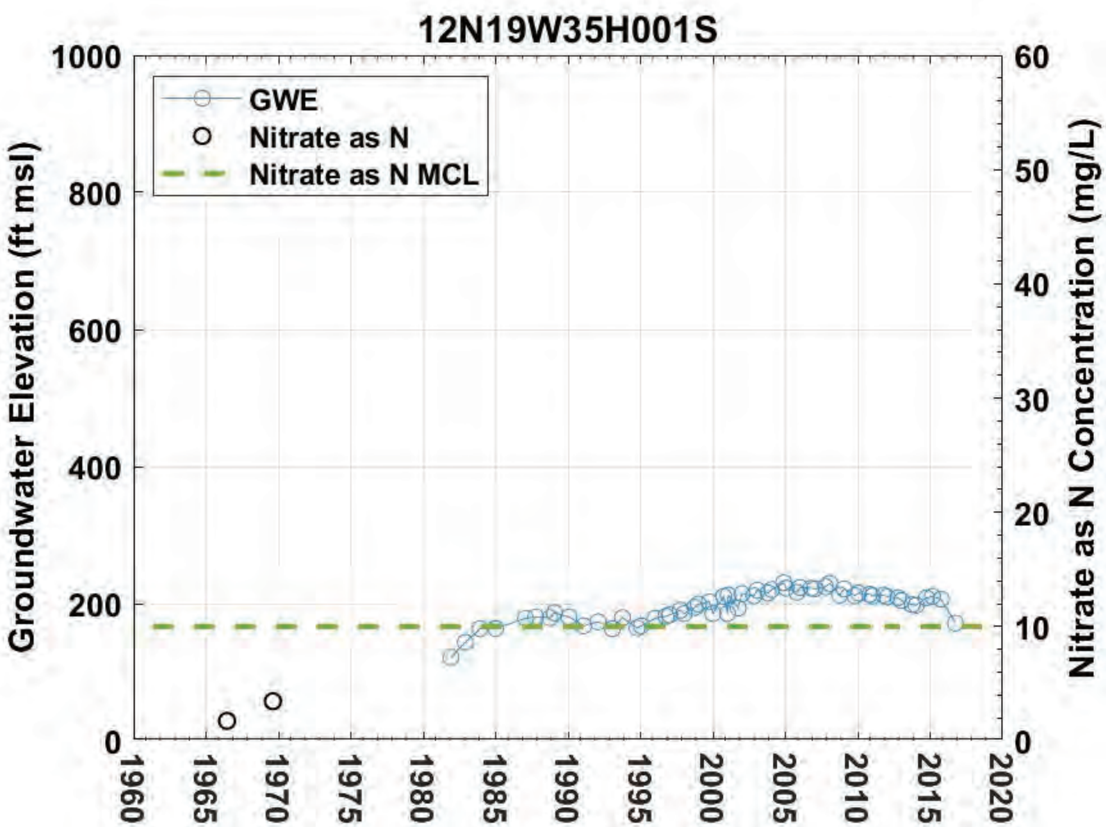

12N19W34H001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

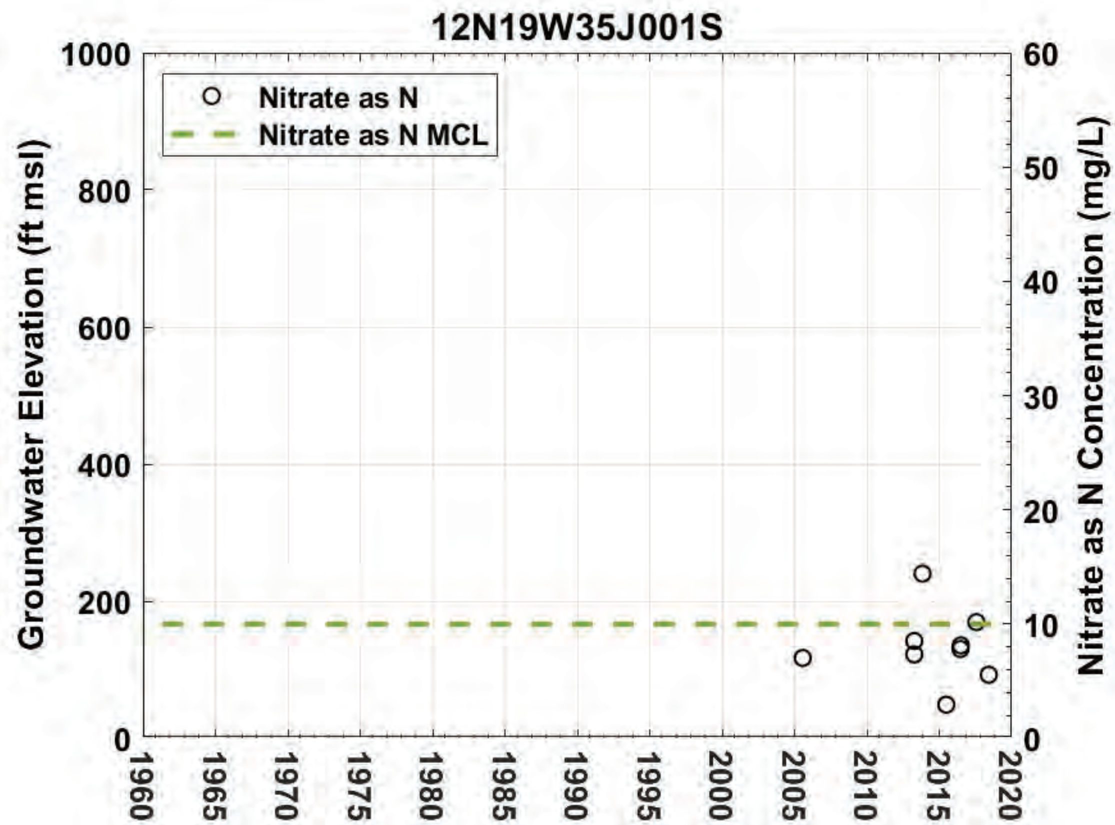

12N19W34P001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

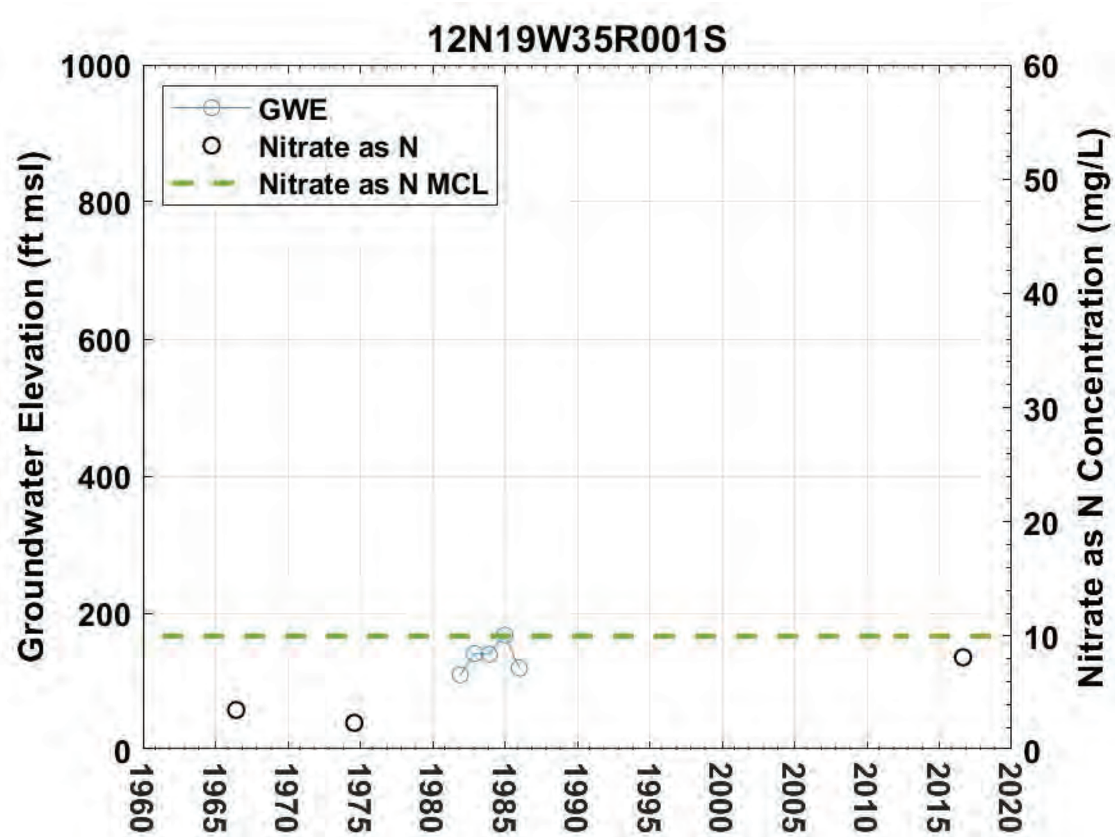

12N19W34R001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

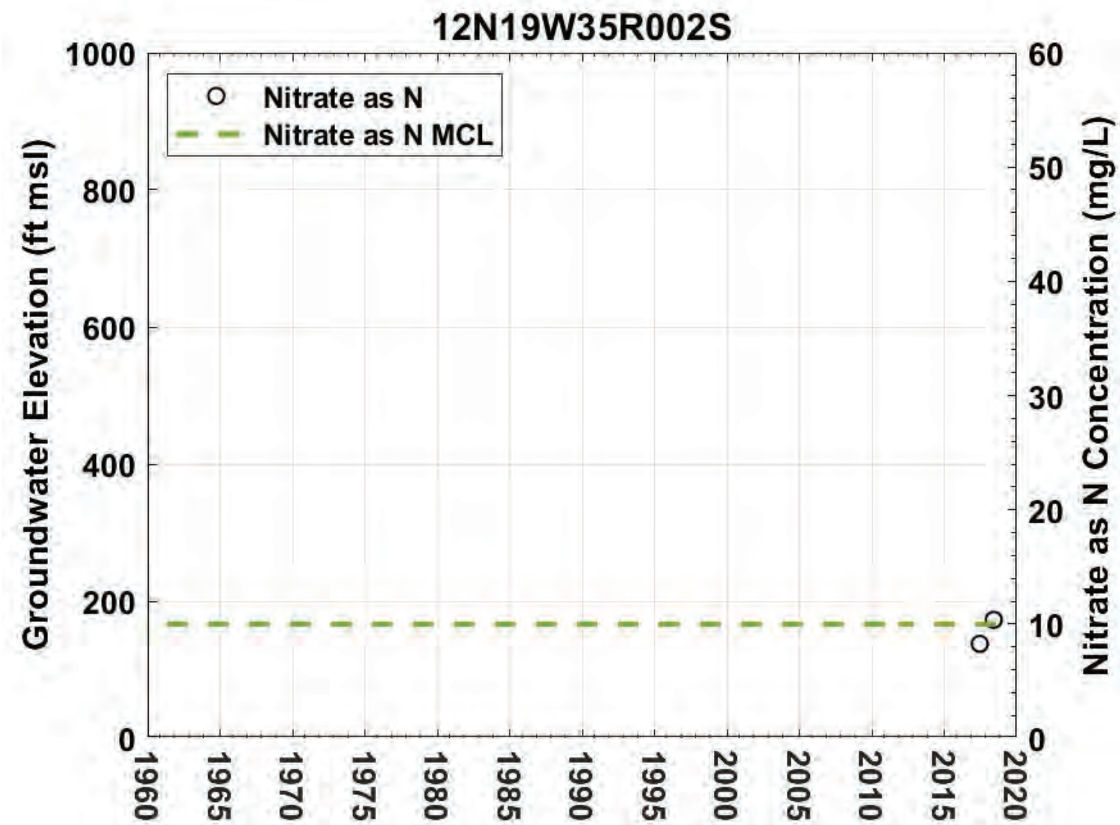

12N19W35A001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

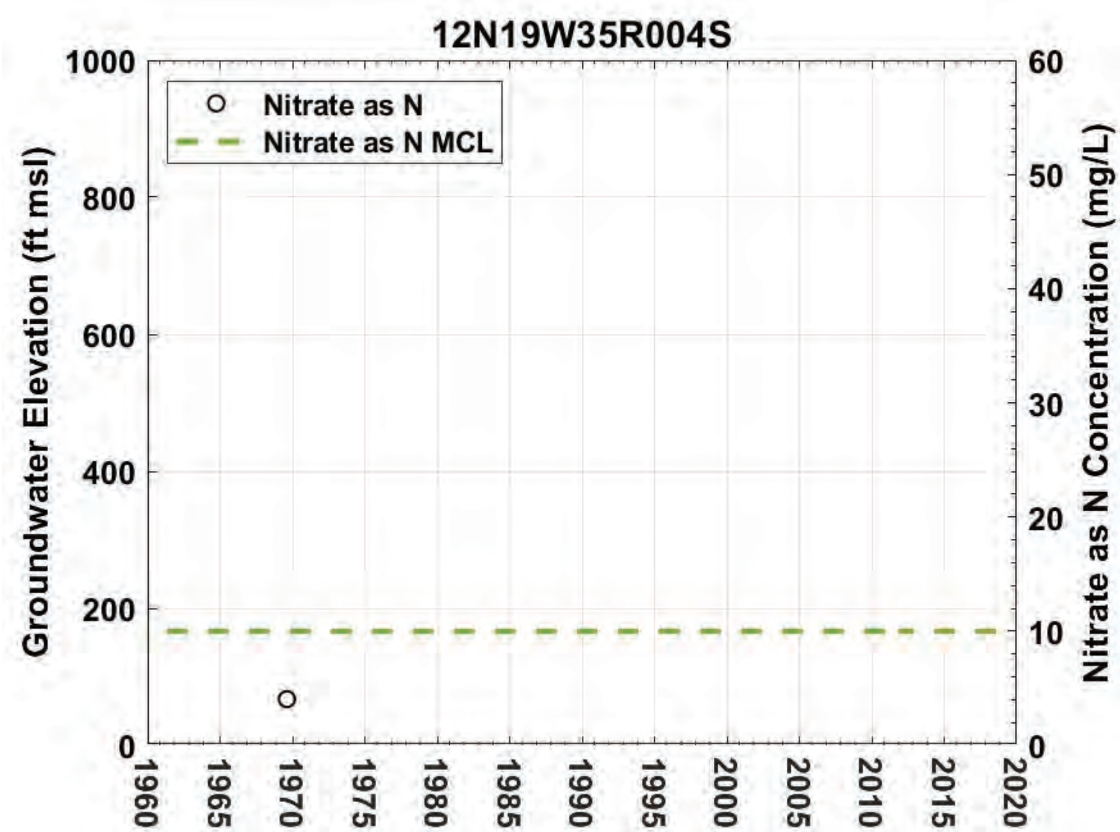

12N19W35B001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

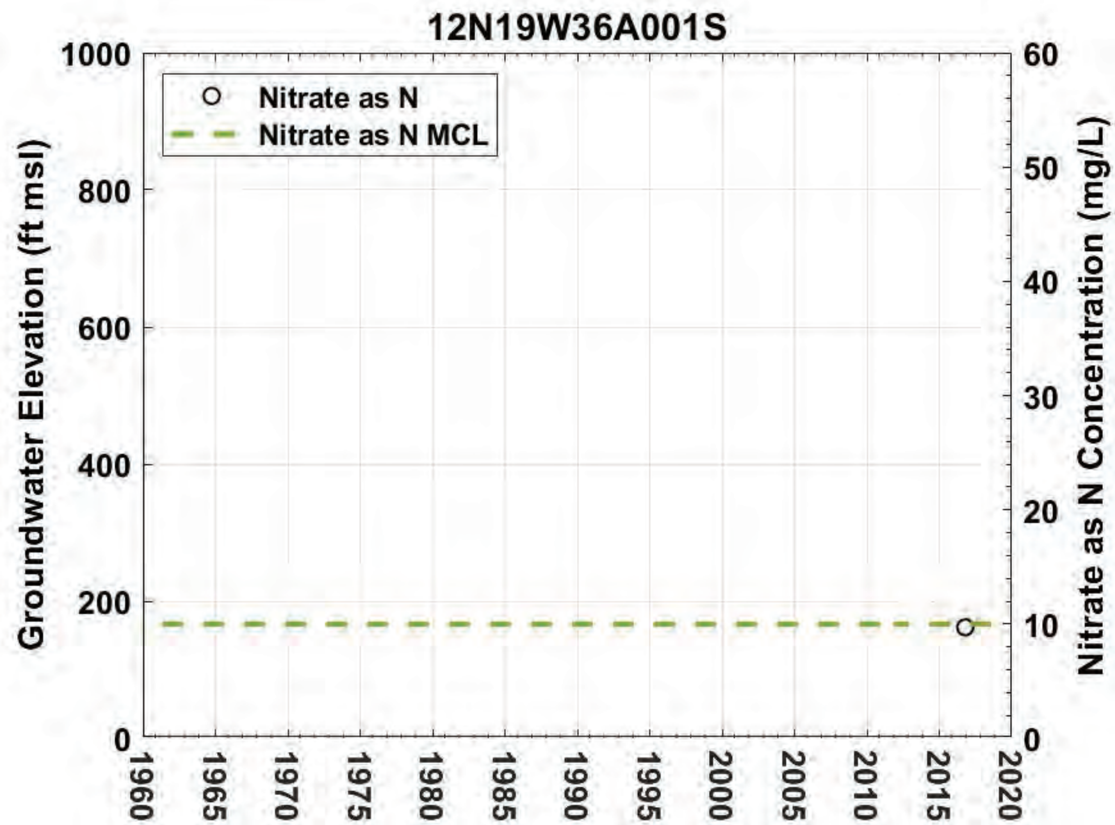

12N19W35H001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


12N19W35J001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

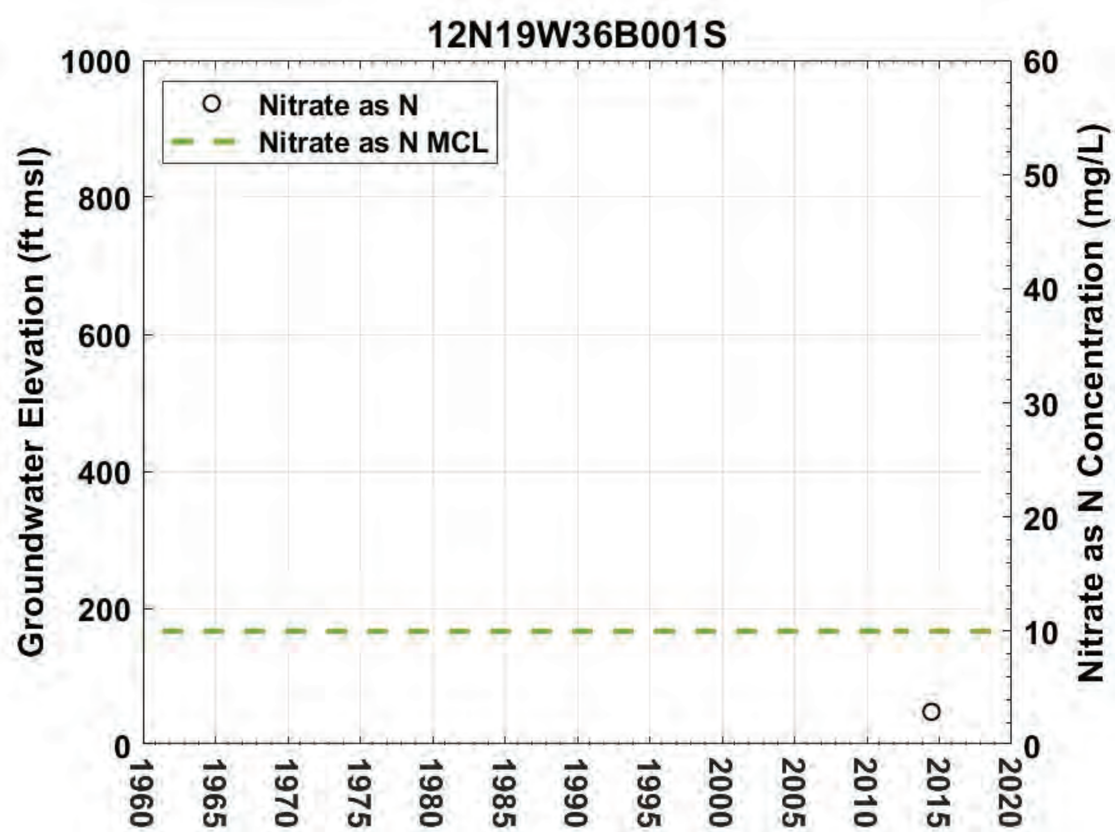

12N19W35R001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


12N19W35R002S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

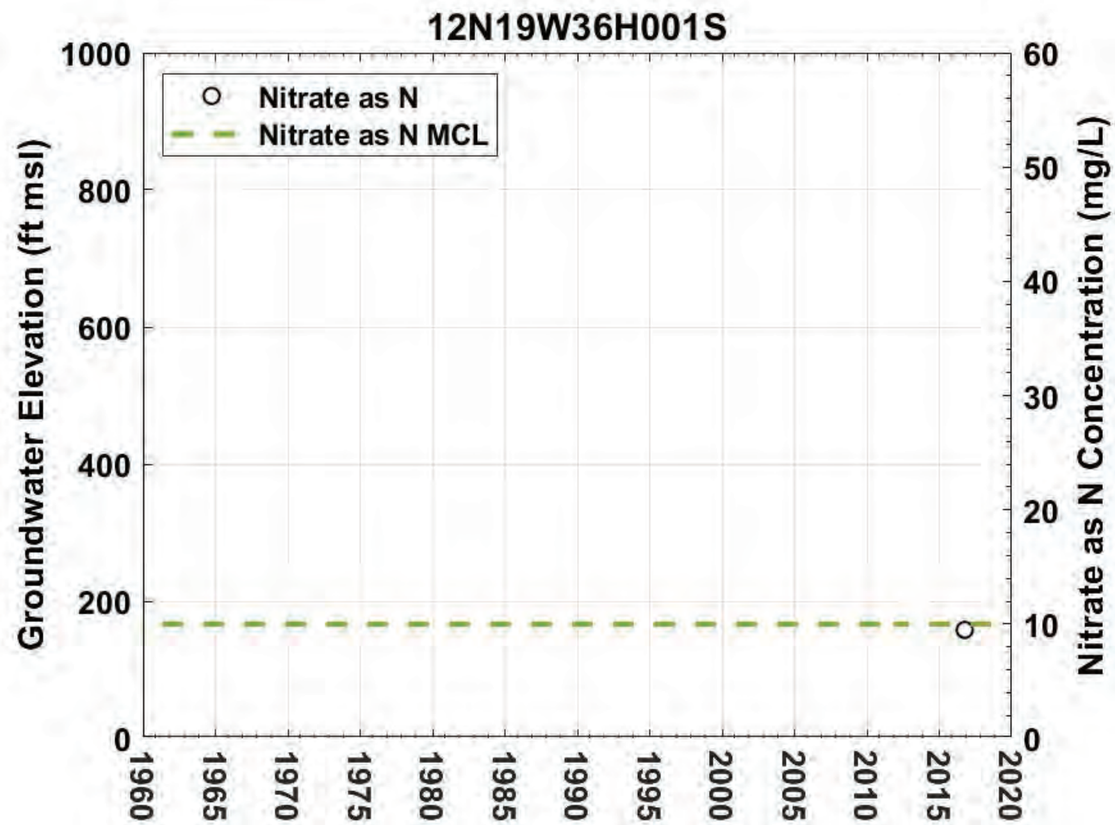

12N19W35R004S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

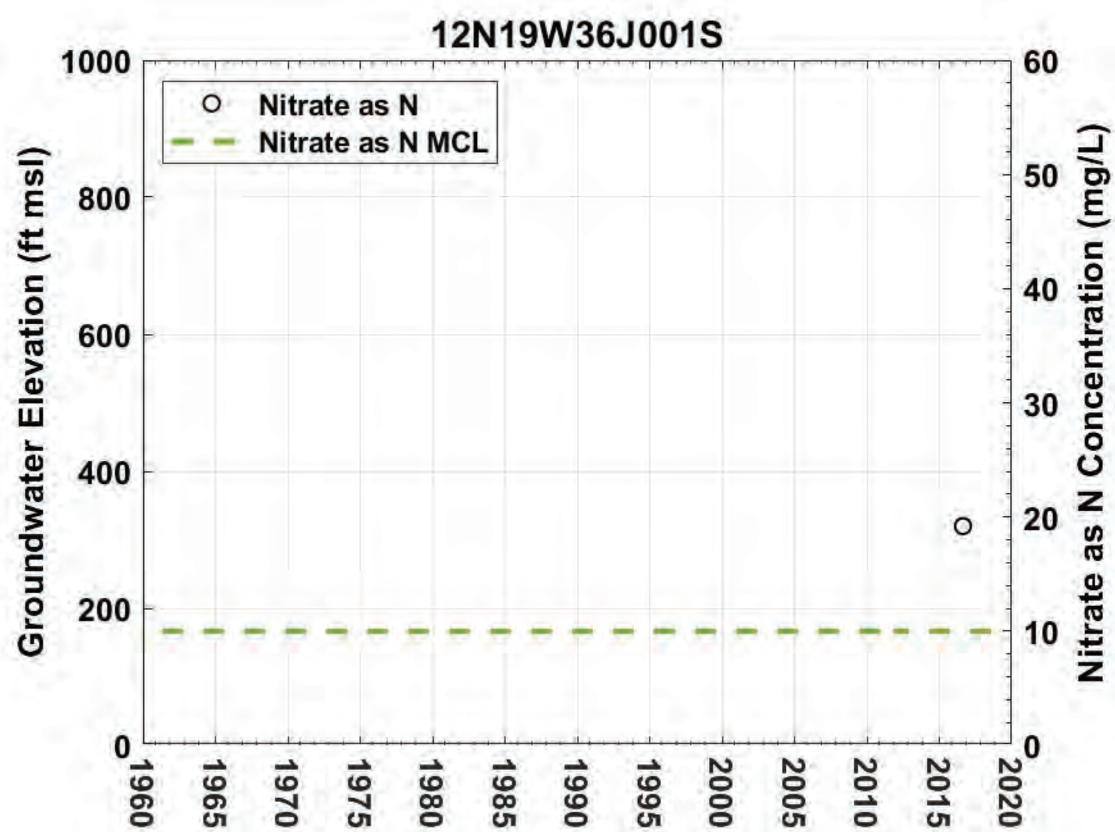


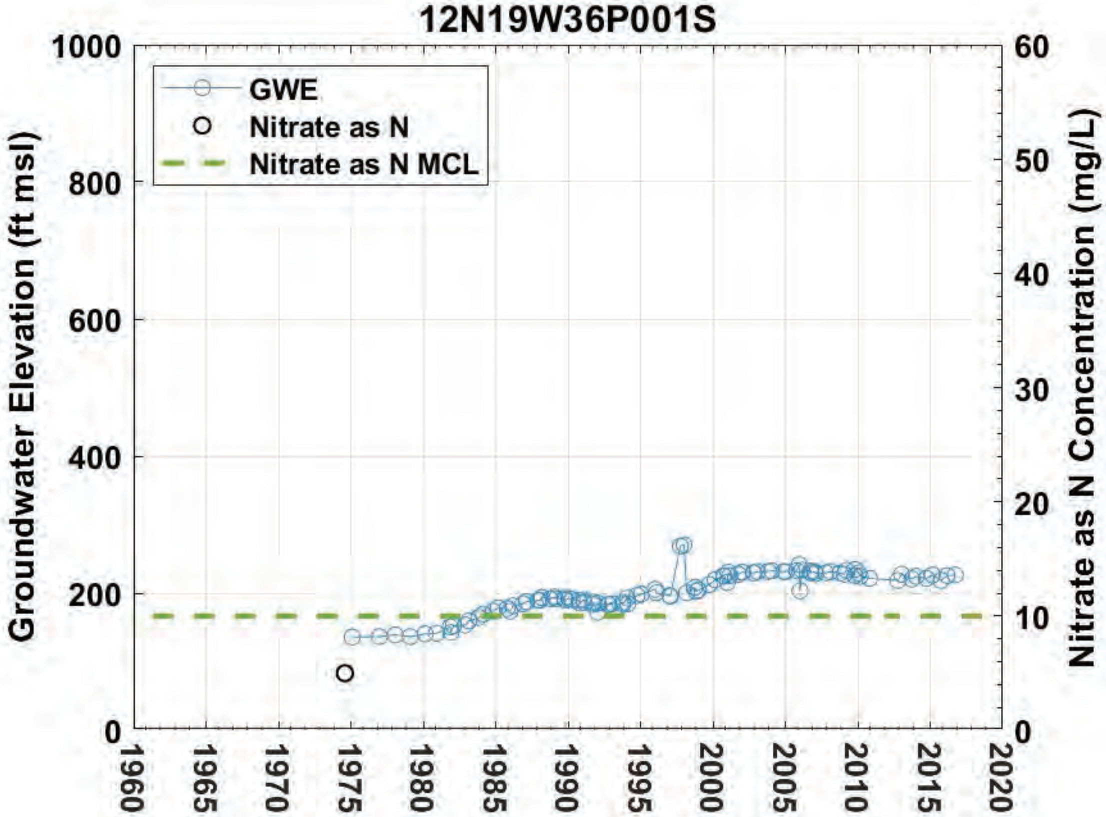
12N19W36A001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)

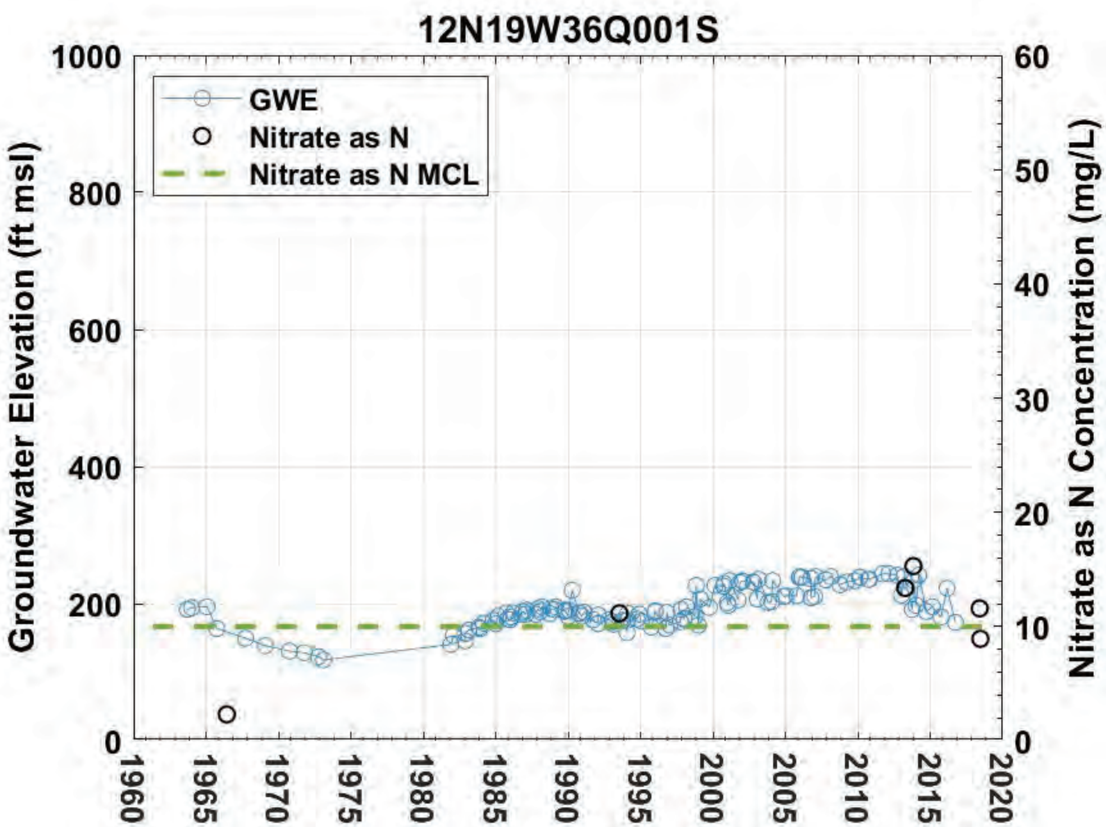


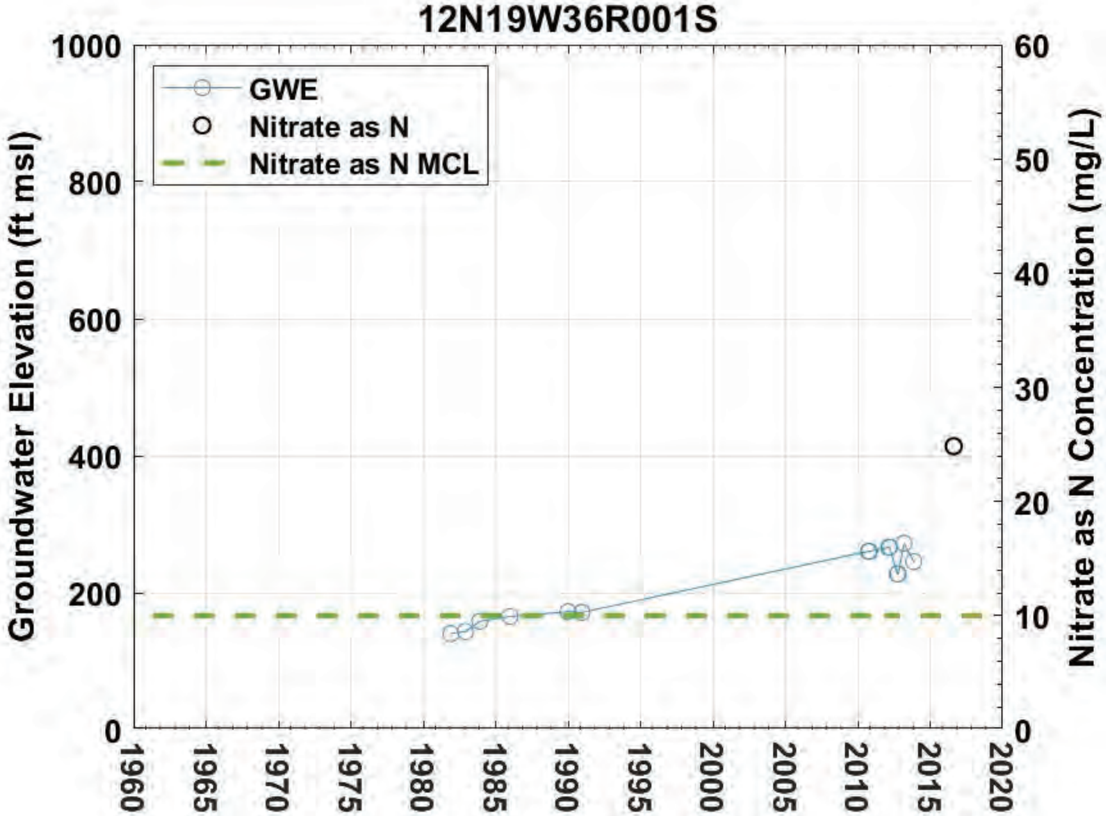
12N19W36B001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)

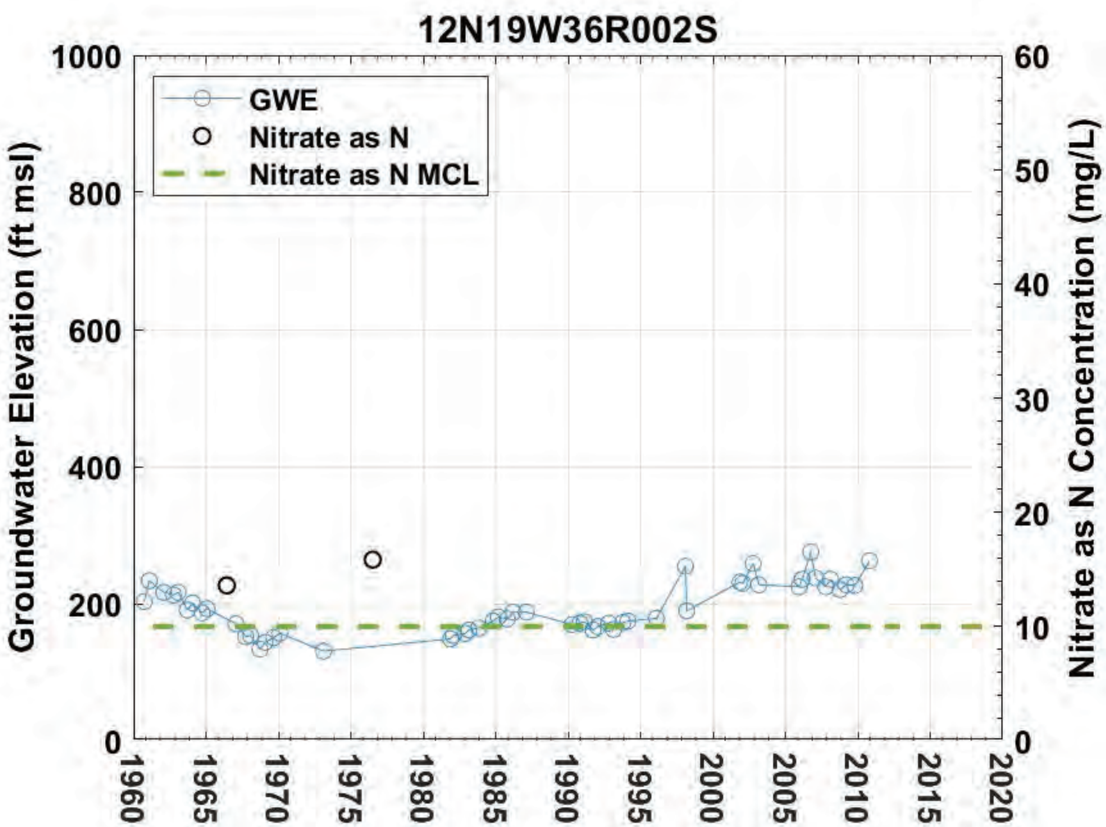

12N19W36H001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

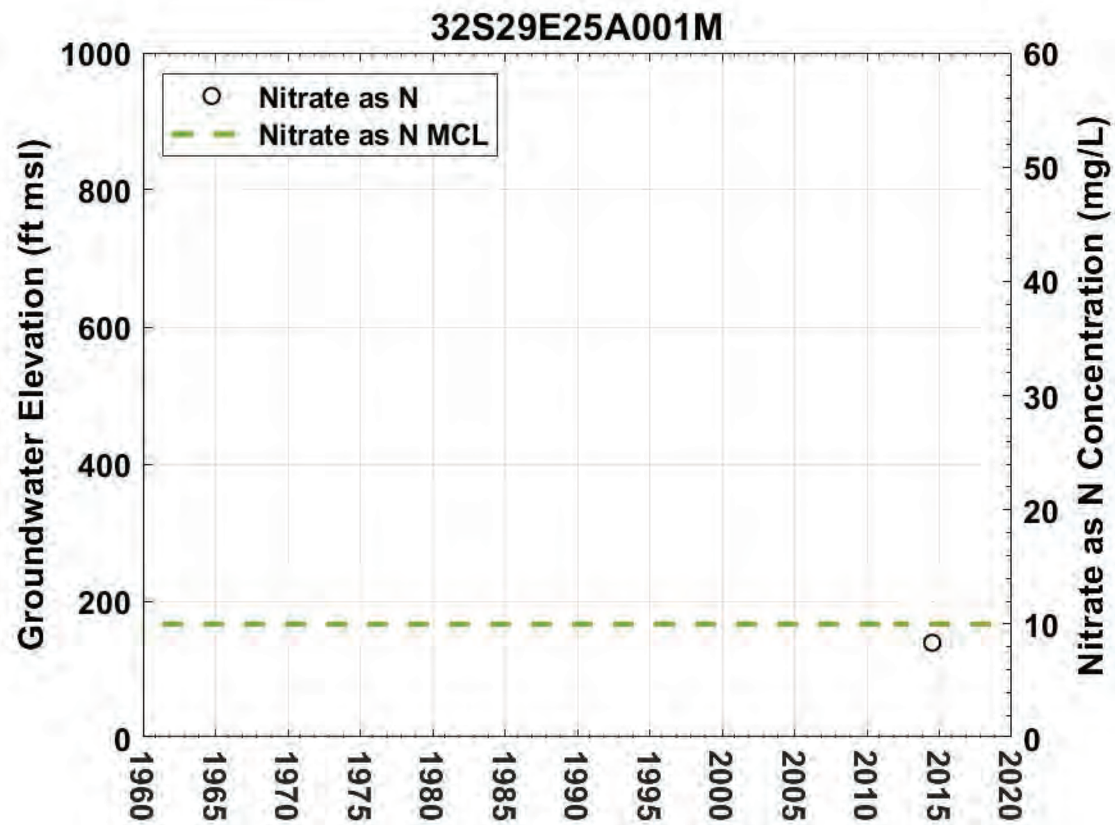

12N19W36J001S
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

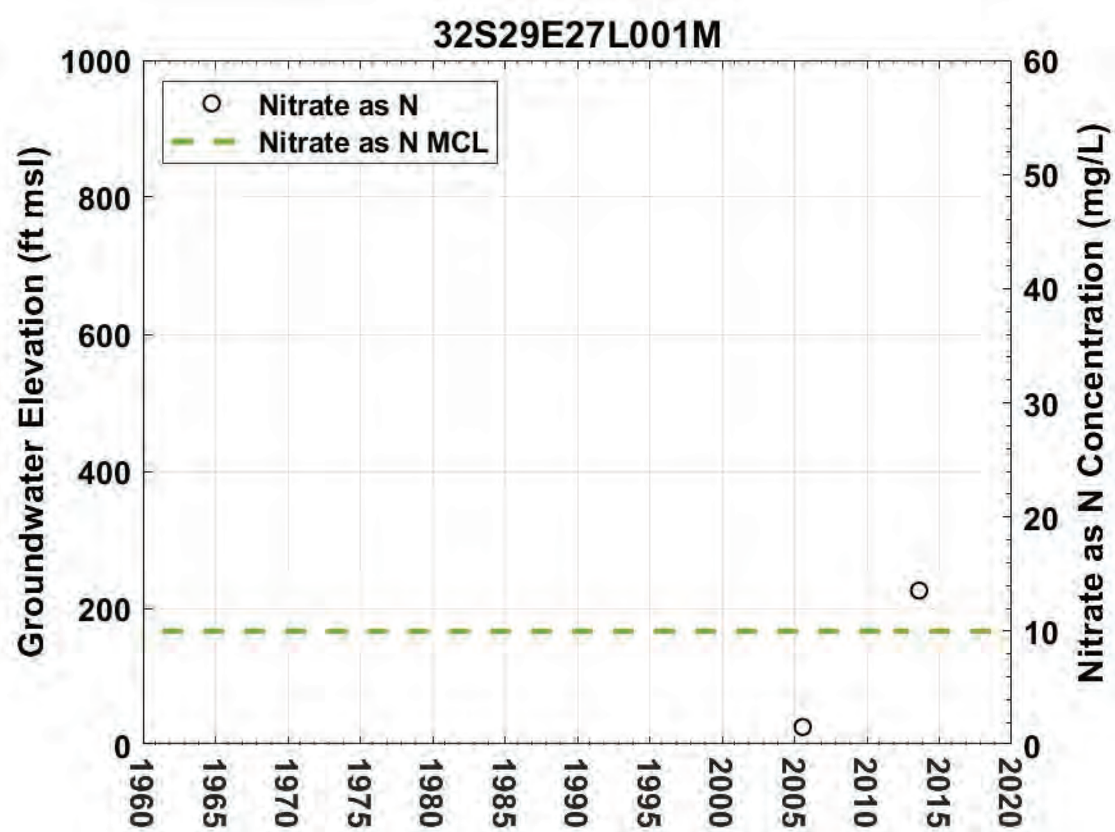

12N19W36P001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

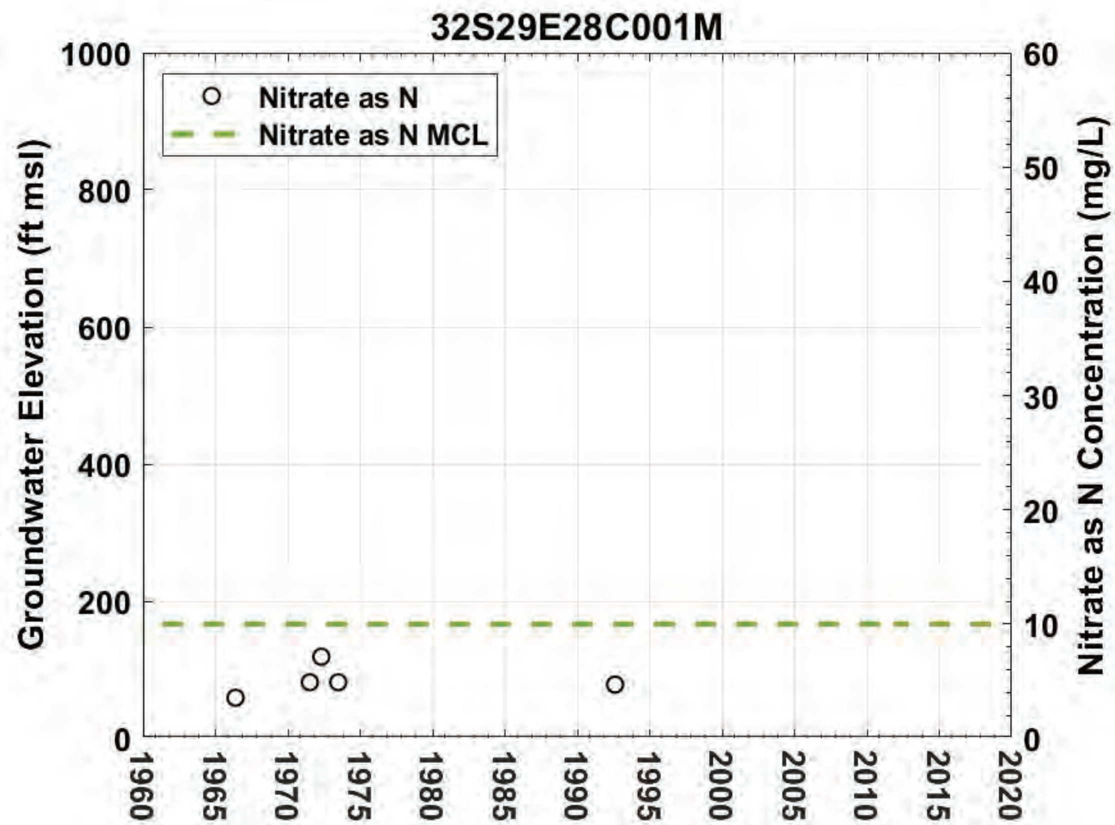

12N19W36Q001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


12N19W36R001S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

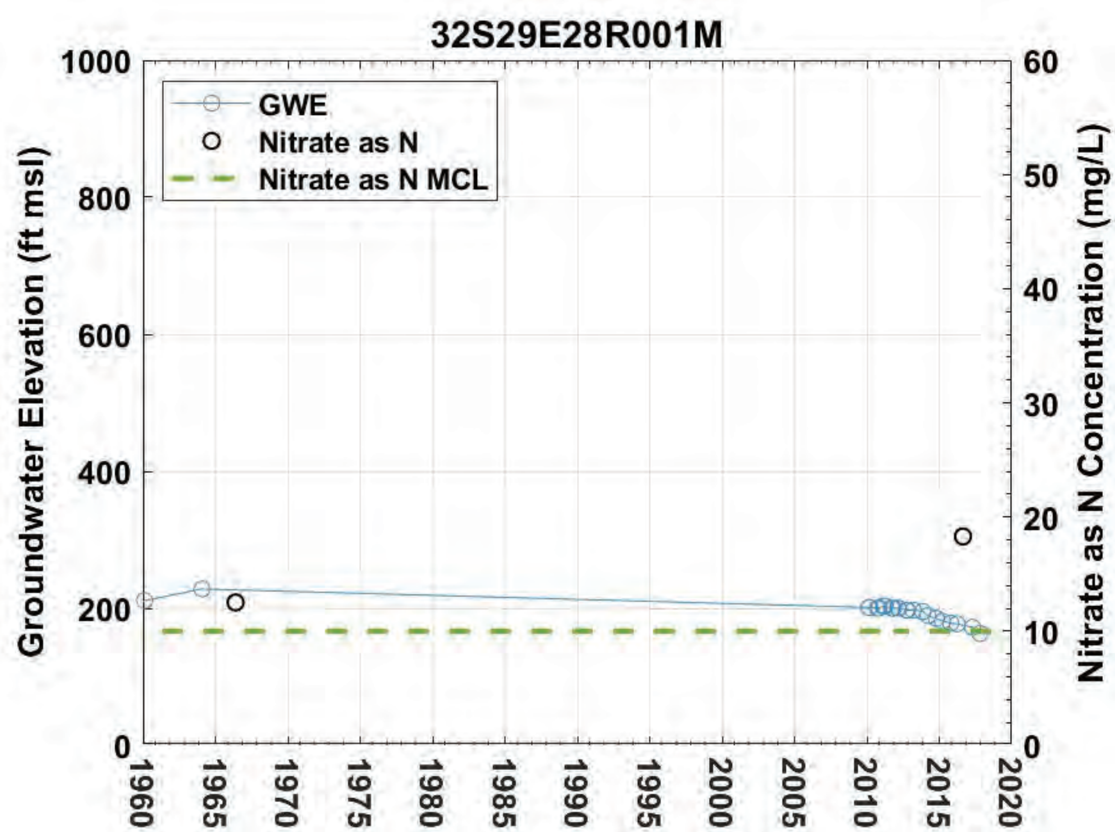

12N19W36R002S
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


32S29E25A001M
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

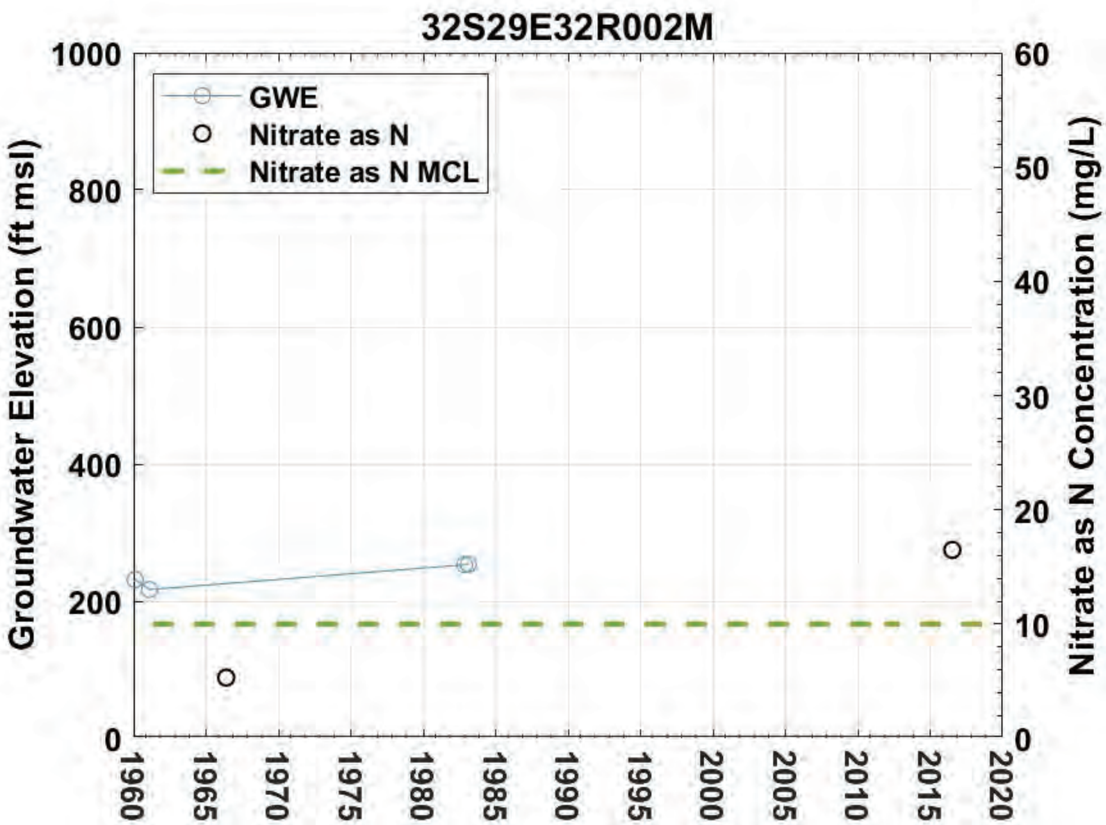

32S29E27L001M
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



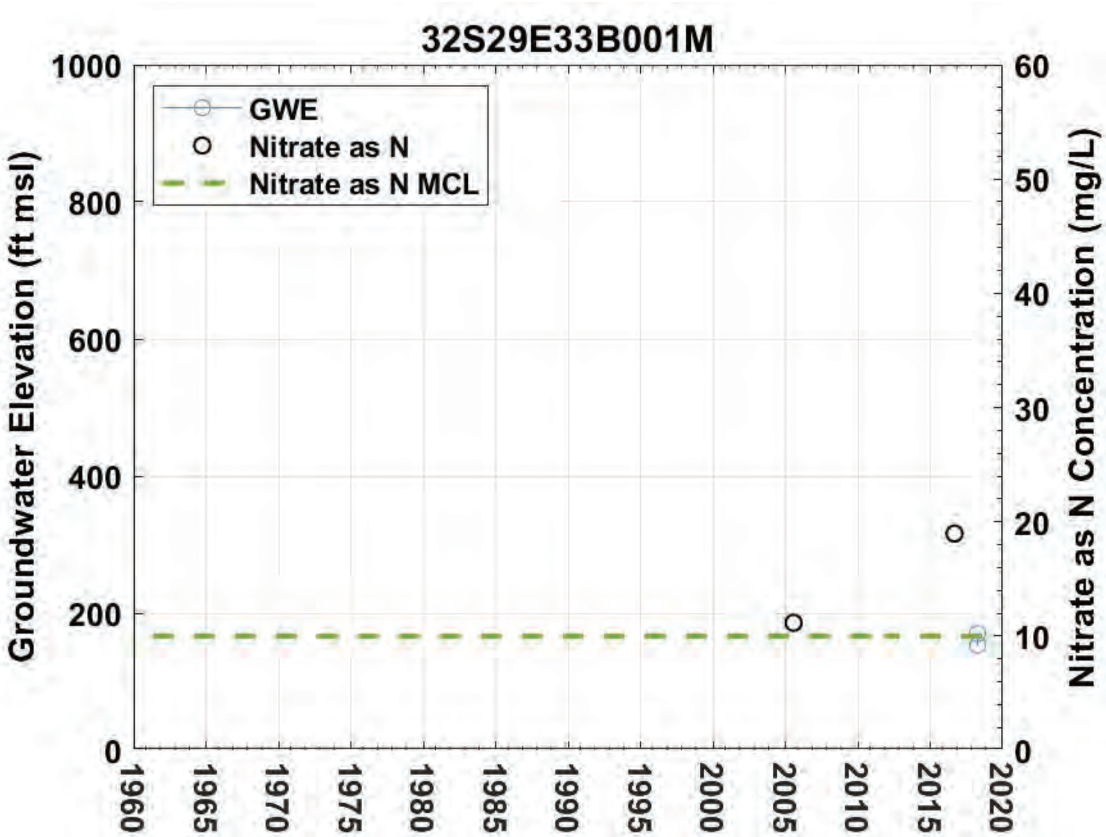
32S29E28C001M
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



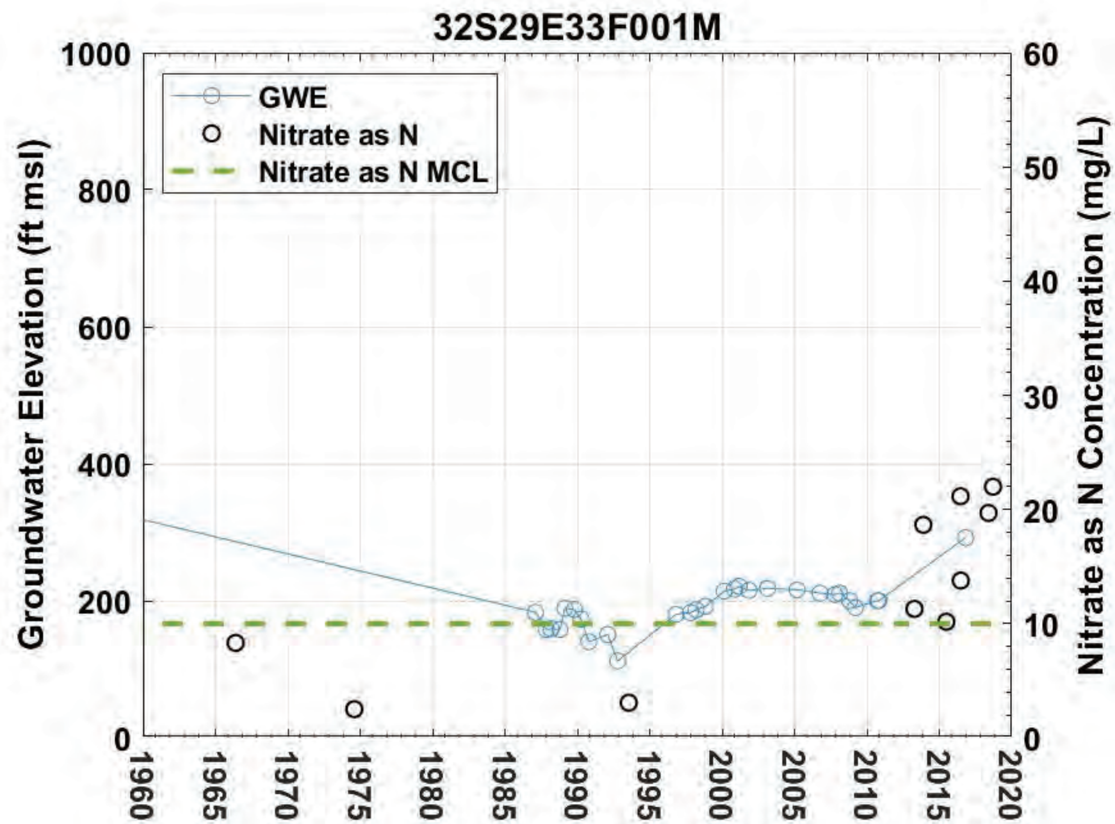
32S29E28R001M
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

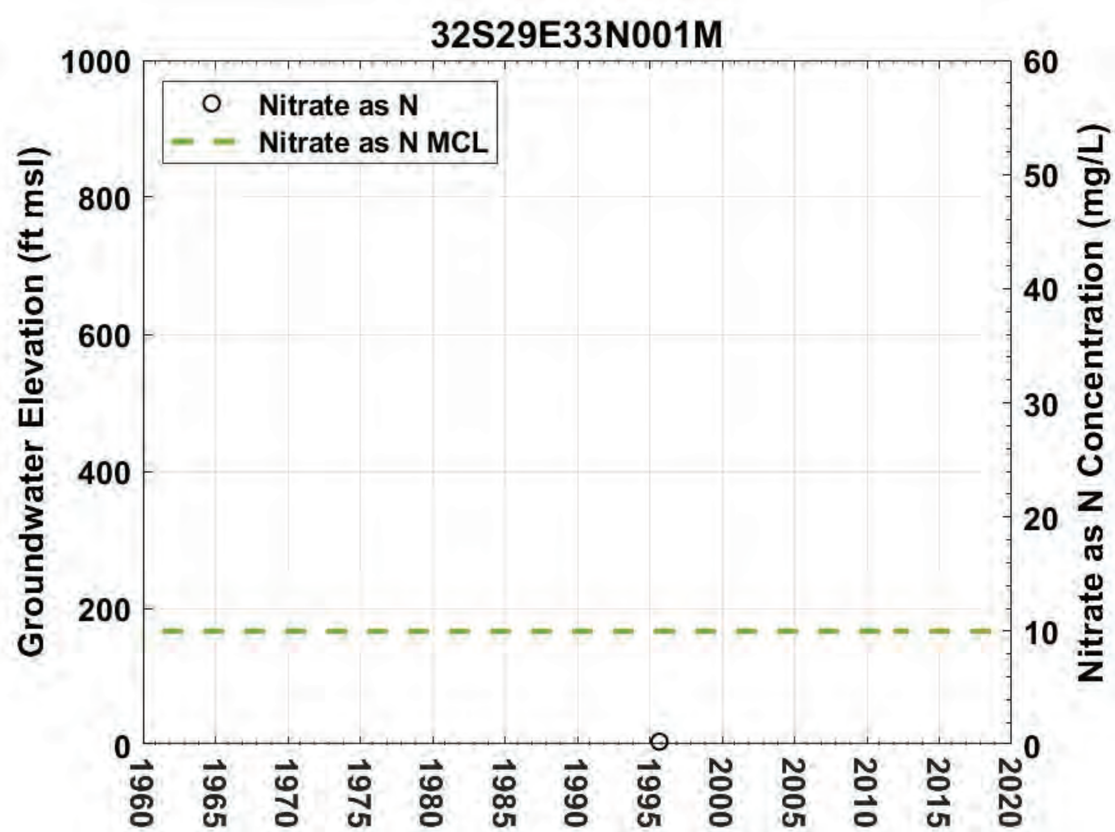


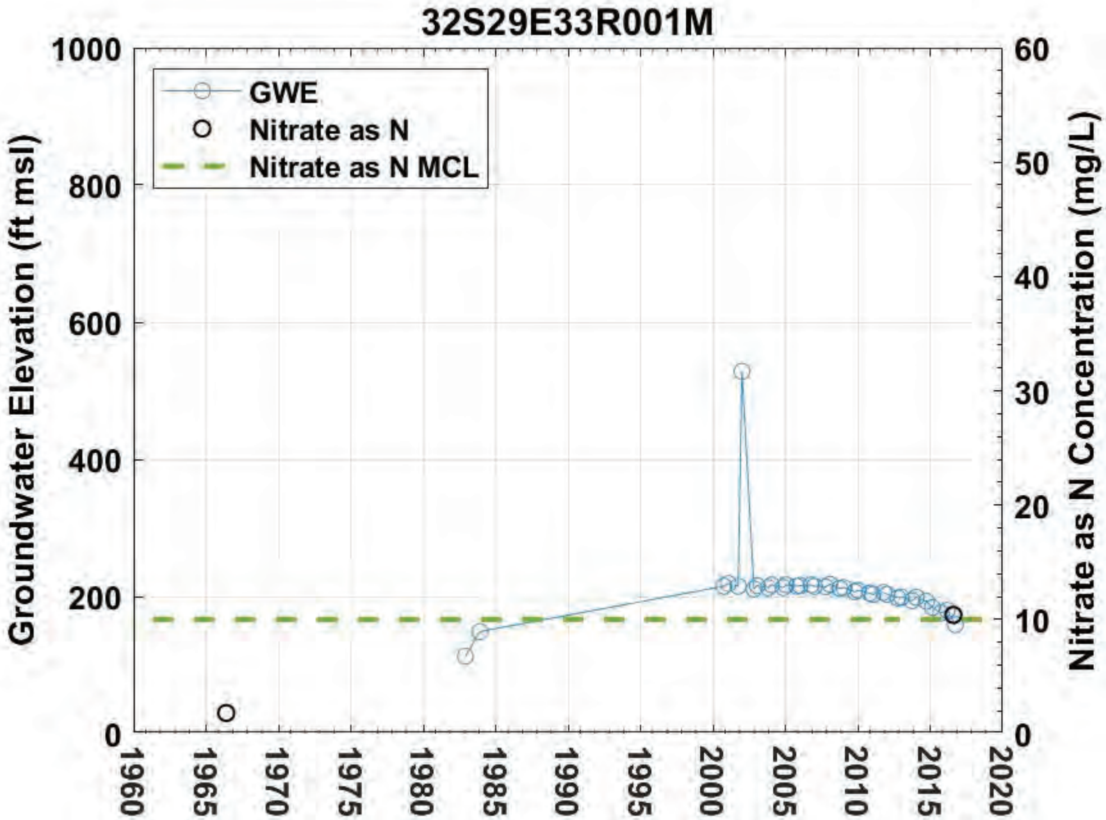
32S29E32R002M
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



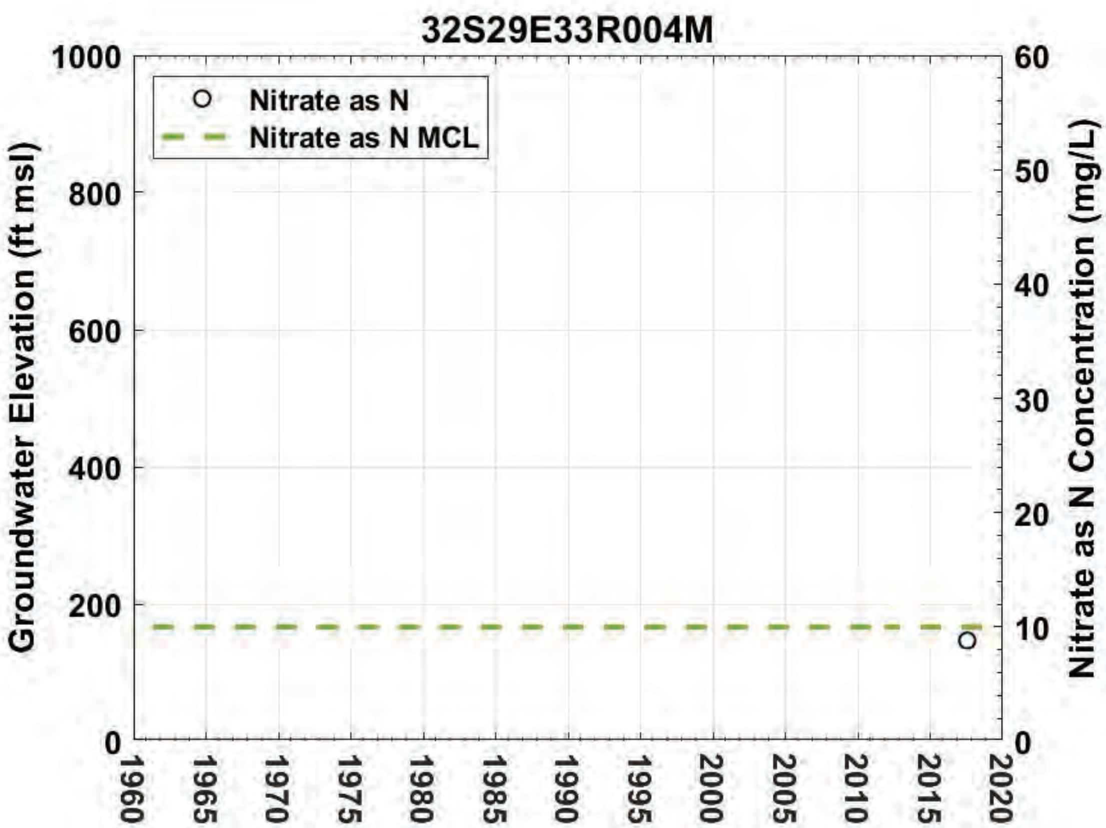
32S29E33B001M
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


32S29E33F001M
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

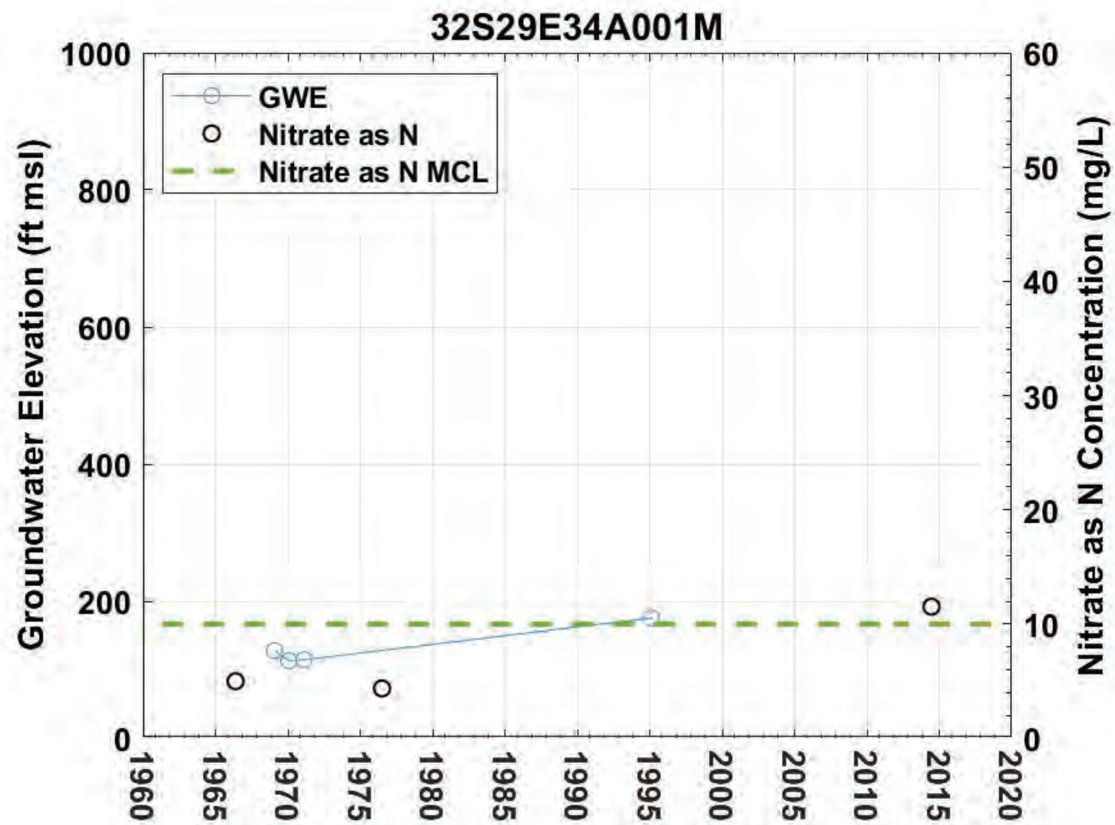

32S29E33N001M
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

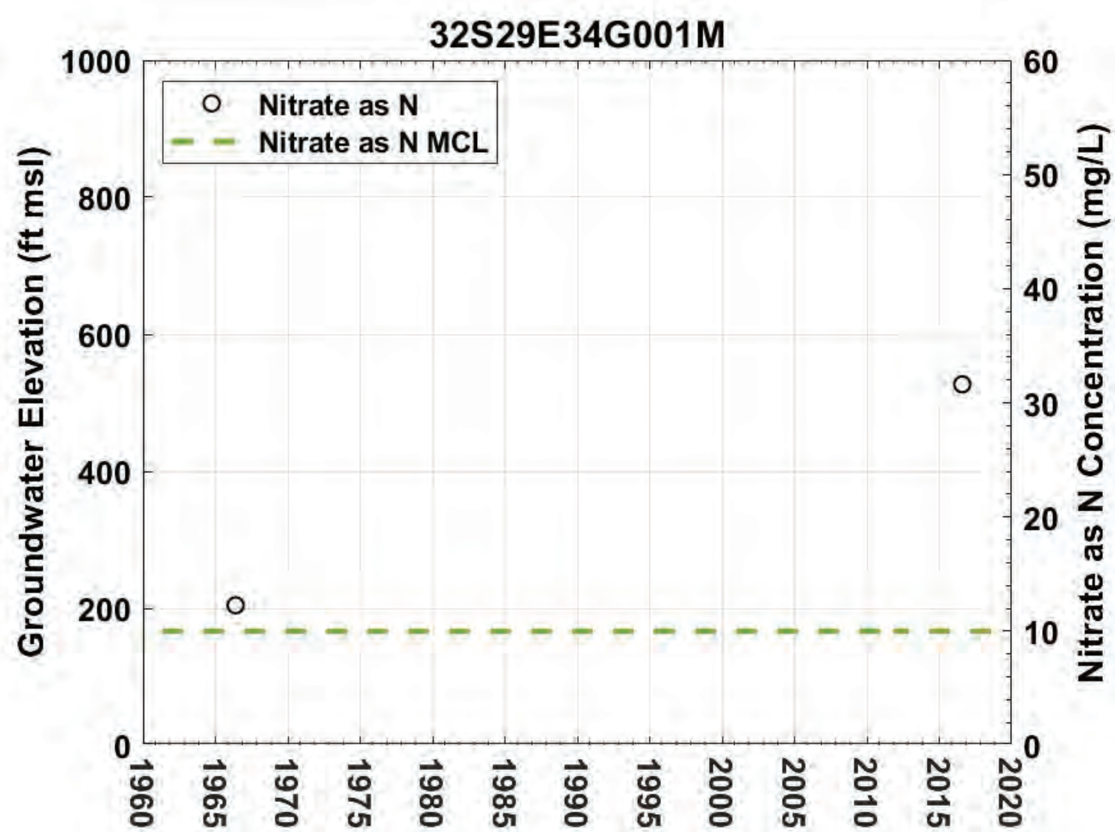


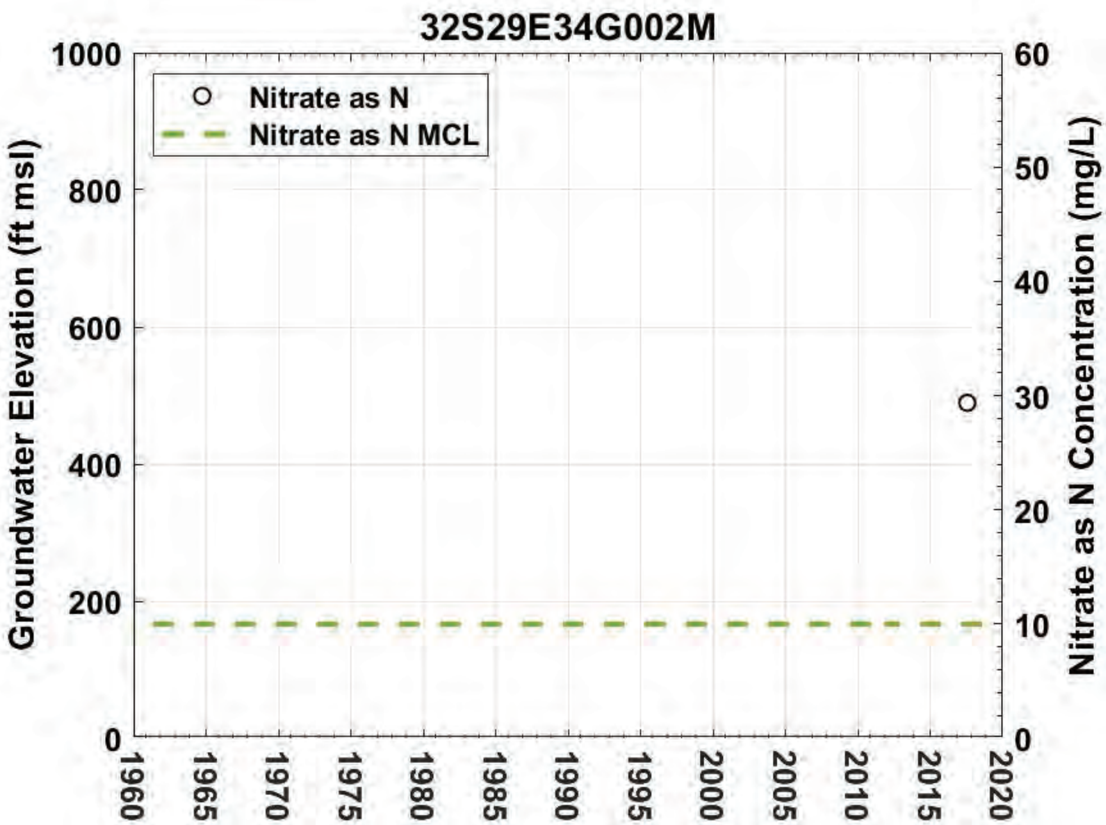
32S29E33R001M
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

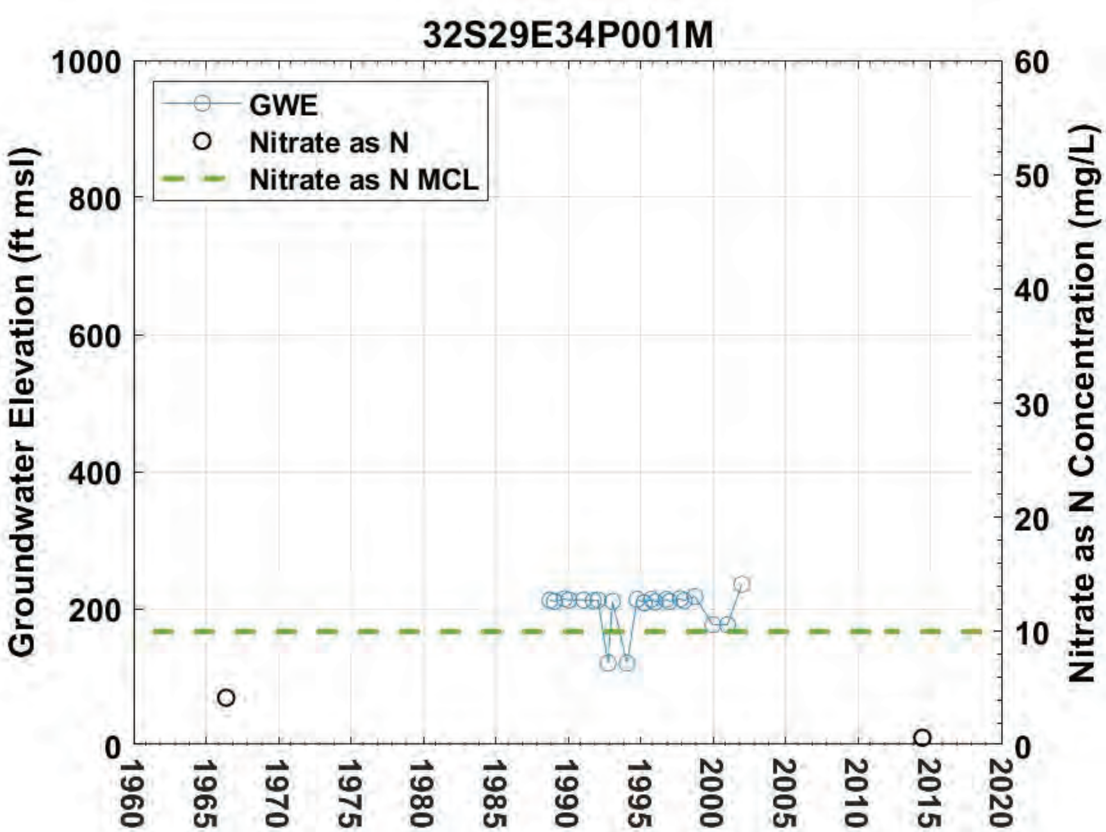


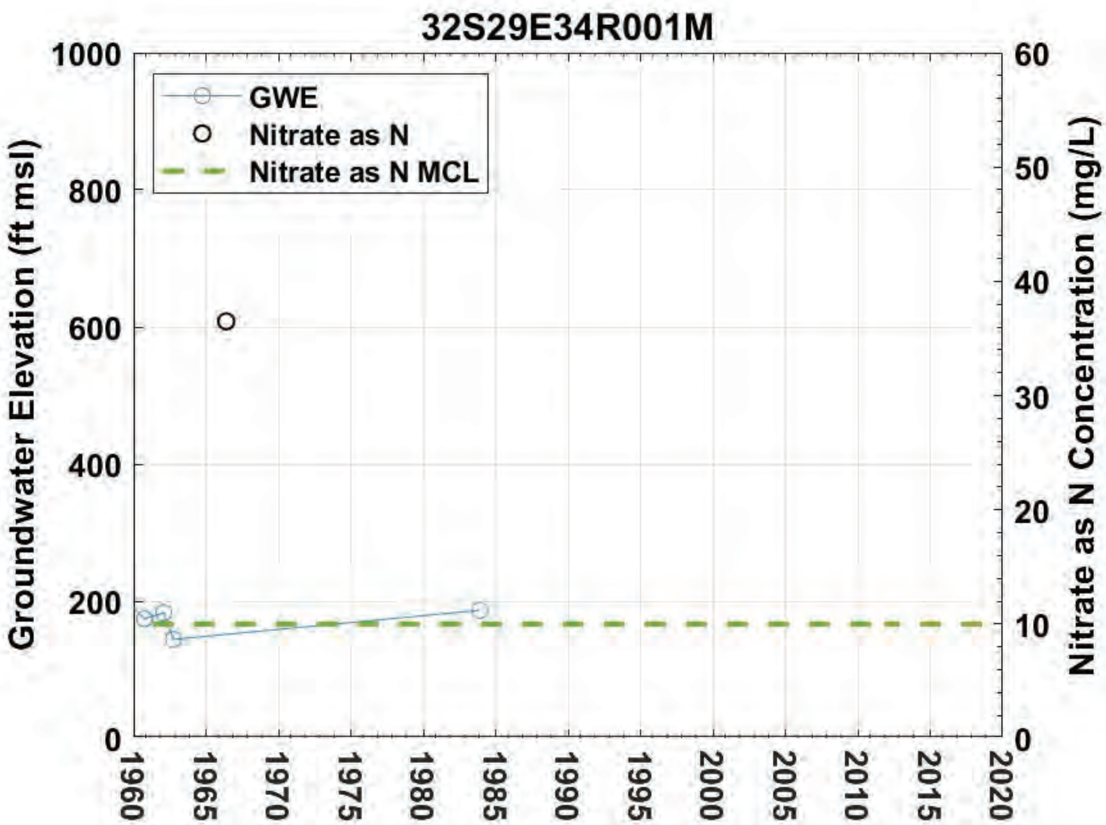
32S29E33R004M
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

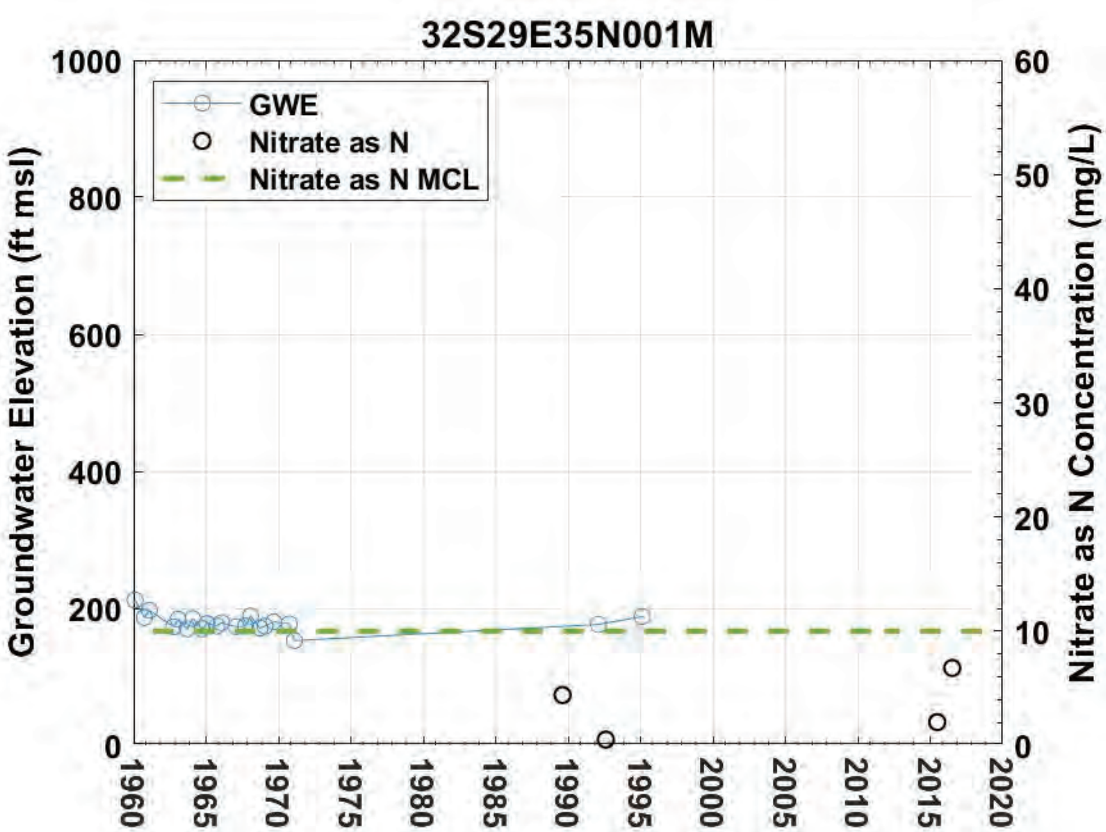

32S29E34A001M
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

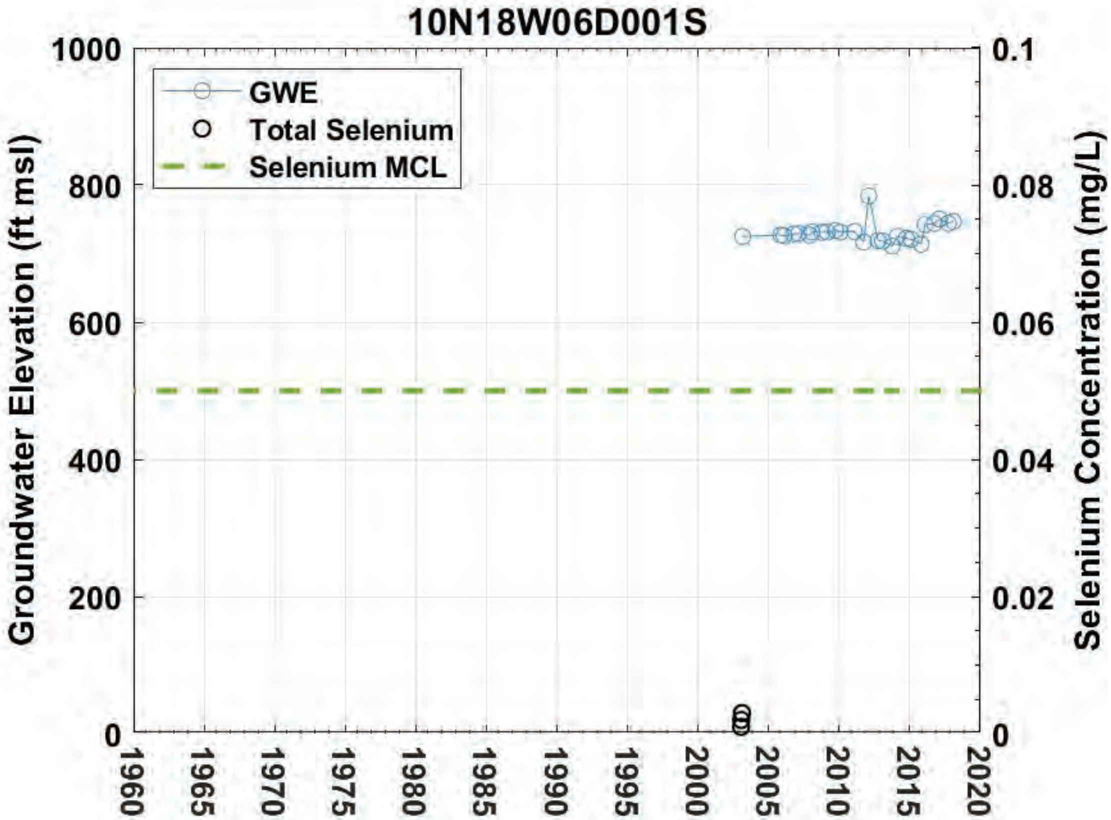

32S29E34G001M
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
1000
800
600
400
200
0
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


32S29E34G002M
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

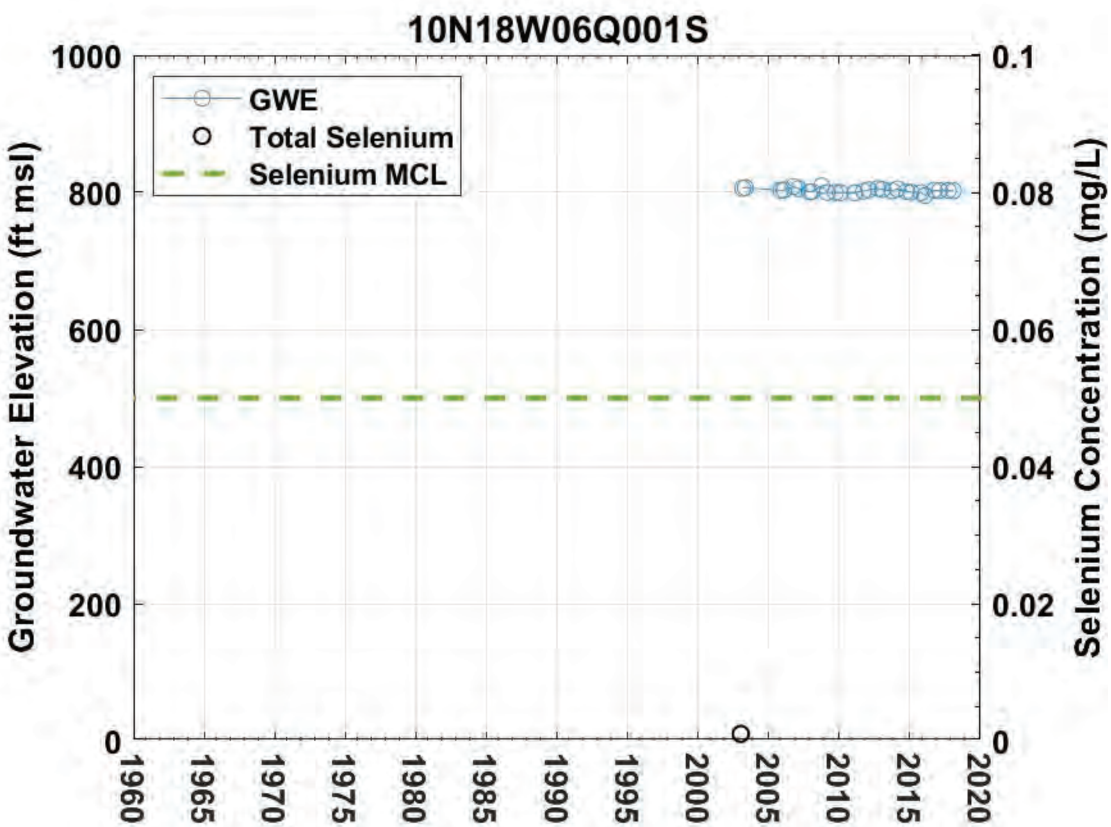

32S29E34P001M
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


32S29E34R001M
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

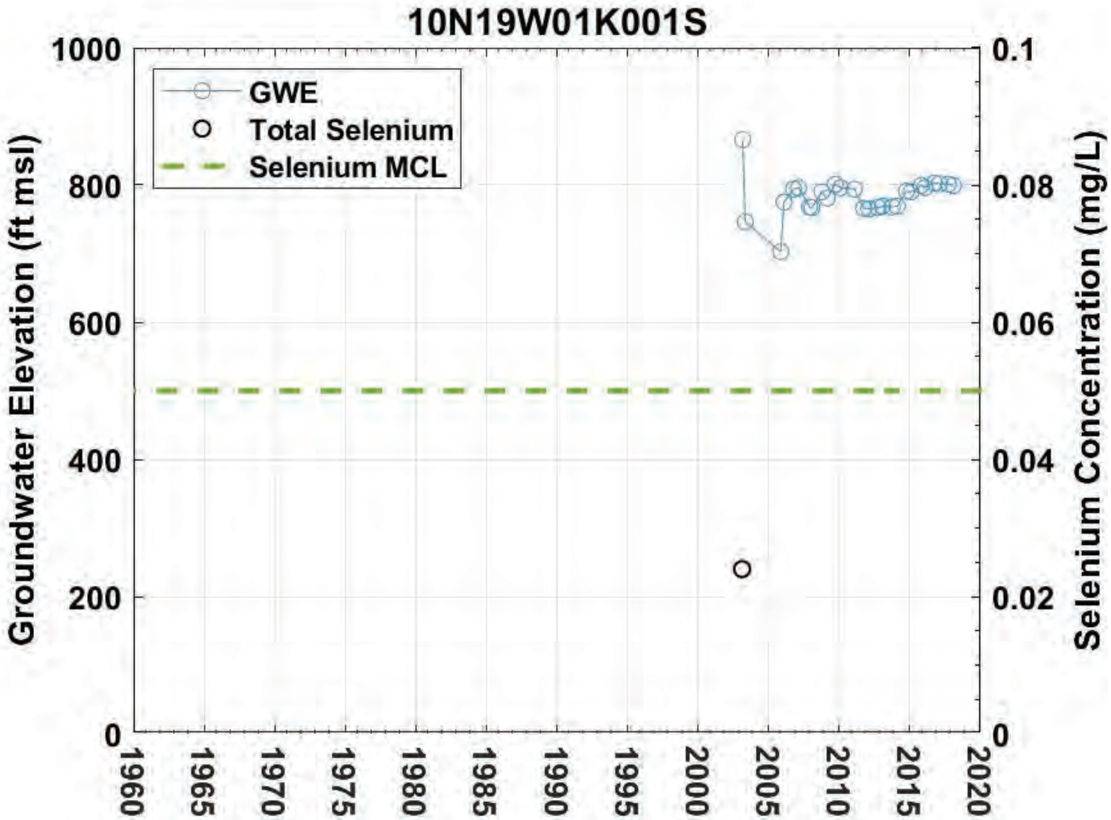

32S29E35N001M
GWE
Nitrate as N
Nitrate as N MCL
Groundwater Elevation (ft msl)
Nitrate as N Concentration (mg/L)
0
200
400
600
800
1000
0
10
20
30
40
50
60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

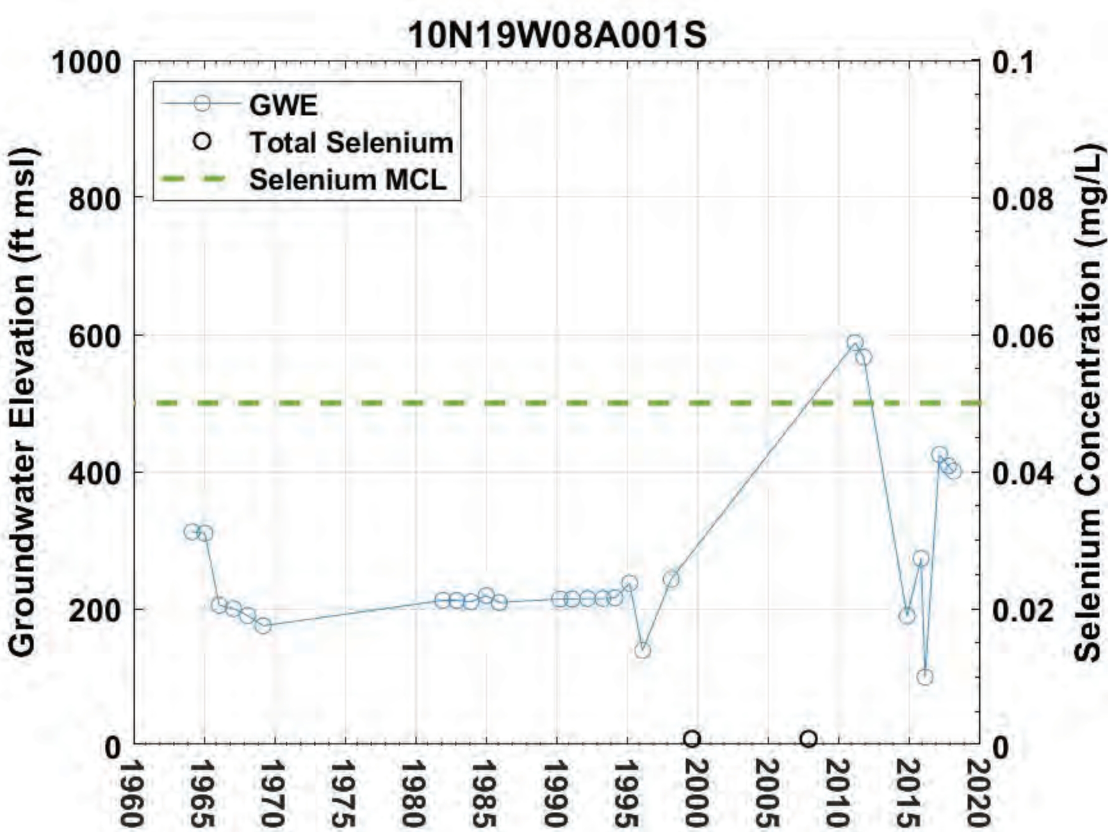


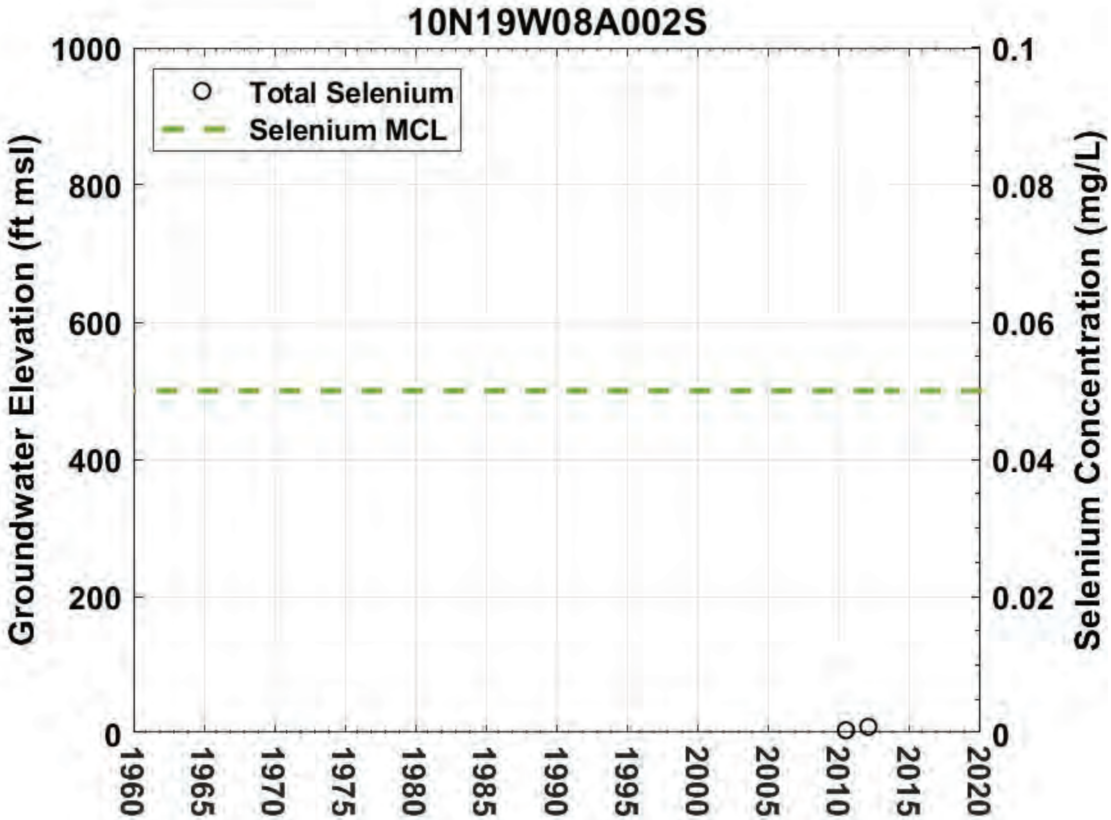
10N18W06D001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



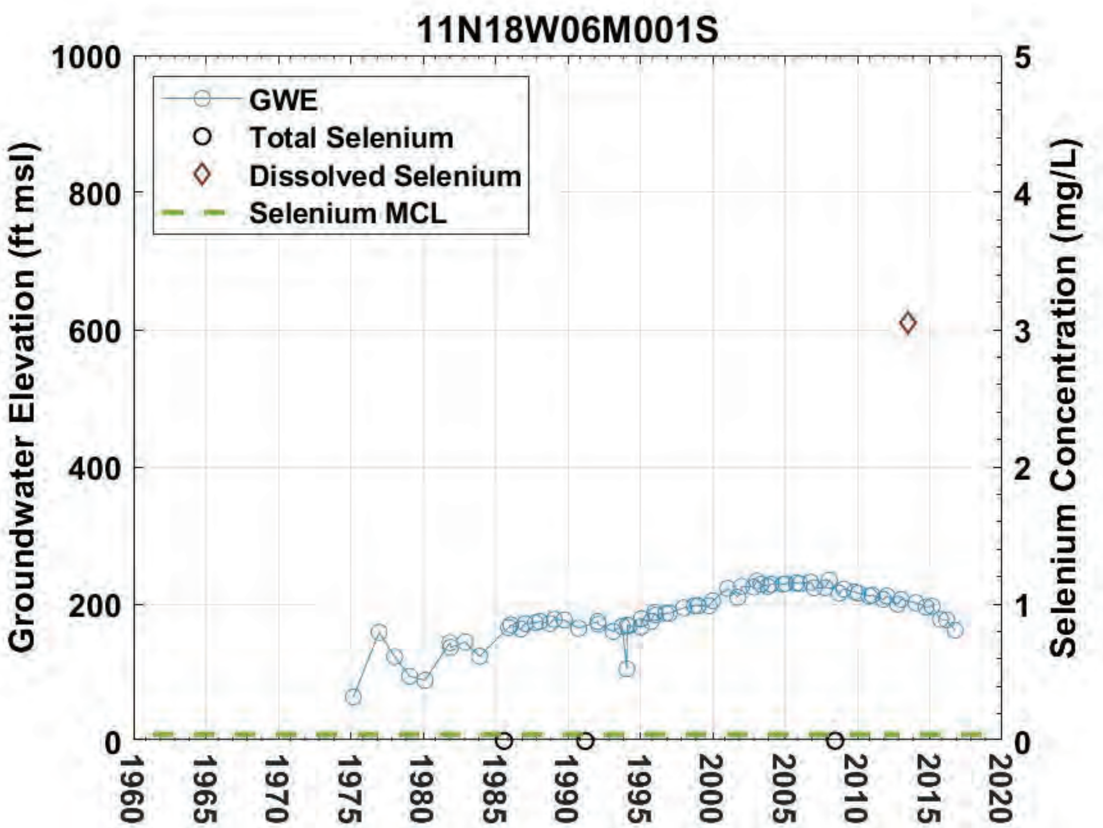
10N18W06Q001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


10N19W01K001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

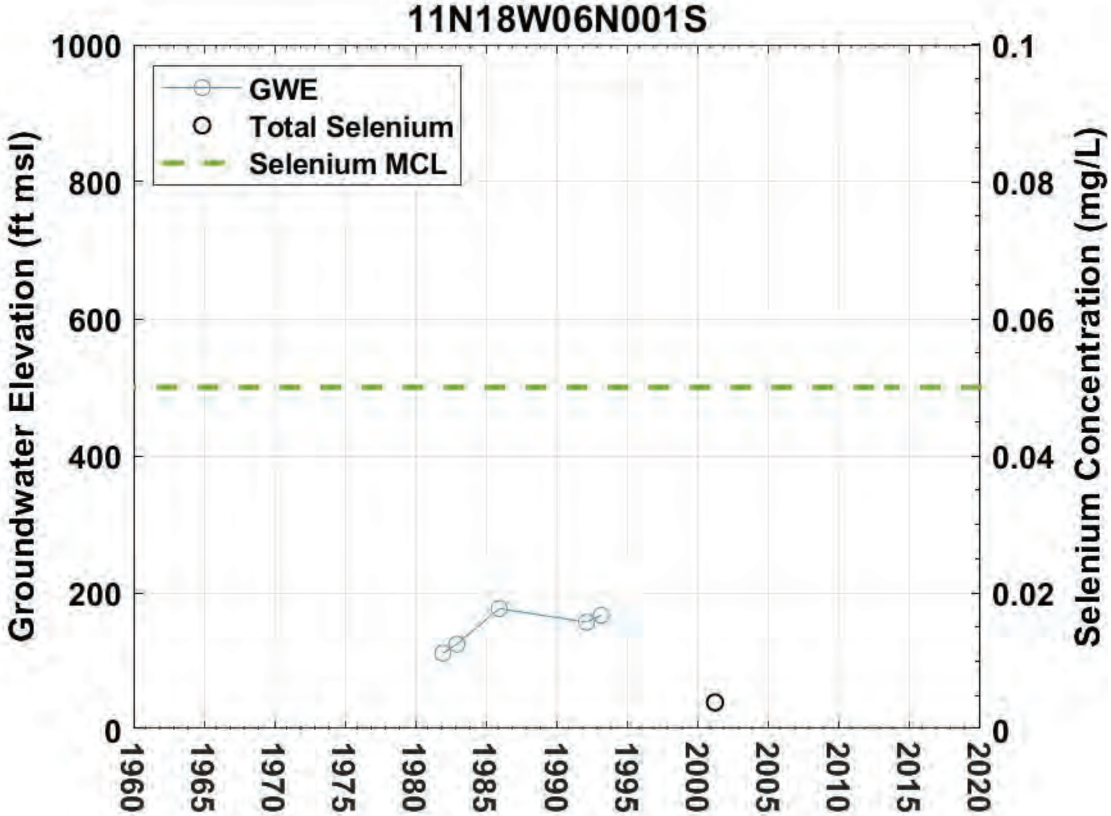

10N19W08A001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

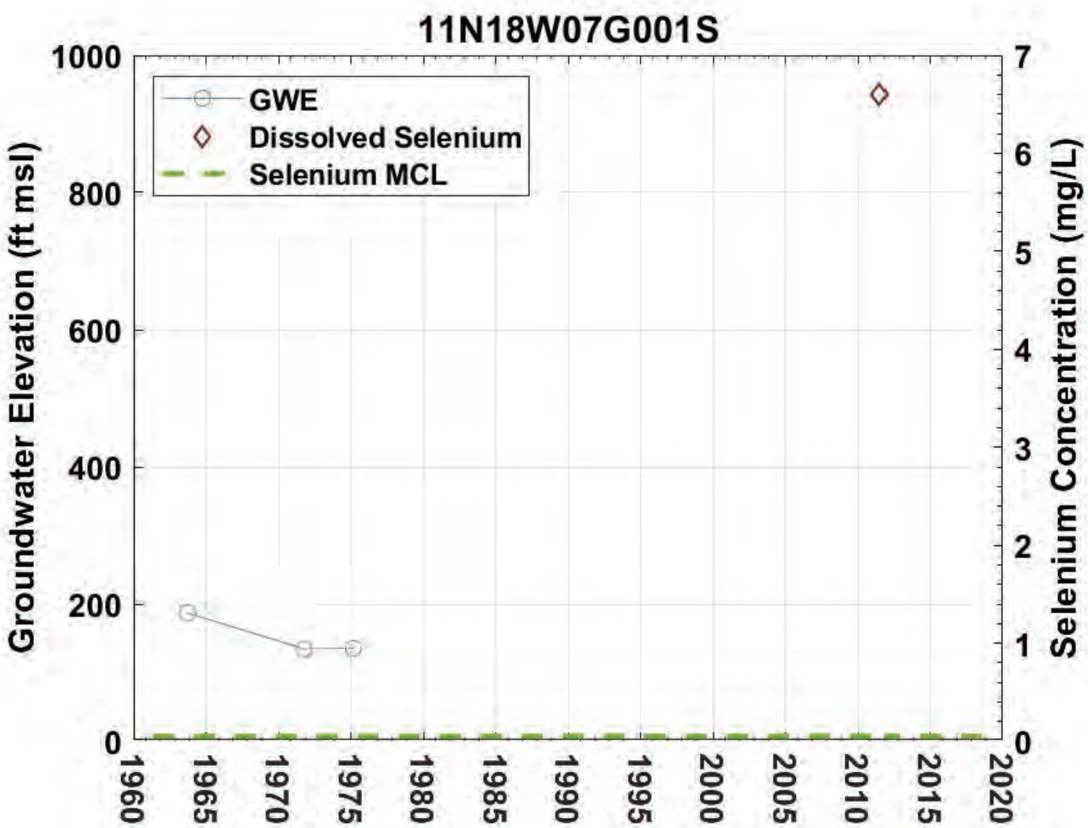


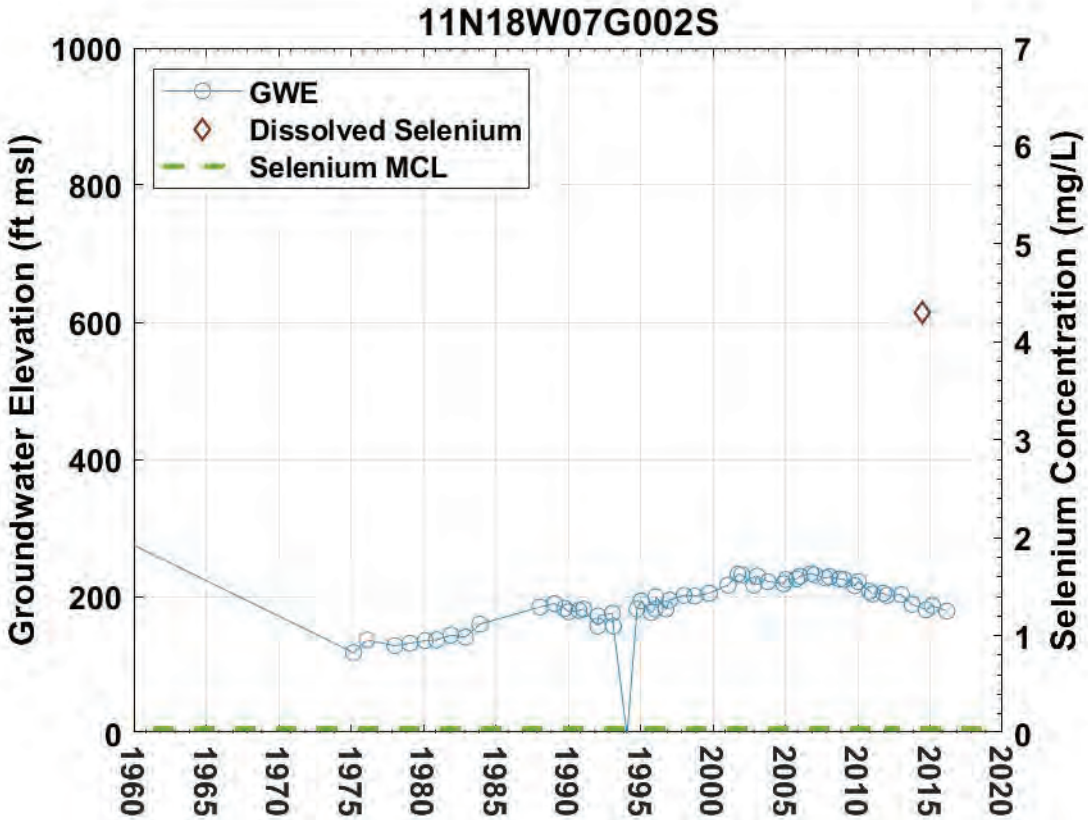
10N19W08A002S
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

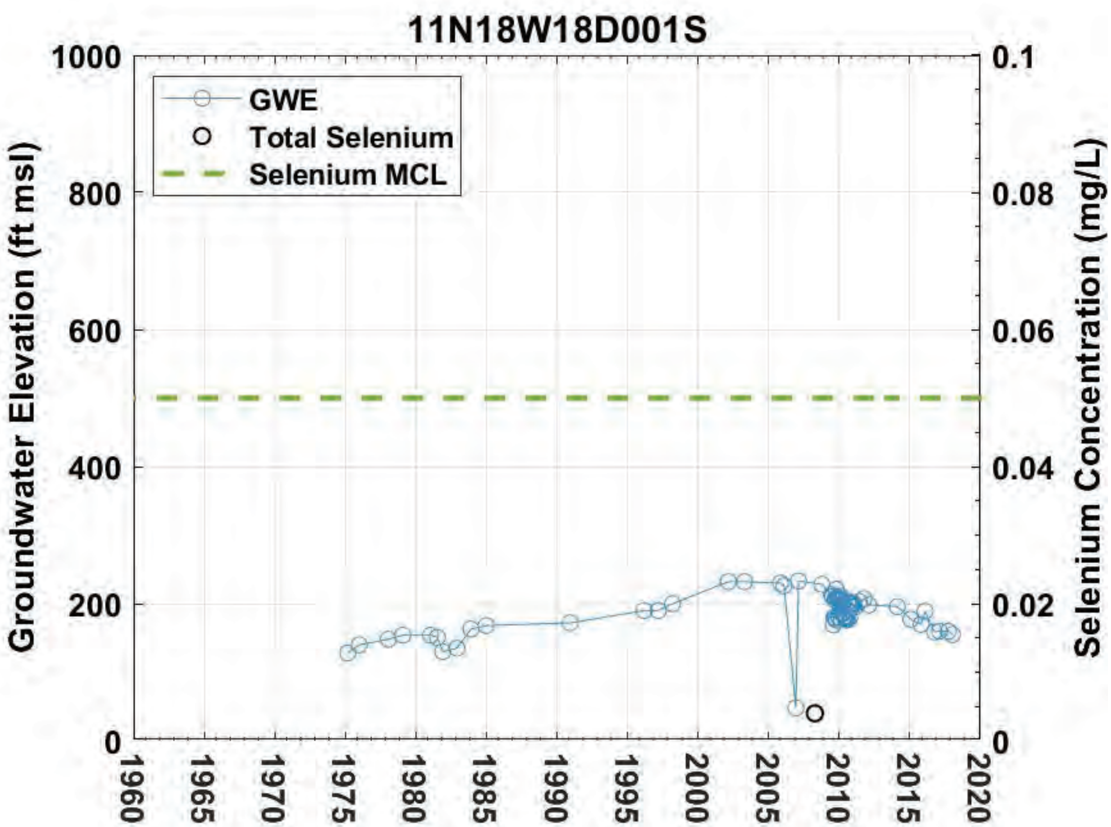


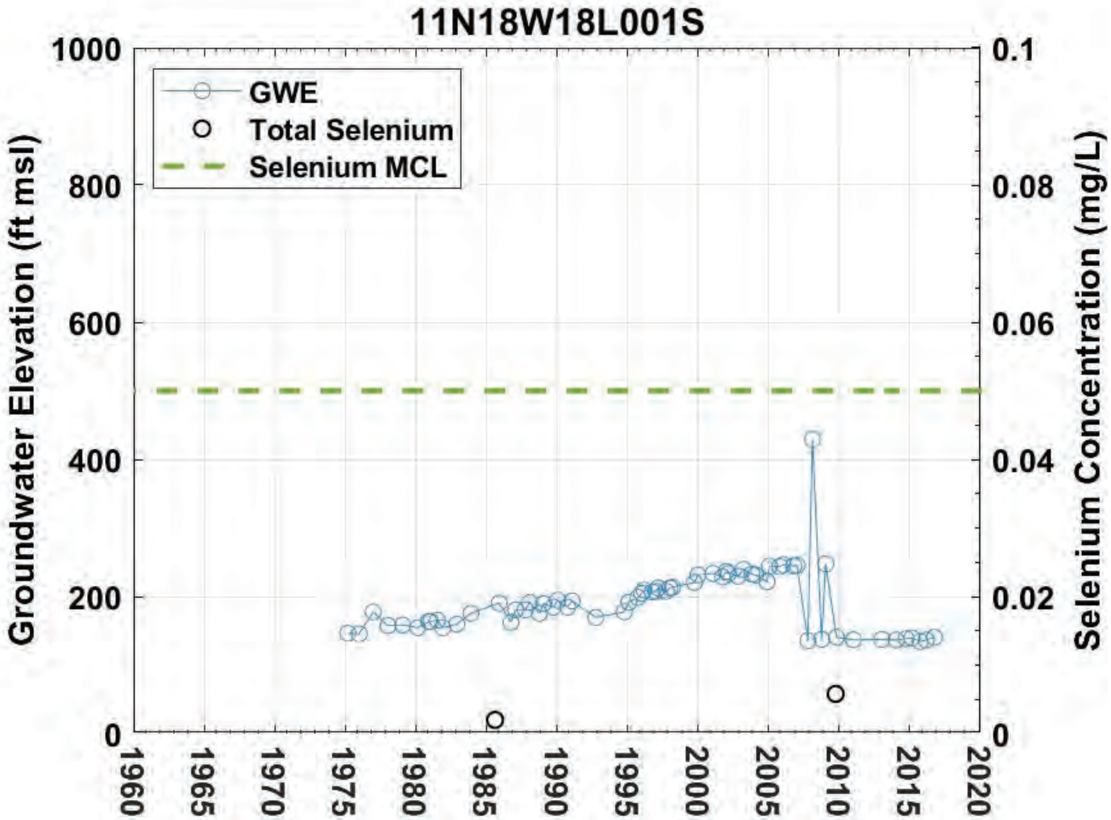
11N18W06M001S
GWE
Total Selenium
Dissolved Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
5
4
3
2
1
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

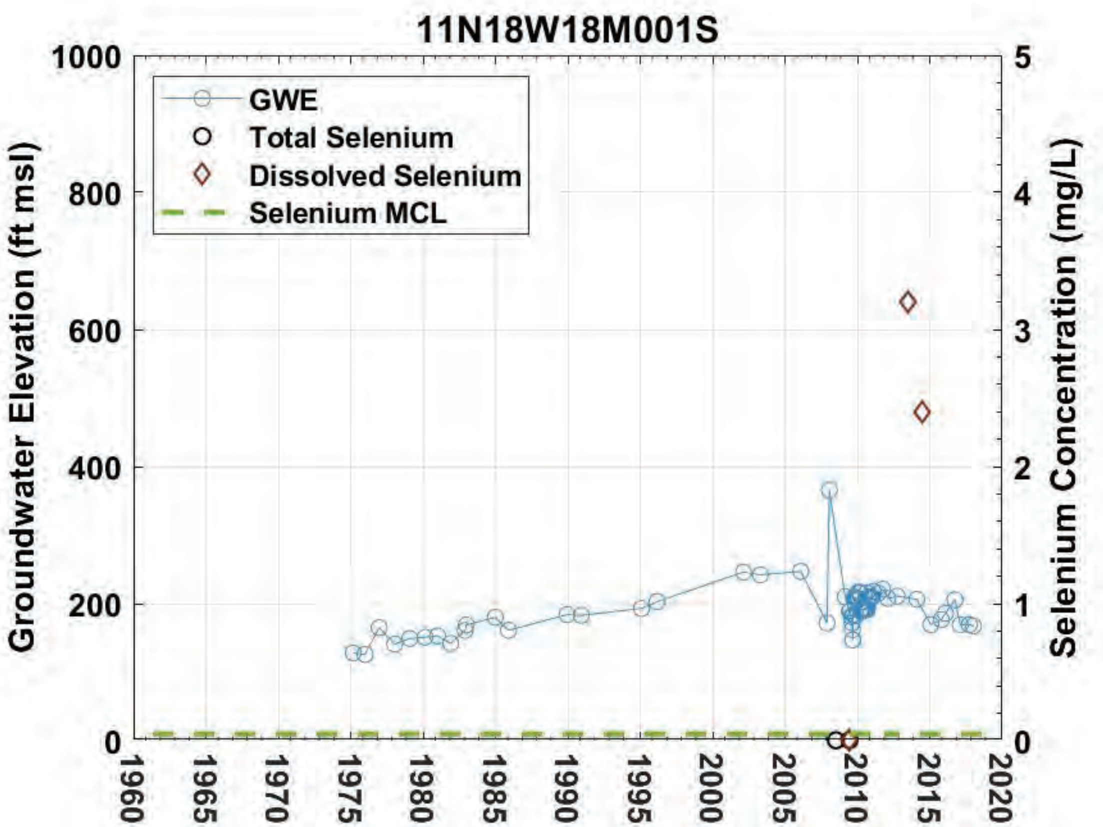

11N18W06N001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

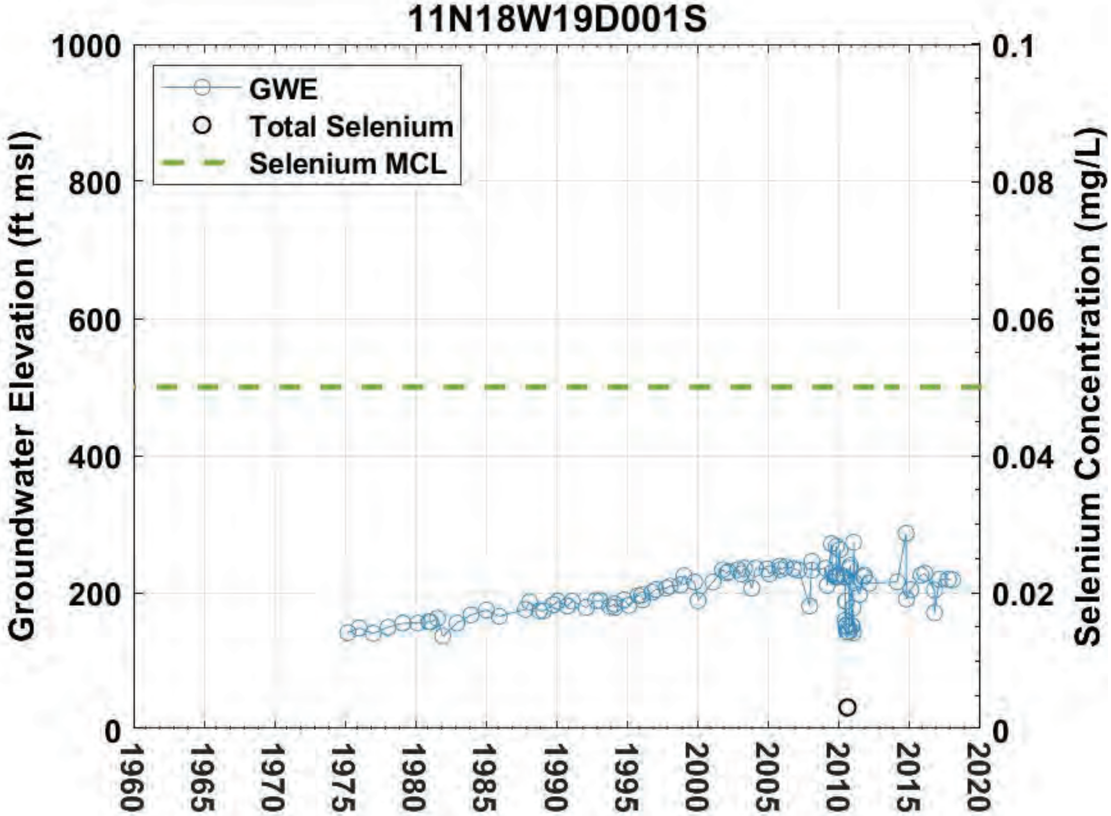

11N18W07G001S
GWE
Dissolved Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
7
6
5
4
3
2
1
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N18W07G002S
GWE
Dissolved Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
7
6
5
4
3
2
1
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

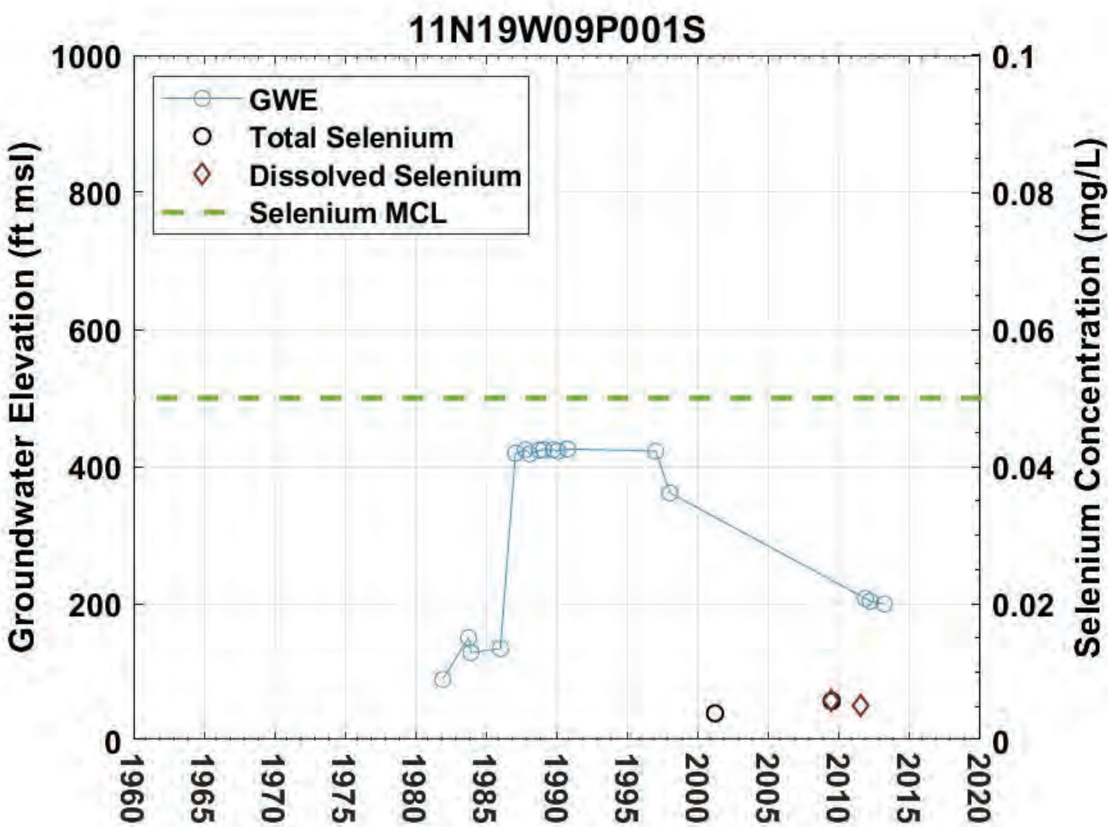

11N18W18D001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N18W18L001S
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
GWE
Total Selenium
Selenium MCL
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

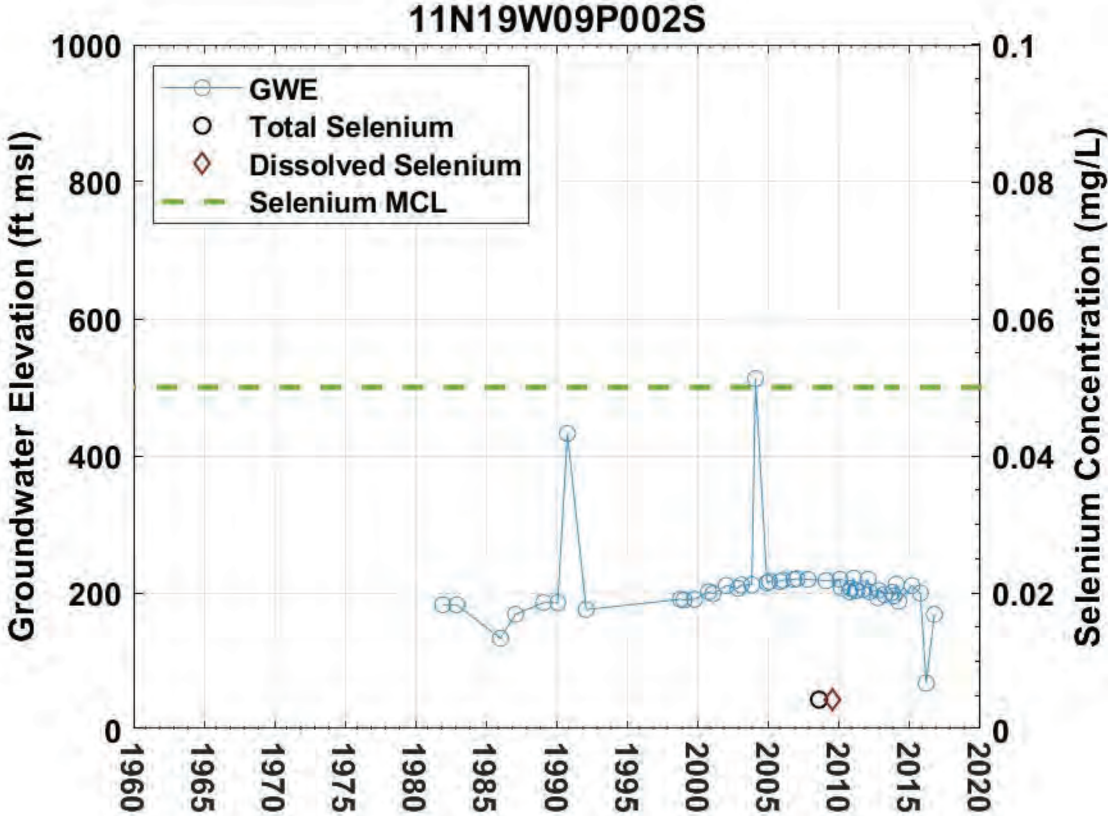

11N18W18M001S
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
GWE
Total Selenium
Dissolved Selenium
Selenium MCL
1000
800
600
400
200
0
5
4
3
2
1
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

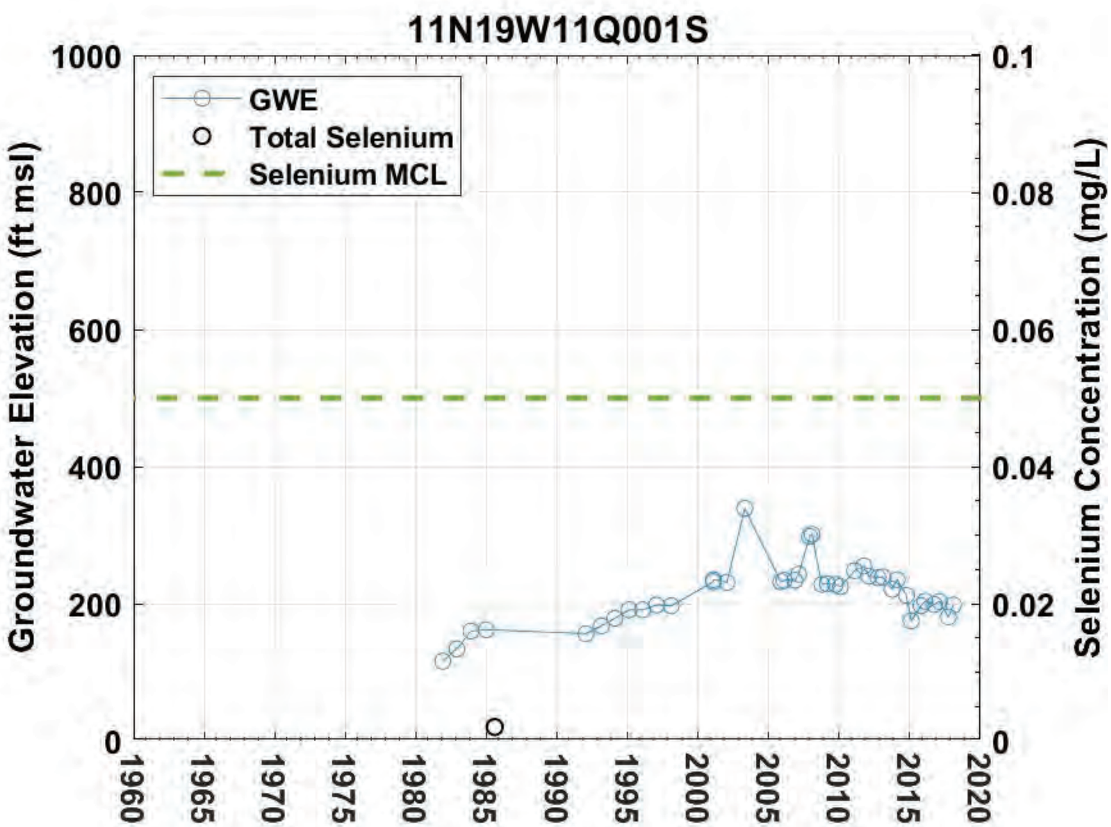


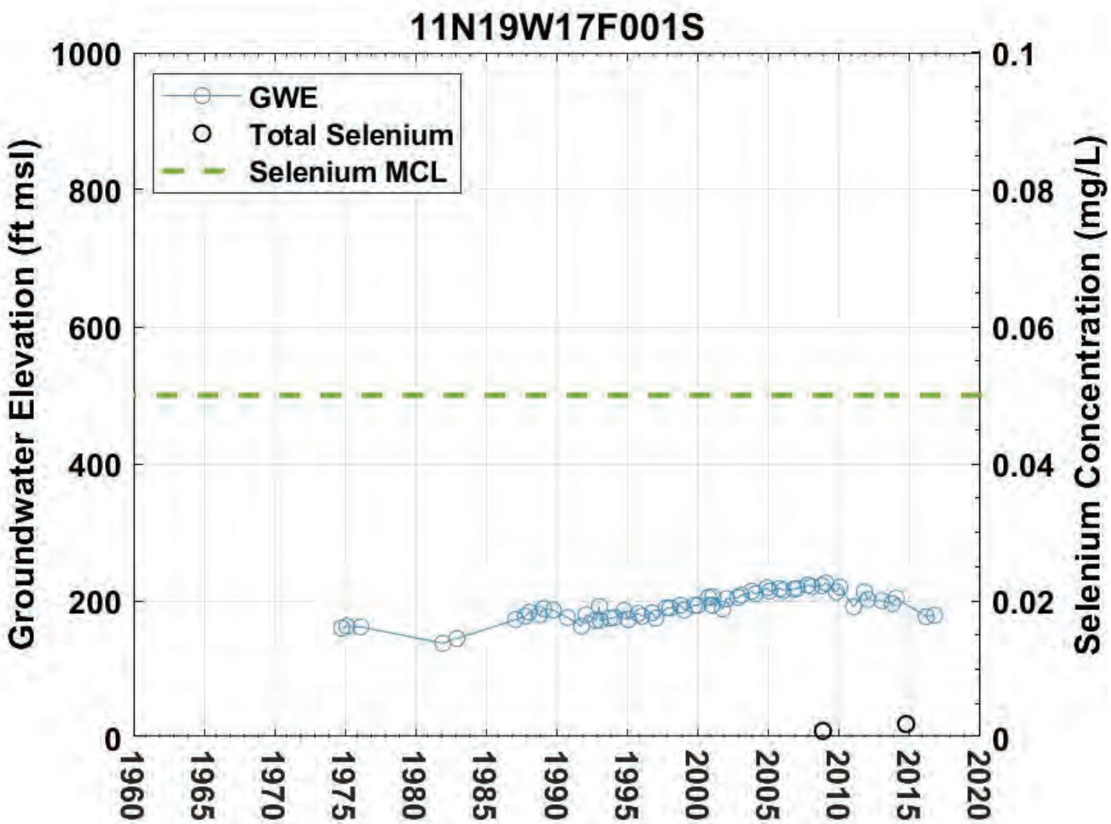
11N18W19D001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

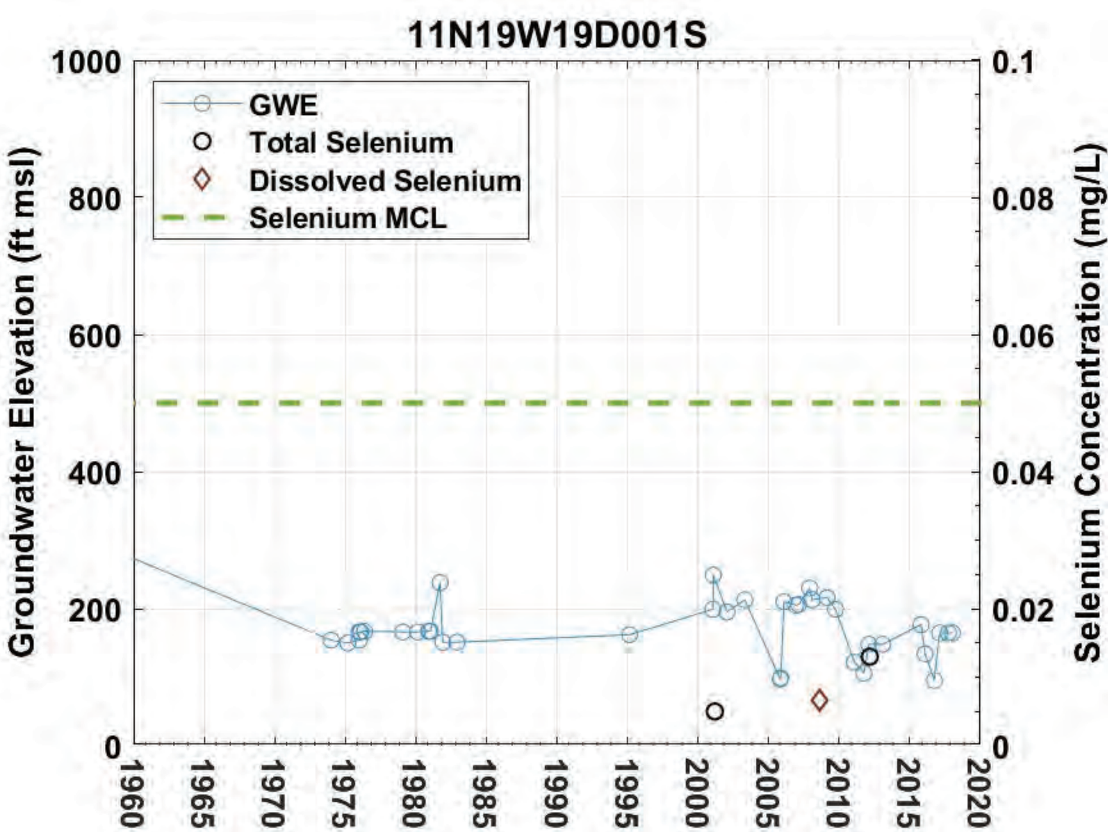


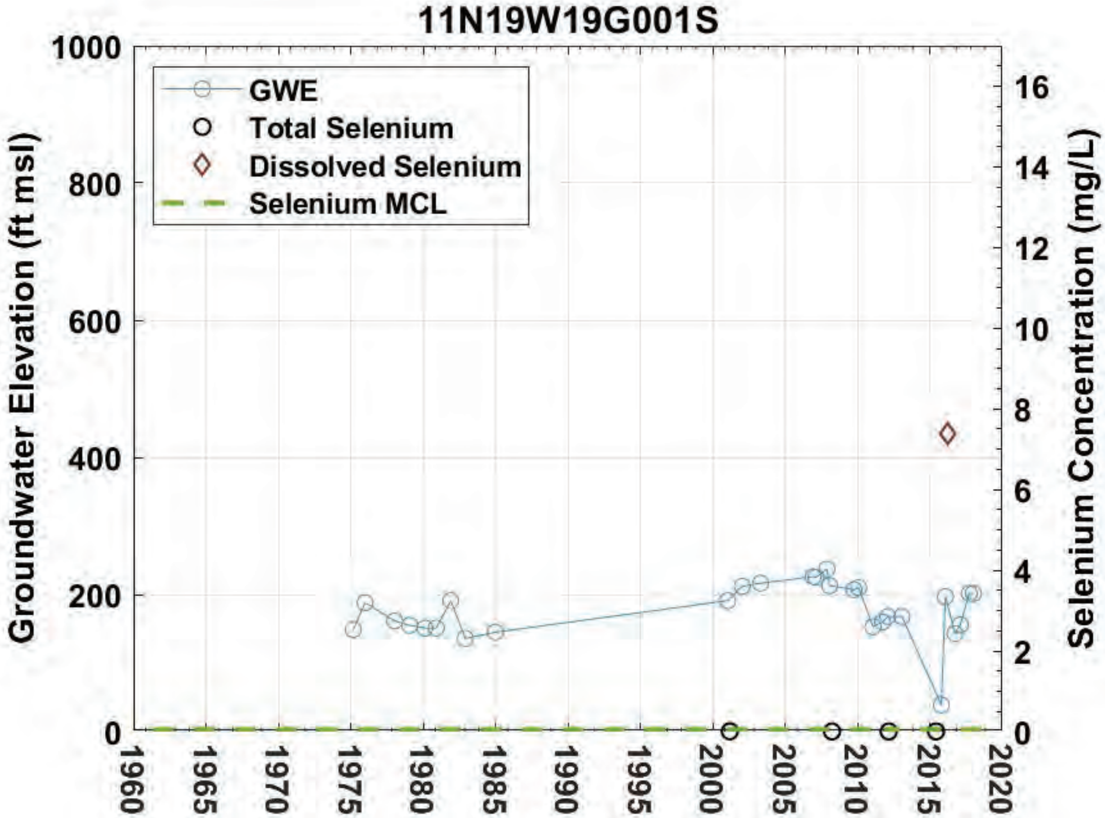
11N19W09P001S
GWE
Total Selenium
Dissolved Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

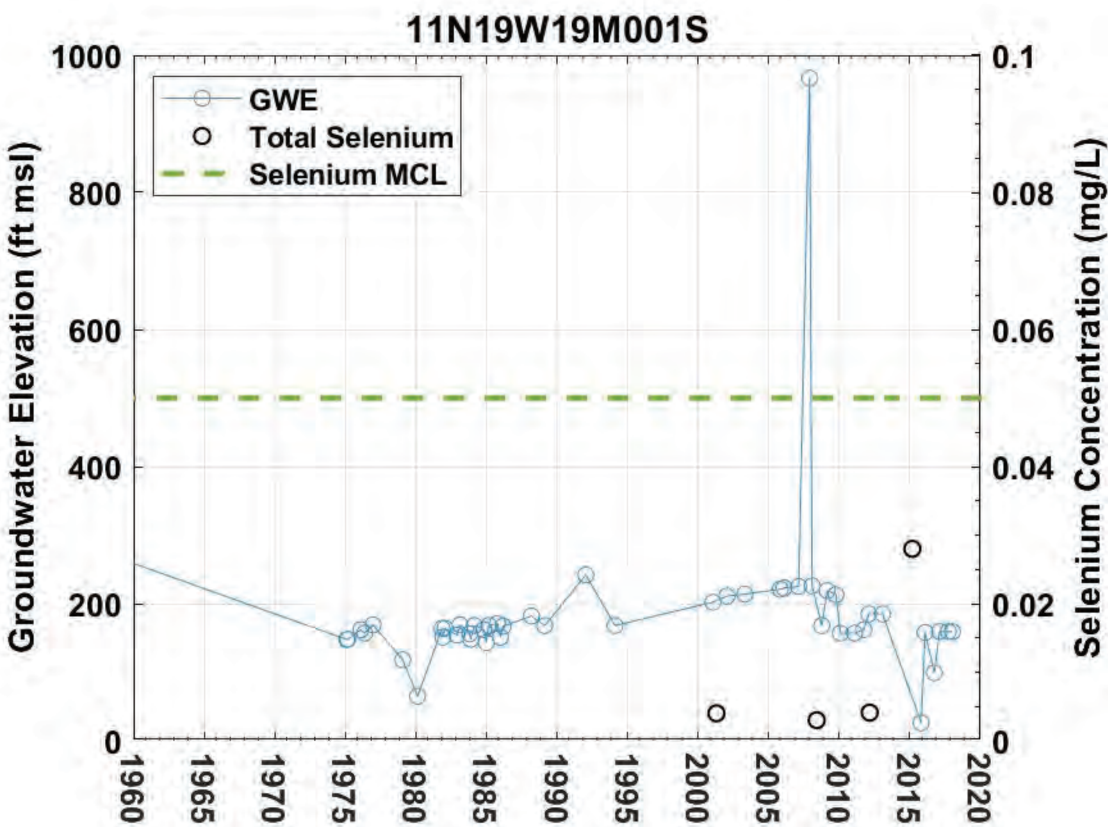

11N19W09P002S
GWE
Total Selenium
Dissolved Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
0
200
400
600
800
1000
0
0.02
0.04
0.06
0.08
0.1
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

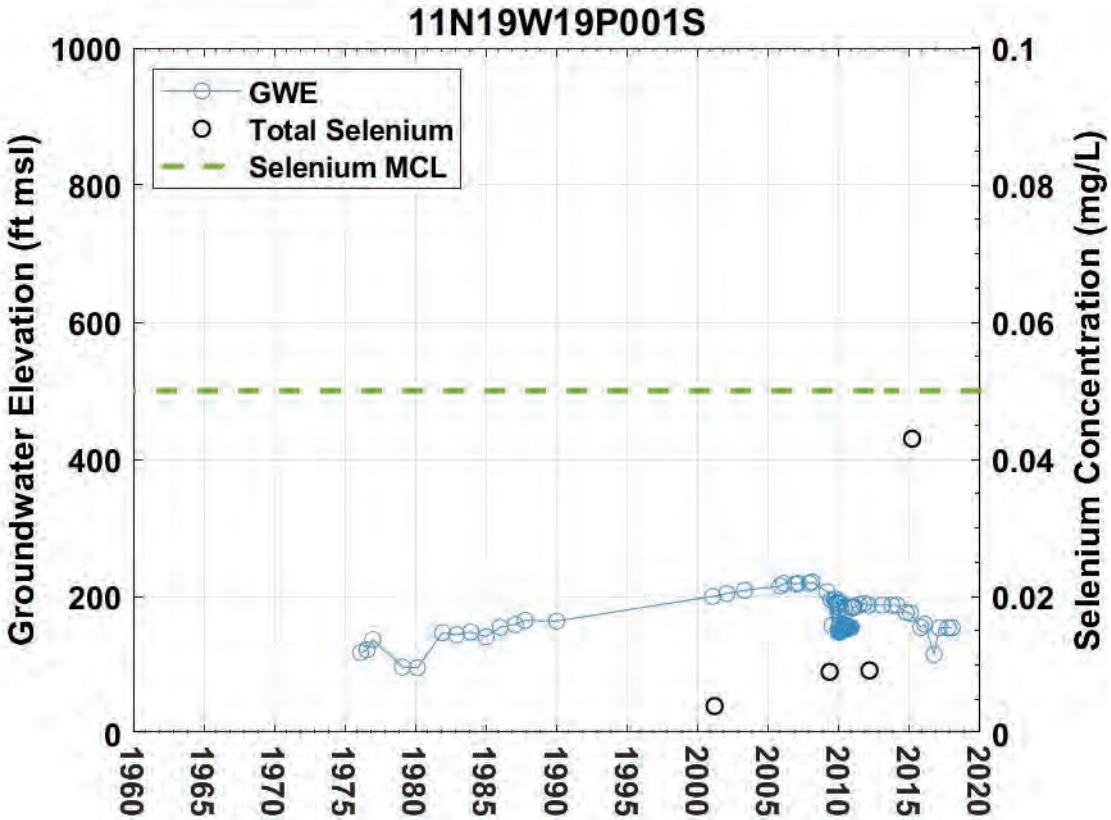

11N19W11Q001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
0
200
400
600
800
1000
0
0.02
0.04
0.06
0.08
0.1
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

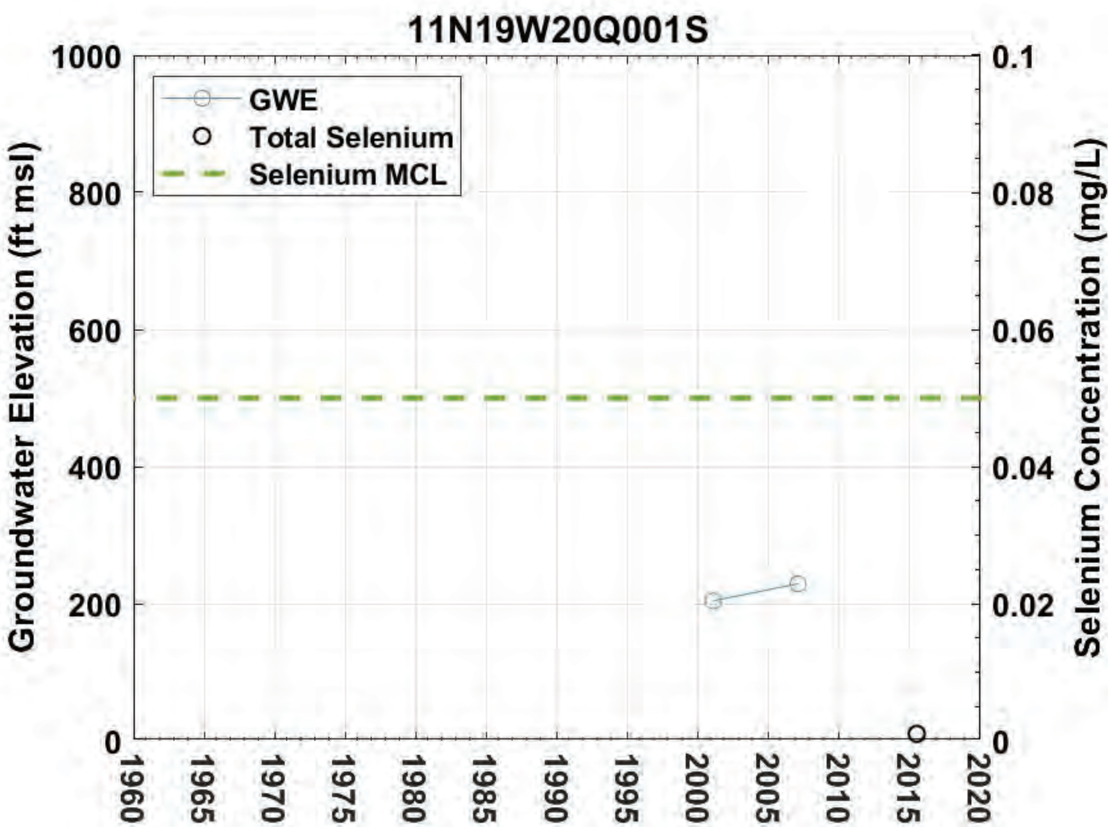

11N19W17F001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

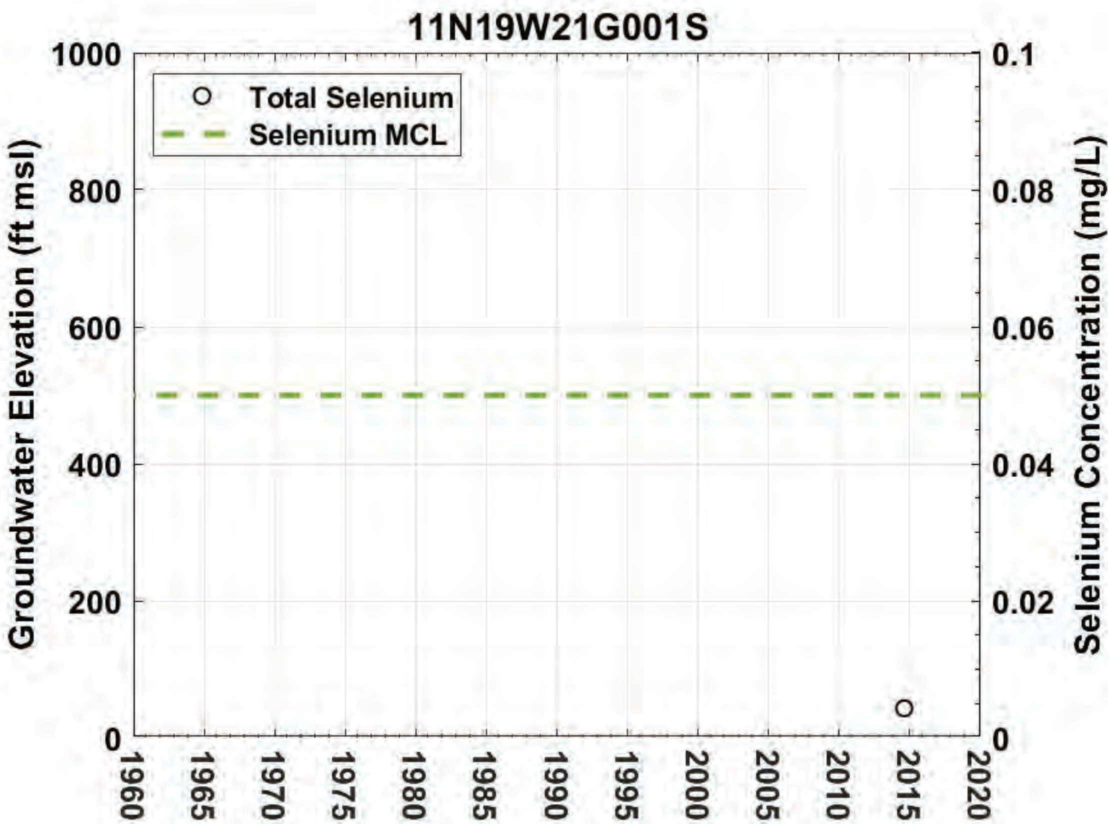

11N19W19D001S
GWE
Total Selenium
Dissolved Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

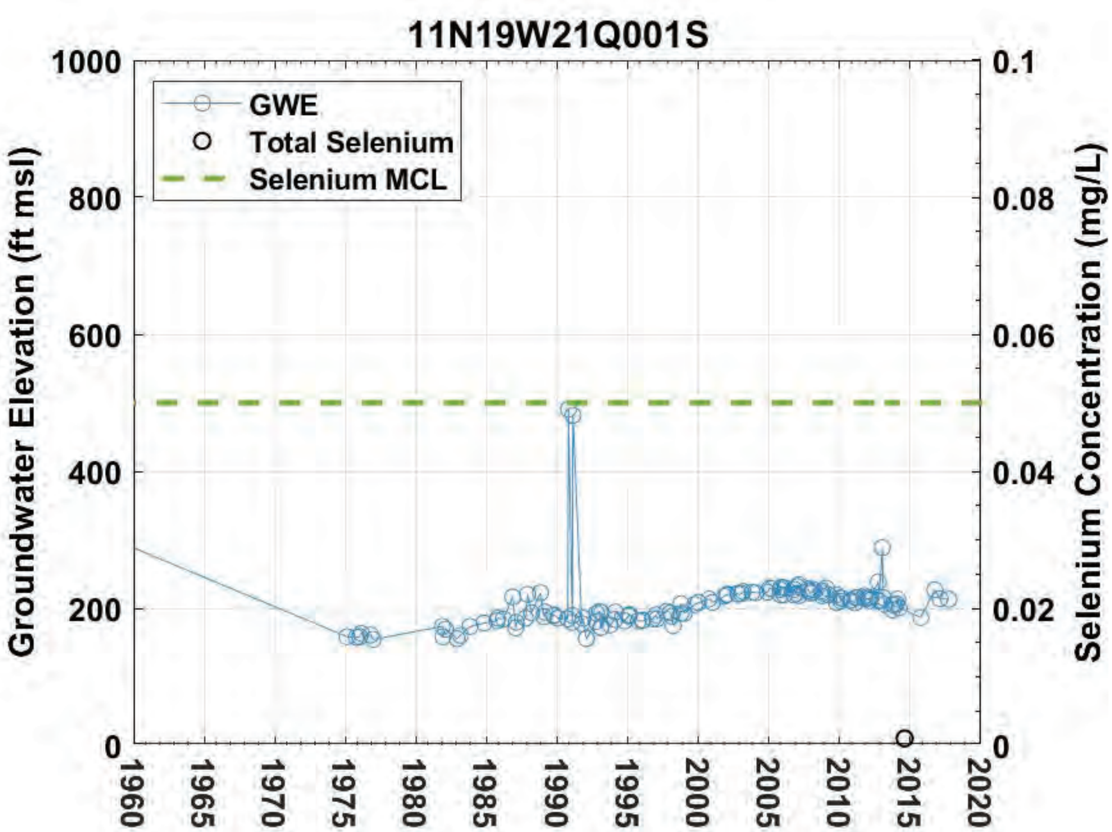

11N19W19G001S
GWE
Total Selenium
Dissolved Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
0
200
400
600
800
1000
0
2
4
6
8
10
12
14
16
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

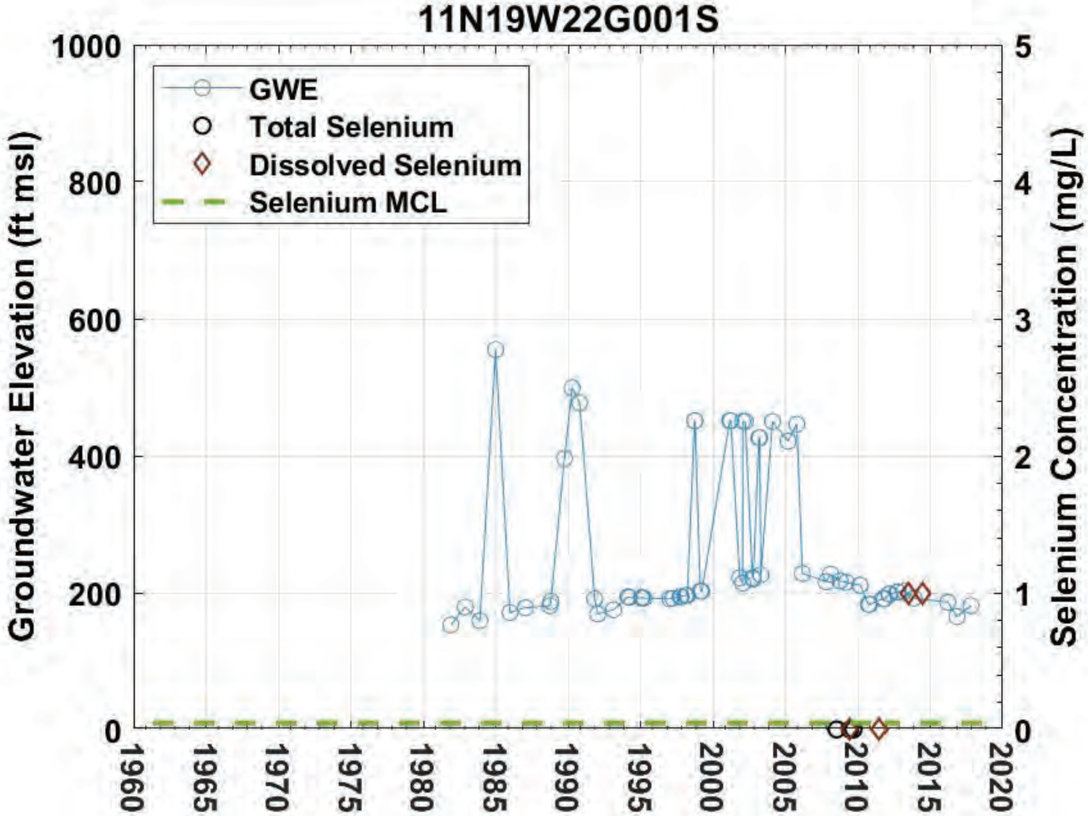

11N19W19M001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
0
200
400
600
800
1000
0
0.02
0.04
0.06
0.08
0.1
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W19P001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

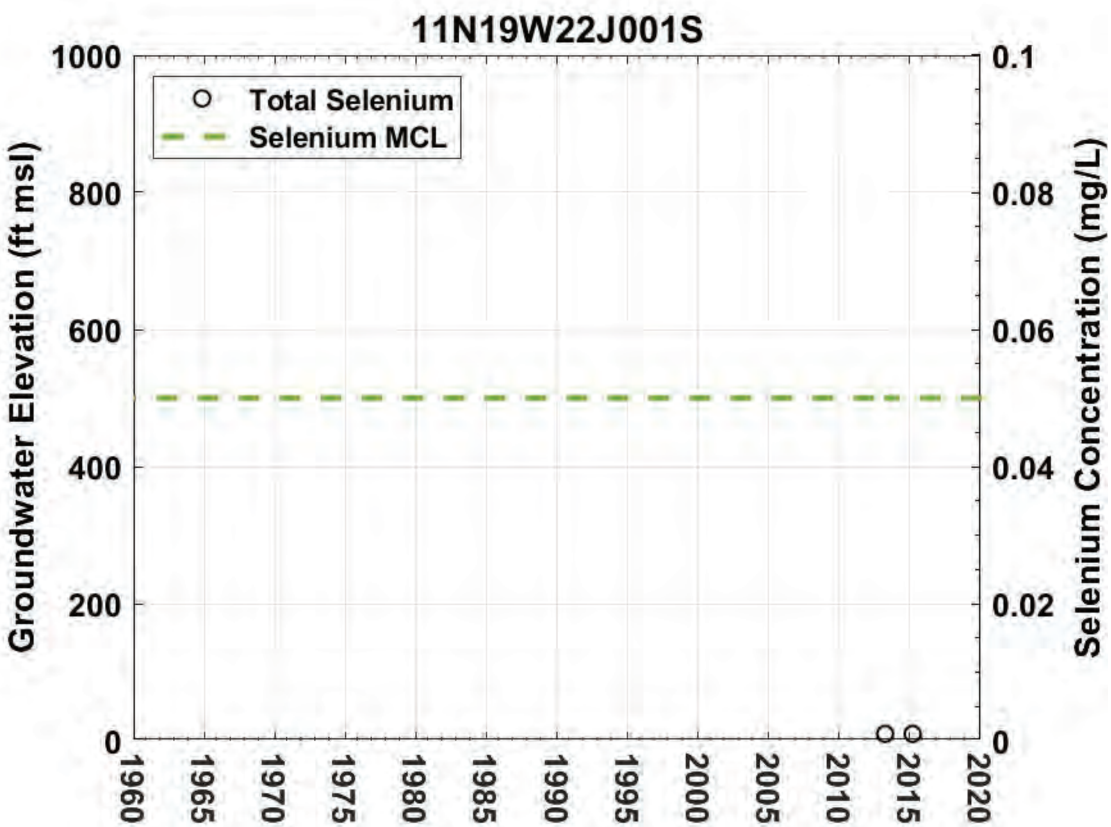

11N19W20Q001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W21G001S
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

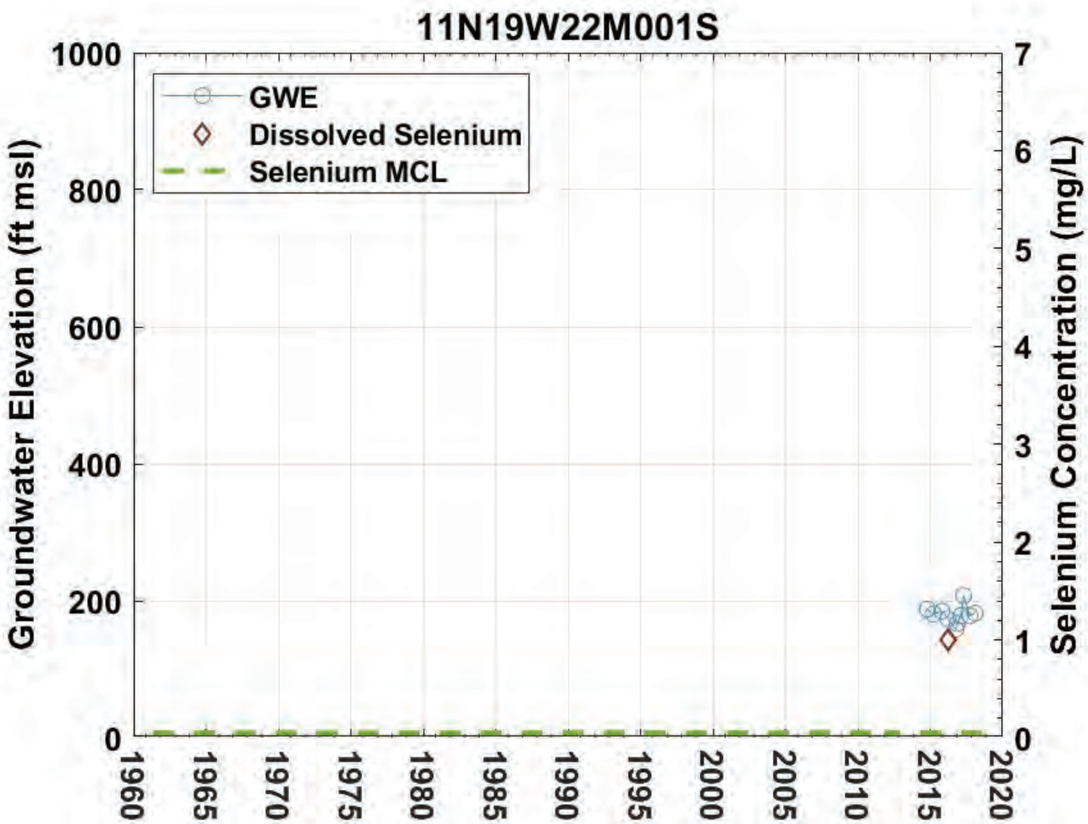

11N19W21Q001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



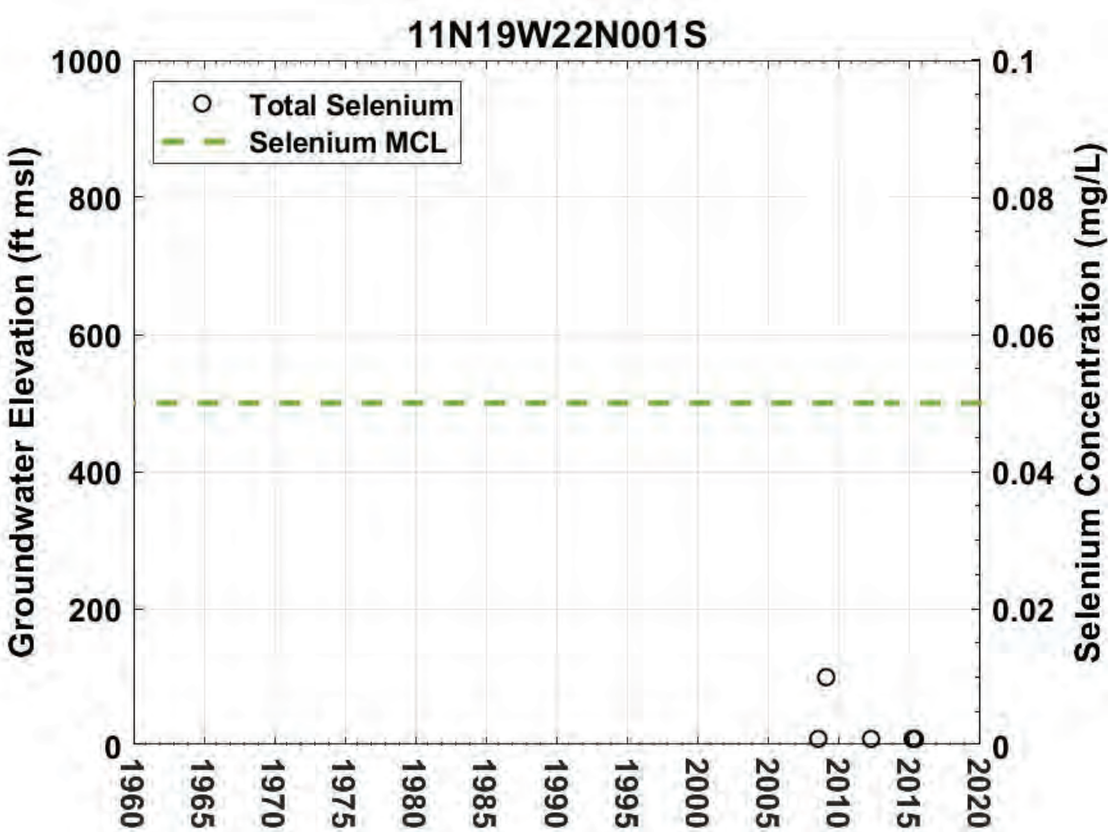
11N19W22G001S
GWE
Total Selenium
Dissolved Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
0
200
400
600
800
1000
0
1
2
3
4
5
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



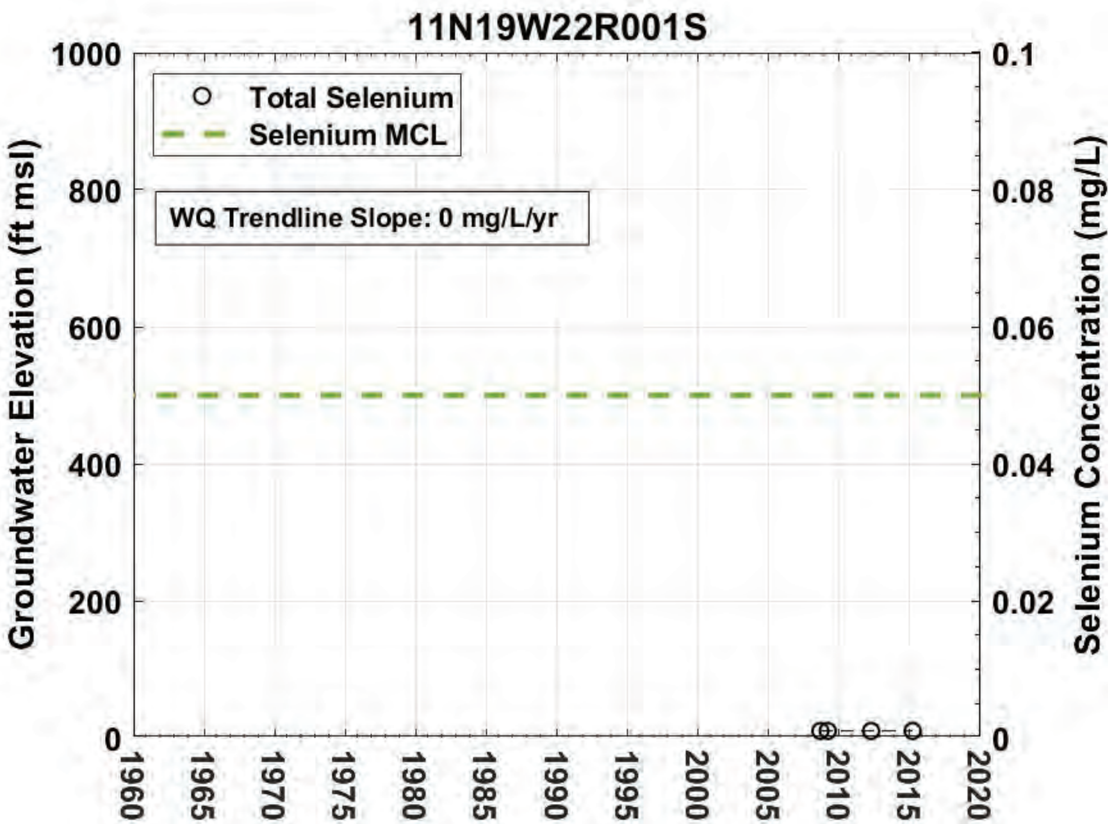
11N19W22J001S
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
0
200
400
600
800
1000
0
0.02
0.04
0.06
0.08
0.1
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

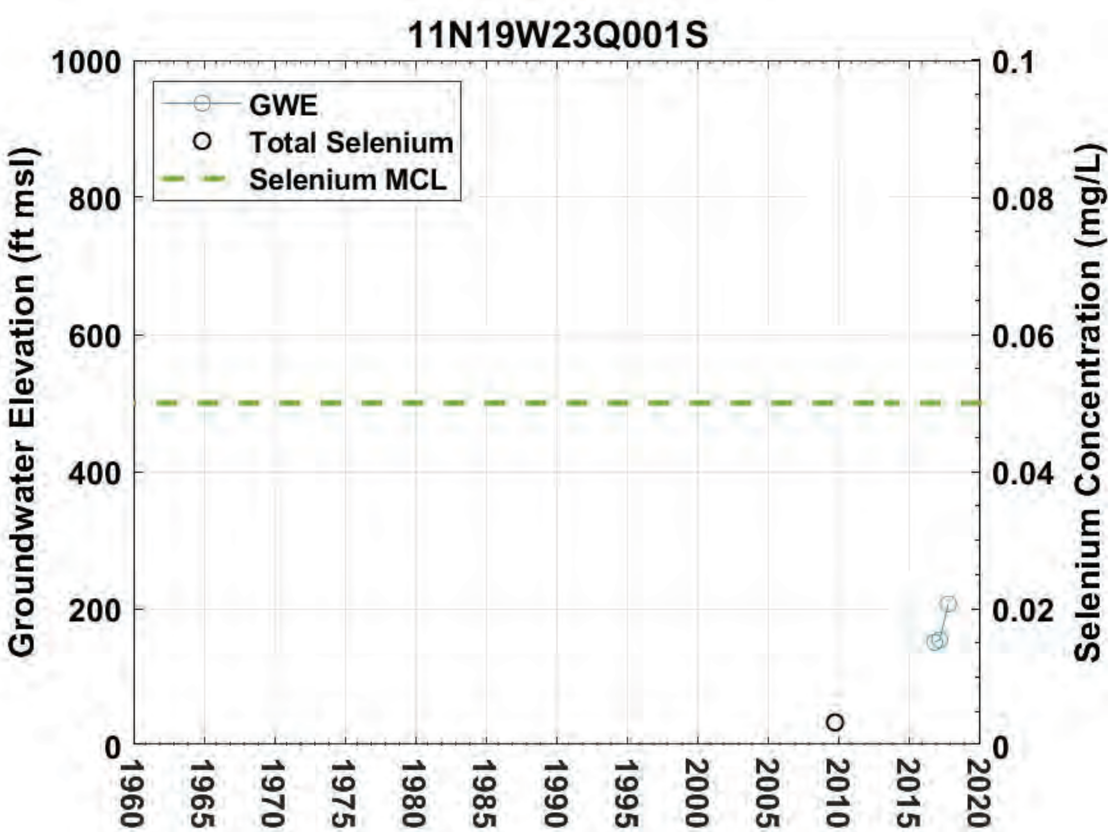


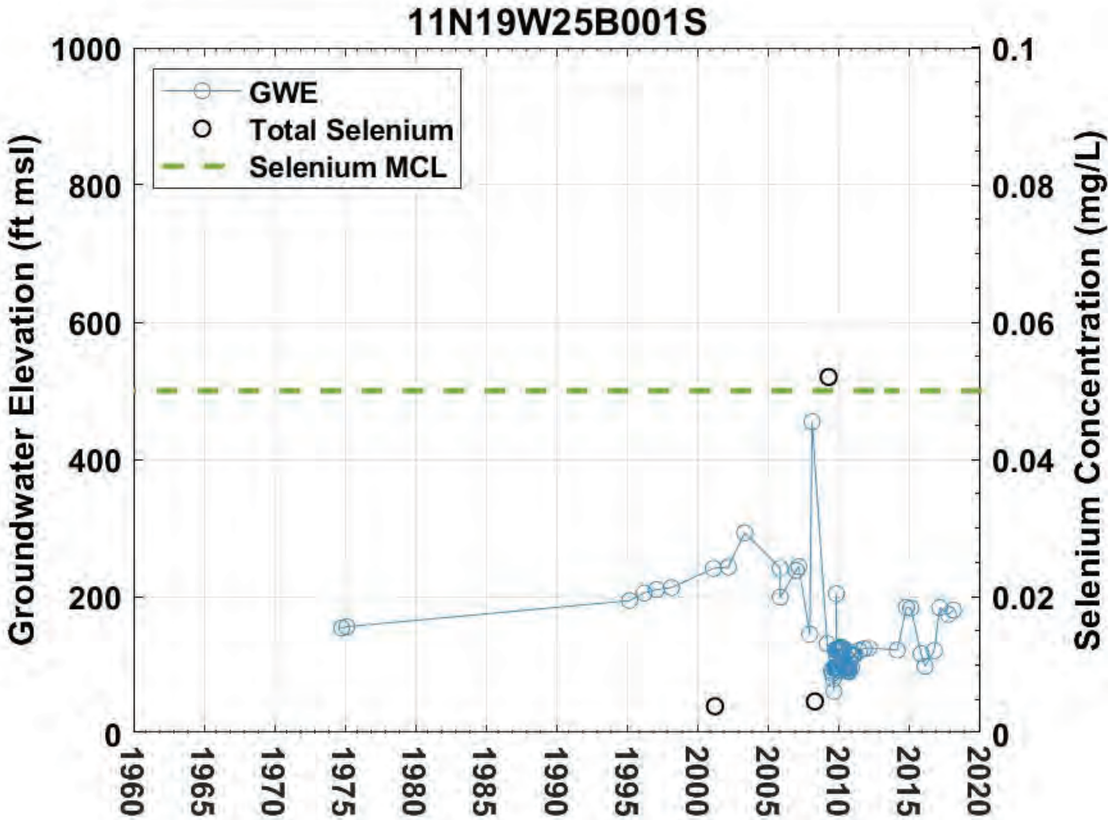
11N19W22M001S
GWE
Dissolved Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
0
200
400
600
800
1000
0
1
2
3
4
5
6
7
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

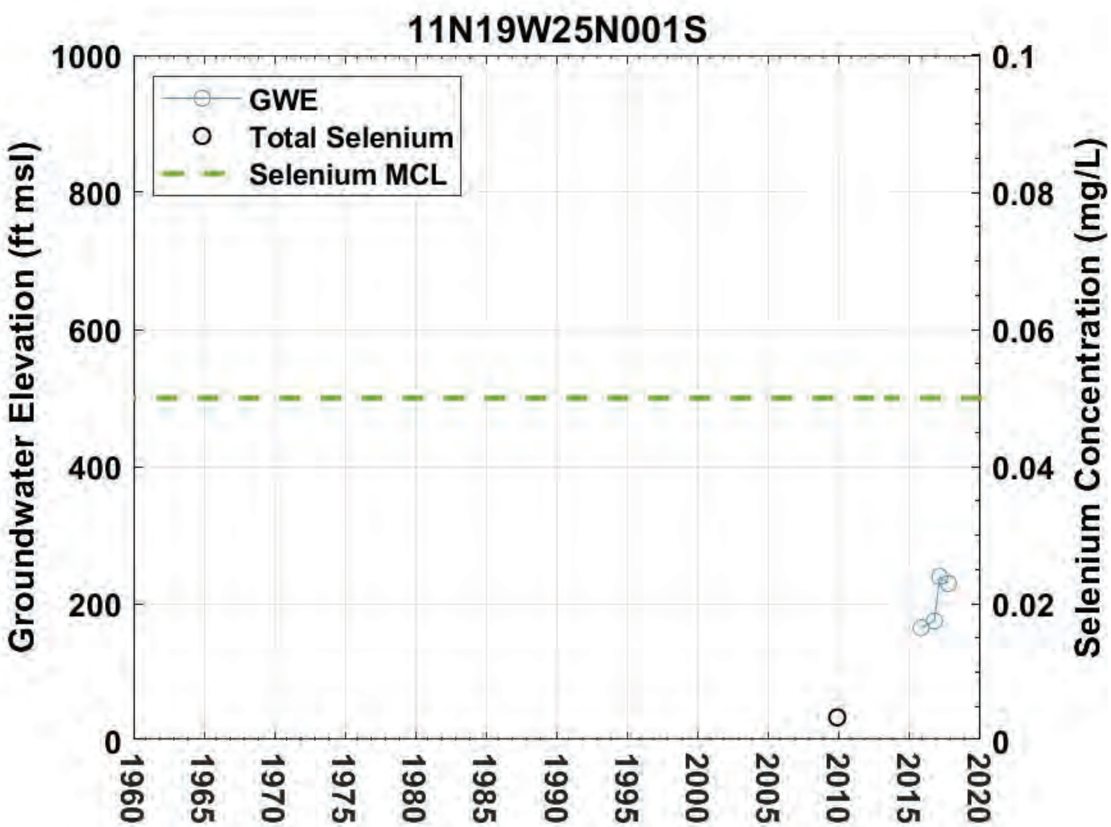


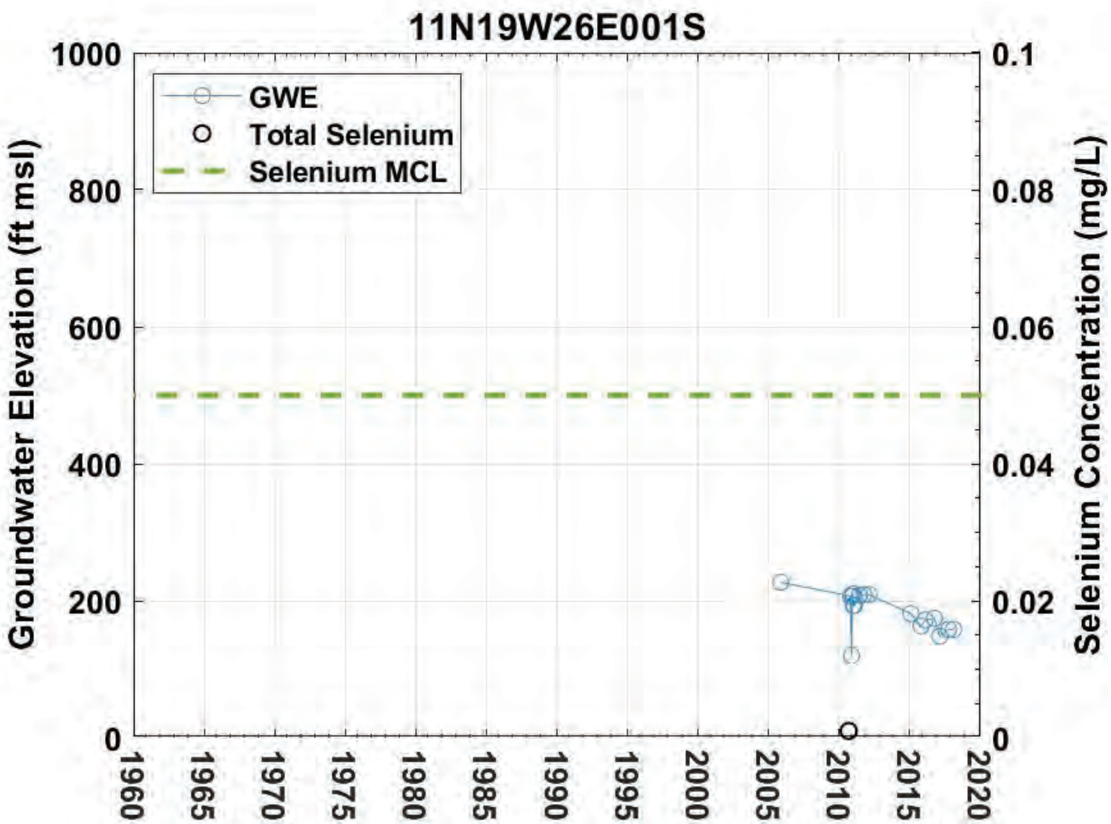
11N19W22N001S
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
0
200
400
600
800
1000
0
0.02
0.04
0.06
0.08
0.1
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

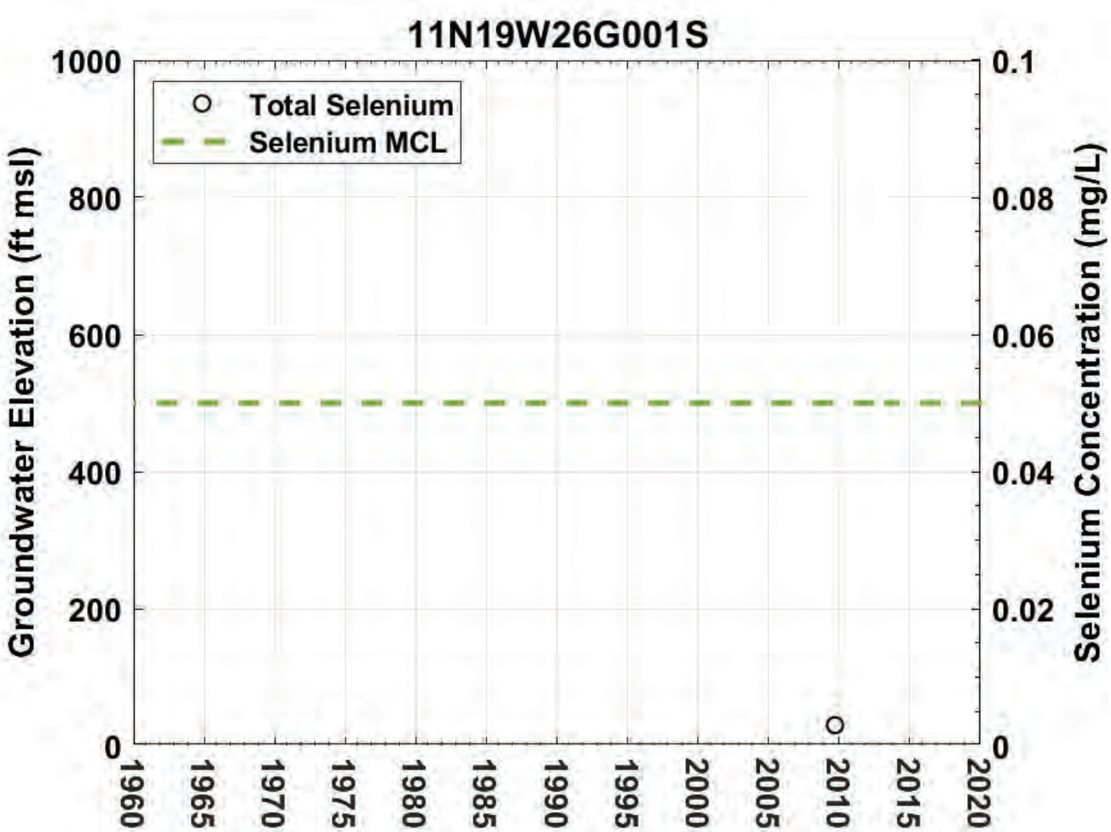

11N19W22R001S
Total Selenium
Selenium MCL
WQ Trendline Slope: 0 mg/L/yr
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

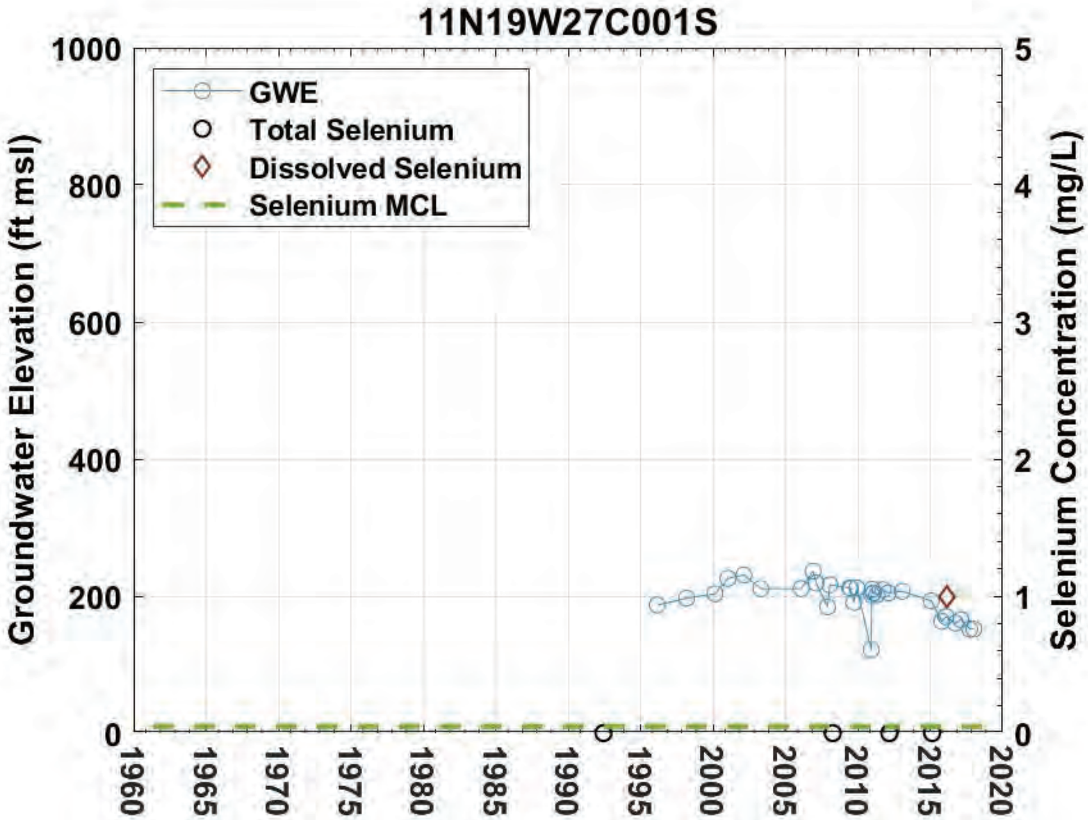

11N19W23Q001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W25B001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

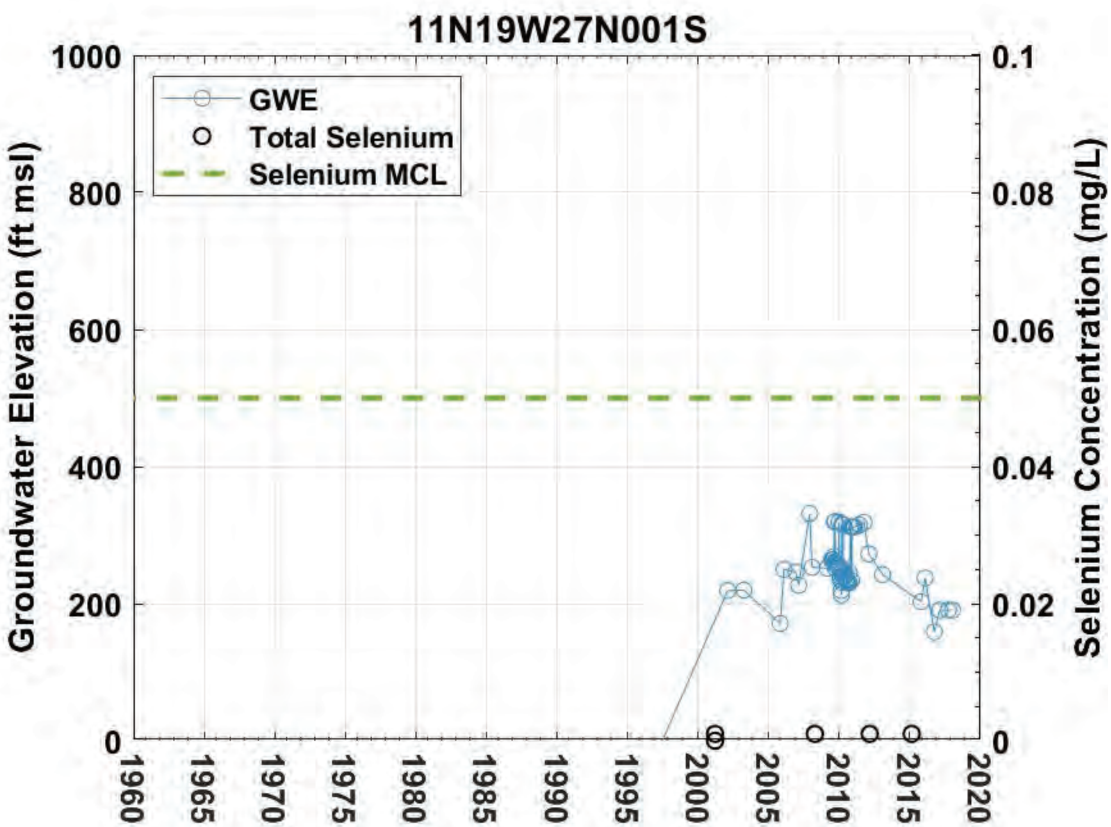

11N19W25N001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W26E001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

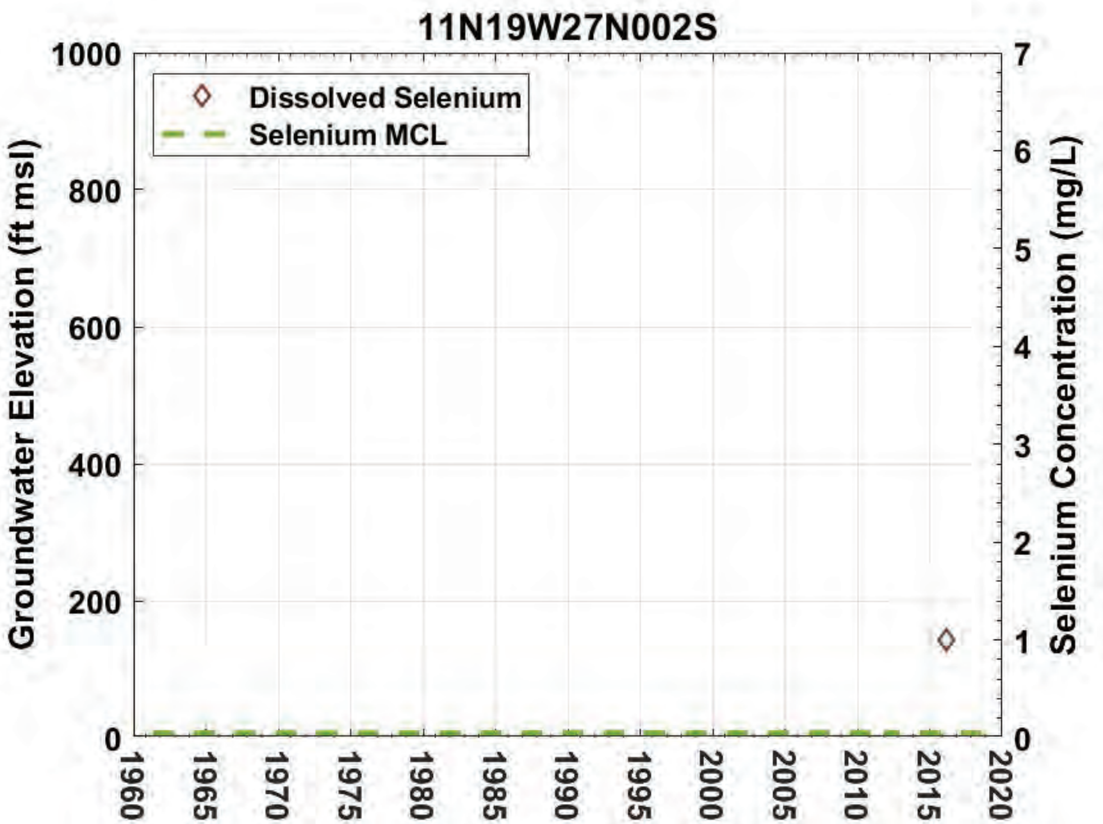

11N19W26G001S
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



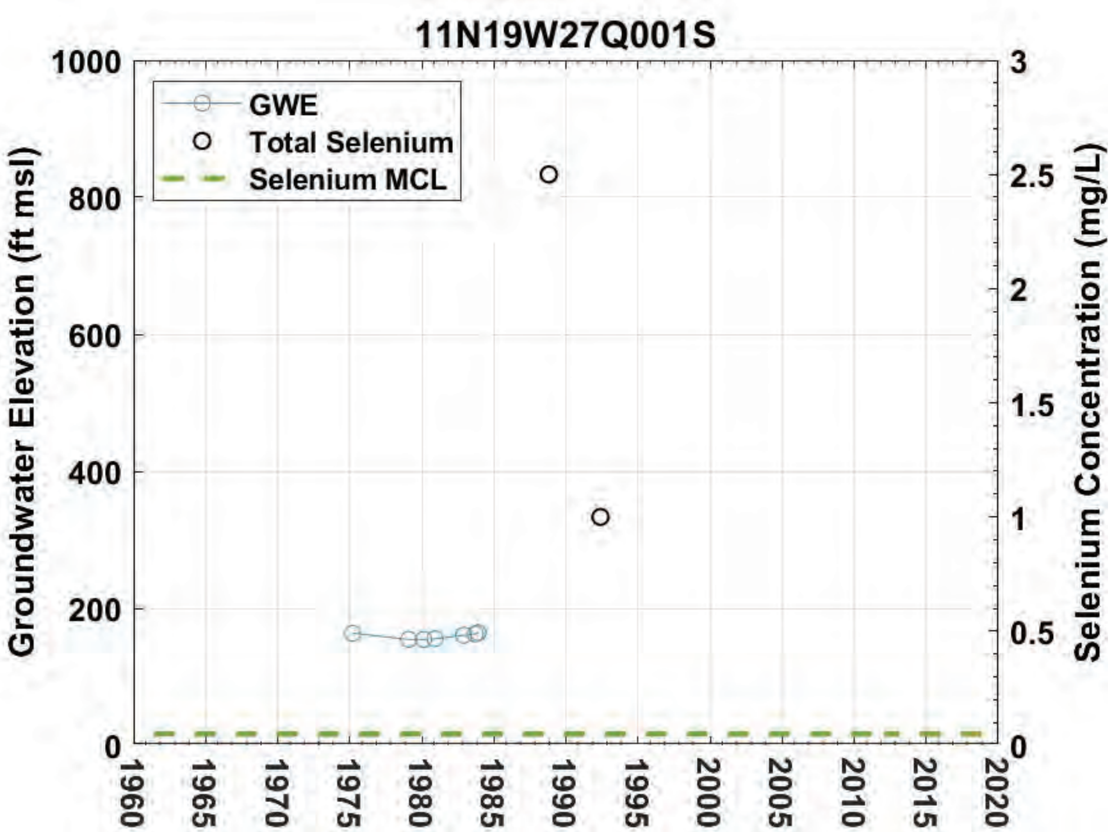
11N19W27C001S
GWE
Total Selenium
Dissolved Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
5
4
3
2
1
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



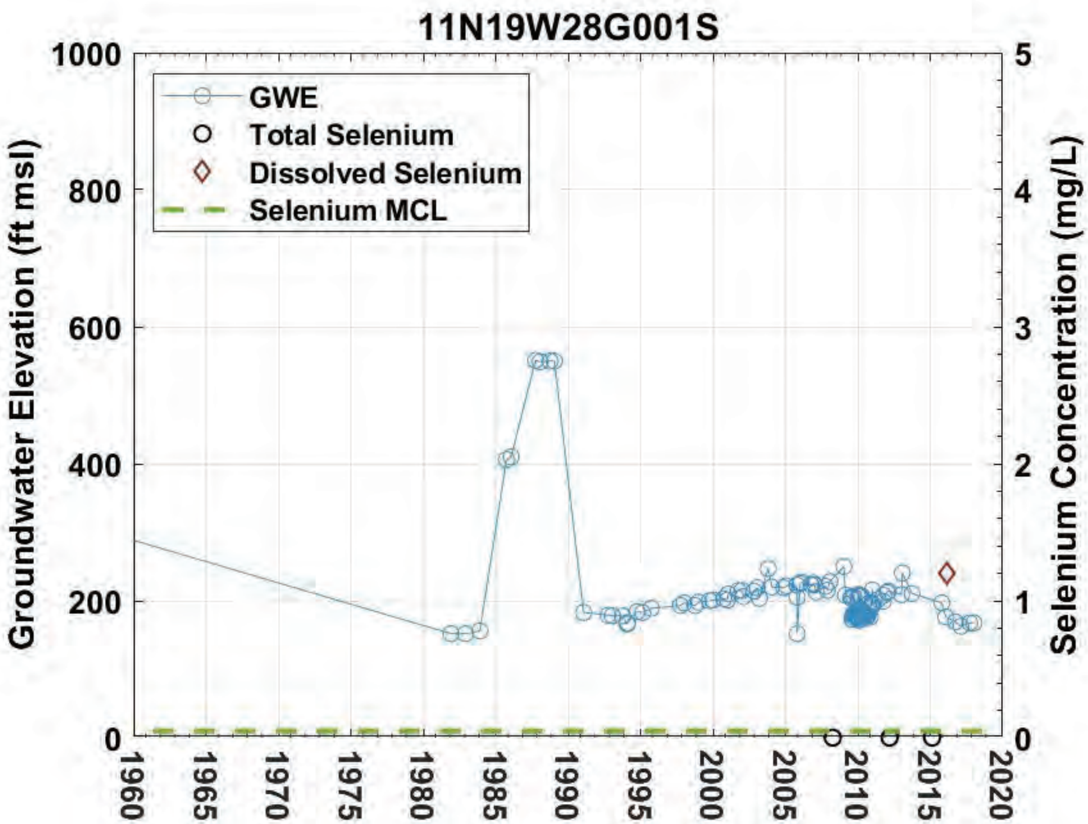
11N19W27N001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

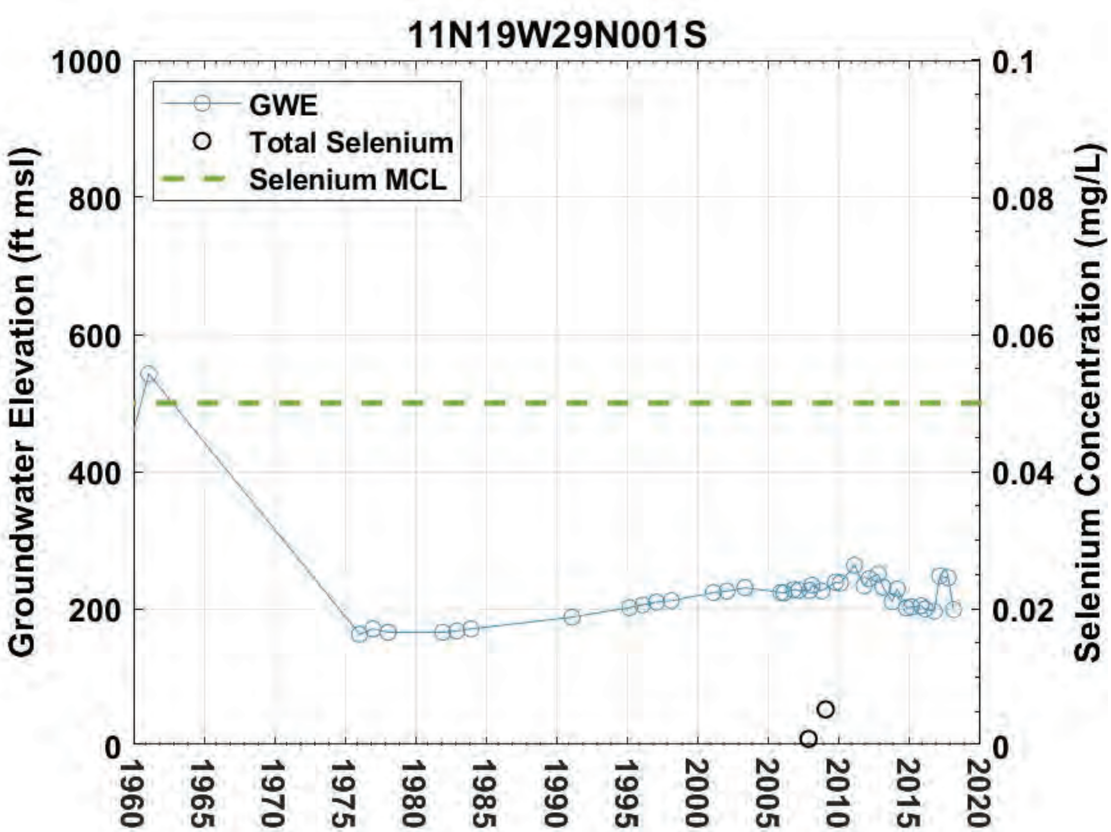


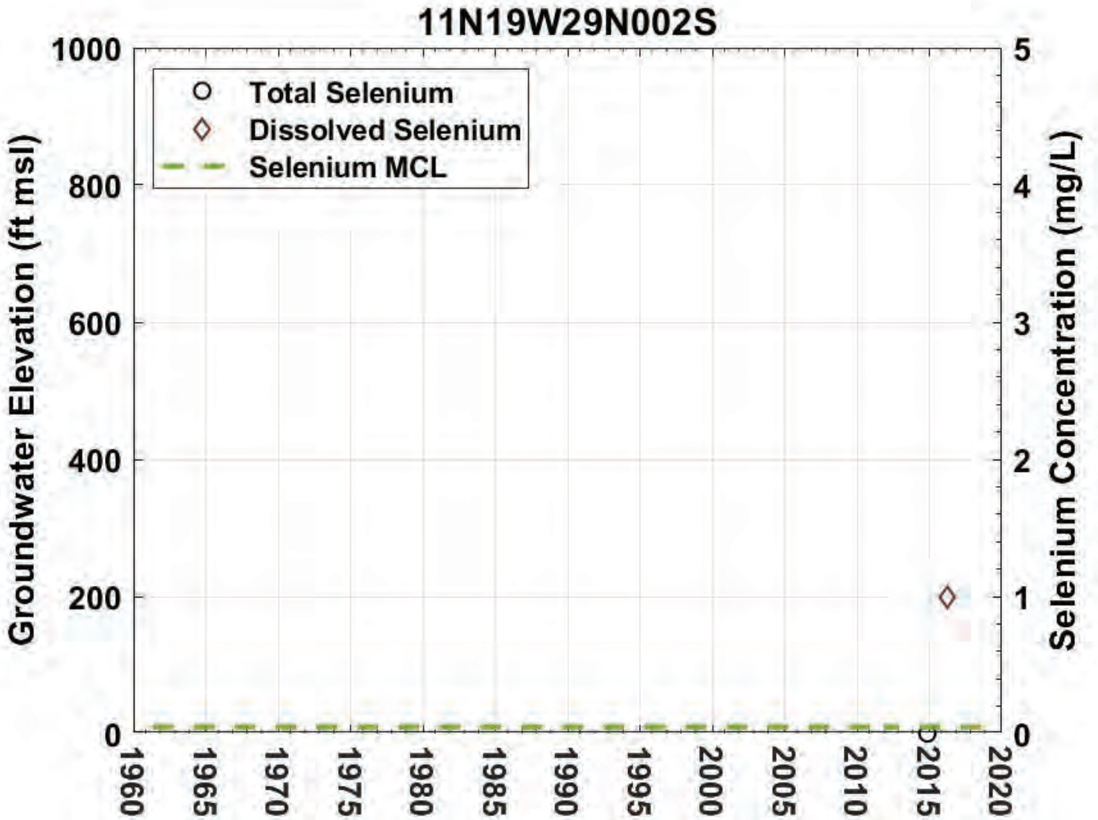
11N19W27N002S
Dissolved Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
0
200
400
600
800
1000
0
1
2
3
4
5
6
7
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

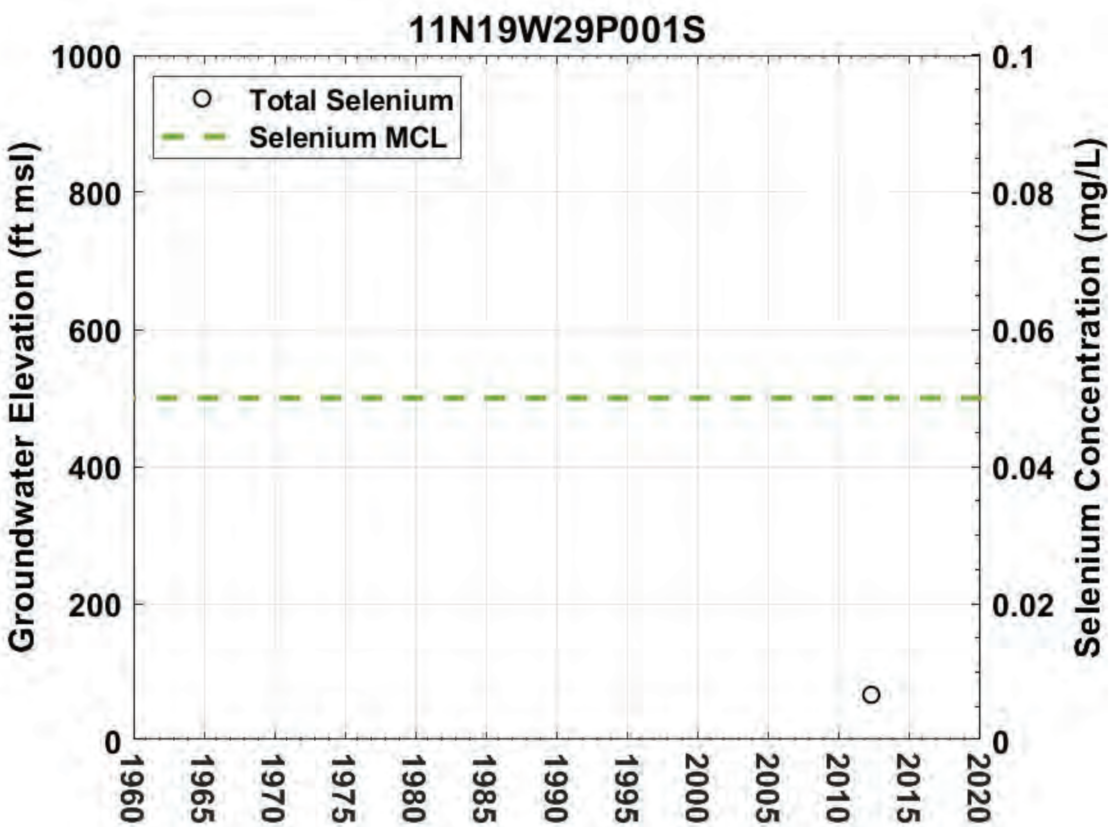


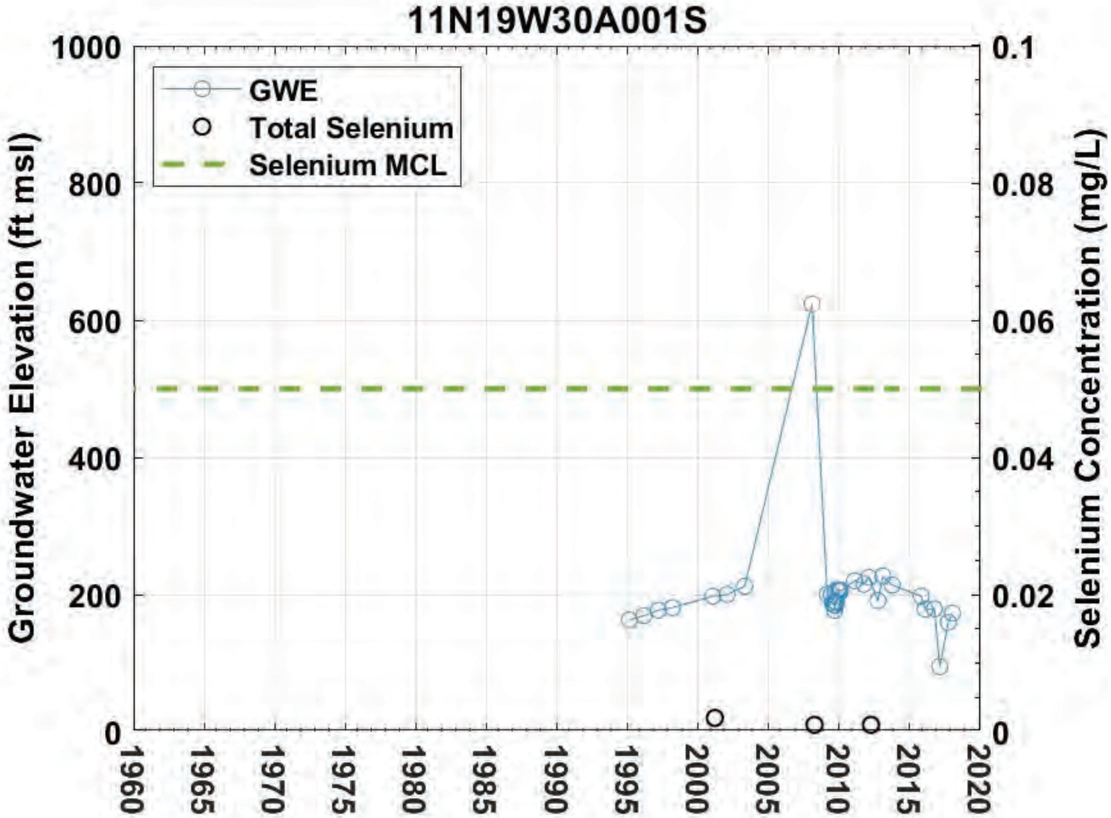
11N19W27Q001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
0
200
400
600
800
1000
0
0.5
1
1.5
2
2.5
3
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

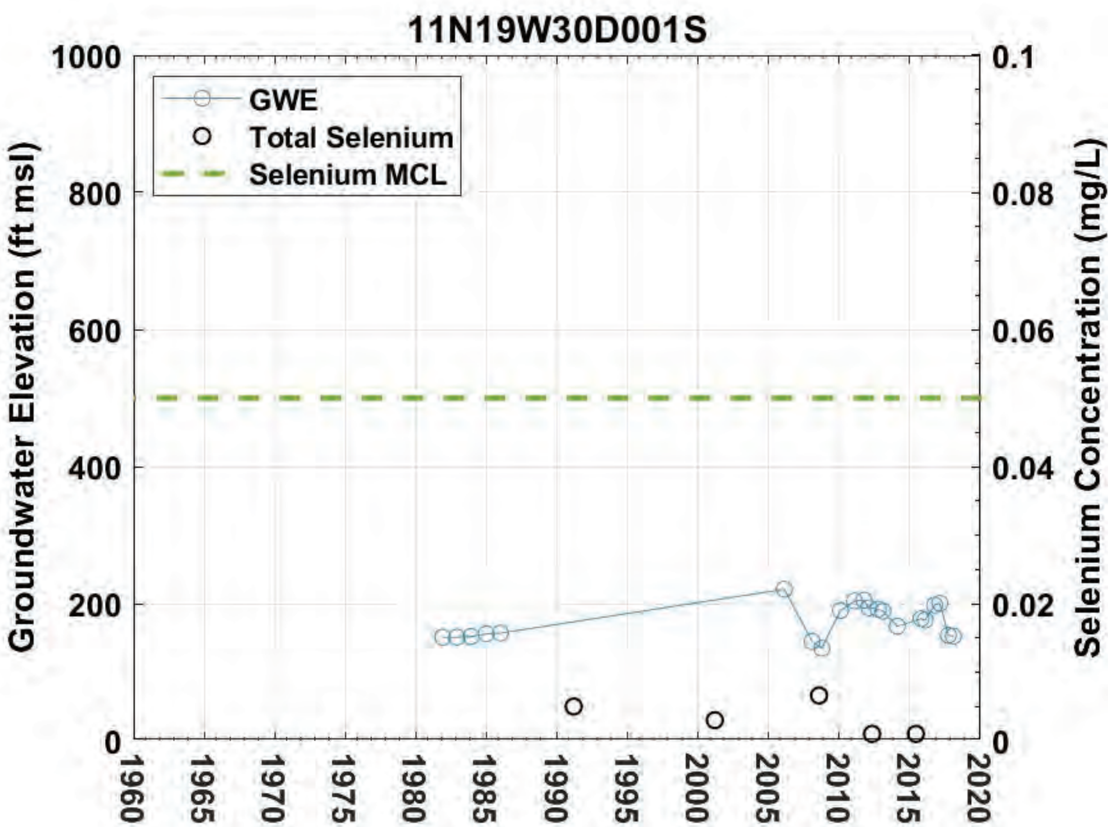

11N19W28G001S
GWE
Total Selenium
Dissolved Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
0
200
400
600
800
1000
0
1
2
3
4
5
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

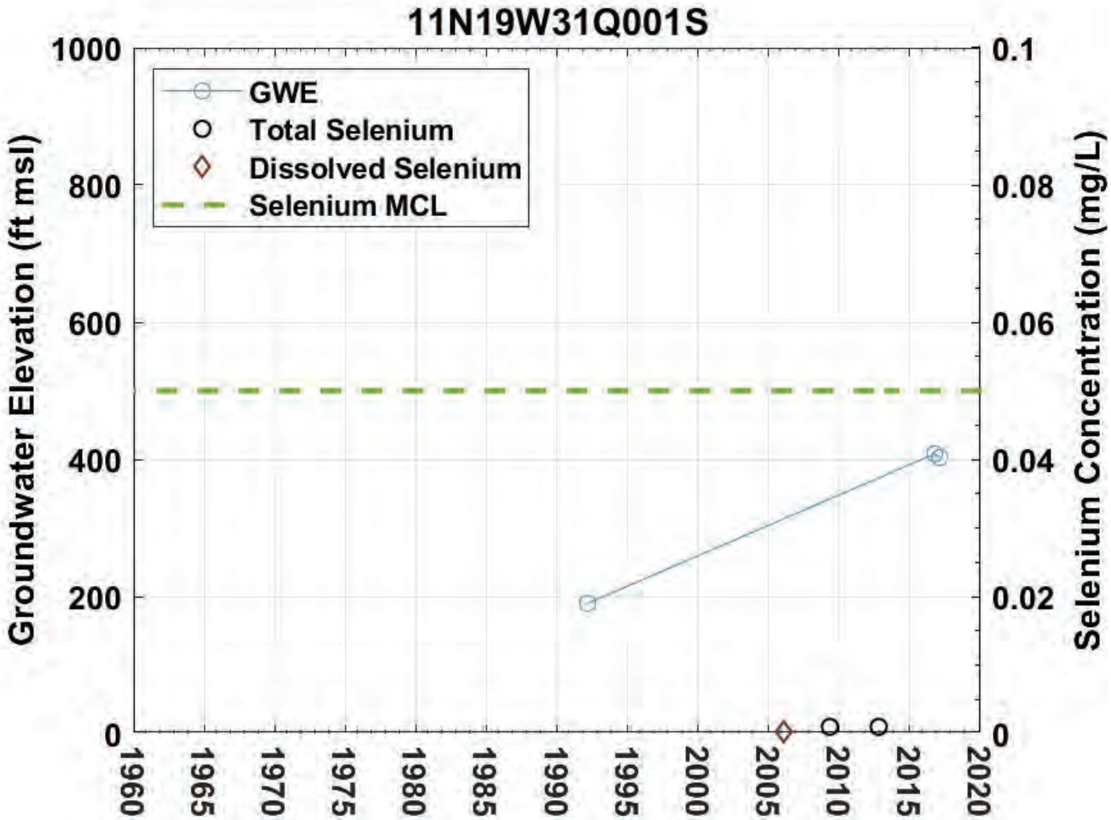

11N19W29N001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
0
200
400
600
800
1000
0
0.02
0.04
0.06
0.08
0.1
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W29N002S
Total Selenium
Dissolved Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
5
4
3
2
1
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

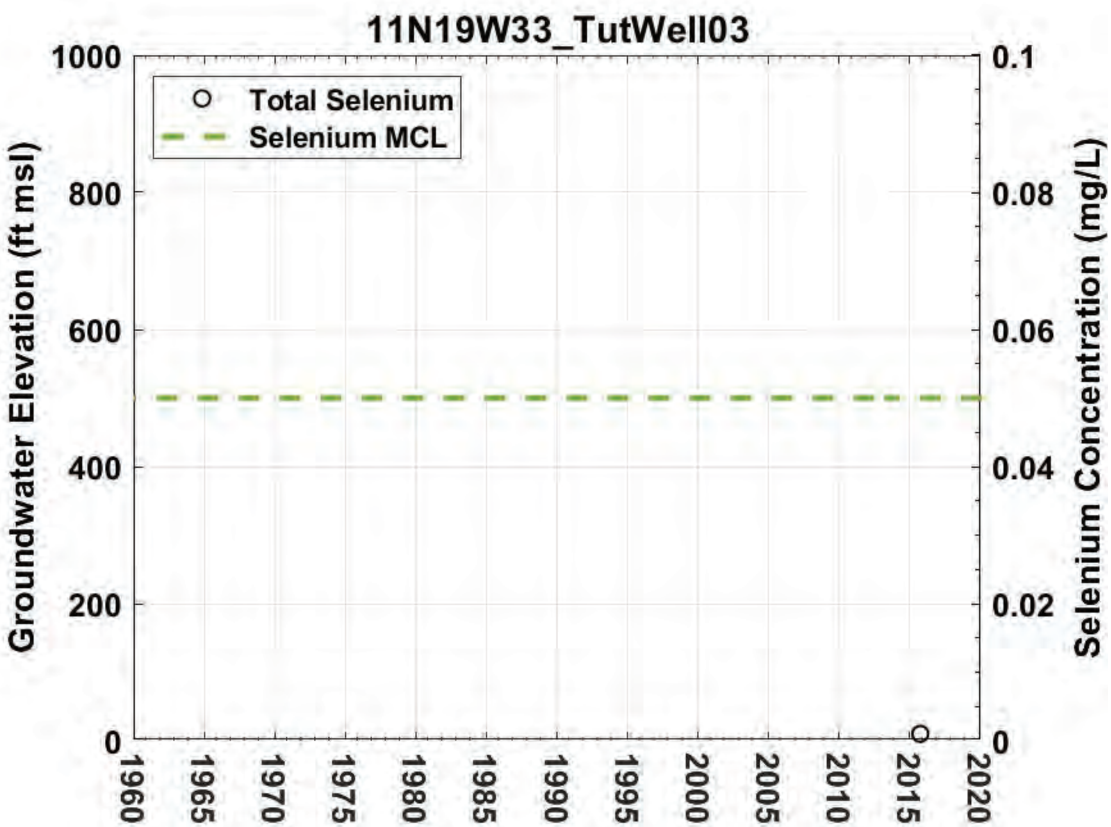

11N19W29P001S
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W30A001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

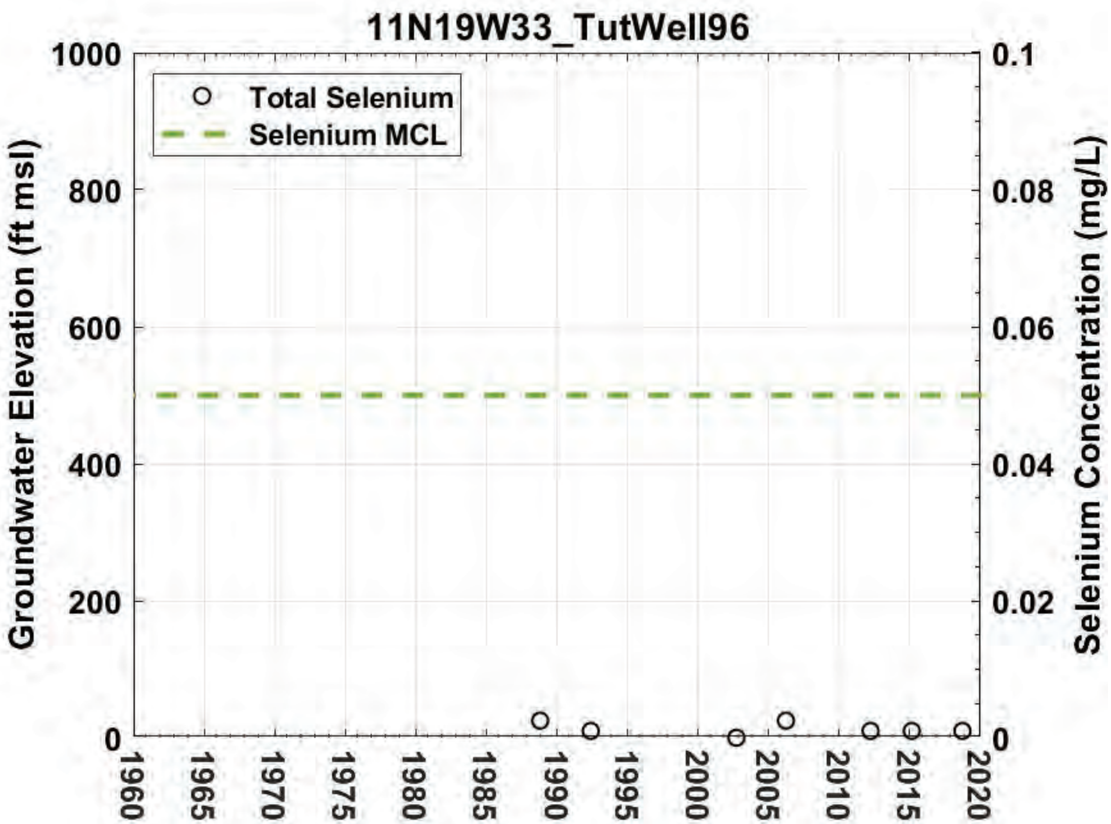

11N19W30D001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

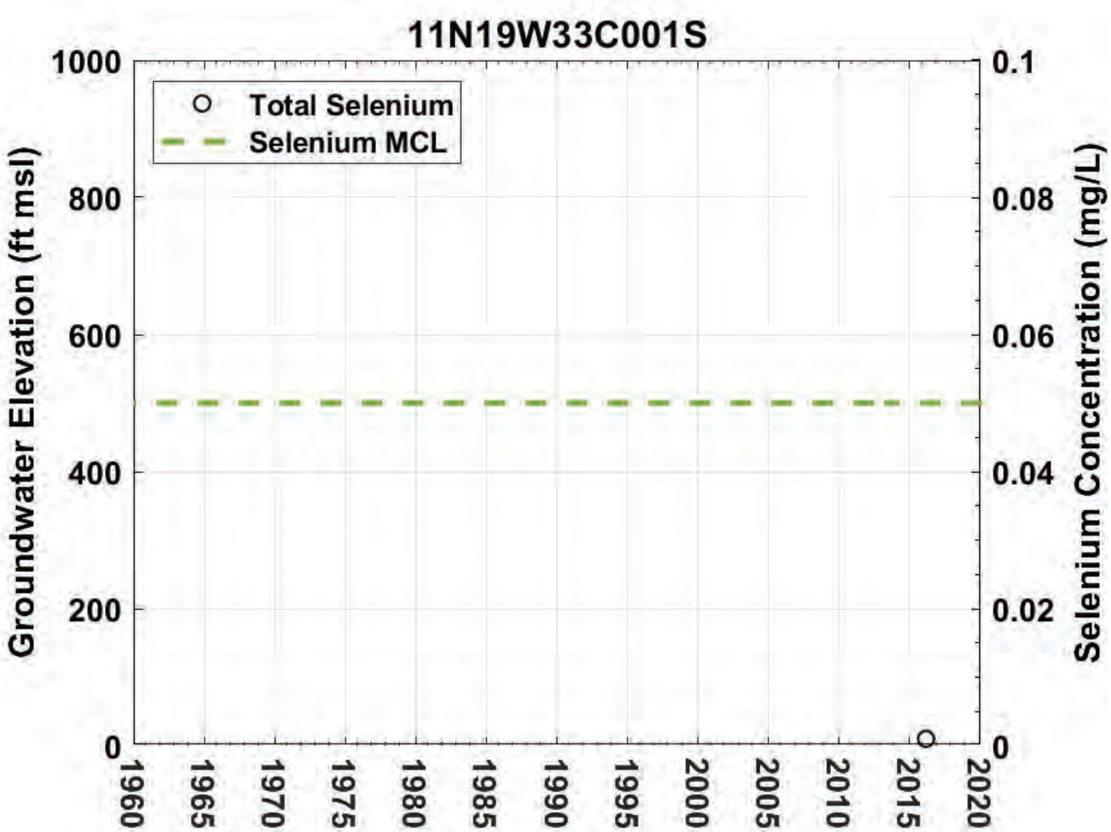


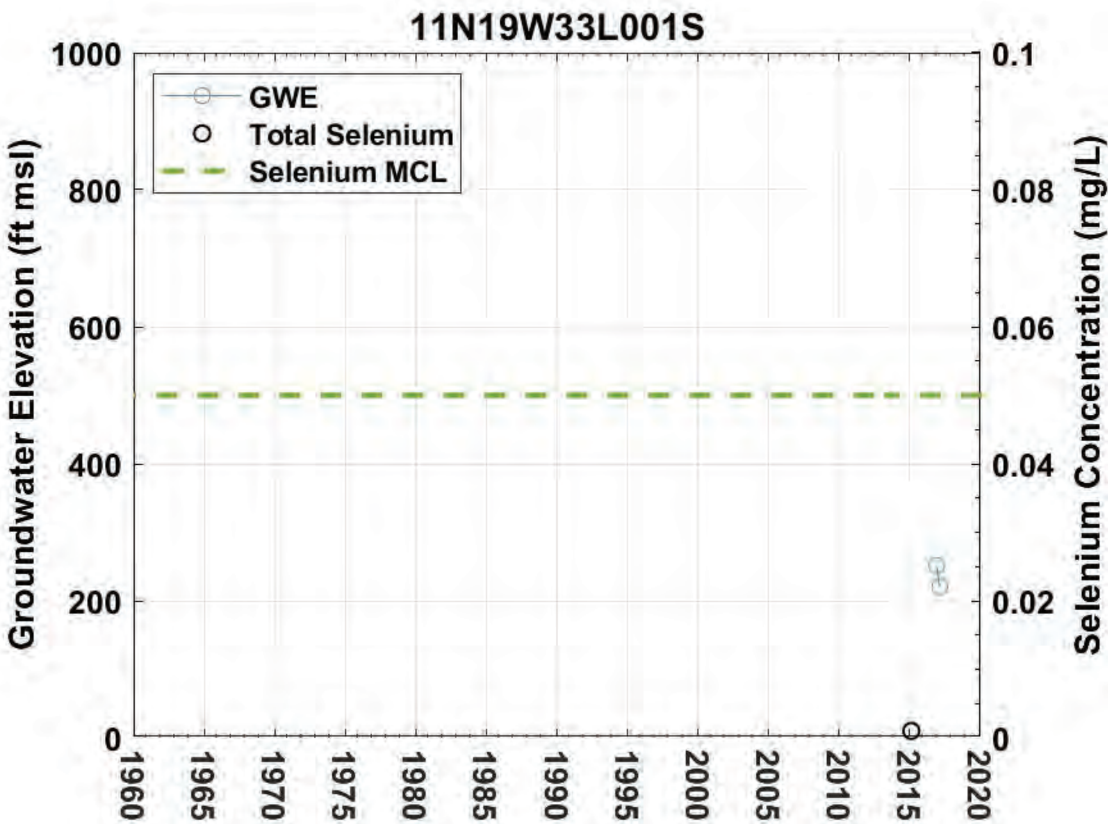
11N19W31Q001S
GWE
Total Selenium
Dissolved Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

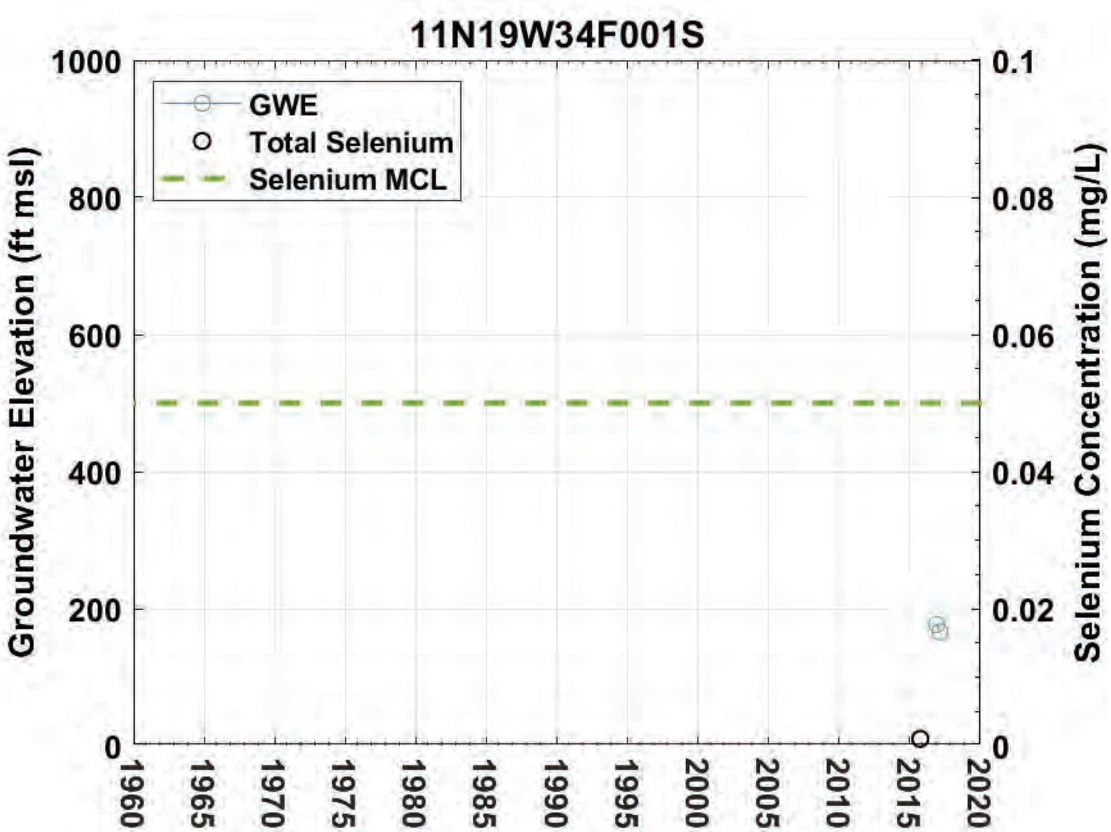


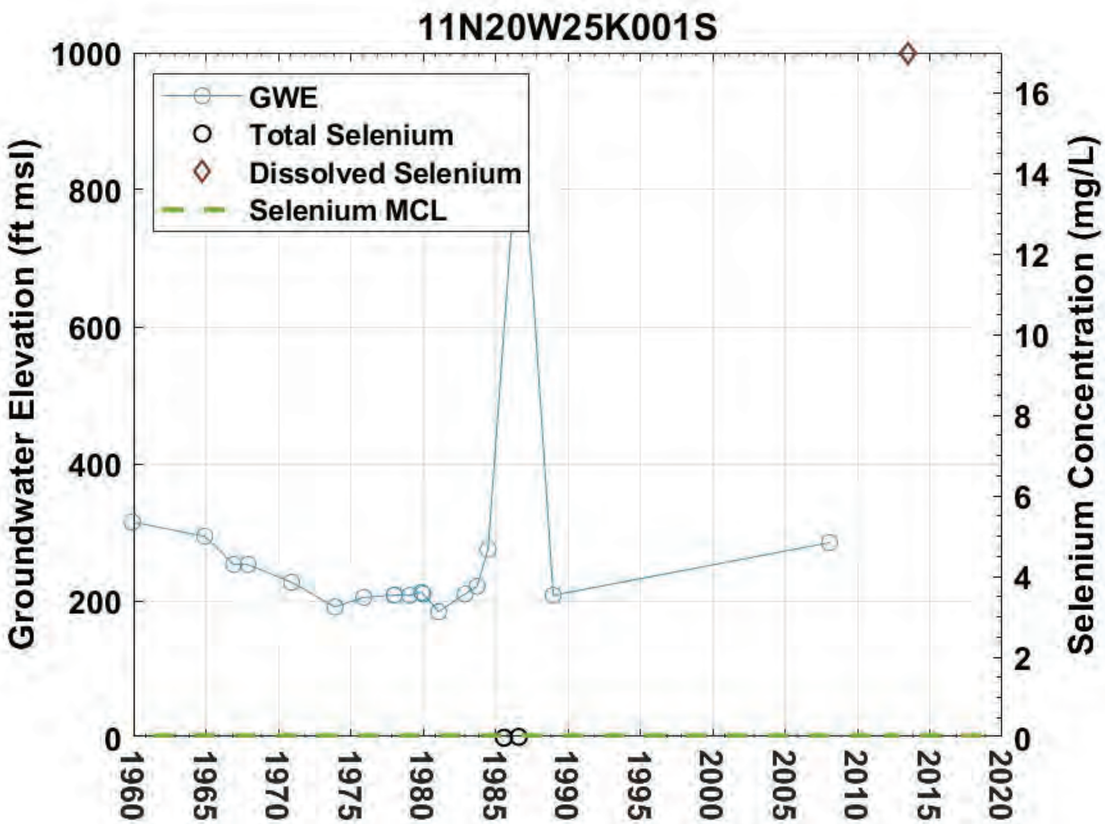
11N19W33_TutWell03
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W33_TutWell96
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

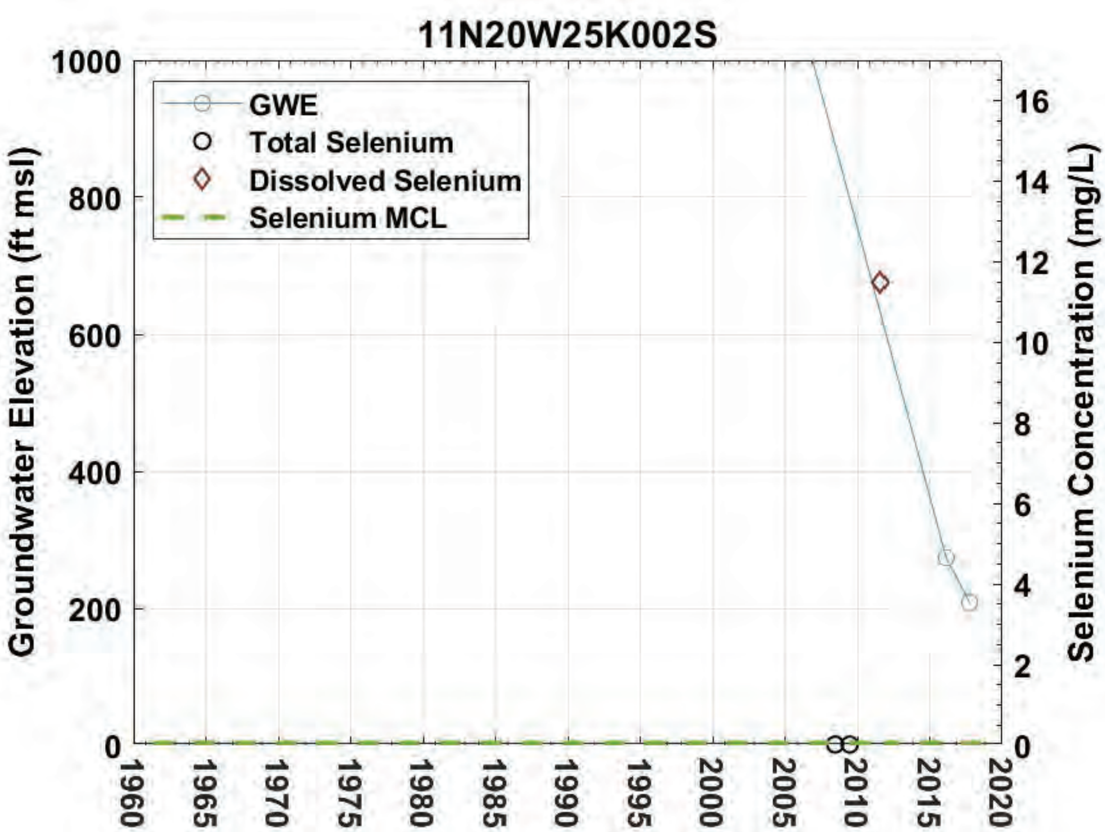

11N19W33C001S
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W33L001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

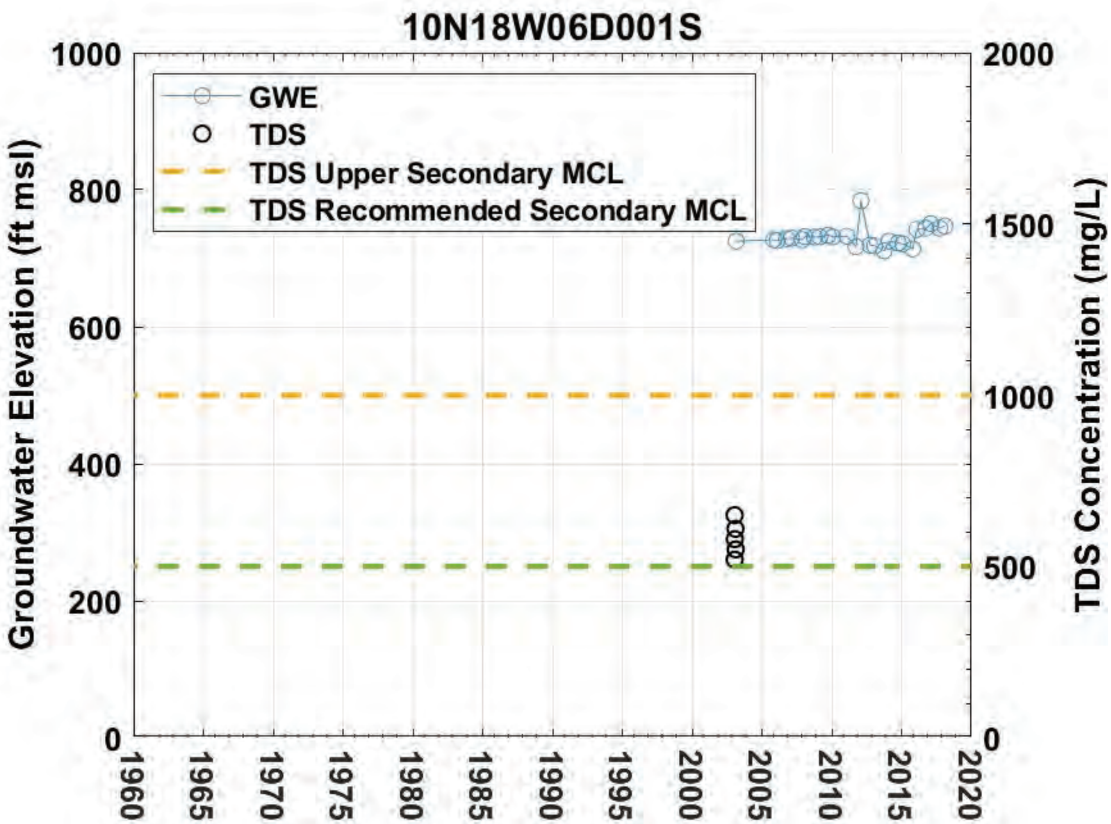

11N19W34F001S
GWE
Total Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
0.1
0.08
0.06
0.04
0.02
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



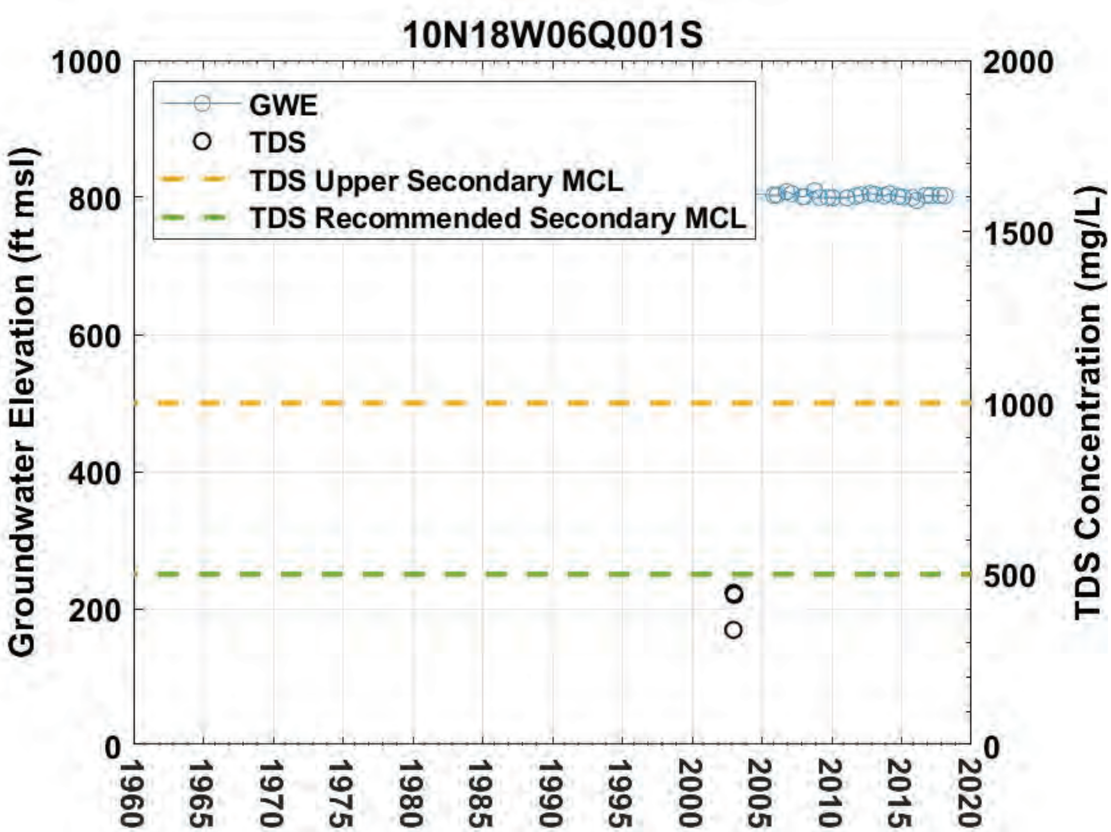
11N20W25K001S
GWE
Total Selenium
Dissolved Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
16
14
12
10
8
6
4
2
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



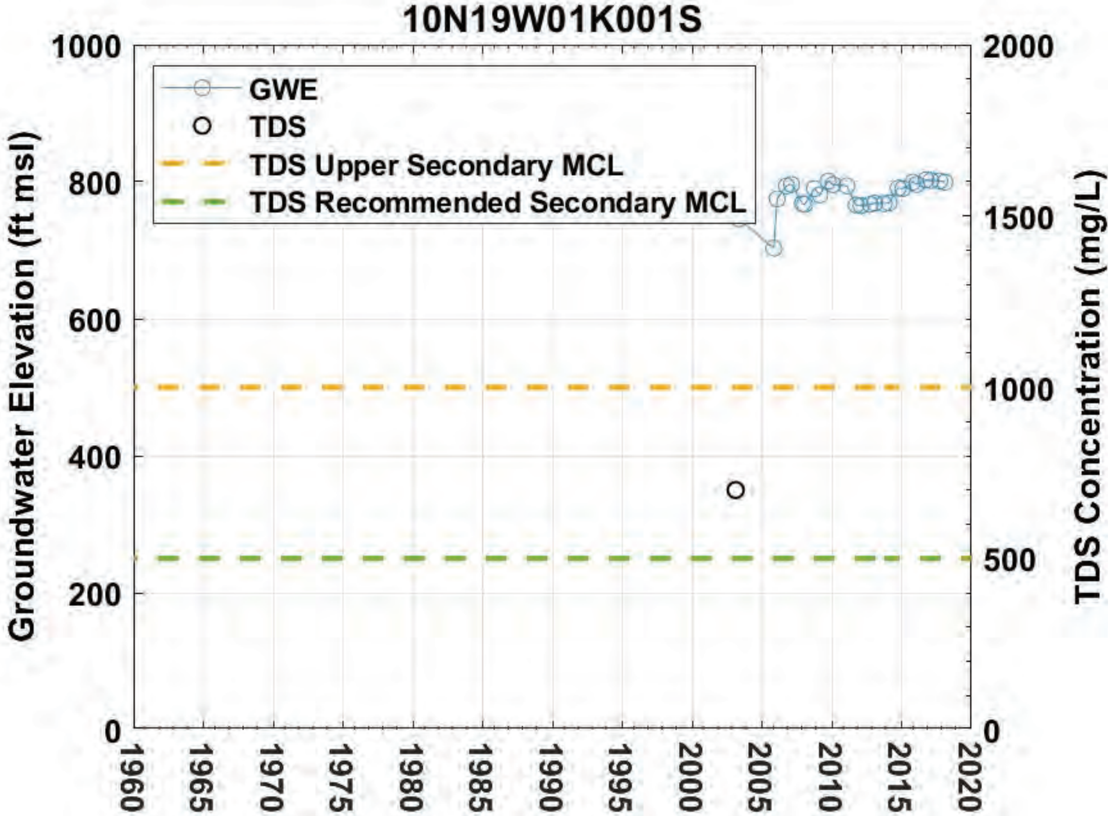
11N20W25K002S
GWE
Total Selenium
Dissolved Selenium
Selenium MCL
Groundwater Elevation (ft msl)
Selenium Concentration (mg/L)
1000
800
600
400
200
0
16
14
12
10
8
6
4
2
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

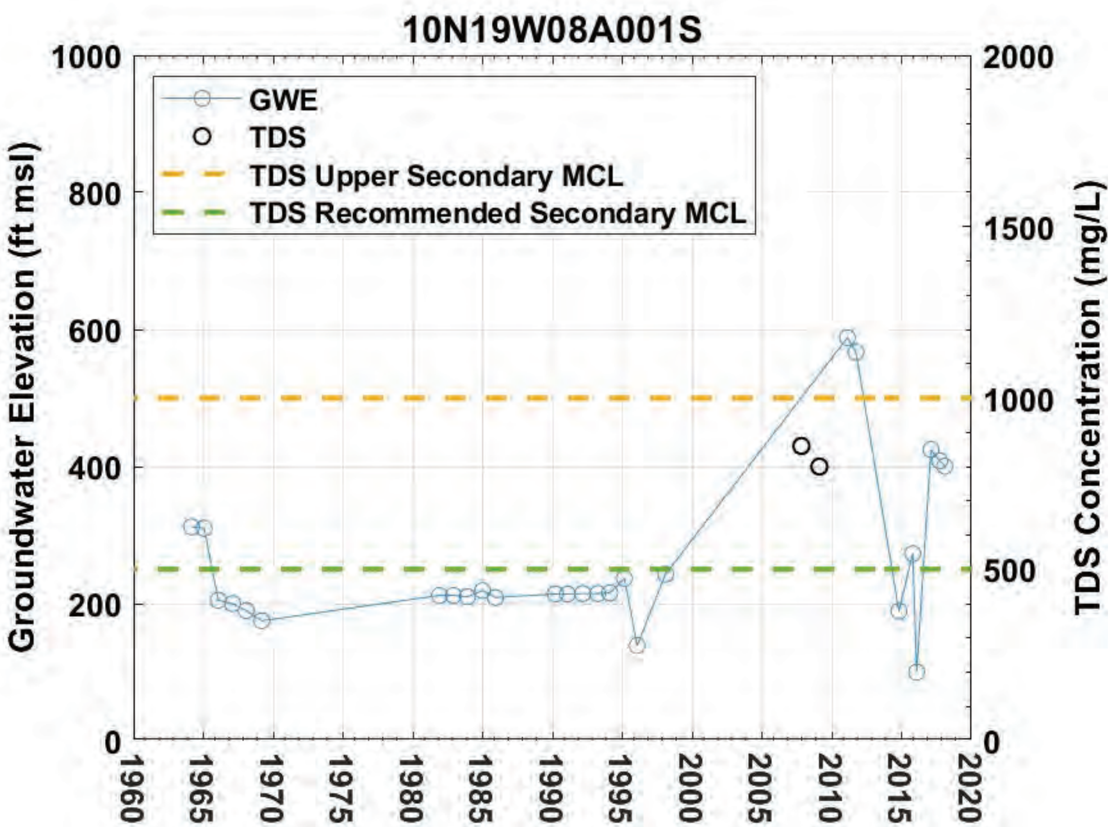


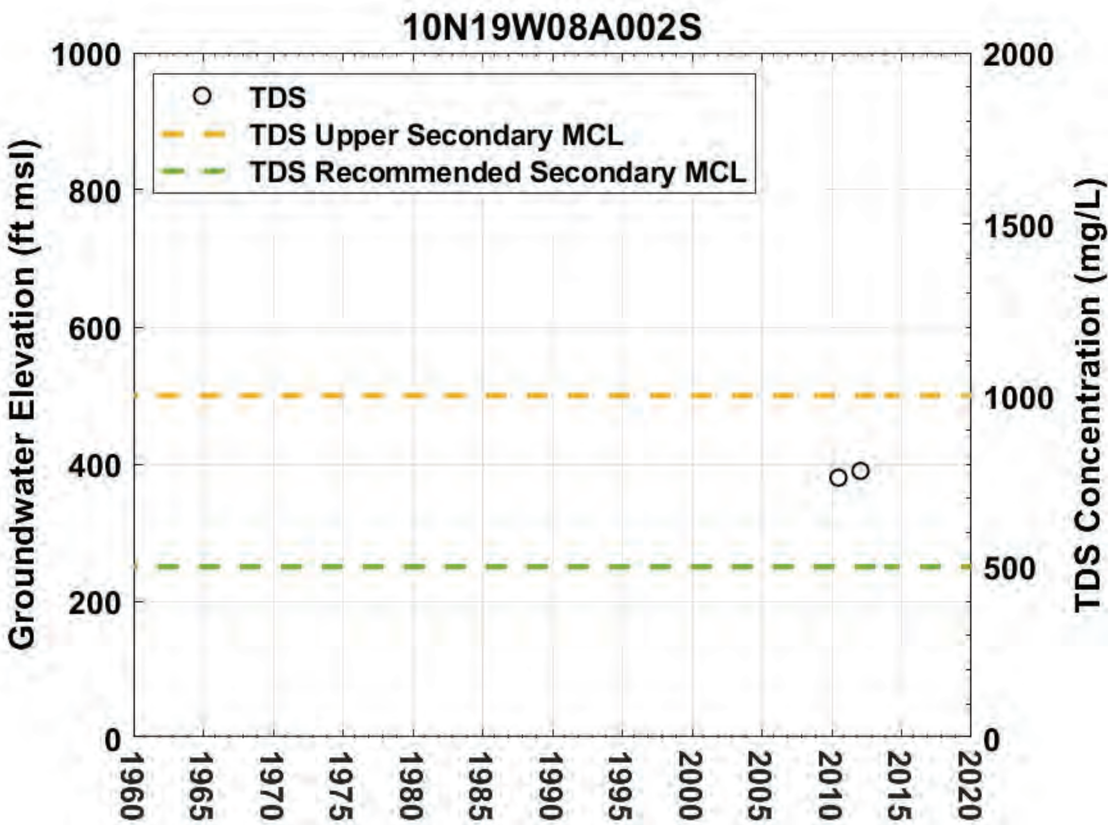
10N18W06D001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



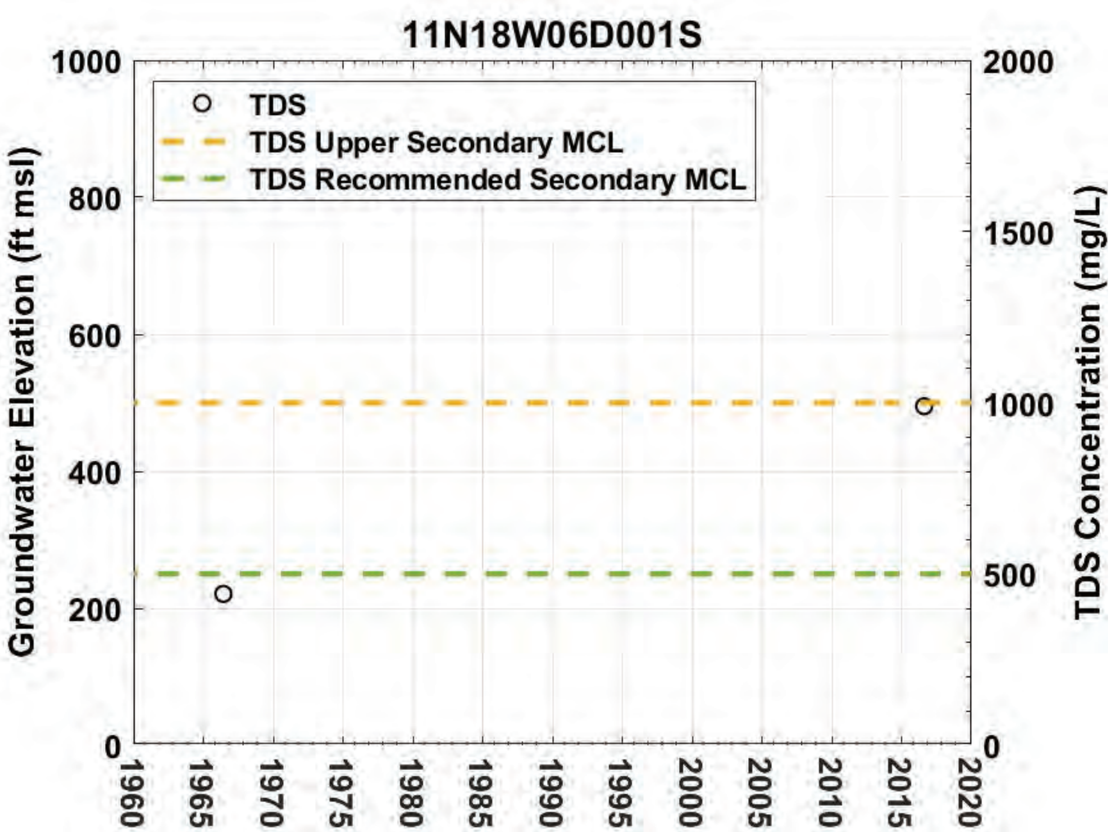
10N18W06Q001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


10N19W01K001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

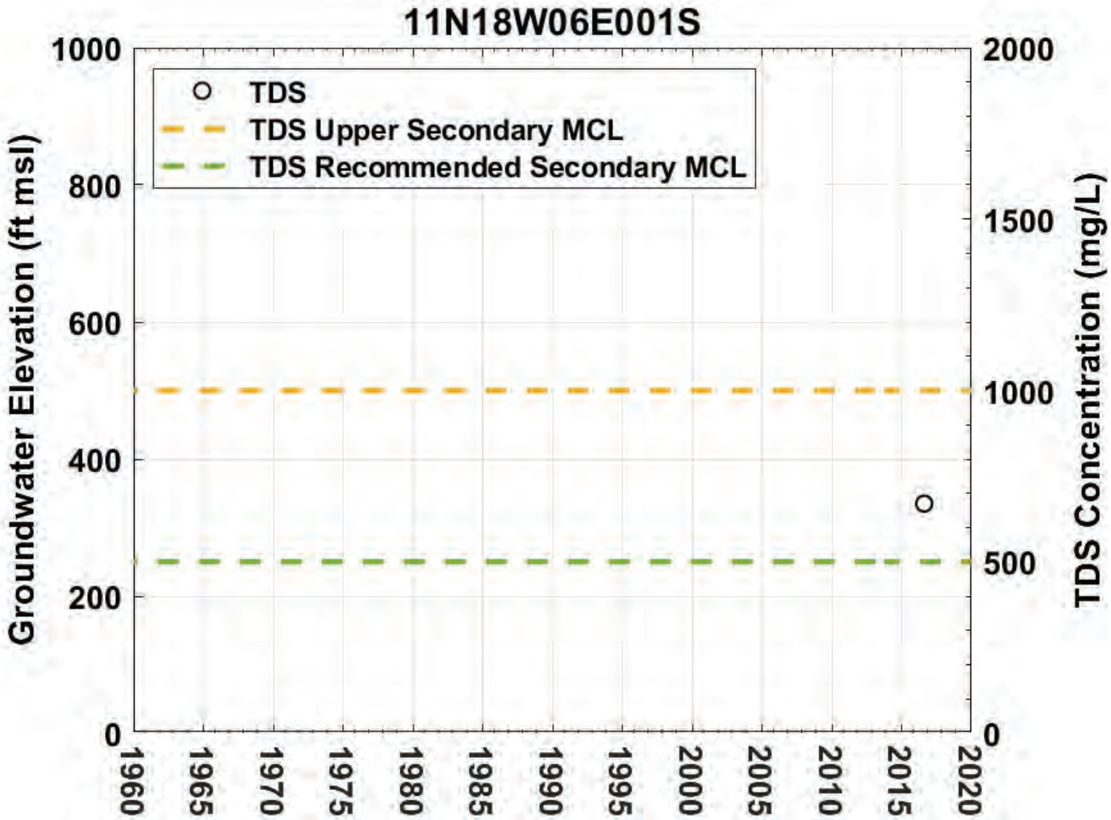

10N19W08A001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



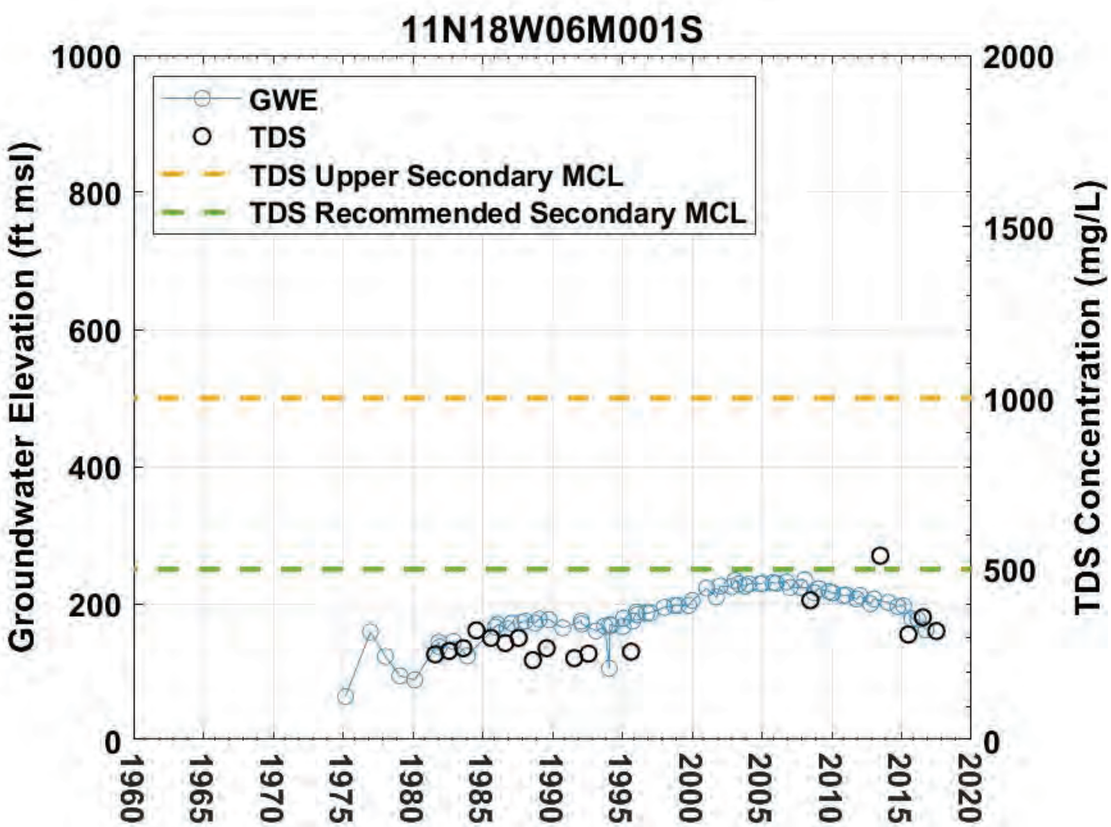
10N19W08A002S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



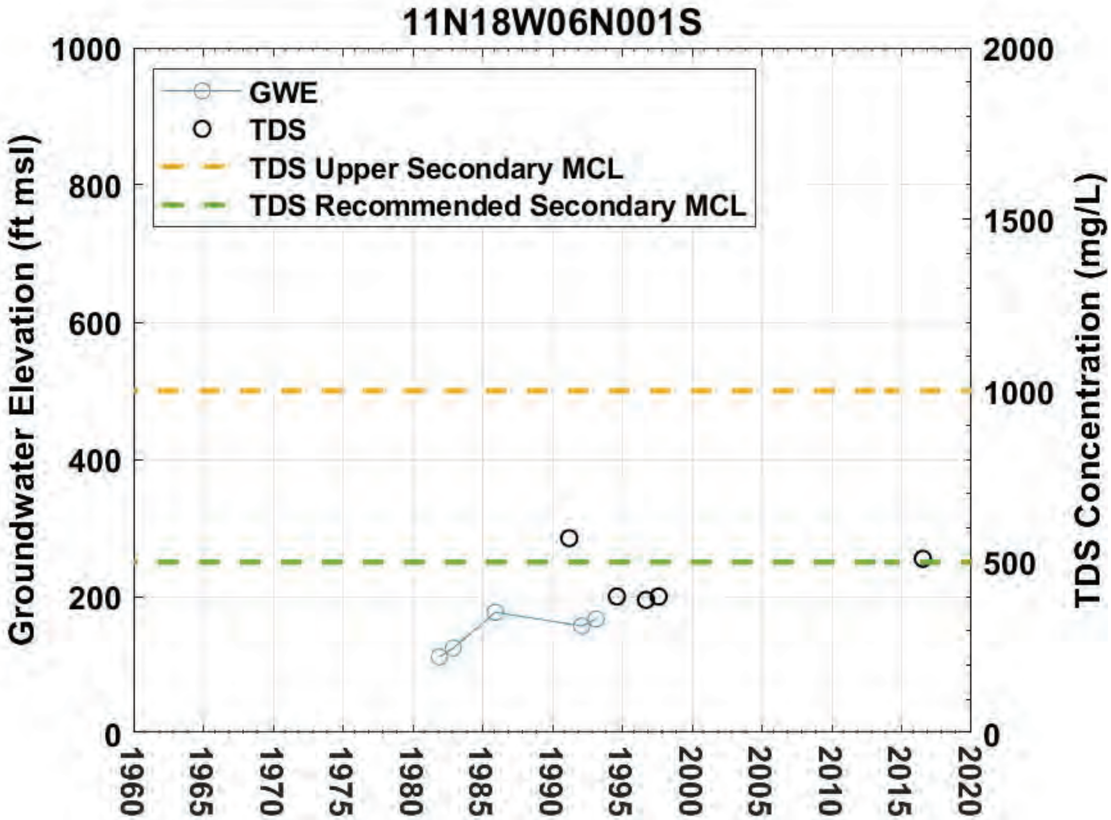
11N18W06D001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

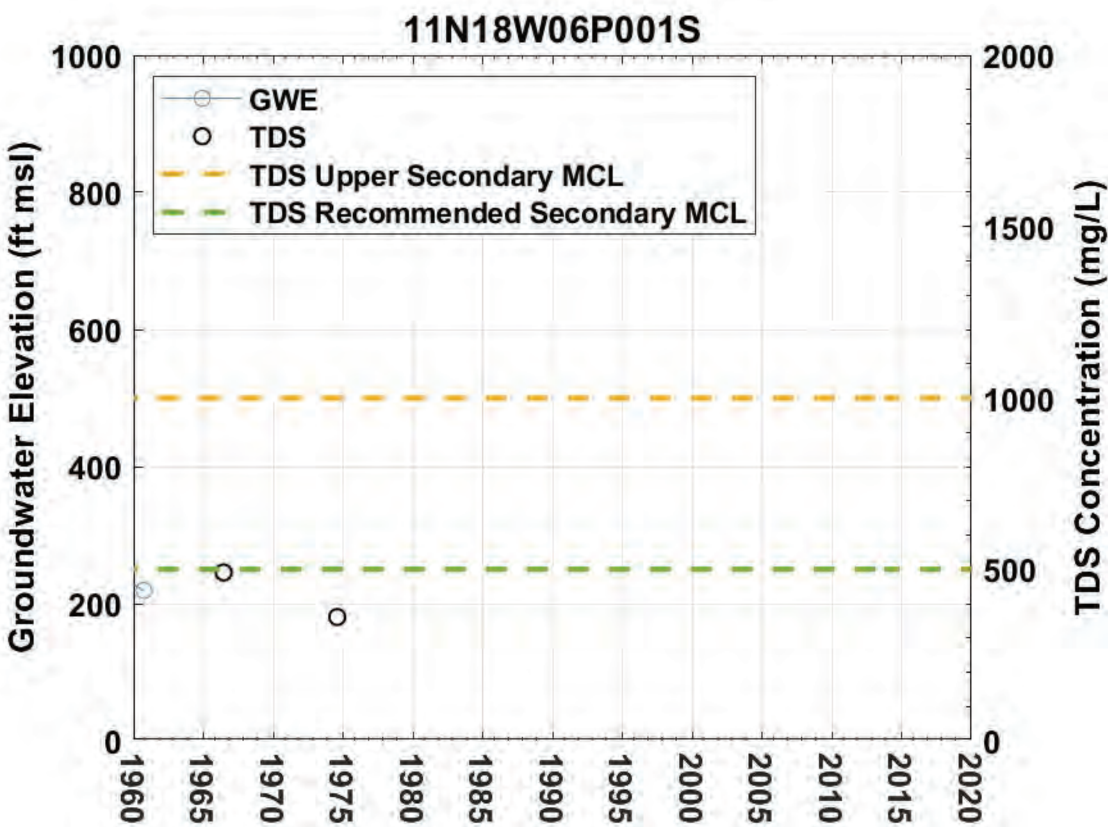


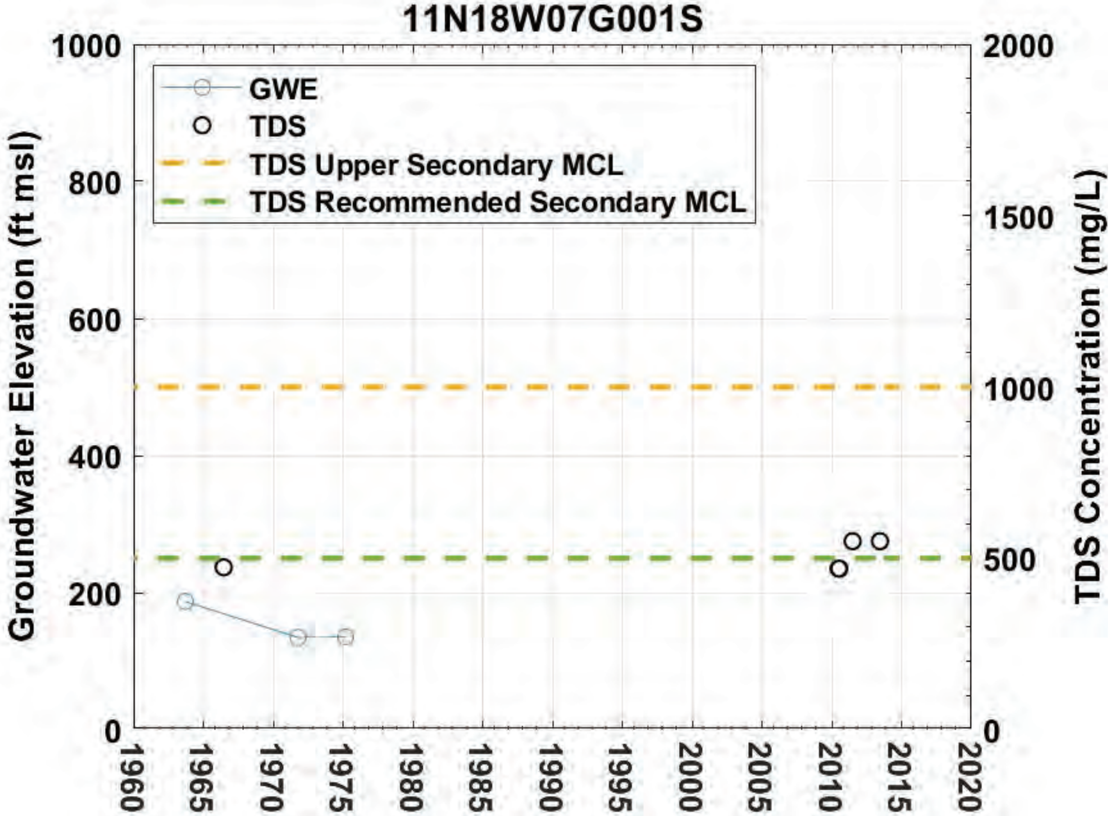
11N18W06E001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

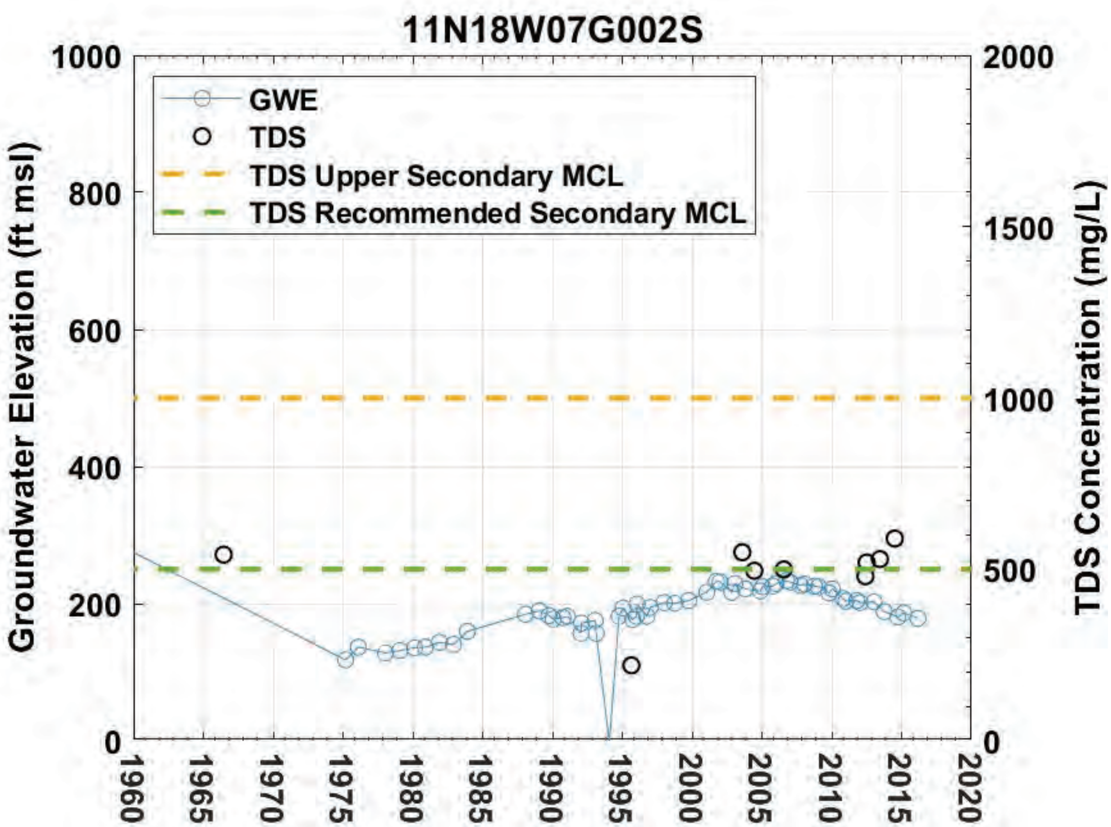


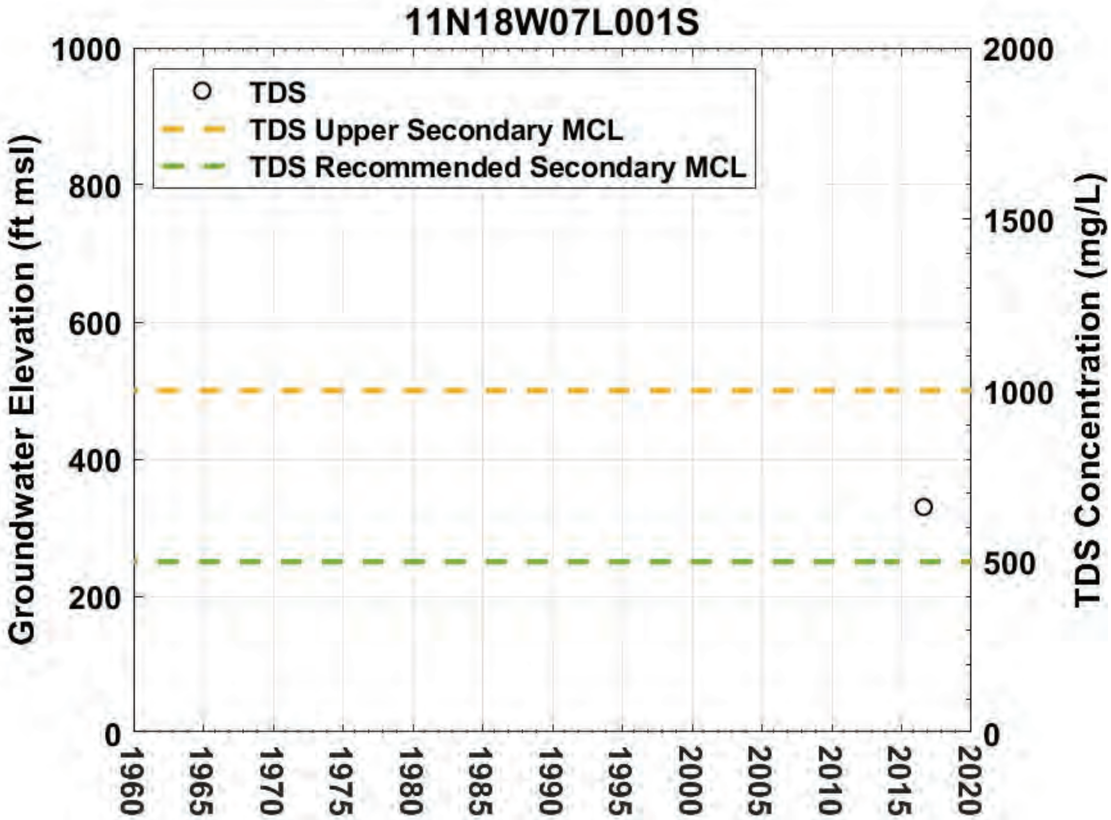
11N18W06M001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N18W06N001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

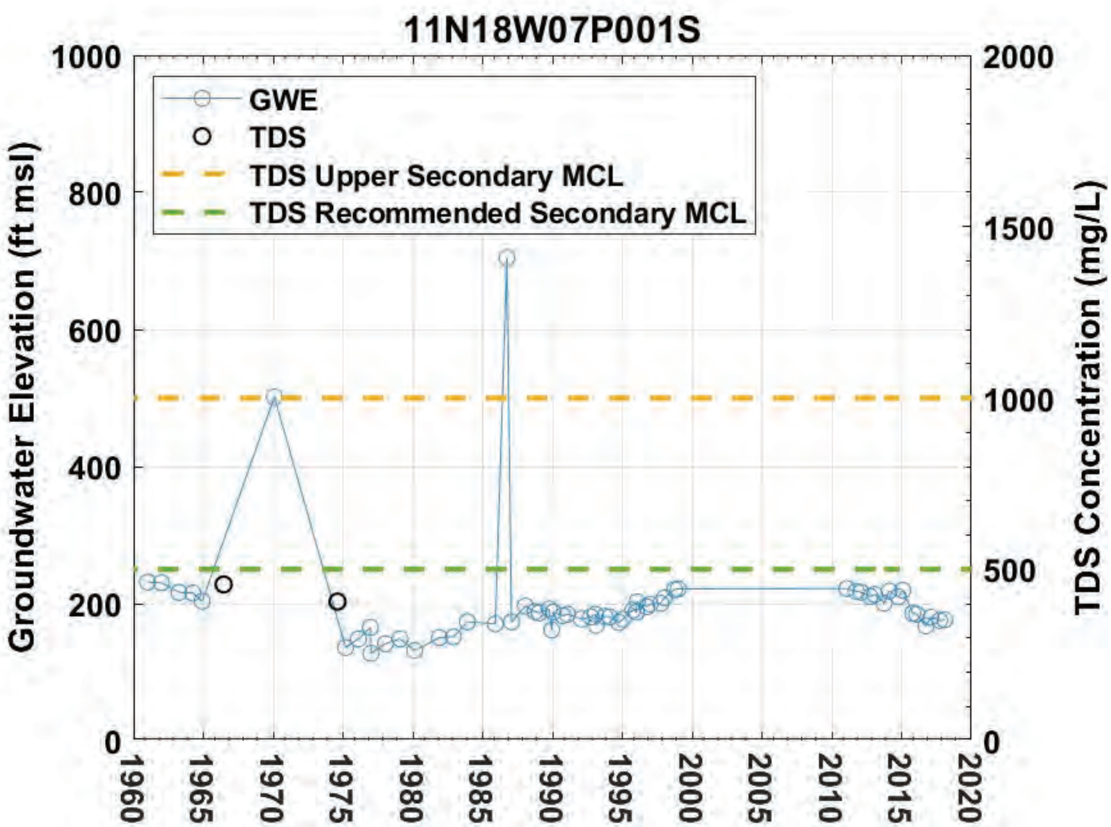

11N18W06P001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N18W07G001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

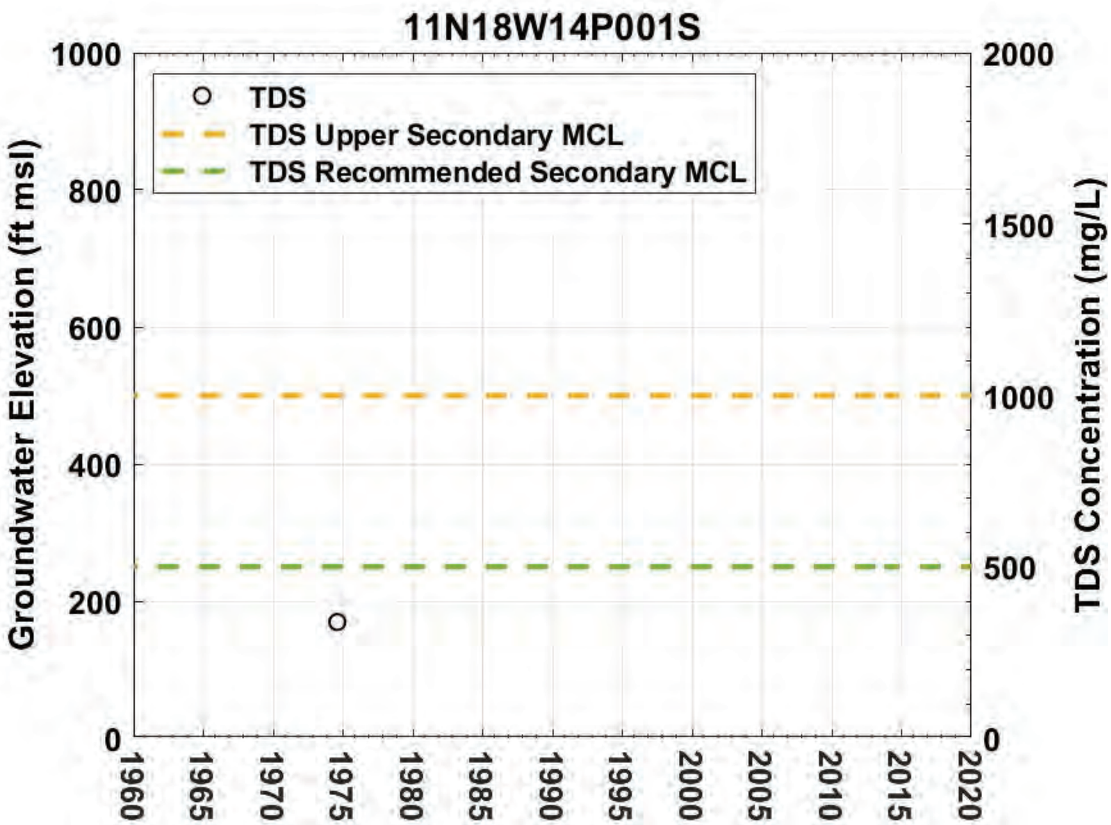

11N18W07G002S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



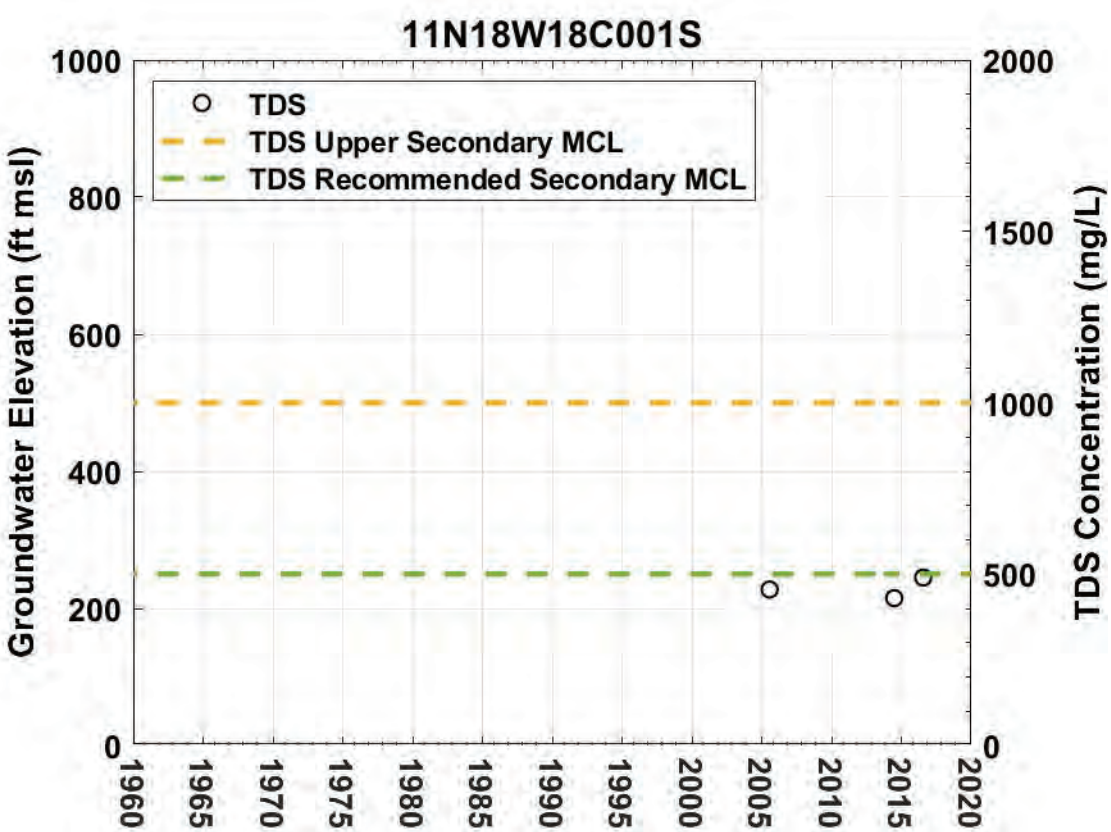
11N18W07L001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



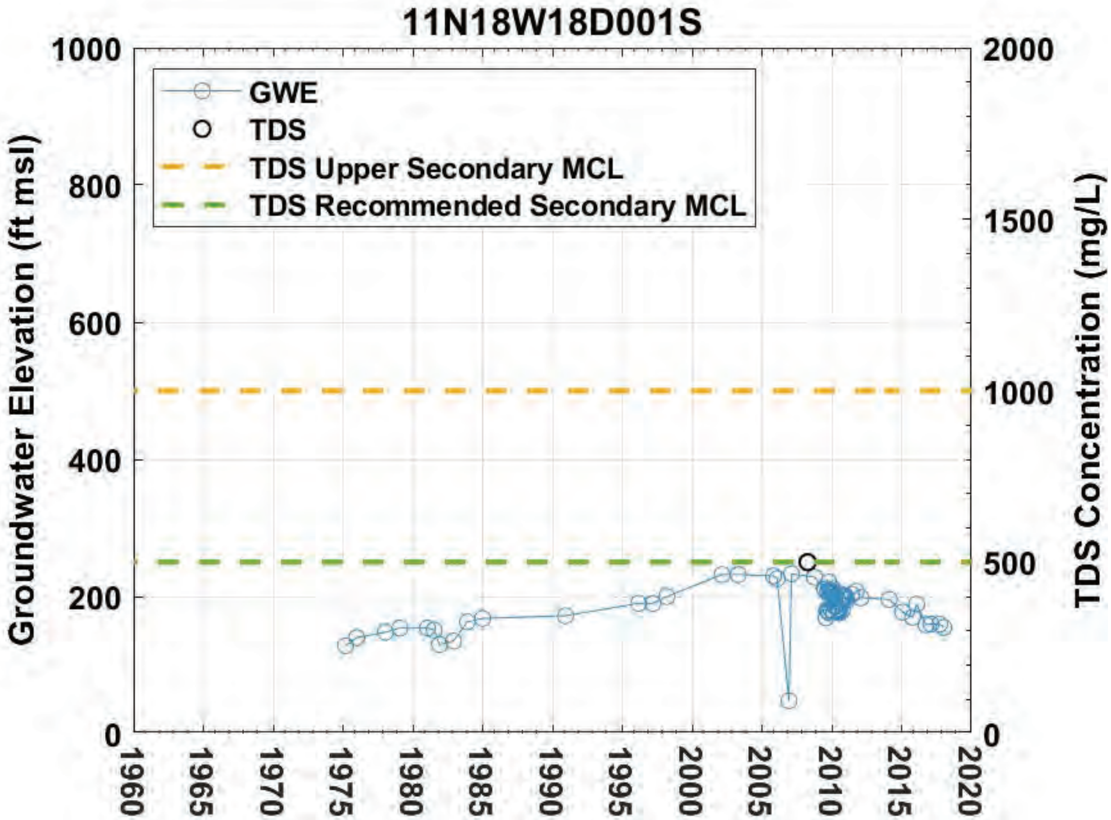
11N18W07P001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

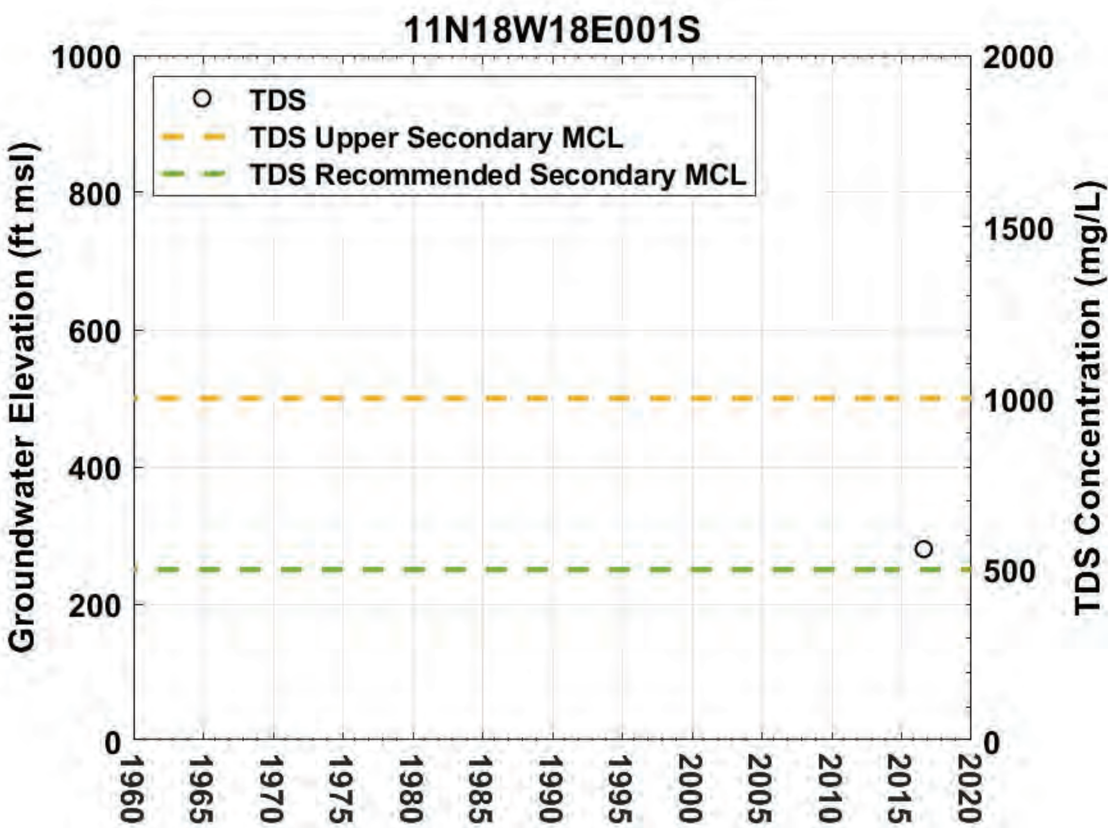


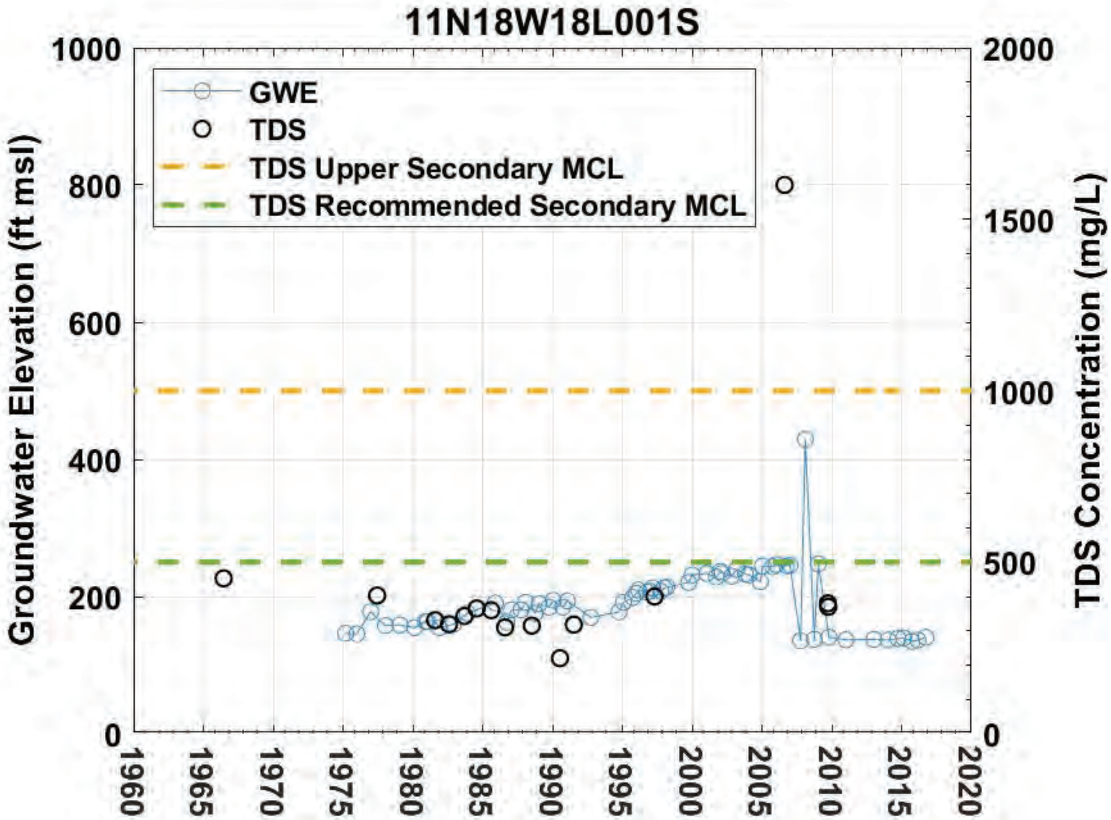
11N18W14P001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



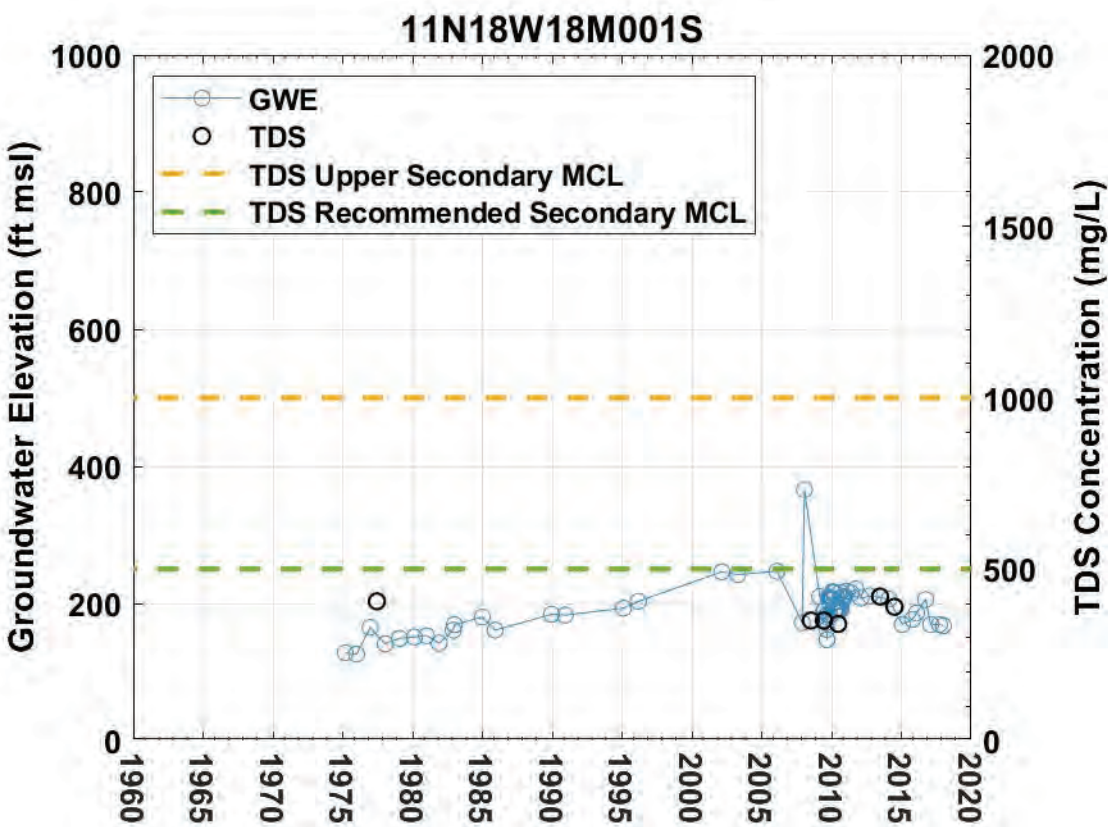
11N18W18C001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N18W18D001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

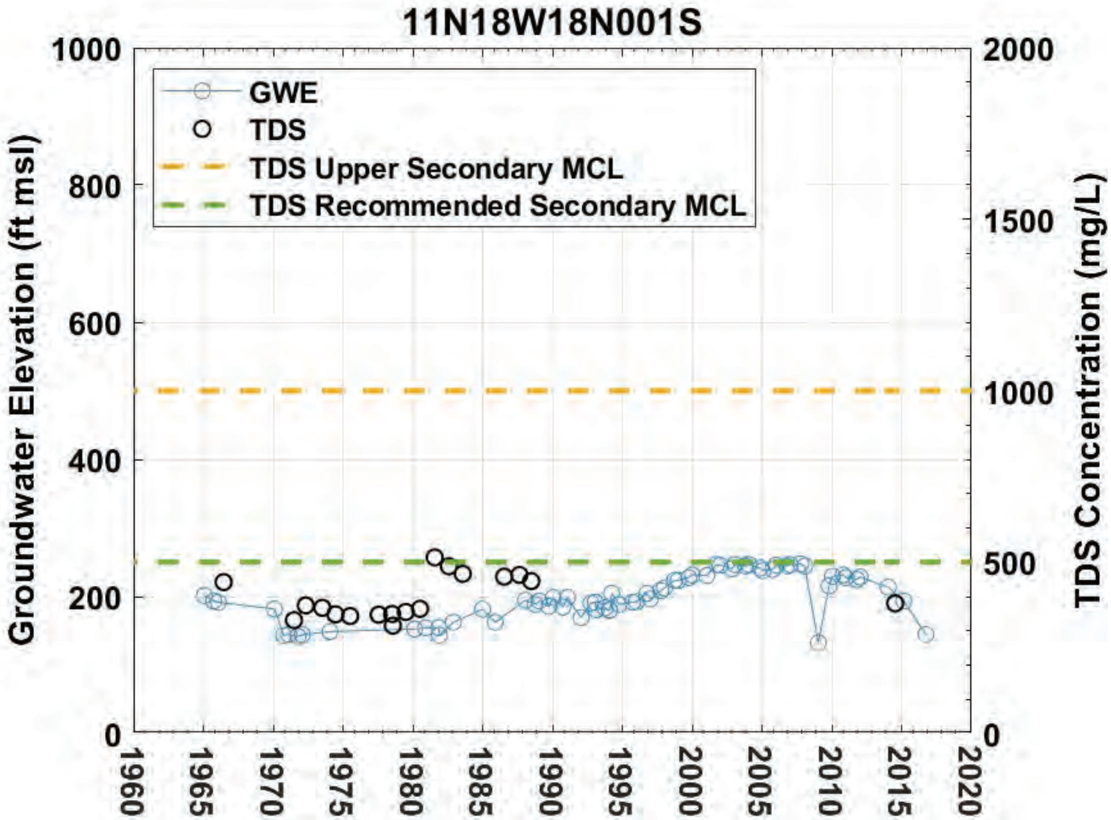

11N18W18E001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

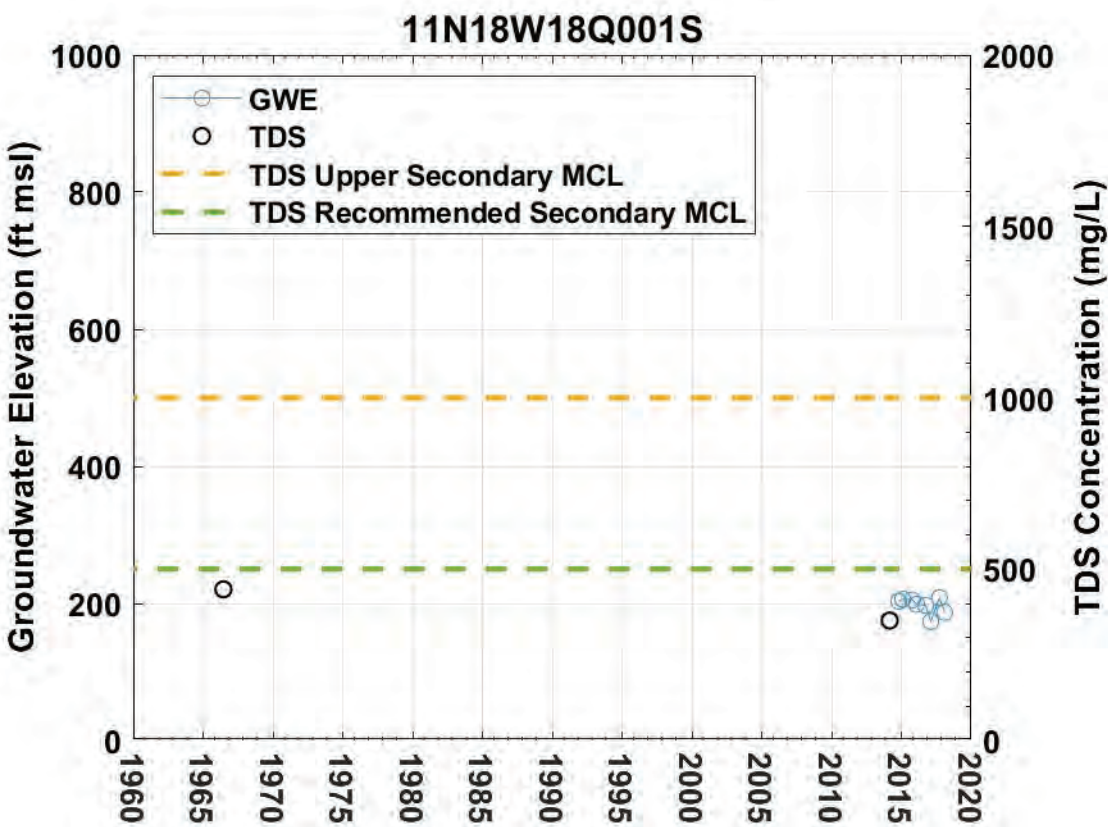


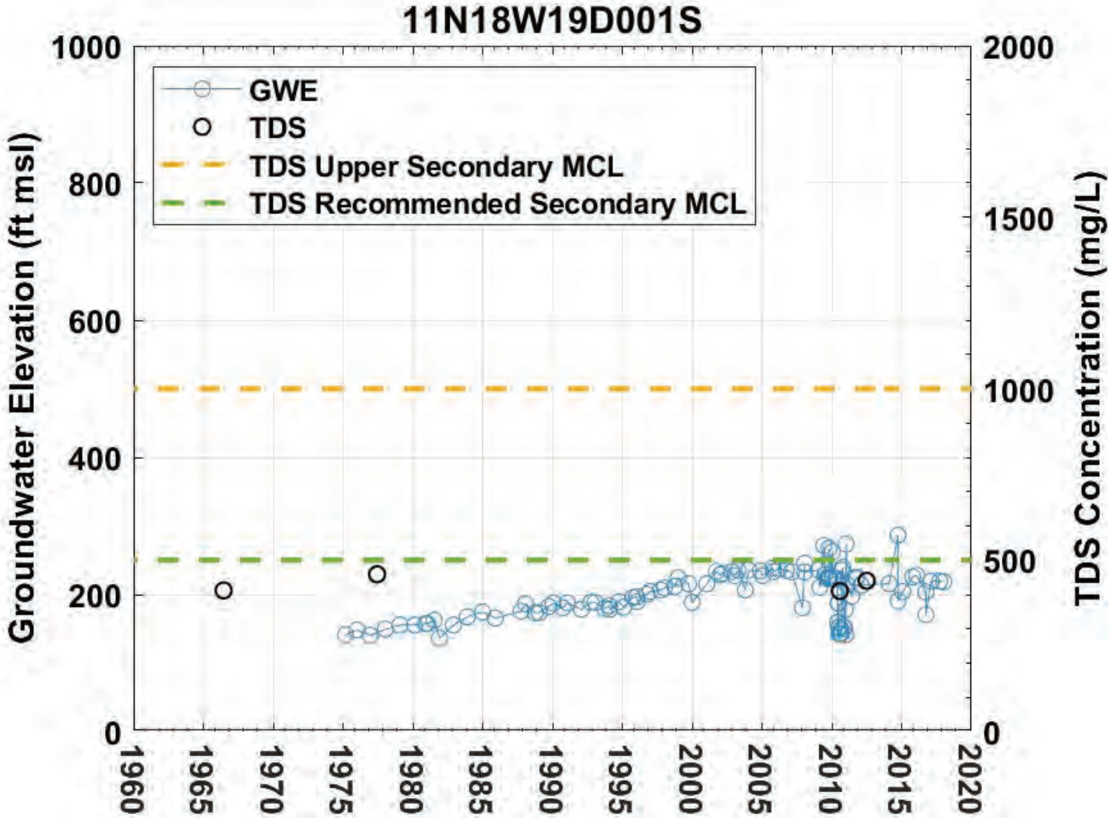
11N18W18L001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL

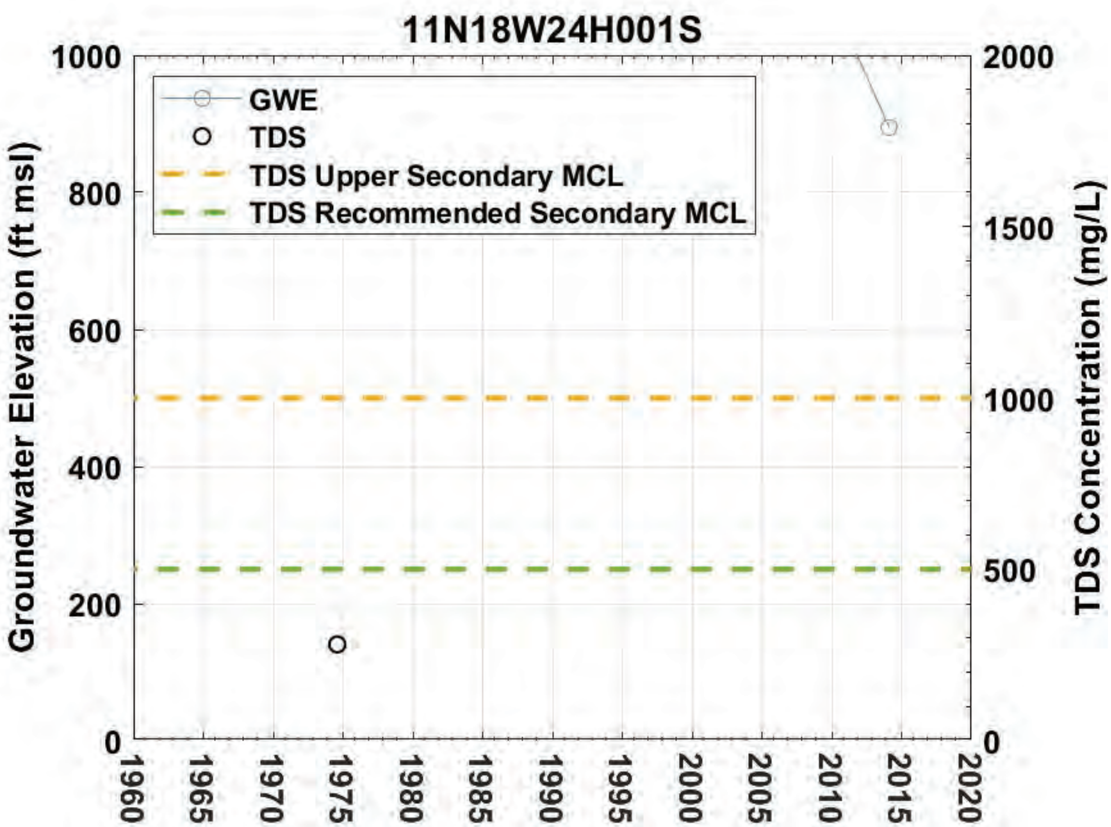


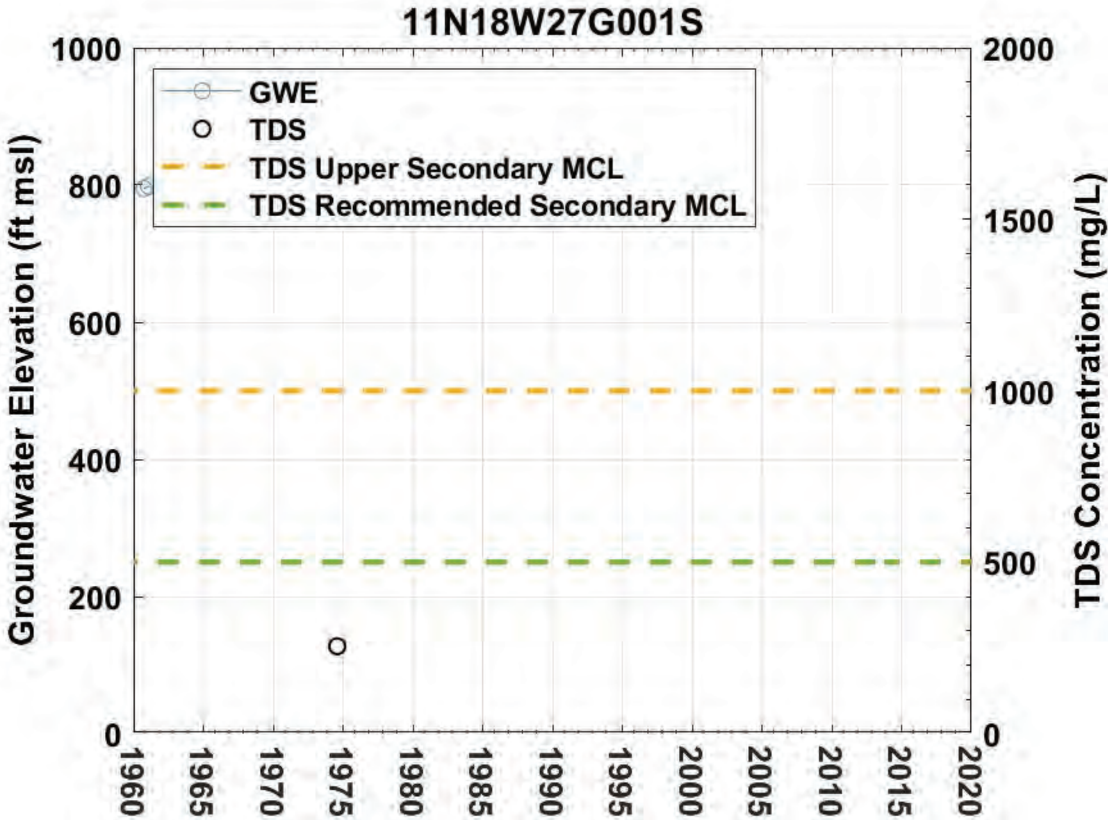
11N18W18M001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL

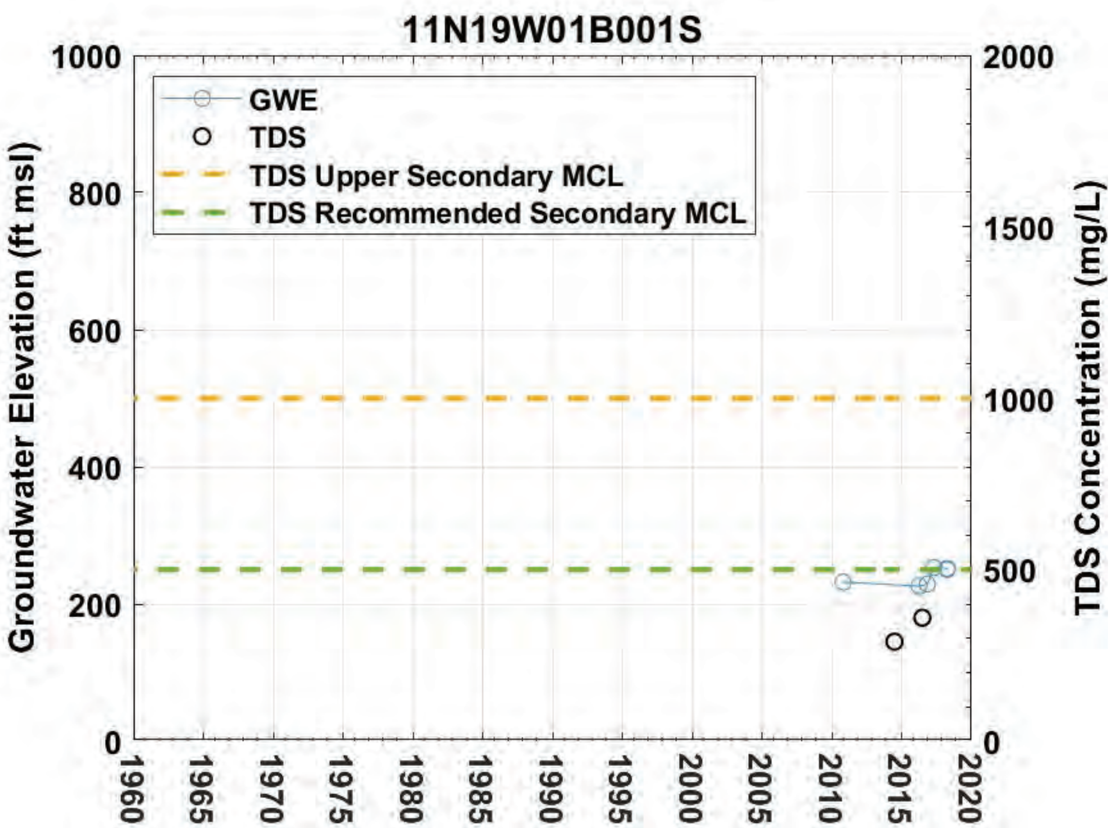

11N18W18N001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

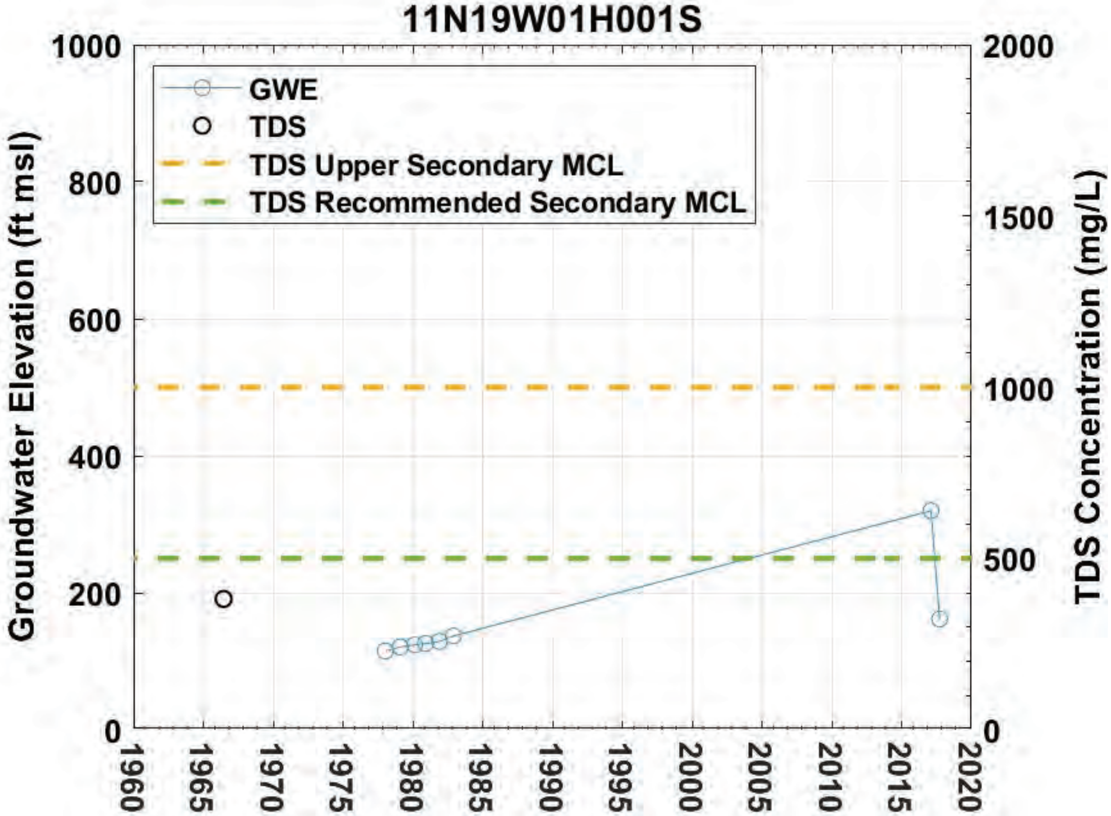

11N18W18Q001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

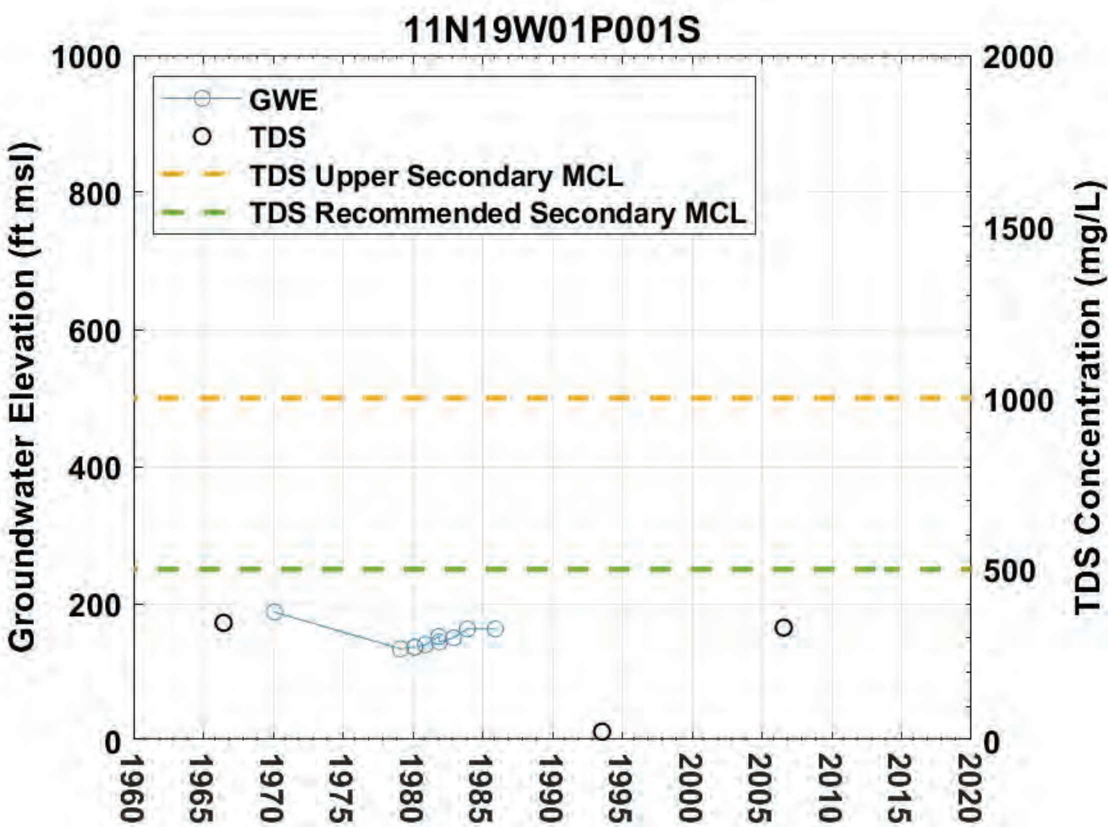

11N18W19D001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

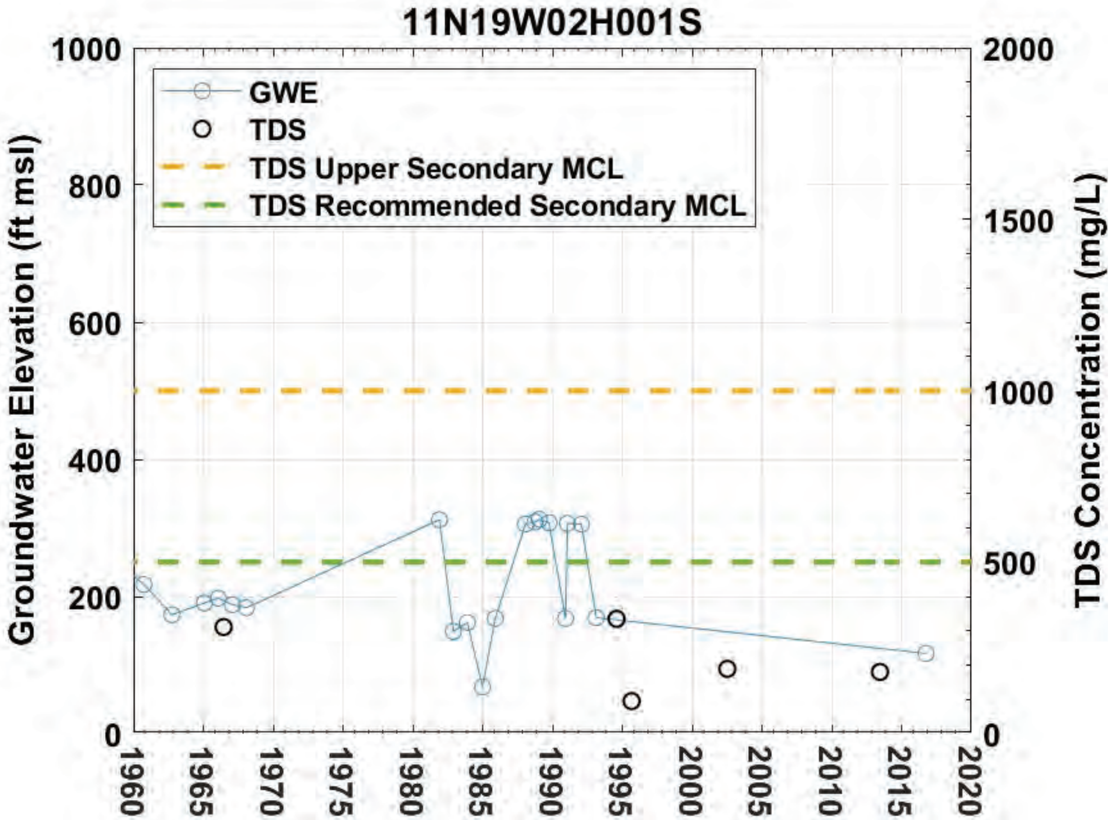

11N18W24H001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

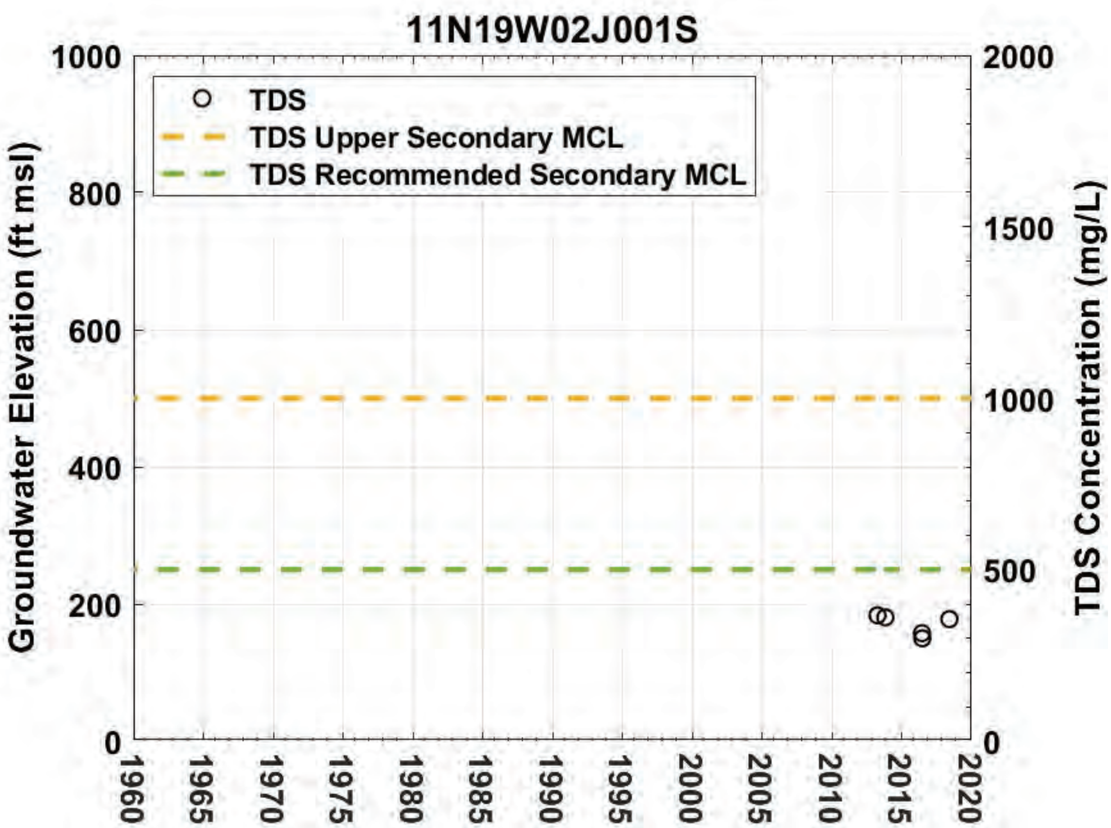

11N18W27G001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

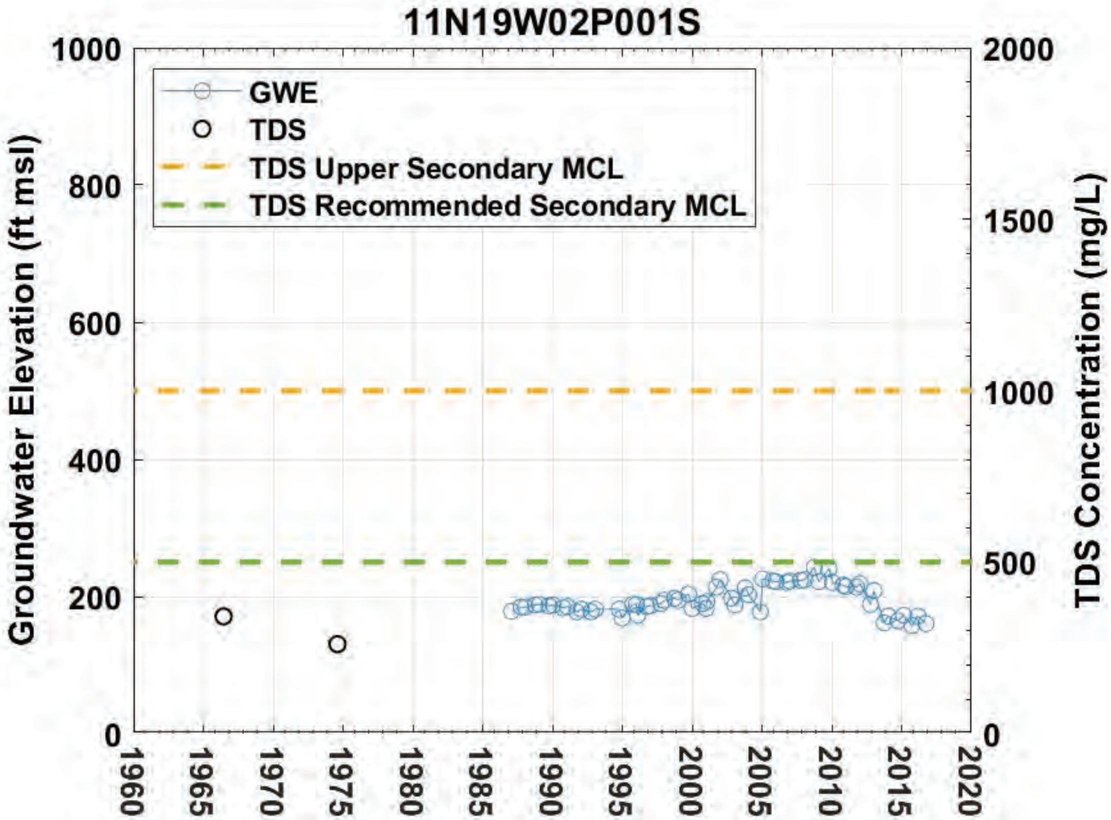

11N19W01B001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

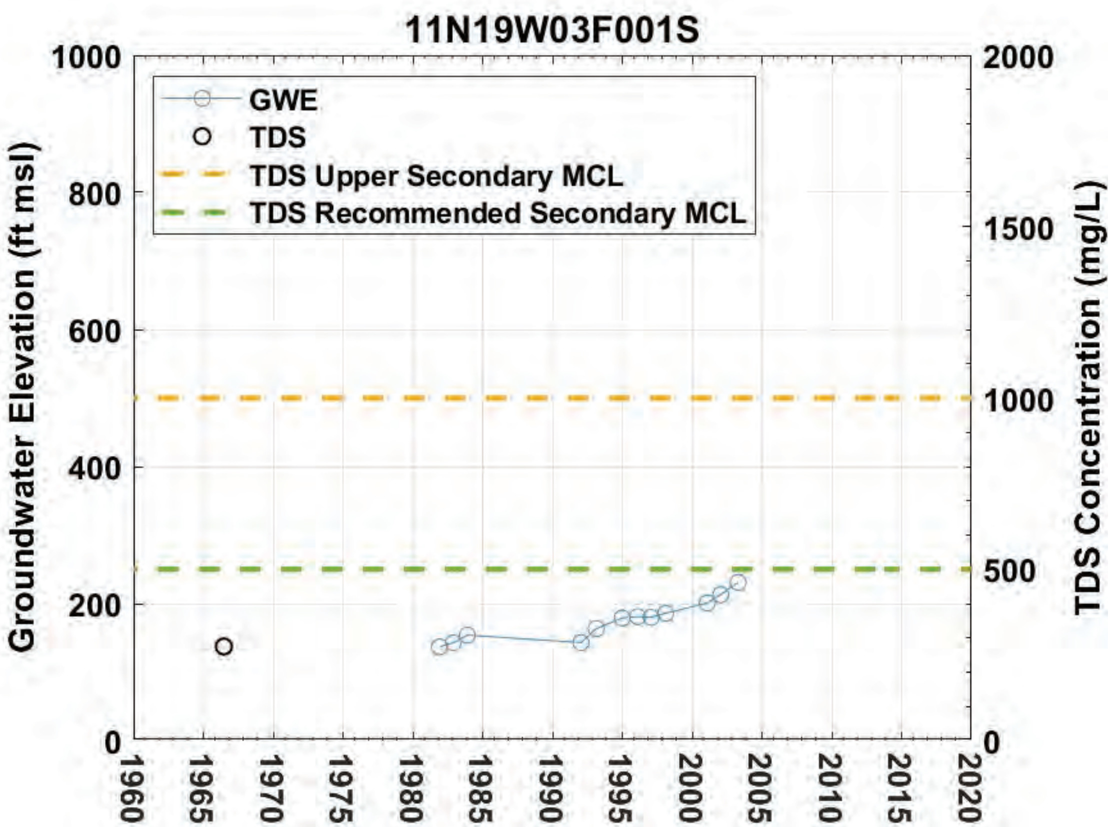

11N19W01H001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

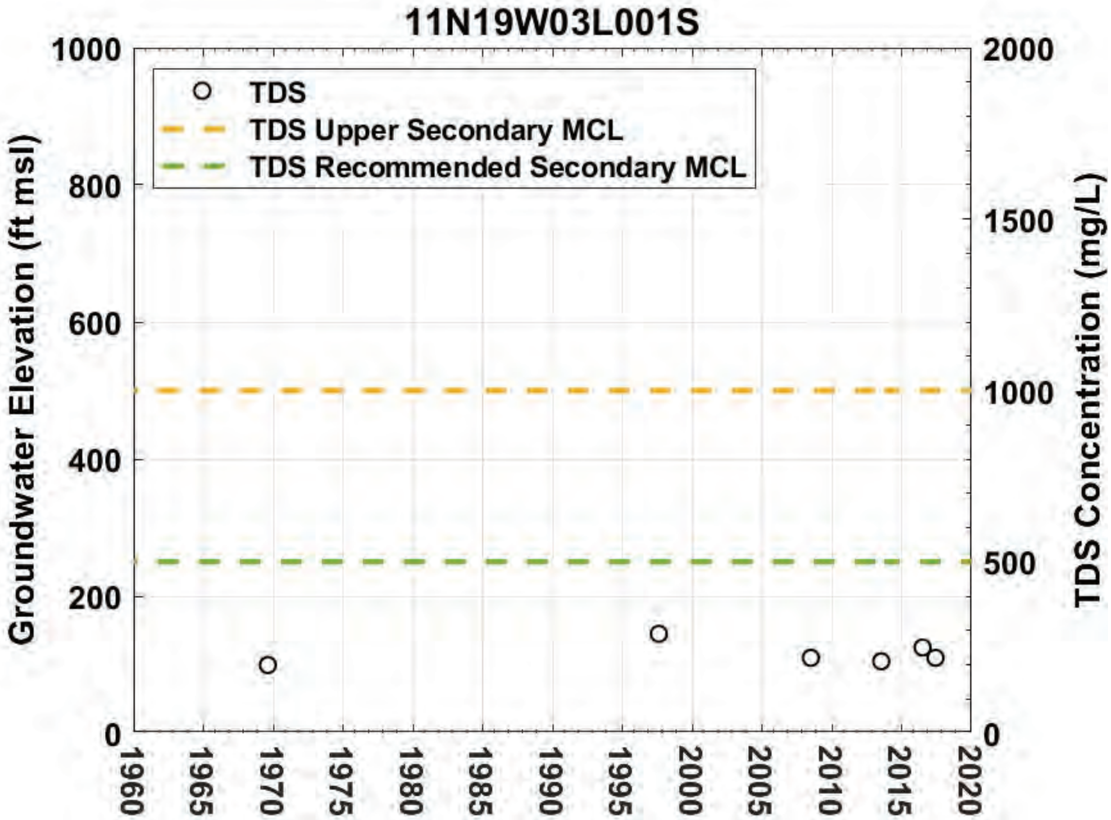

11N19W01P001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W02H001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

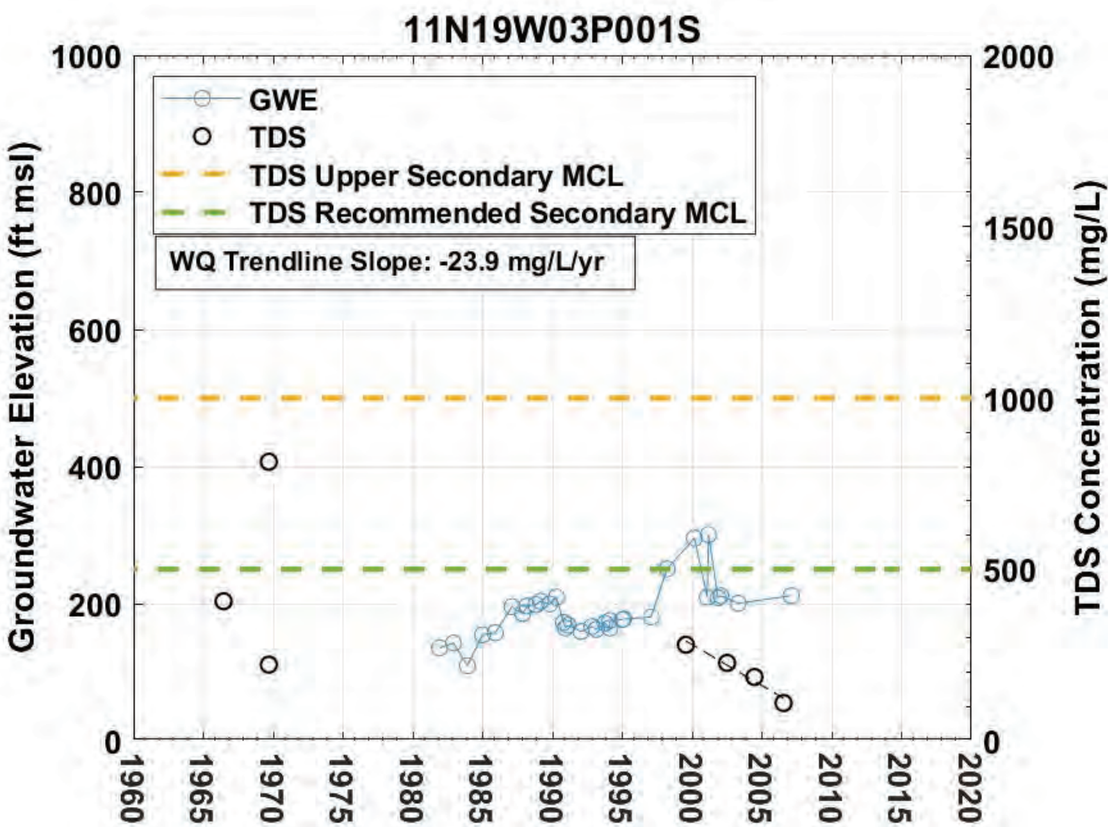

11N19W02J001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W02P001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

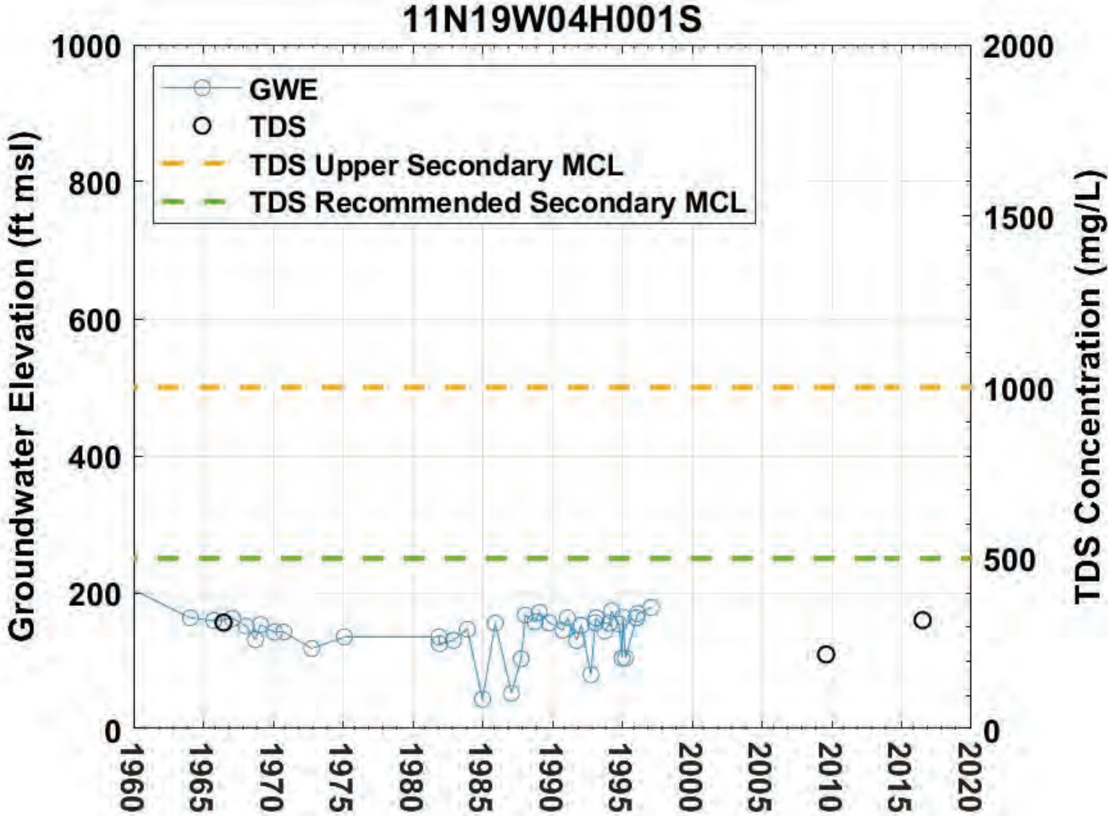

11N19W03F001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

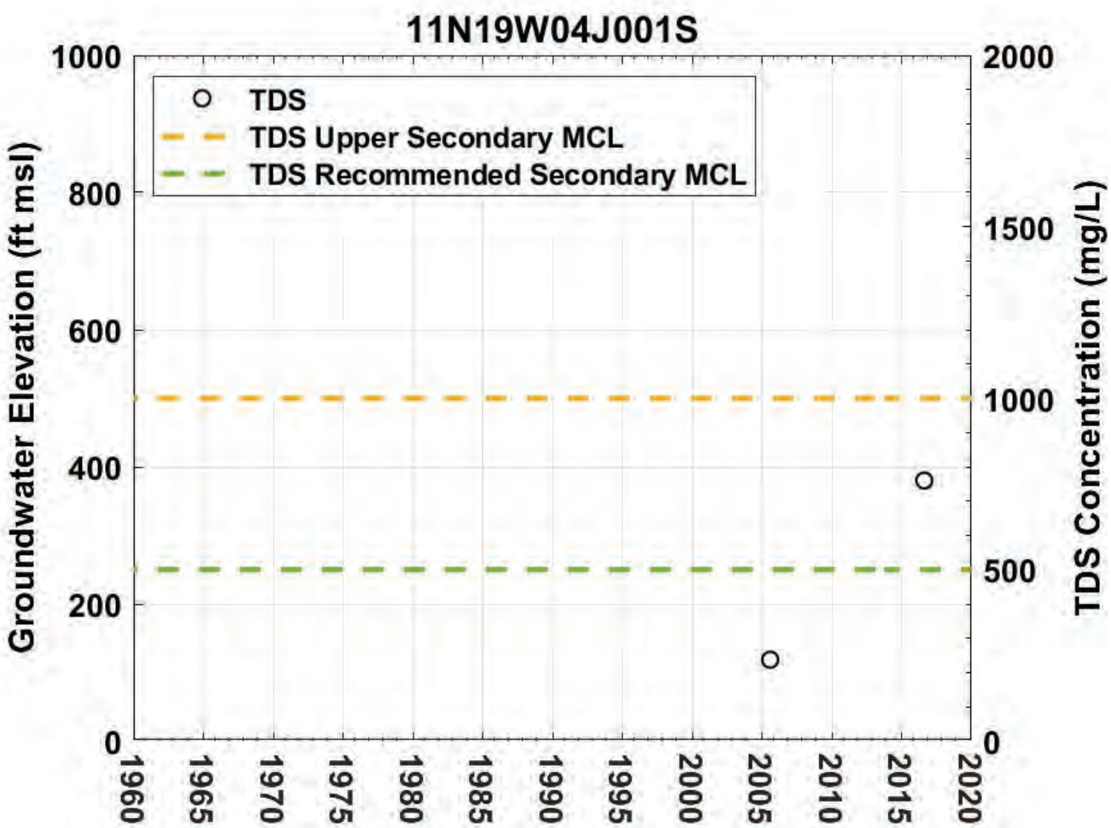


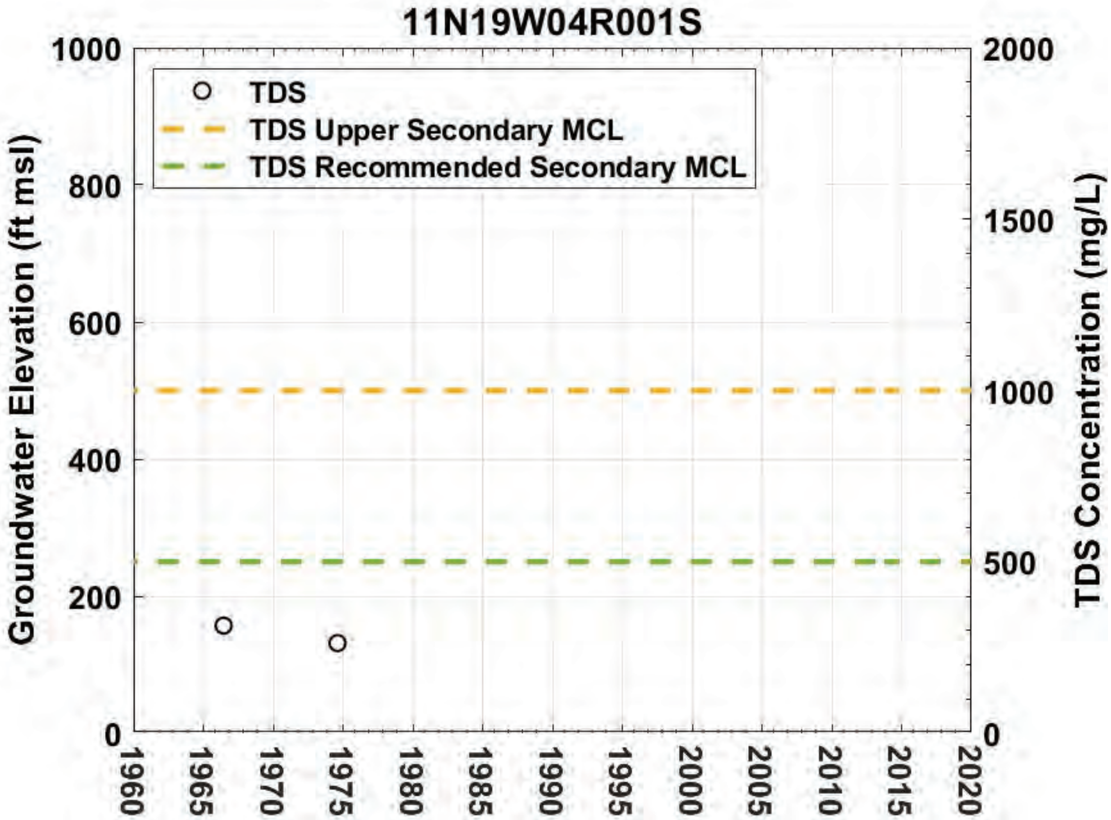
11N19W03L001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

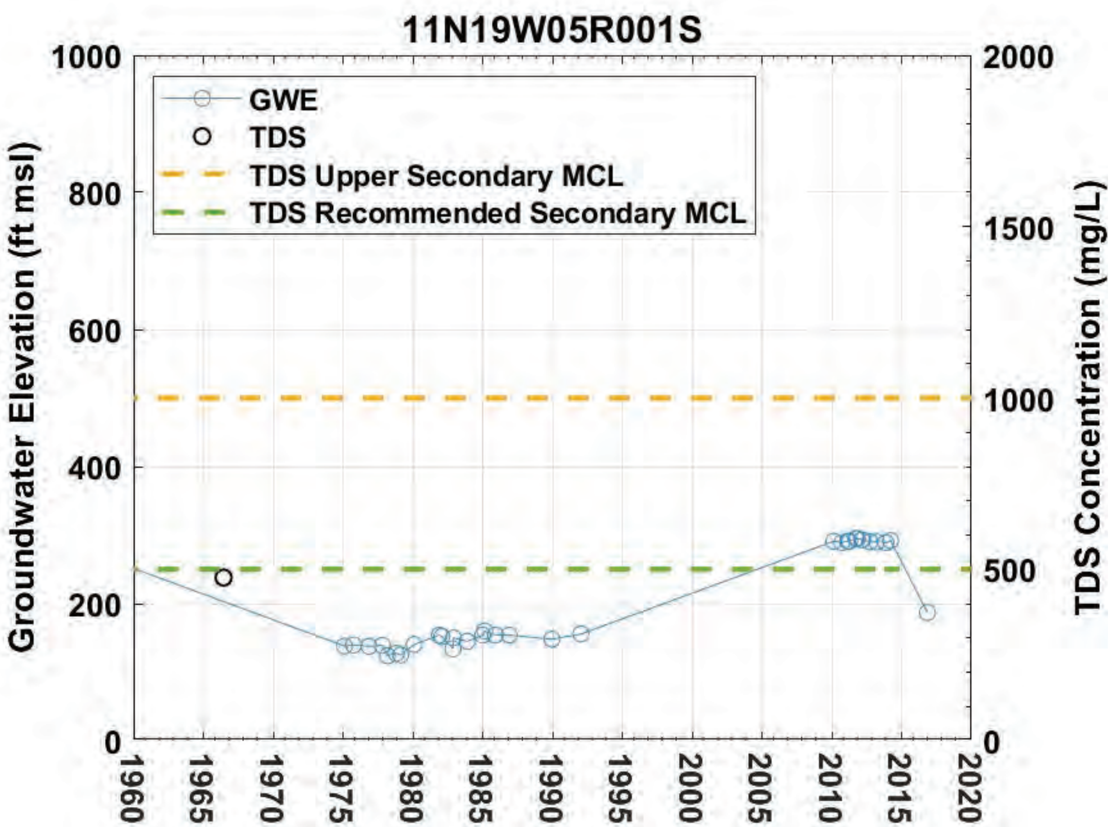


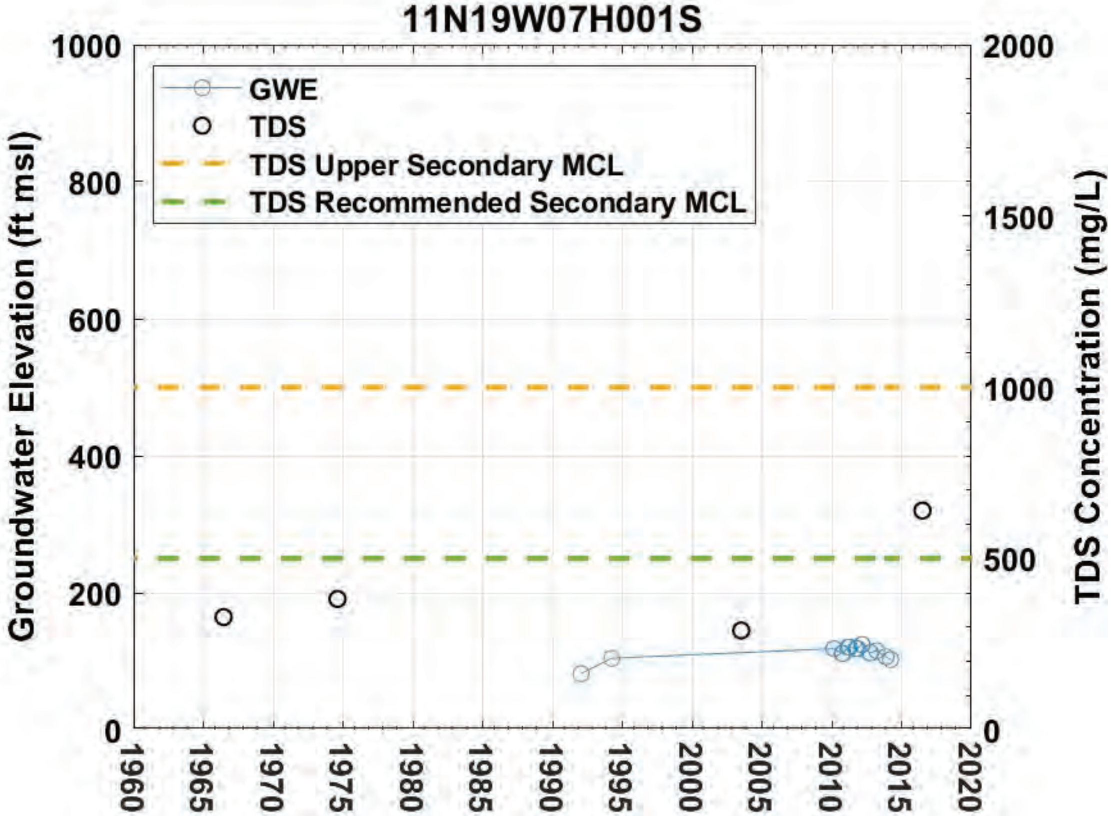
11N19W03P001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
WQ Trendline Slope: -23.9 mg/L/yr
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

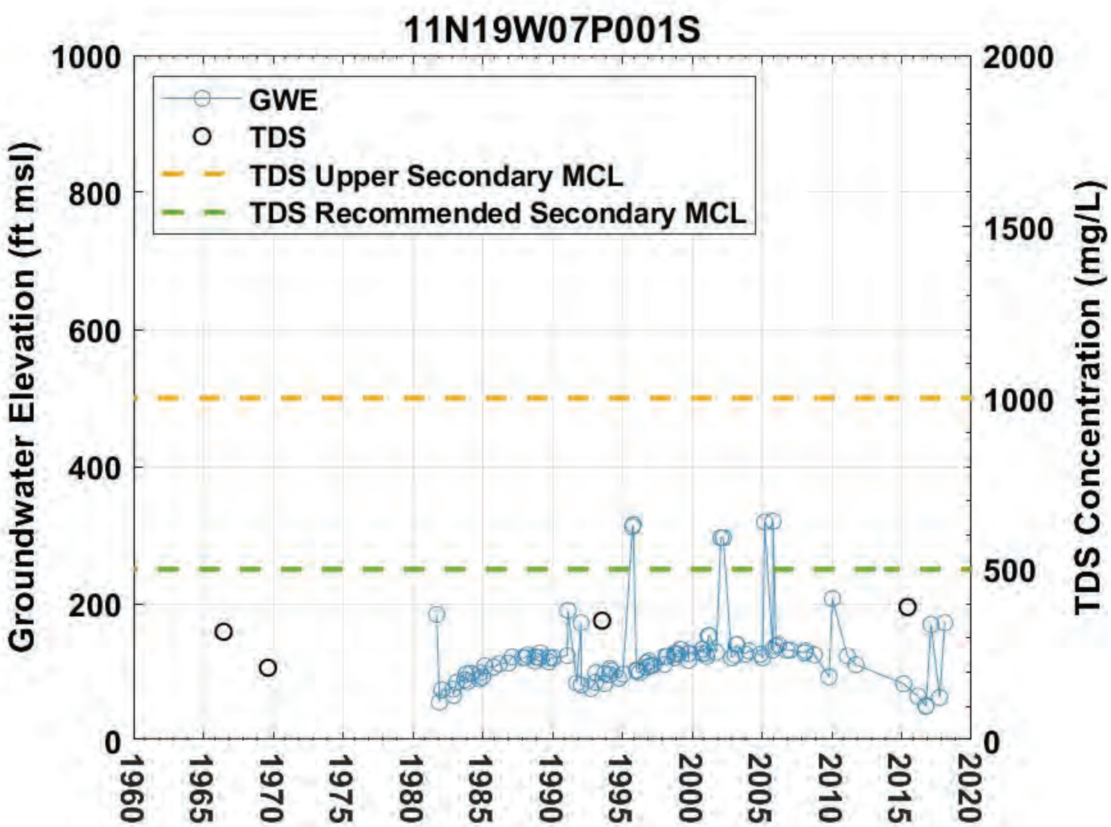

11N19W04H001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

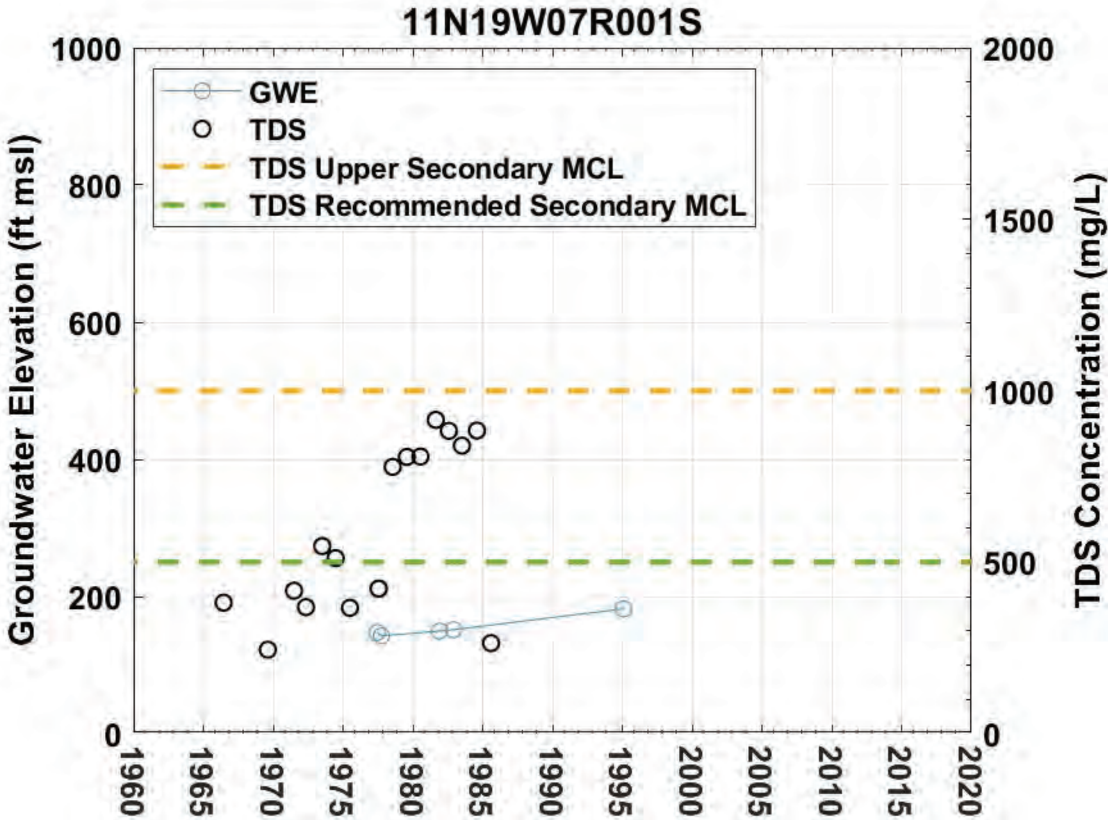

11N19W04J001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

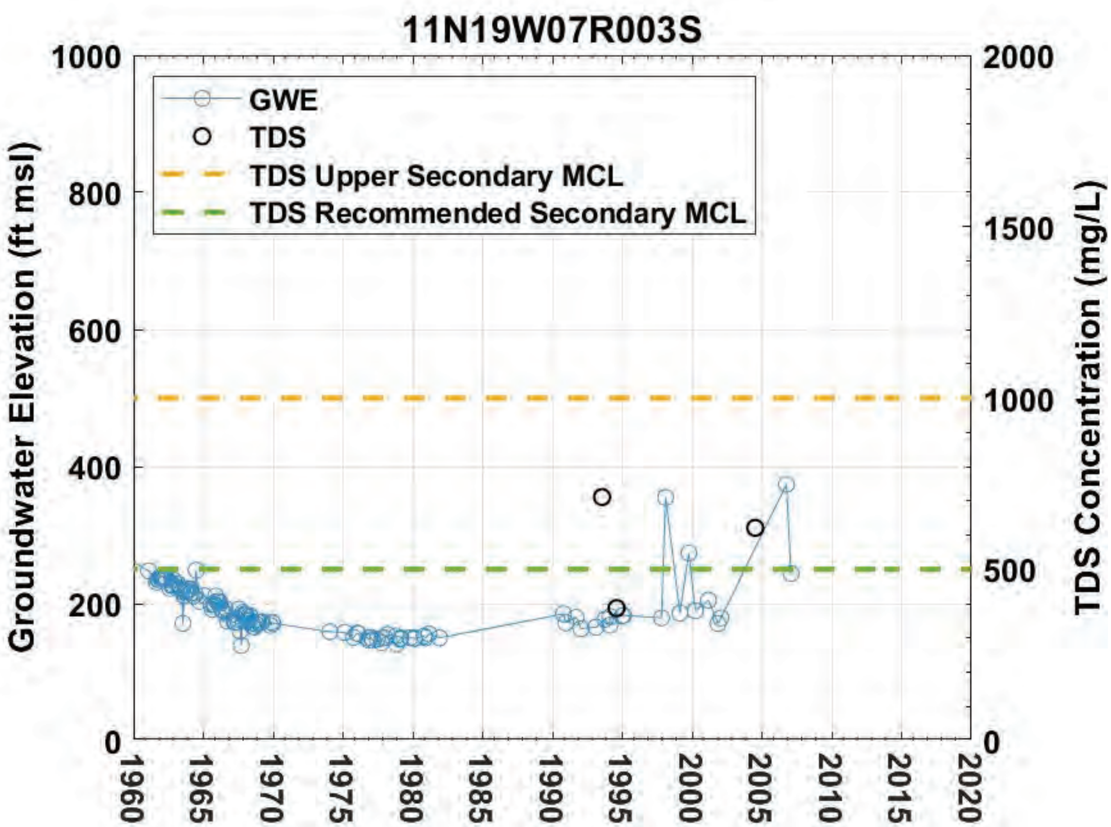

11N19W04R001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

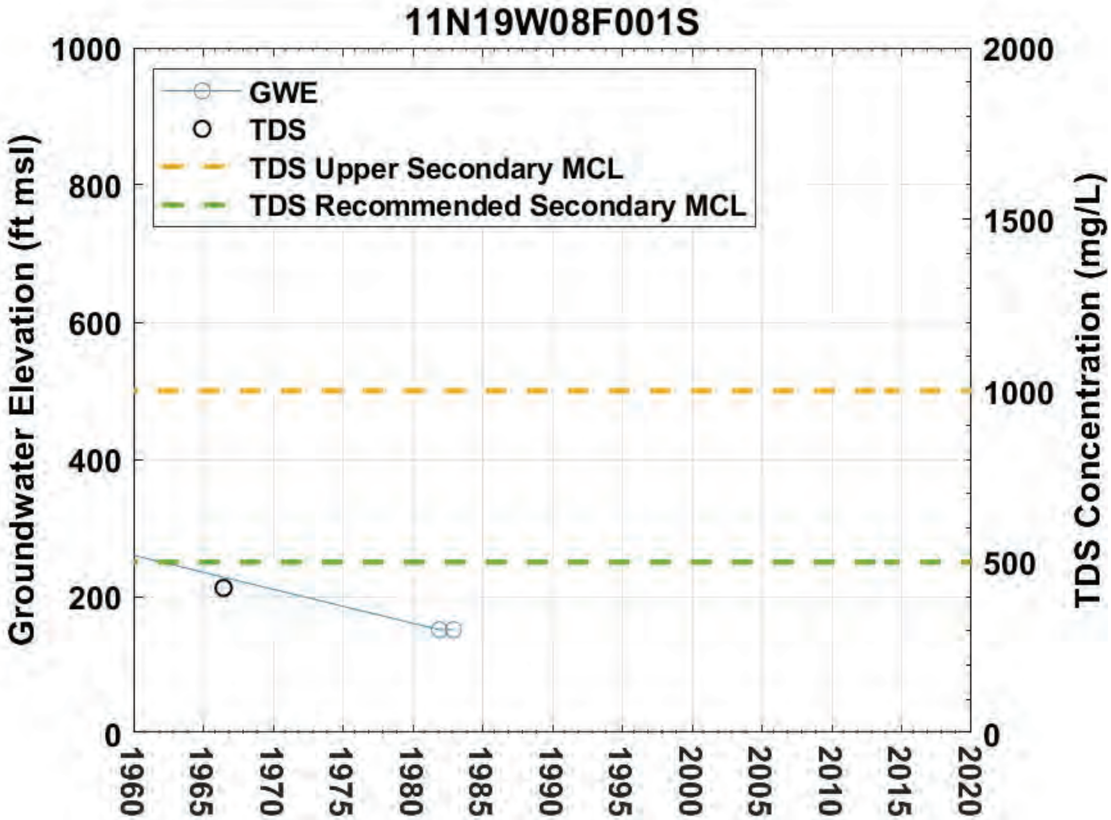

11N19W05R001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

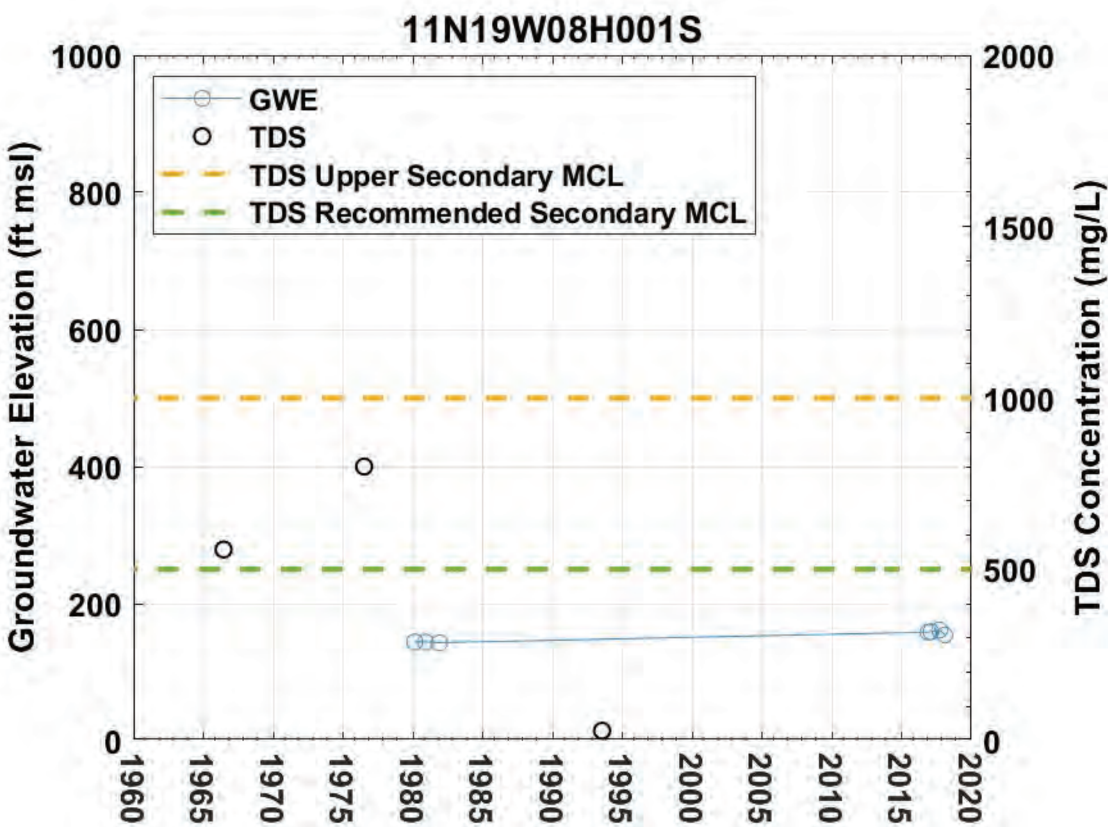

11N19W07H001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

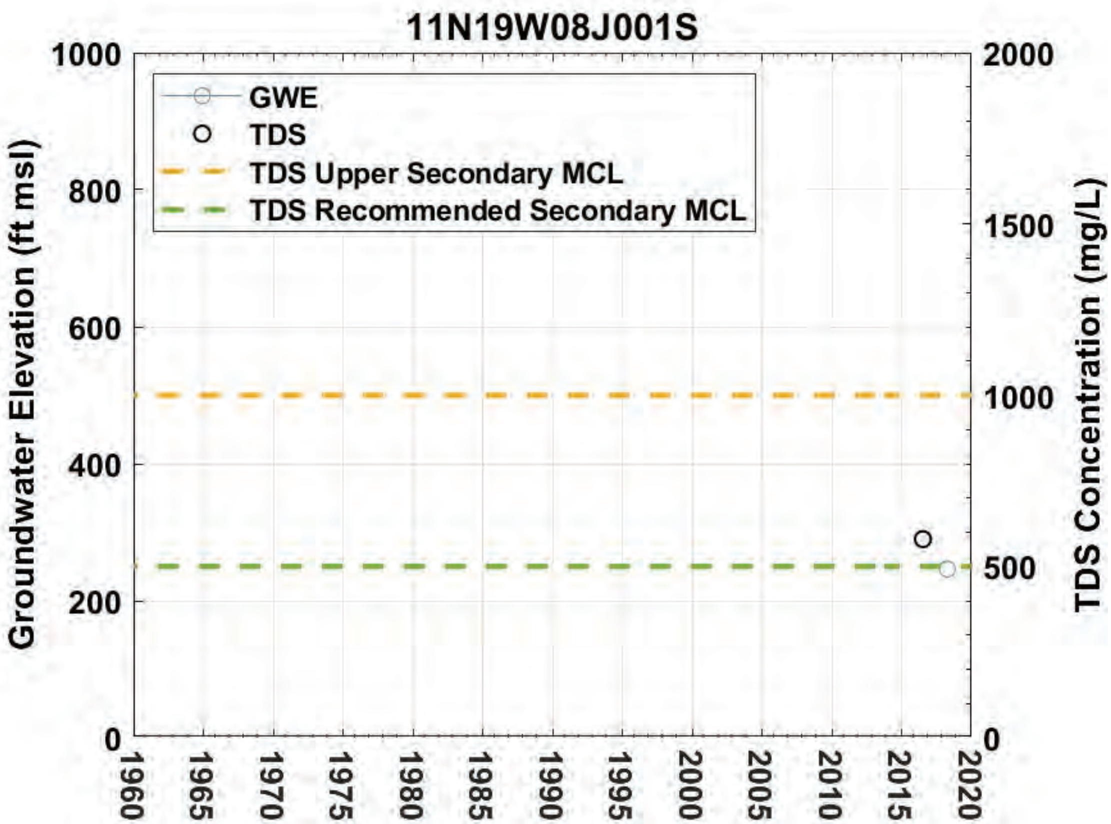

11N19W07P001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

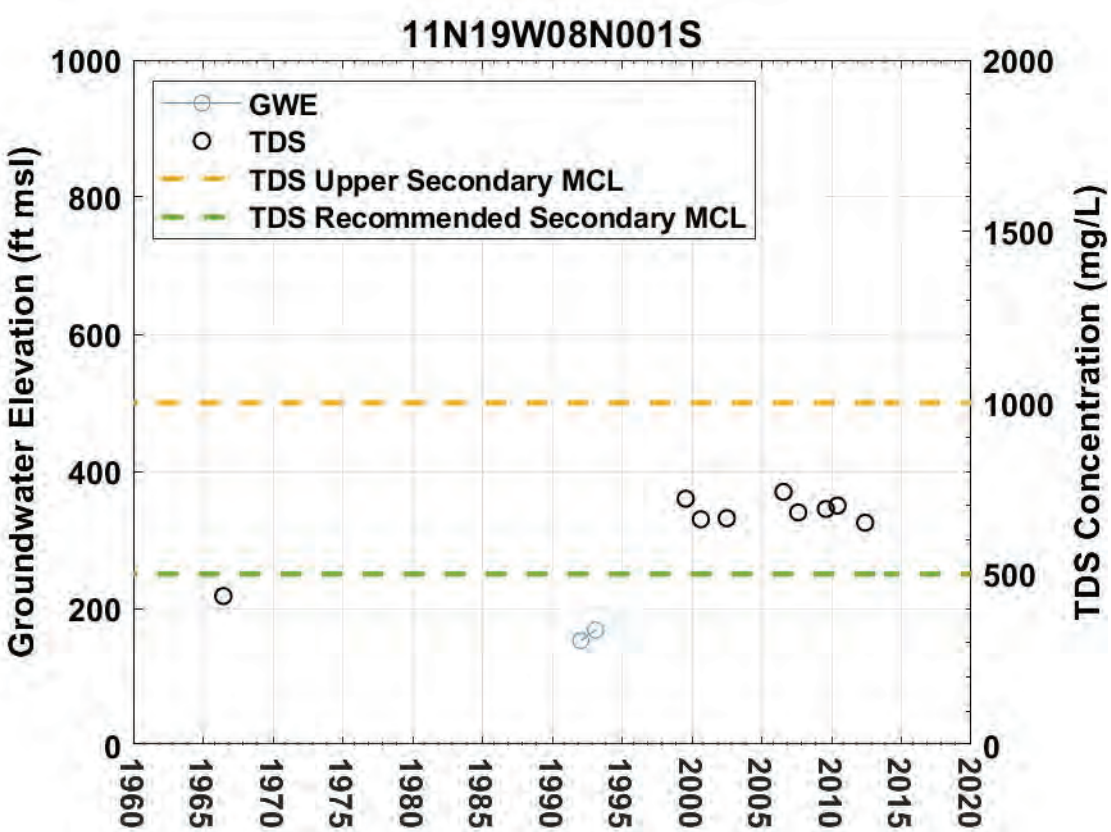

11N19W07R001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

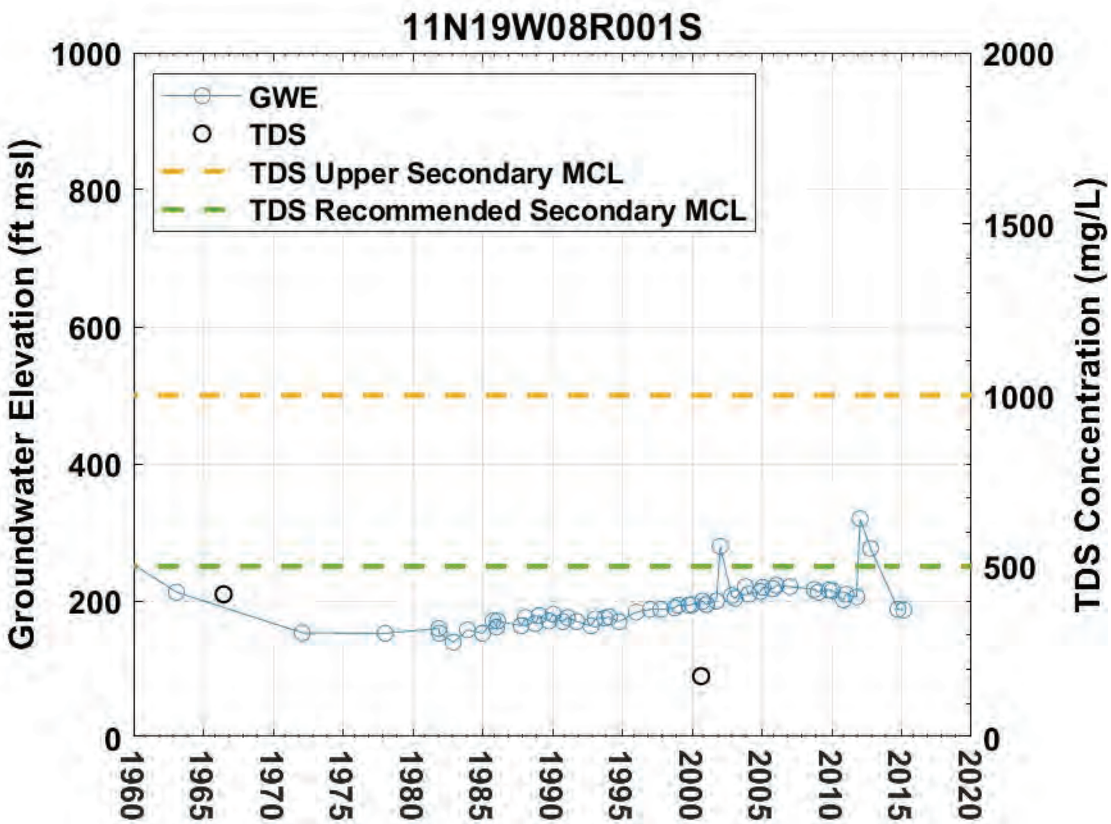

11N19W07R003S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

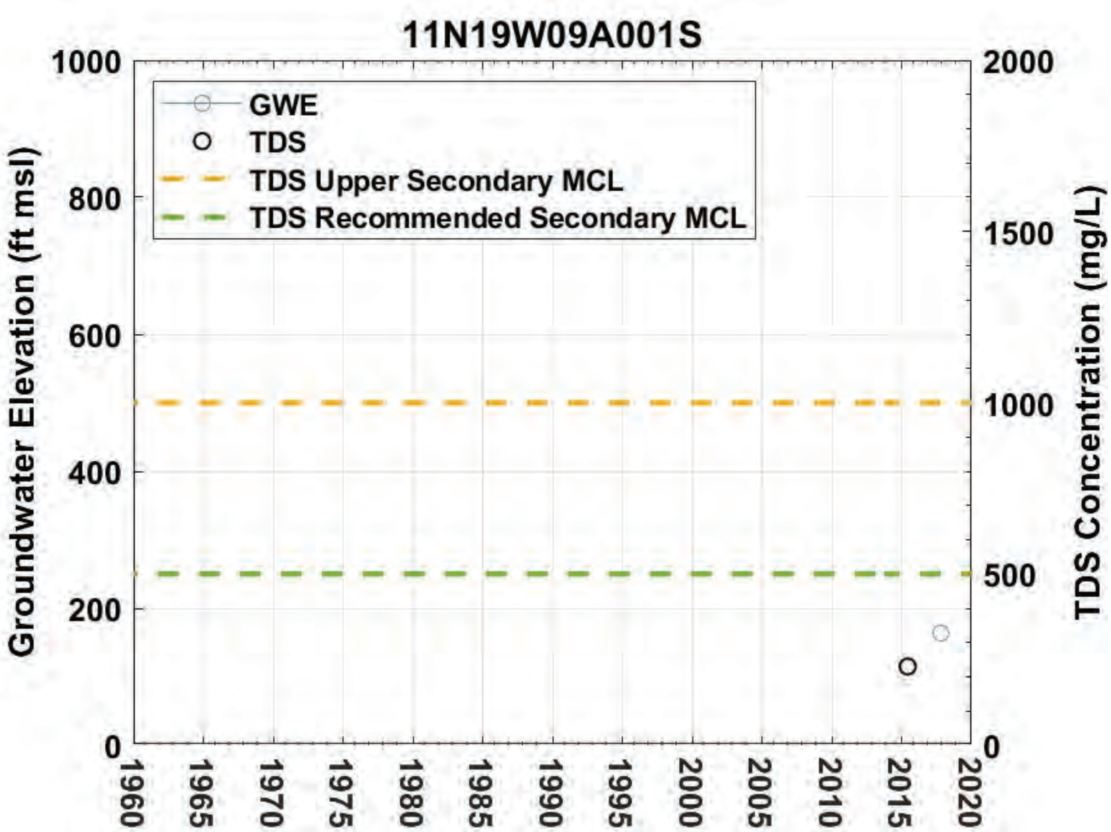

11N19W08F001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

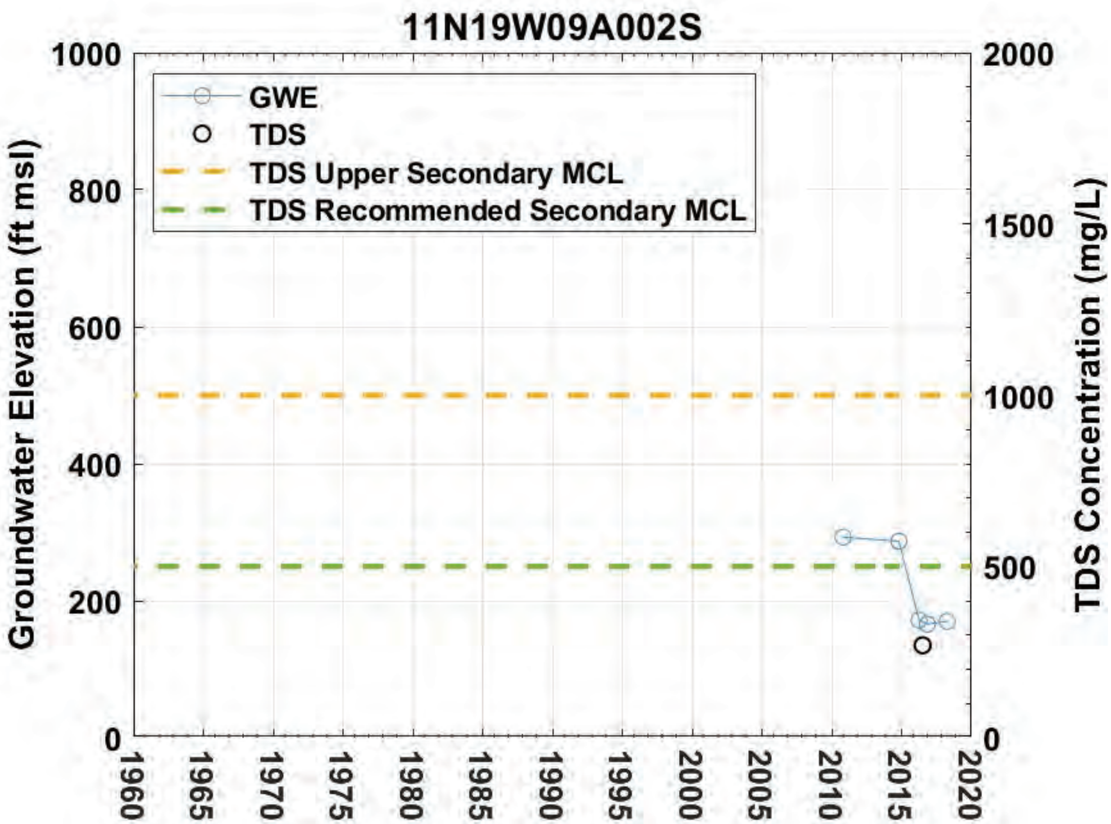

11N19W08H001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

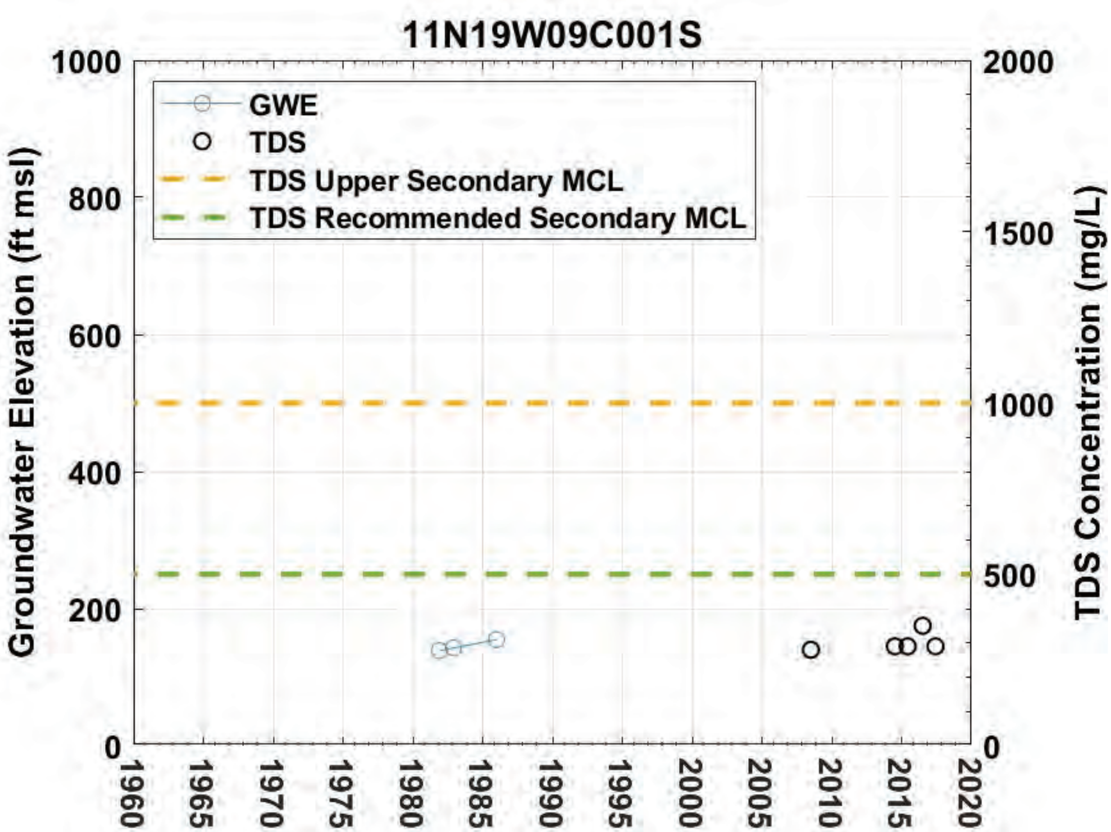

11N19W08J001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

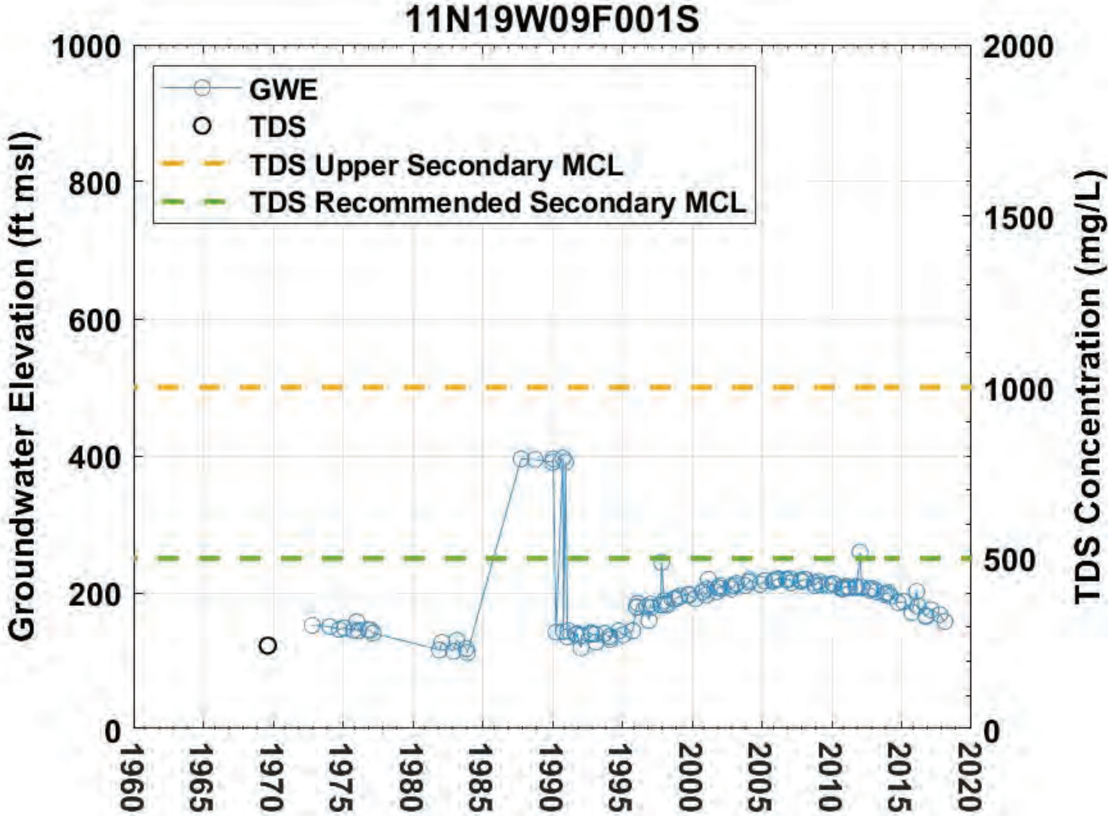

11N19W08N001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

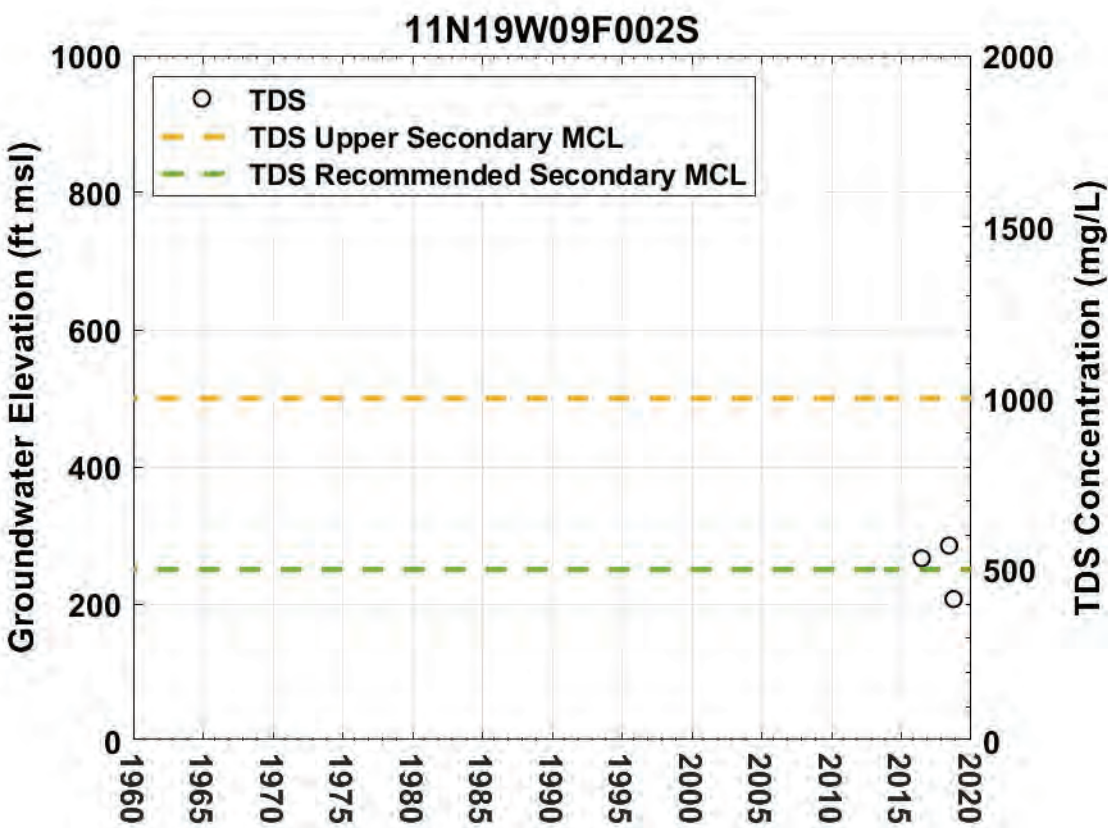

11N19W08R001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

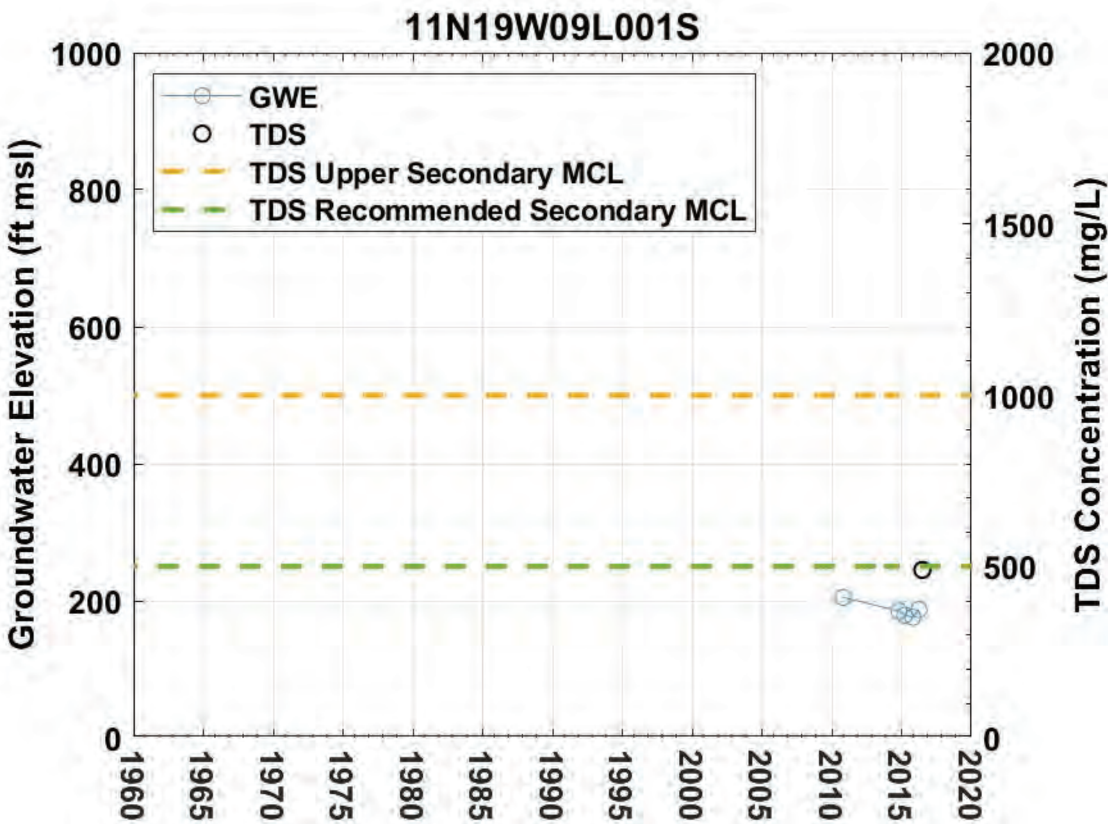

11N19W09A001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W09A002S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

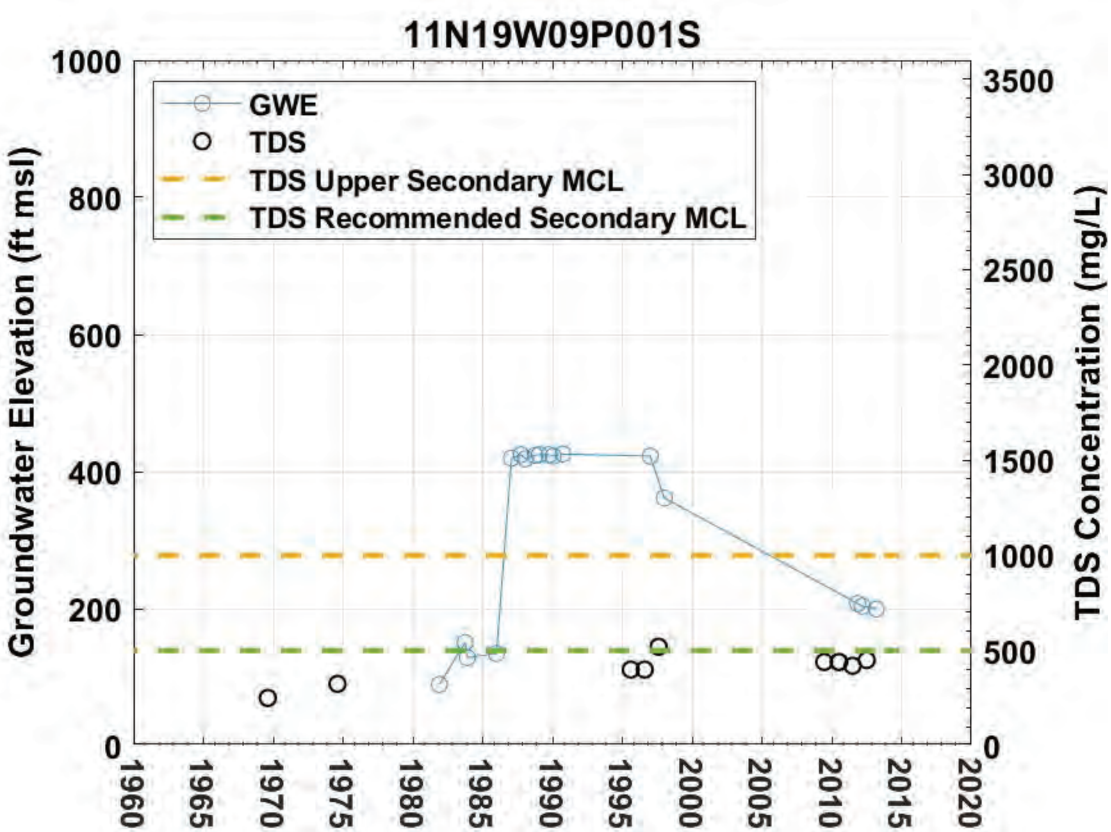

11N19W09C001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W09F001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

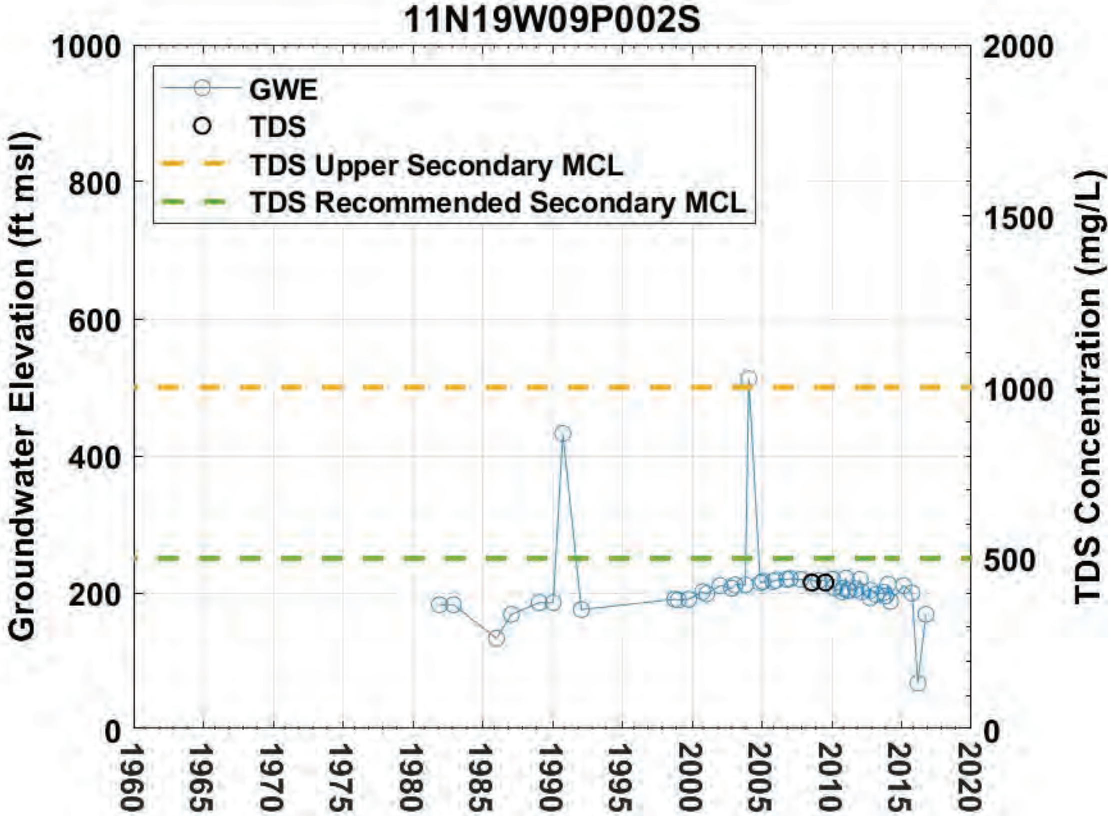

11N19W09F002S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

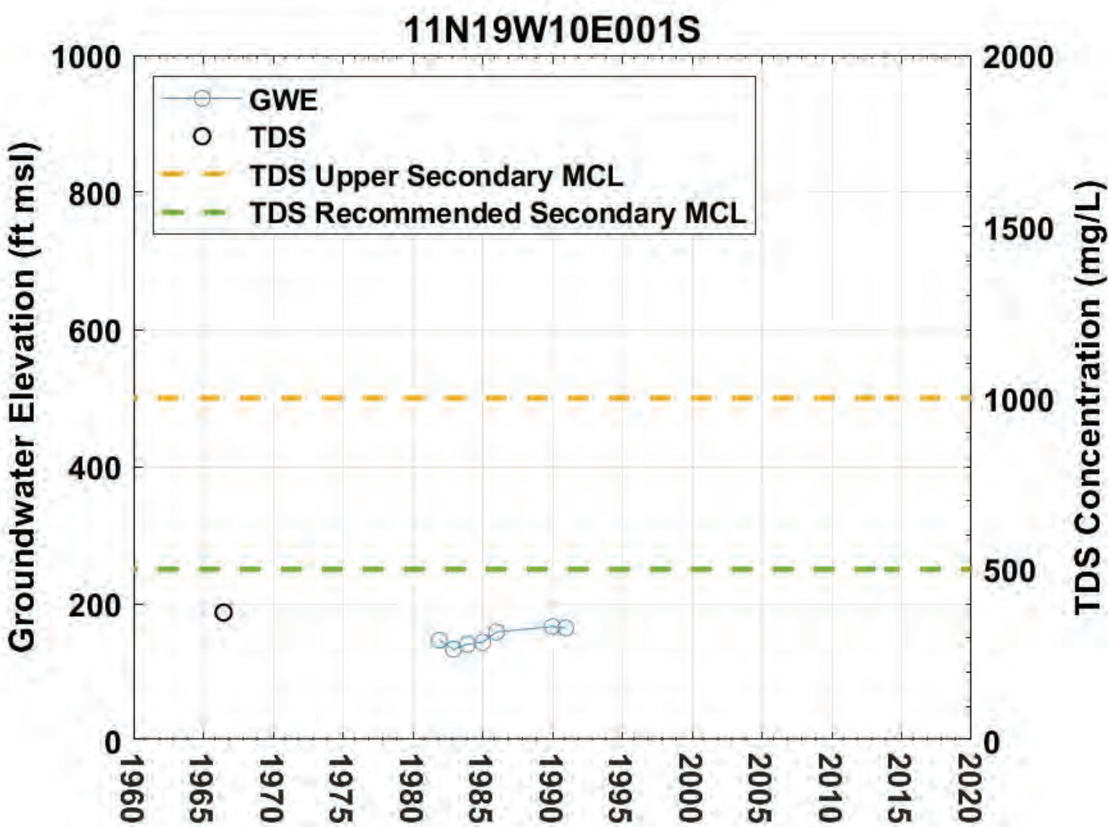


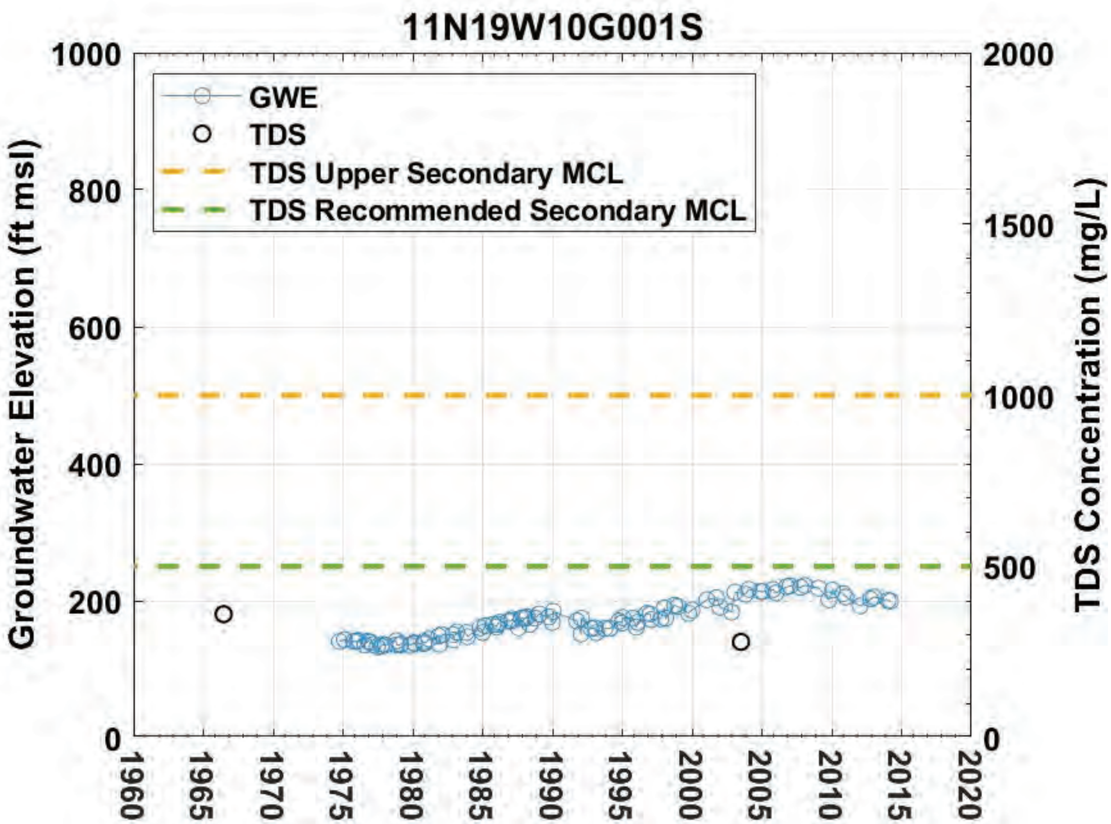
11N19W09L001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

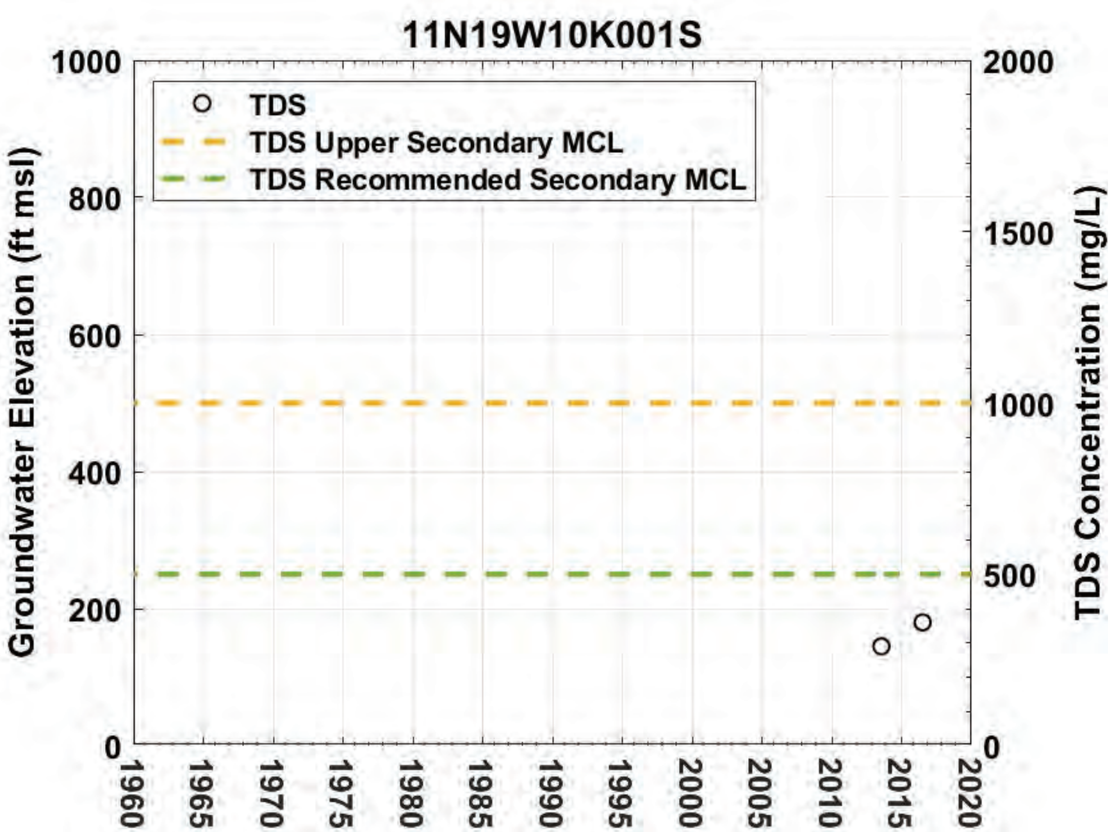


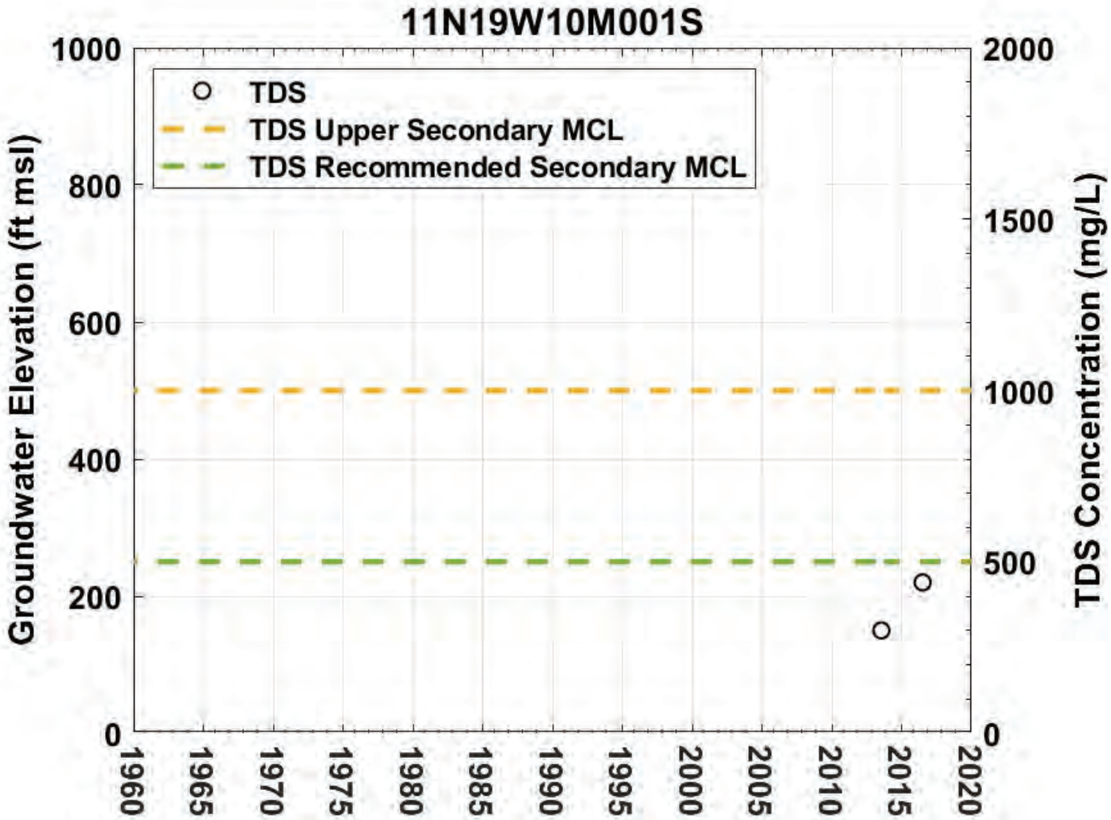
11N19W09P001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
2500
3000
3500
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

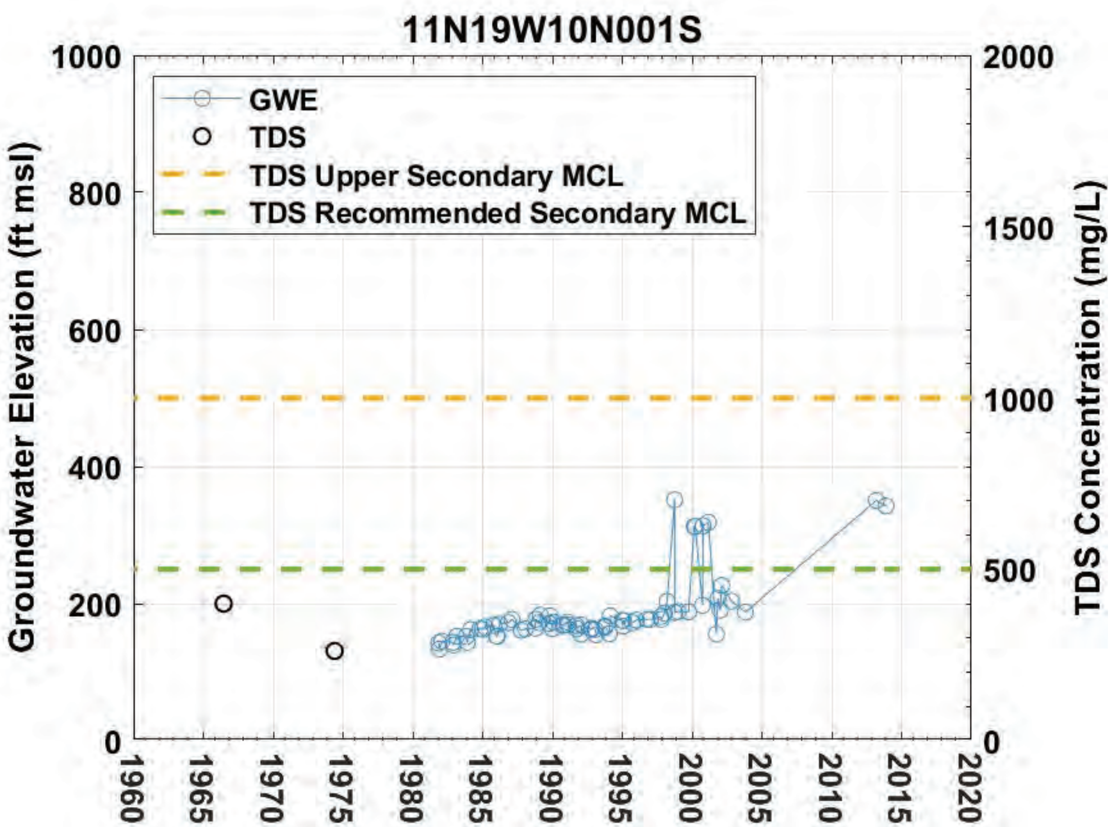

11N19W09P002S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

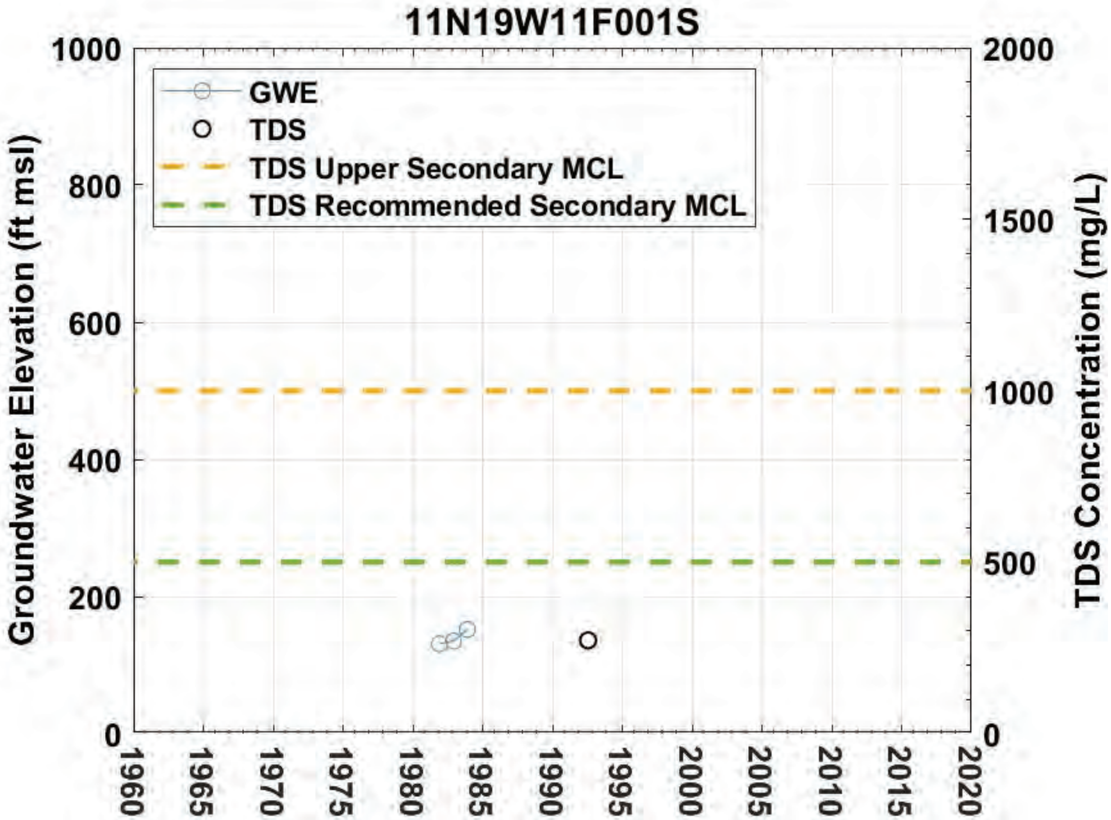

11N19W10E001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

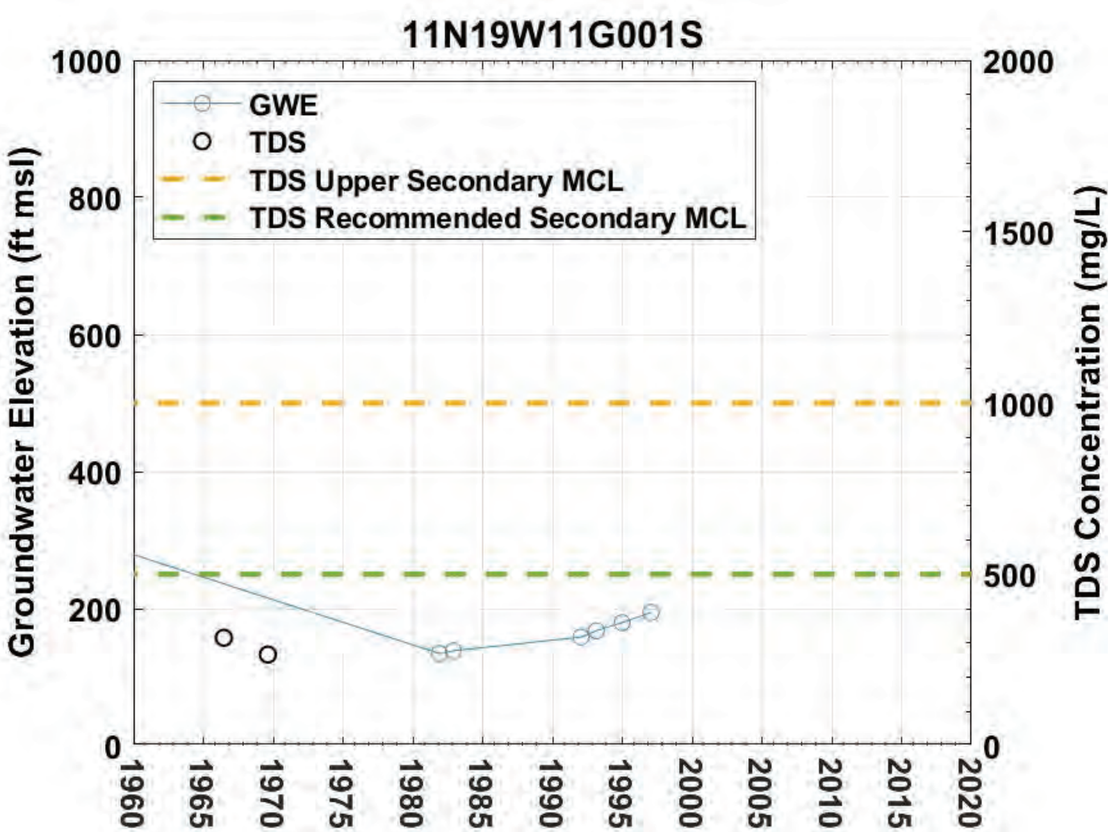

11N19W10G001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)

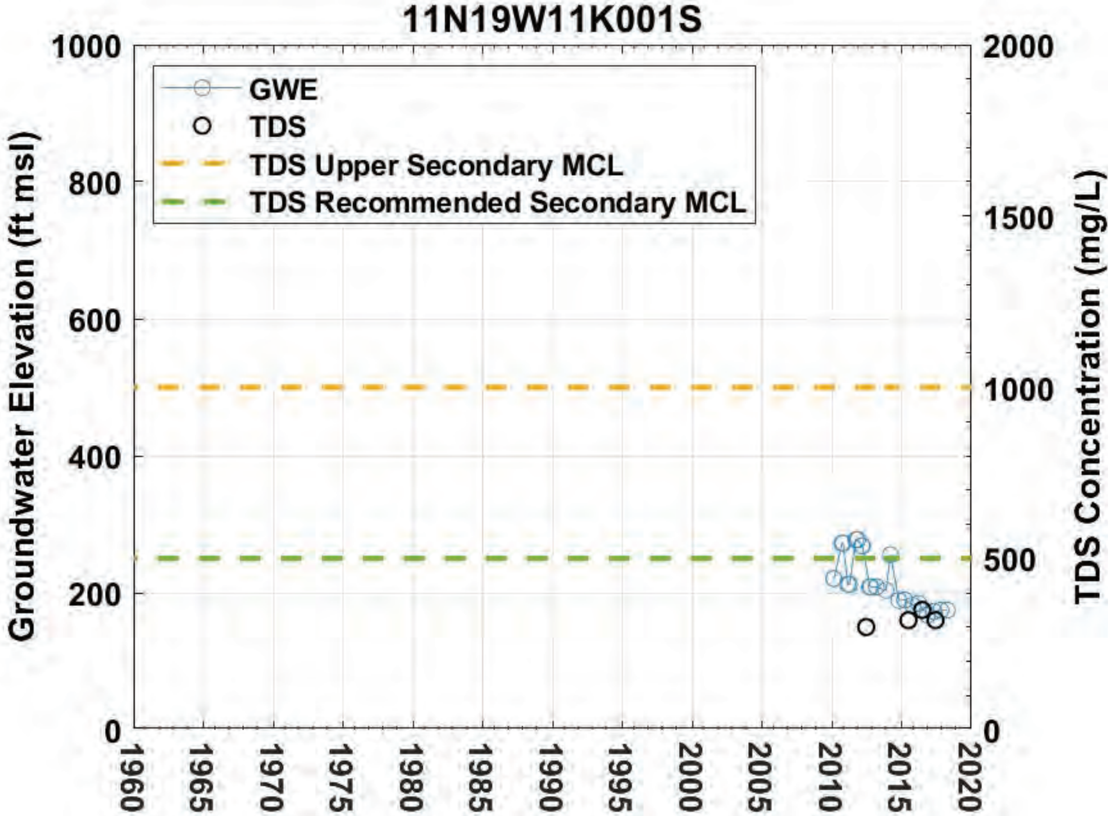

11N19W10K001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)

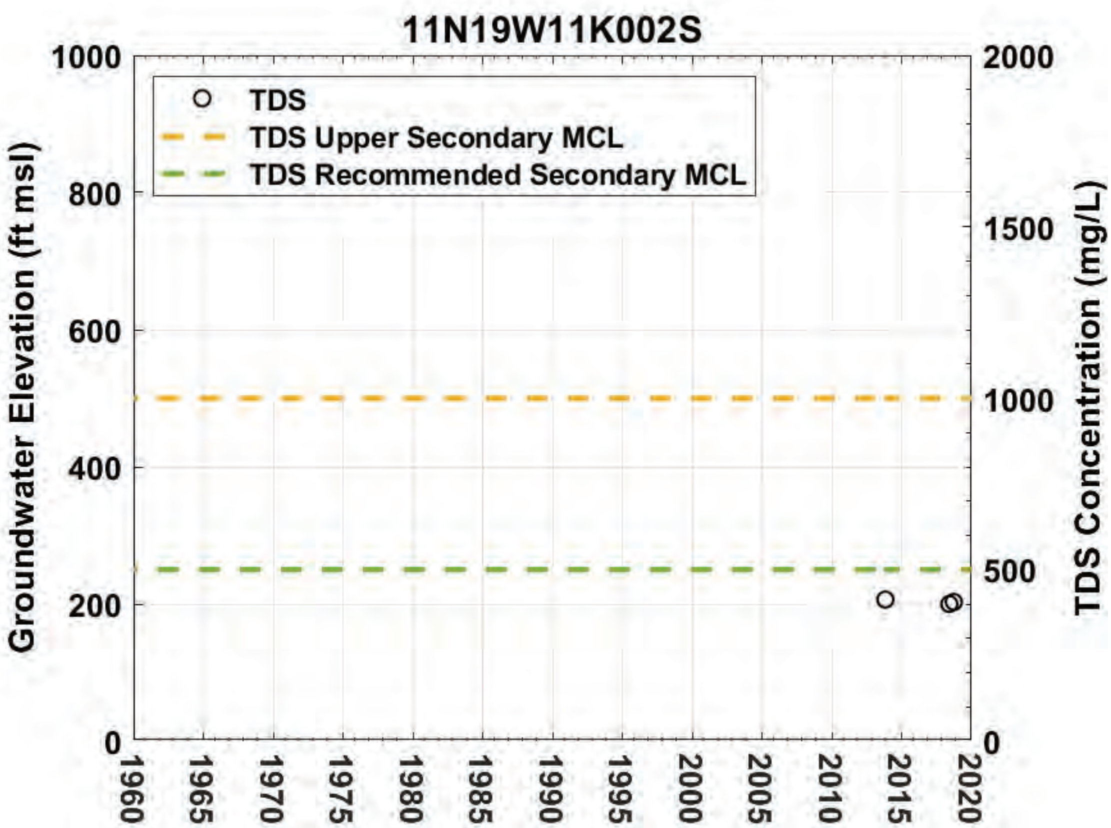

11N19W10M001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

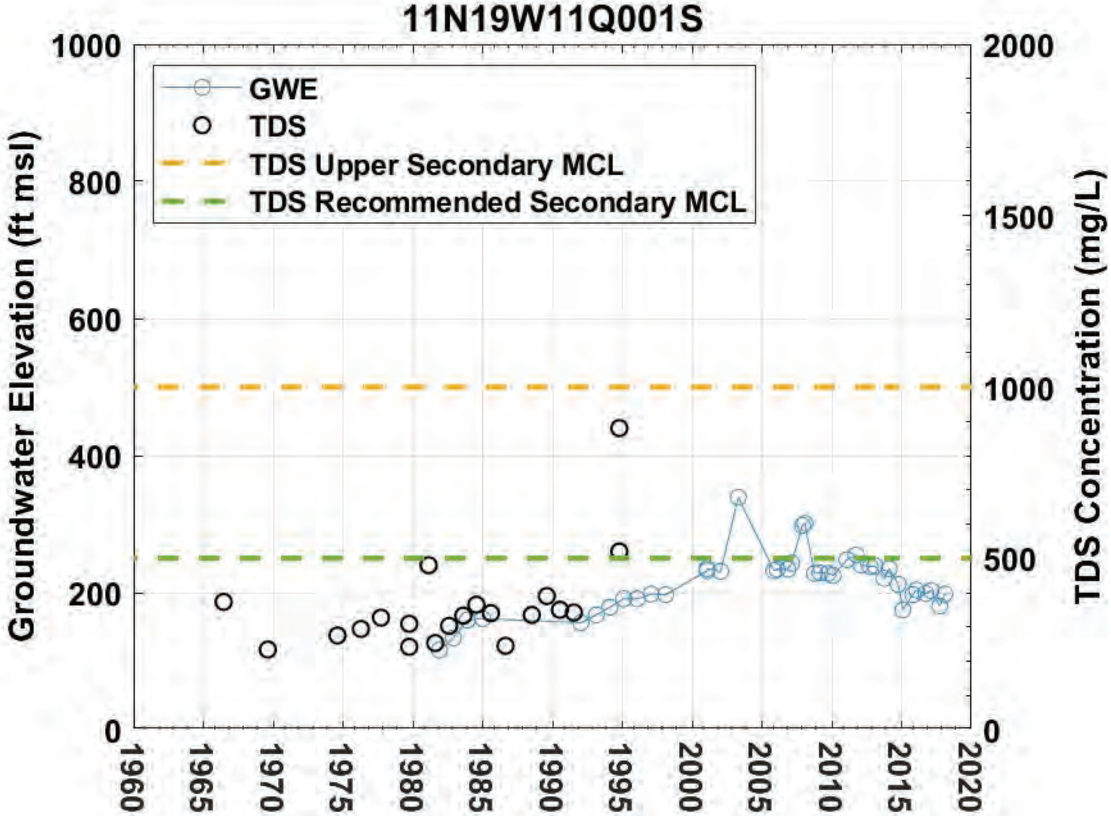

11N19W10N001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

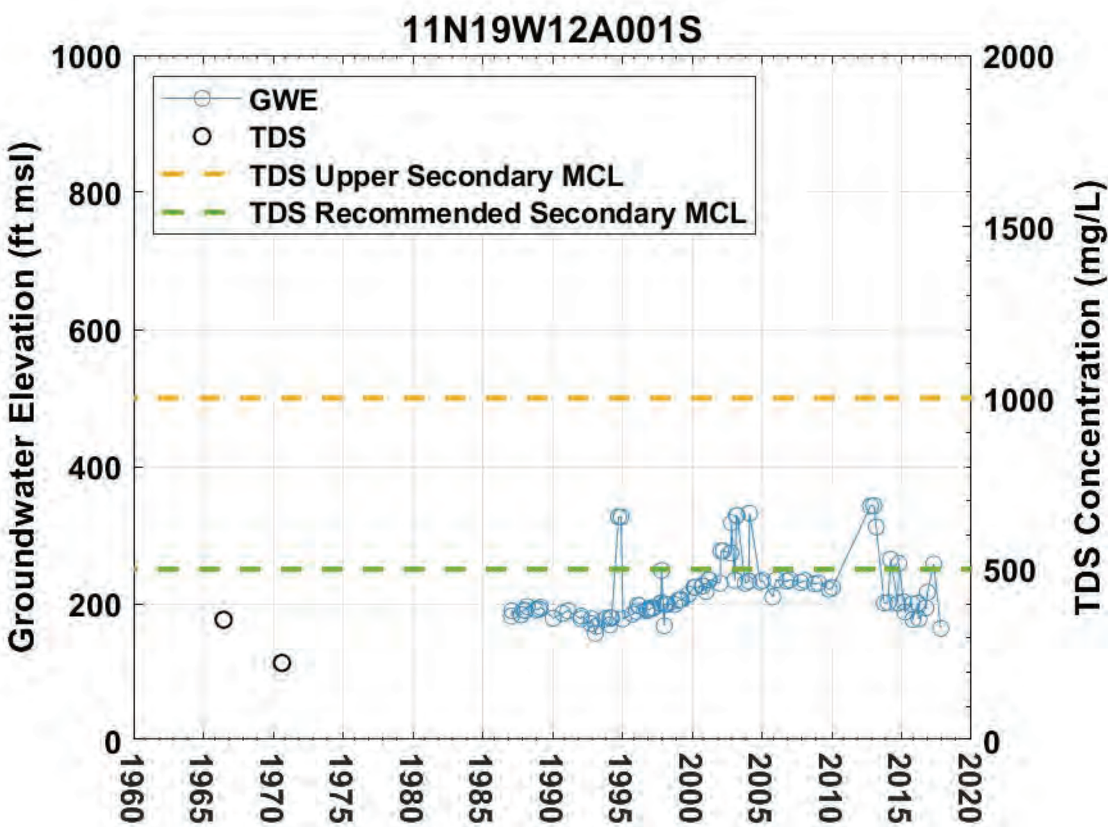

11N19W11F001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

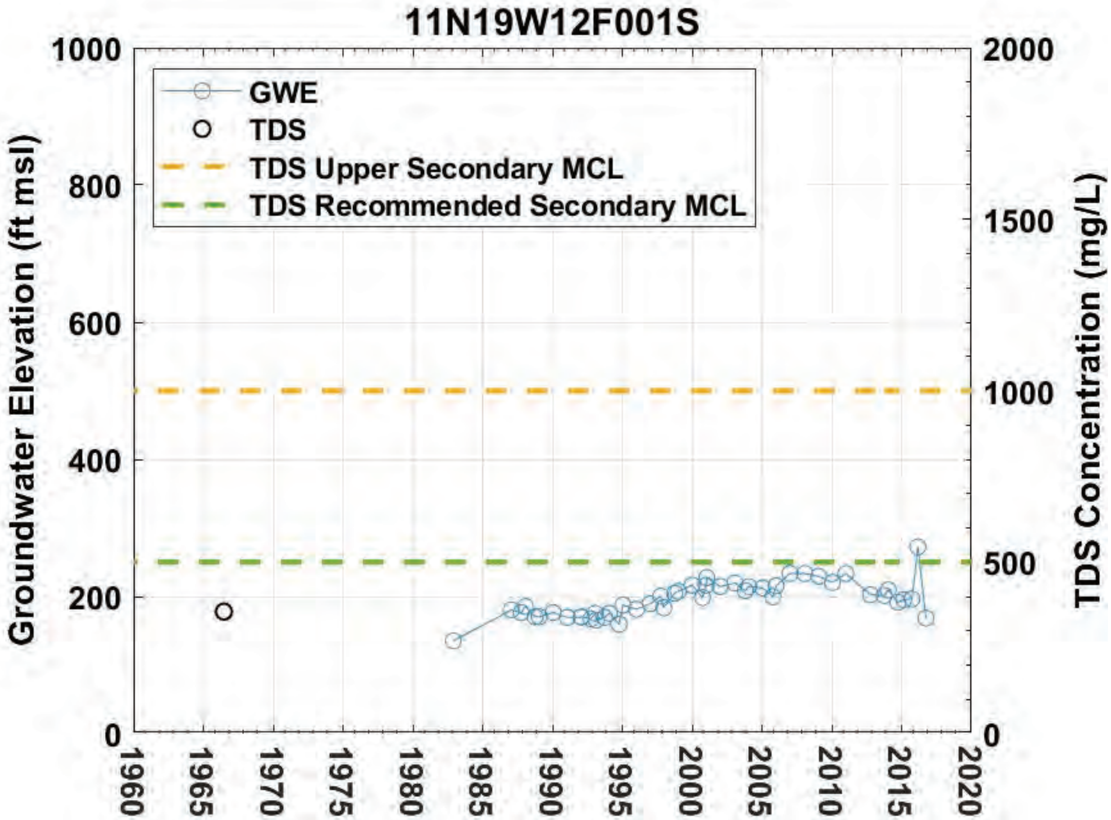

11N19W11G001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W11K001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

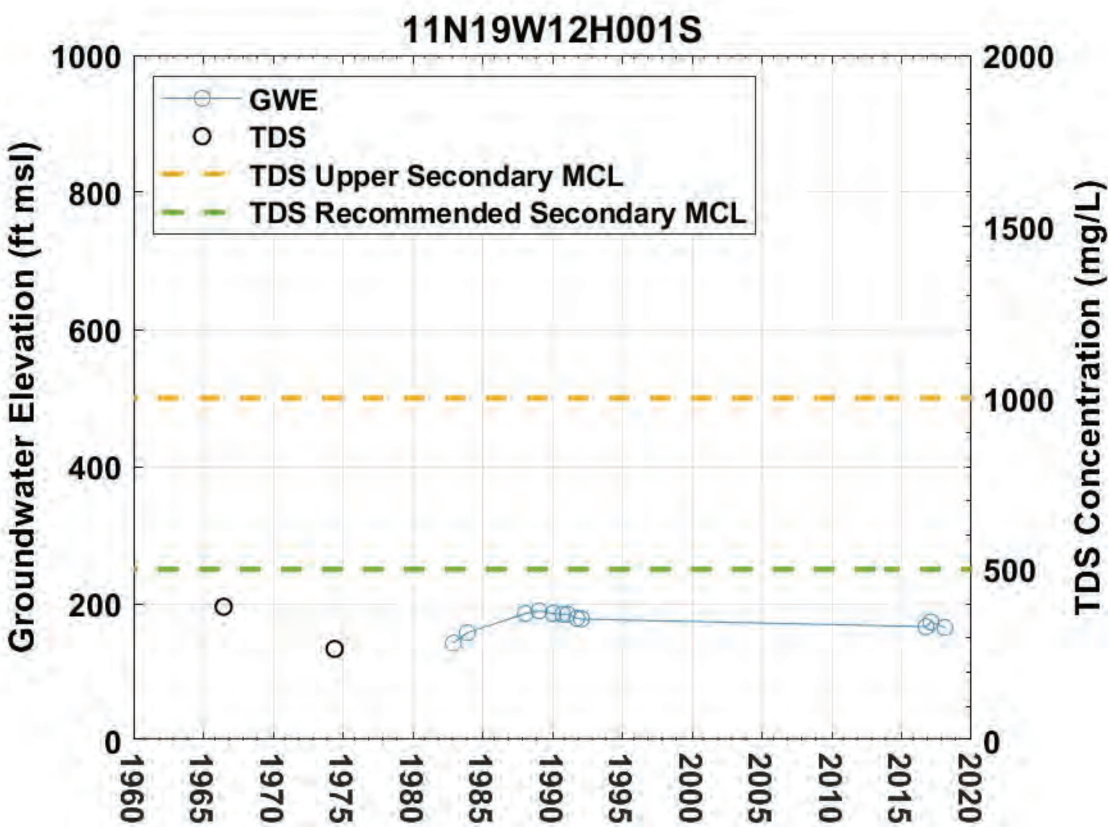

11N19W11K002S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W11Q001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

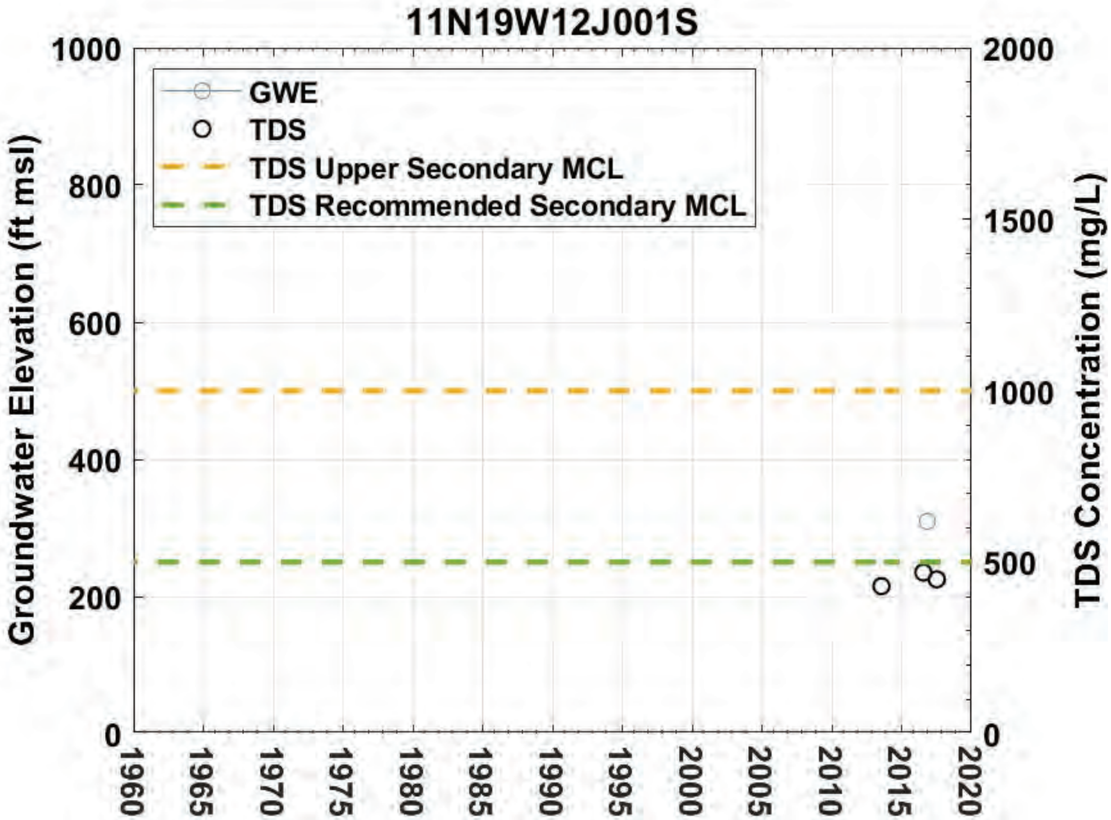

11N19W12A001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

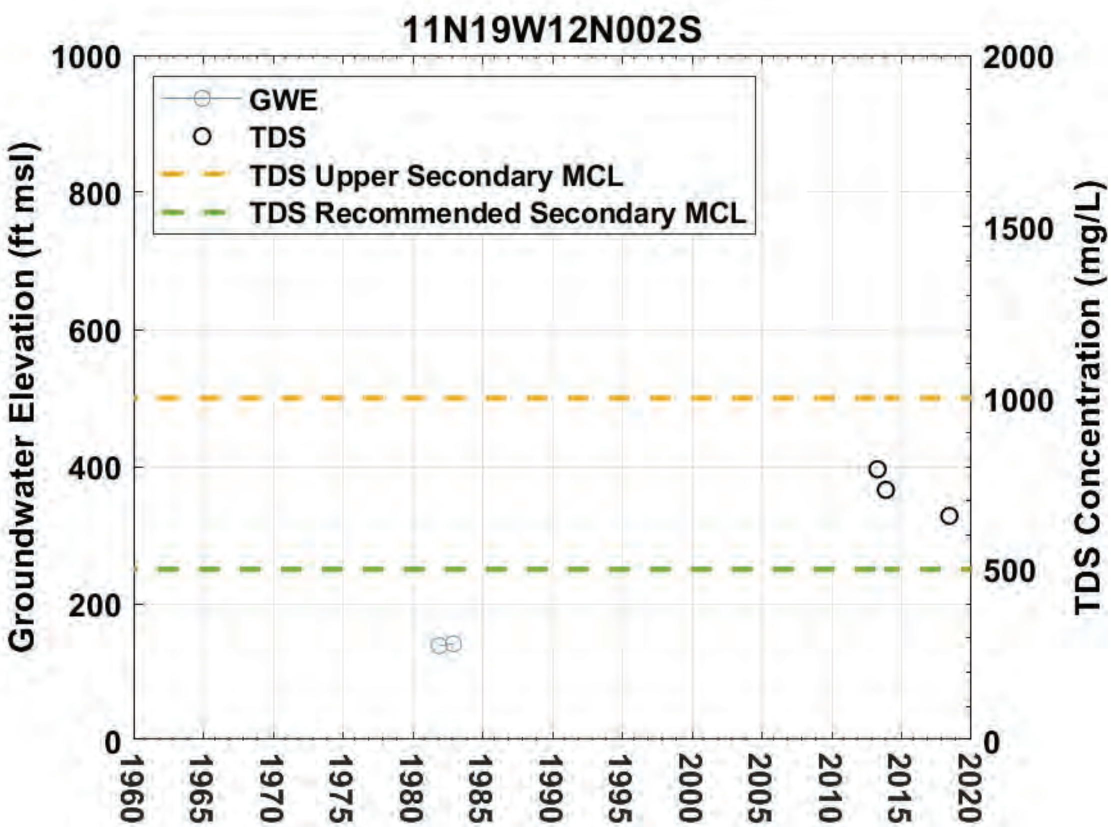


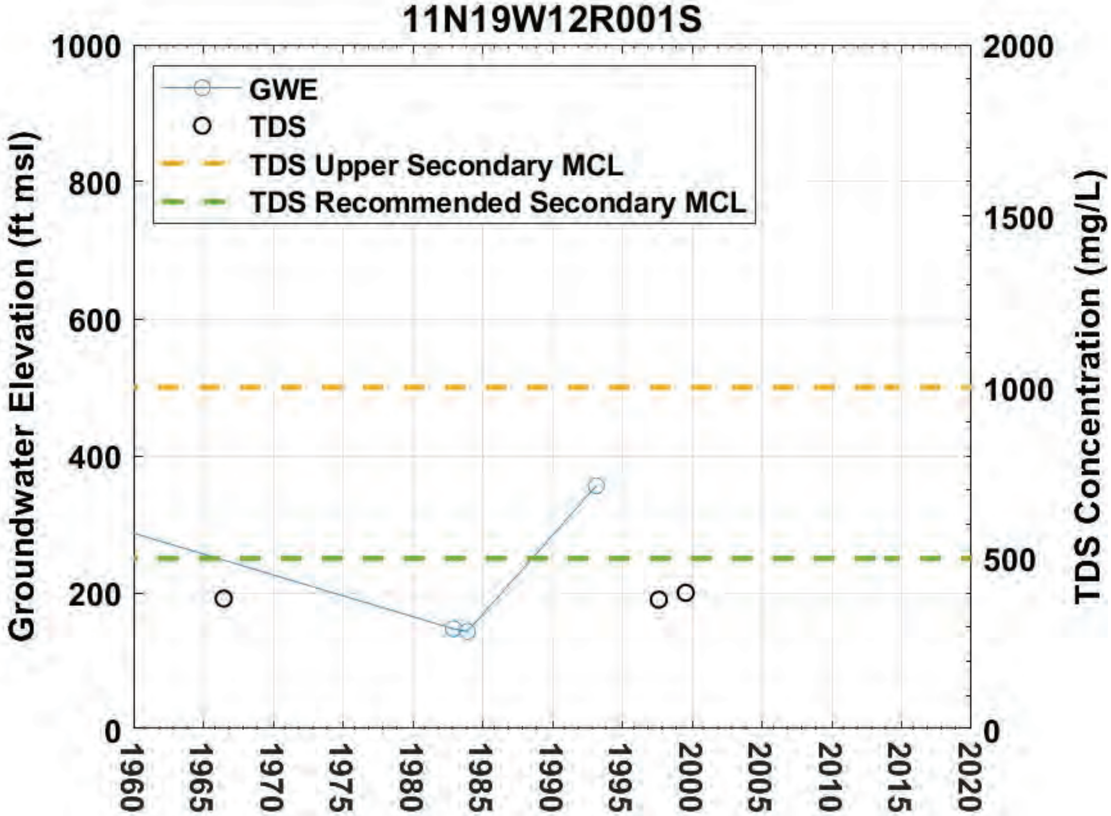
11N19W12F001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

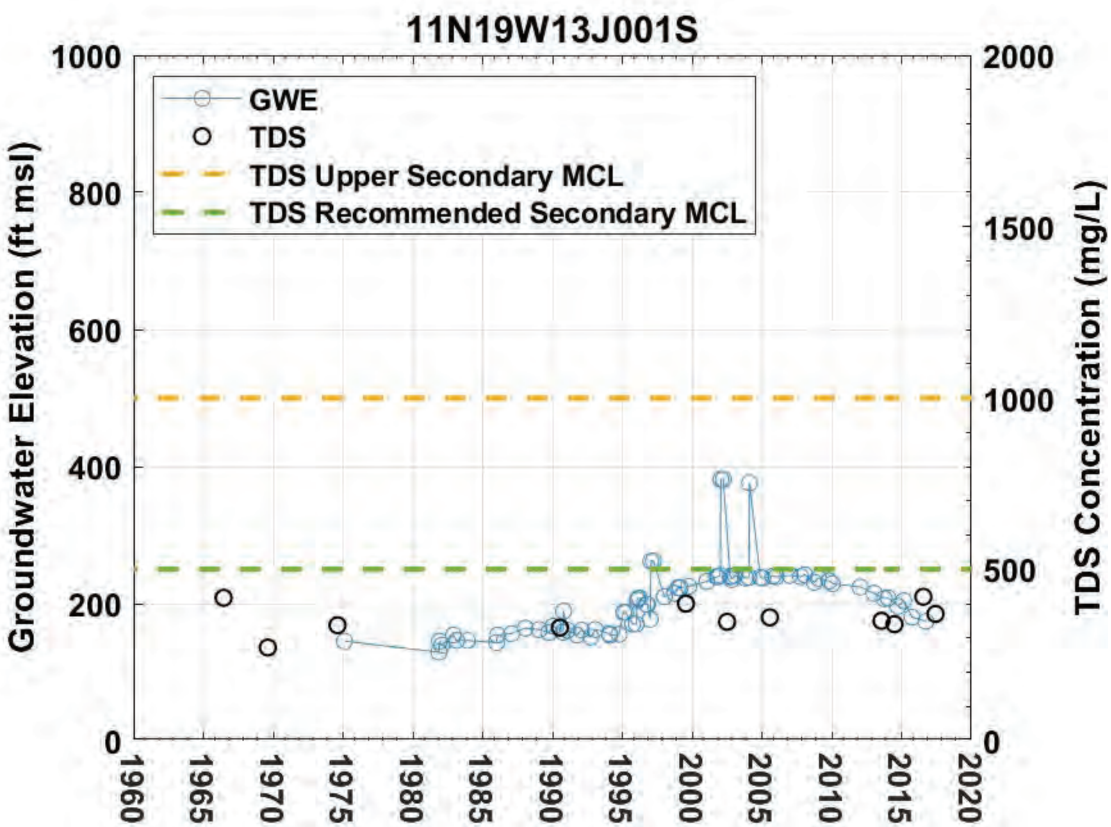


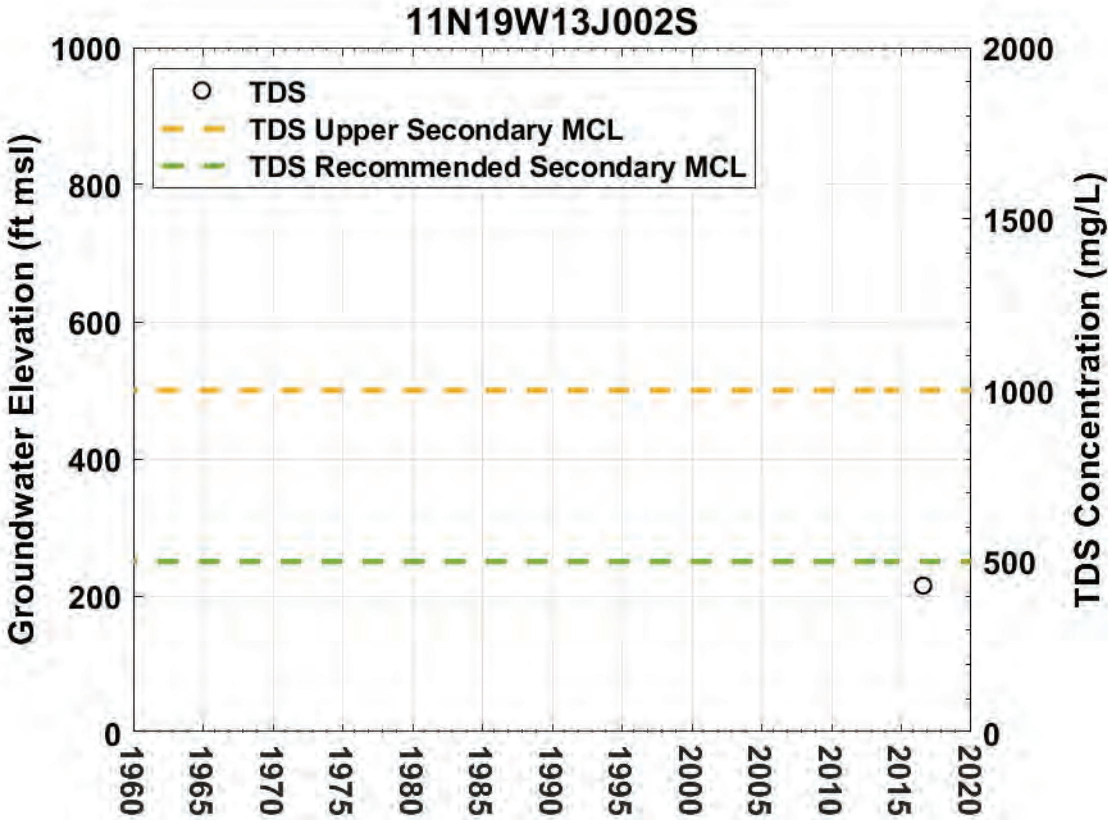
11N19W12H001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

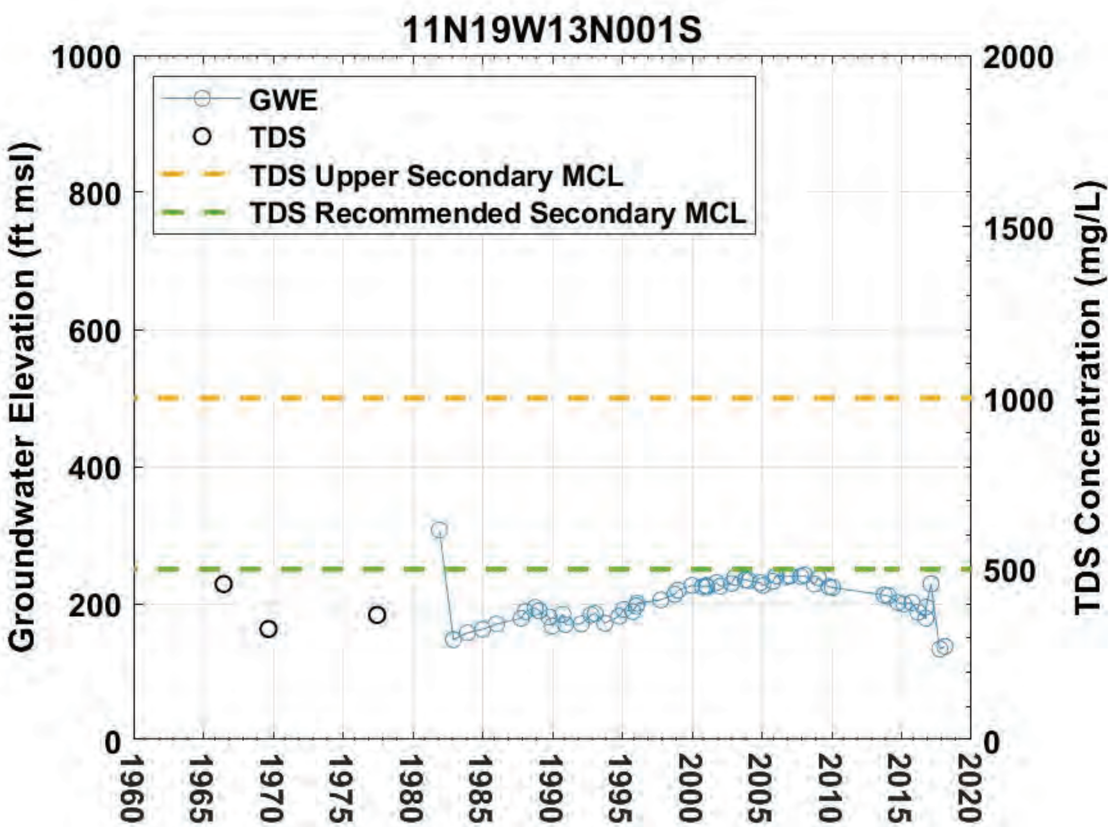

11N19W12J001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

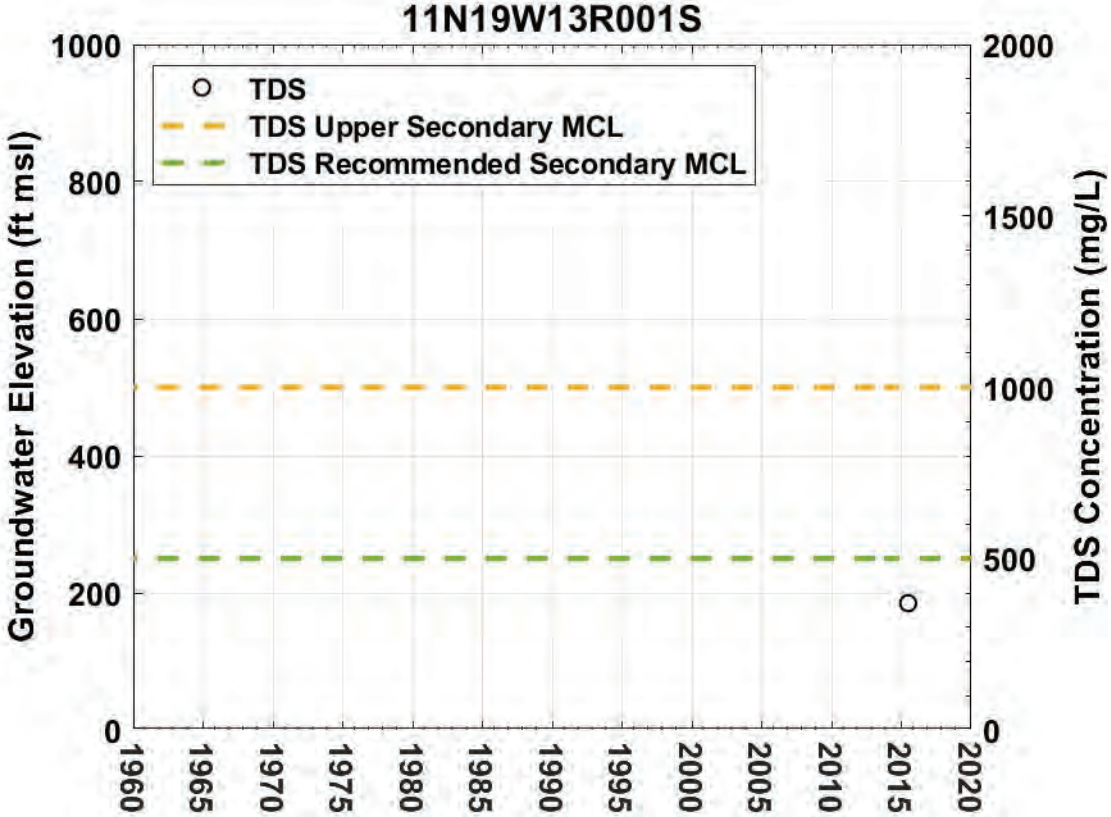

11N19W12N002S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

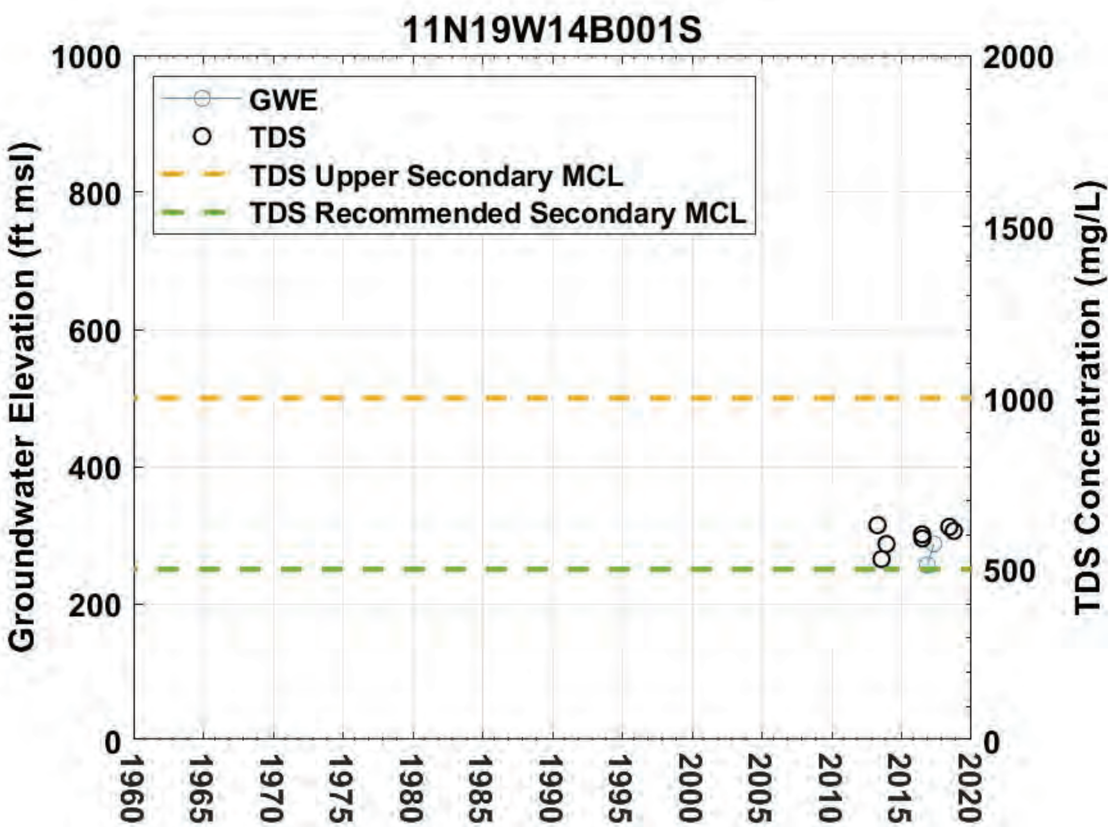

11N19W12R001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

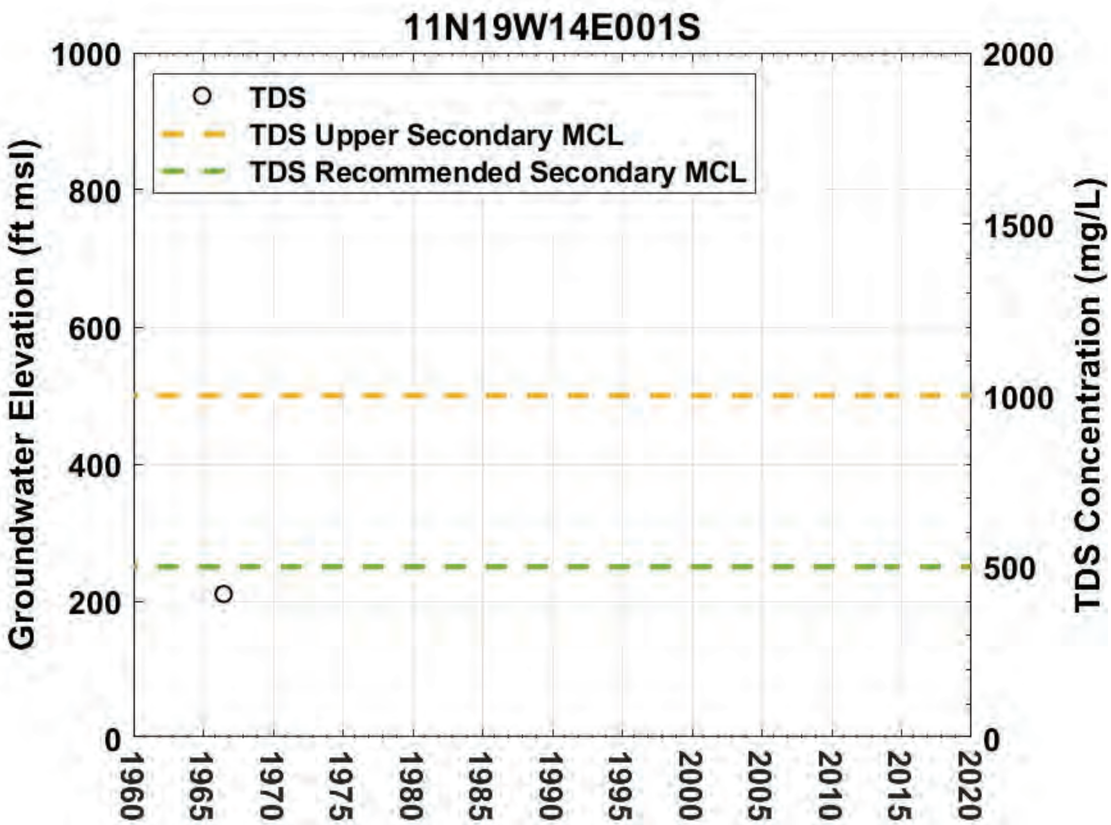

11N19W13J001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

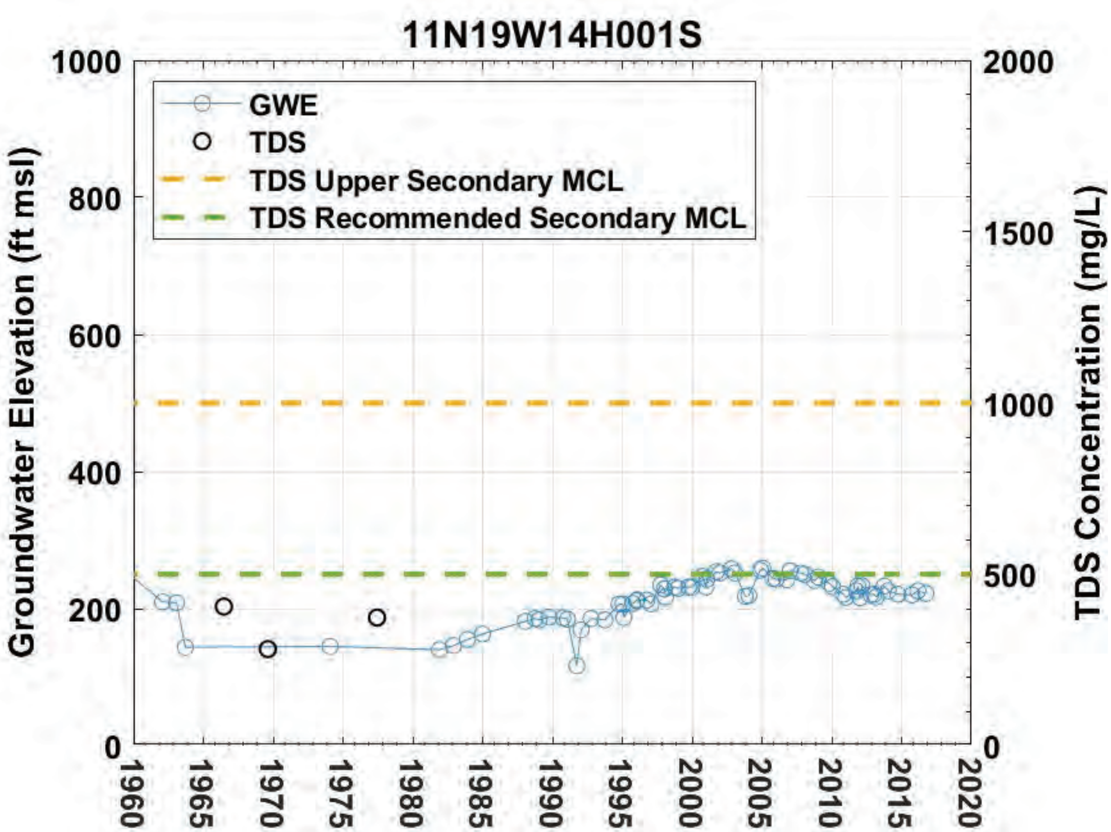

11N19W13J002S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

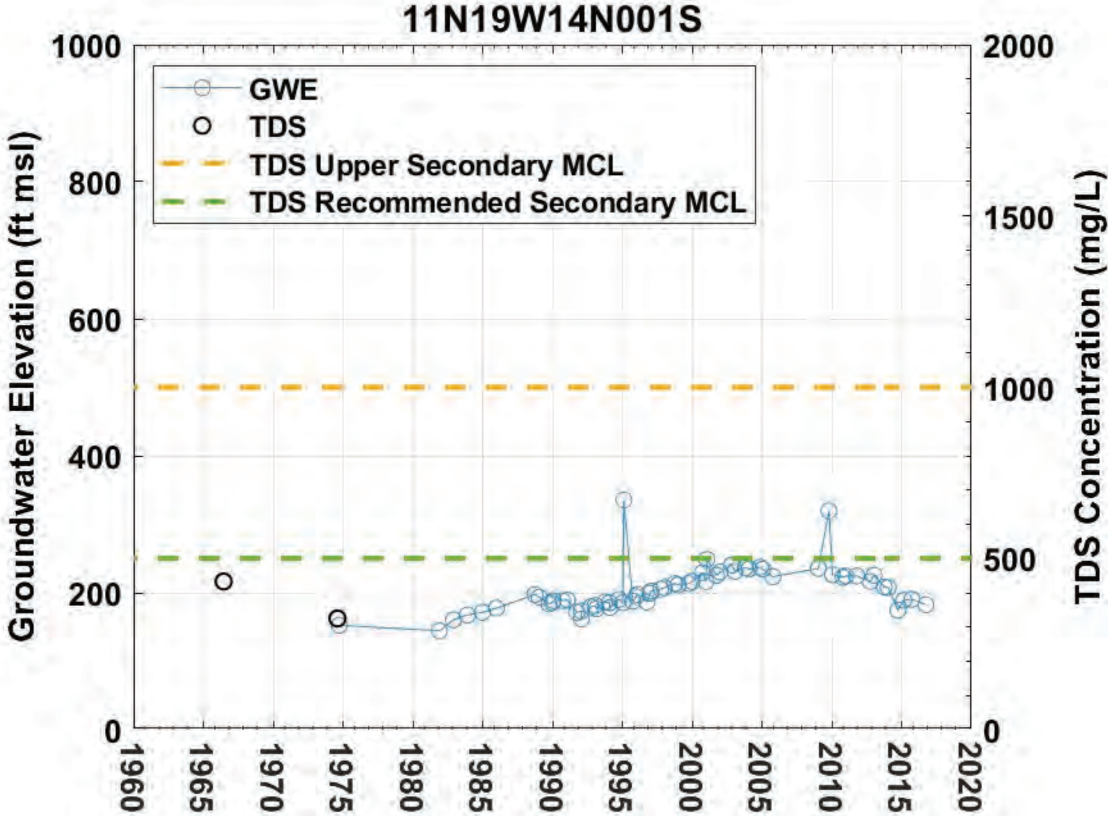

11N19W13N001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

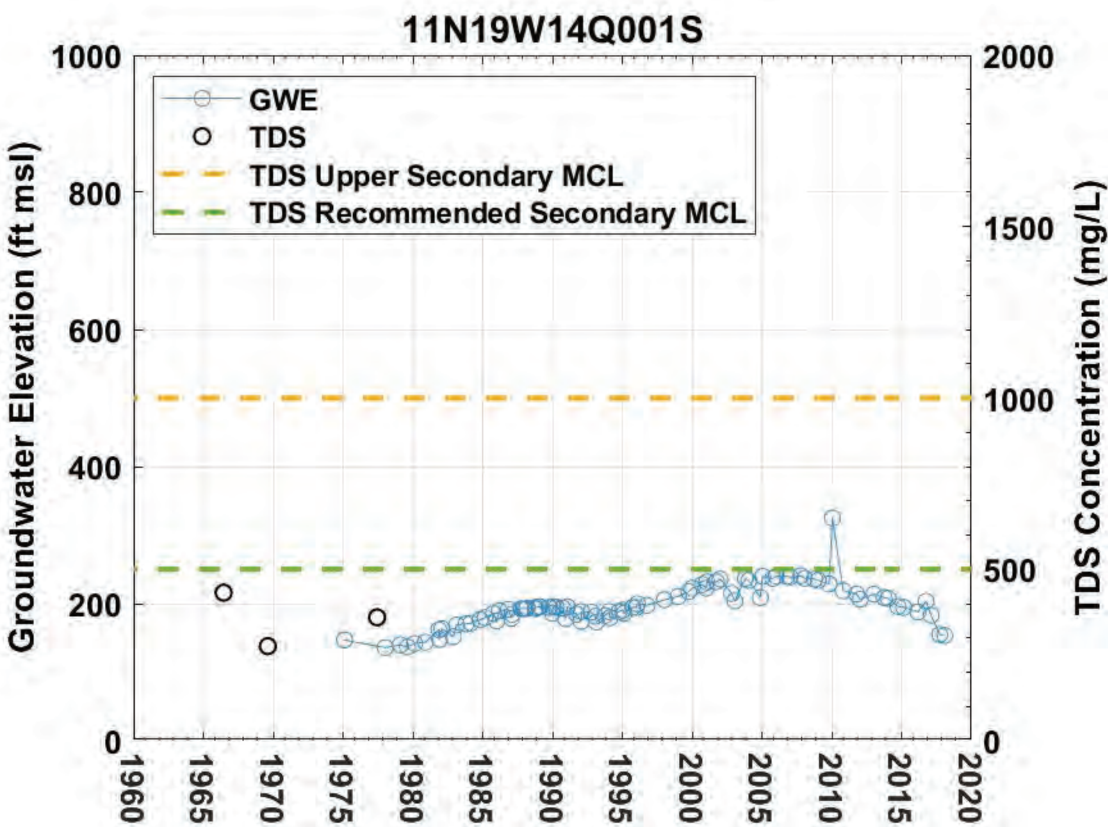

11N19W13R001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

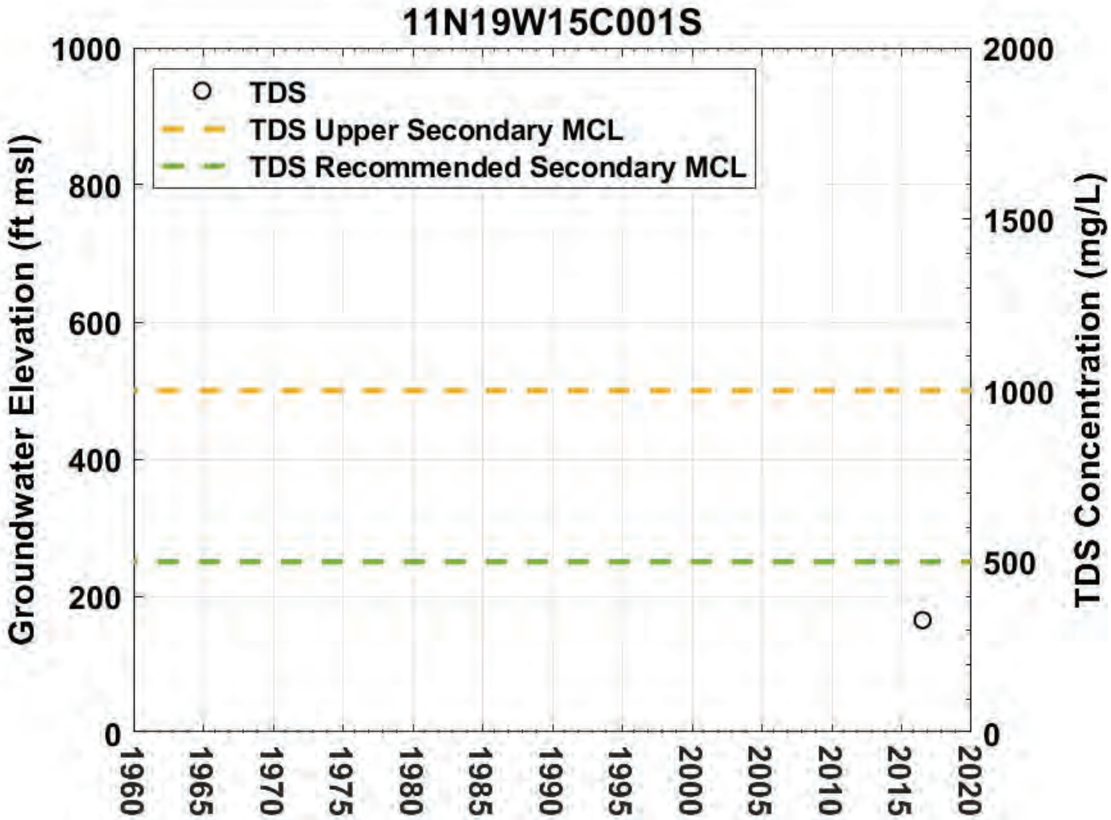

11N19W14B001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

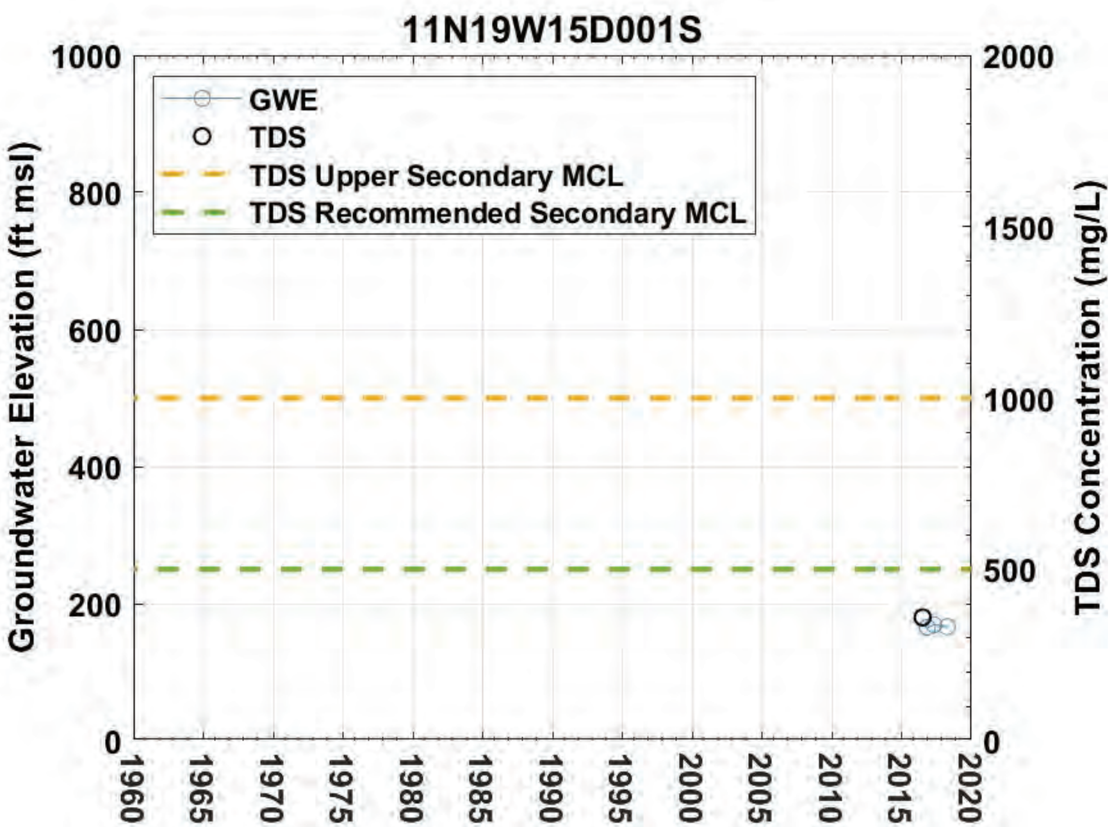

11N19W14E001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

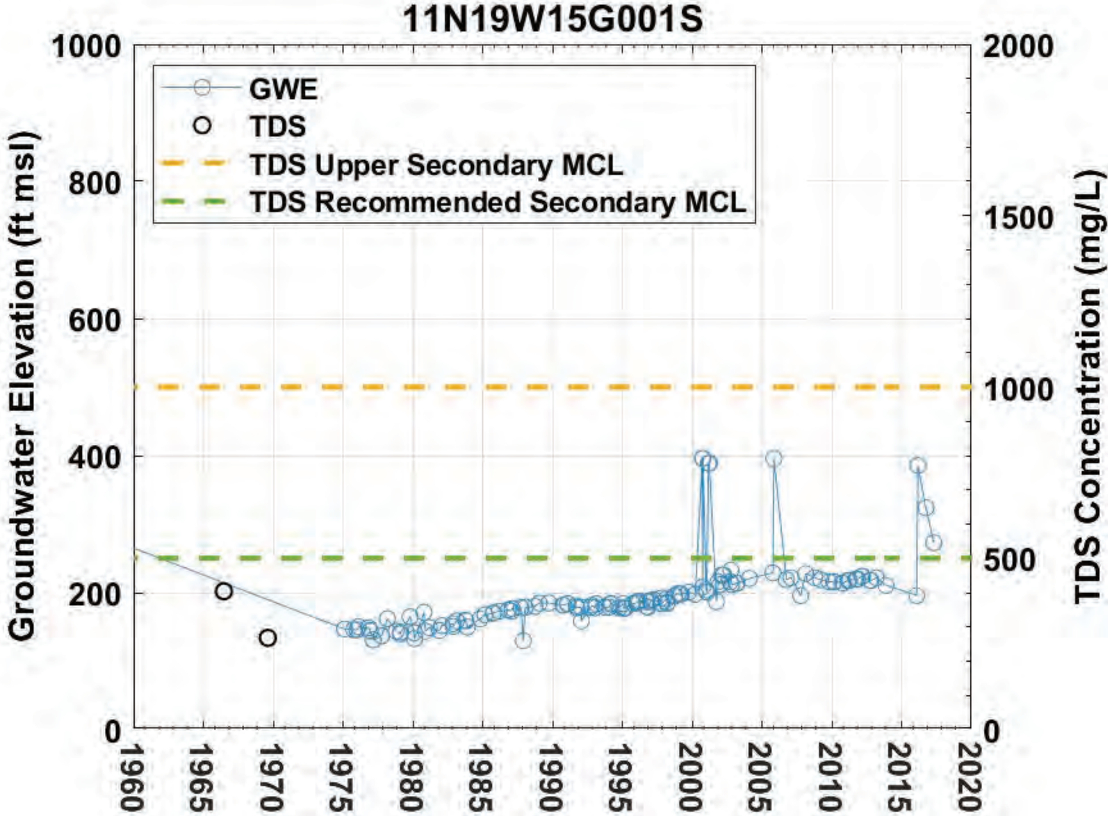

11N19W14H001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

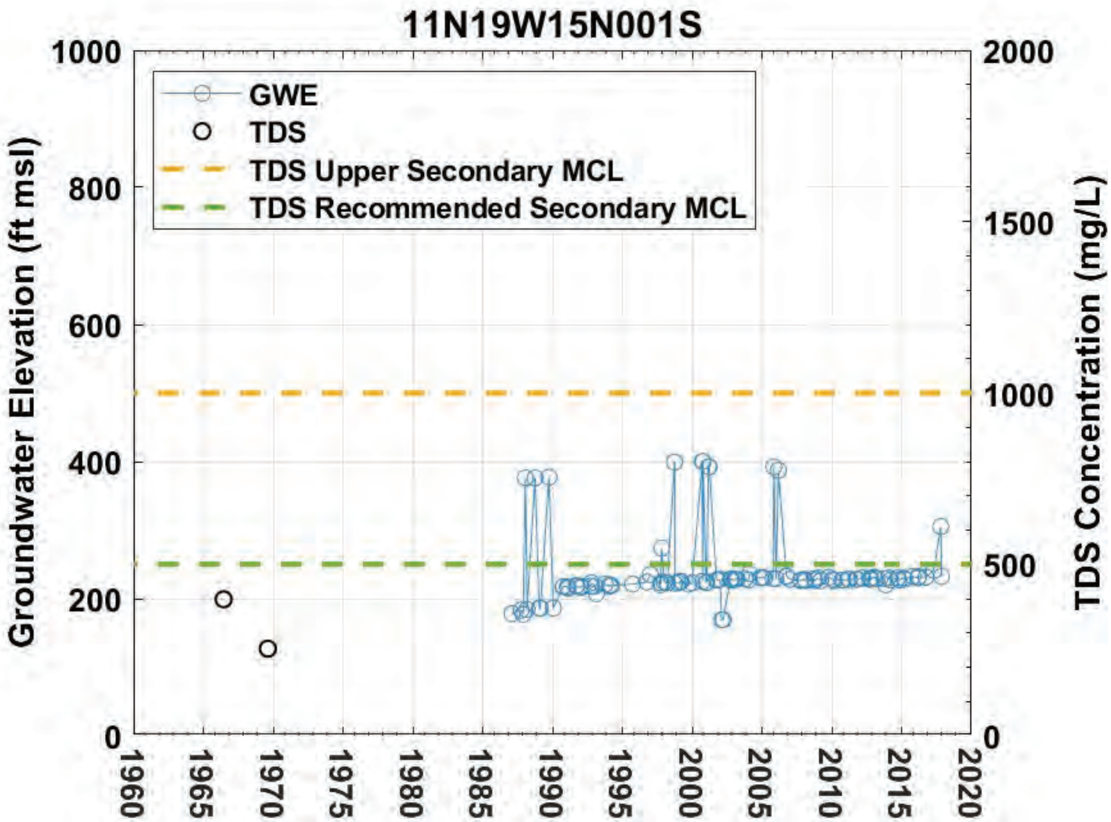

11N19W14N001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

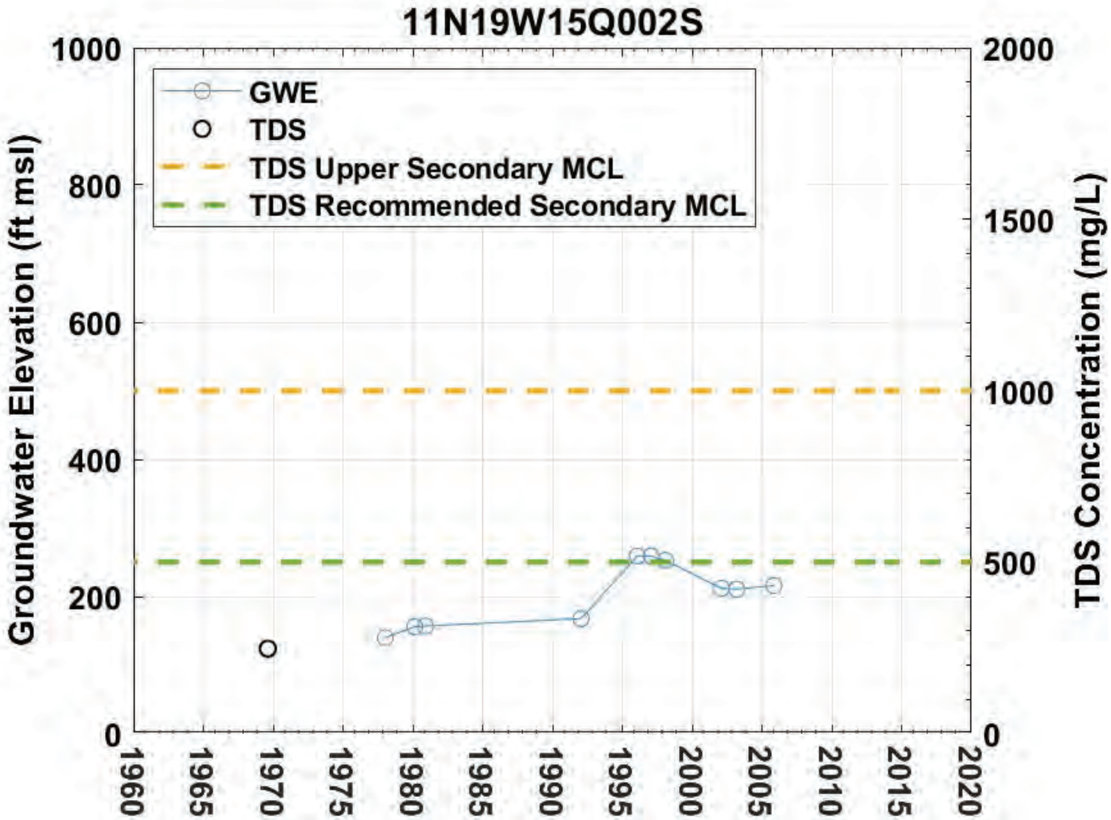

11N19W14Q001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

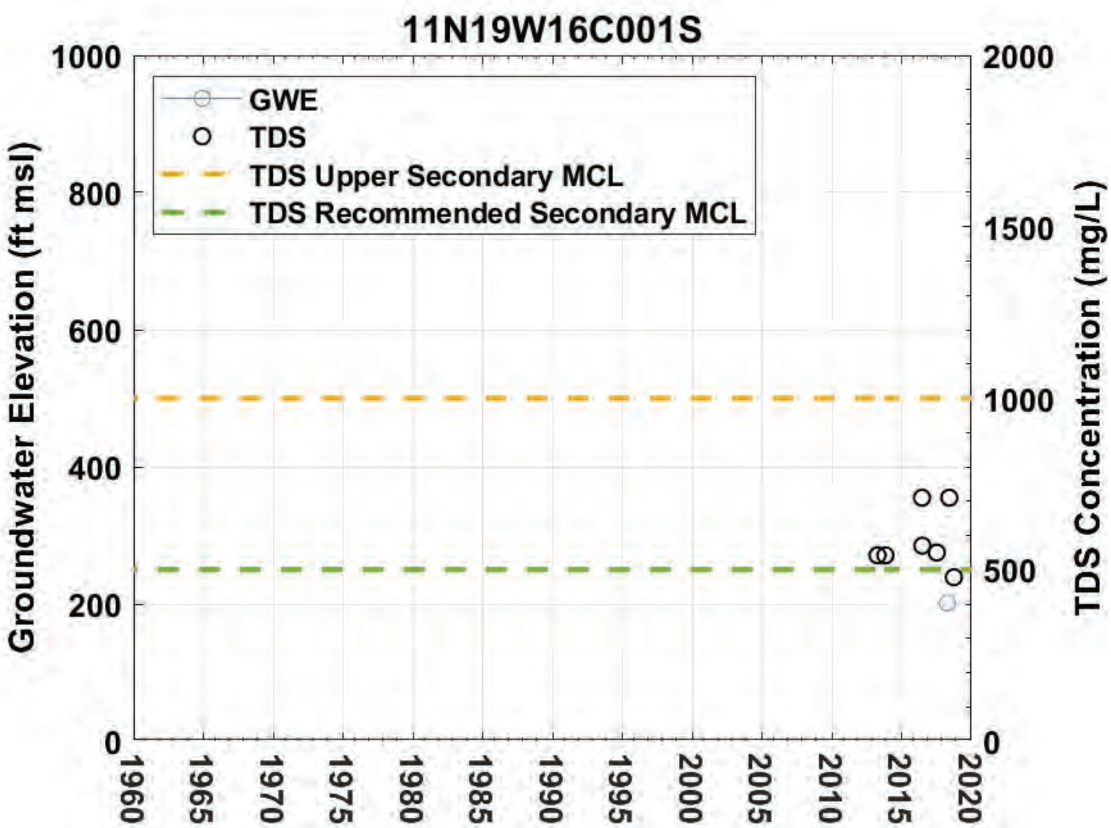

11N19W15C001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

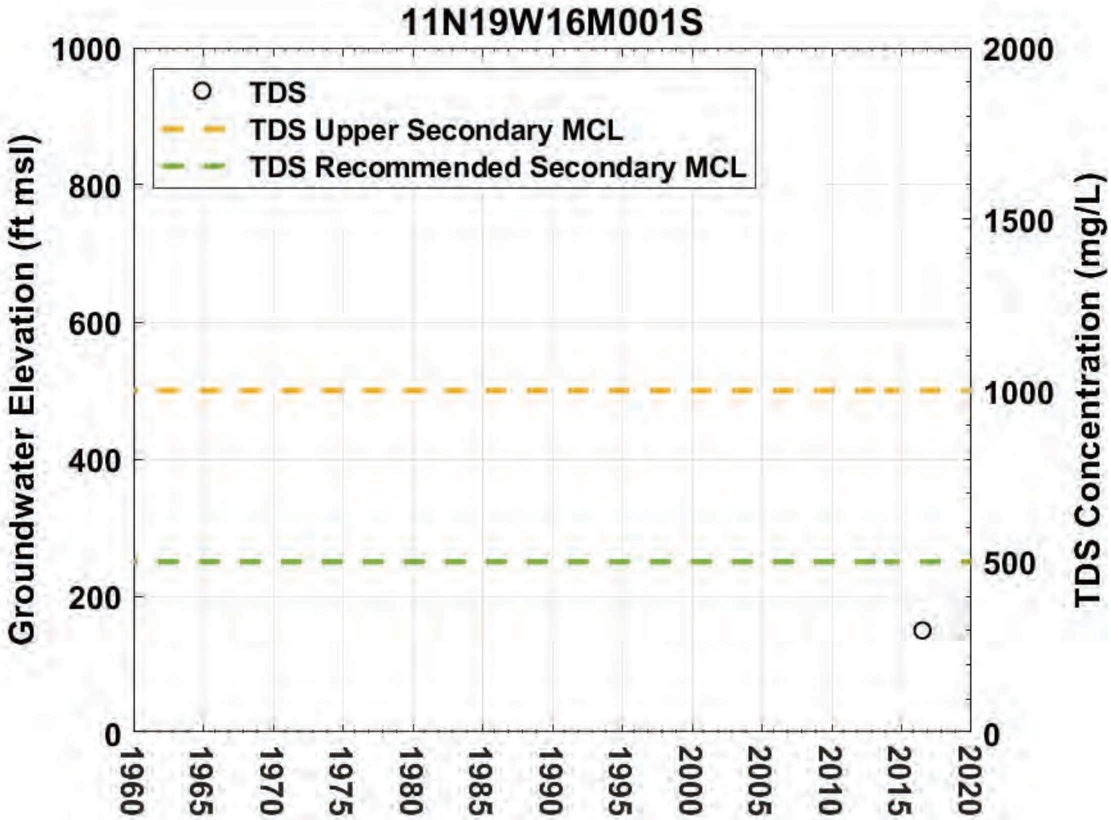

11N19W15D001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W15G001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

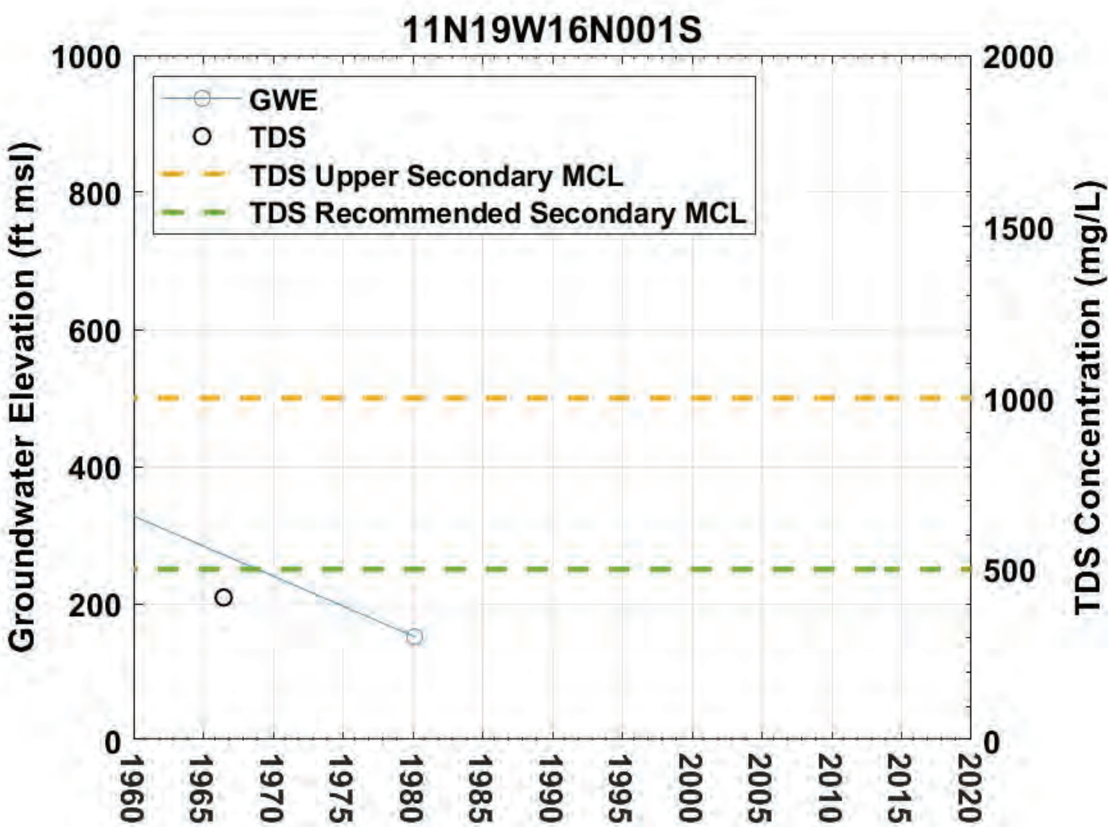

11N19W15N001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W15Q002S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

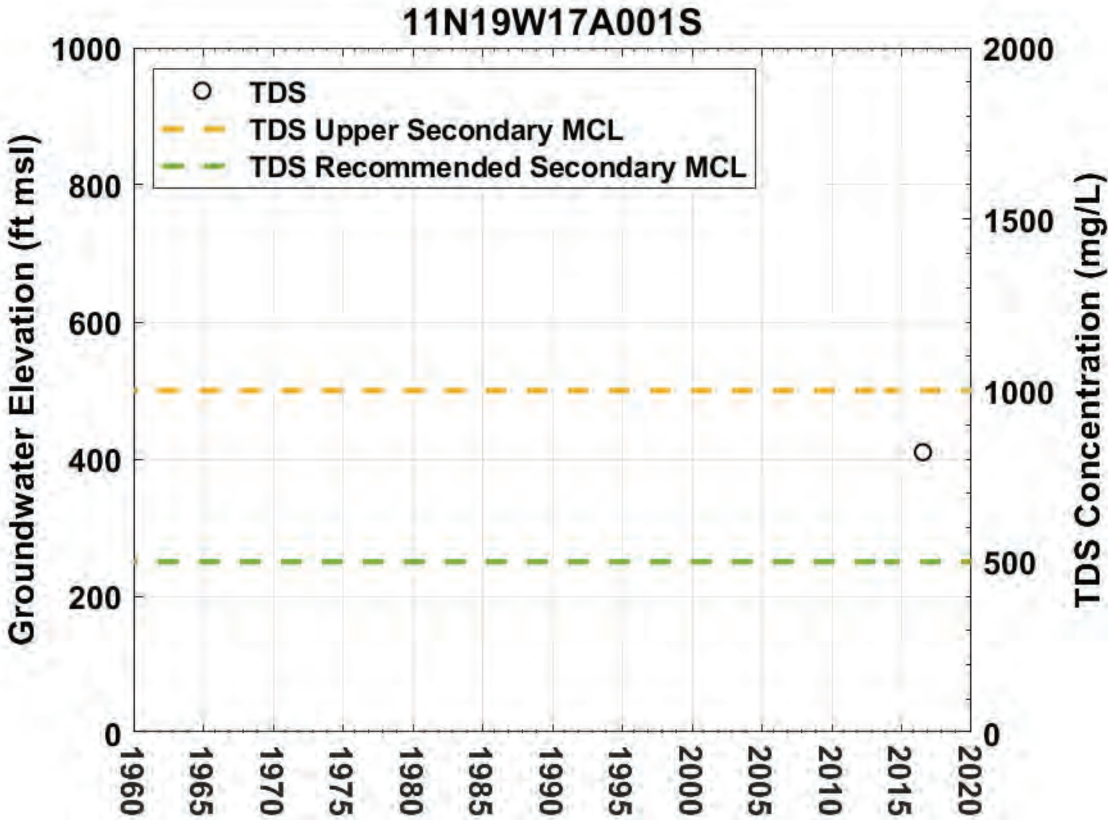

11N19W16C001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

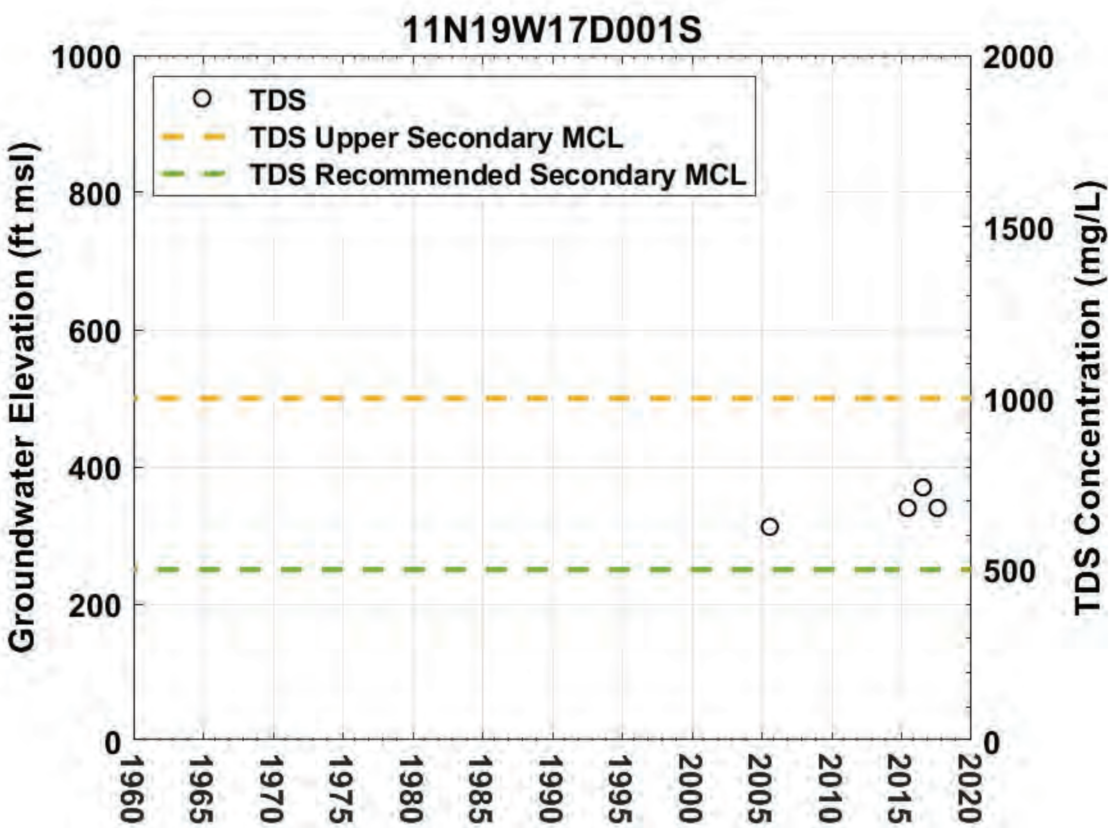


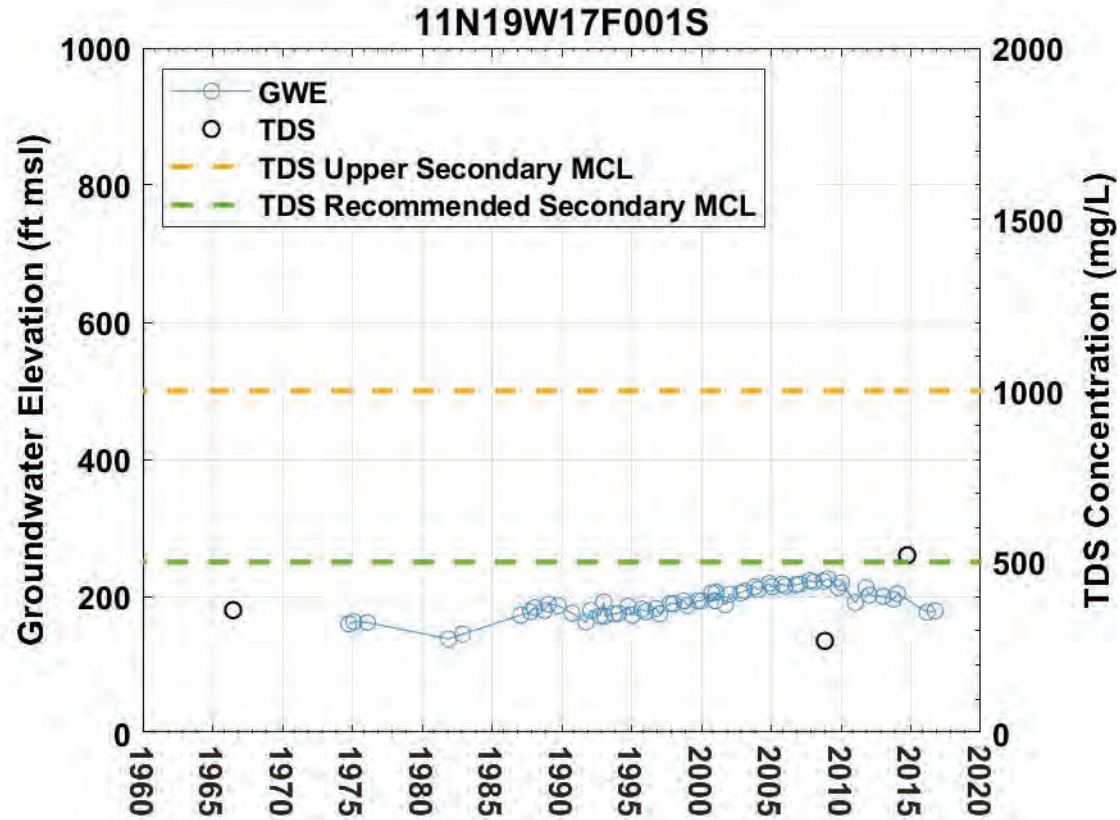
11N19W16M001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



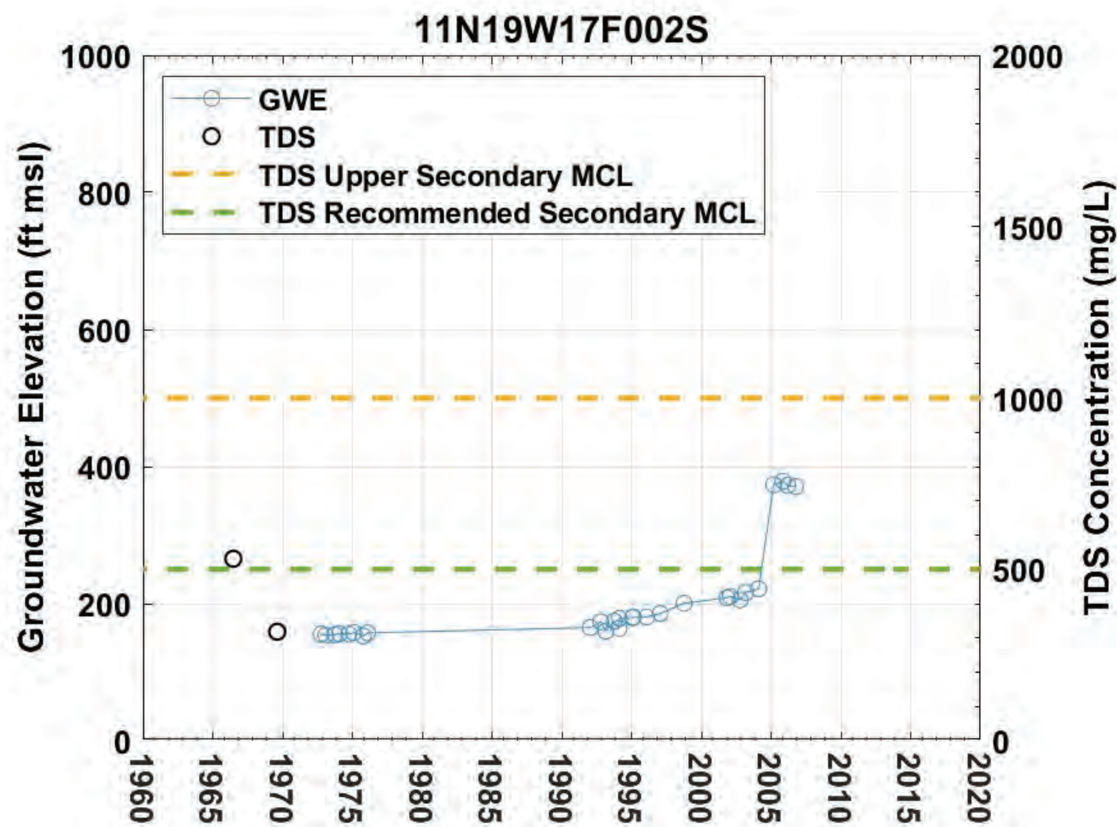
11N19W16N001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W17A001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

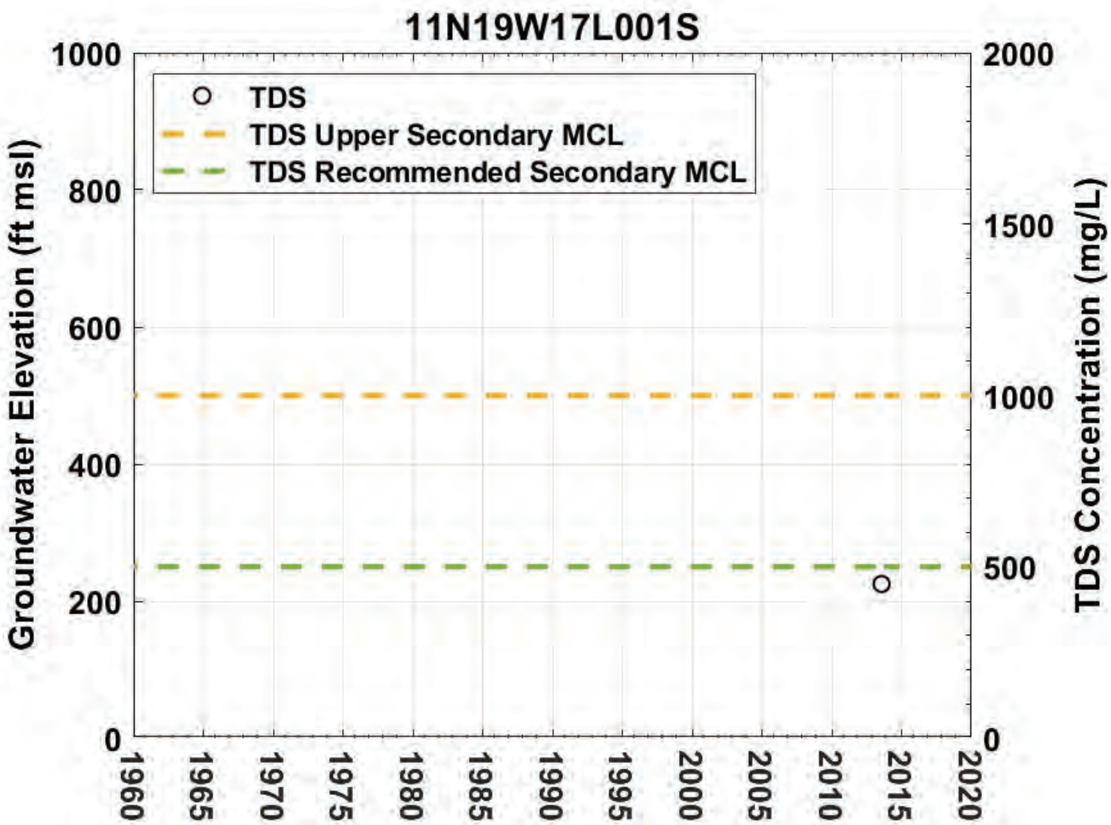

11N19W17D001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

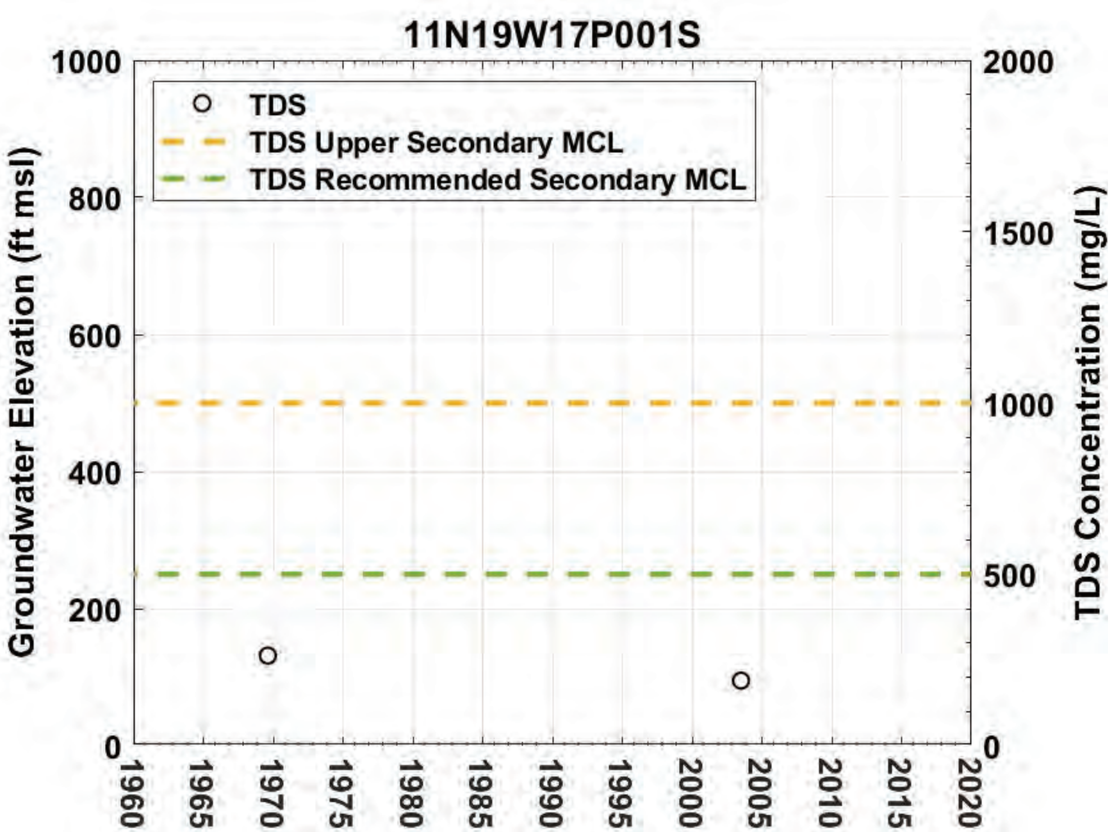


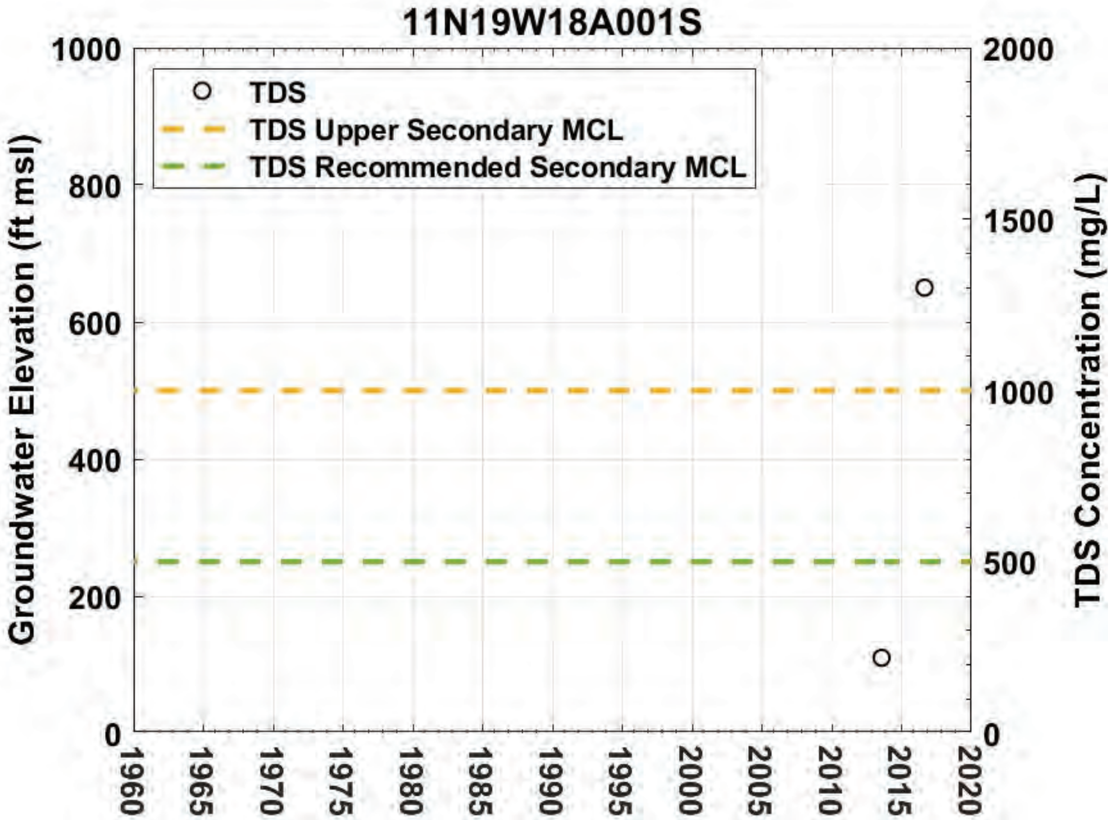
11N19W17F001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

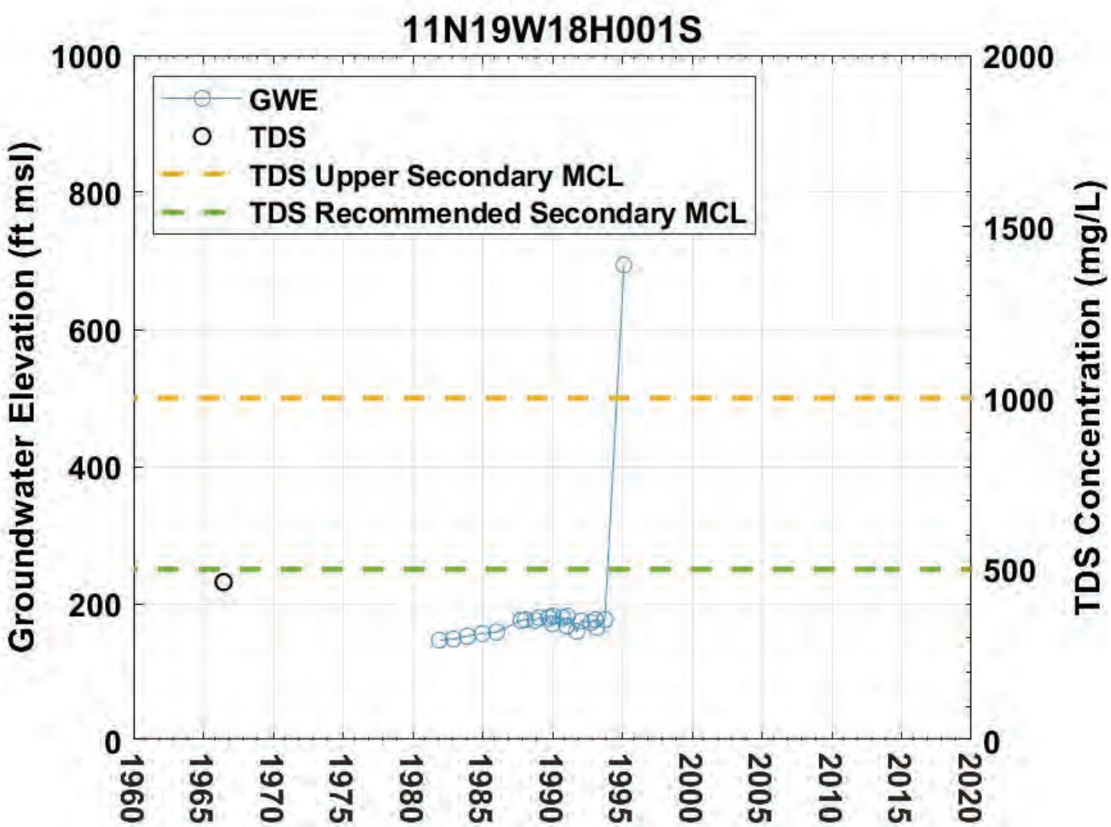


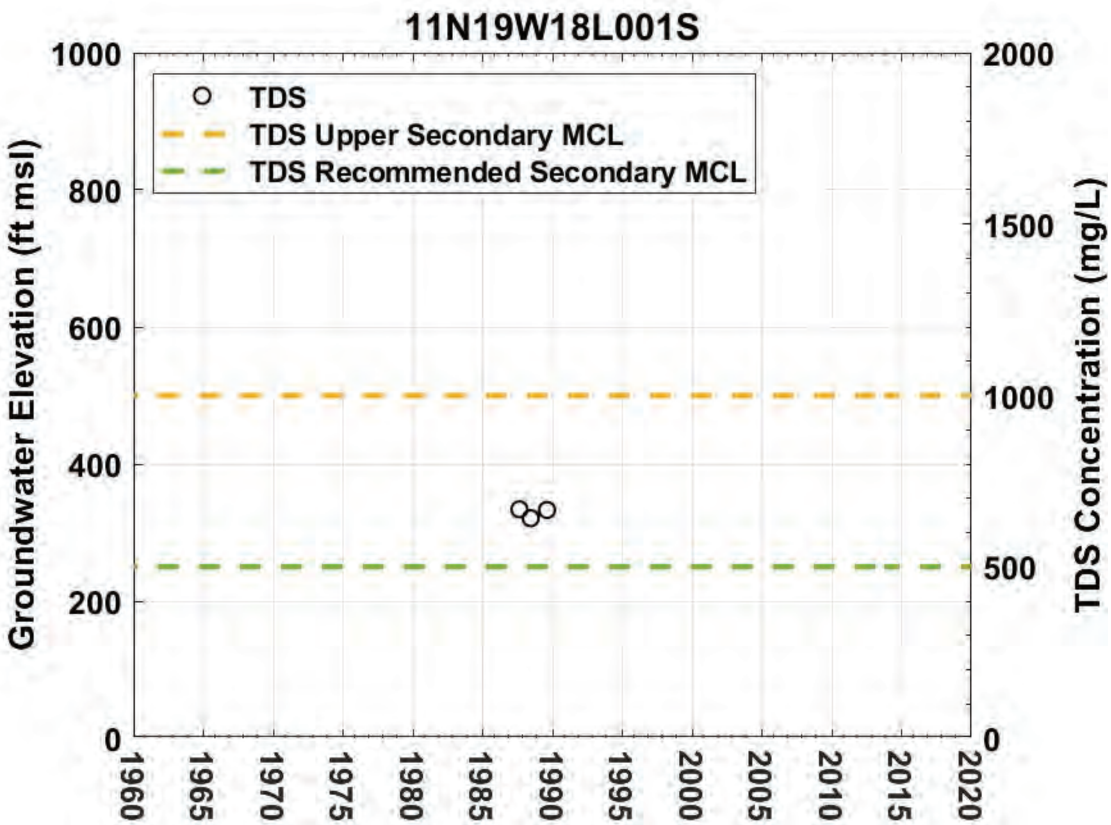
11N19W17F002S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

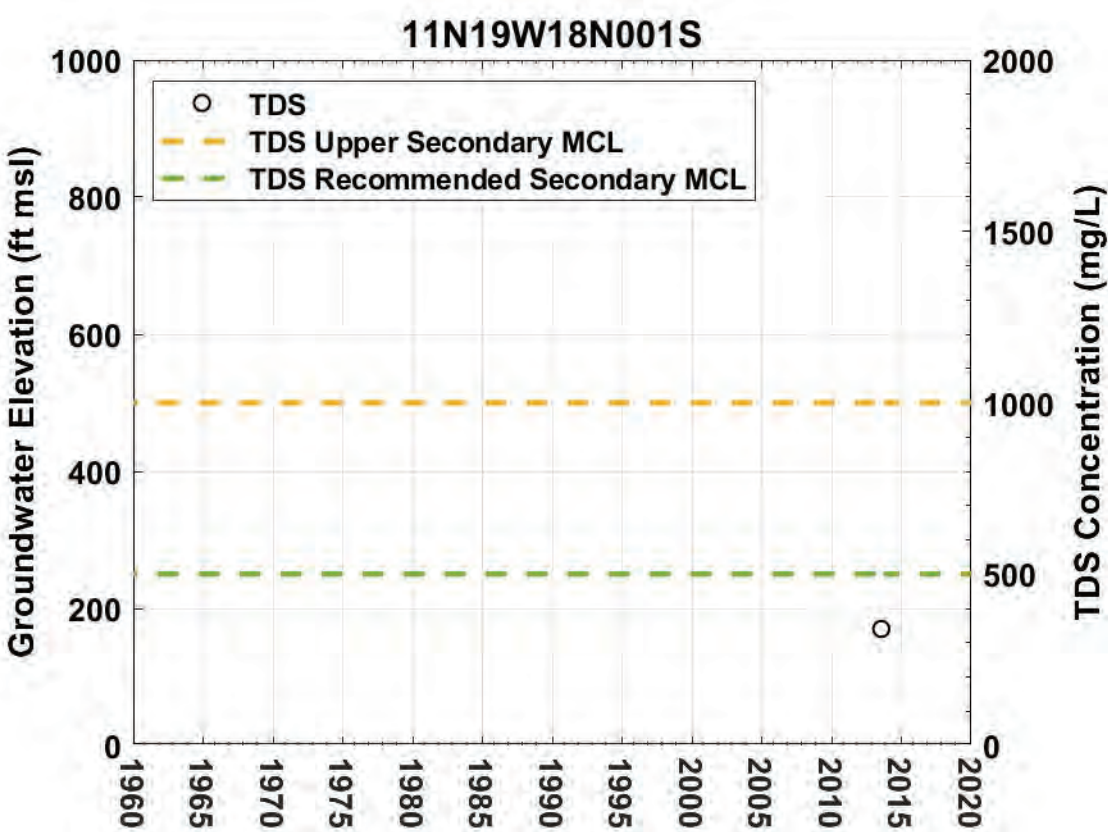

11N19W17L001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

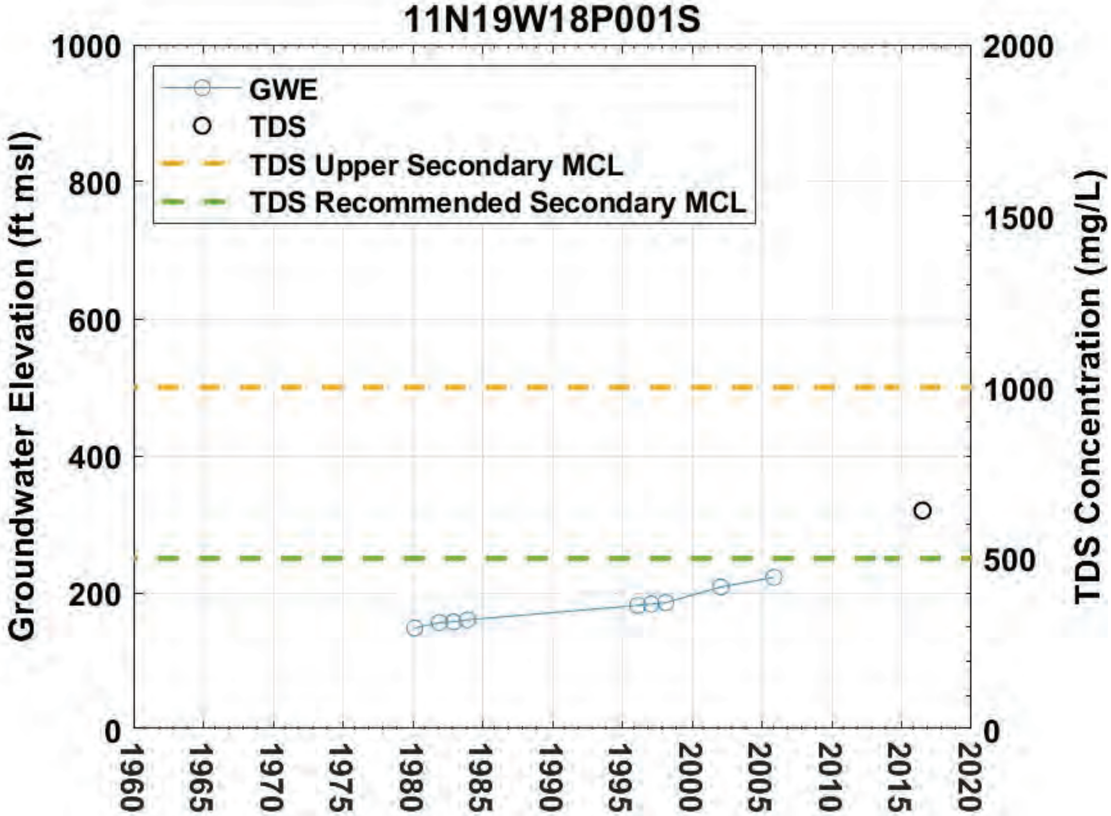

11N19W17P001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

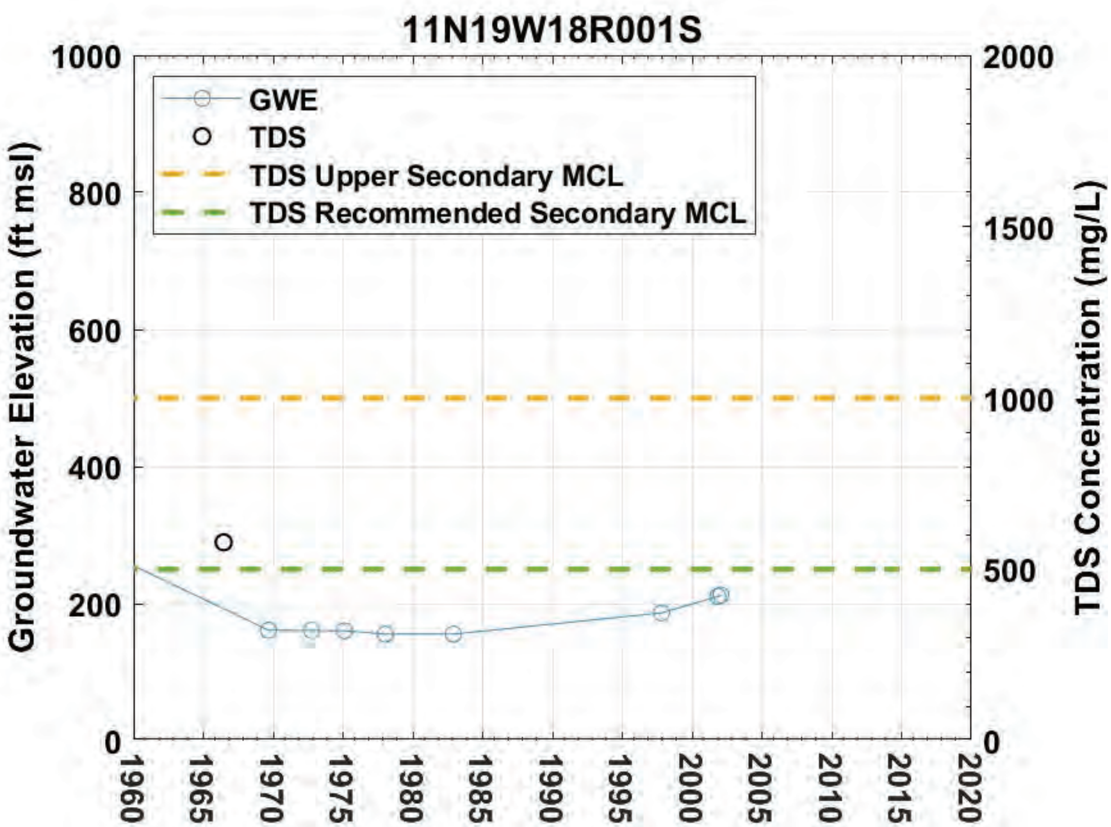

11N19W18A001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

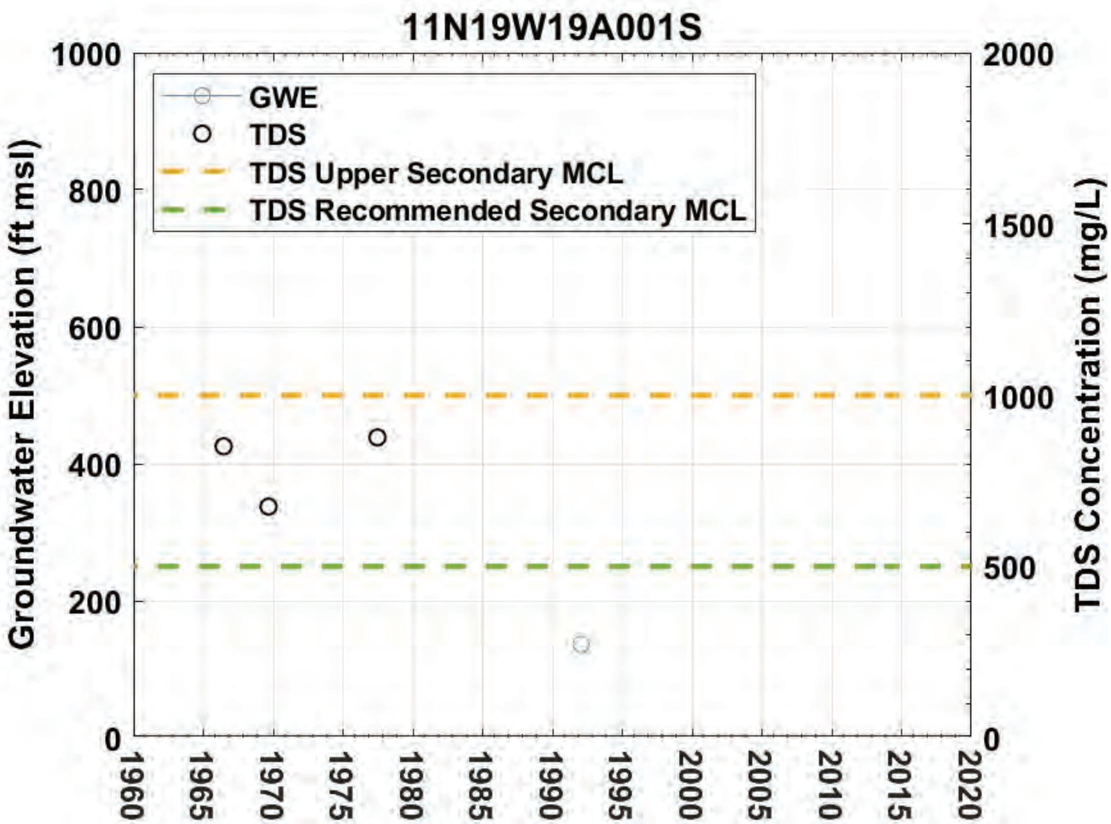

11N19W18H001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W18L001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

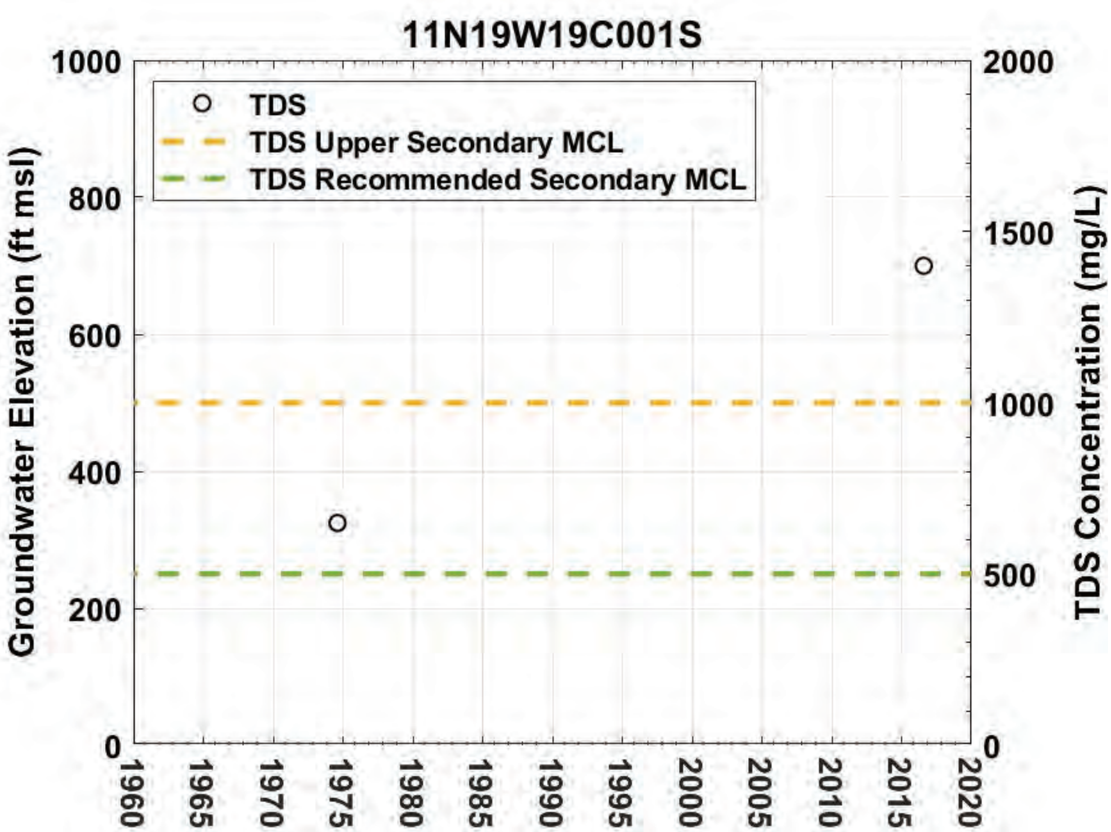

11N19W18N001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W18P001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

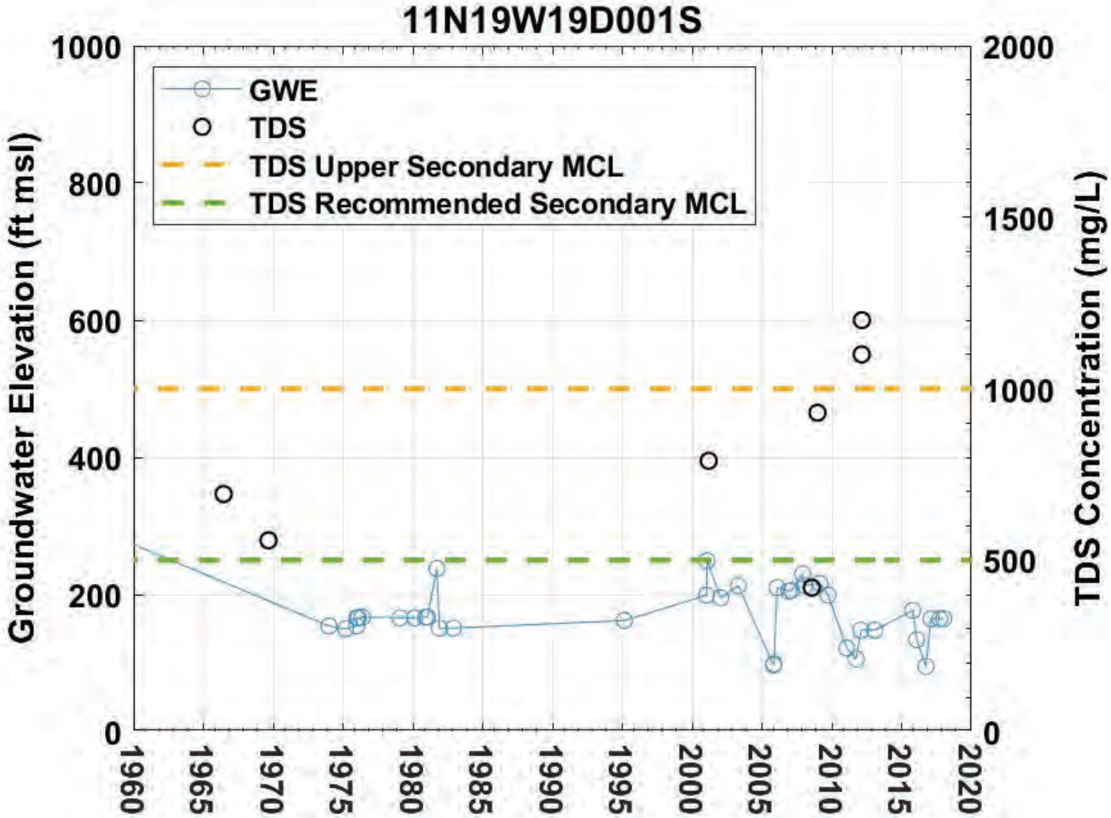

11N19W18R001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



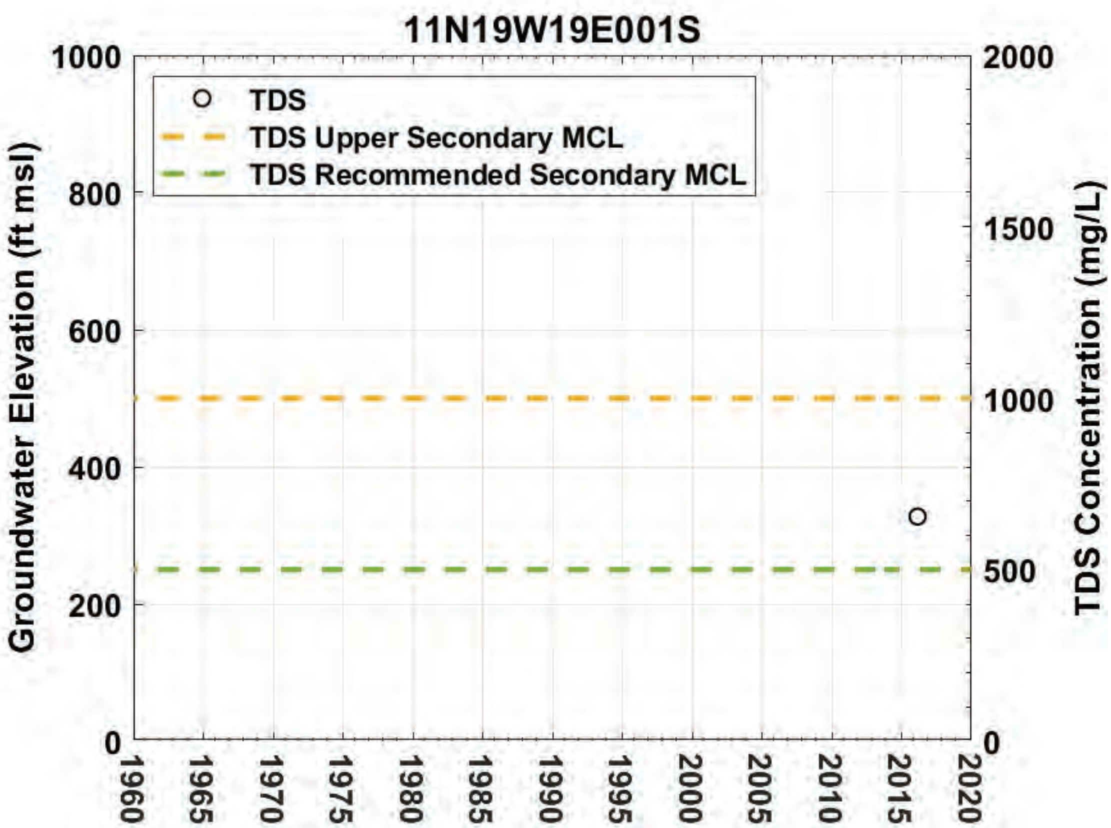
11N19W19A001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



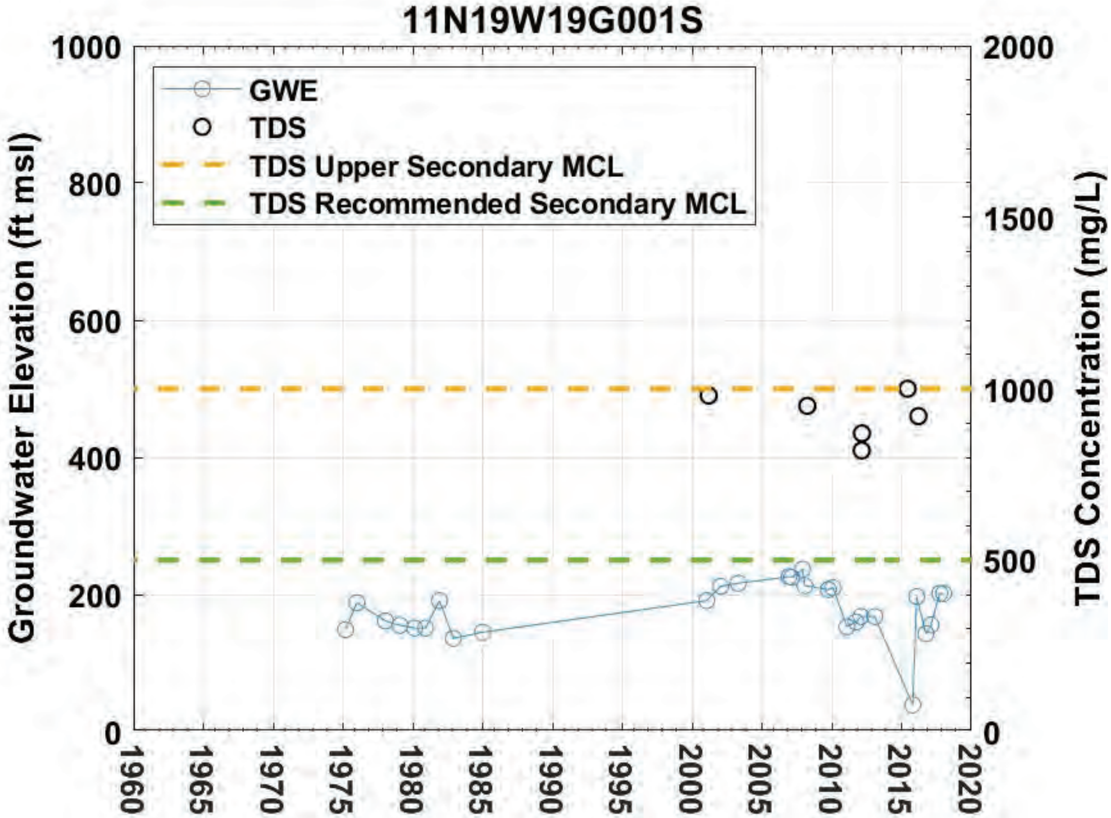
11N19W19C001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

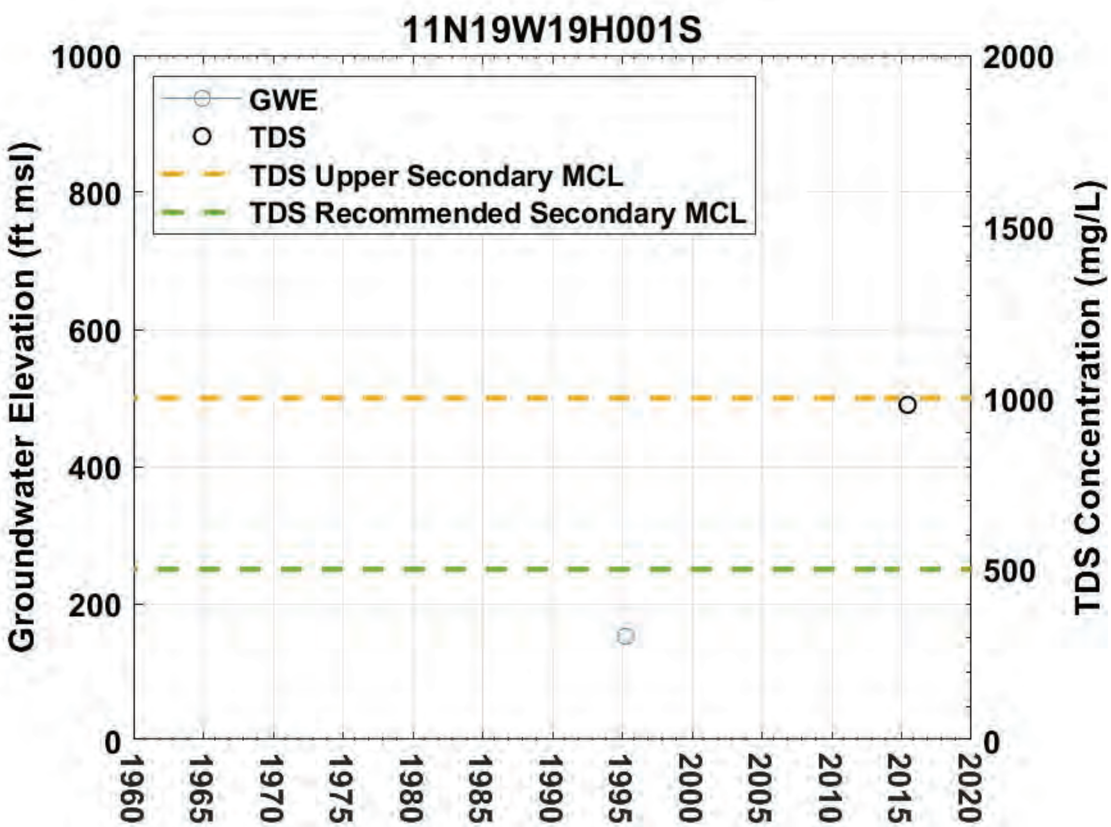


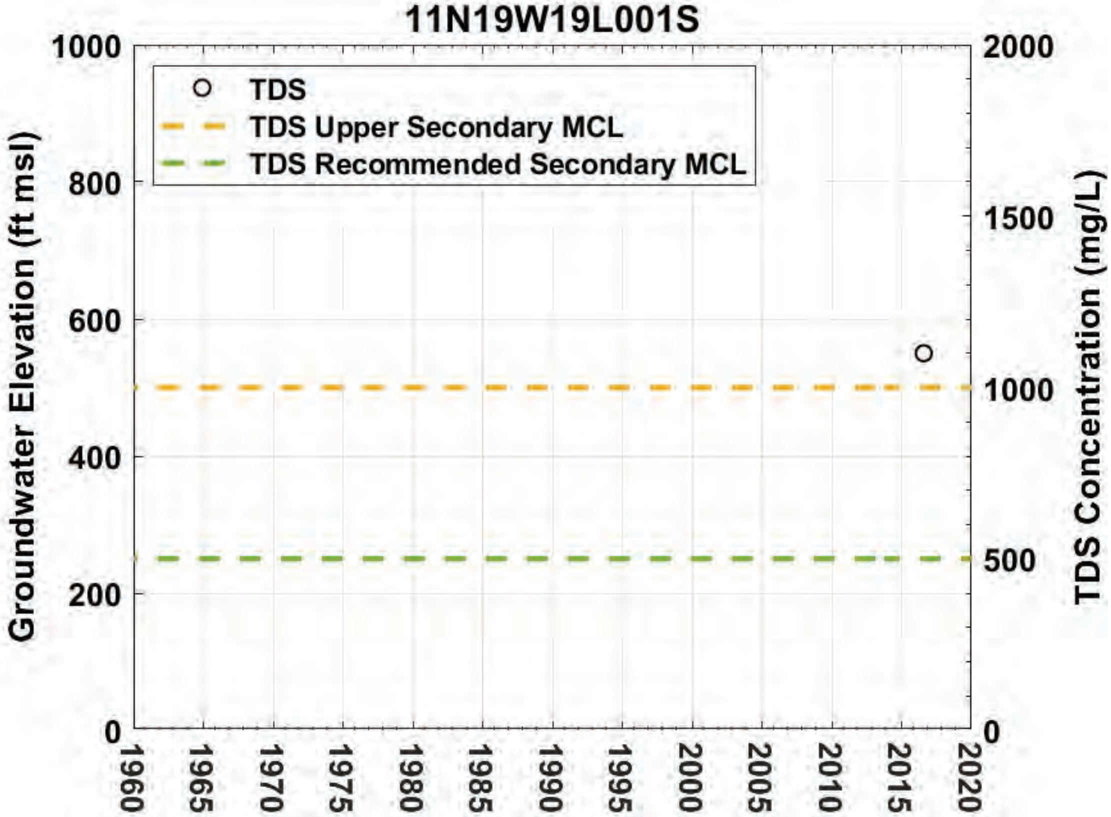
11N19W19D001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)

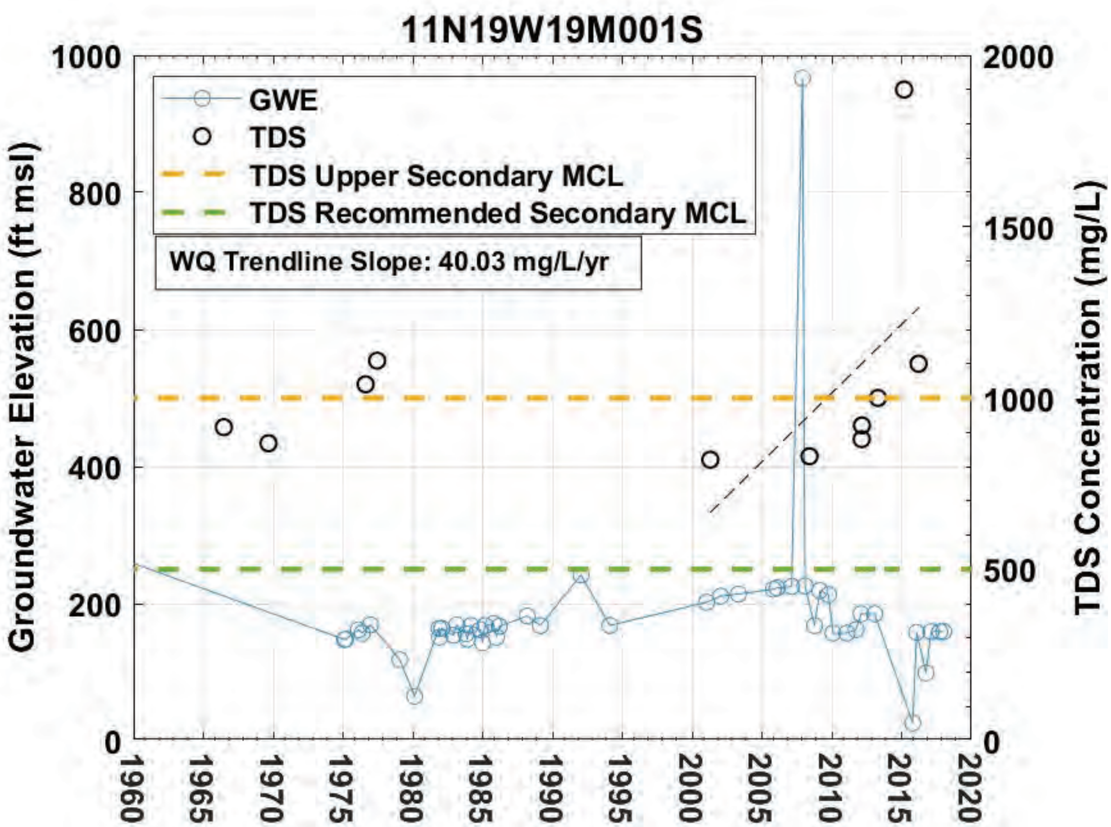


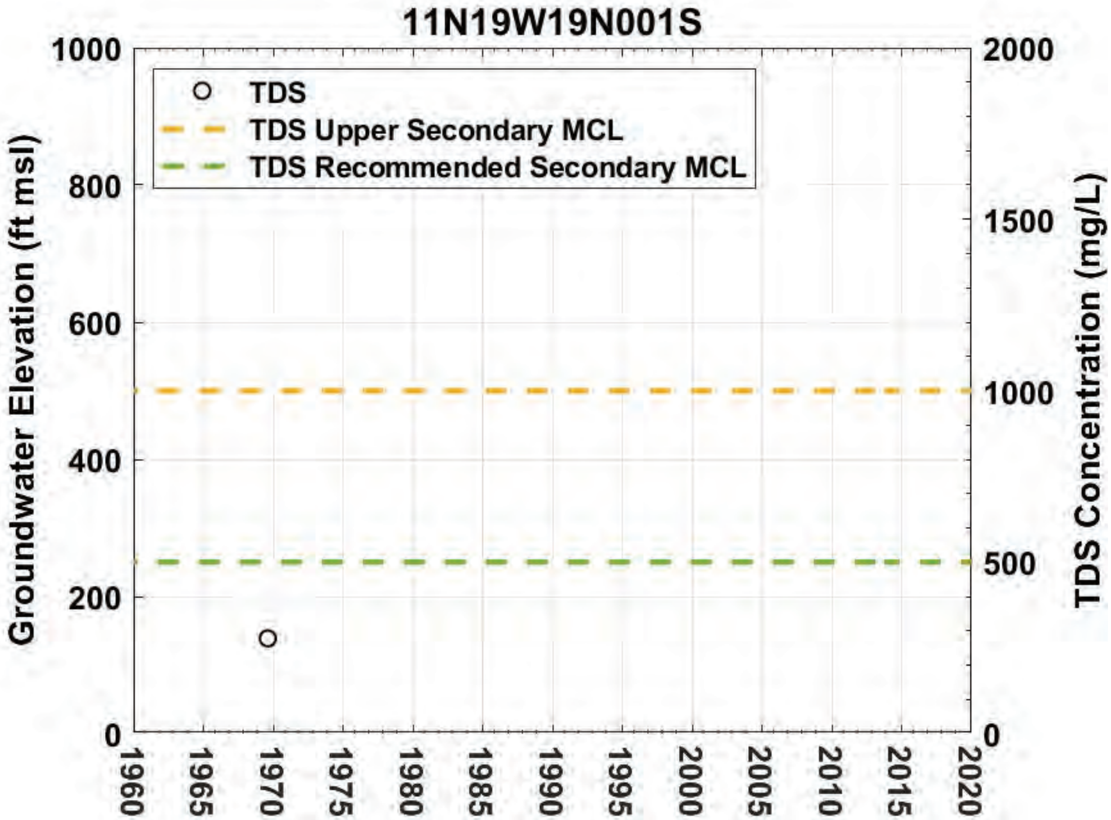
11N19W19E001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)


11N19W19G001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

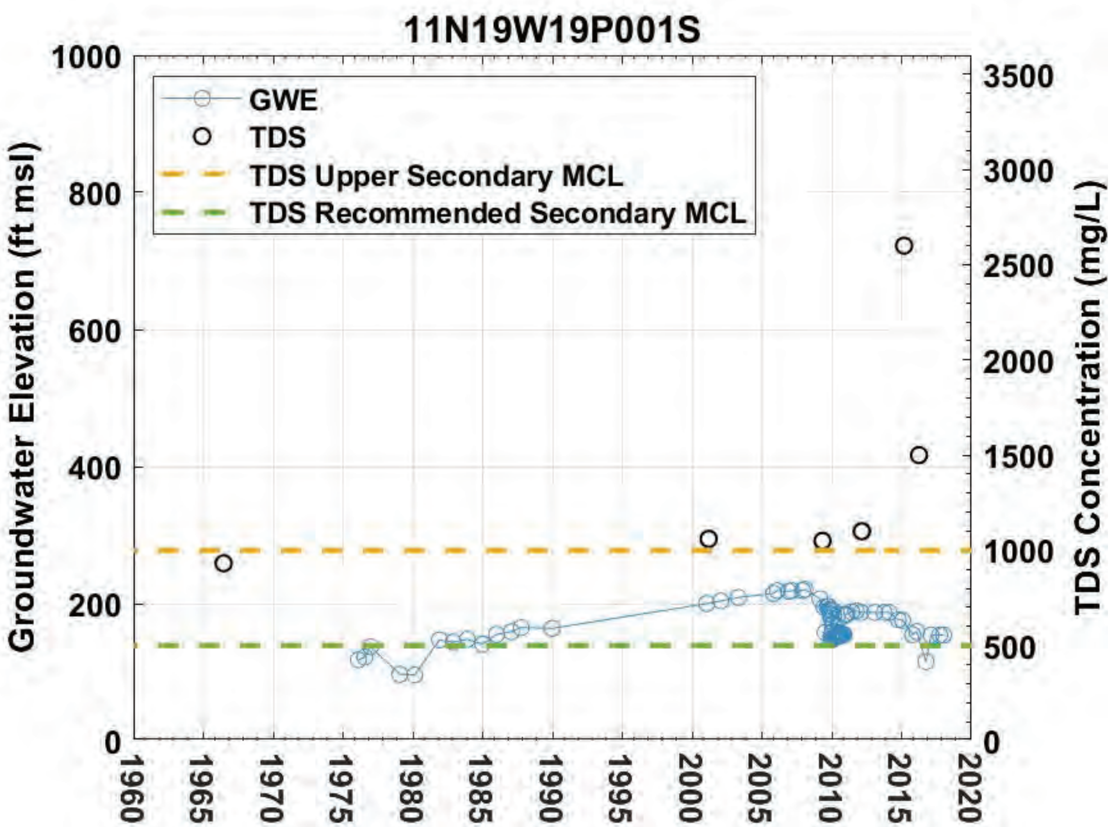

11N19W19H001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W19L001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

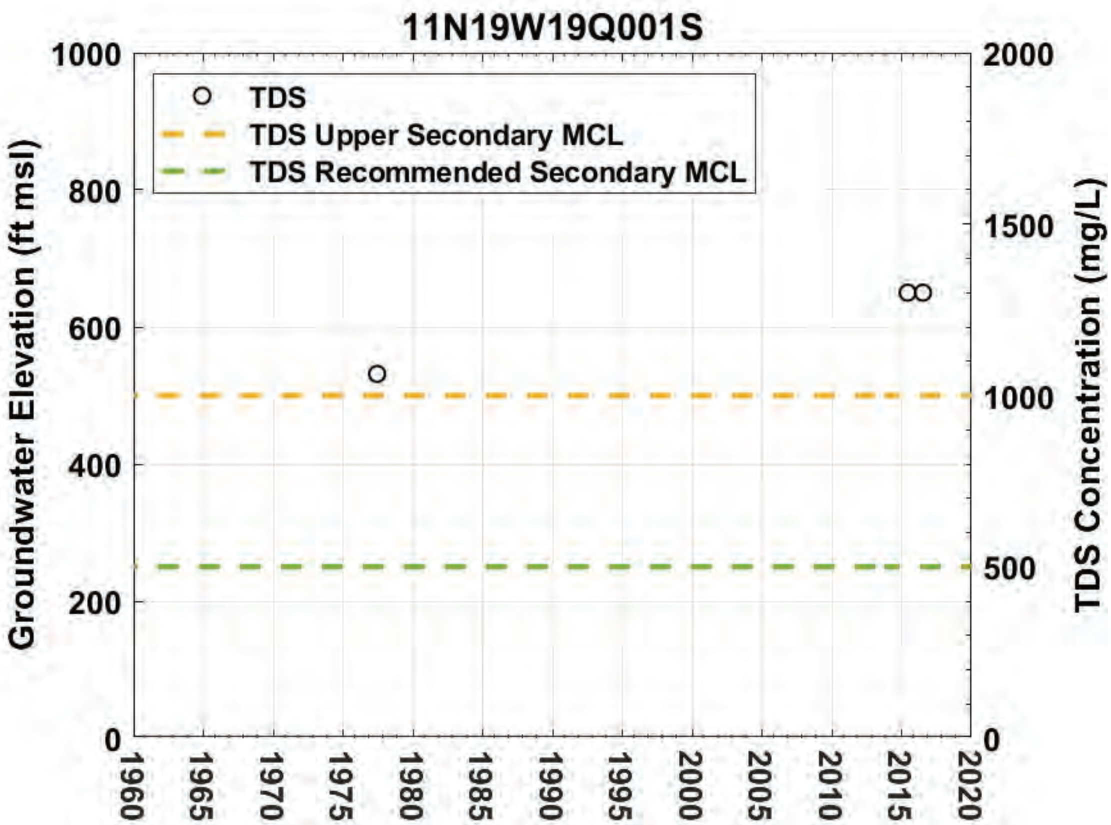

11N19W19M001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
WQ Trendline Slope: 40.03 mg/L/yr
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



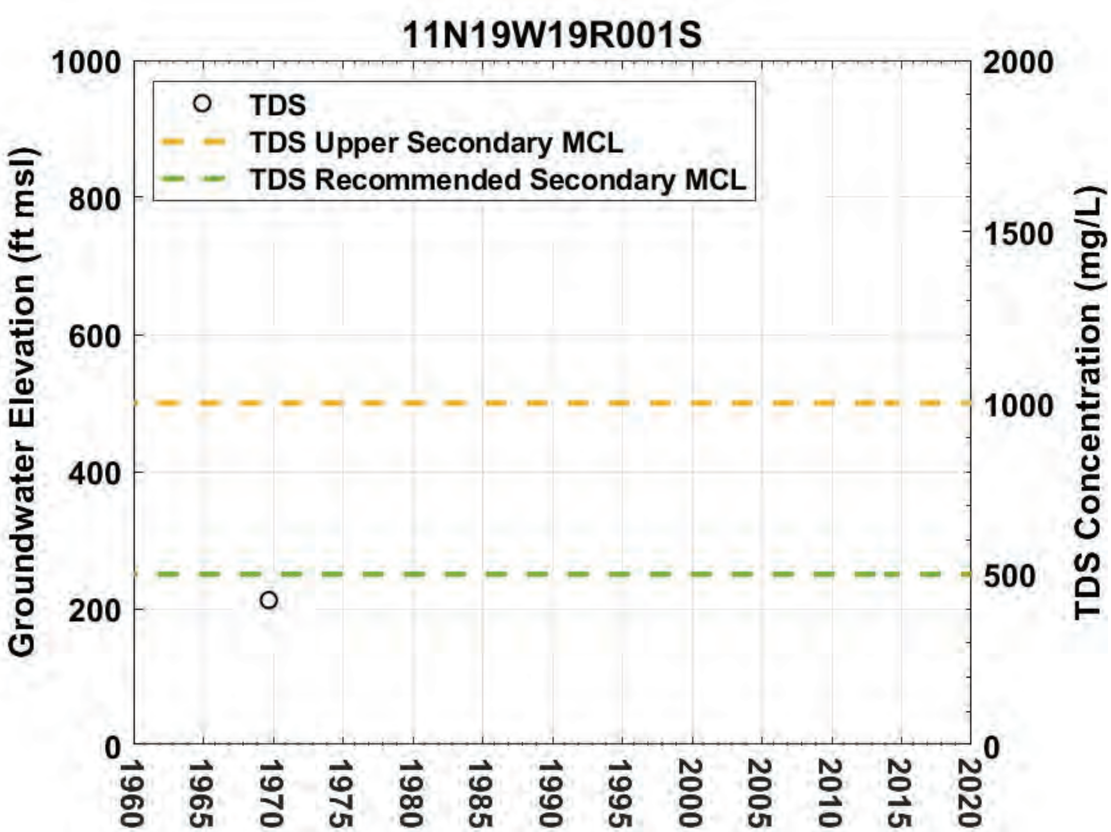
11N19W19N001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



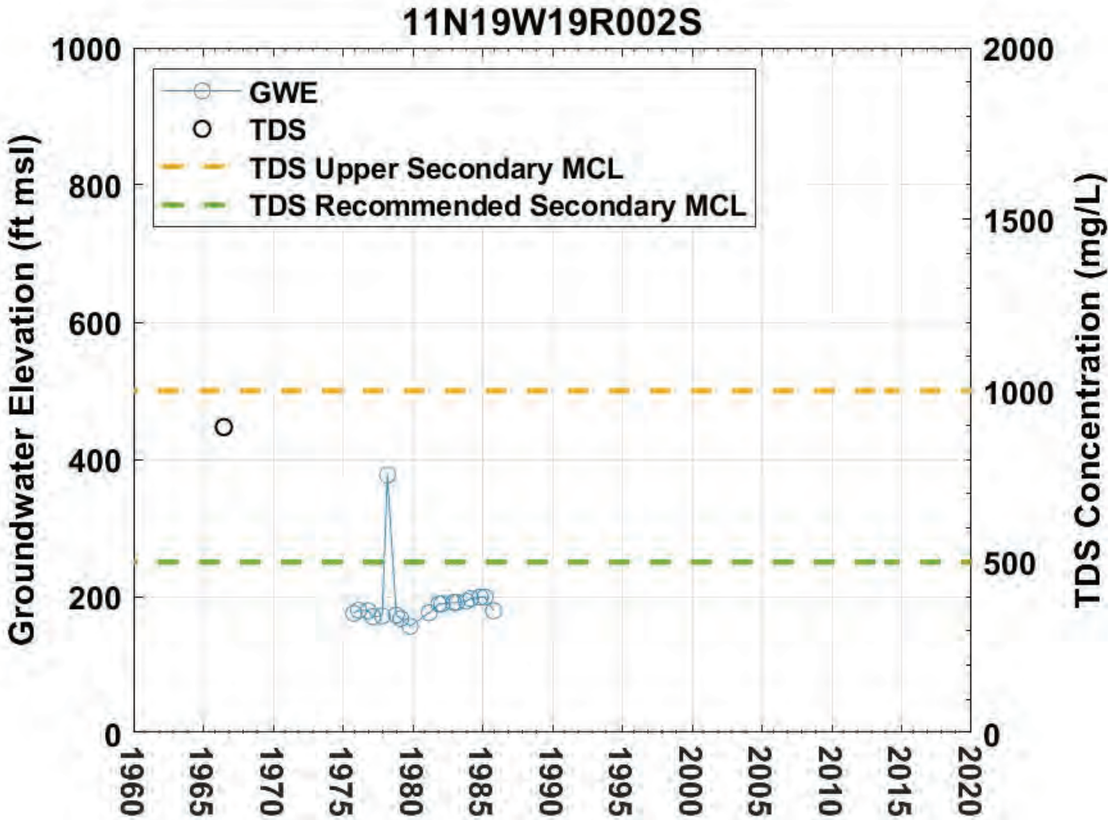
11N19W19P001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
2500
3000
3500
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

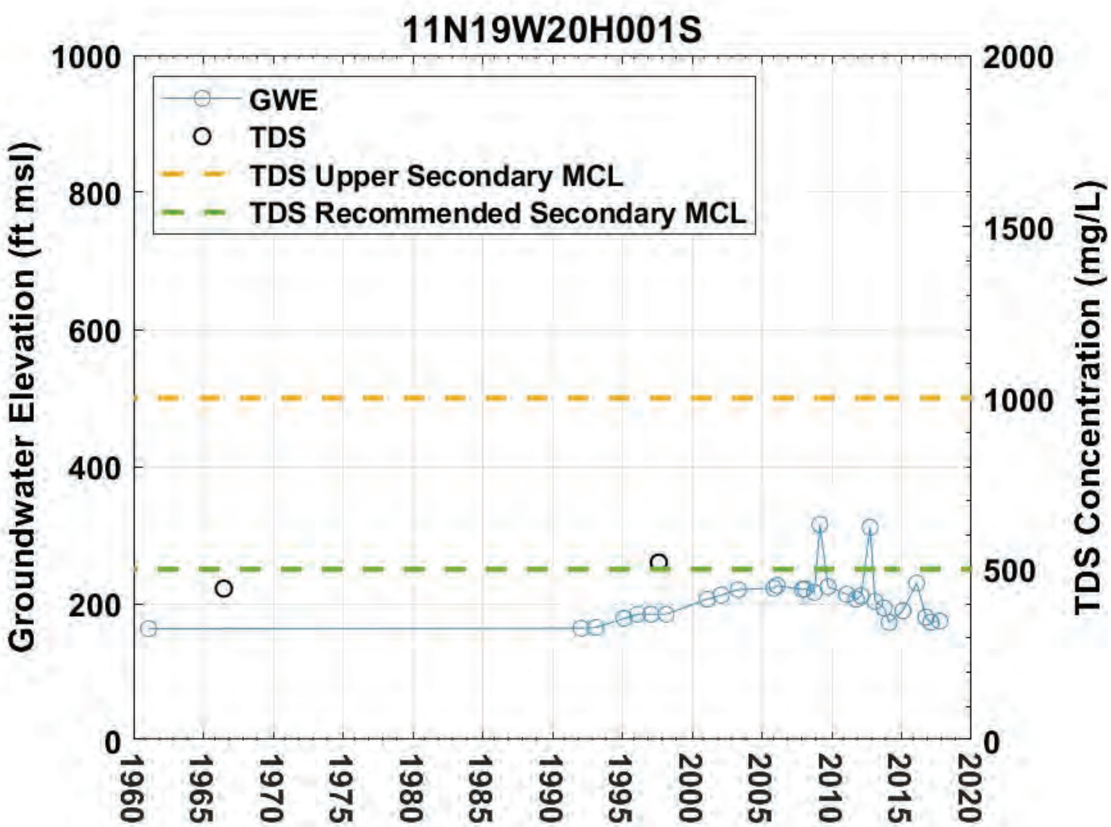


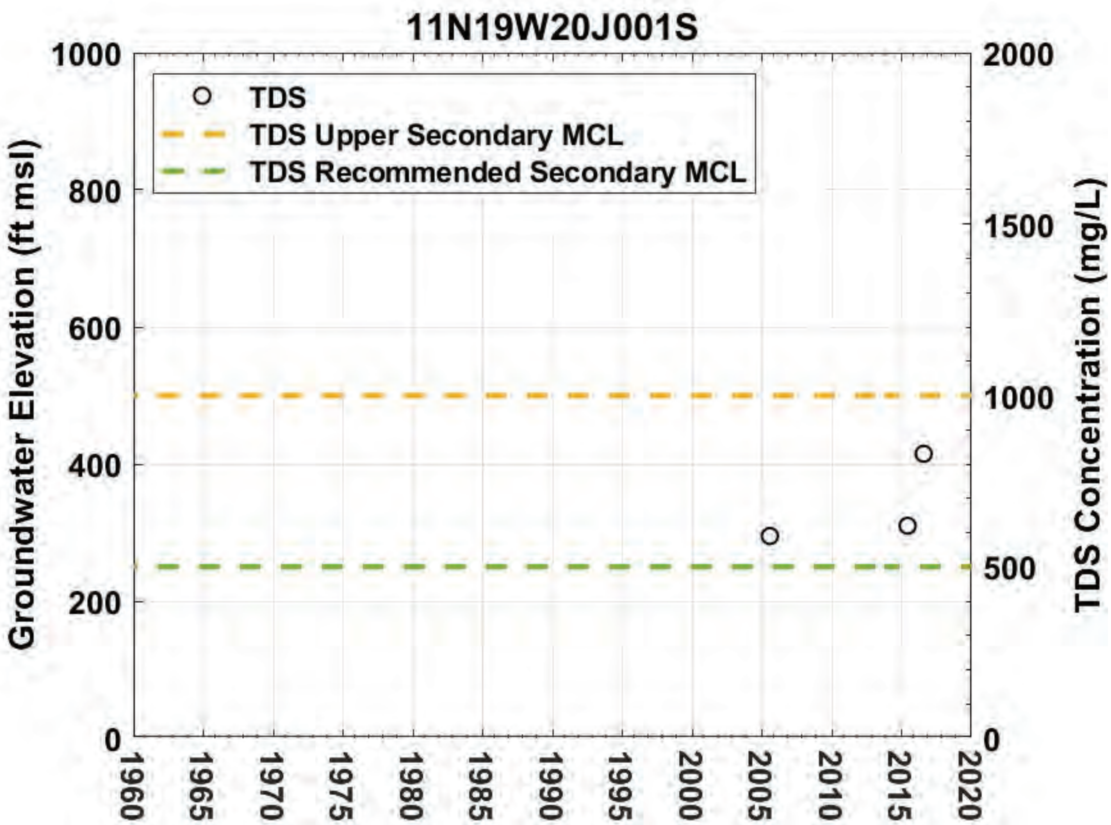
11N19W19Q001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

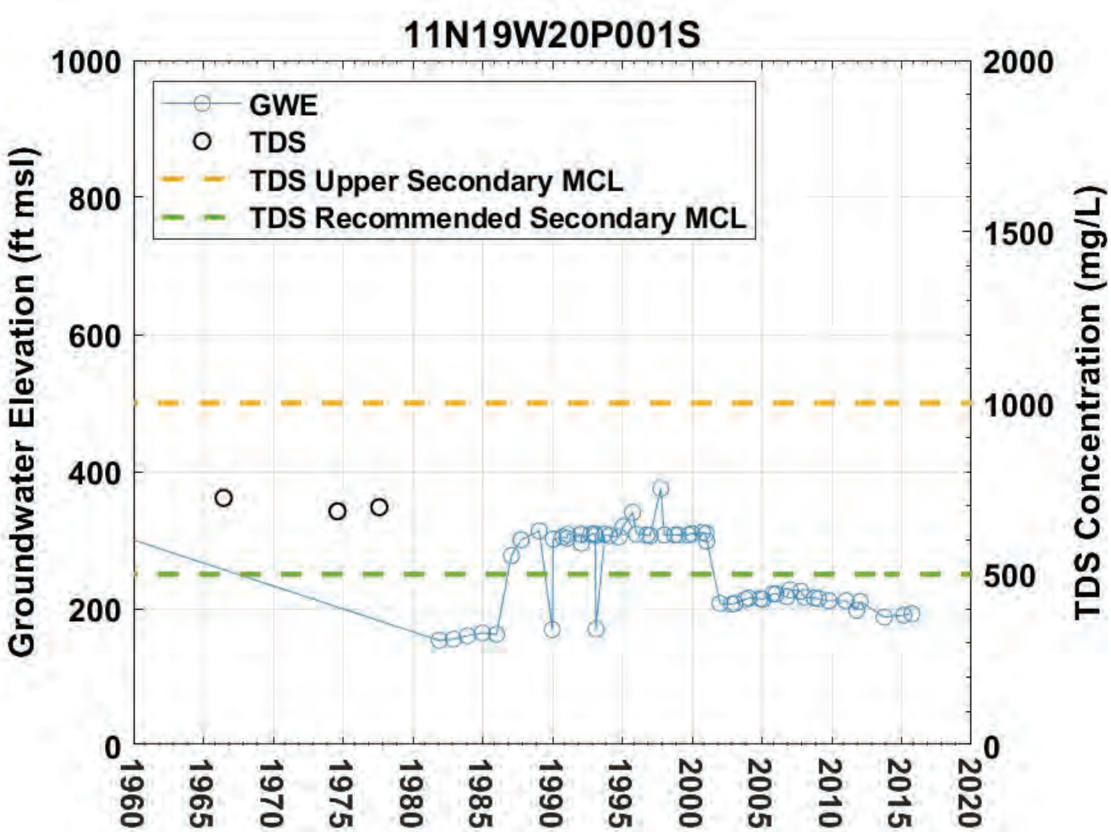


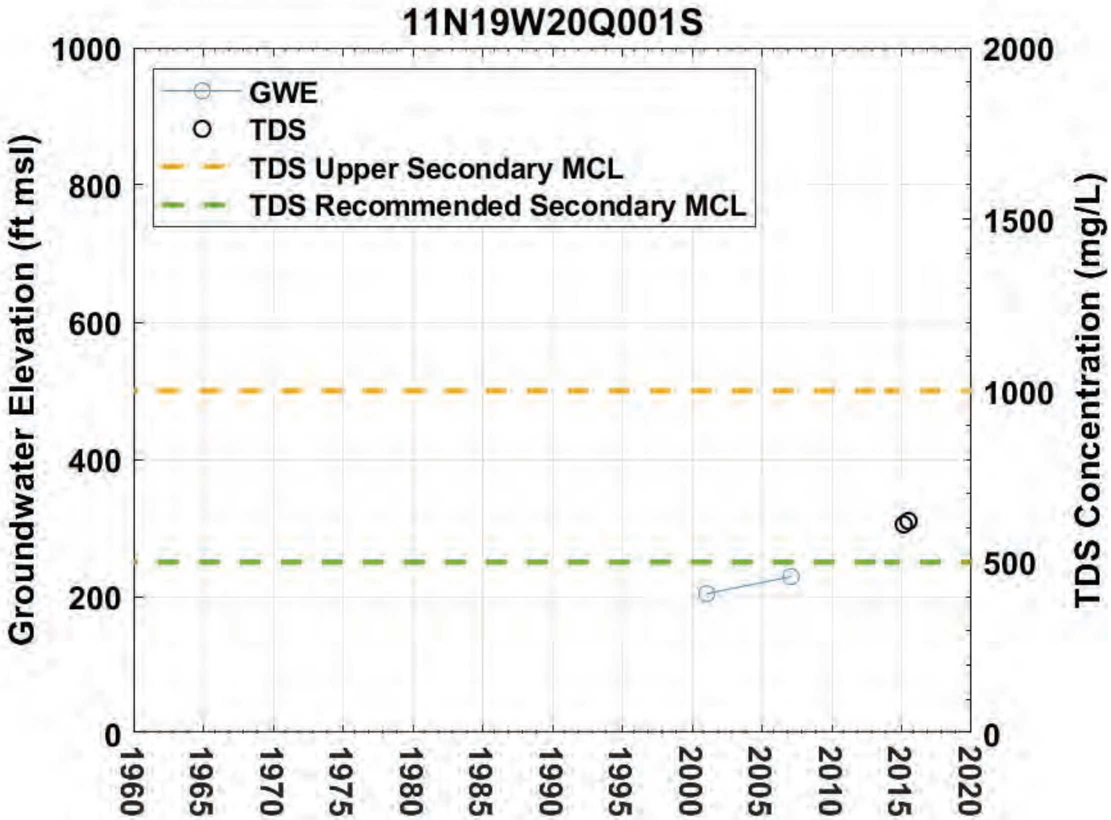
11N19W19R001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W19R002S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

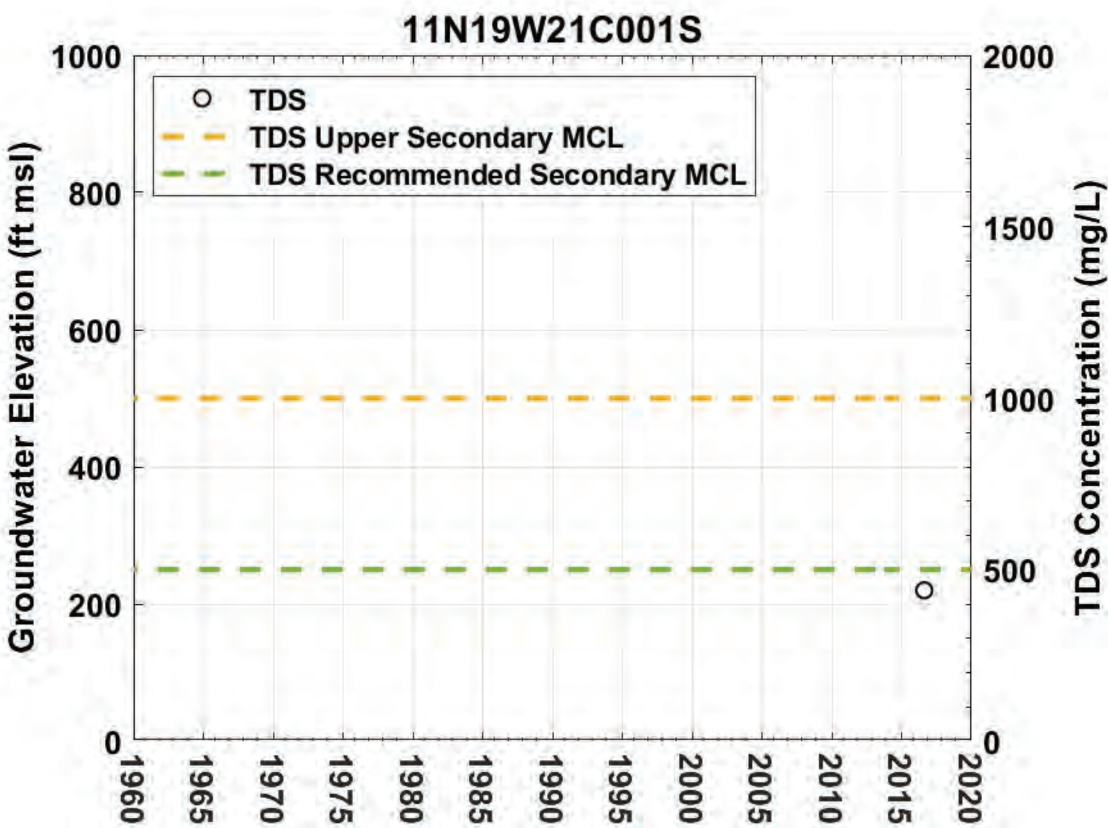

11N19W20H001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W20J001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

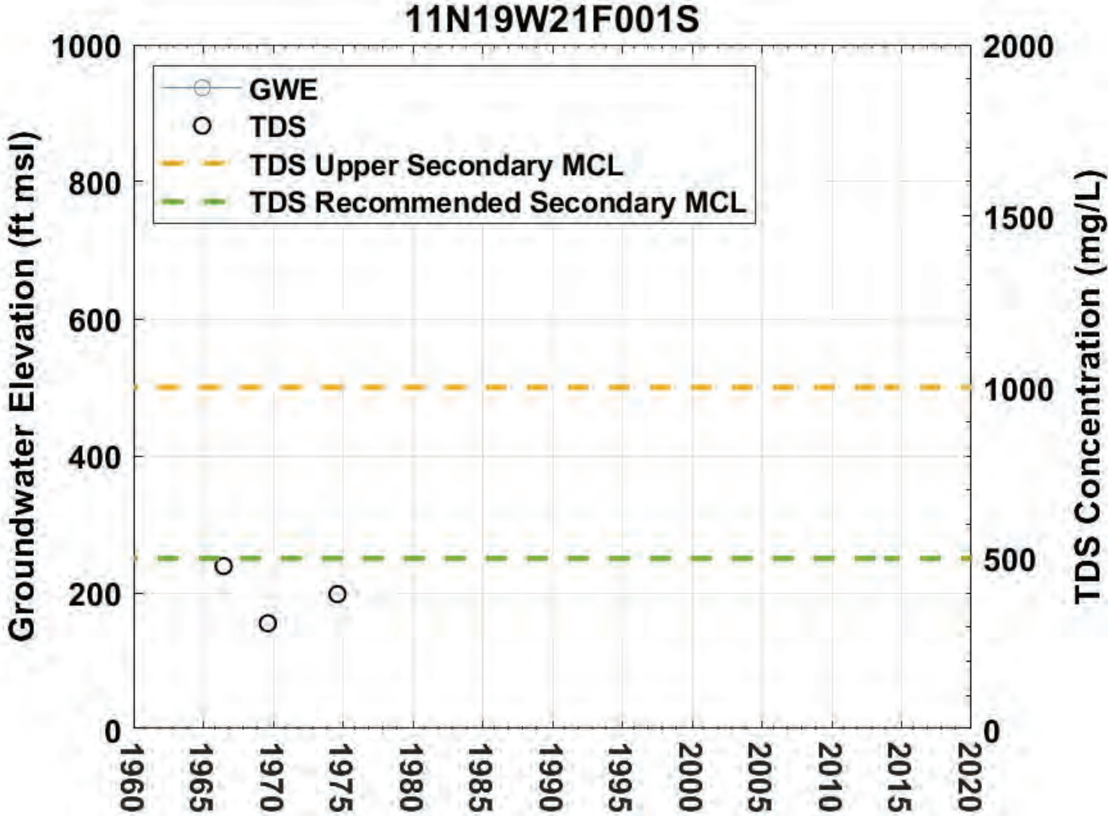

11N19W20P001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

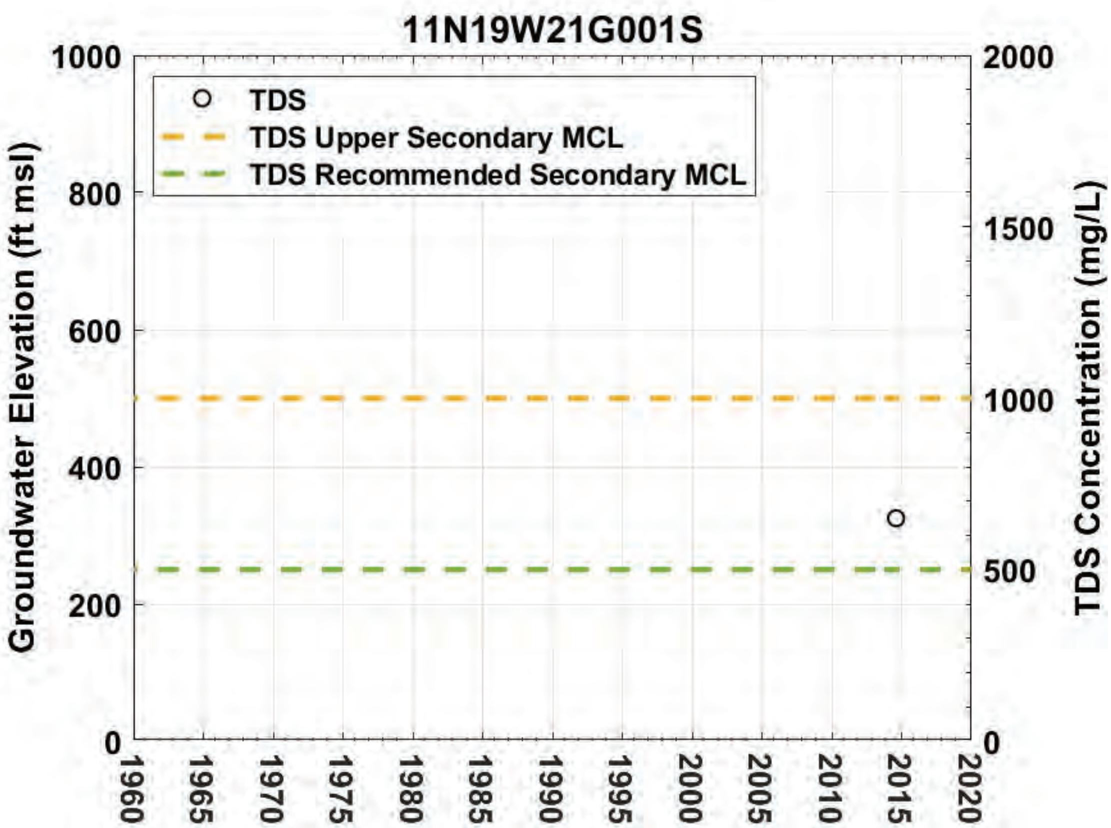


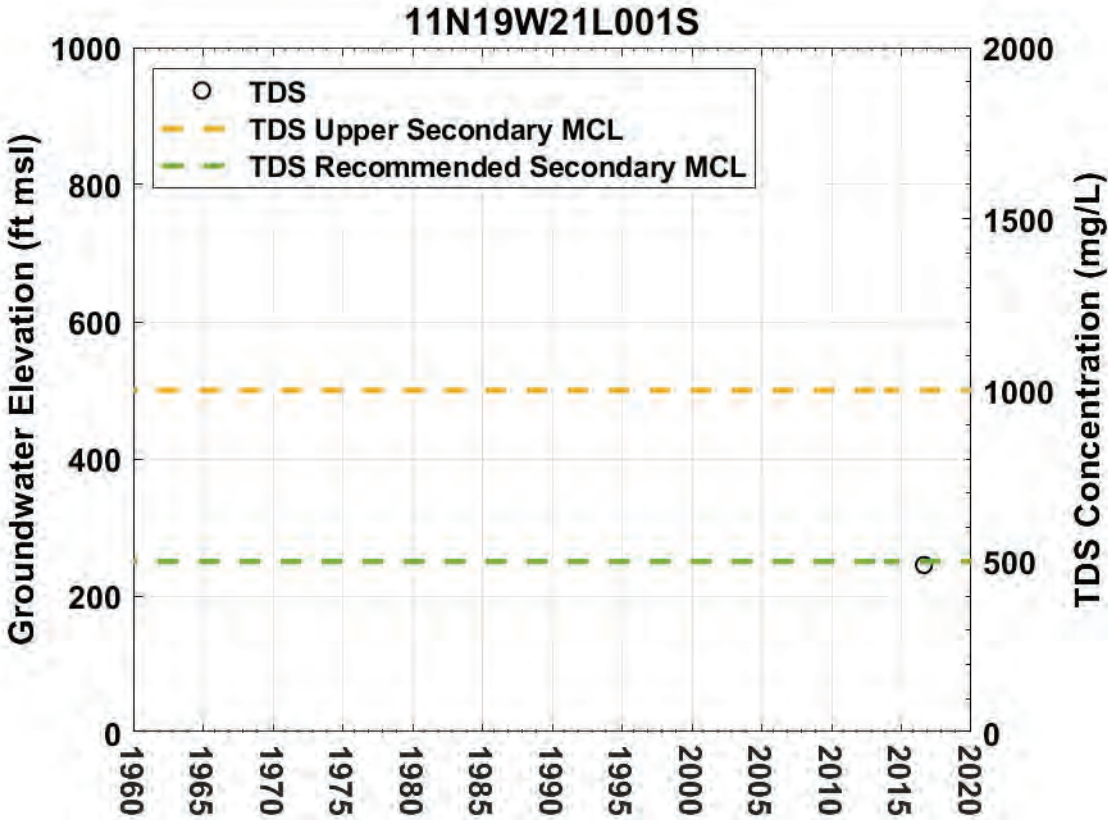
11N19W20Q001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



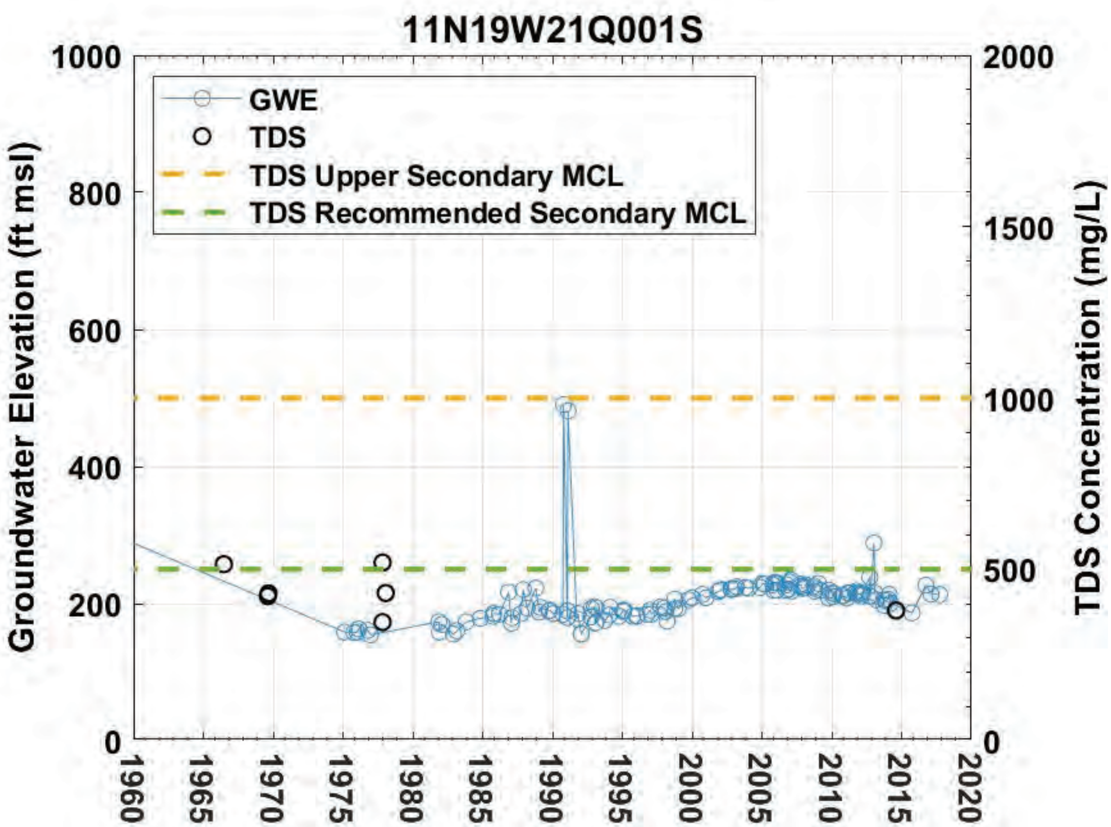
11N19W21C001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W21F001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

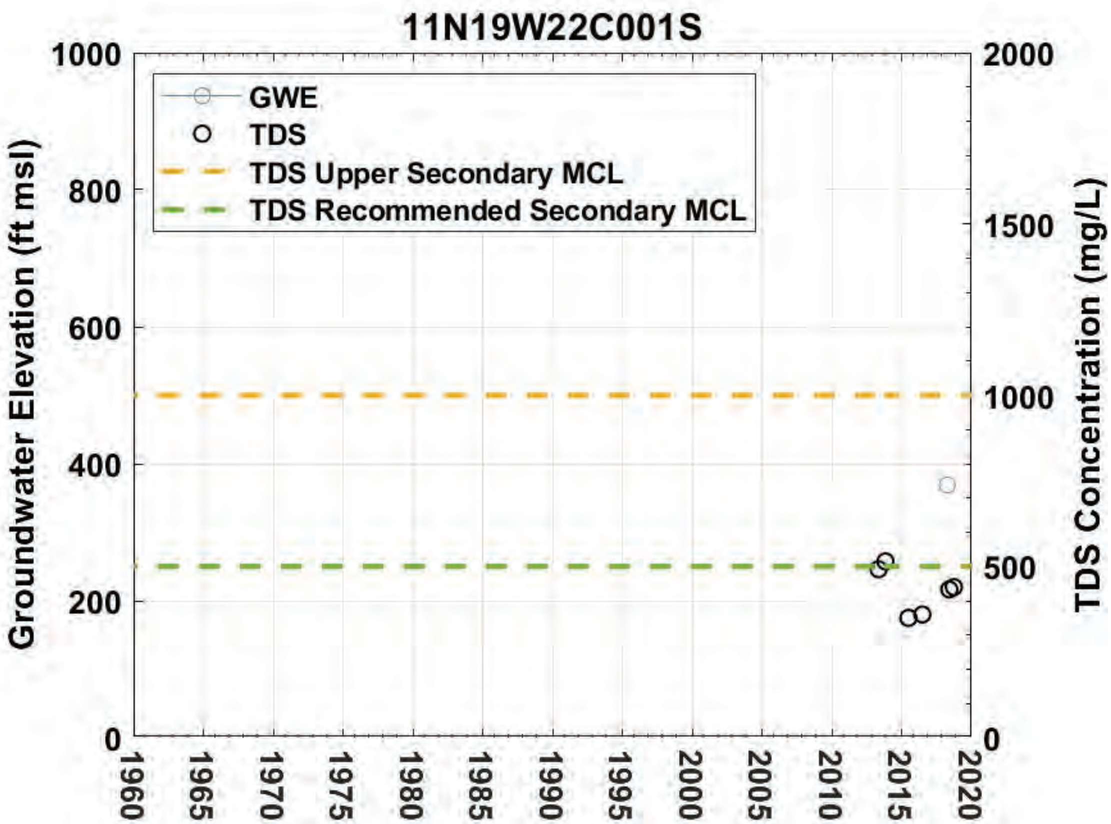

11N19W21G001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

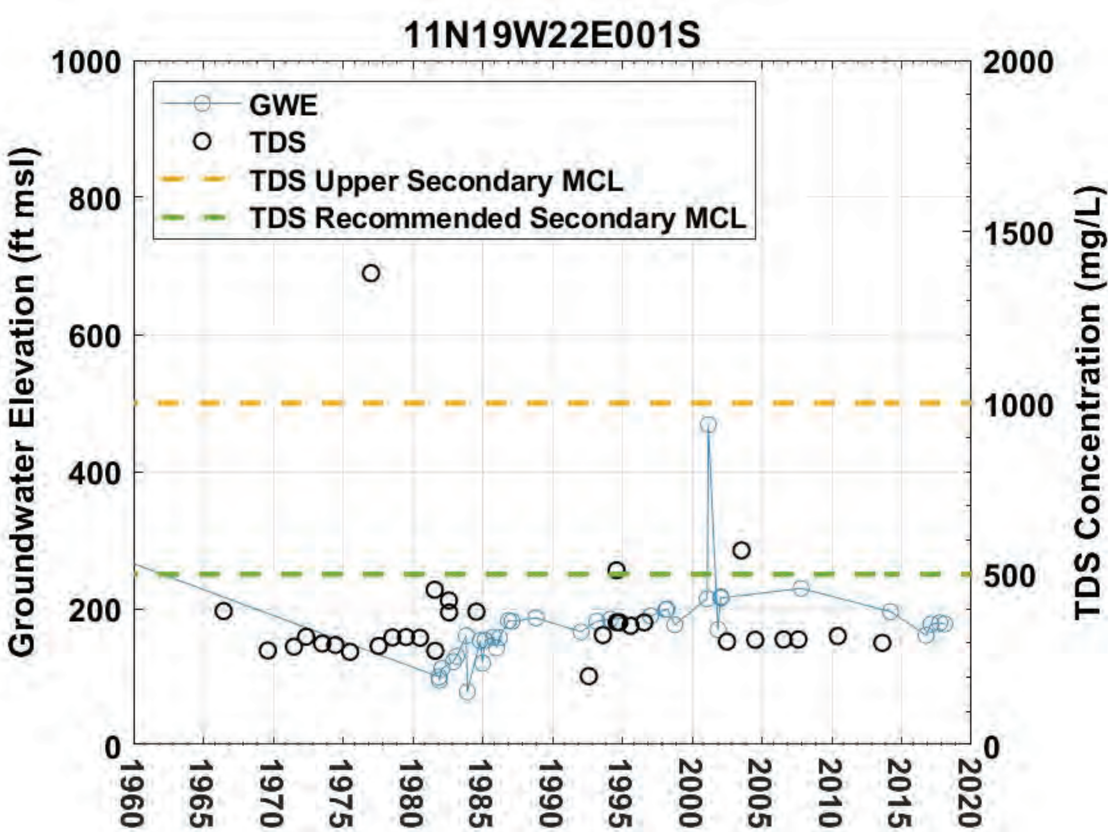


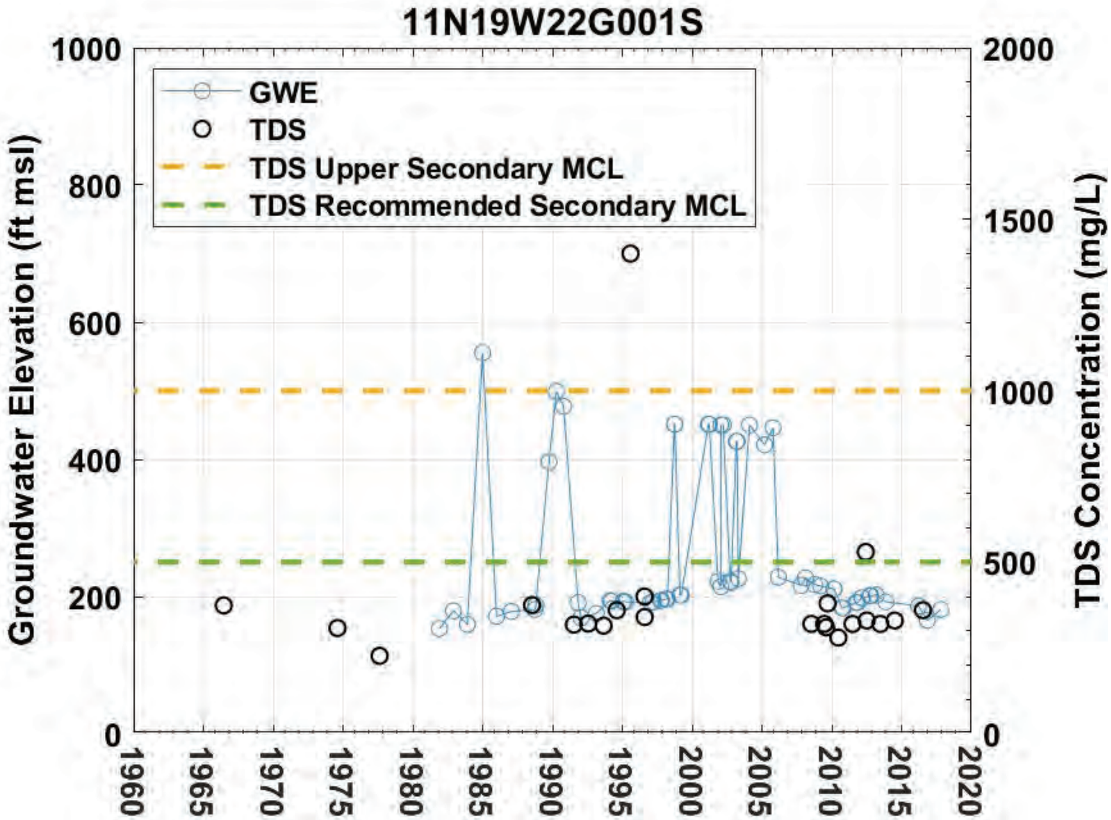
11N19W21L001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

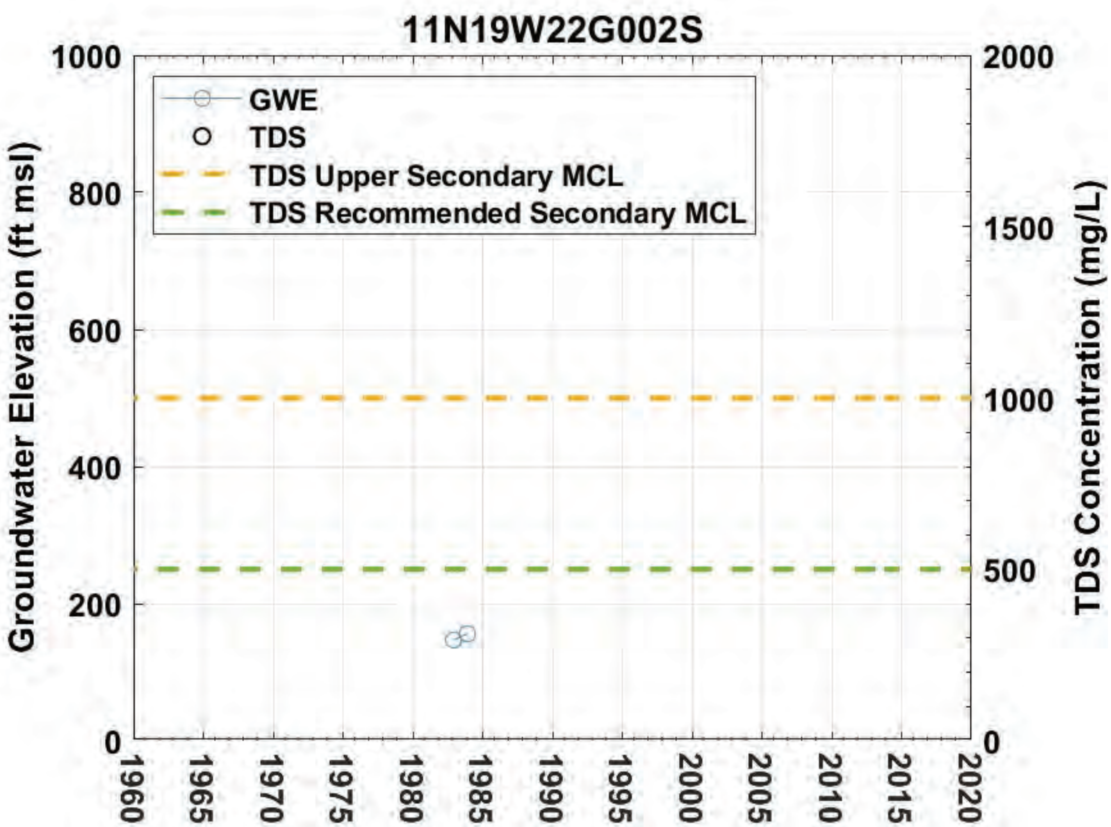


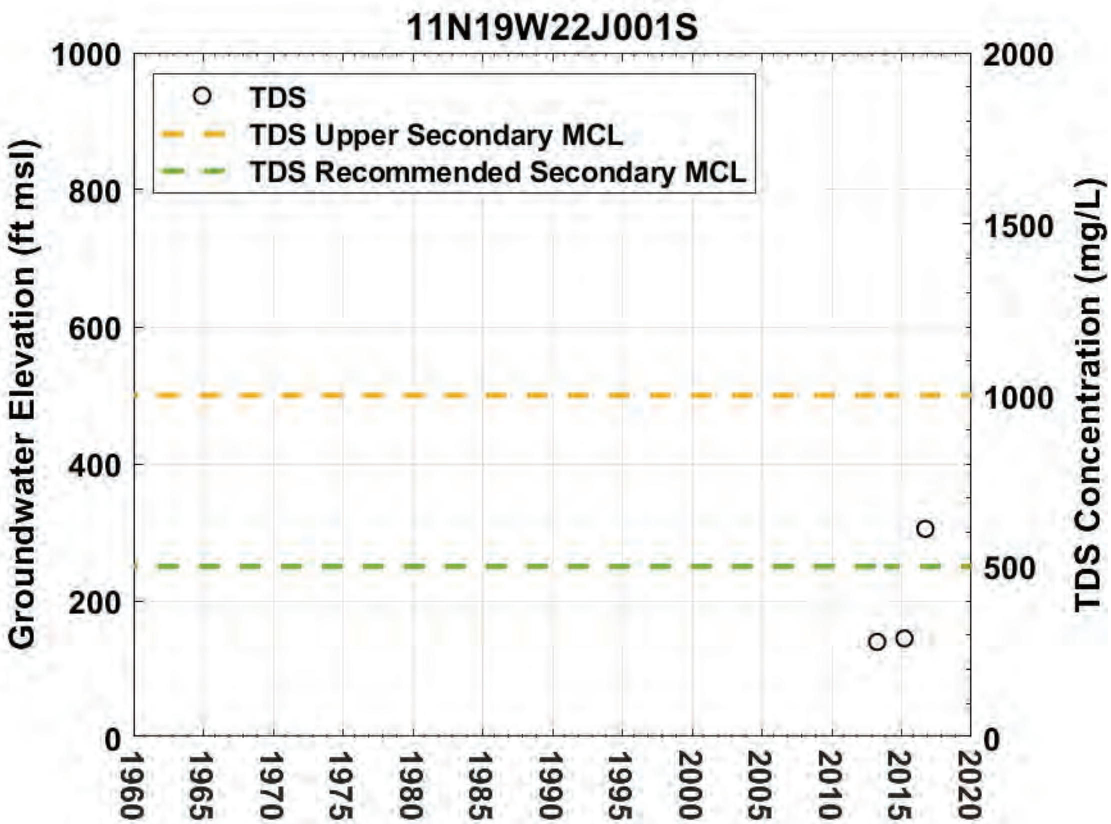
11N19W21Q001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

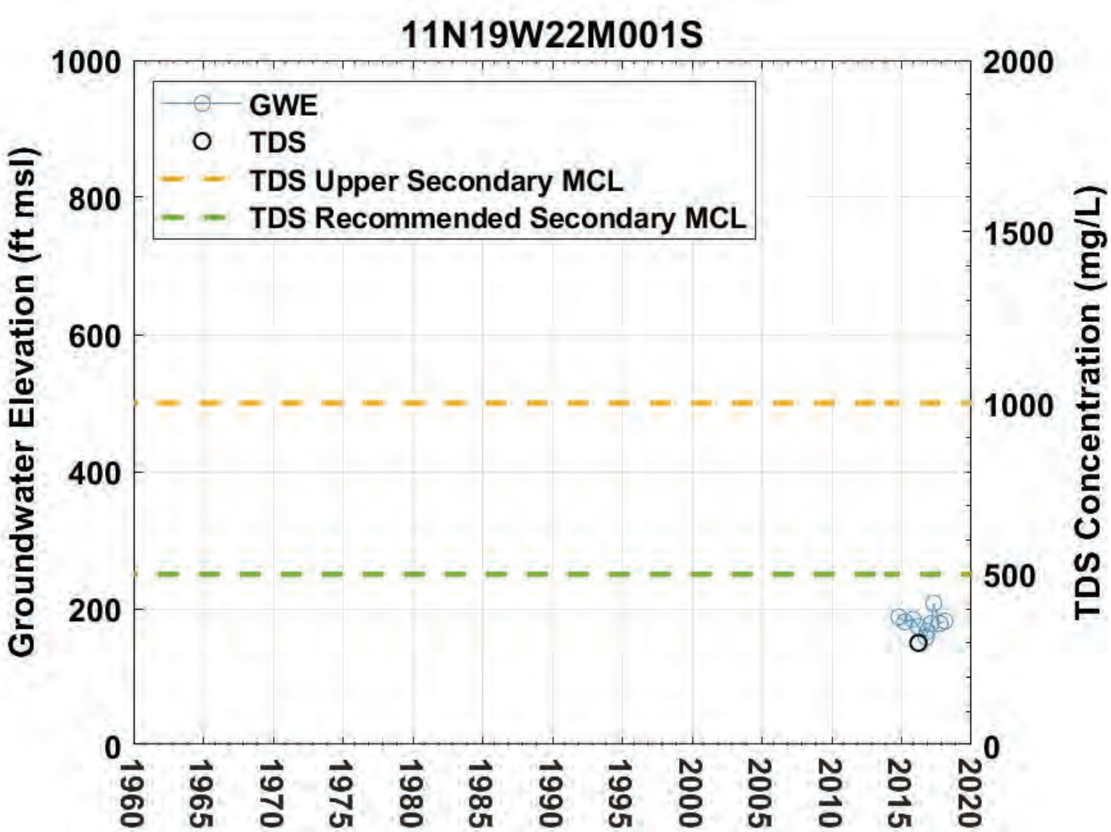

11N19W22C001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

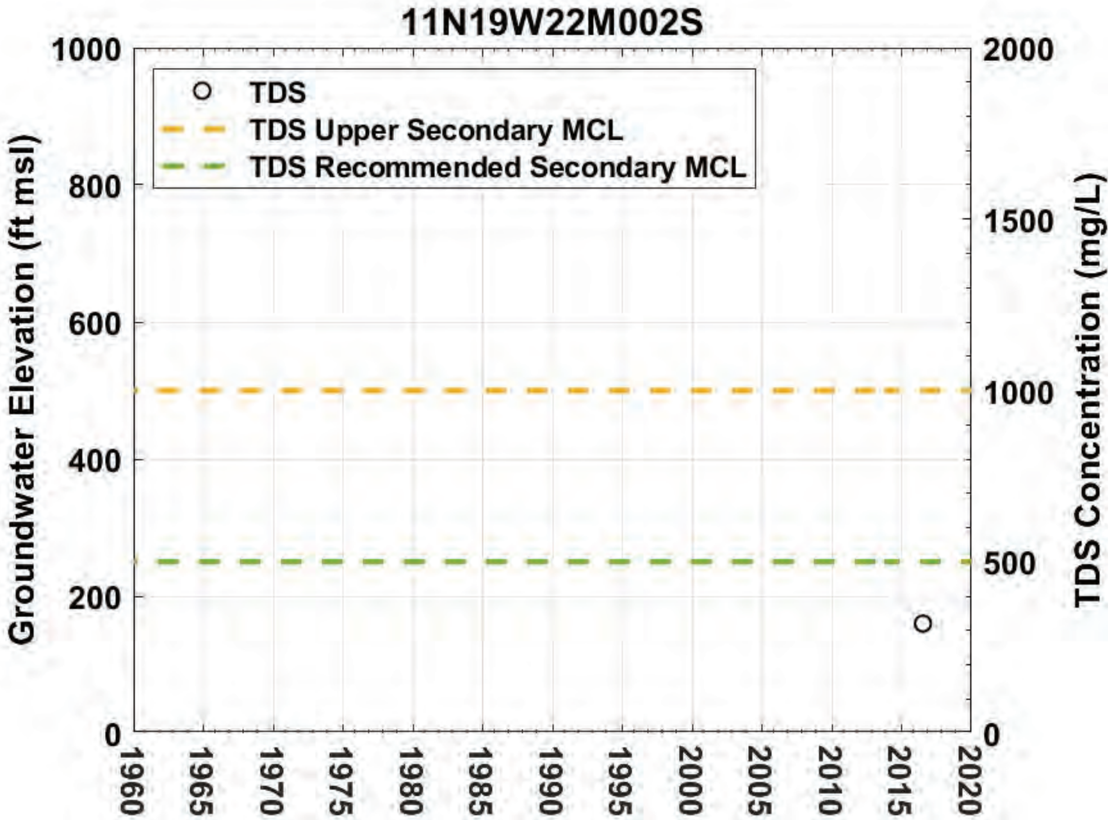

11N19W22E001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

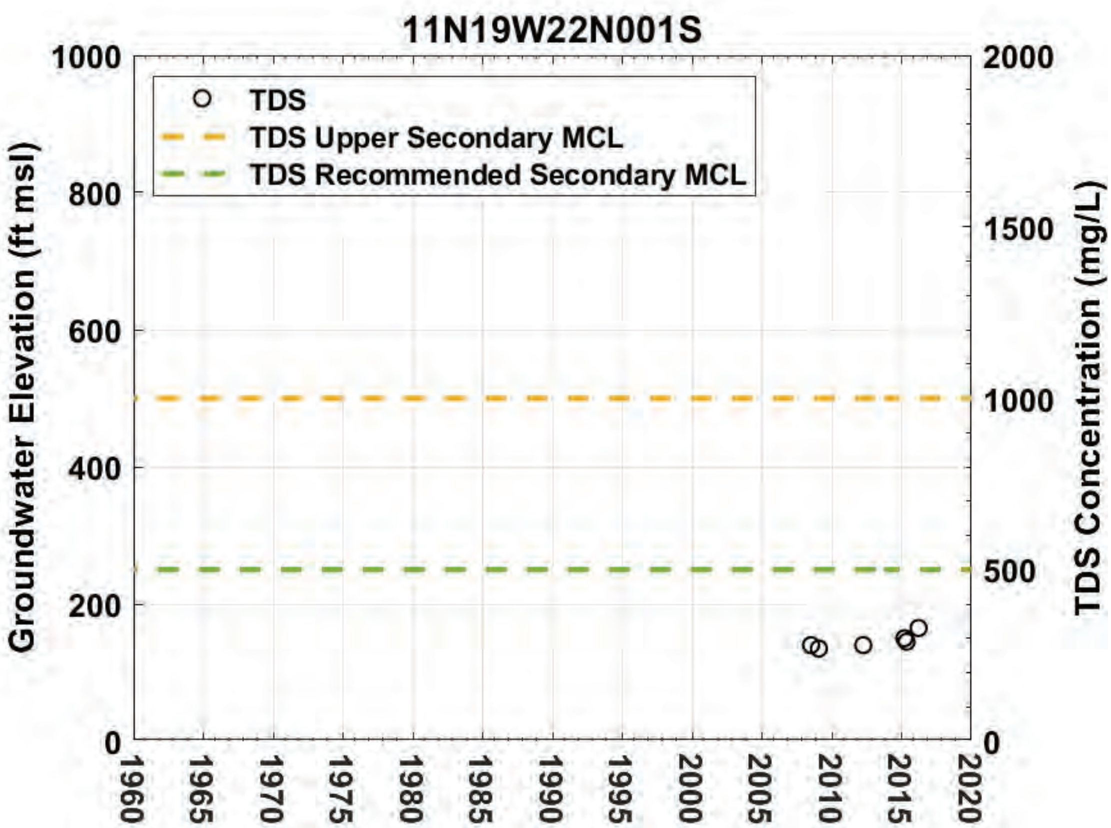

11N19W22G001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

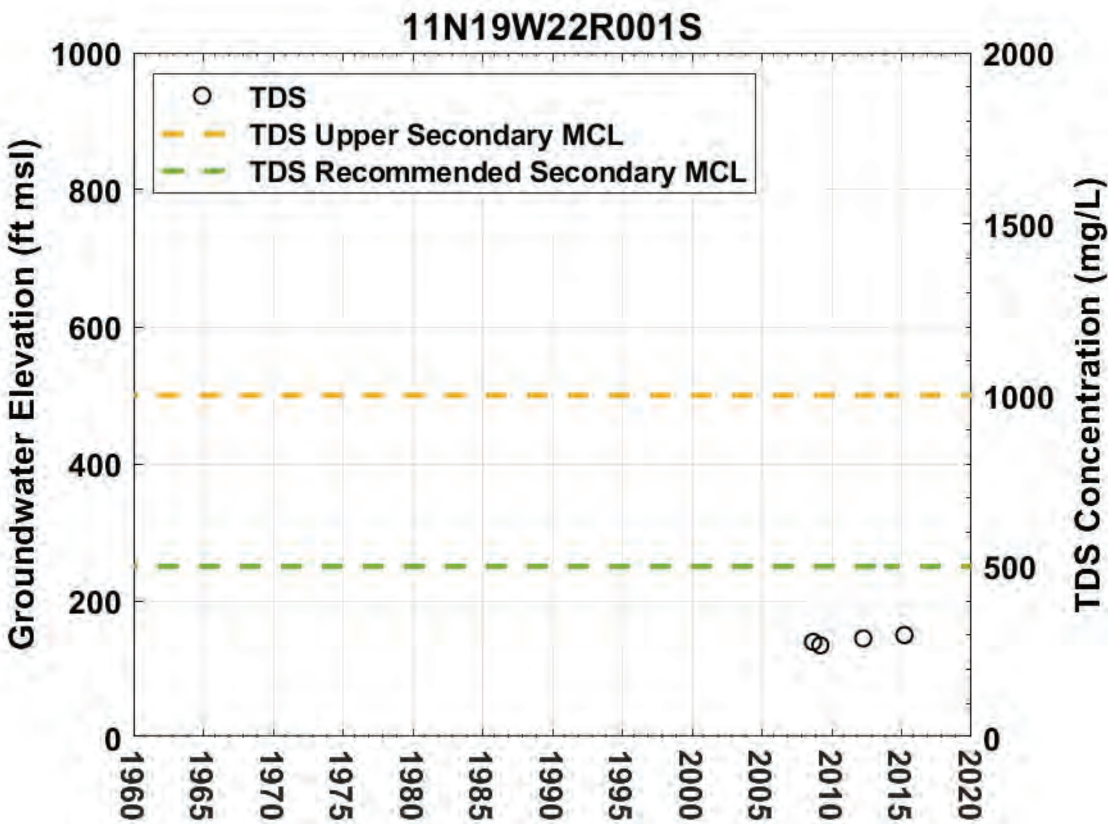

11N19W22G002S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

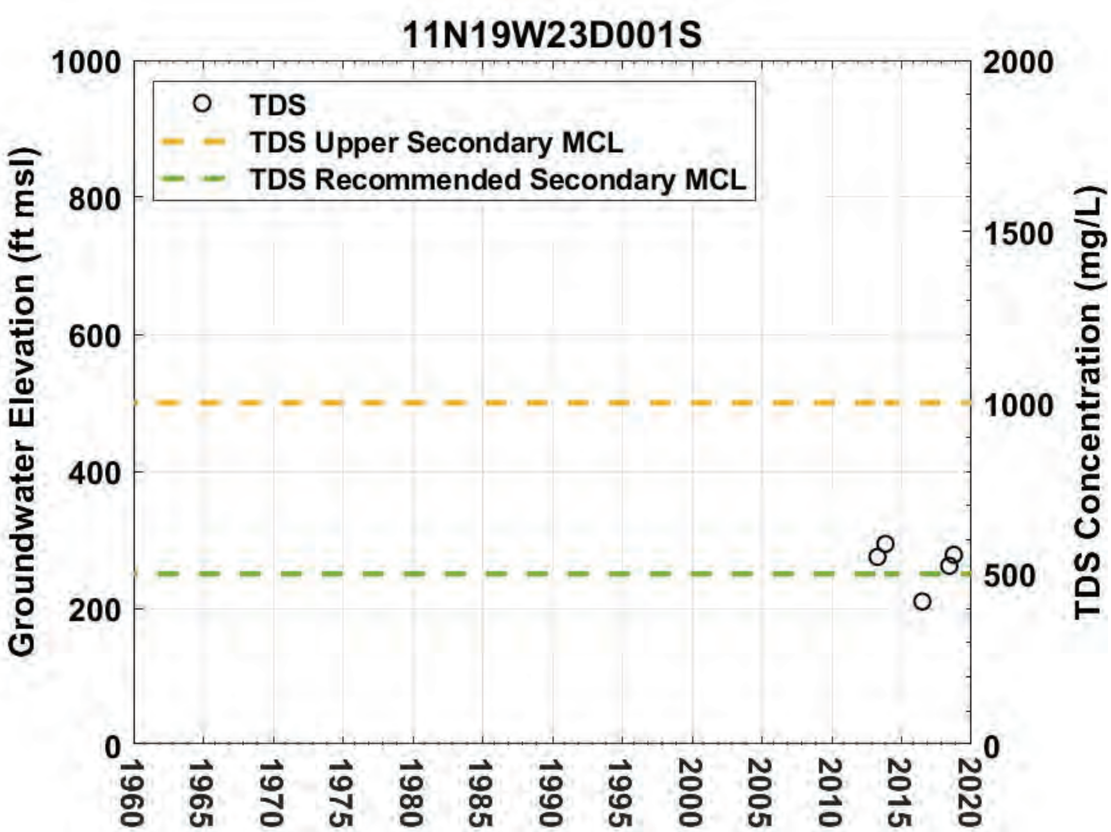

11N19W22J001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

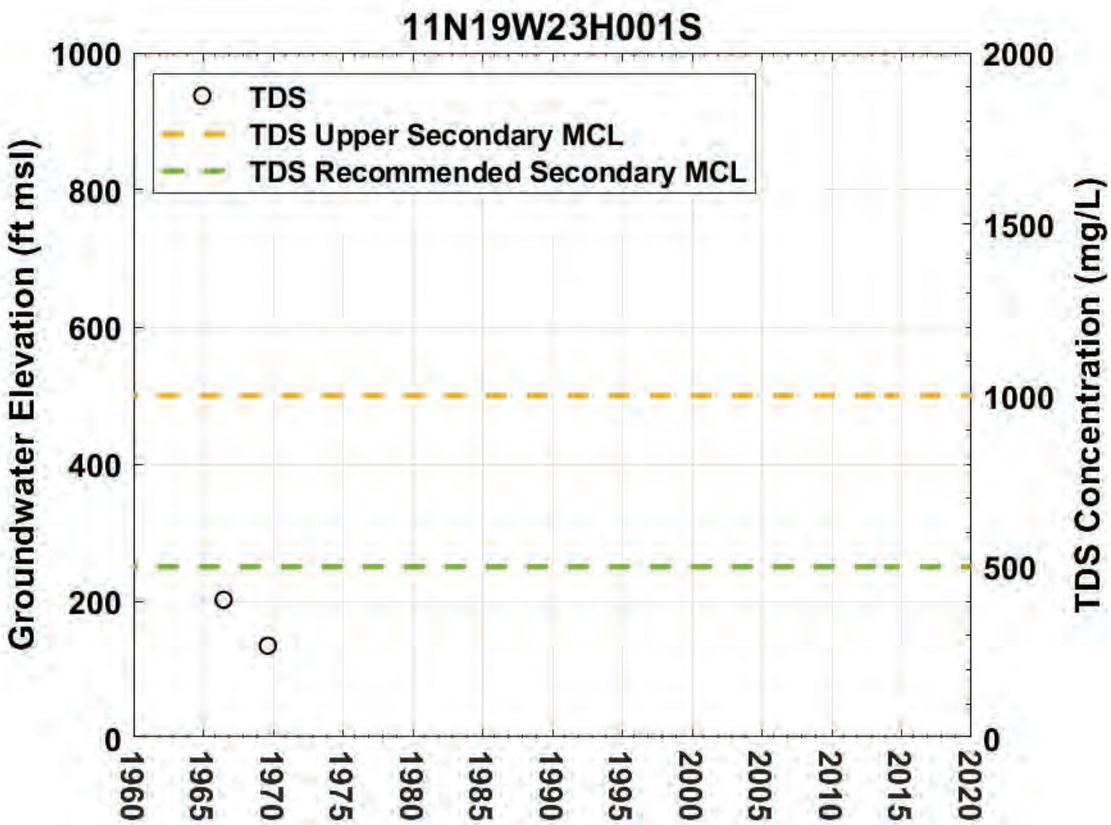

11N19W22M001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

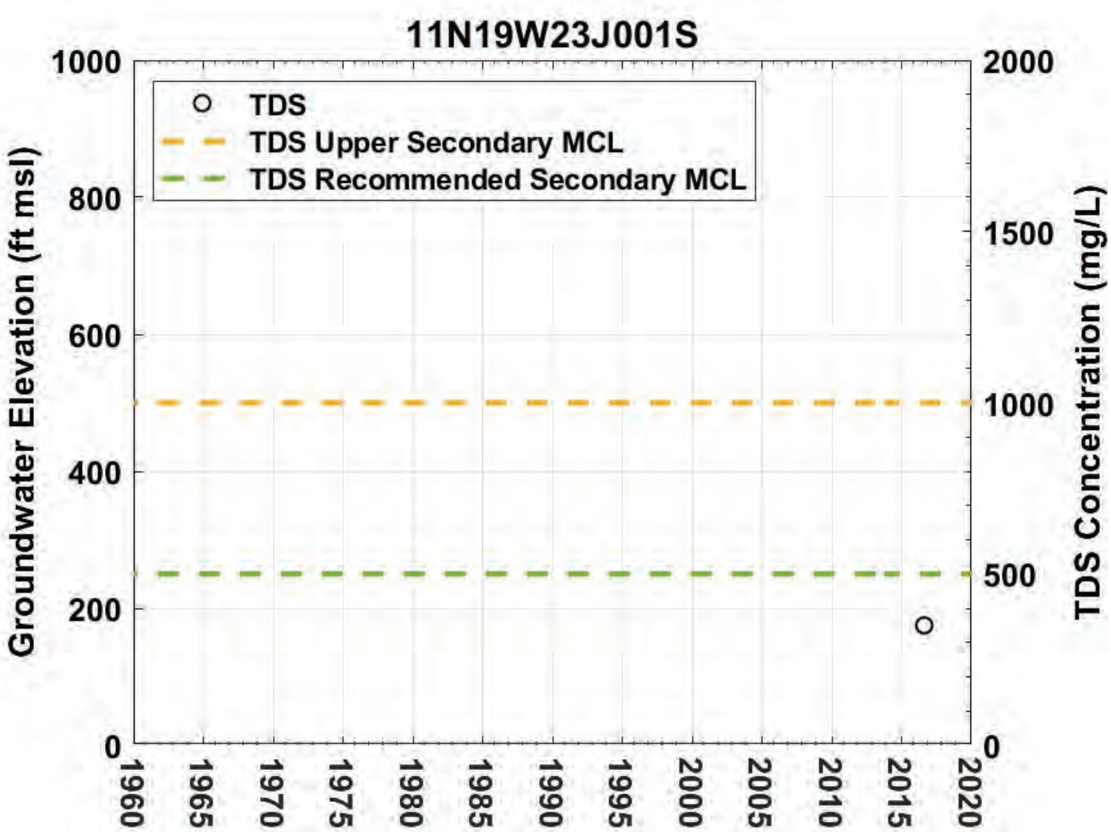

11N19W22M002S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

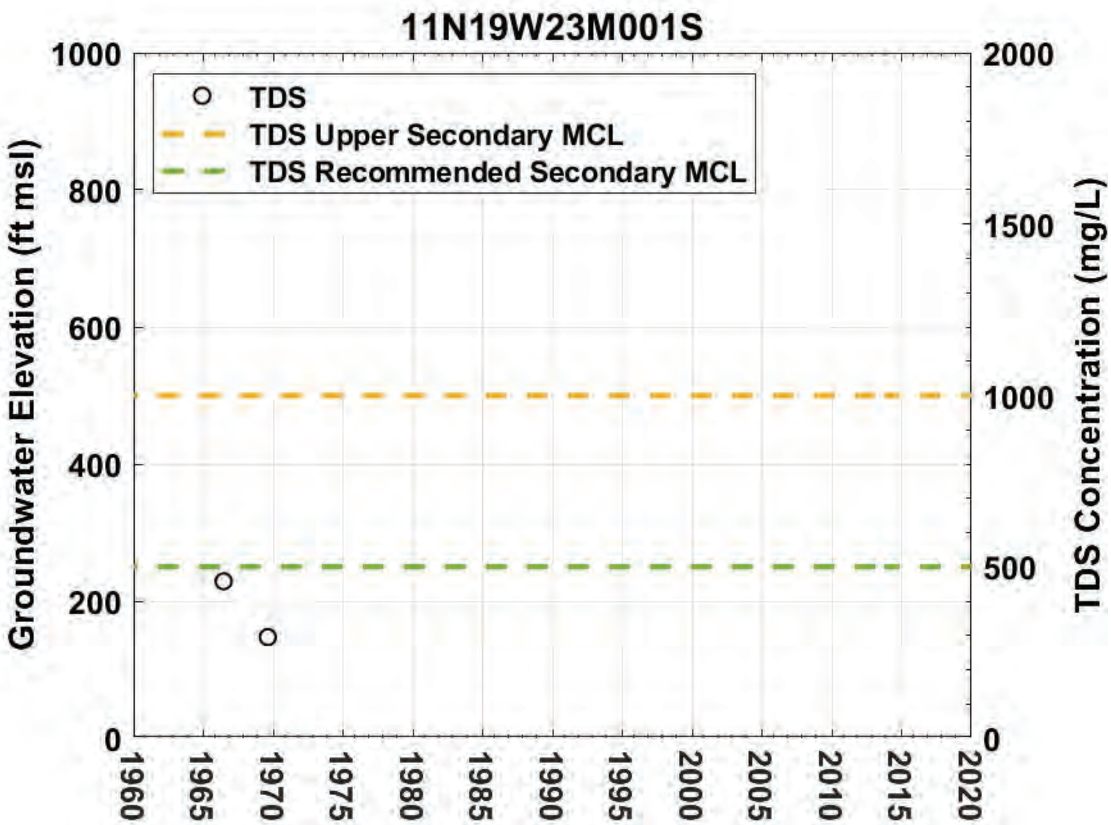

11N19W22N001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

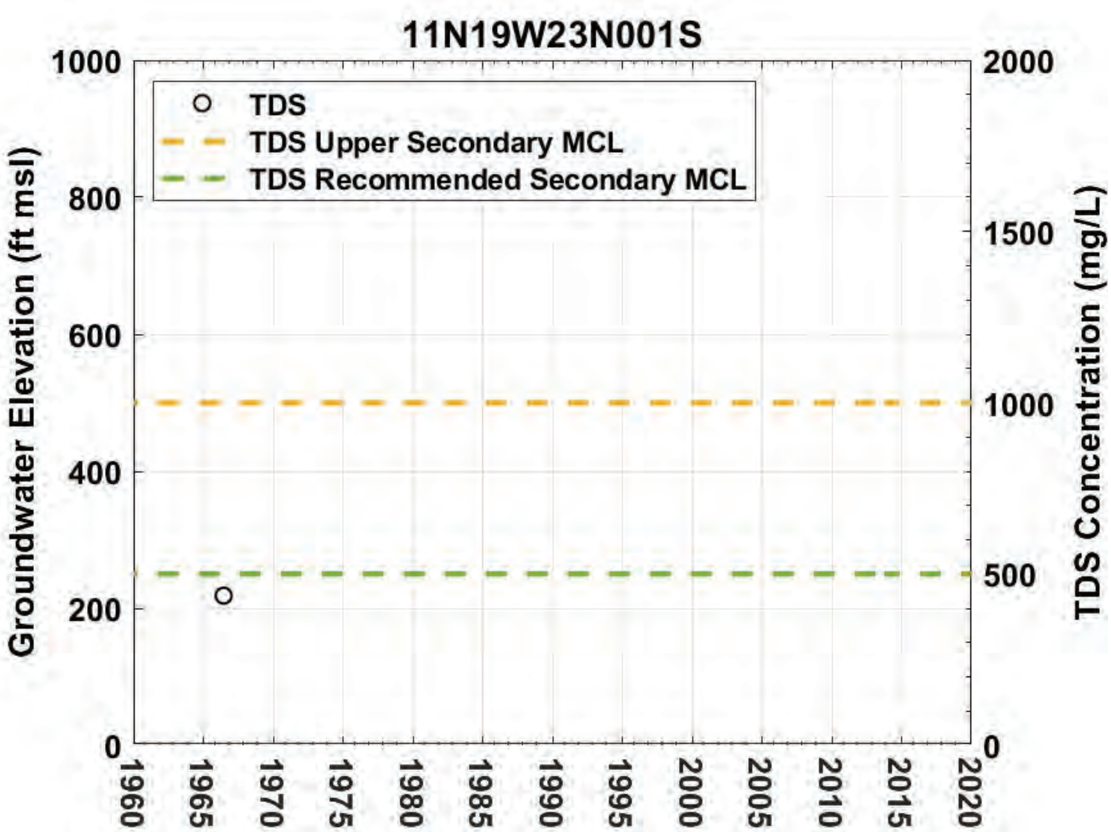

11N19W22R001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

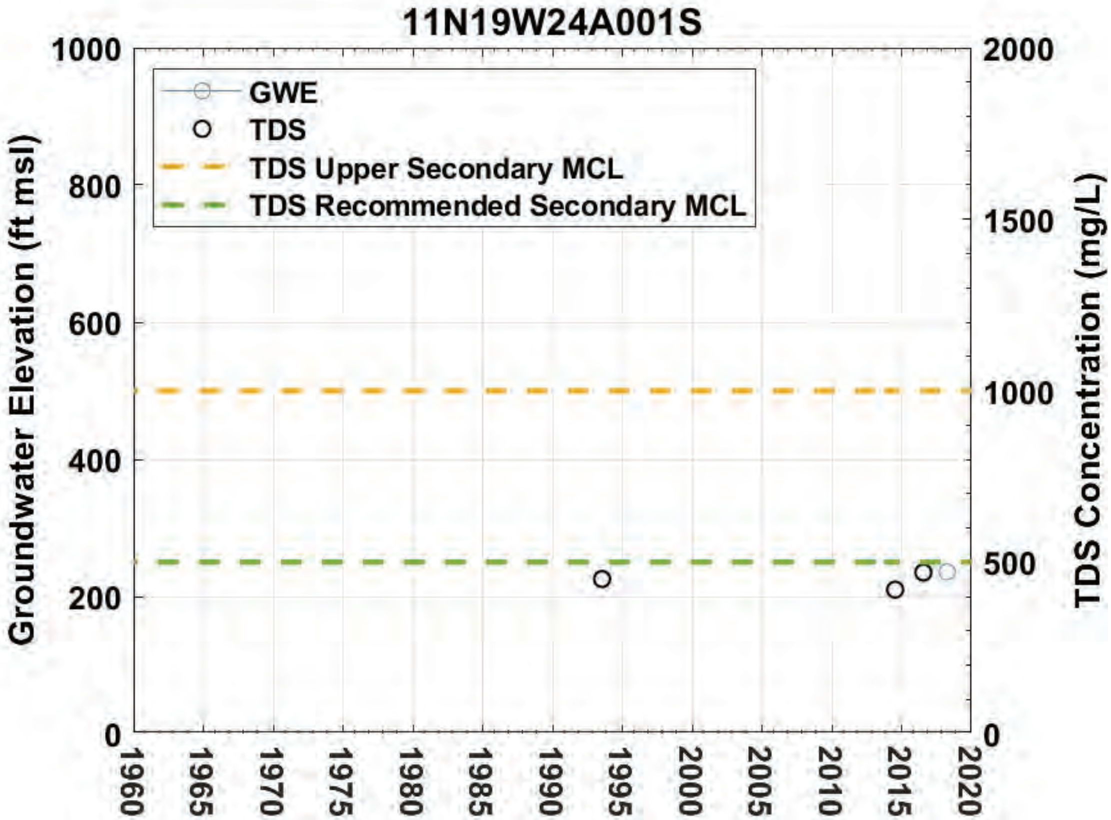

11N19W23D001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

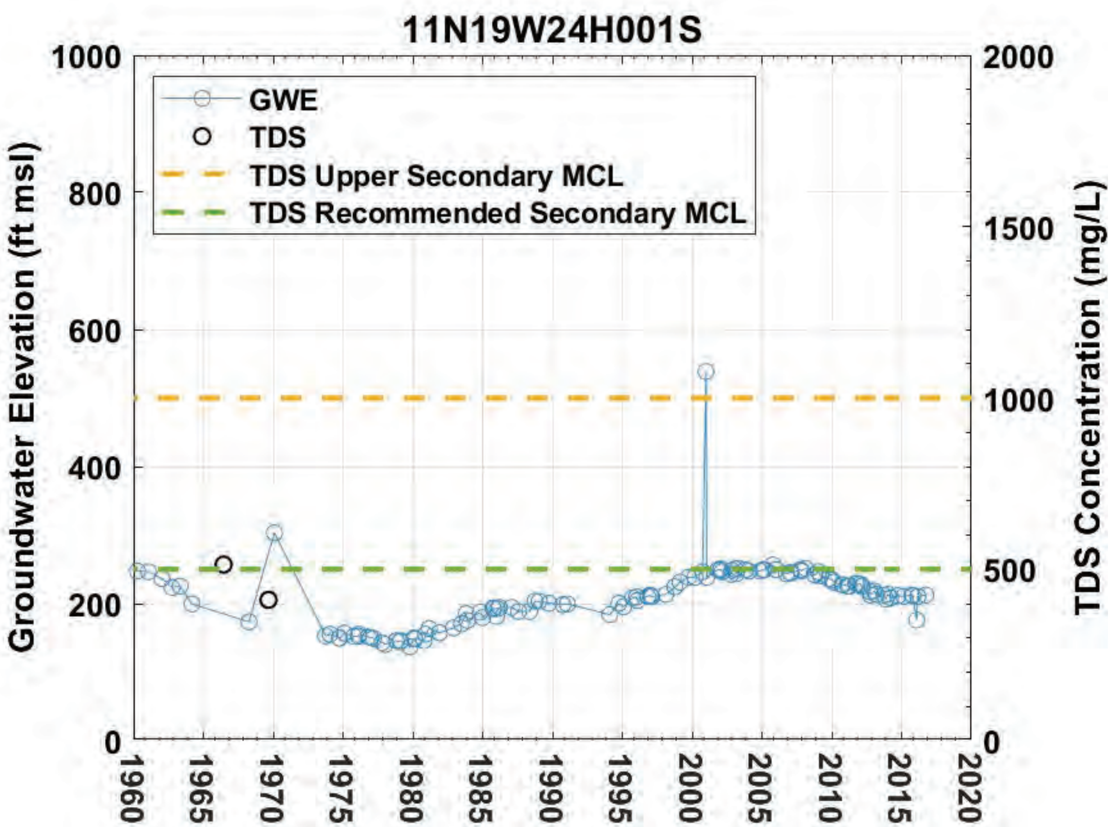

11N19W23H001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

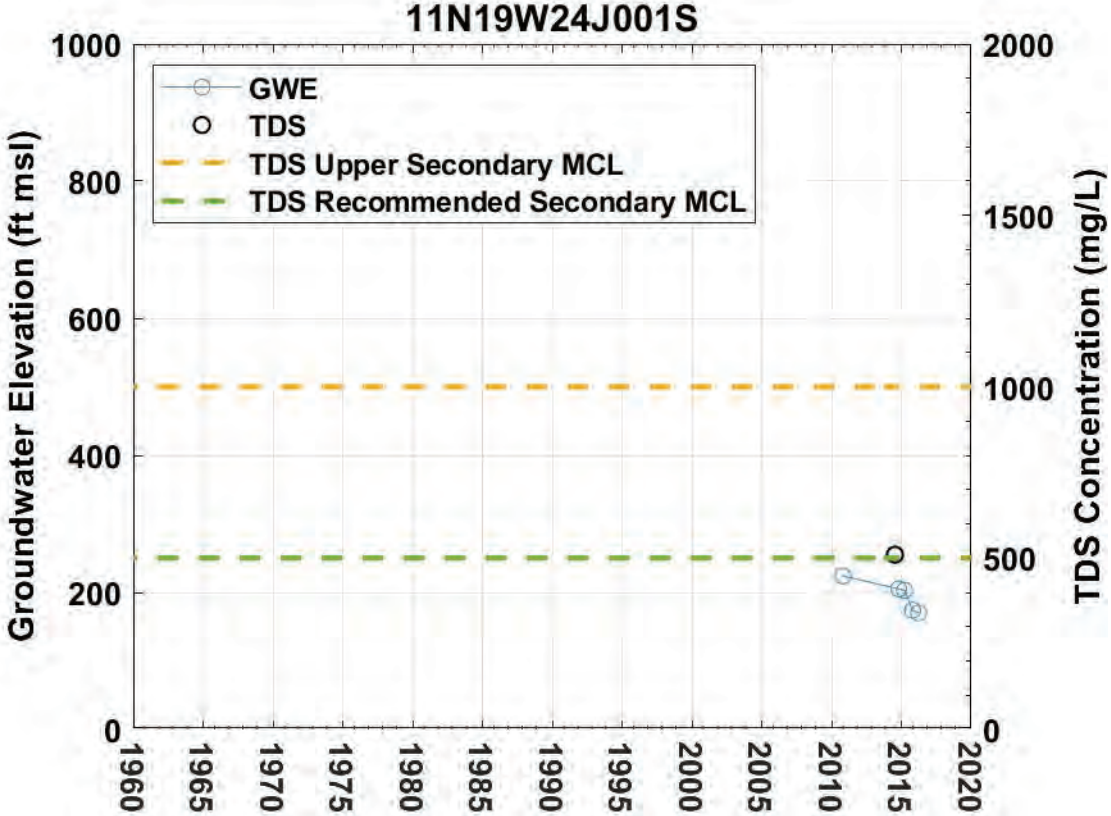

11N19W23J001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

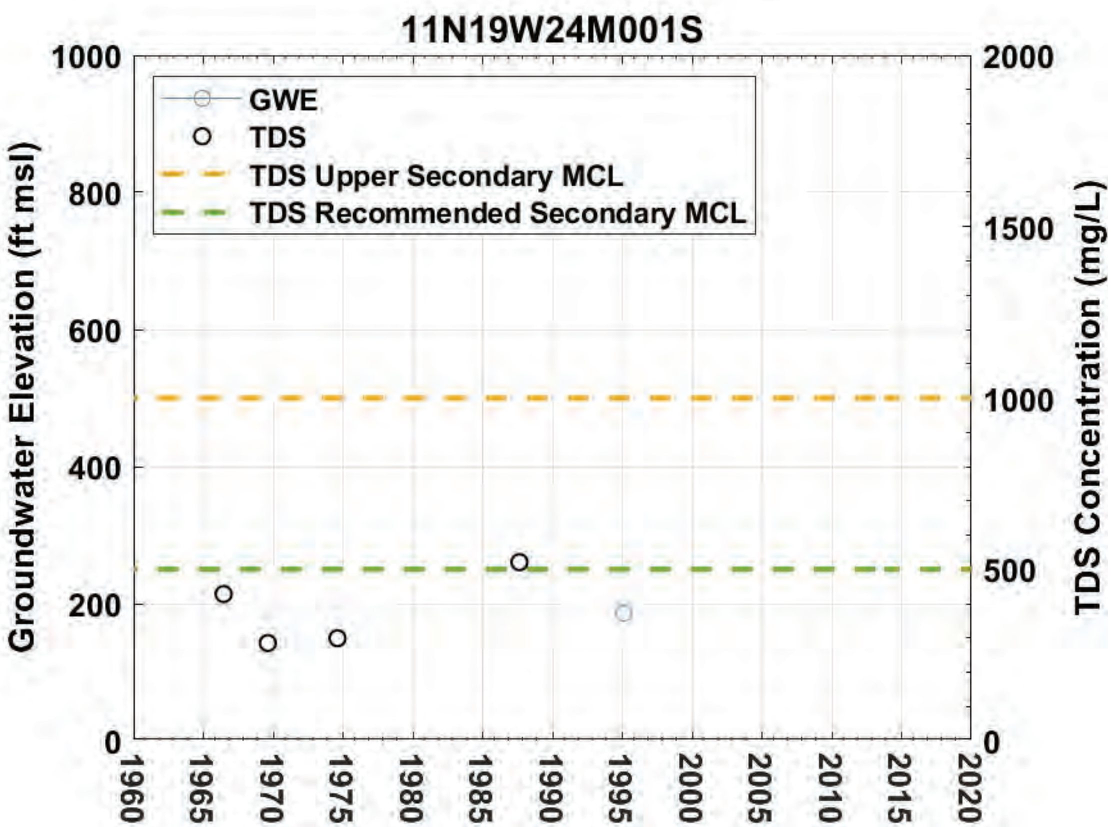

11N19W23M001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

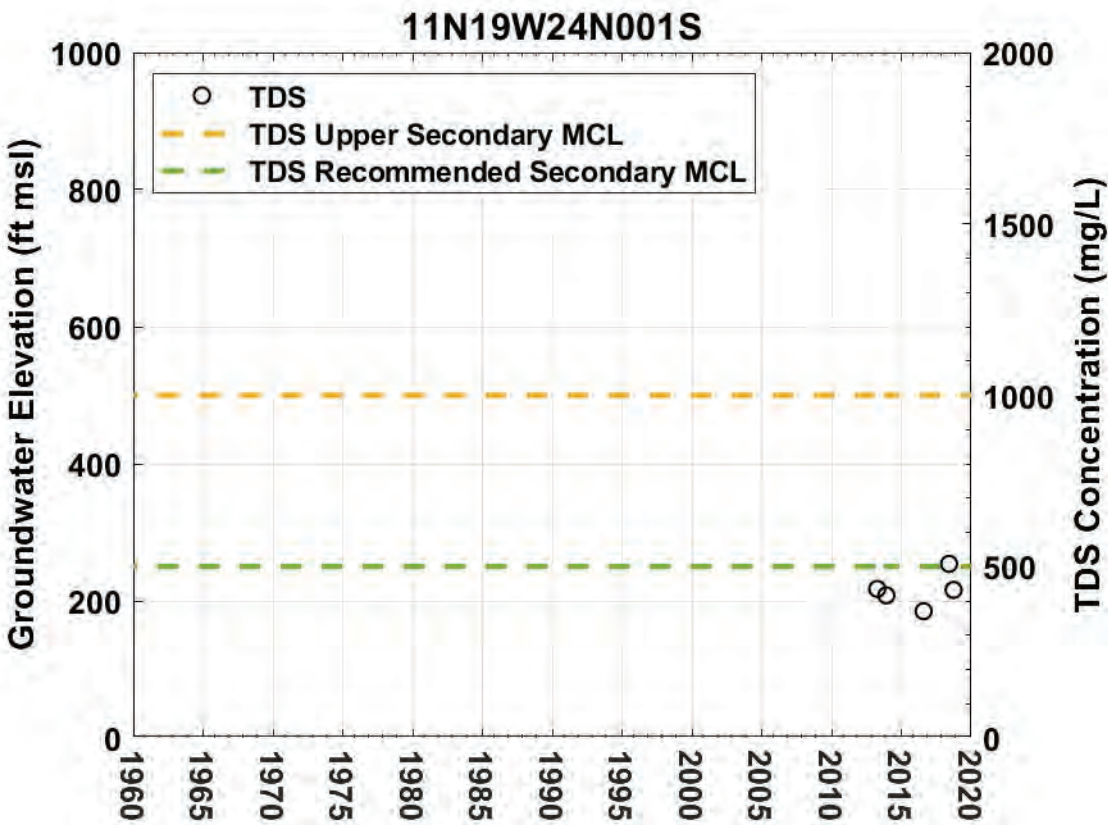

11N19W23N001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

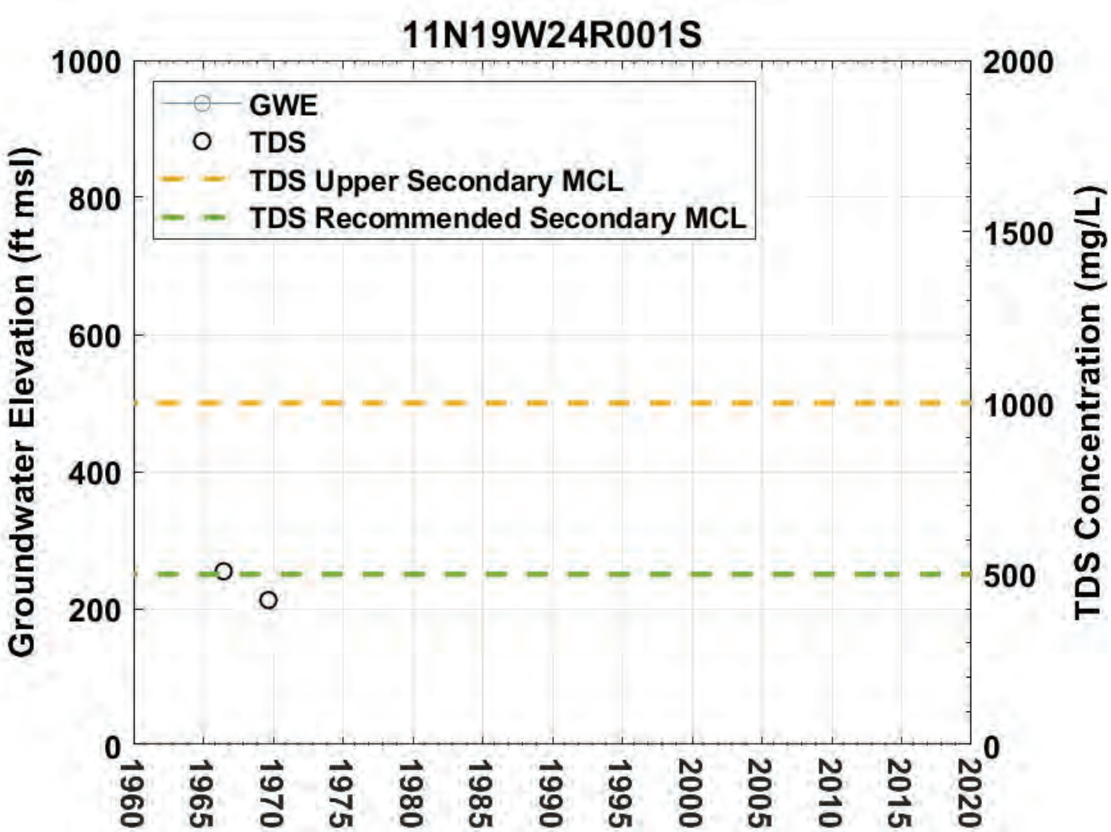

11N19W24A001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

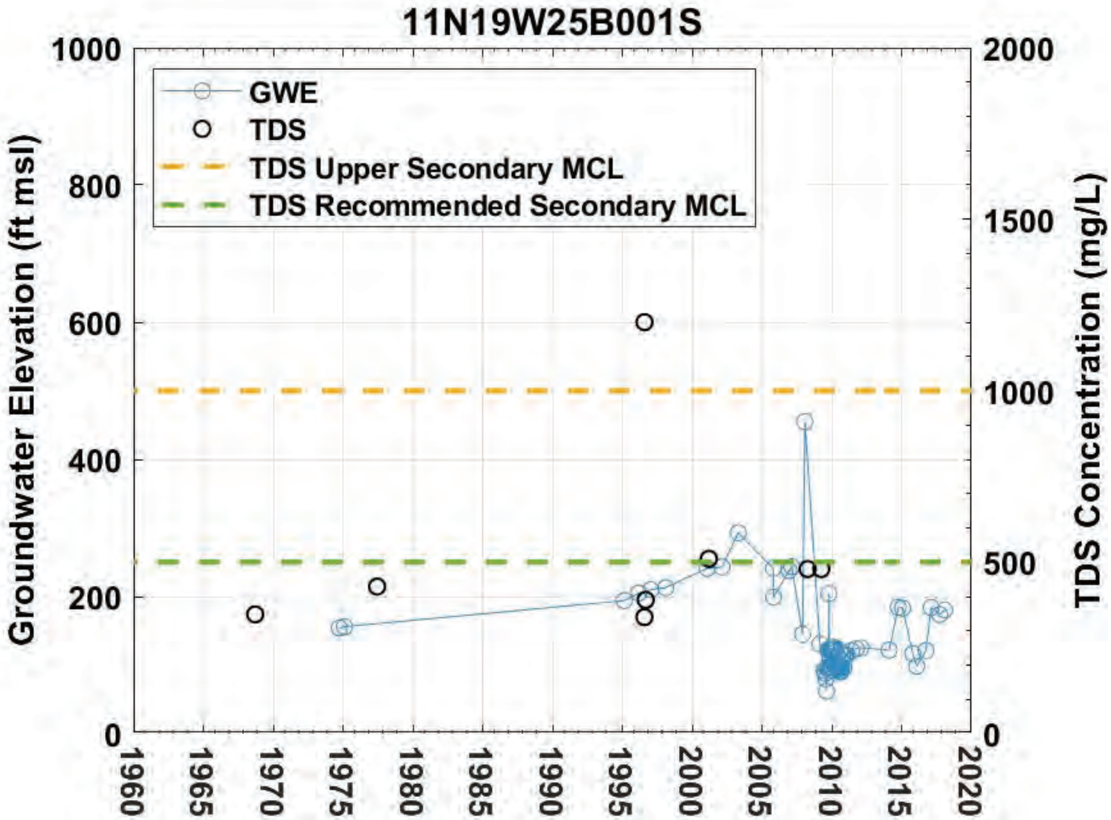

11N19W24H001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

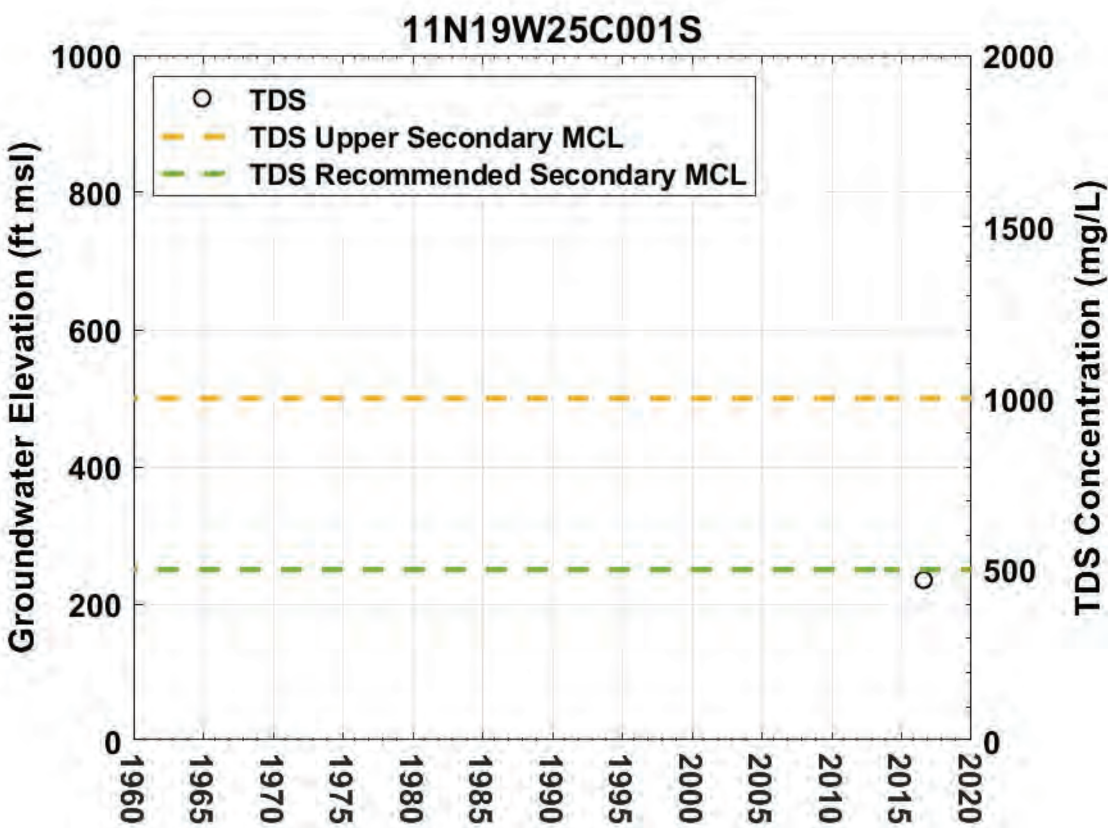

11N19W24J001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

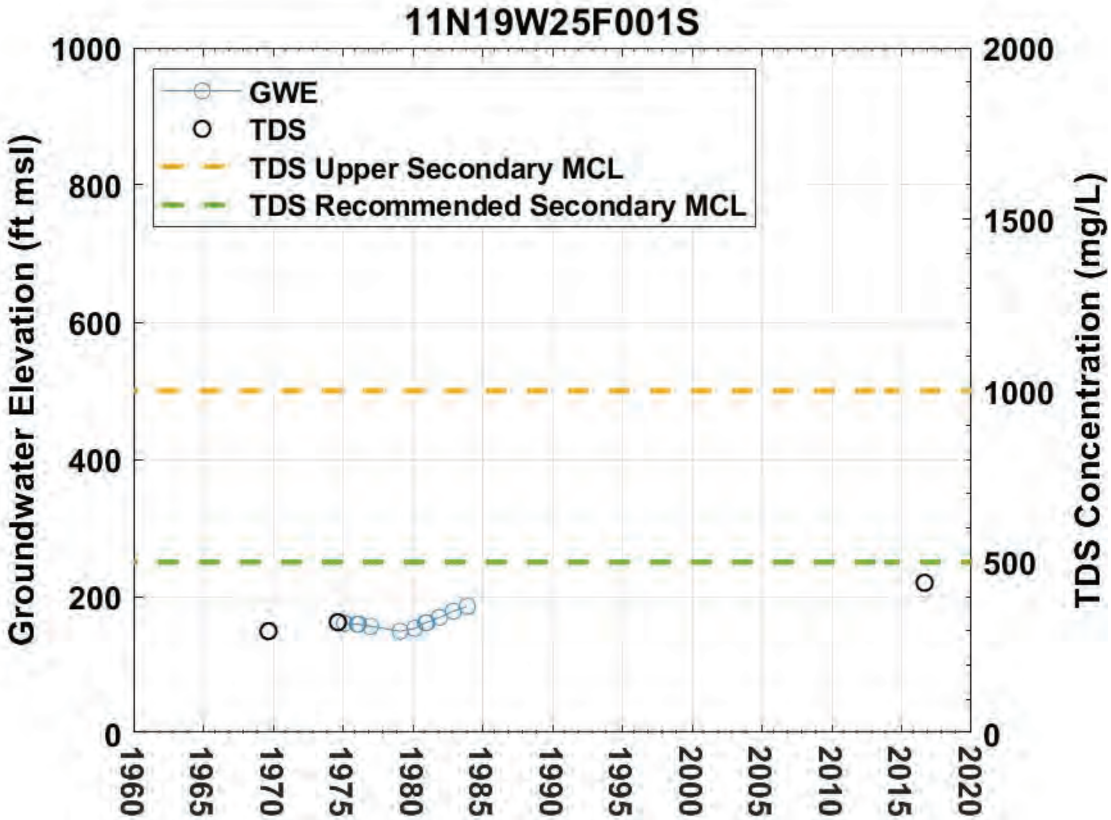

11N19W24M001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

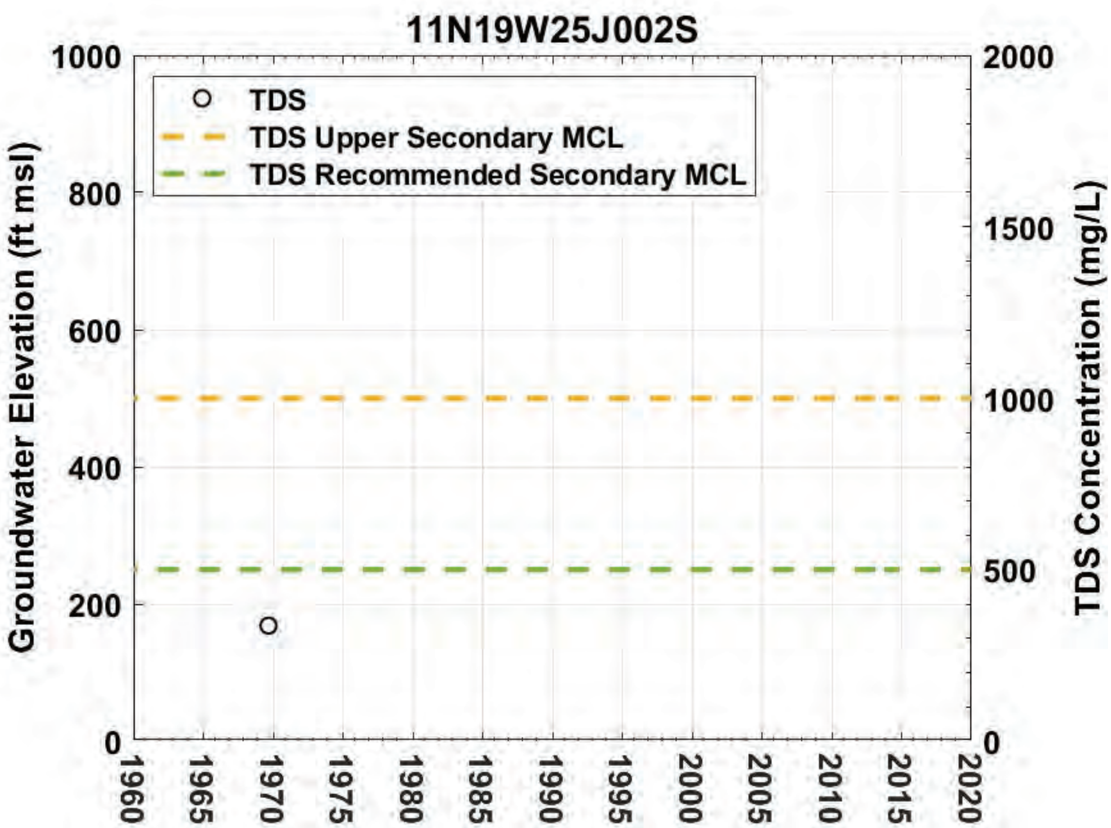

11N19W24N001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

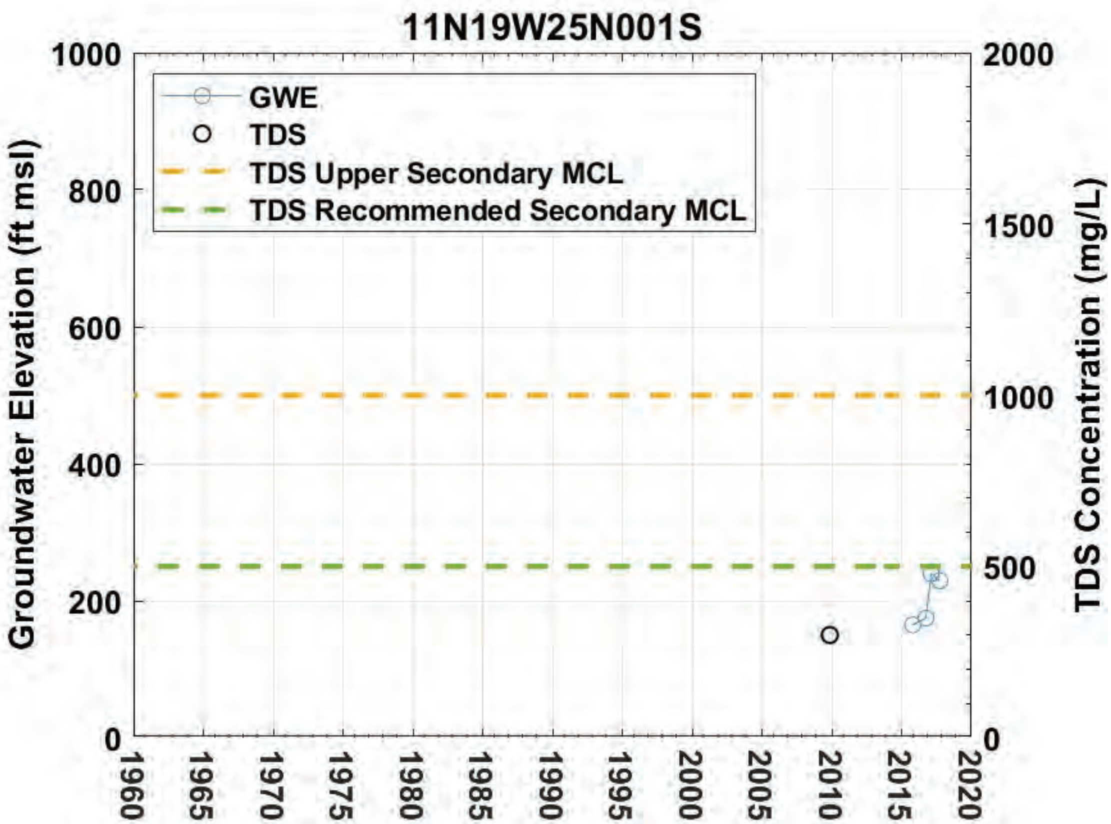

11N19W24R001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

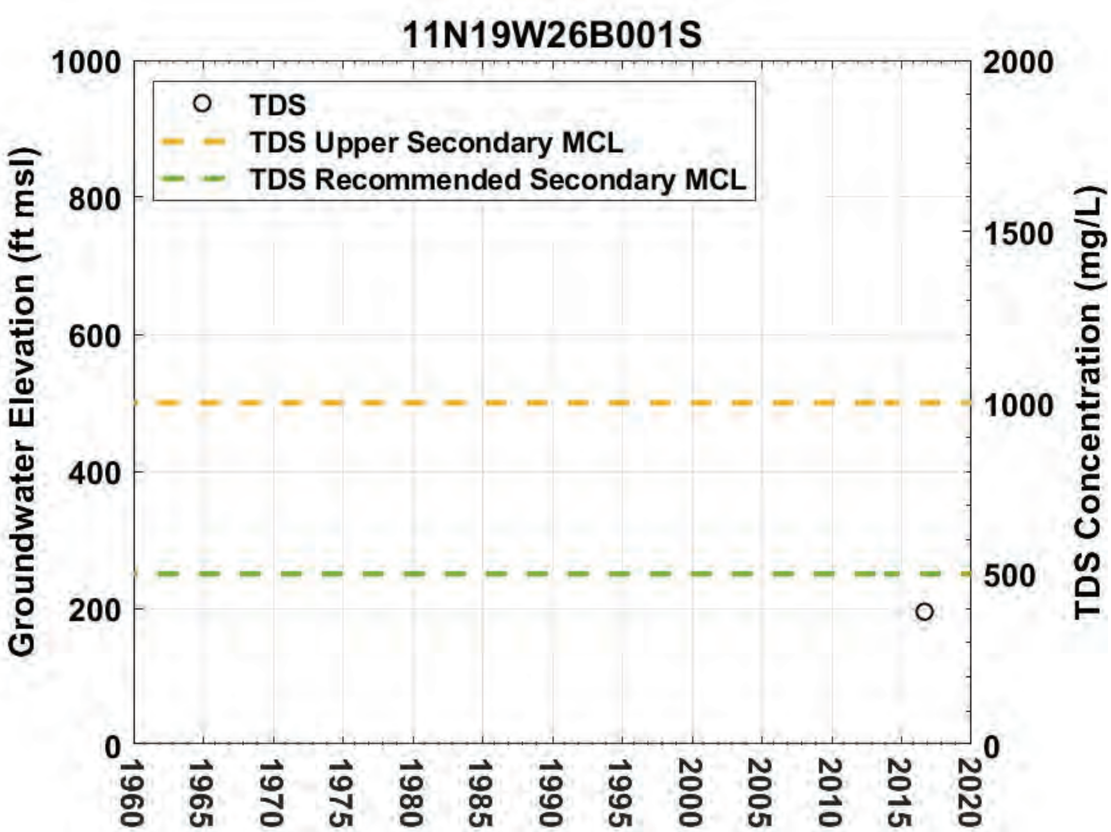

11N19W25B001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

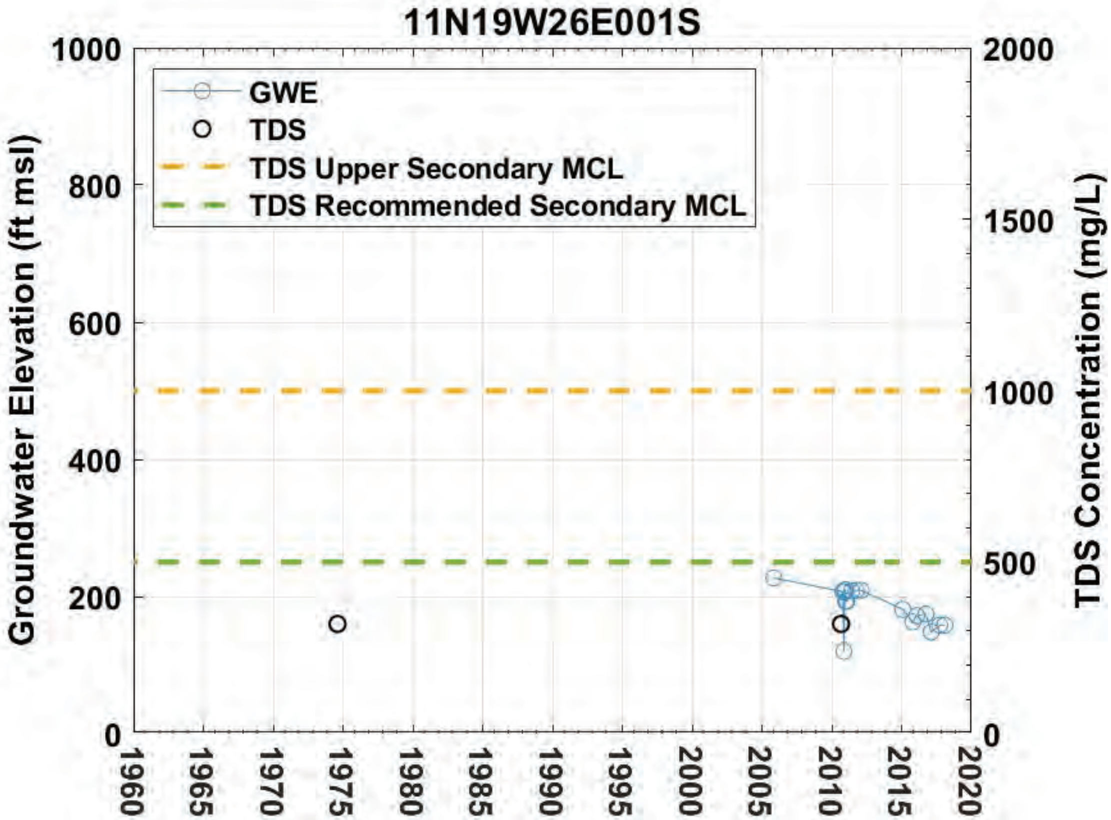

11N19W25C001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

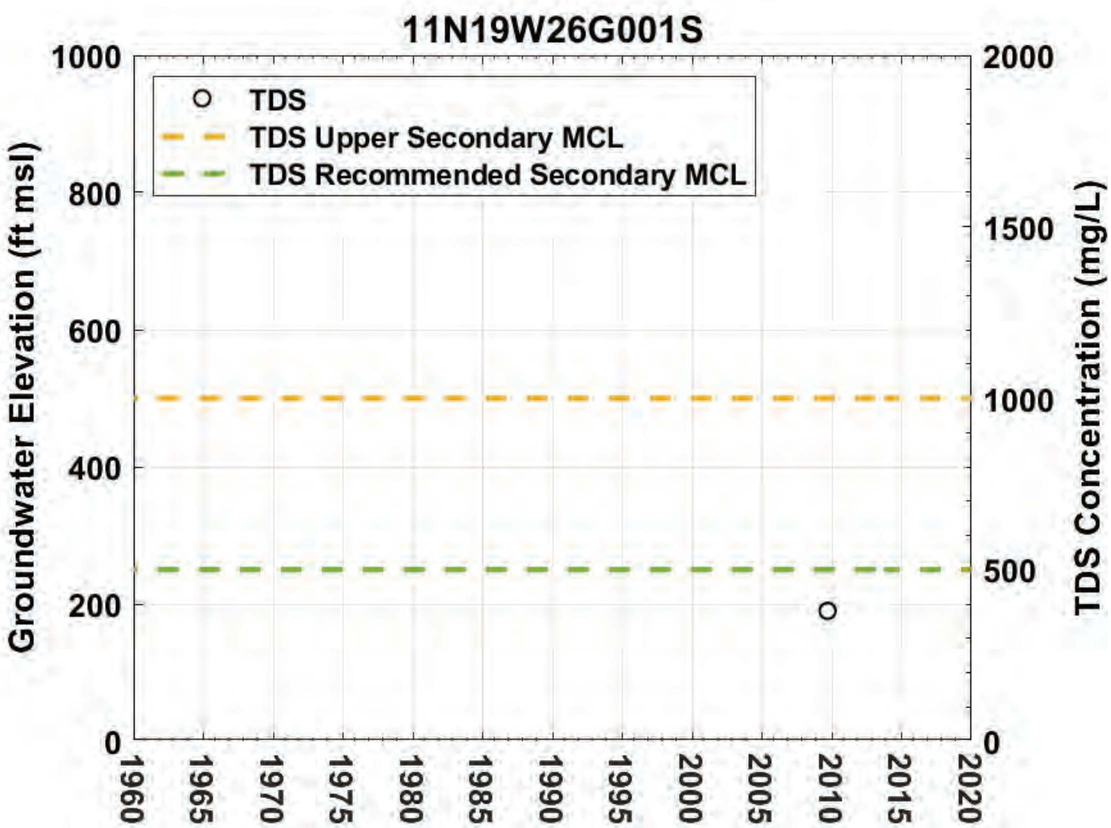

11N19W25F001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

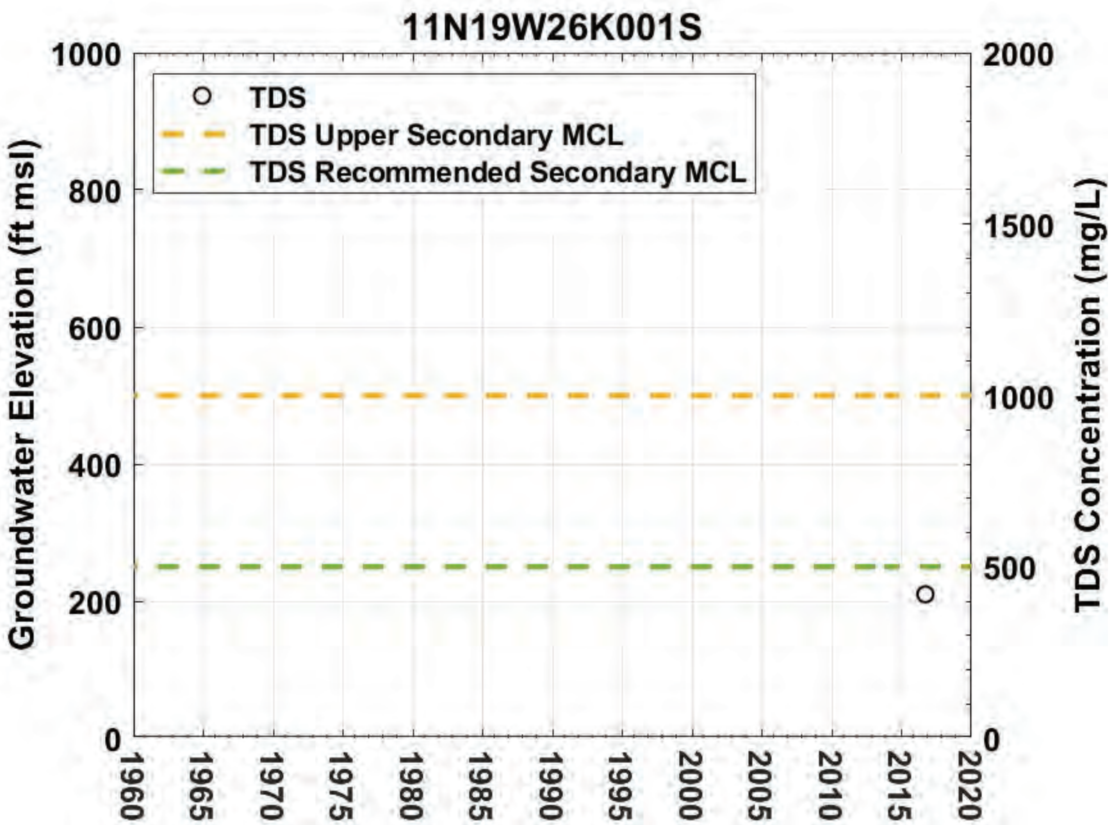

11N19W25J002S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

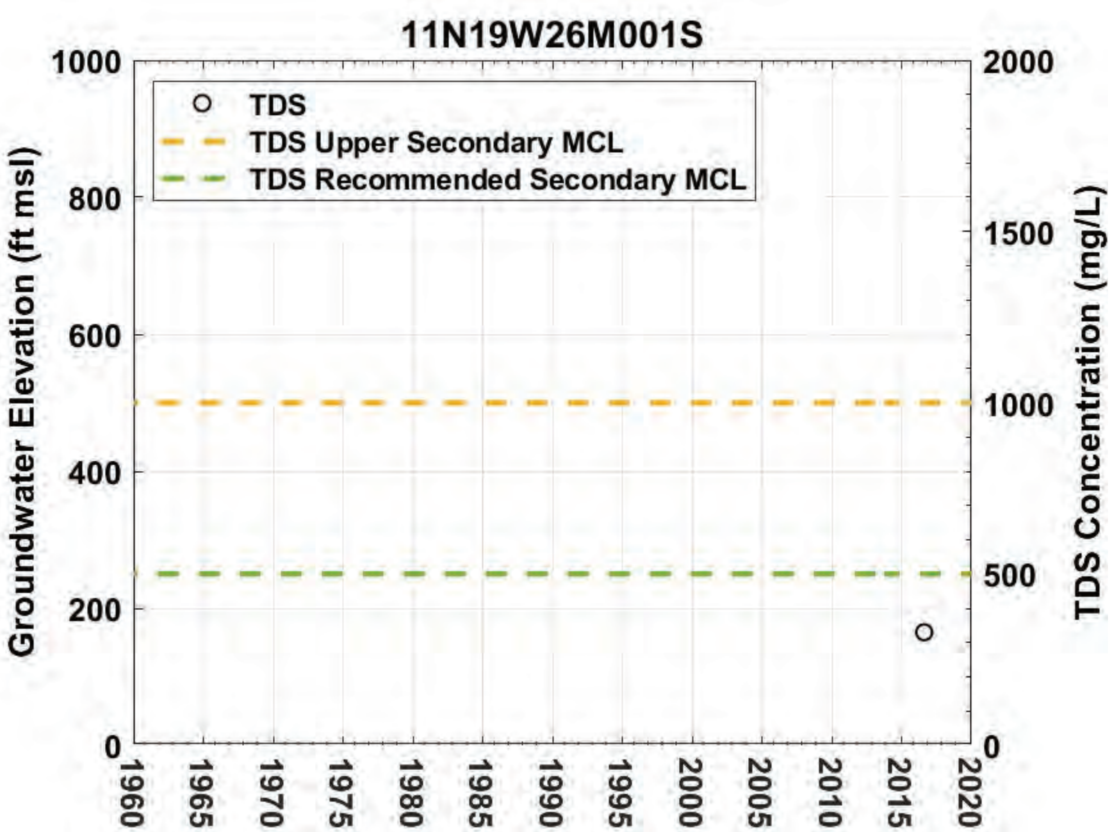

11N19W25N001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

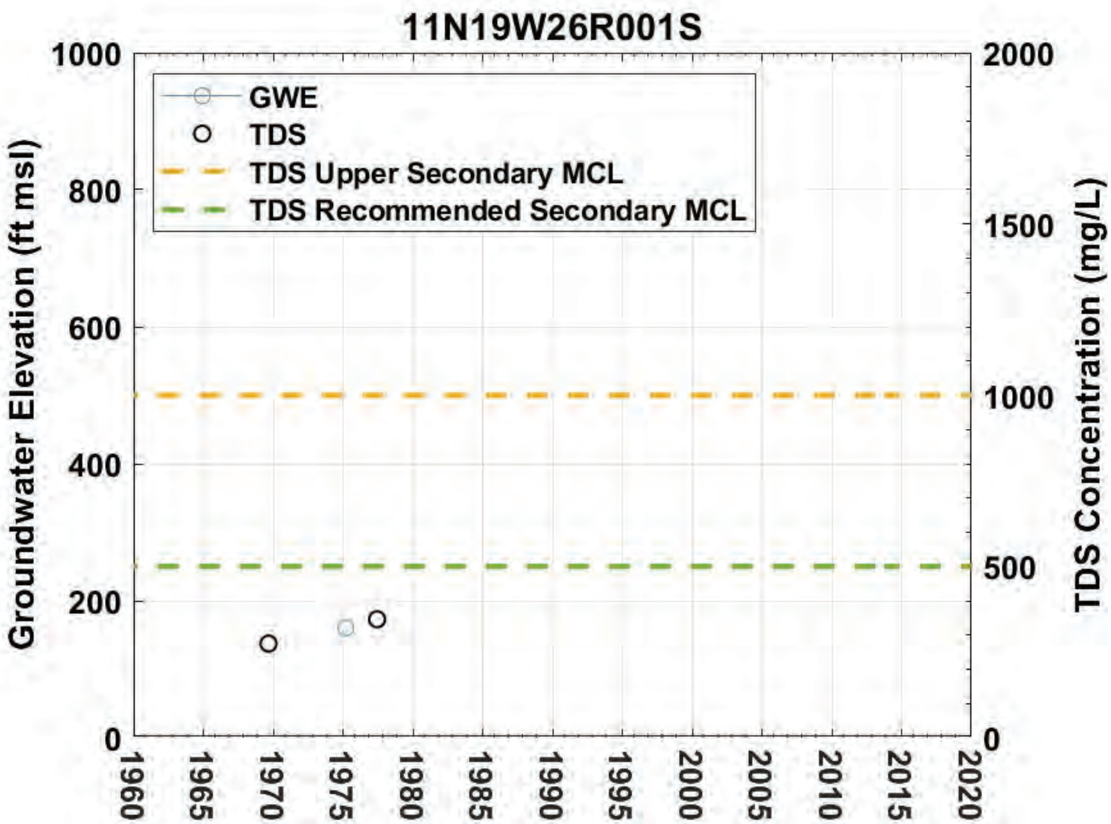

11N19W26B001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

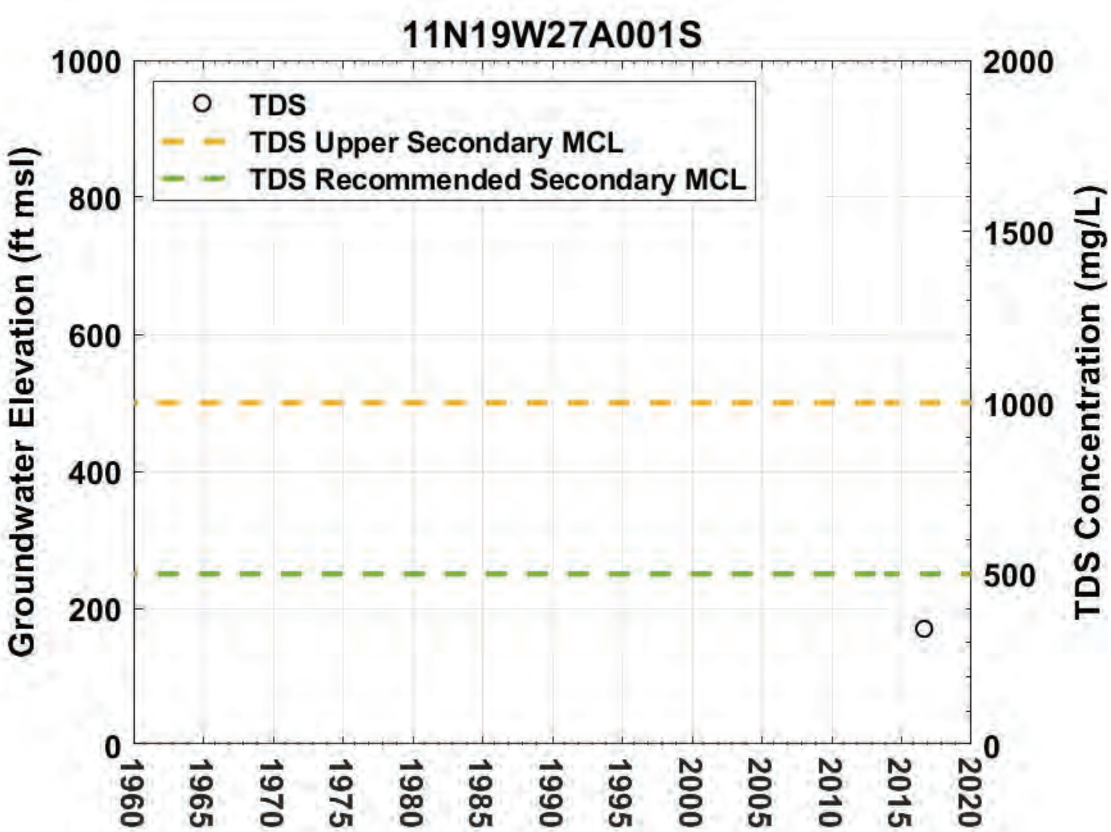

11N19W26E001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

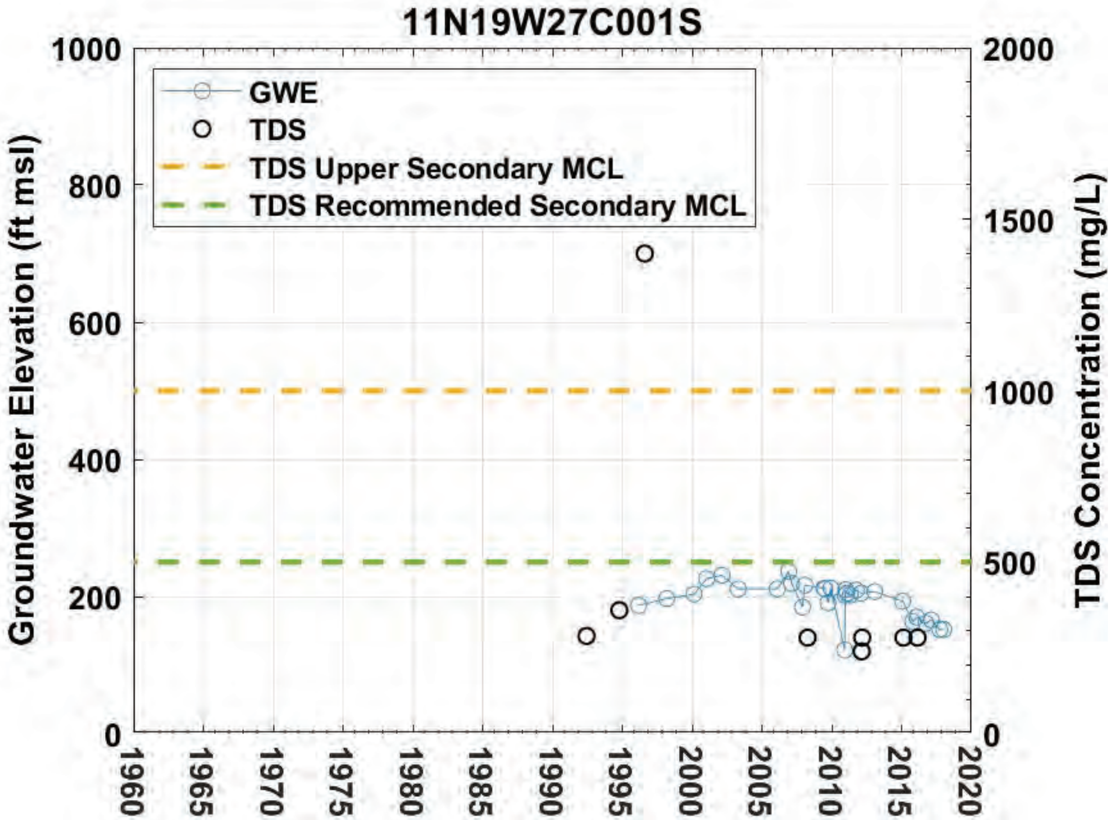

11N19W26G001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W26K001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

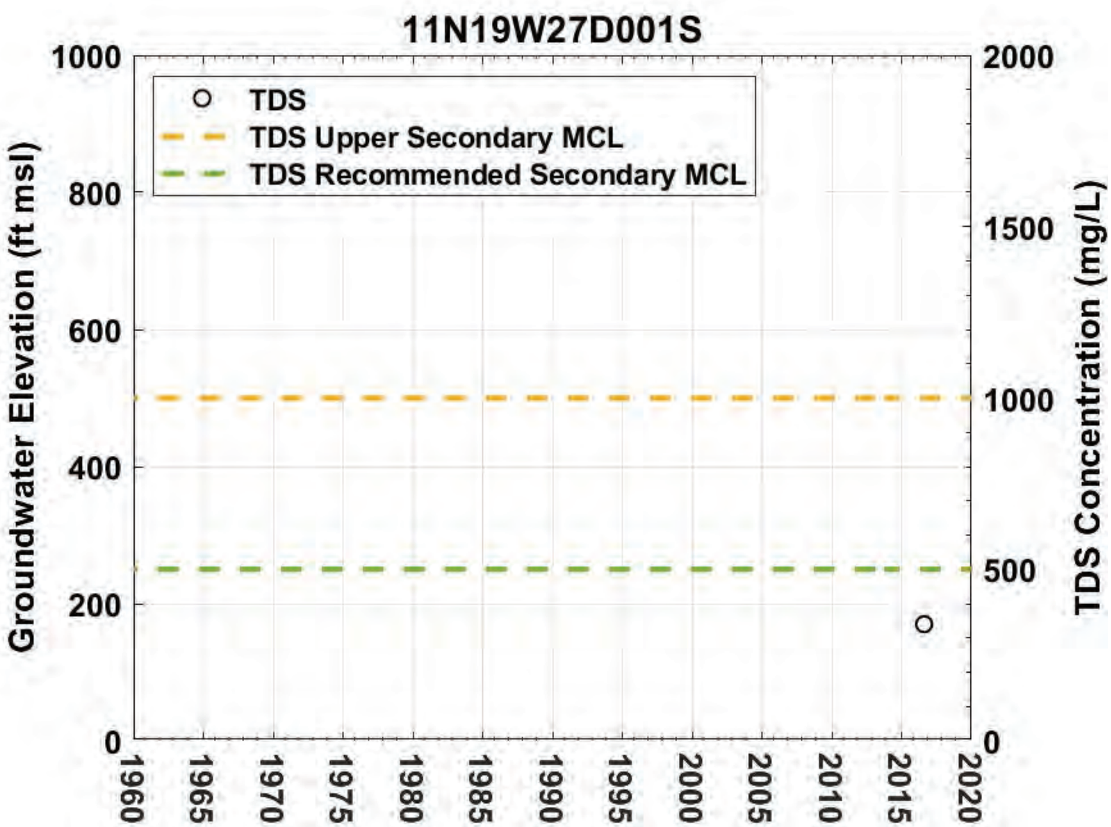

11N19W26M001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W26R001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

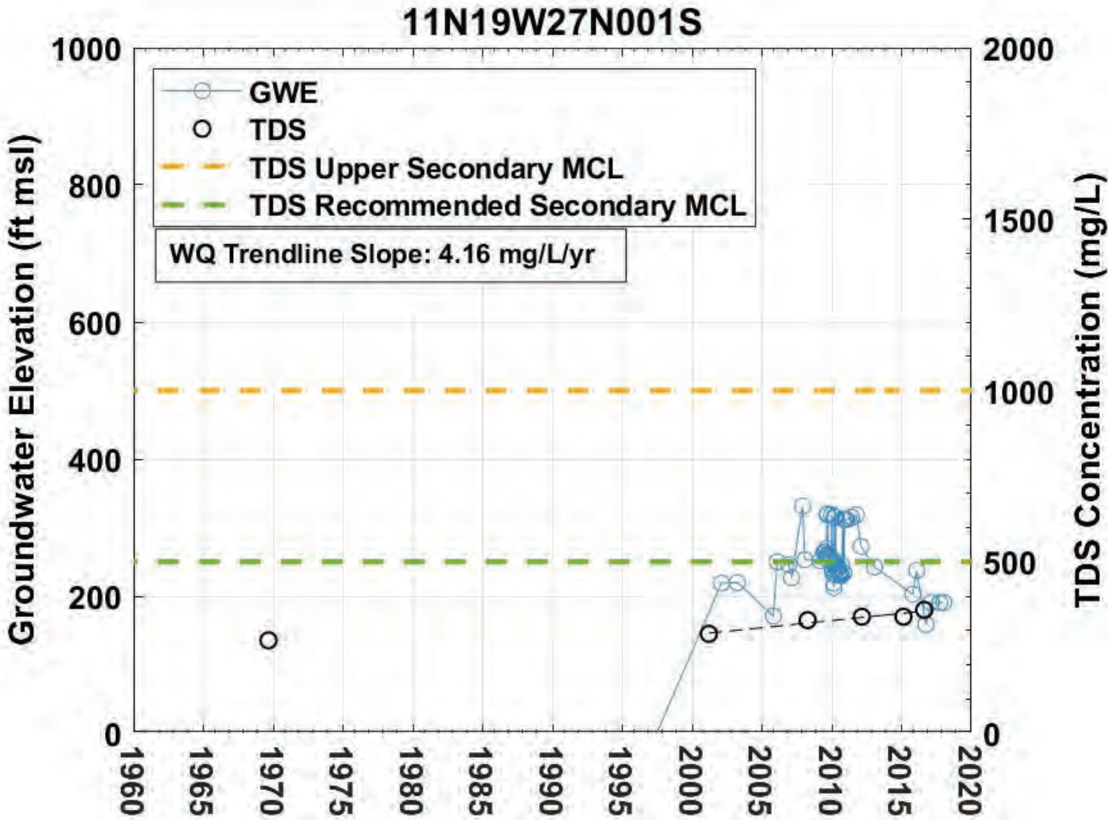

11N19W27A001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

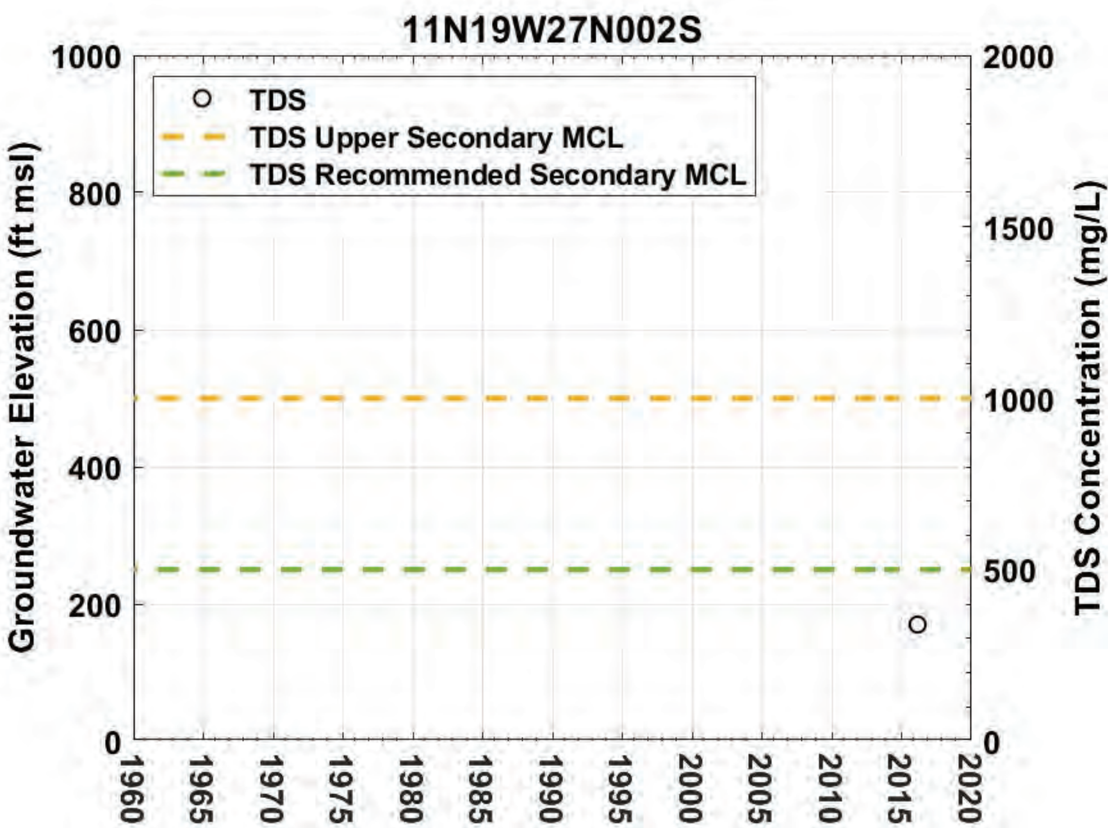


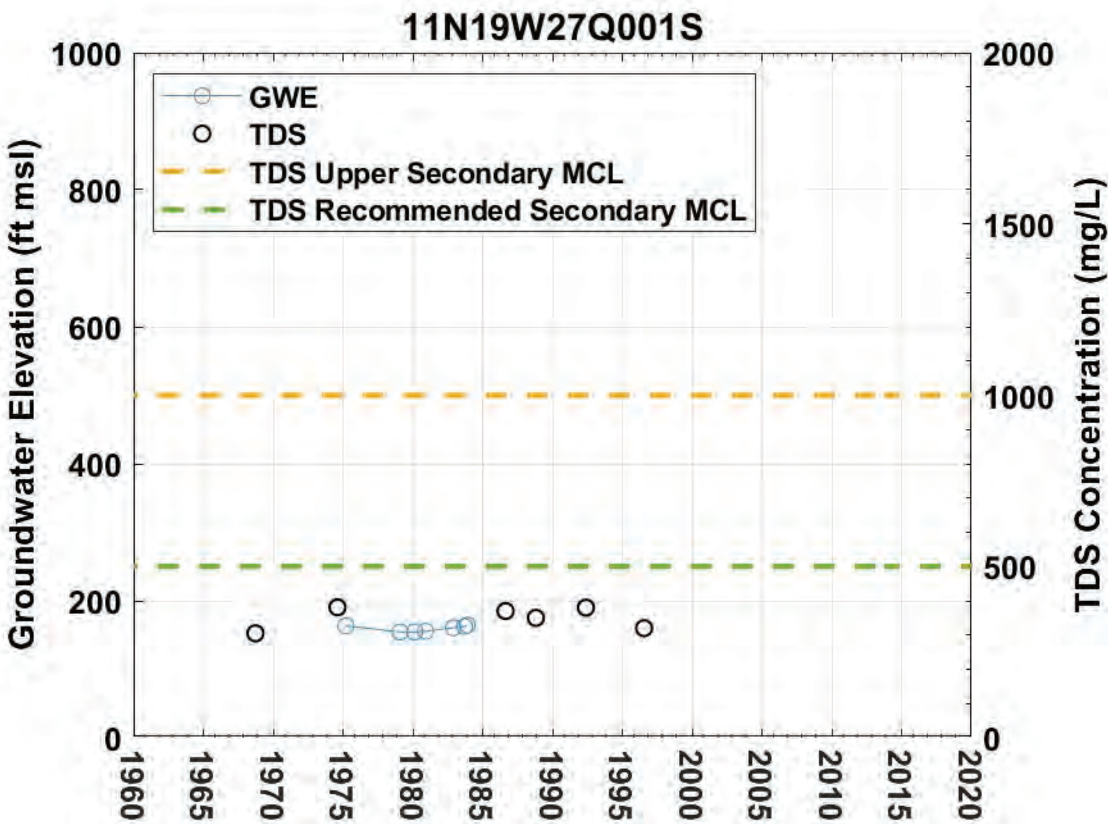
11N19W27C001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

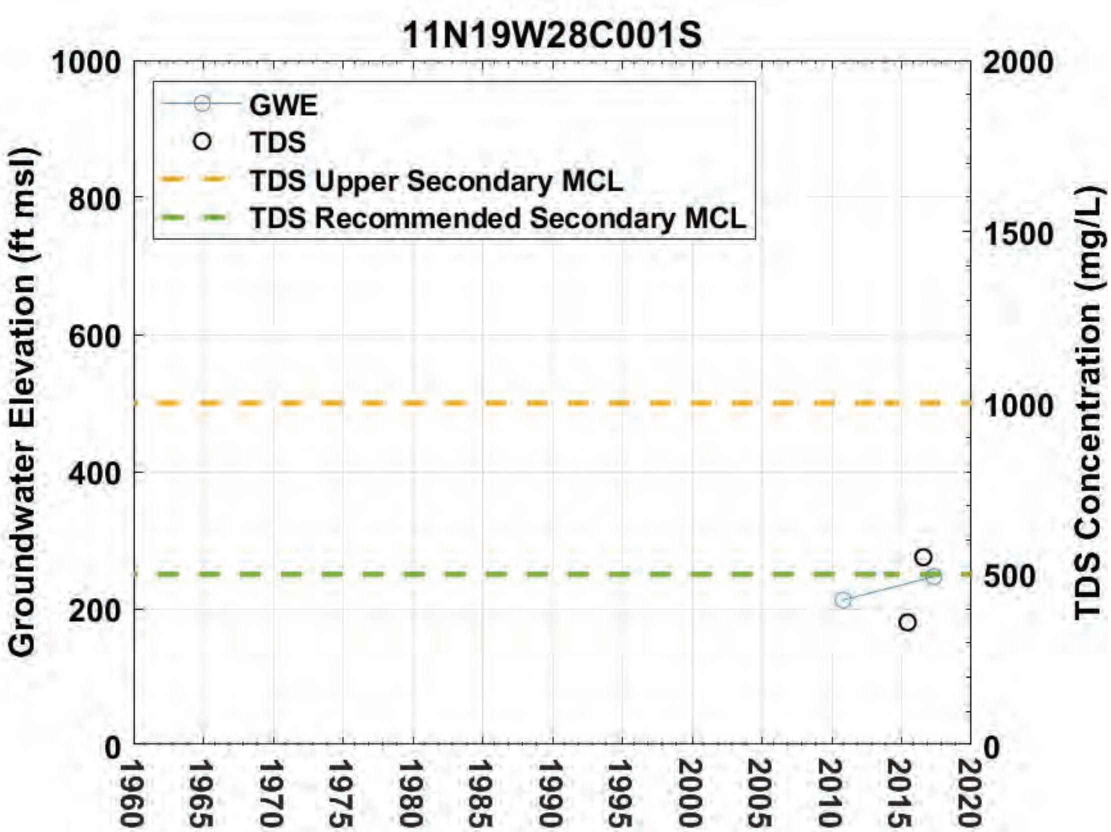


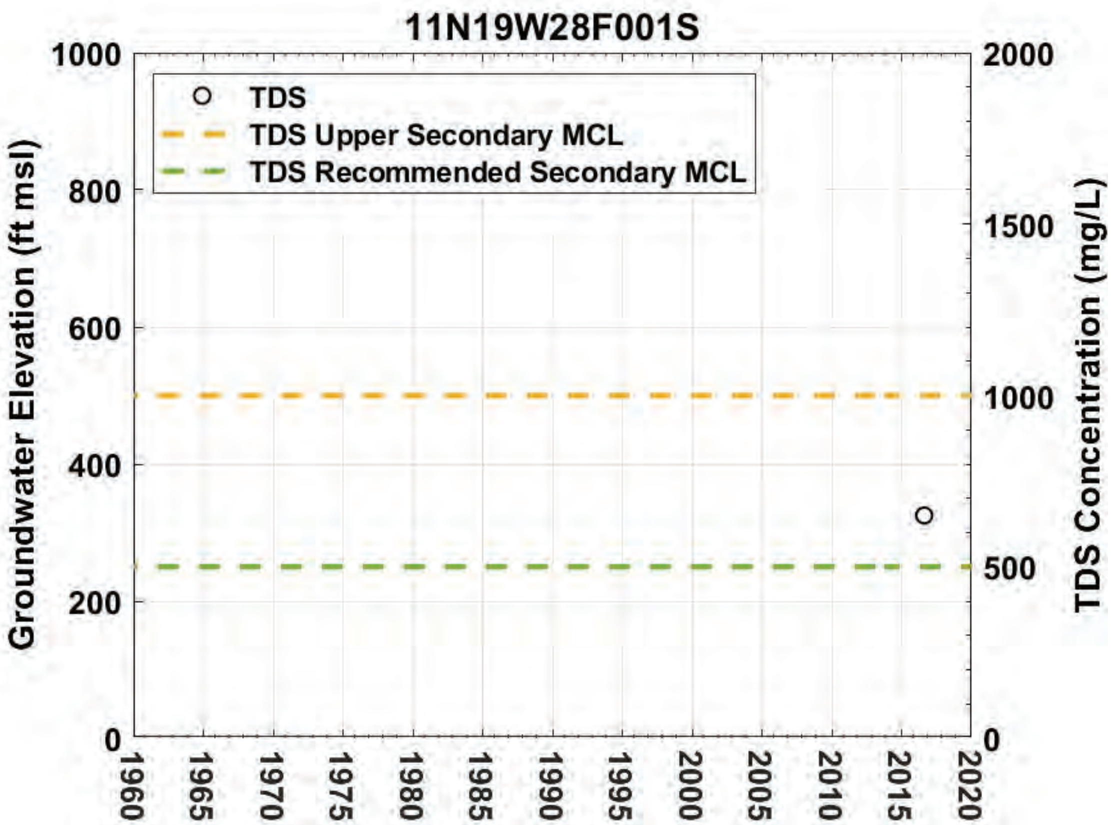
11N19W27D001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

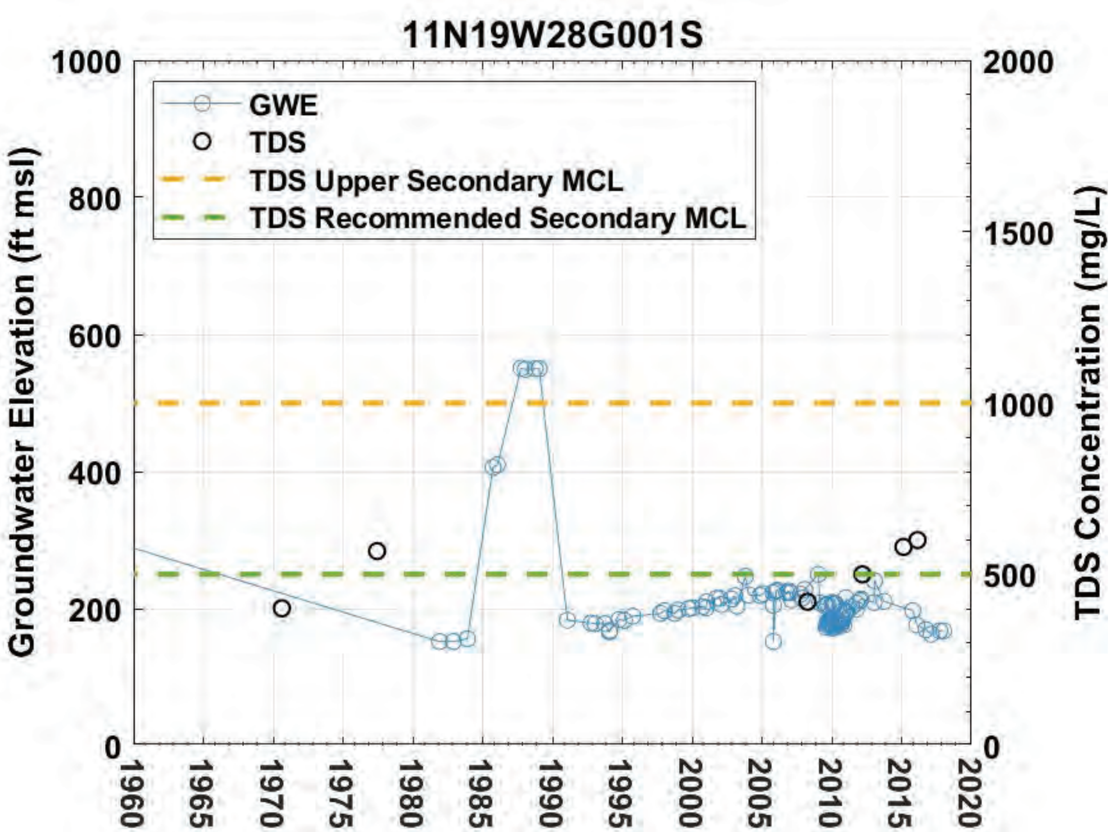

11N19W27N001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
WQ Trendline Slope: 4.16 mg/L/yr
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

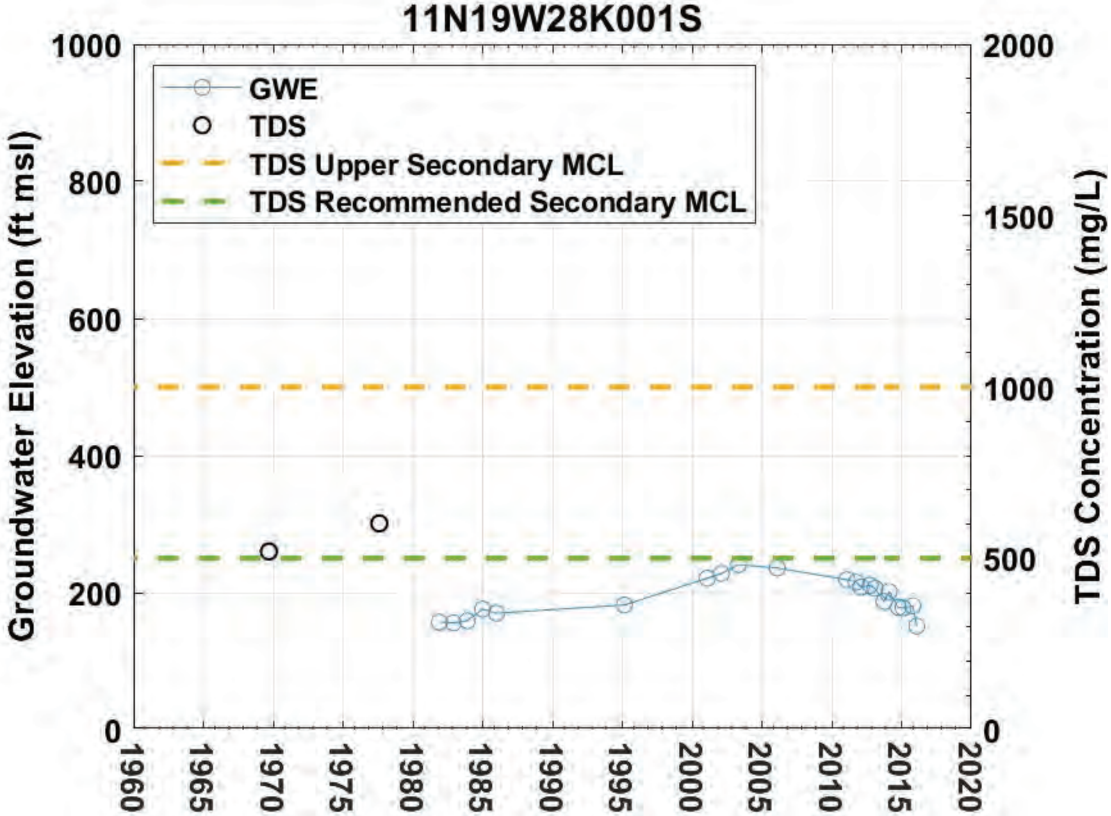

11N19W27N002S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

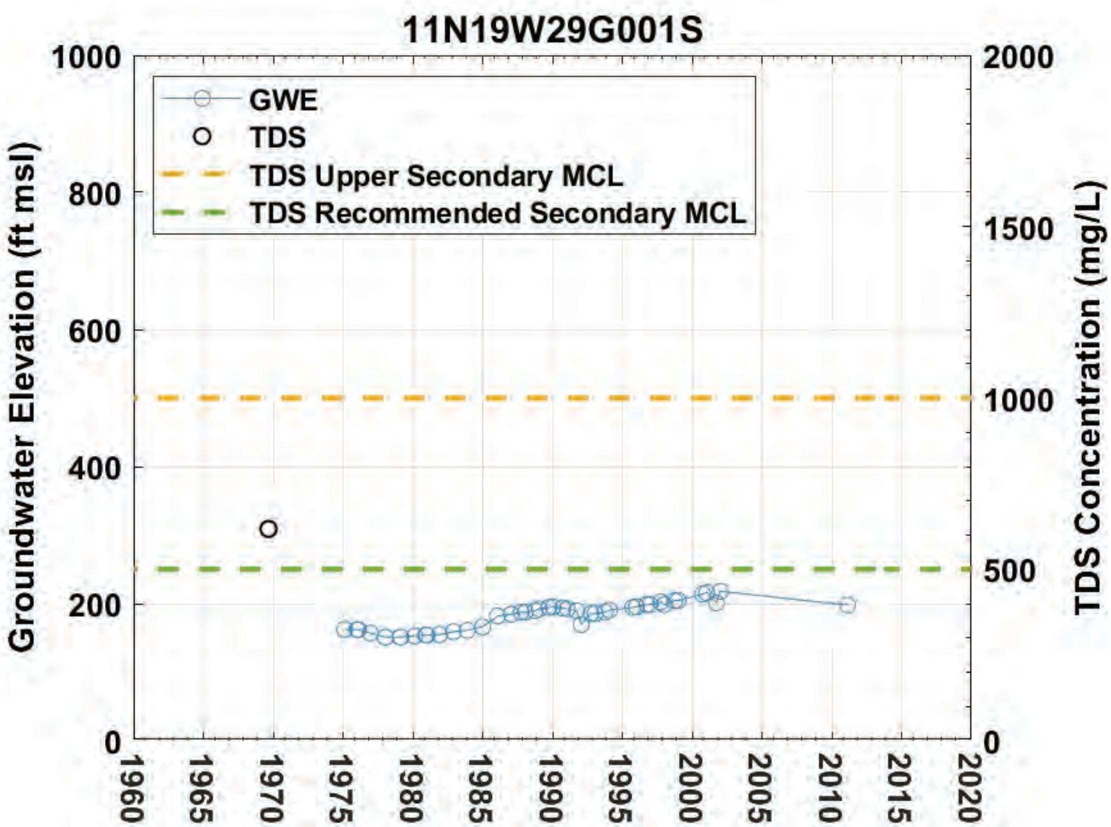

11N19W27Q001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

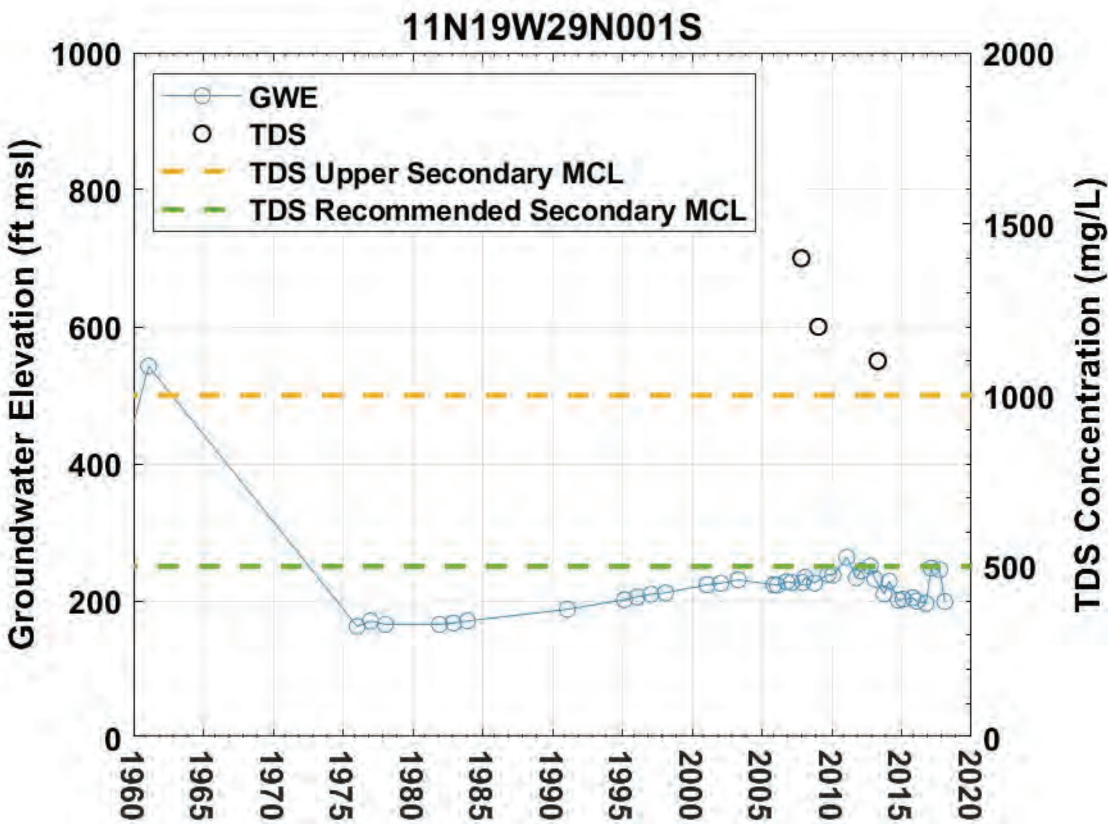

11N19W28C001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W28F001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

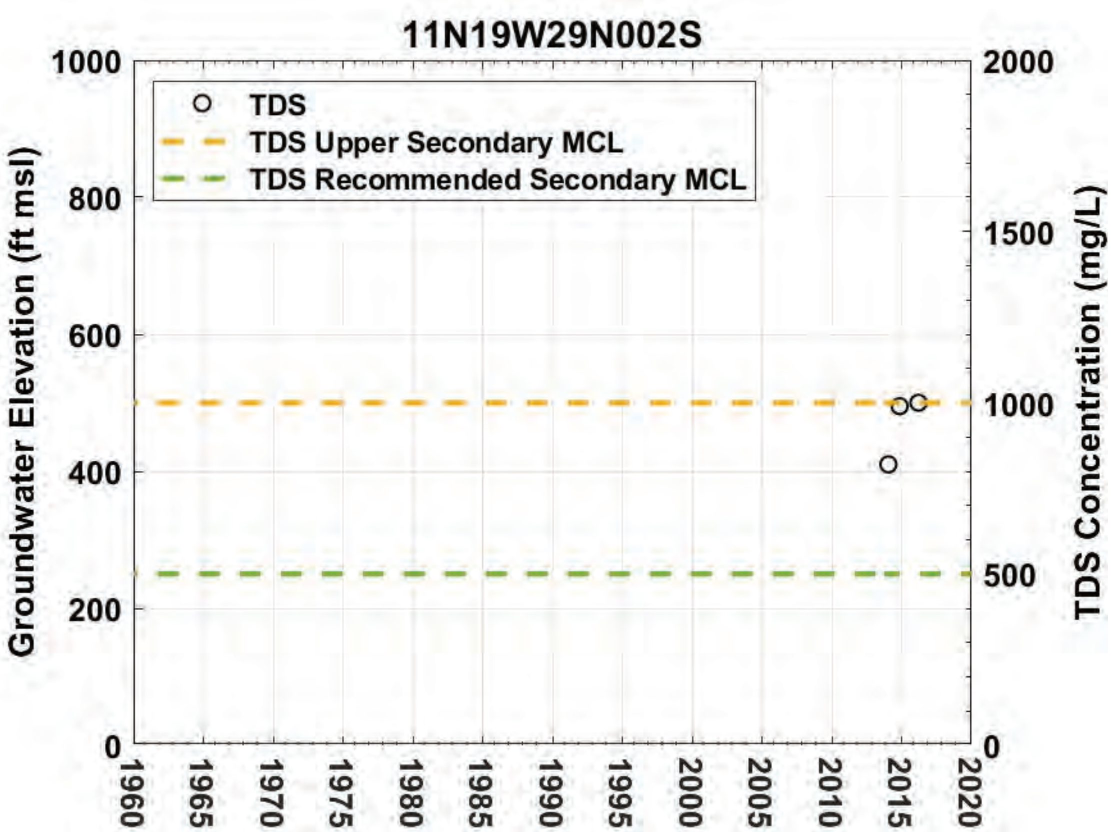

11N19W28G001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W28K001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

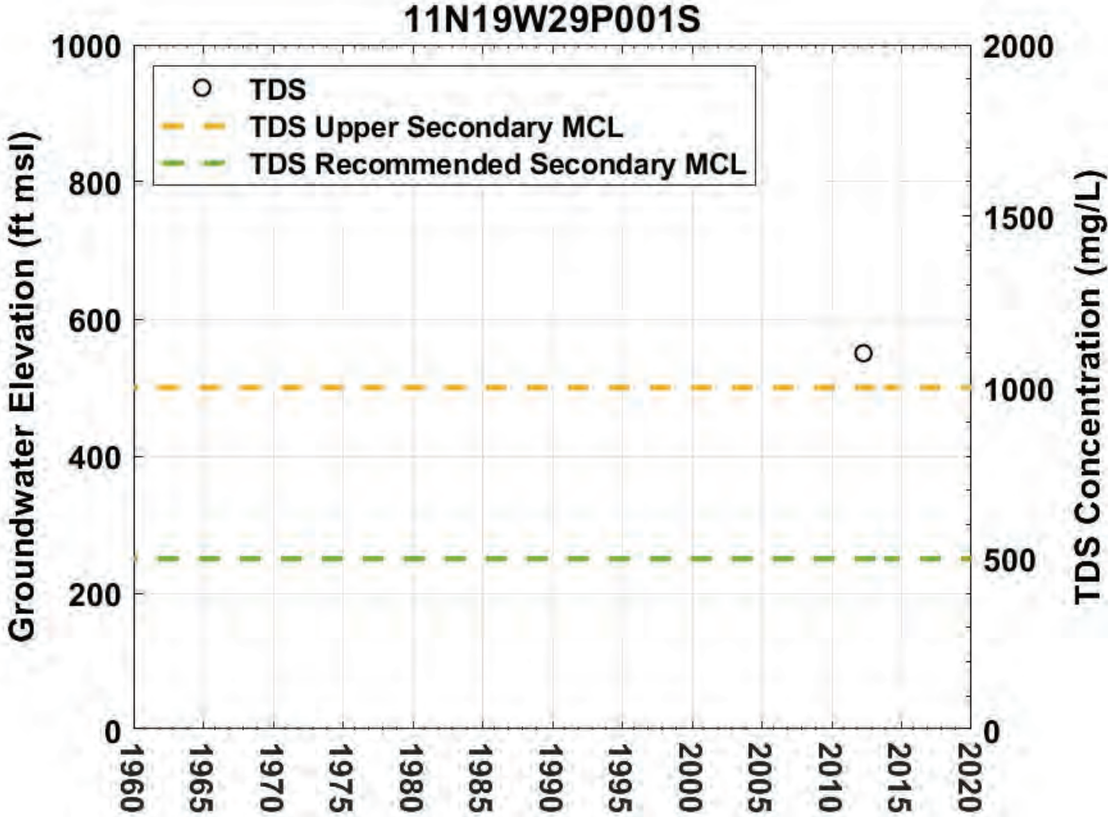

11N19W29G001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

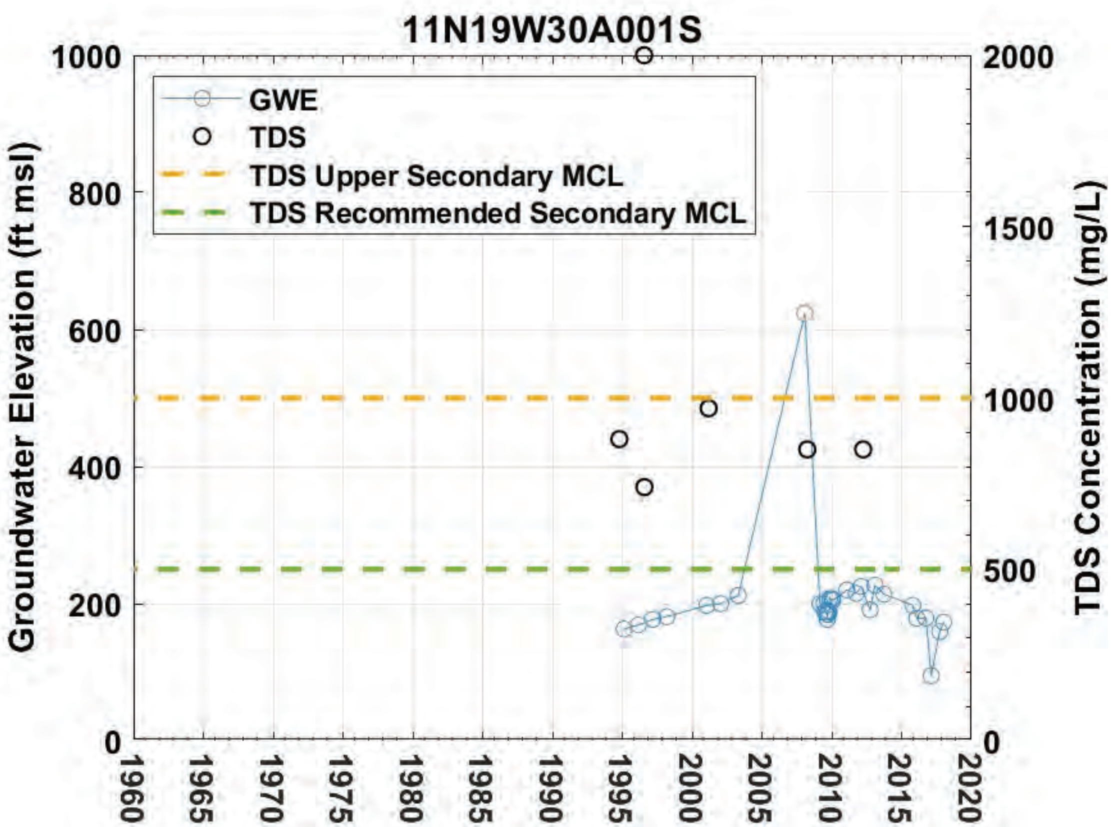


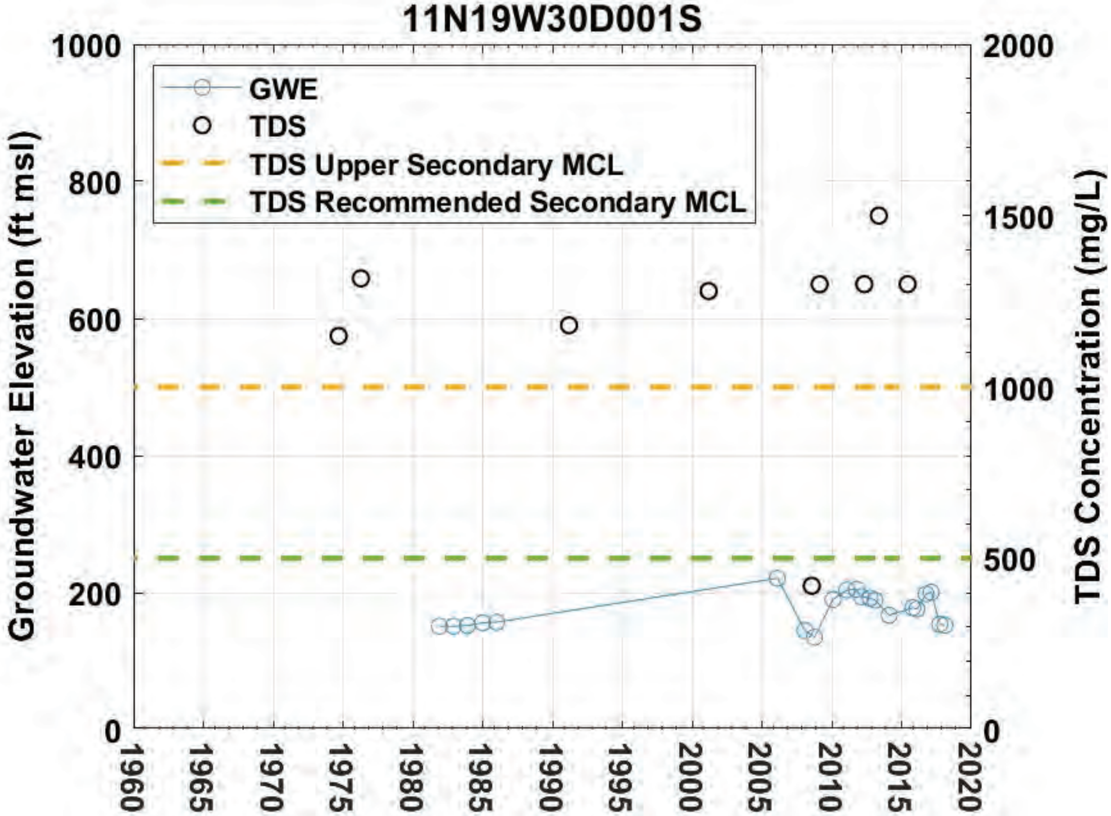
11N19W29N001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

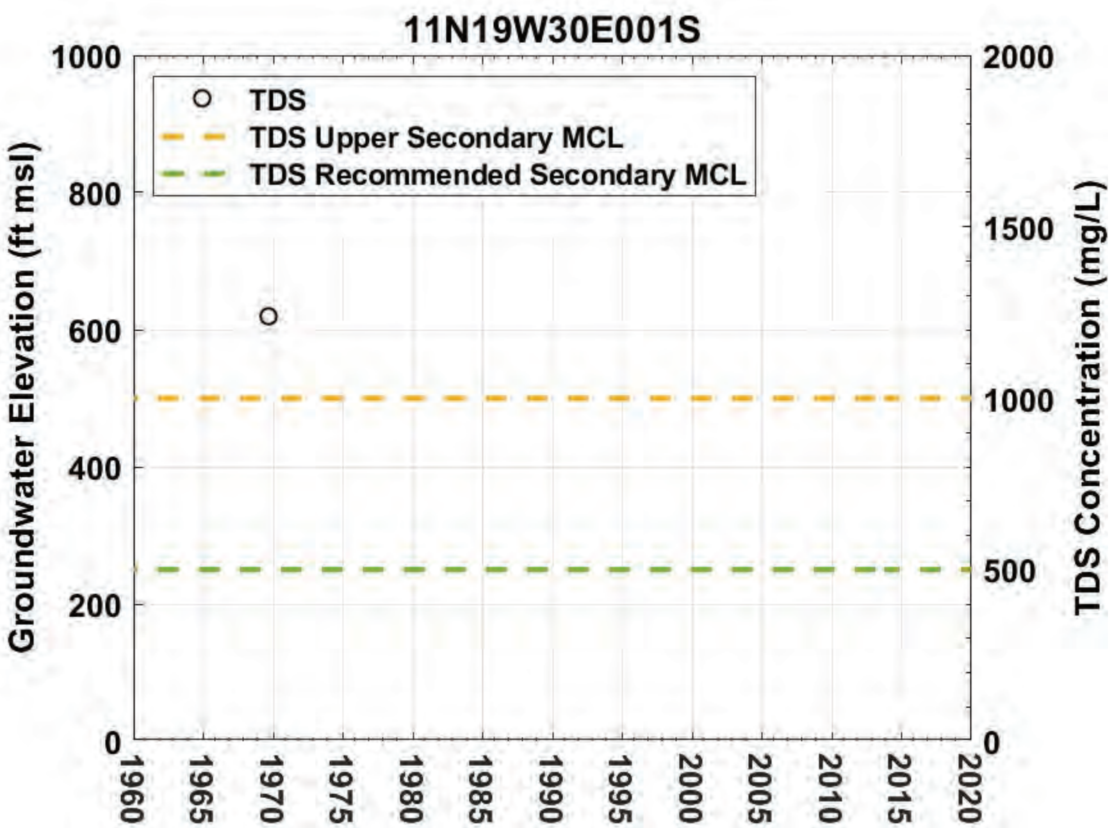


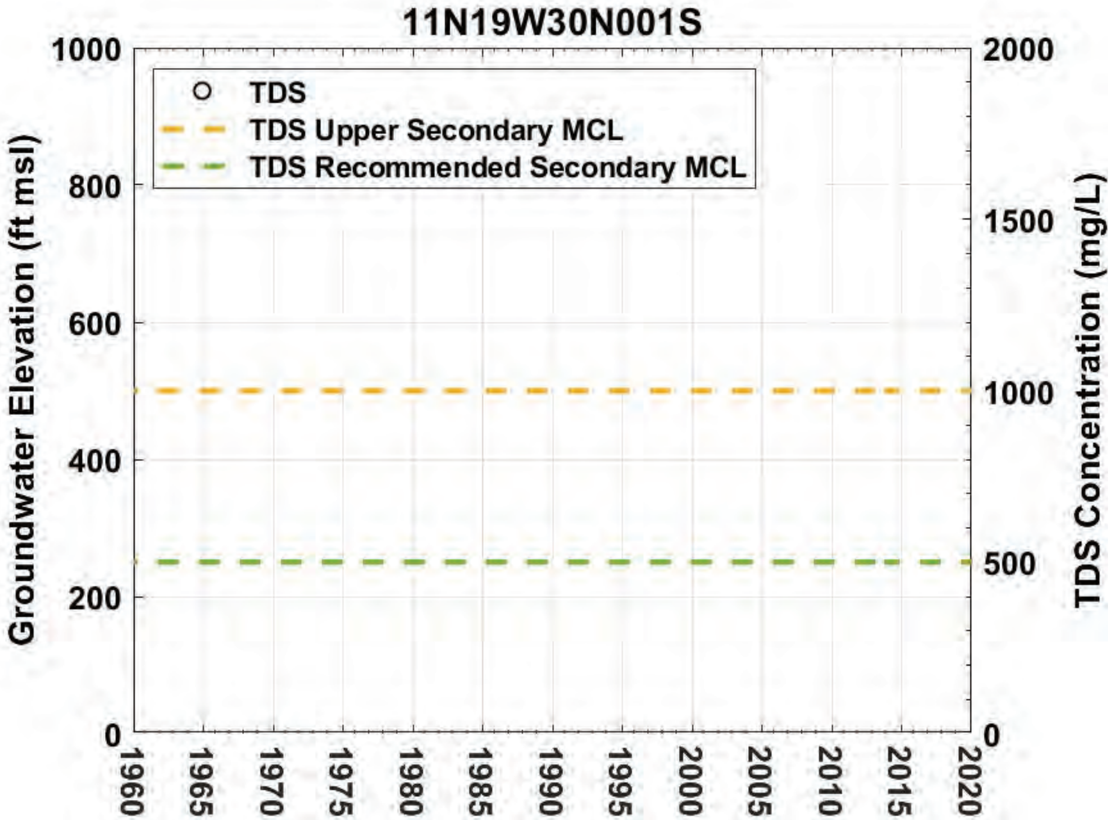
11N19W29N002S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

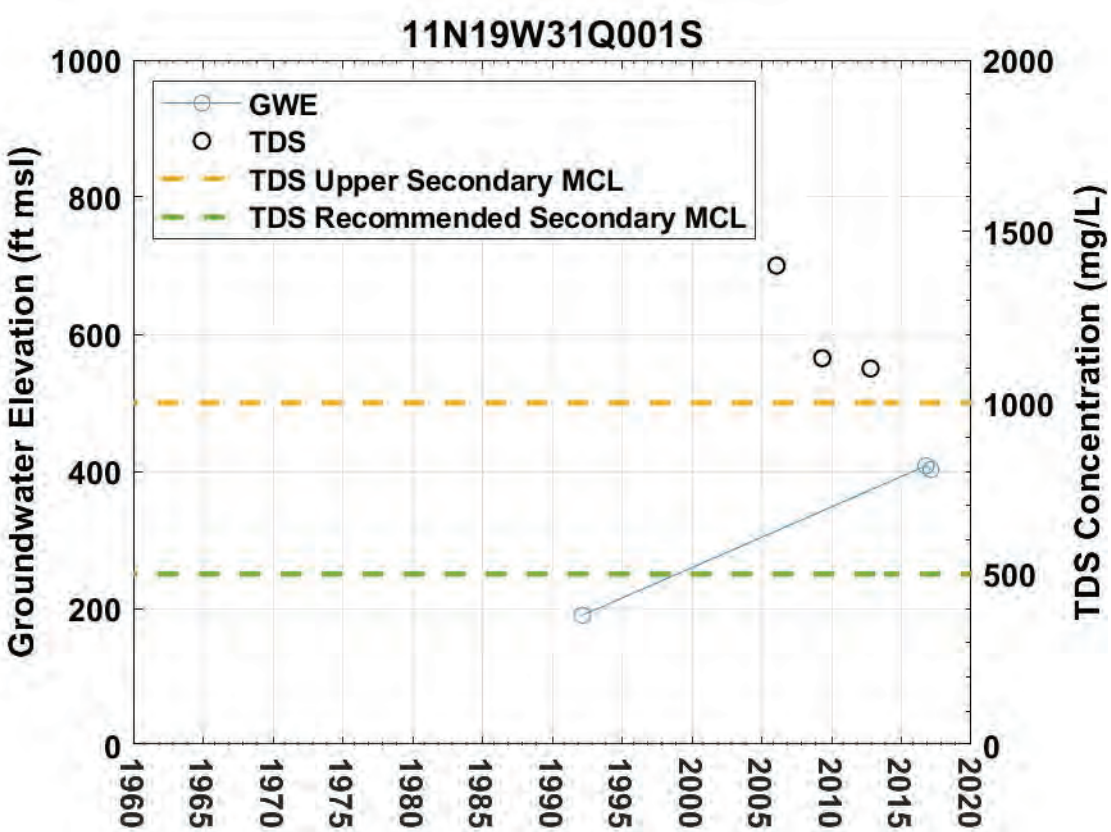

11N19W29P001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

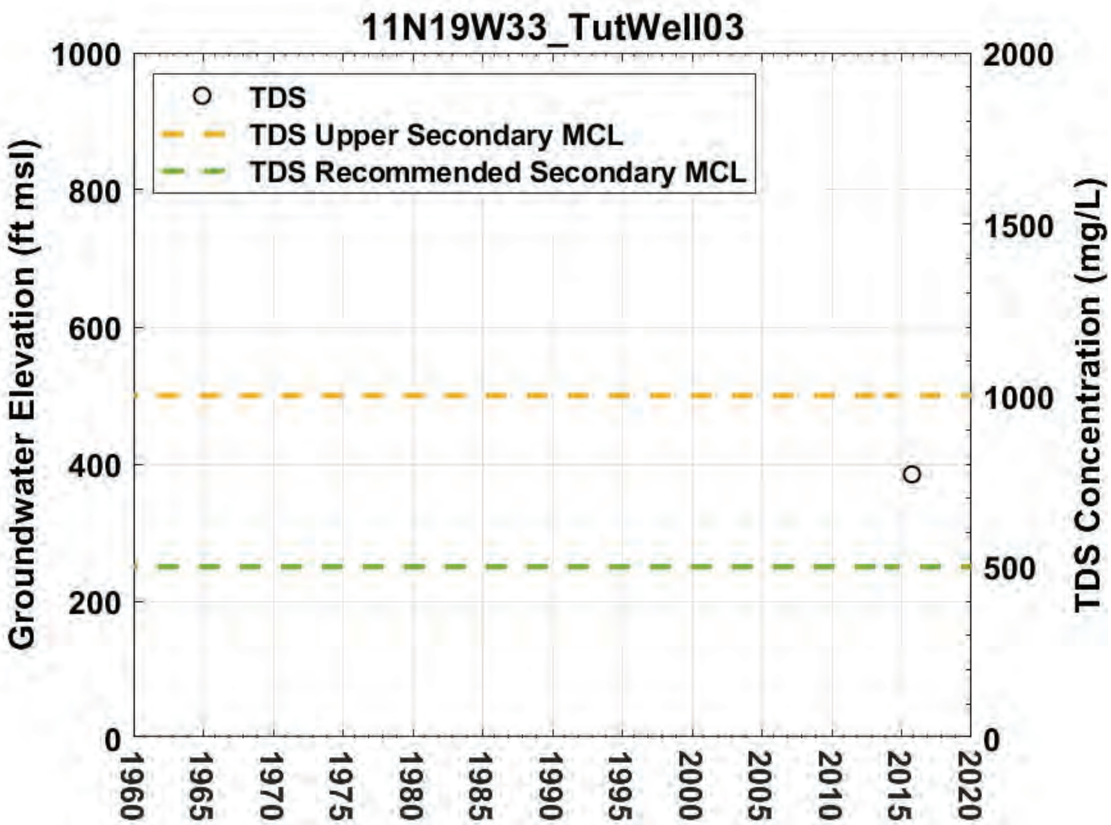

11N19W30A001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

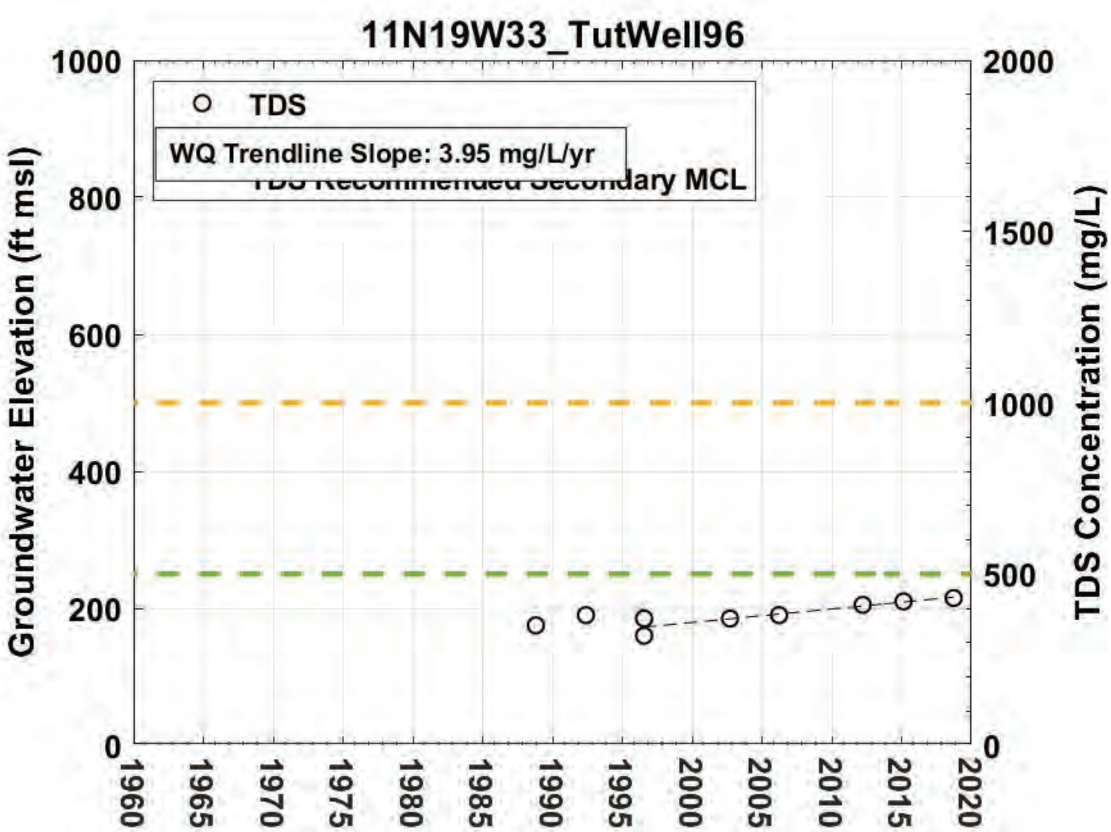

11N19W30D001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

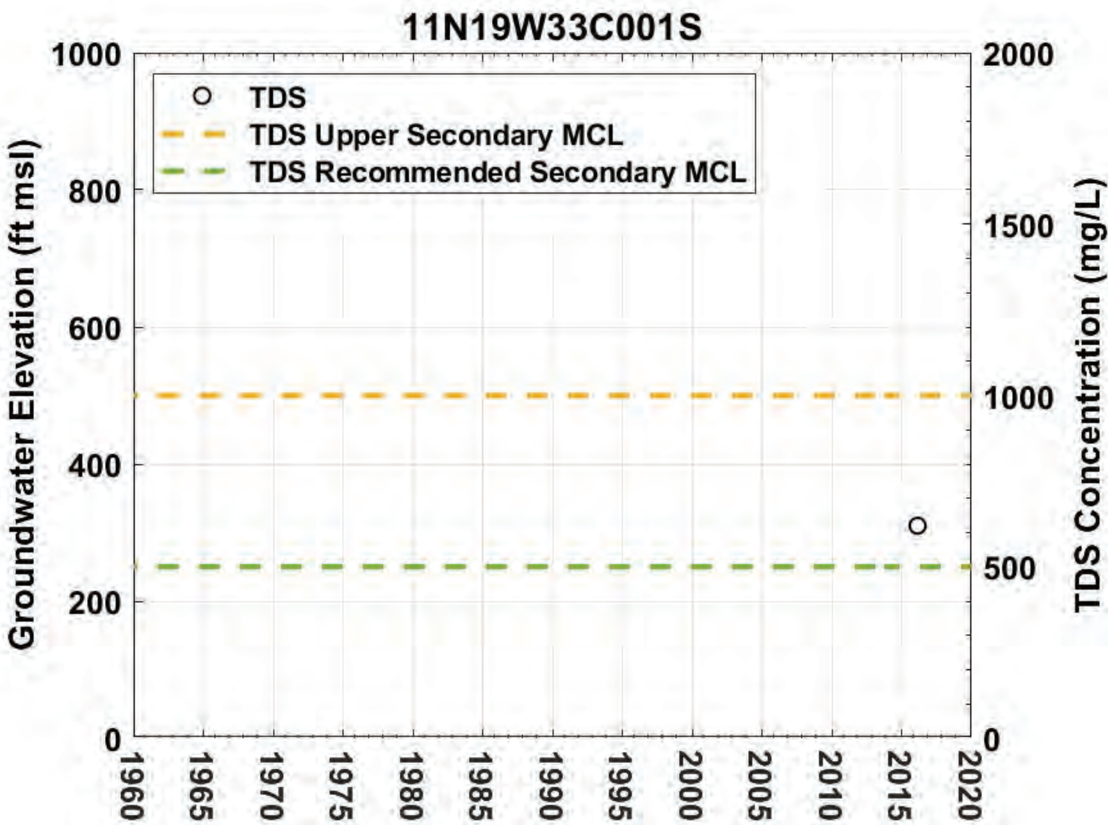

11N19W30E001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

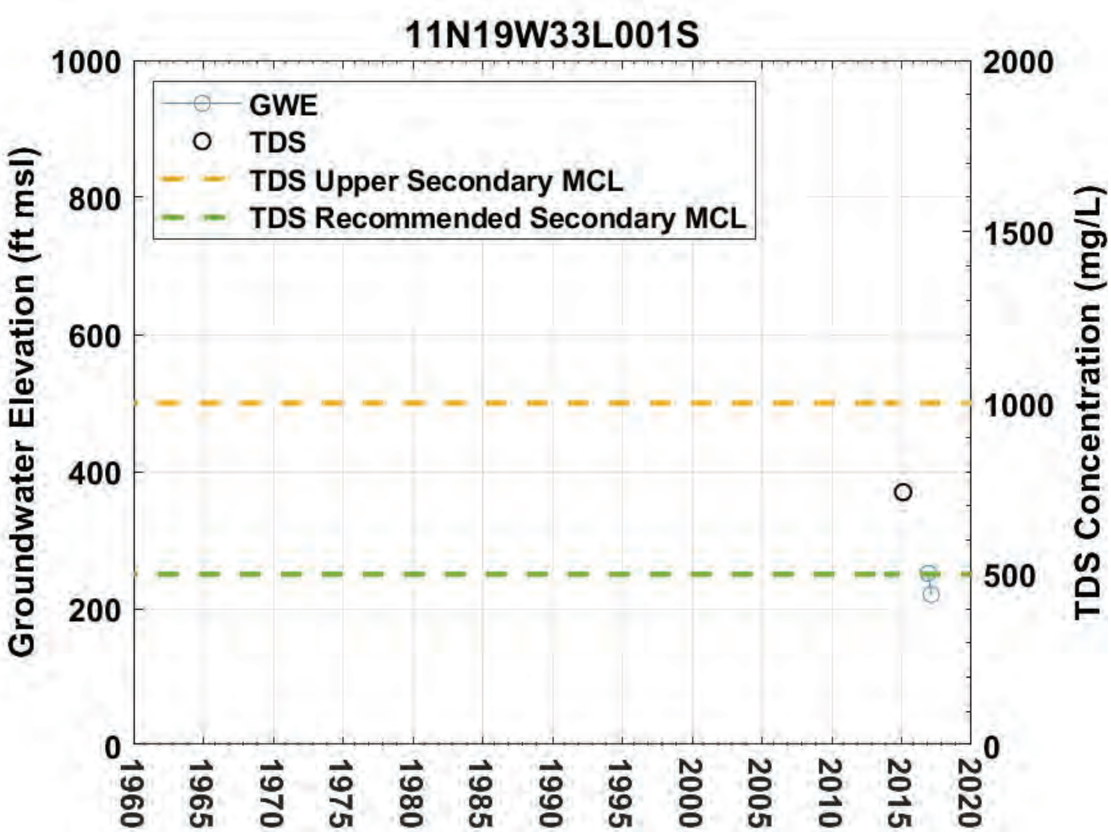

11N19W30N001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

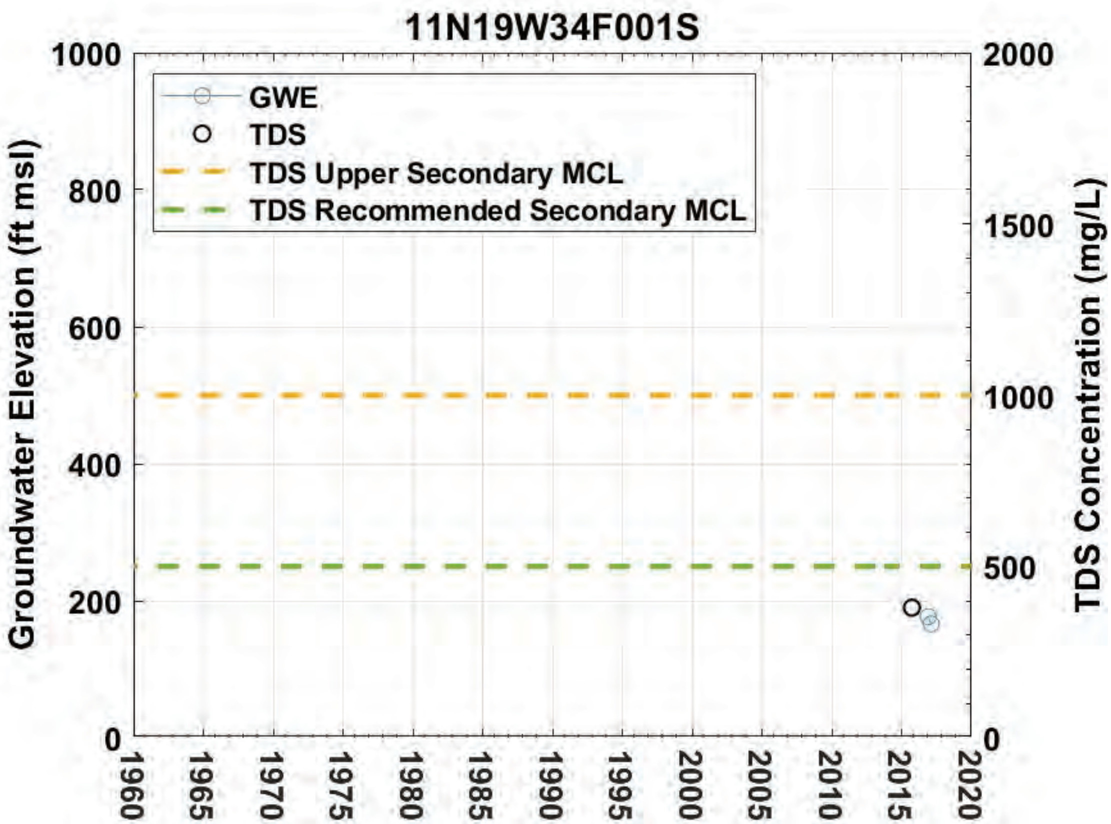

11N19W31Q001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

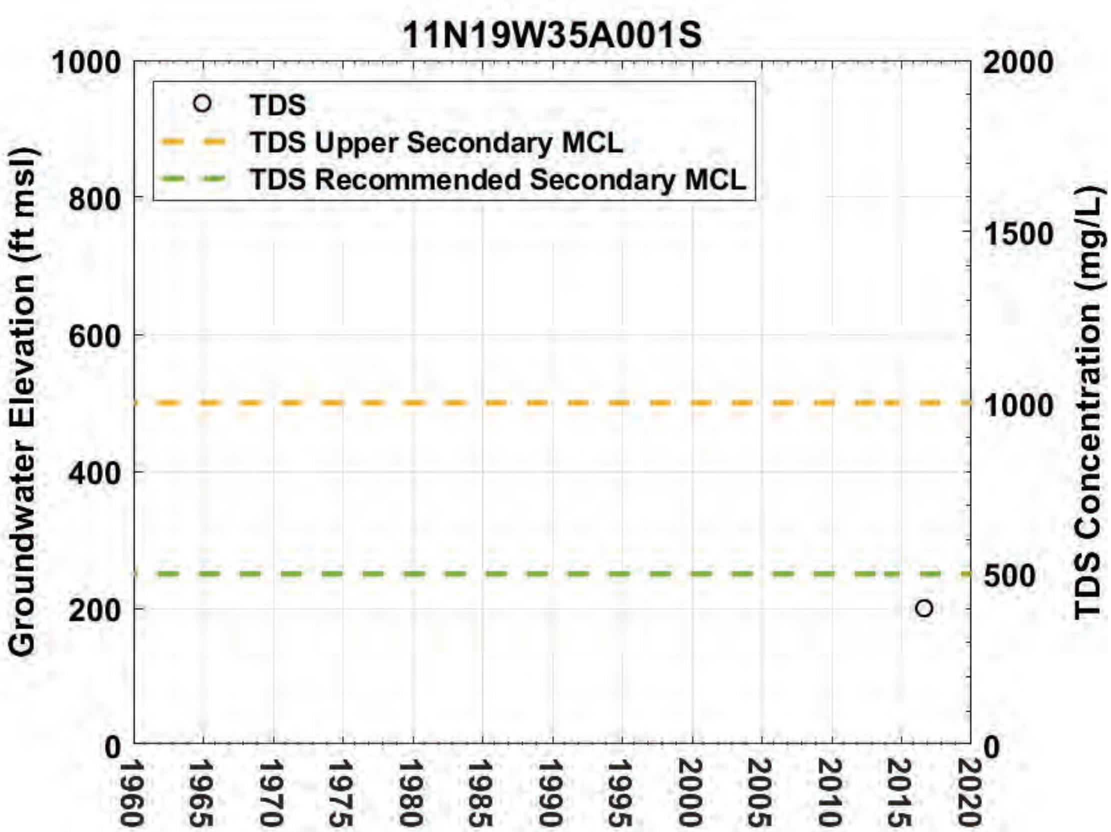

11N19W33_TutWell03
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)

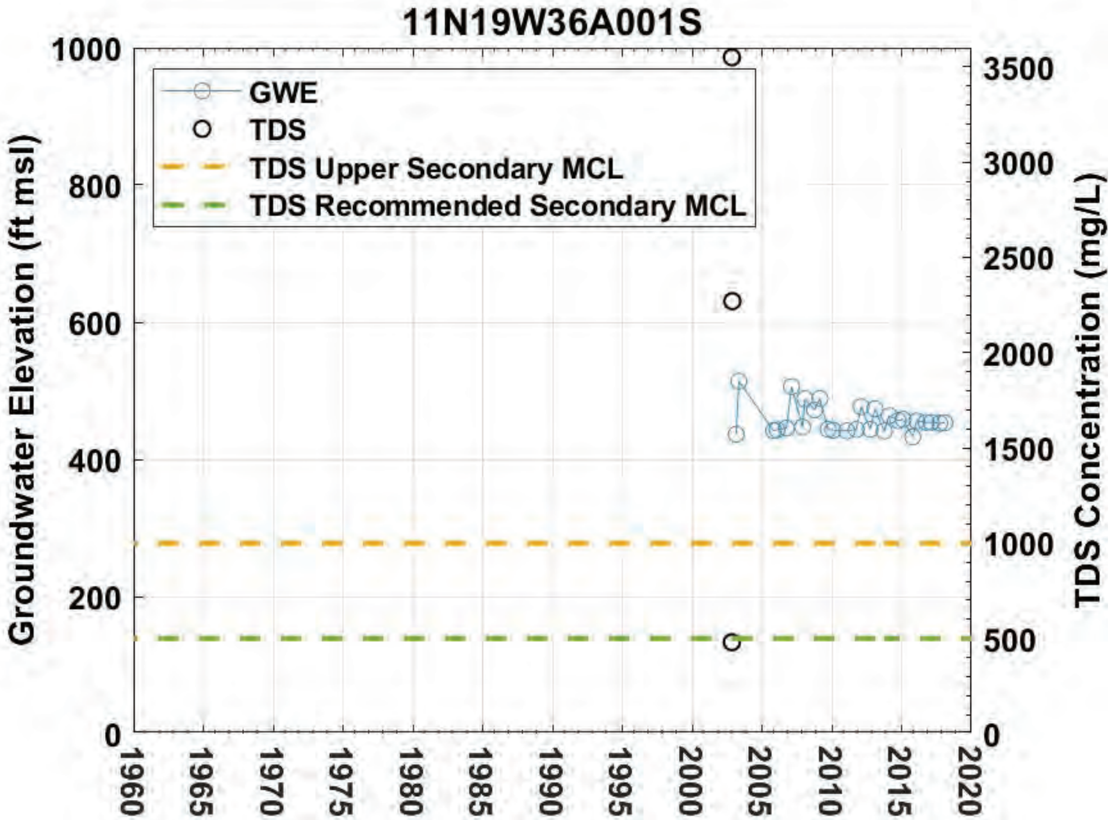

11N19W33_TutWell96
TDS
WQ Trendline Slope: 3.95 mg/L/yr
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)

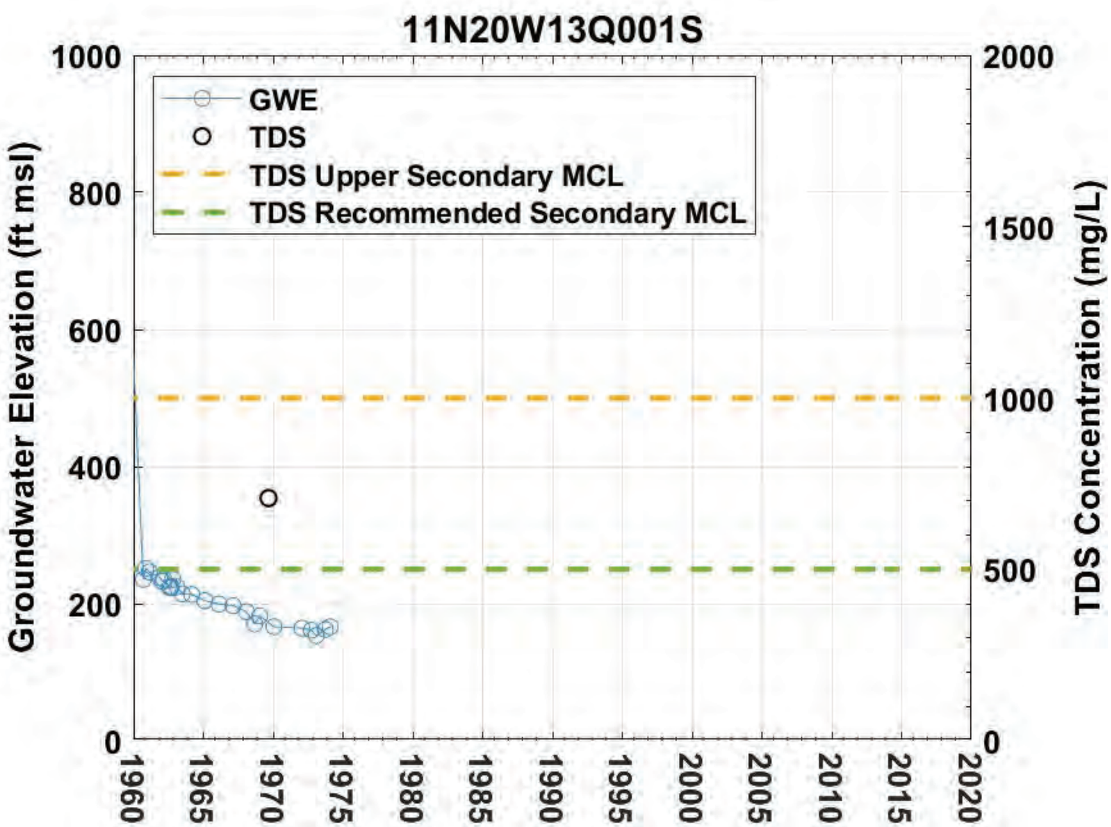

11N19W33C001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

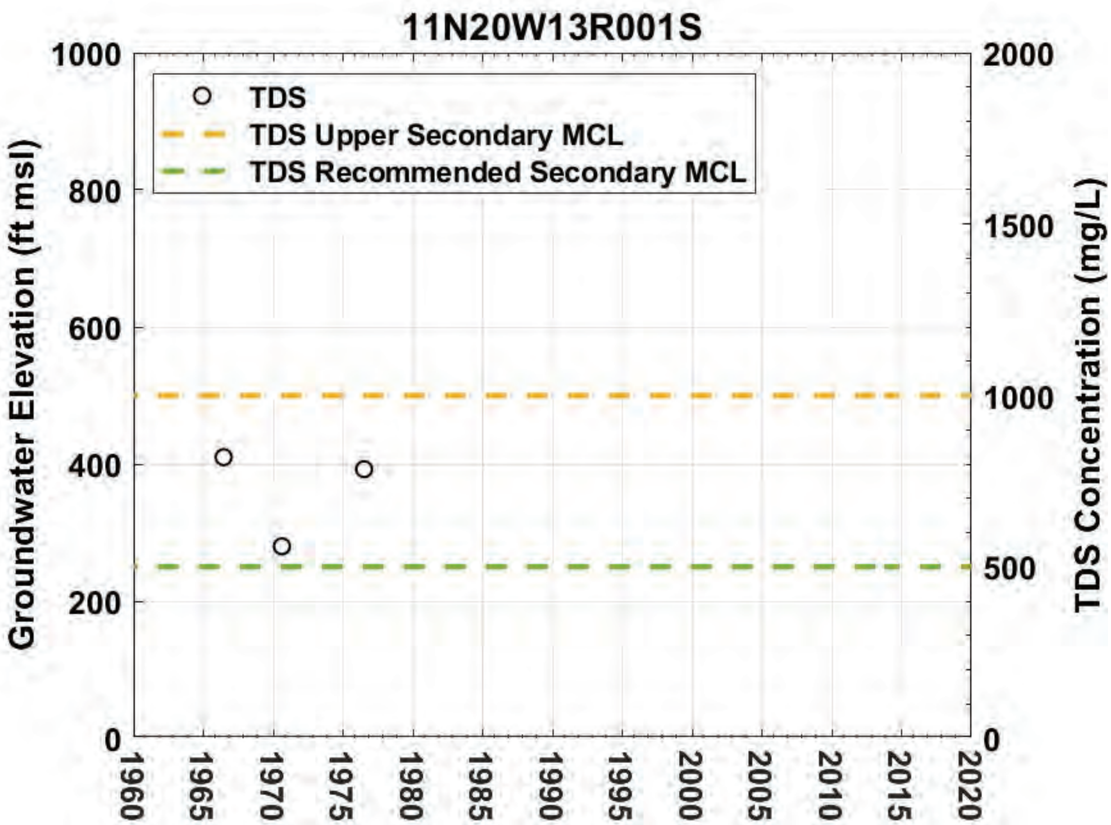

11N19W33L001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

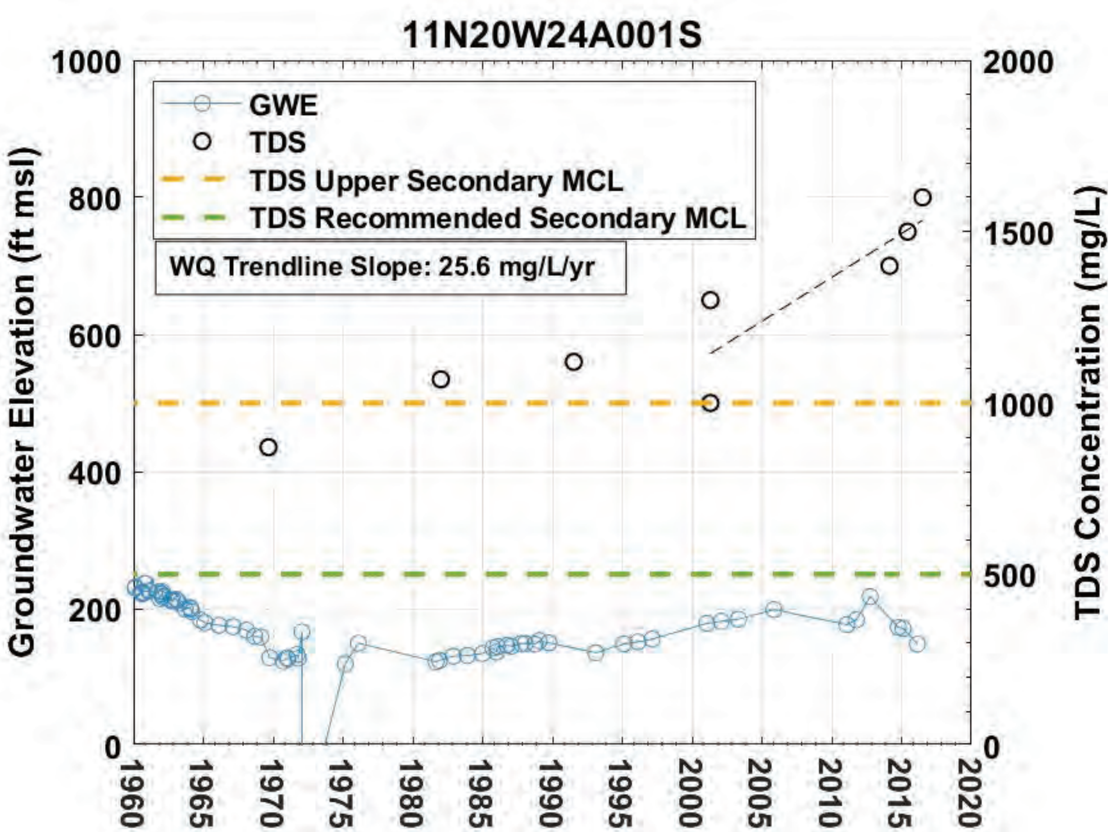

11N19W34F001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

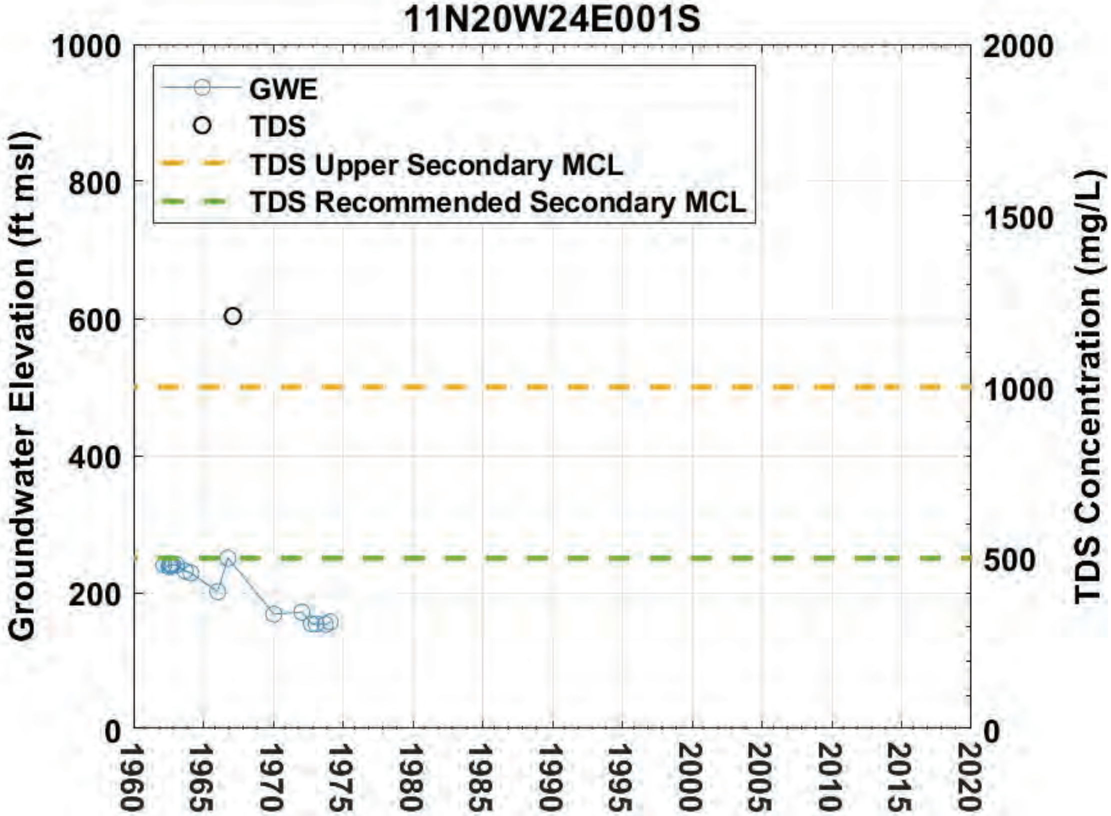

11N19W35A001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

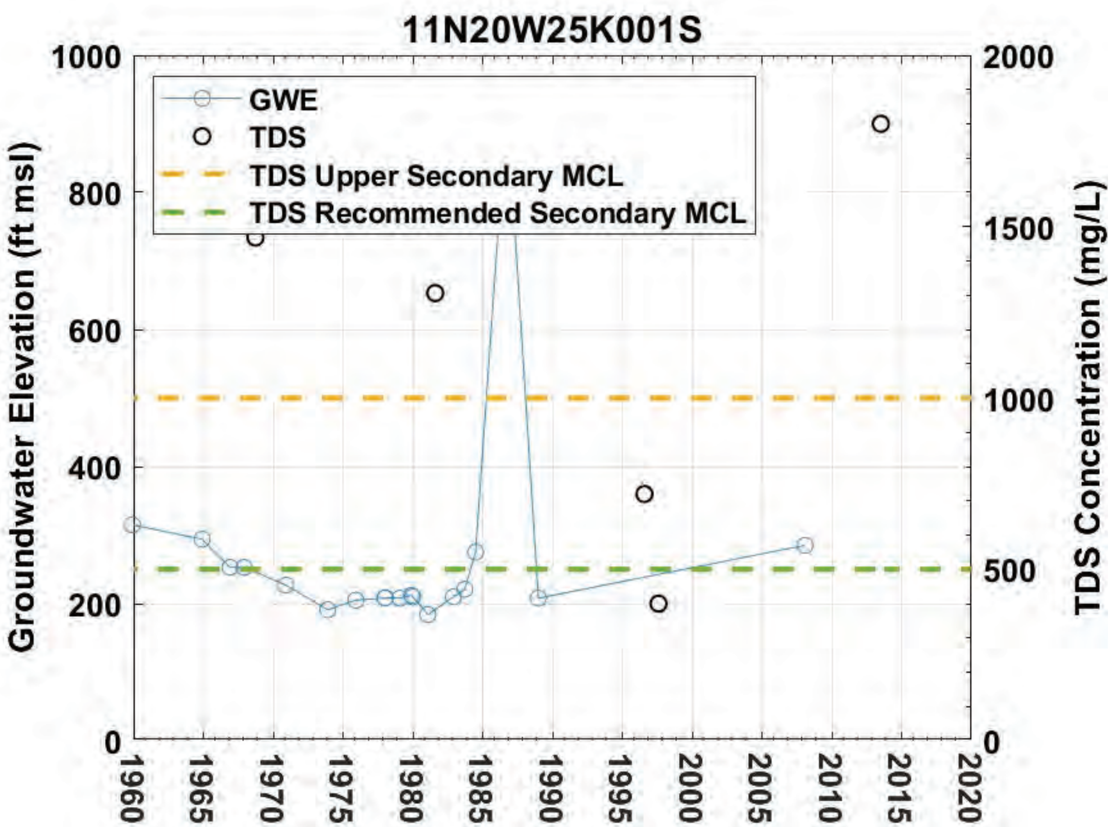

11N19W36A001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
2500
3000
3500
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

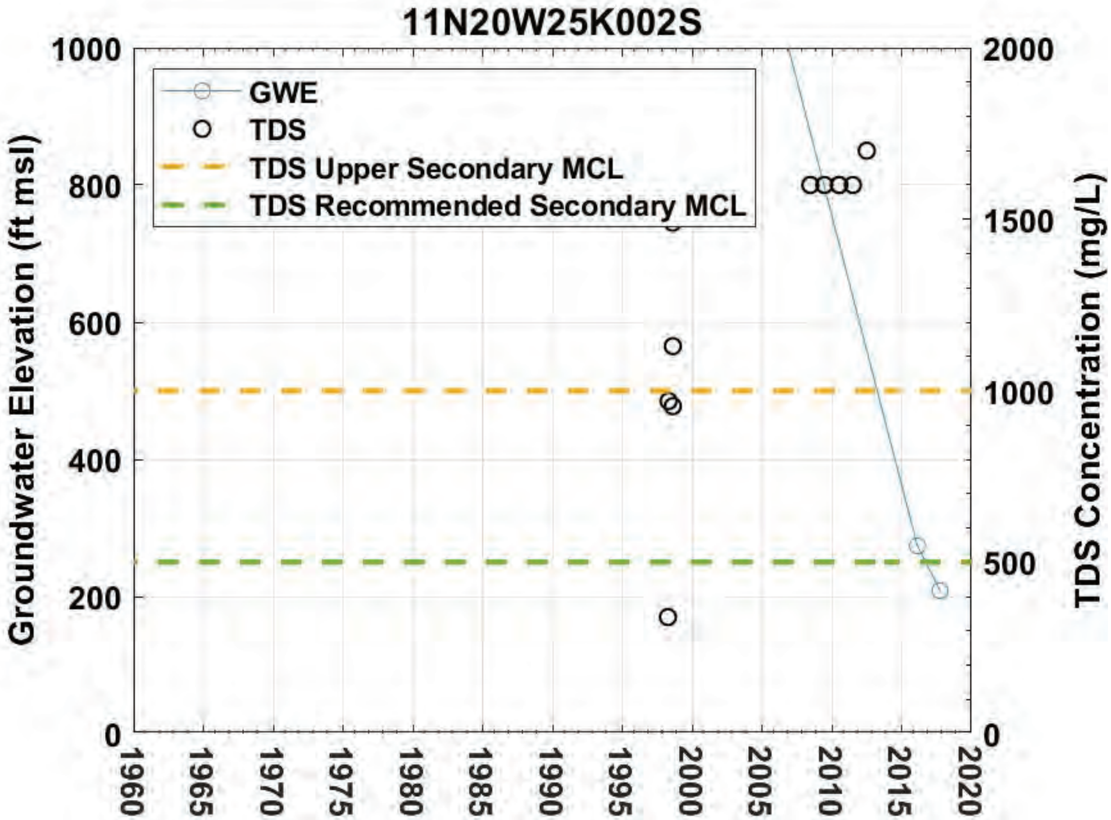

11N20W13Q001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

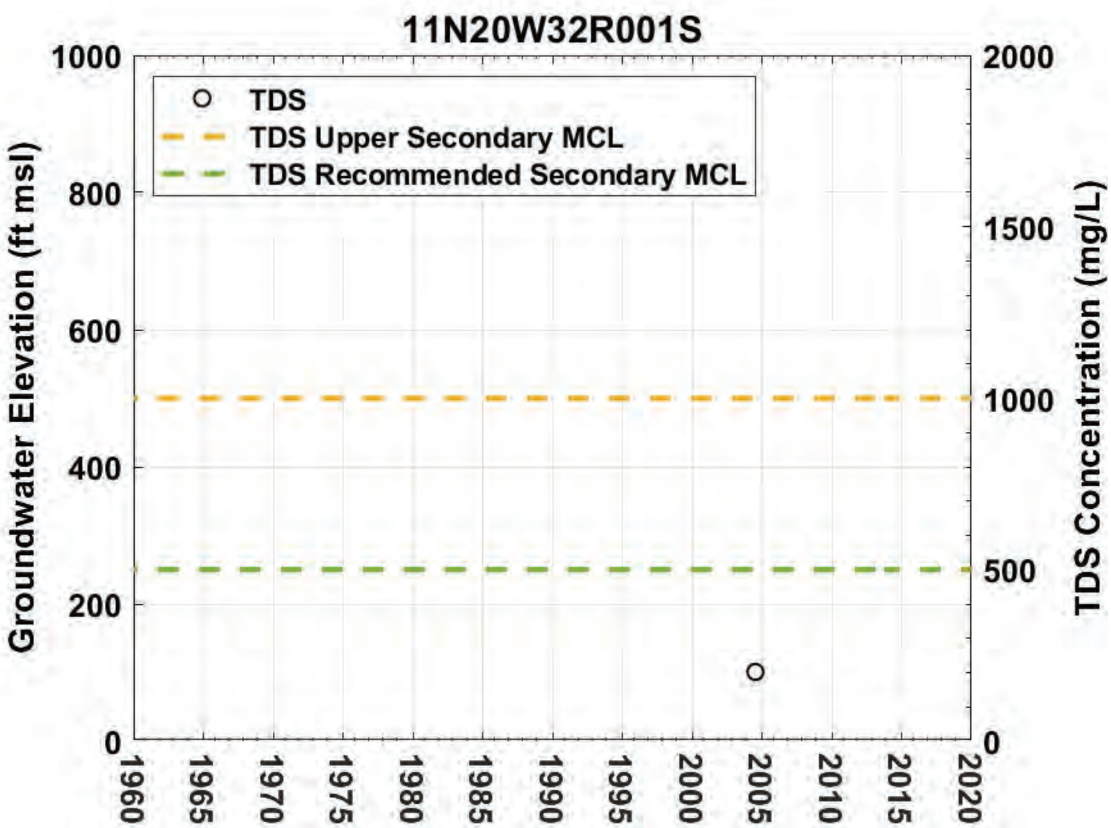

11N20W13R001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

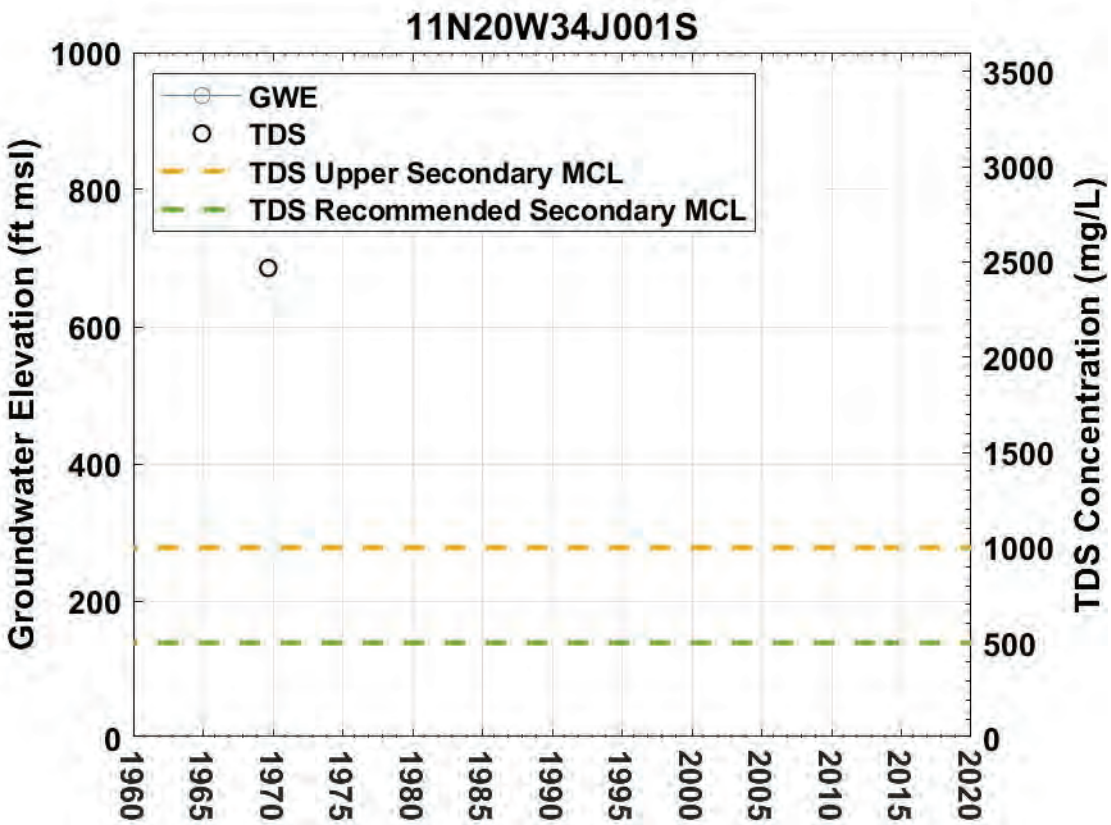

11N20W24A001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
WQ Trendline Slope: 25.6 mg/L/yr
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N20W24E001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

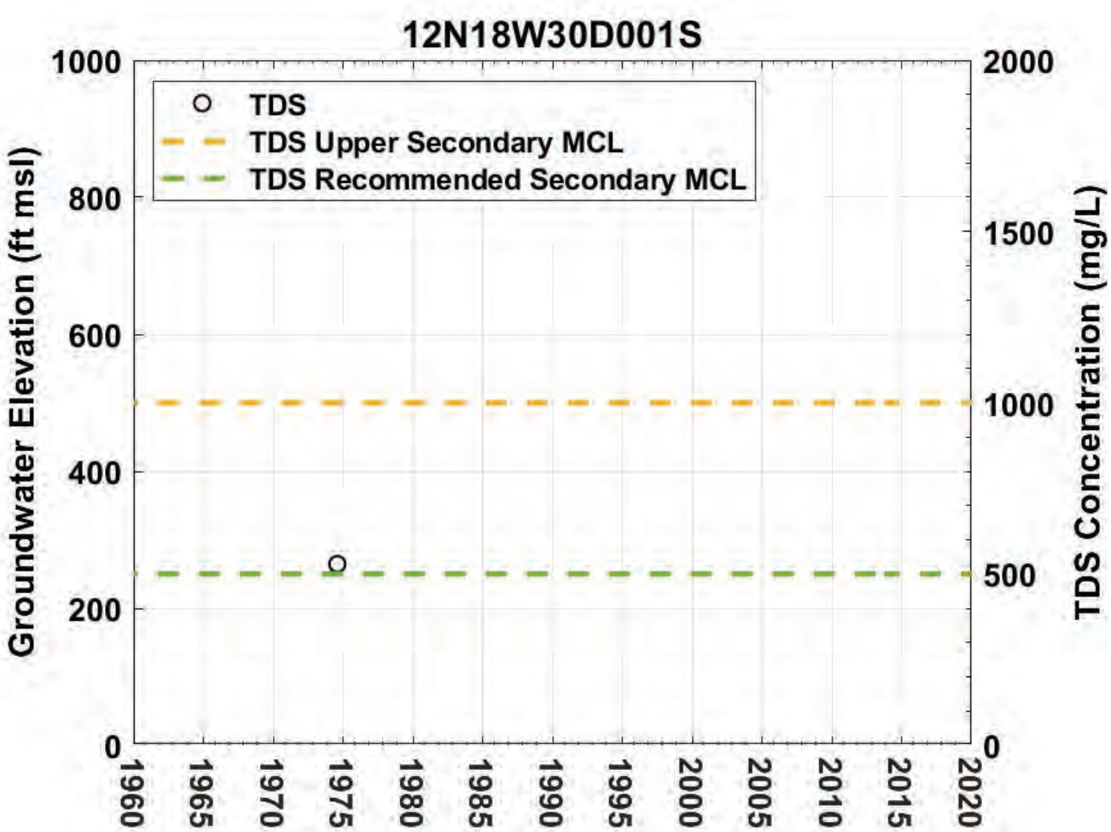

11N20W25K001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N20W25K002S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

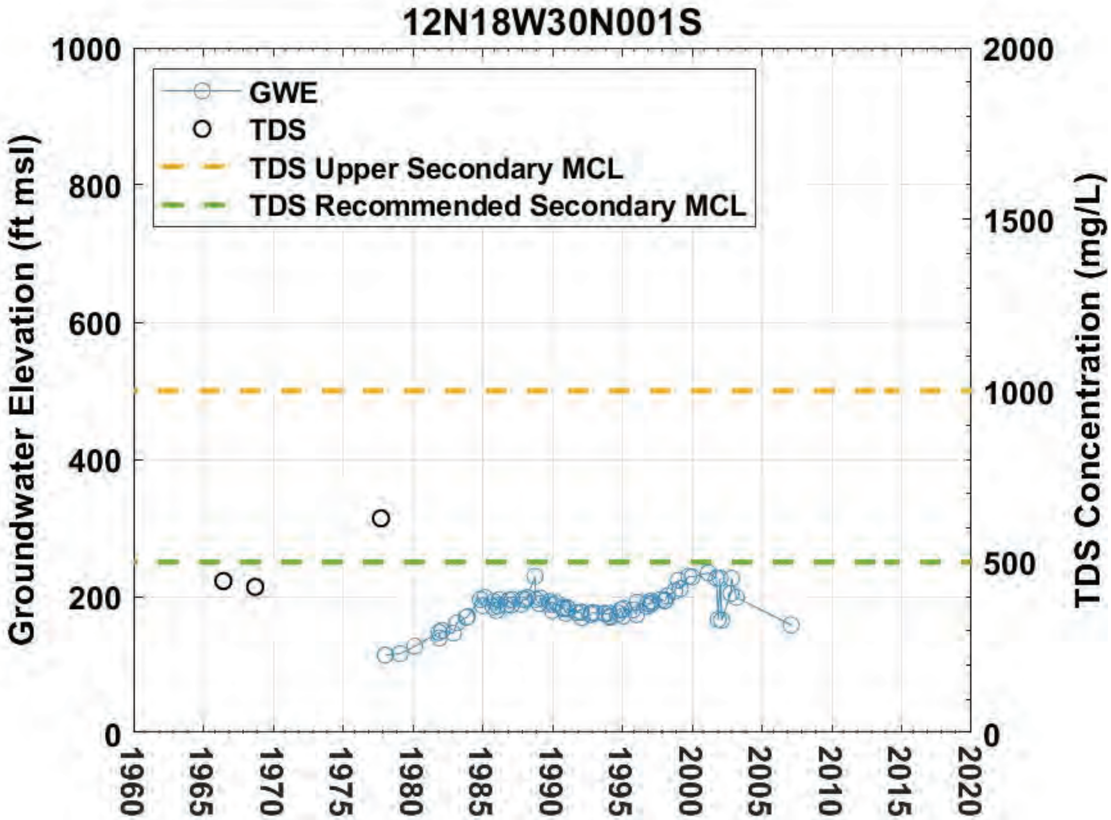

11N20W32R001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

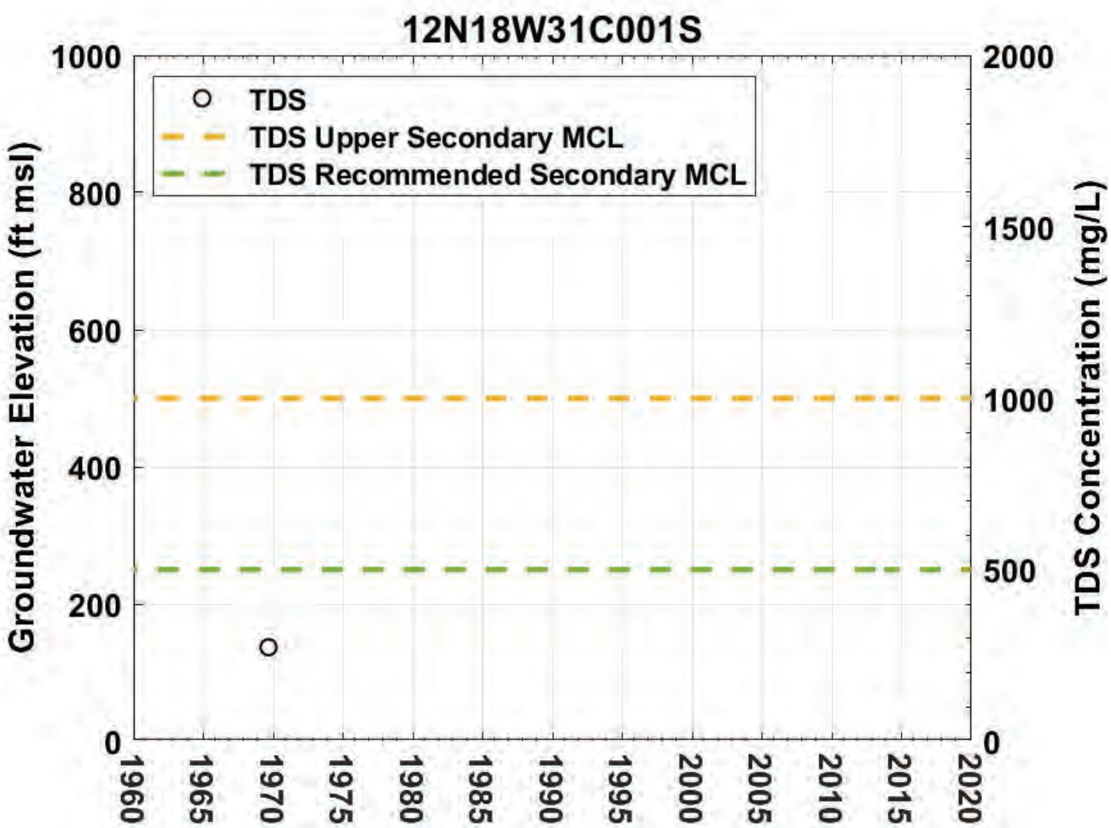


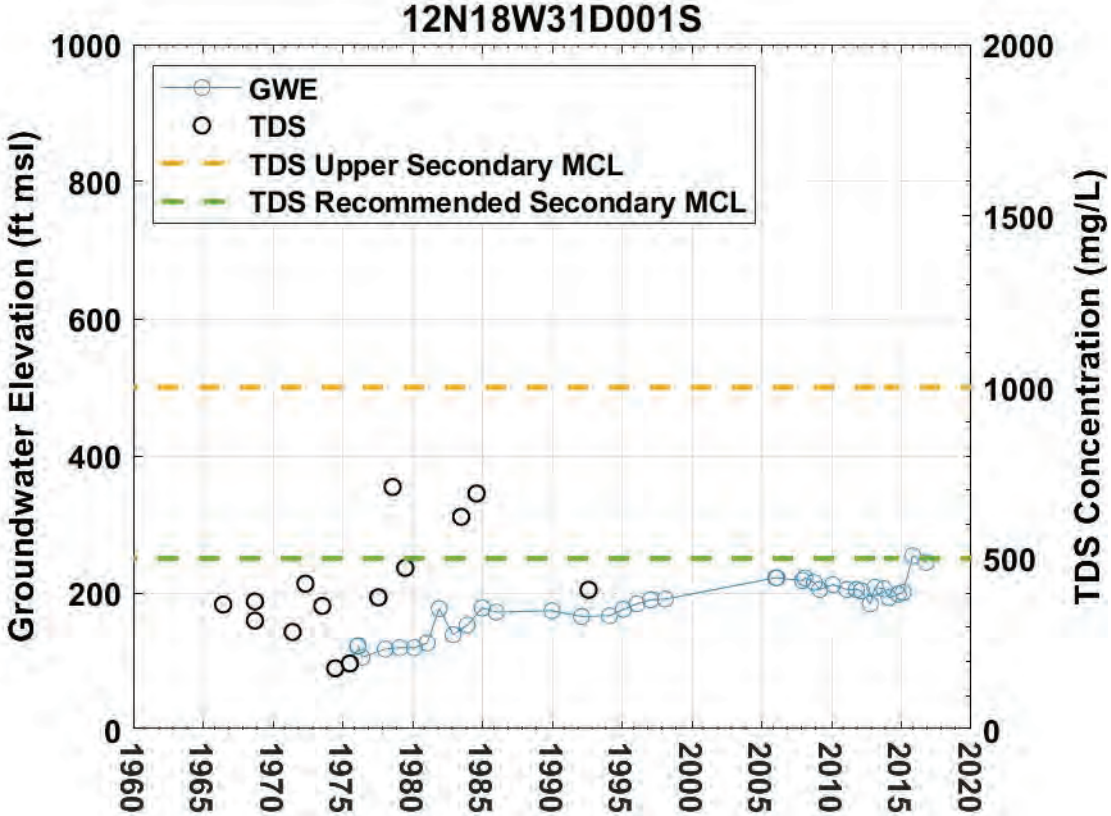
11N20W34J001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
2500
3000
3500
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

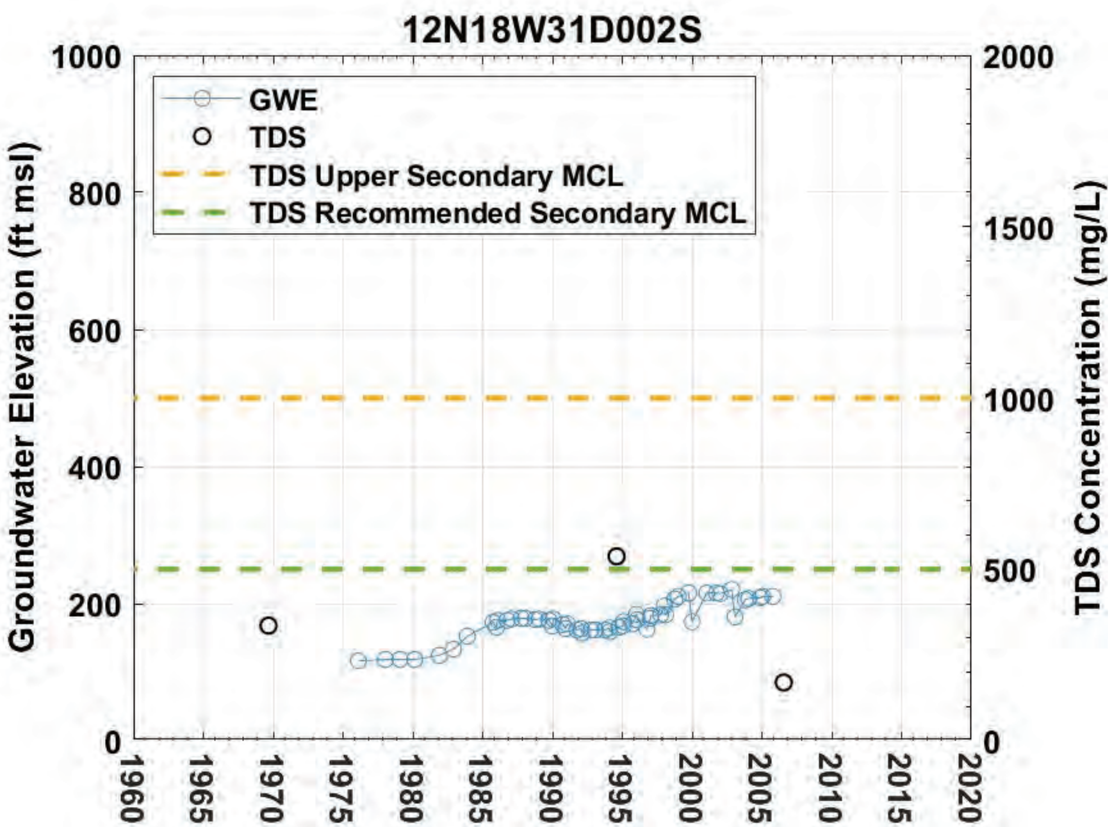


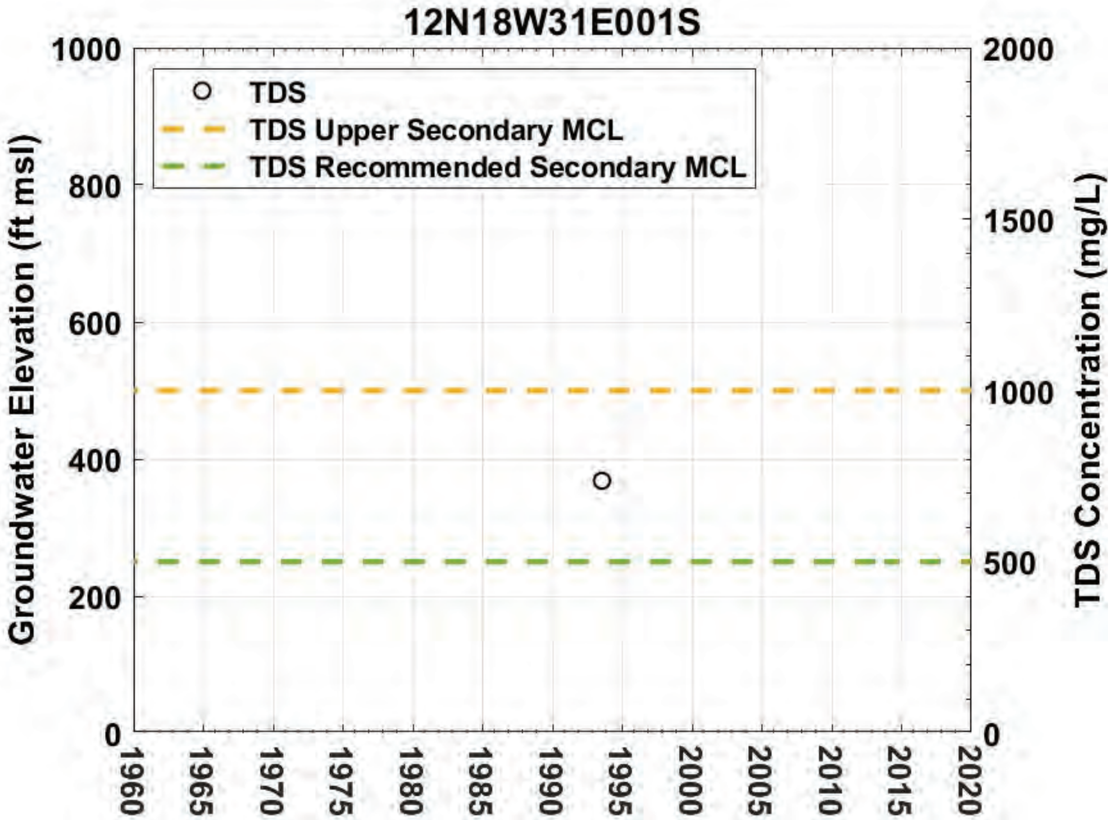
12N18W30D001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

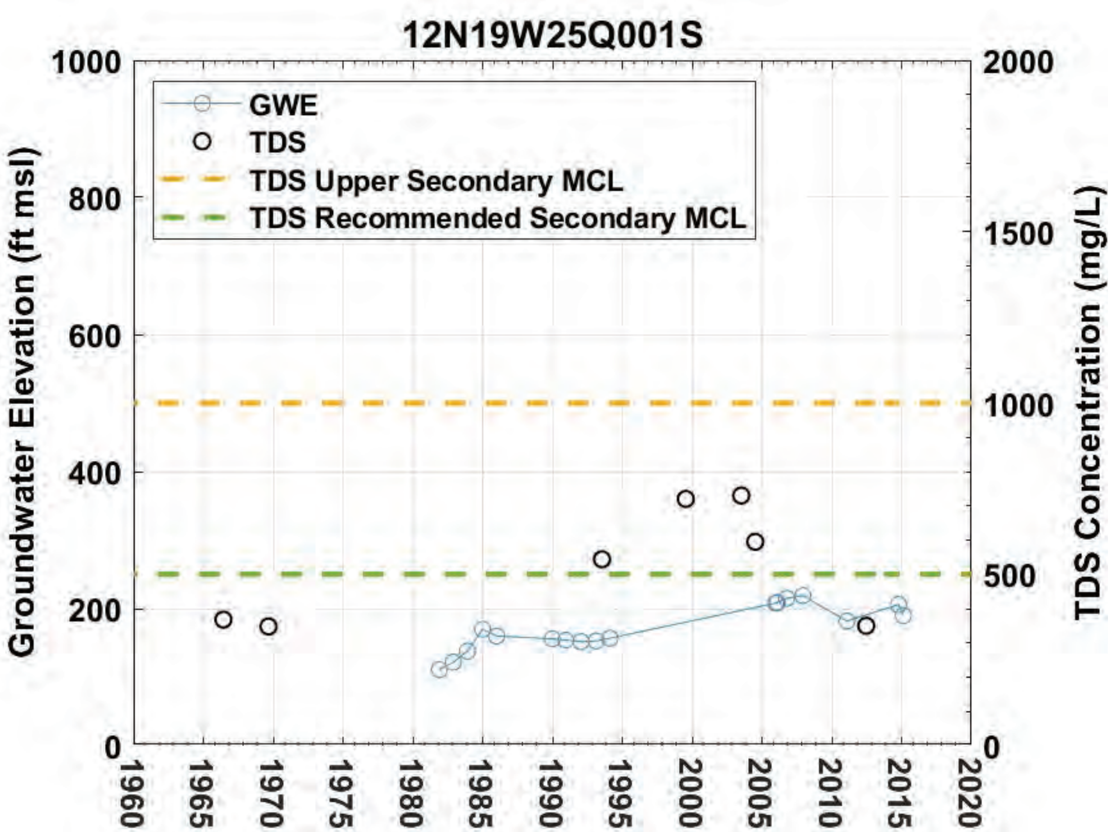

12N18W30N001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

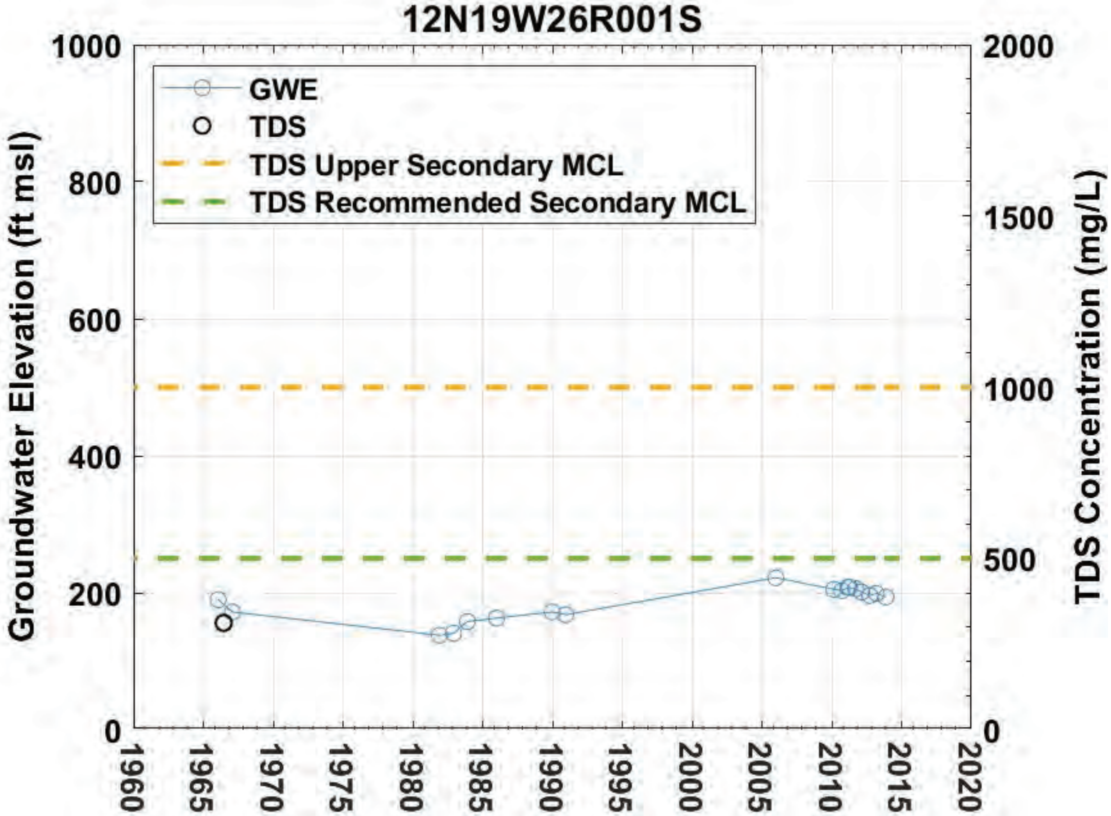

12N18W31C001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

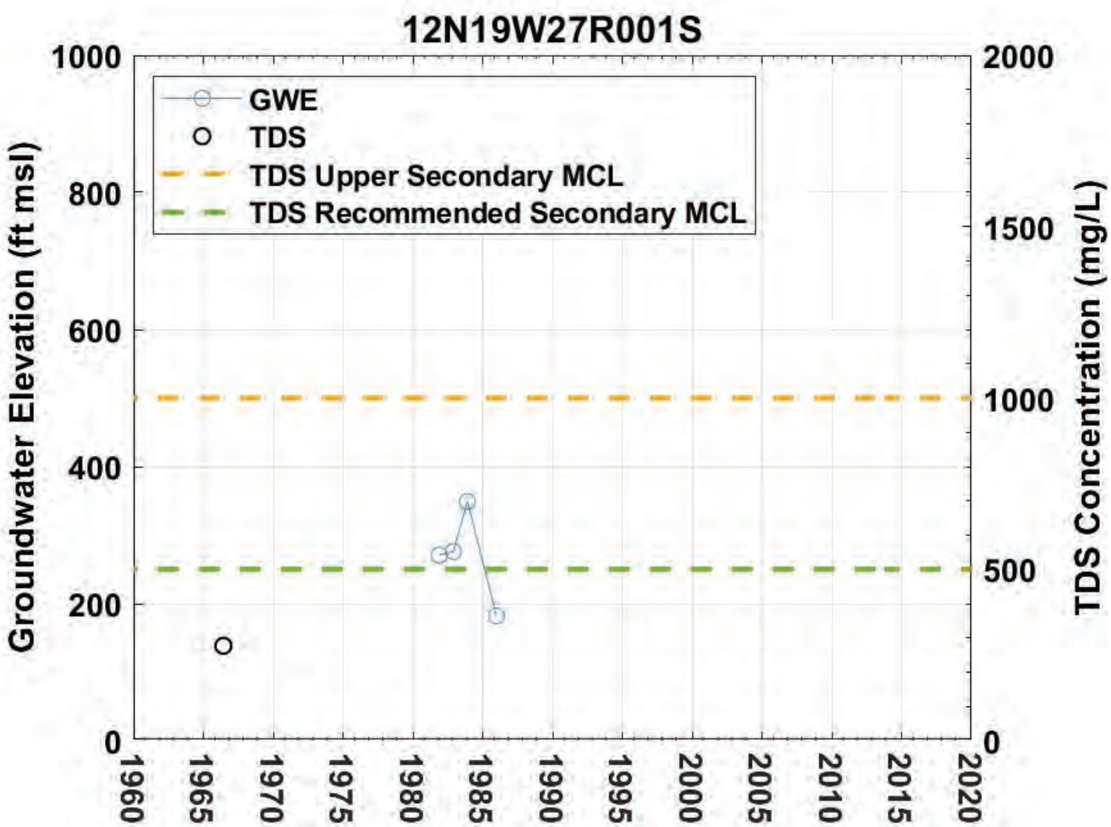

12N18W31D001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

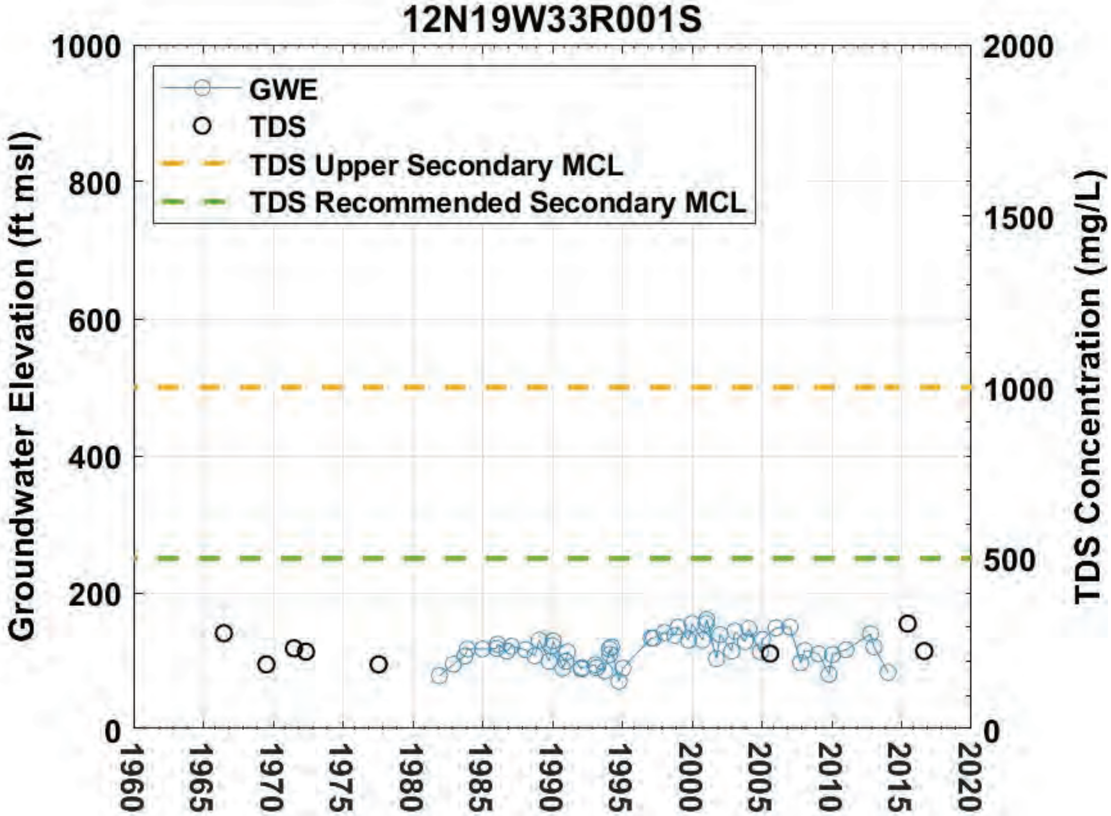

12N18W31D002S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

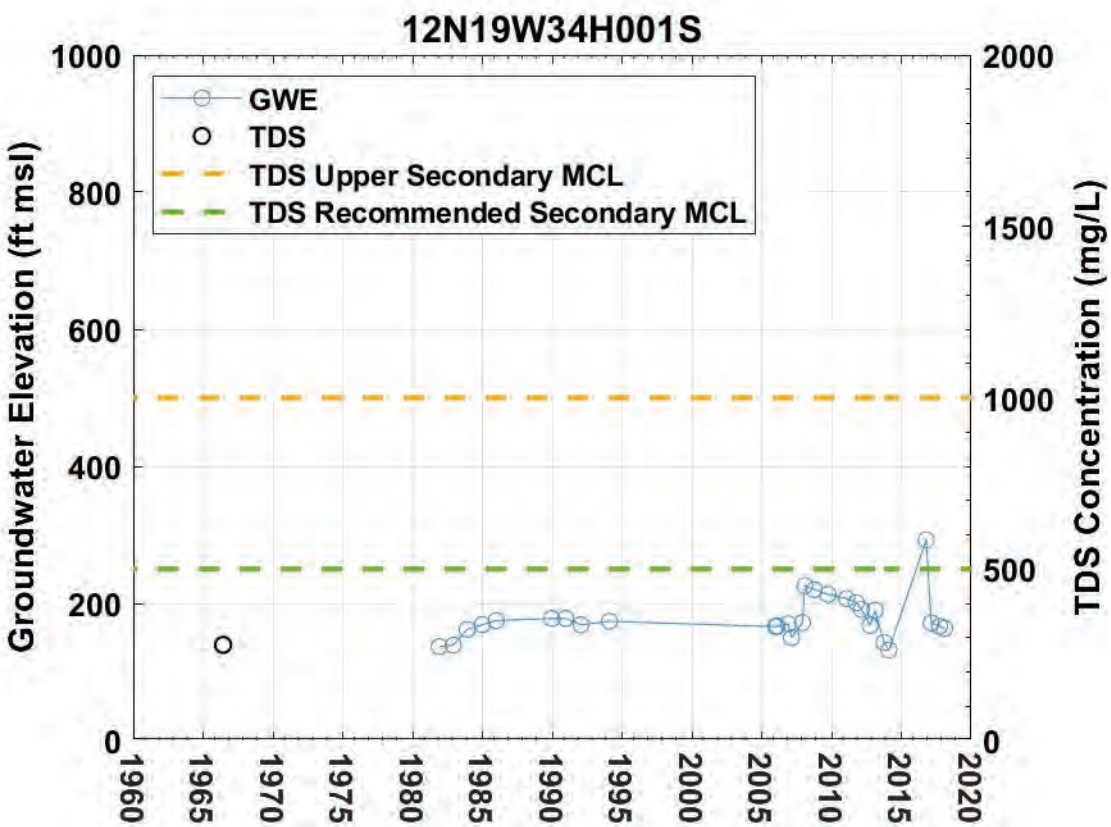

12N18W31E001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

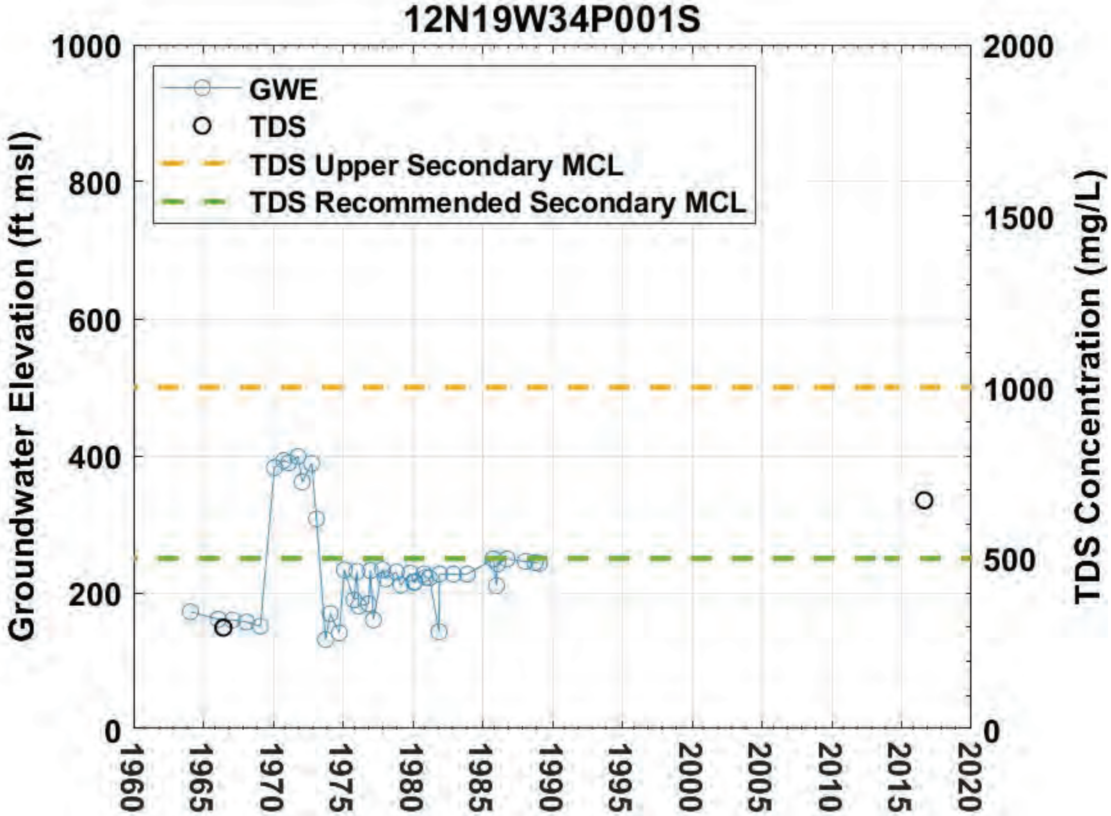

12N19W25Q001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

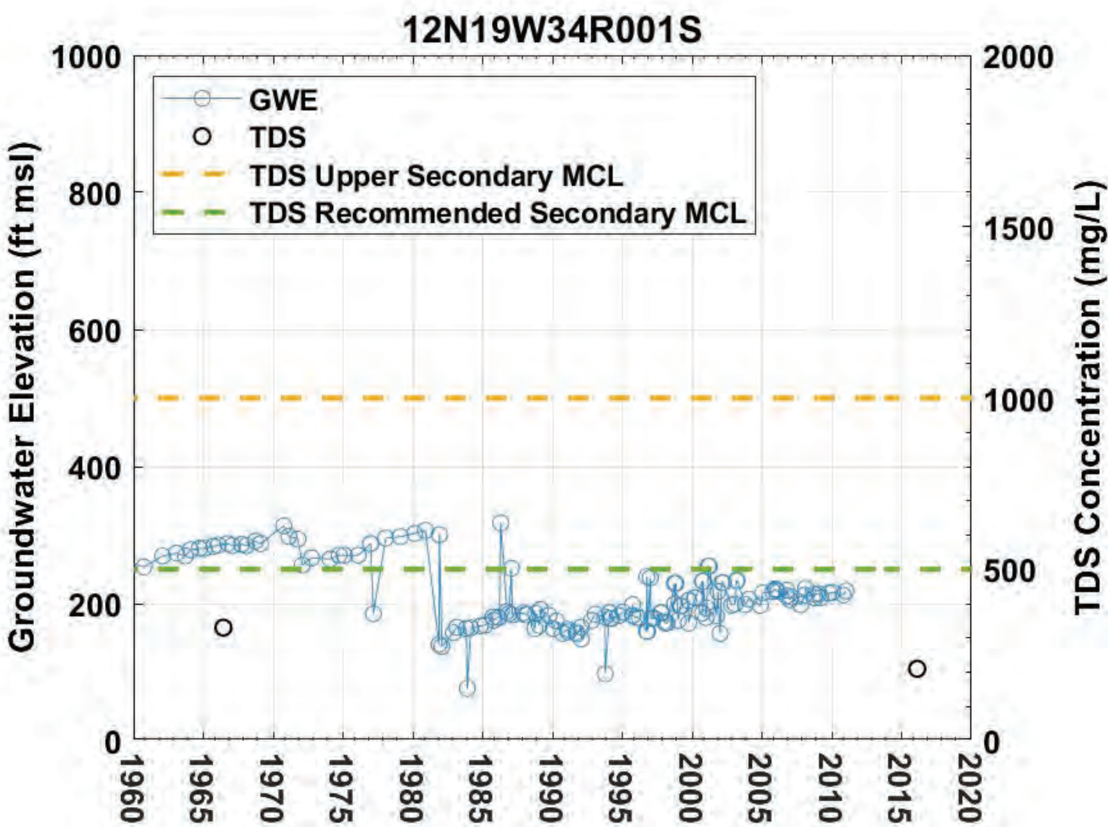

12N19W26R001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

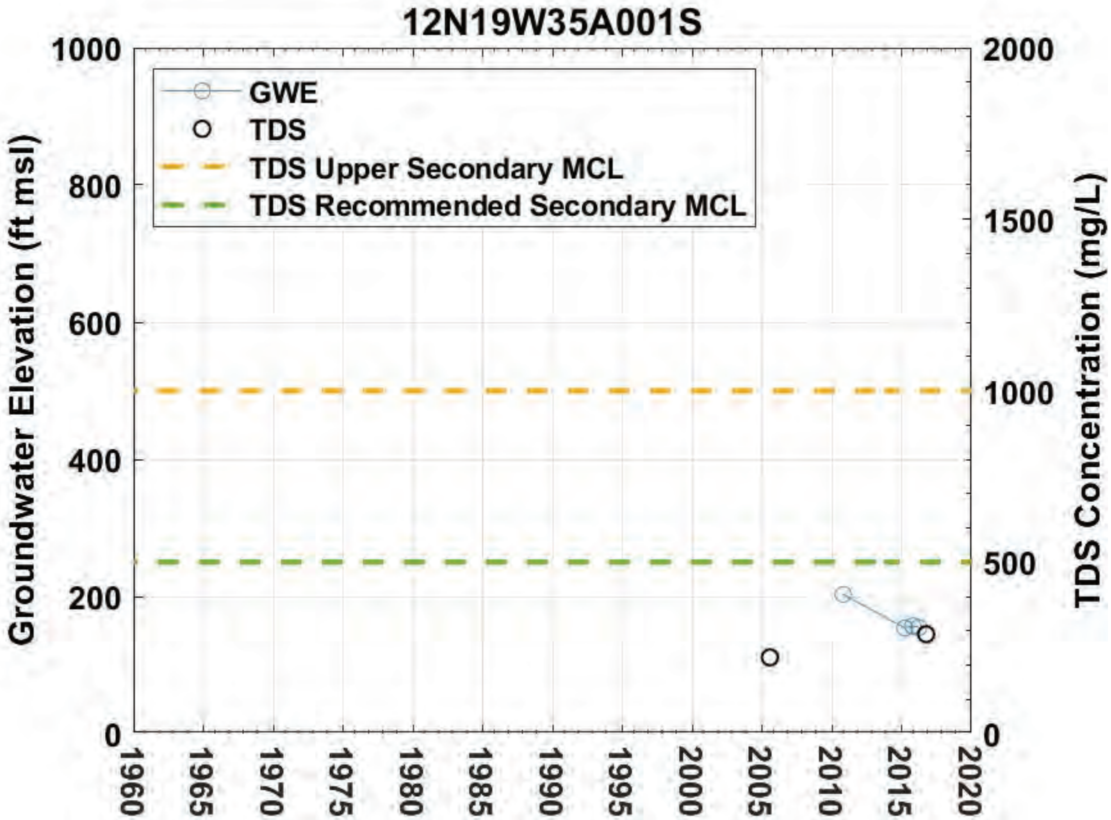

12N19W27R001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


12N19W33R001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

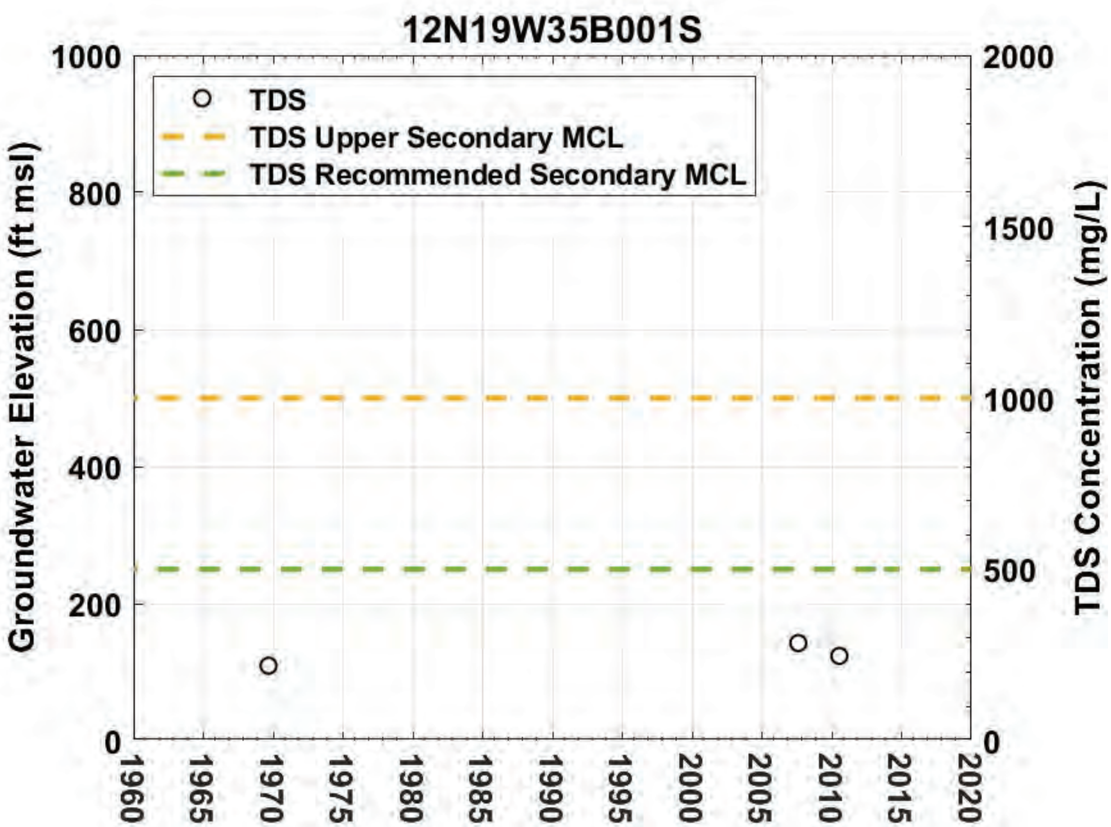

12N19W34H001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


12N19W34P001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

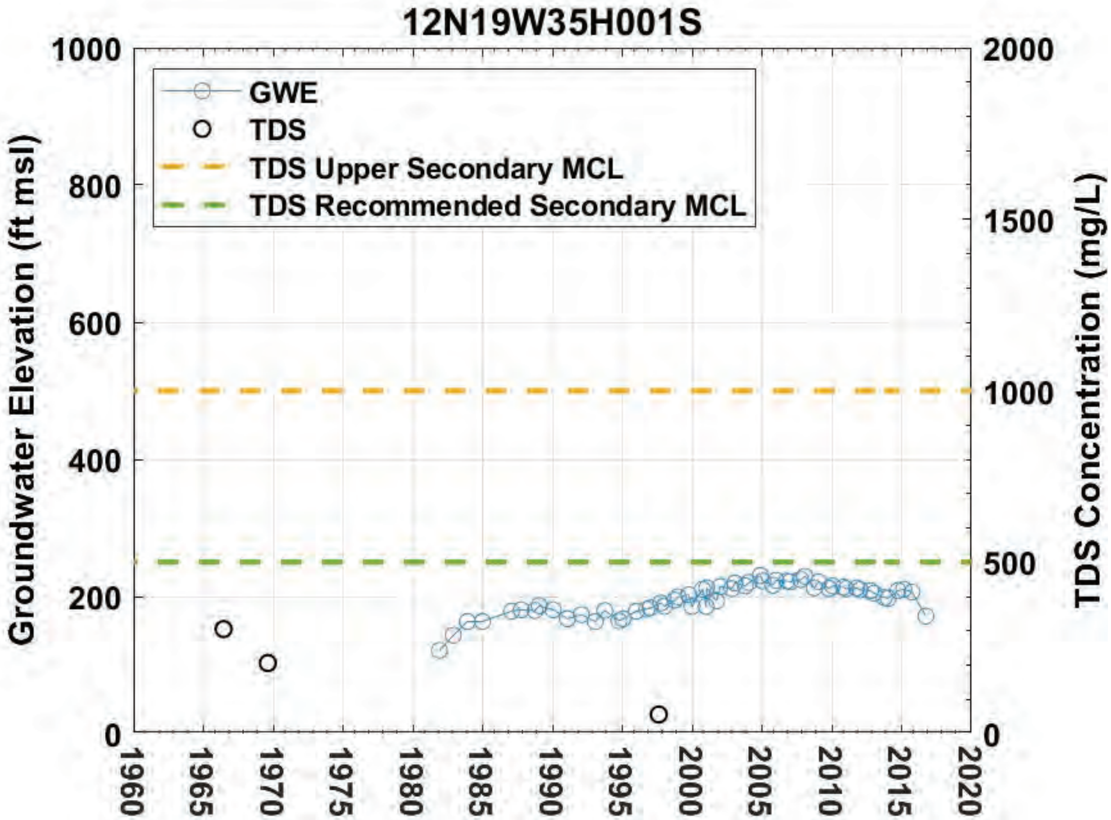

12N19W34R001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

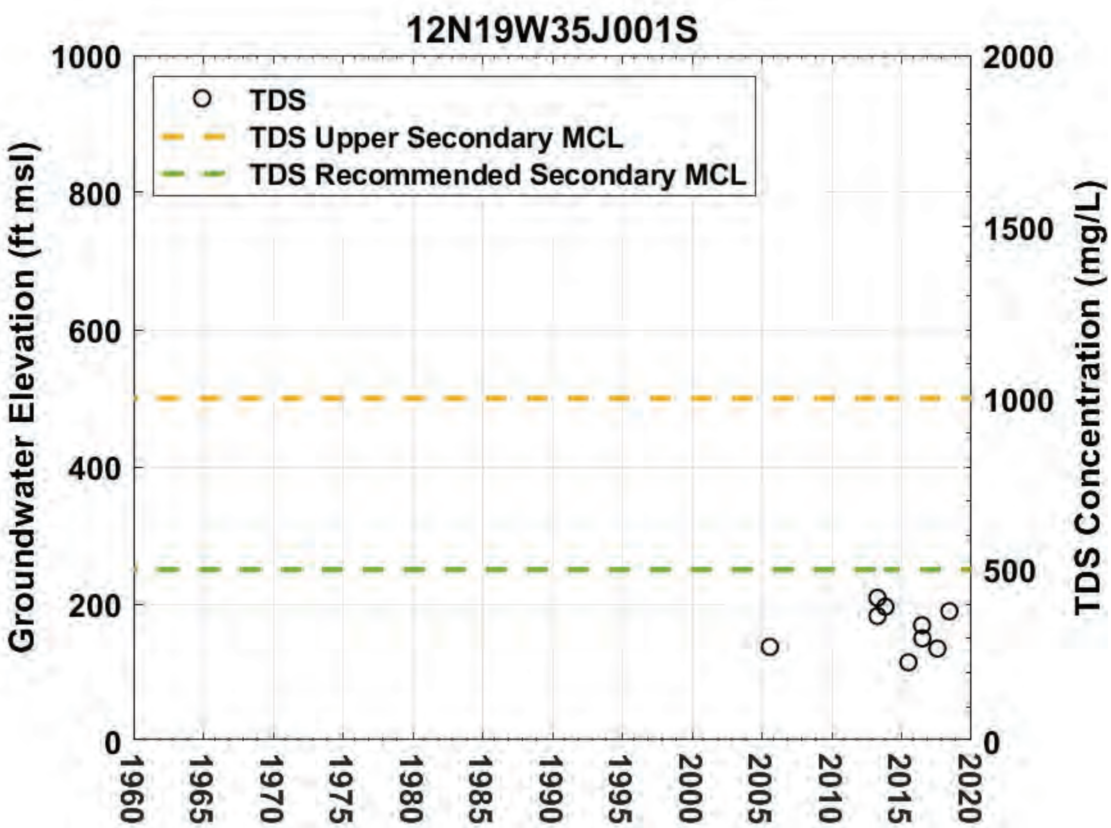


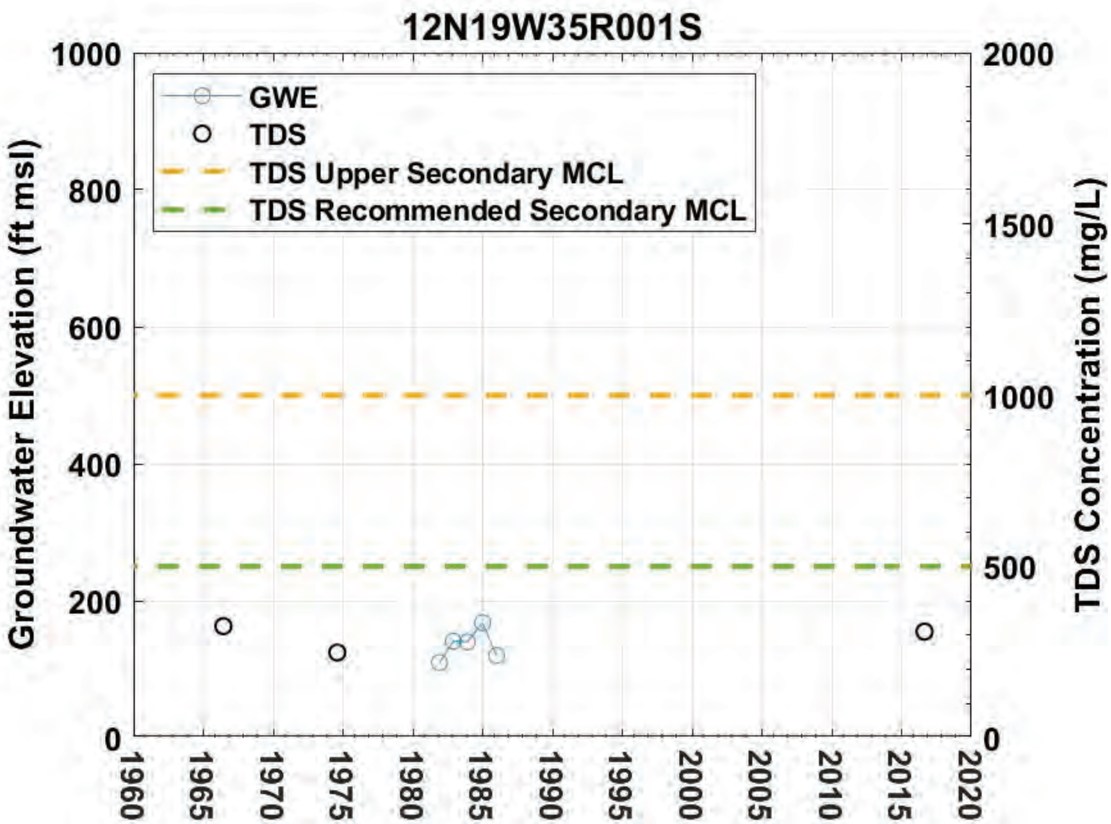
12N19W35A001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

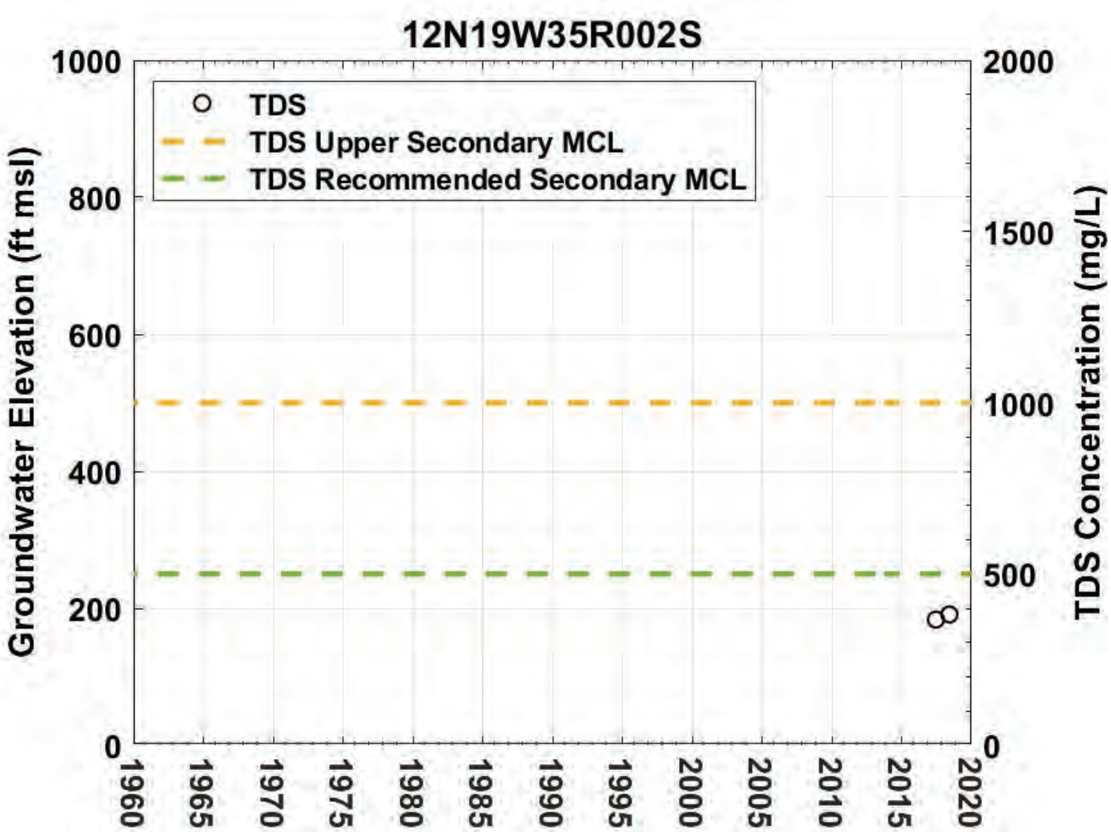


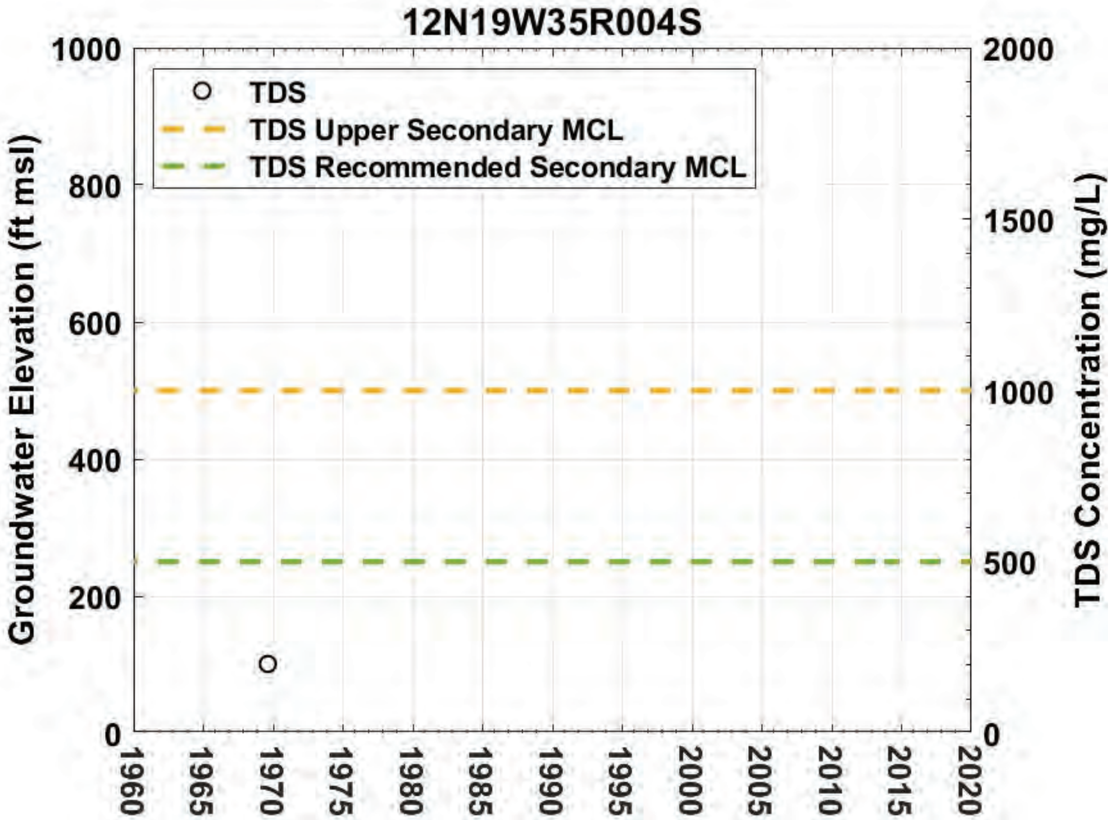
12N19W35B001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

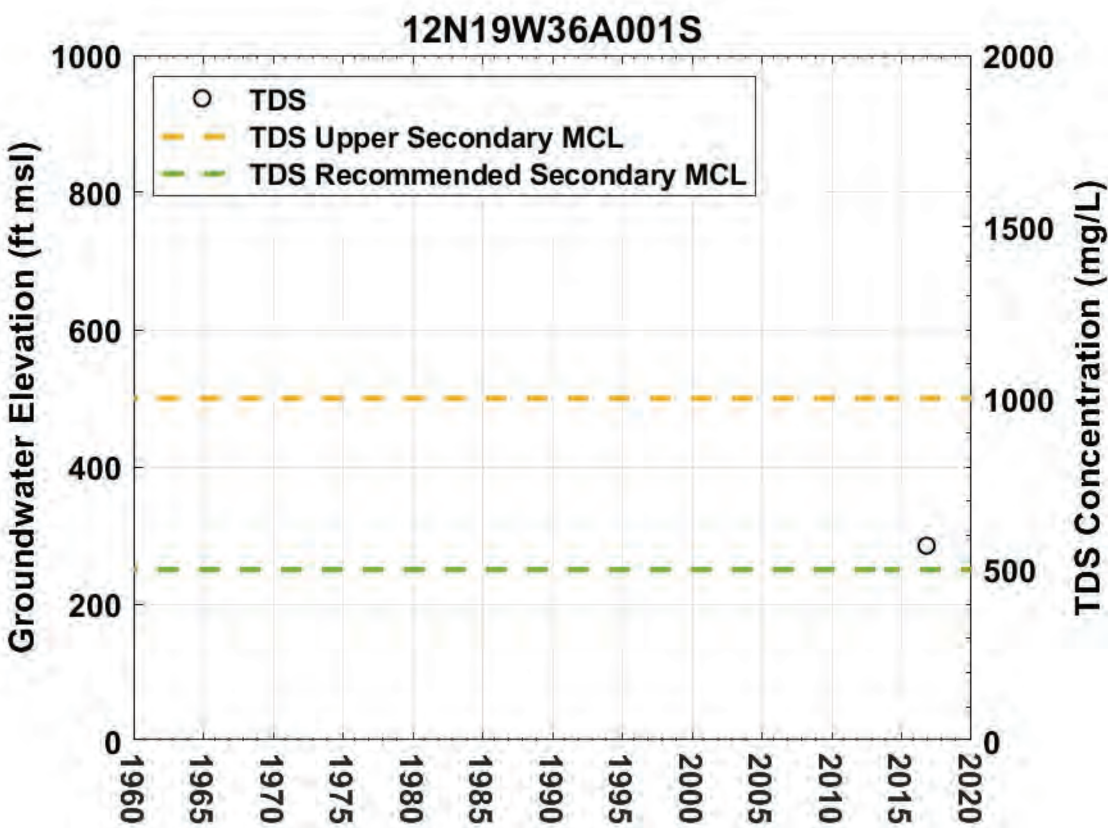

12N19W35H001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

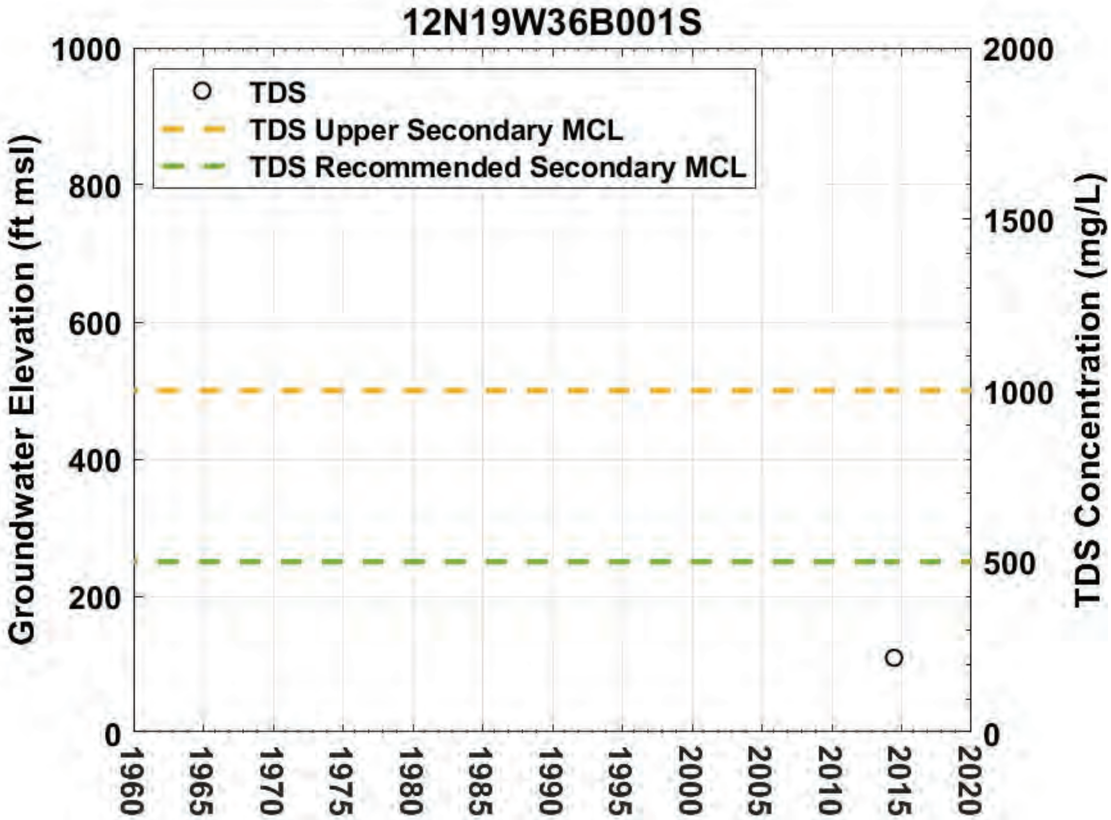

12N19W35J001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

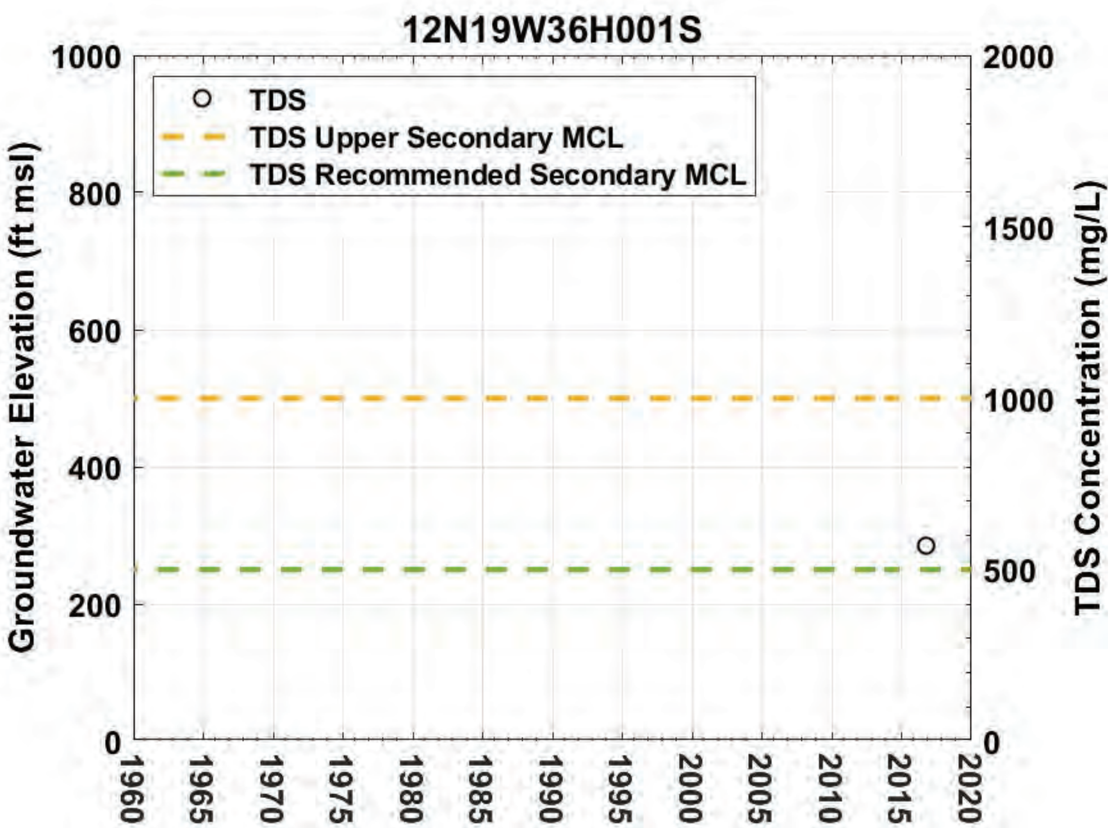

12N19W35R001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

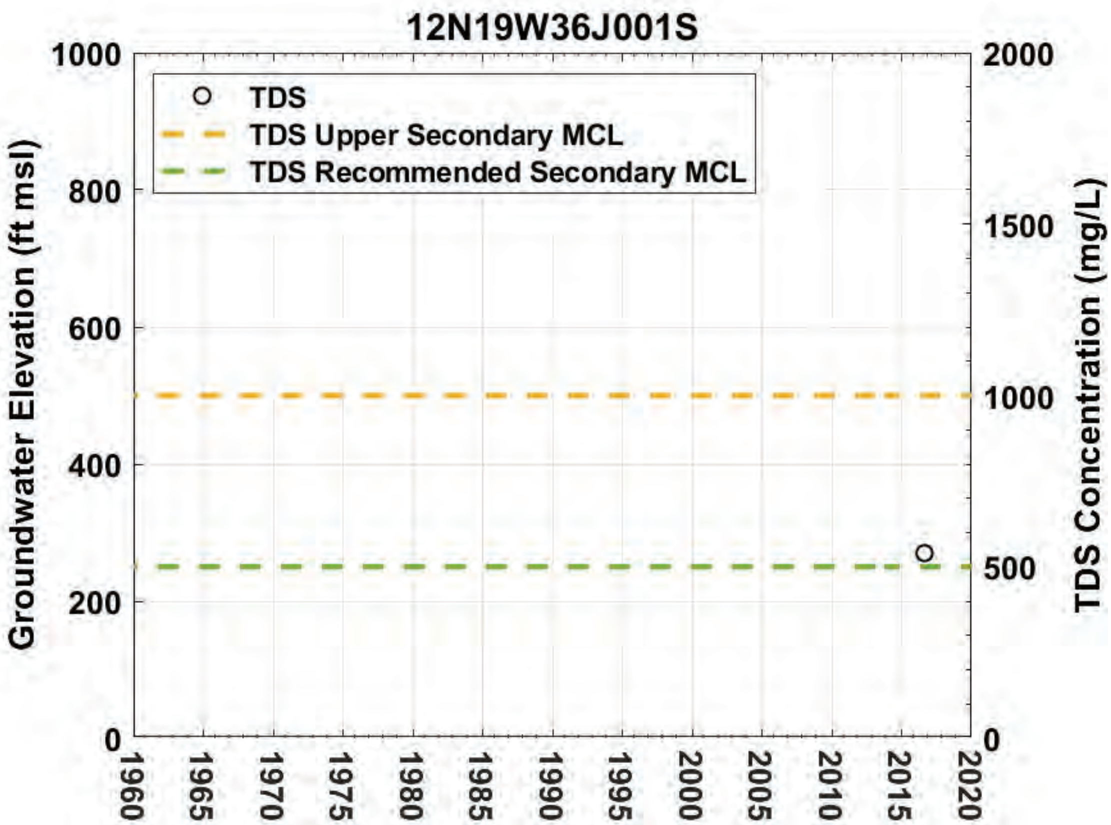

12N19W35R002S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

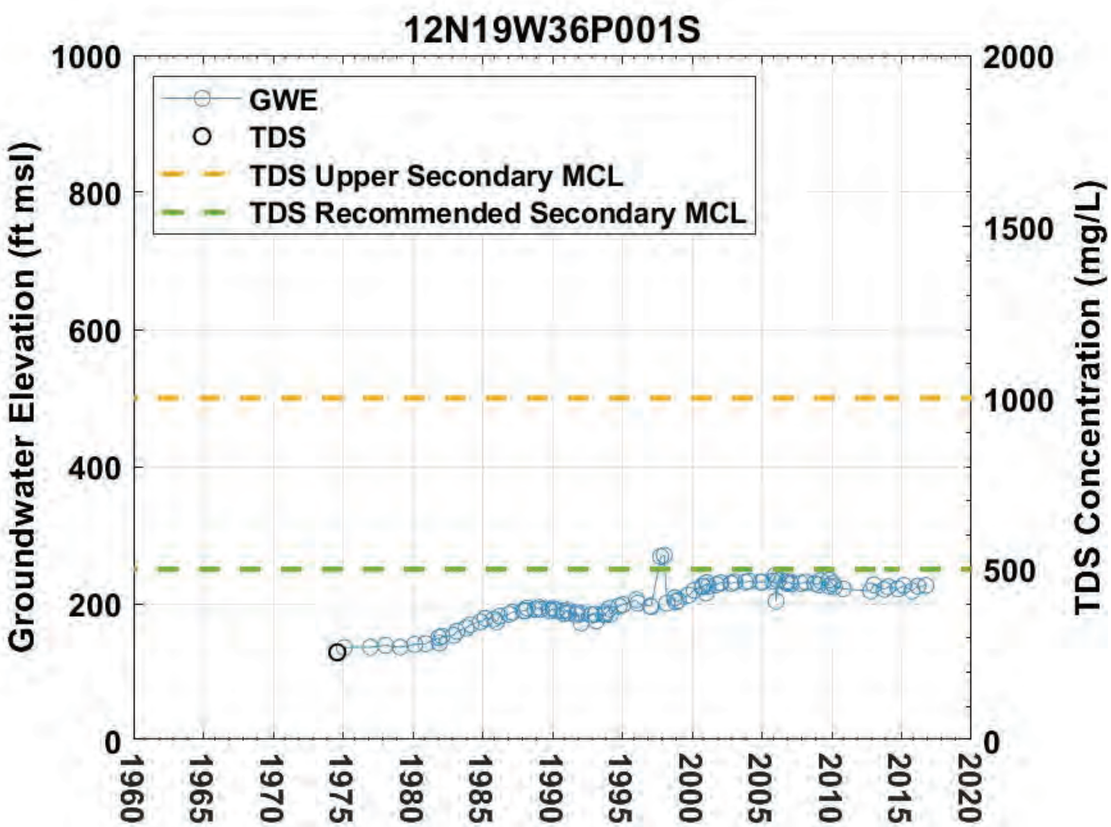

12N19W35R004S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

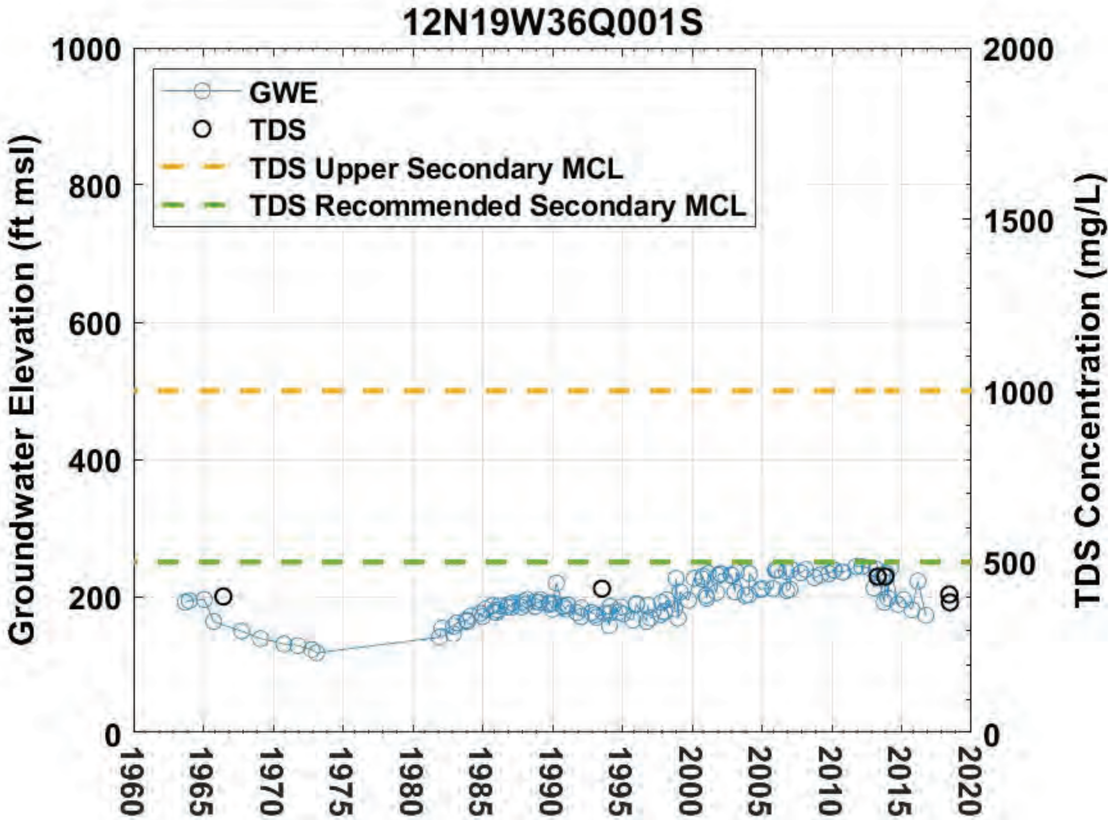

12N19W36A001S
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

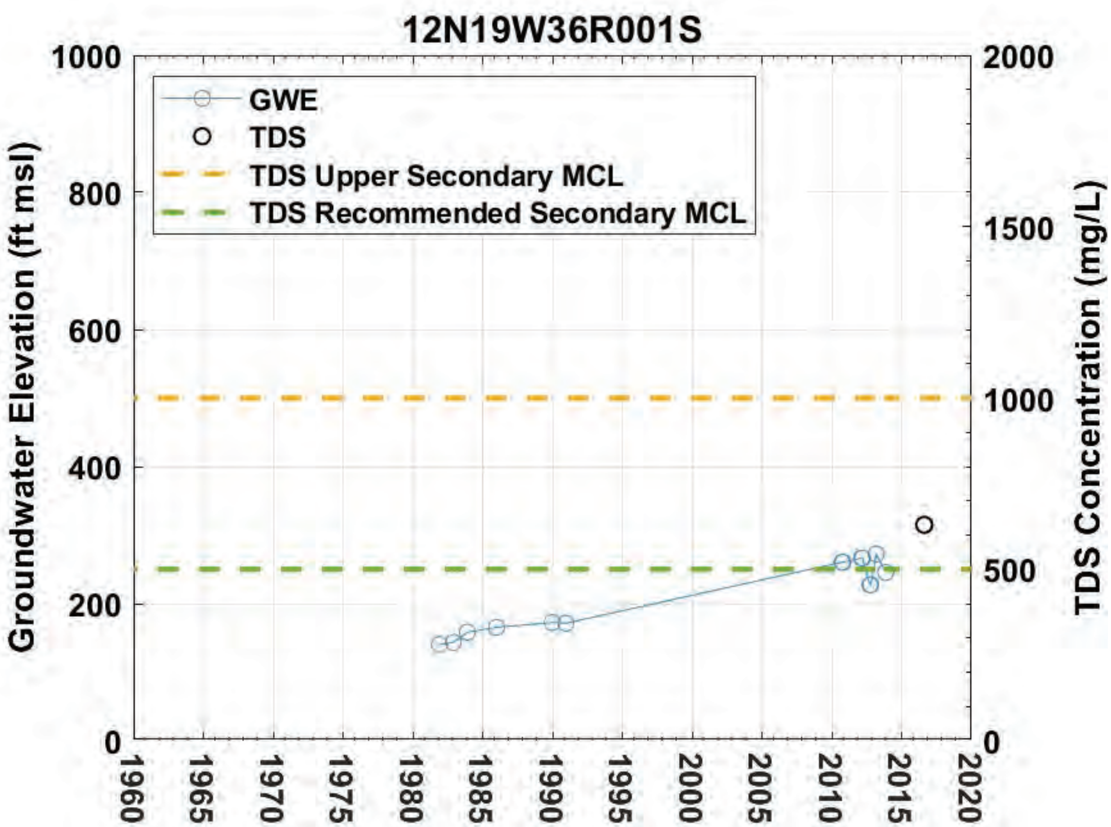

12N19W36B001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

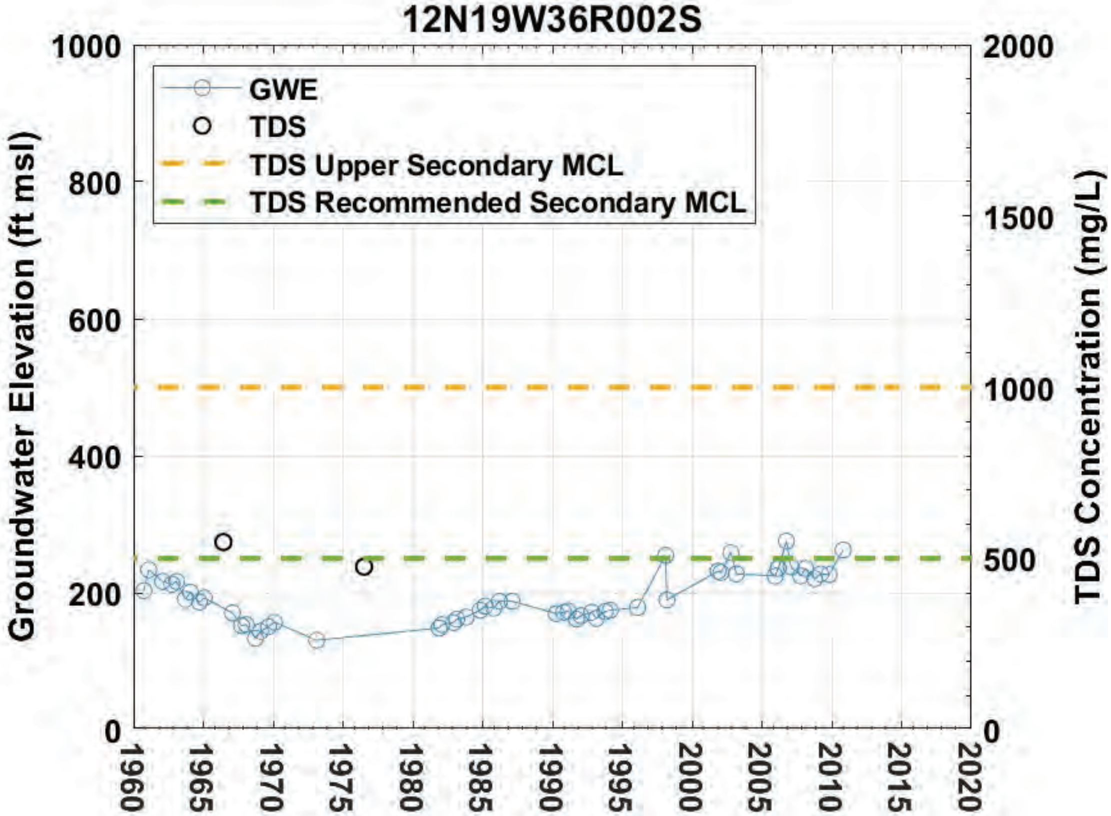

12N19W36H001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

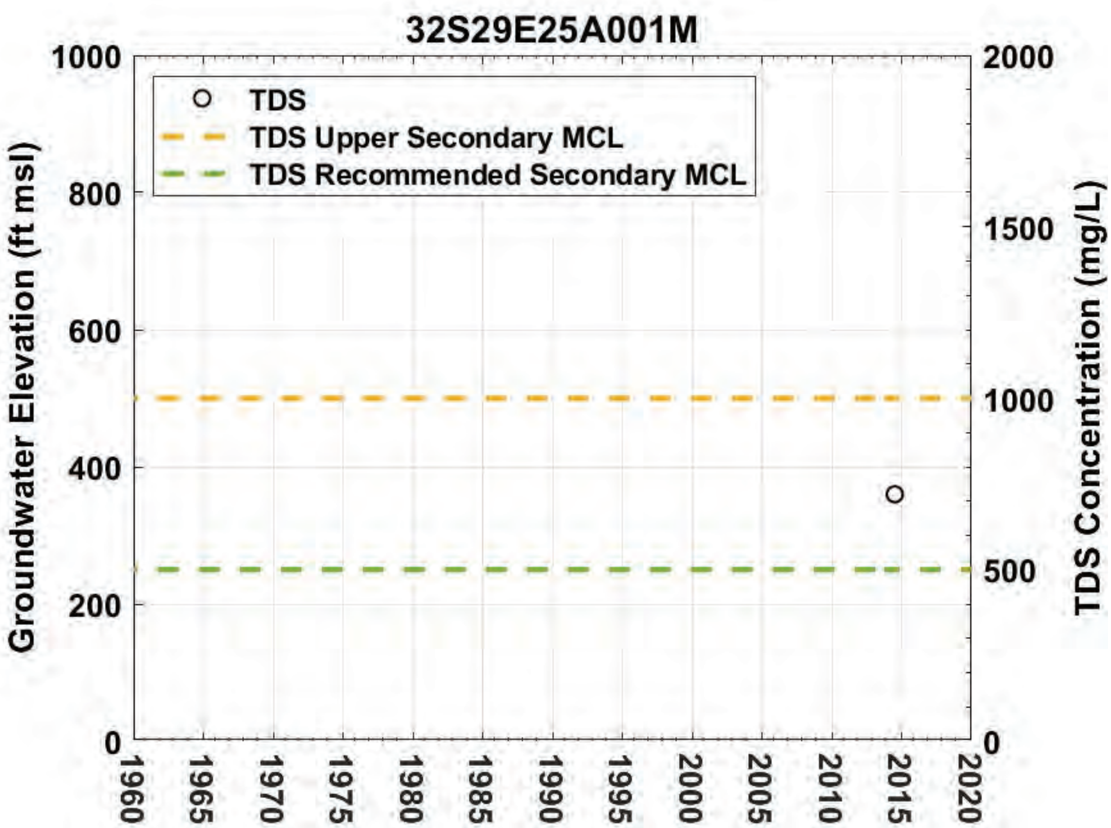

12N19W36J001S
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

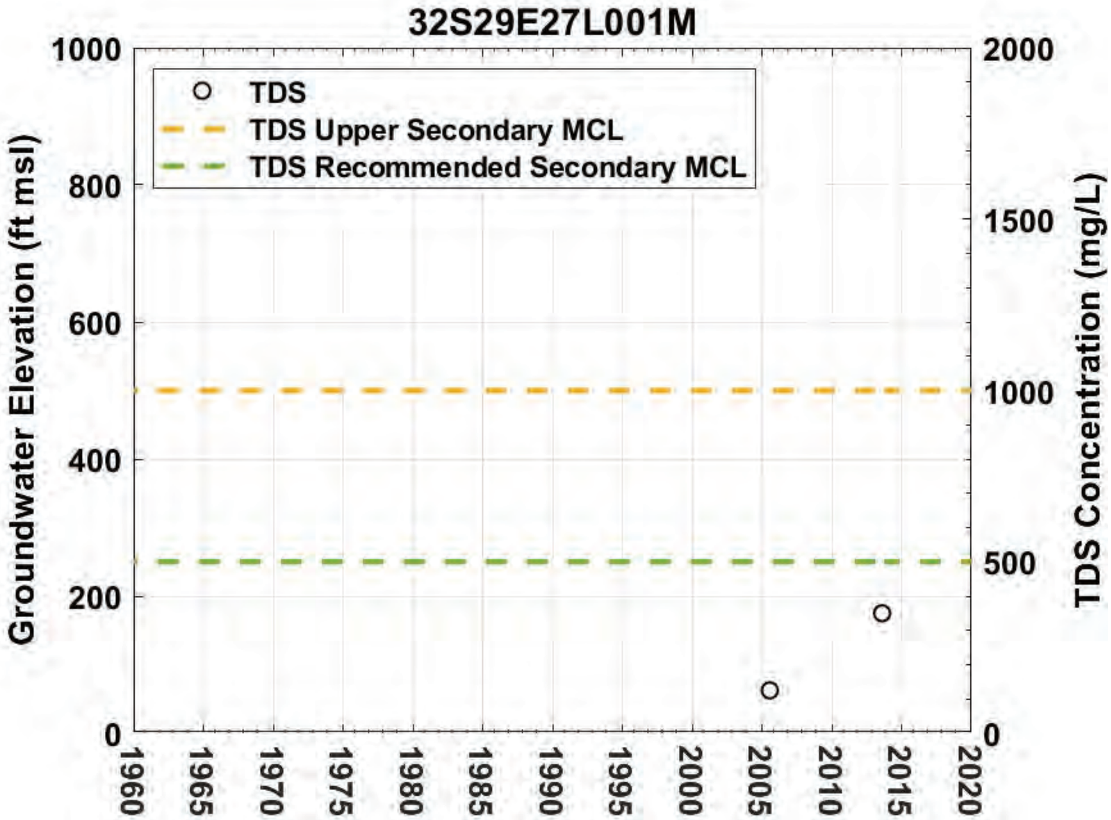

12N19W36P001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


12N19W36Q001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

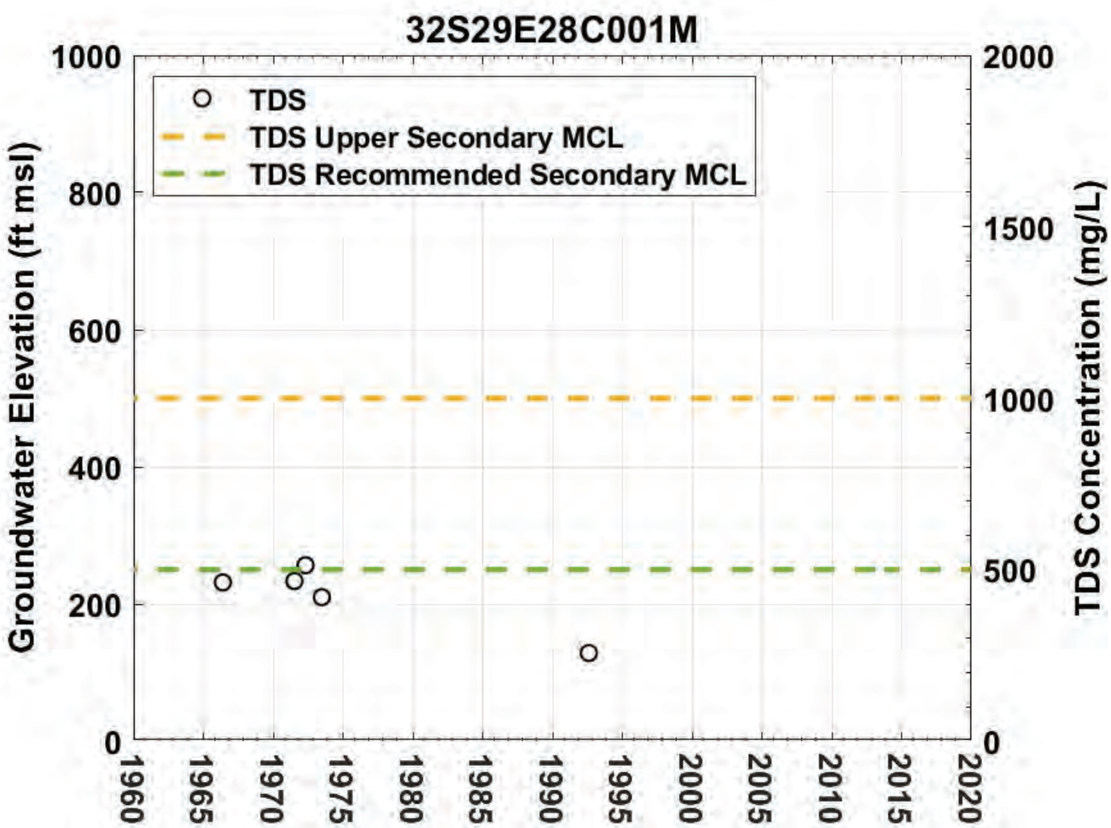

12N19W36R001S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


12N19W36R002S
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

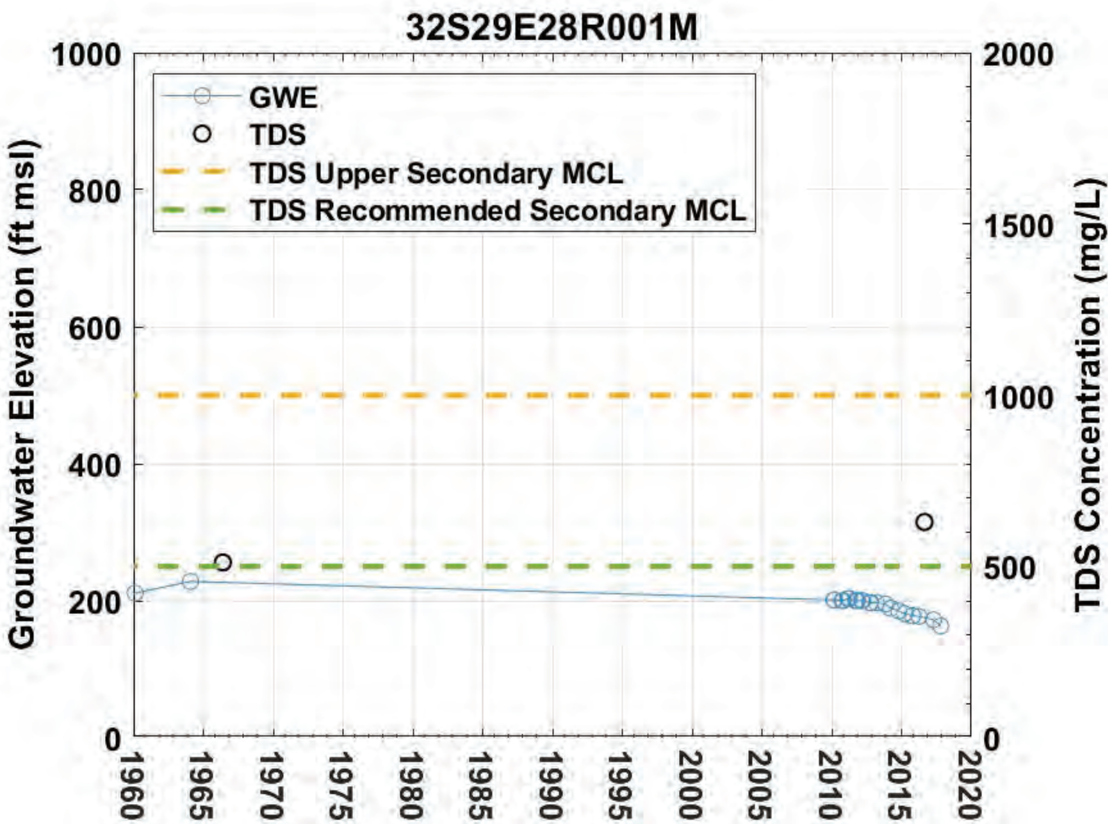

32S29E25A001M
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

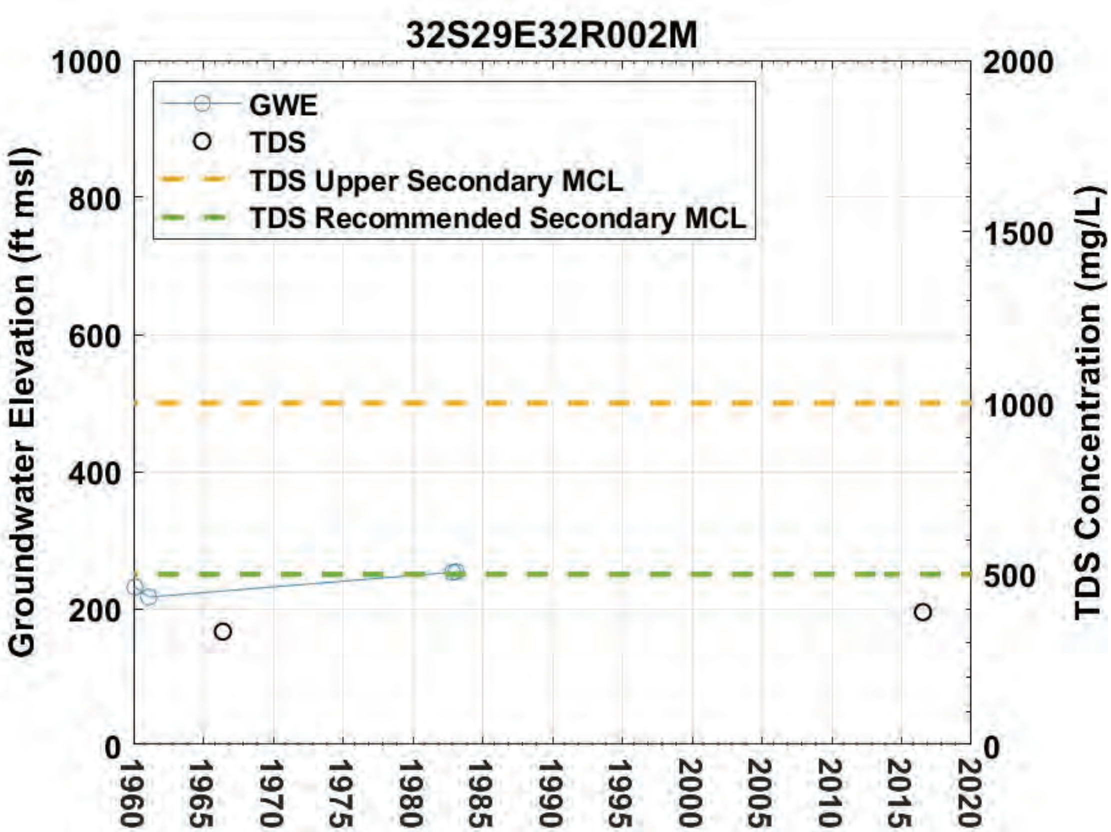


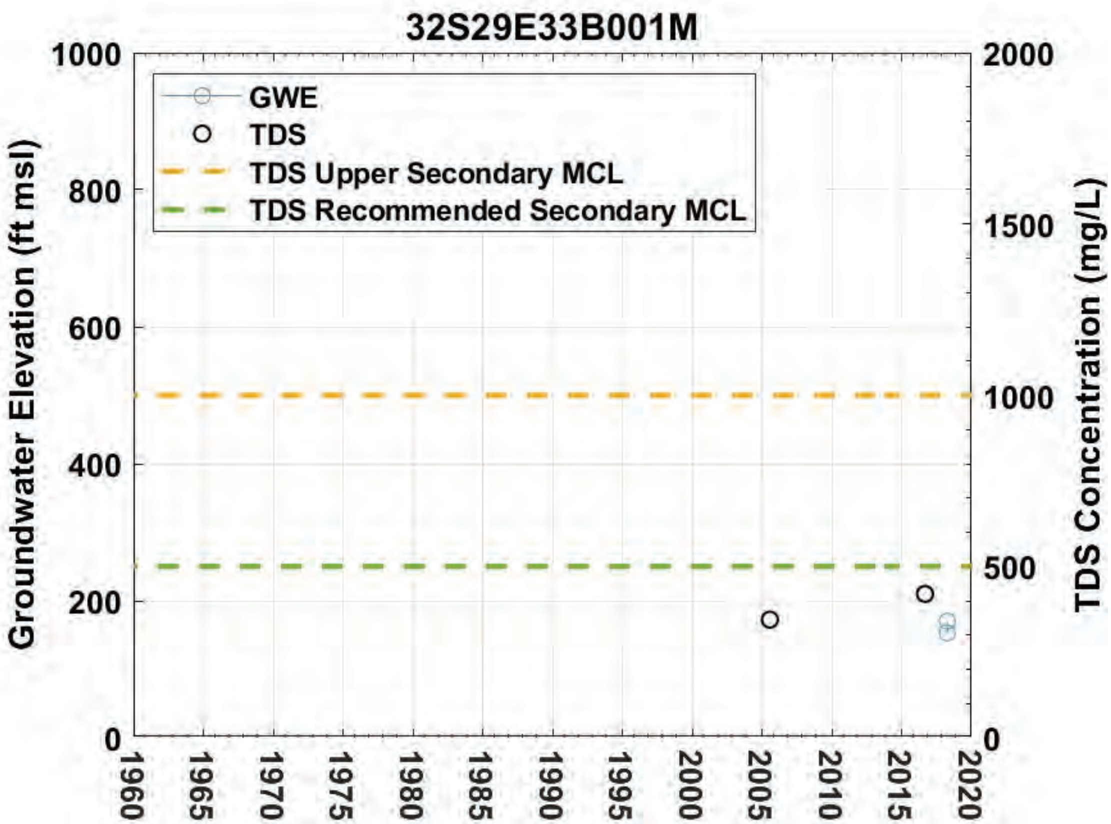
32S29E27L001M
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

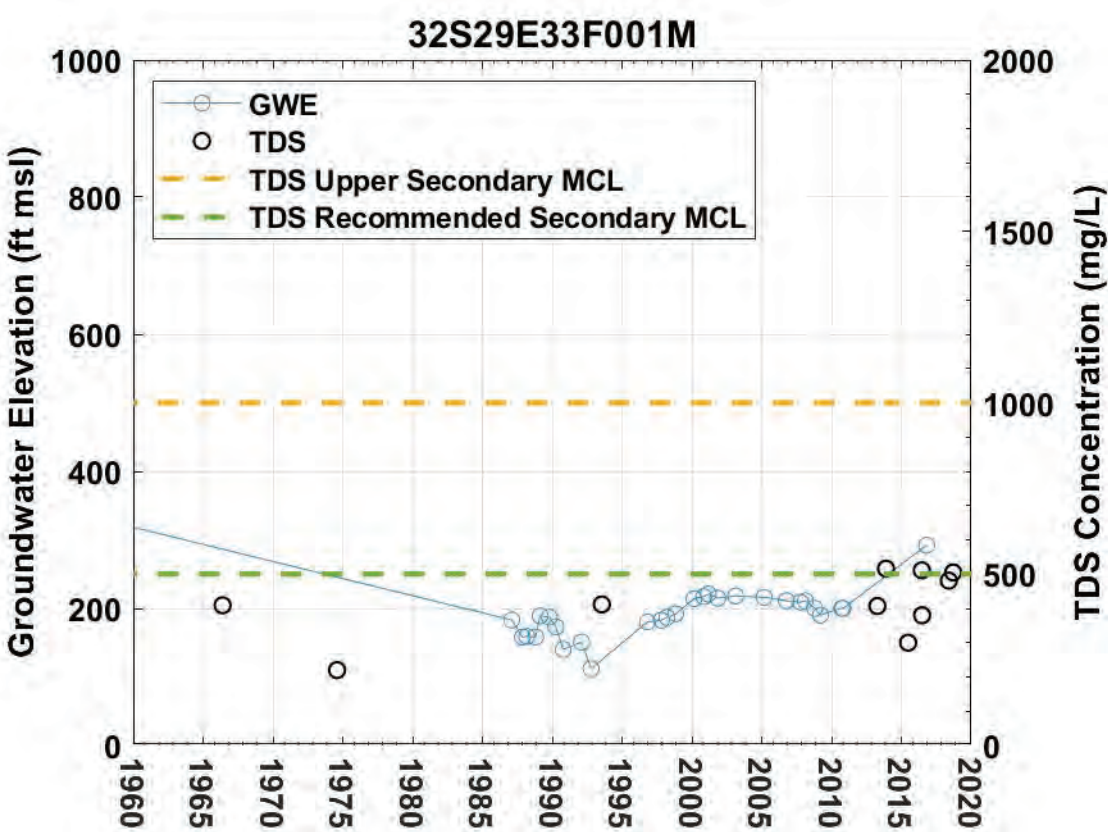


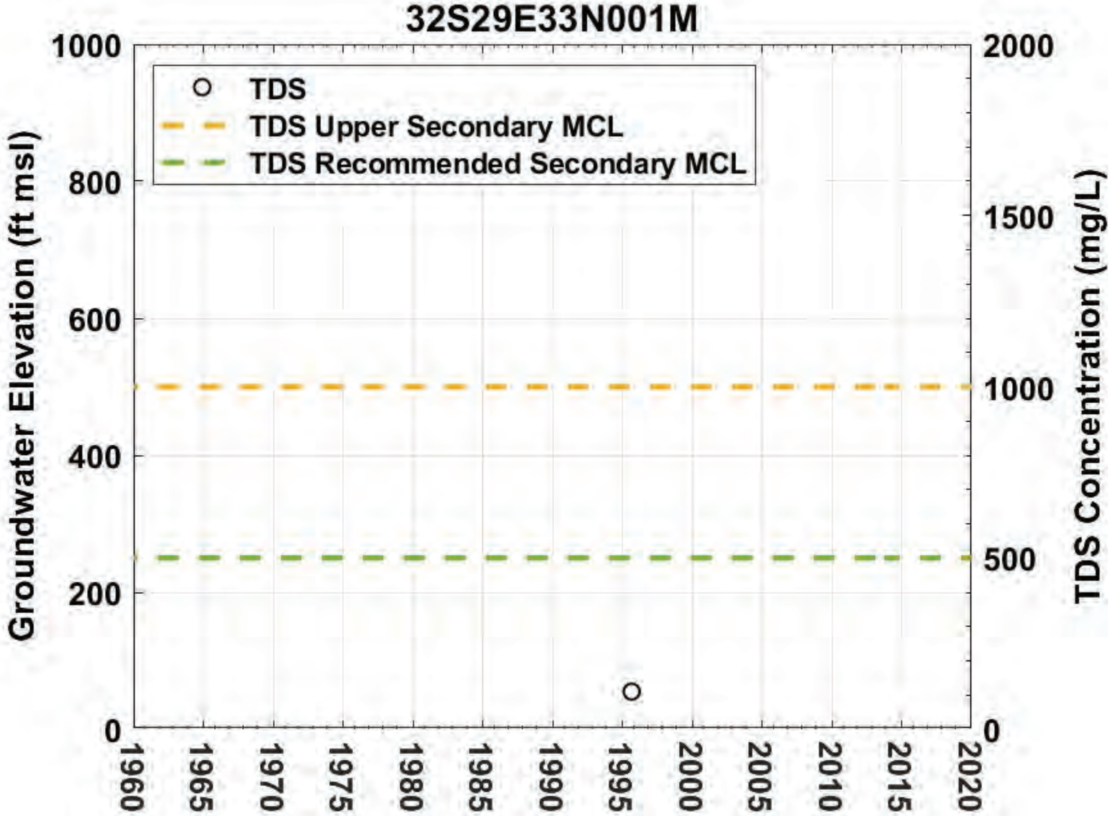
32S29E28C001M
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

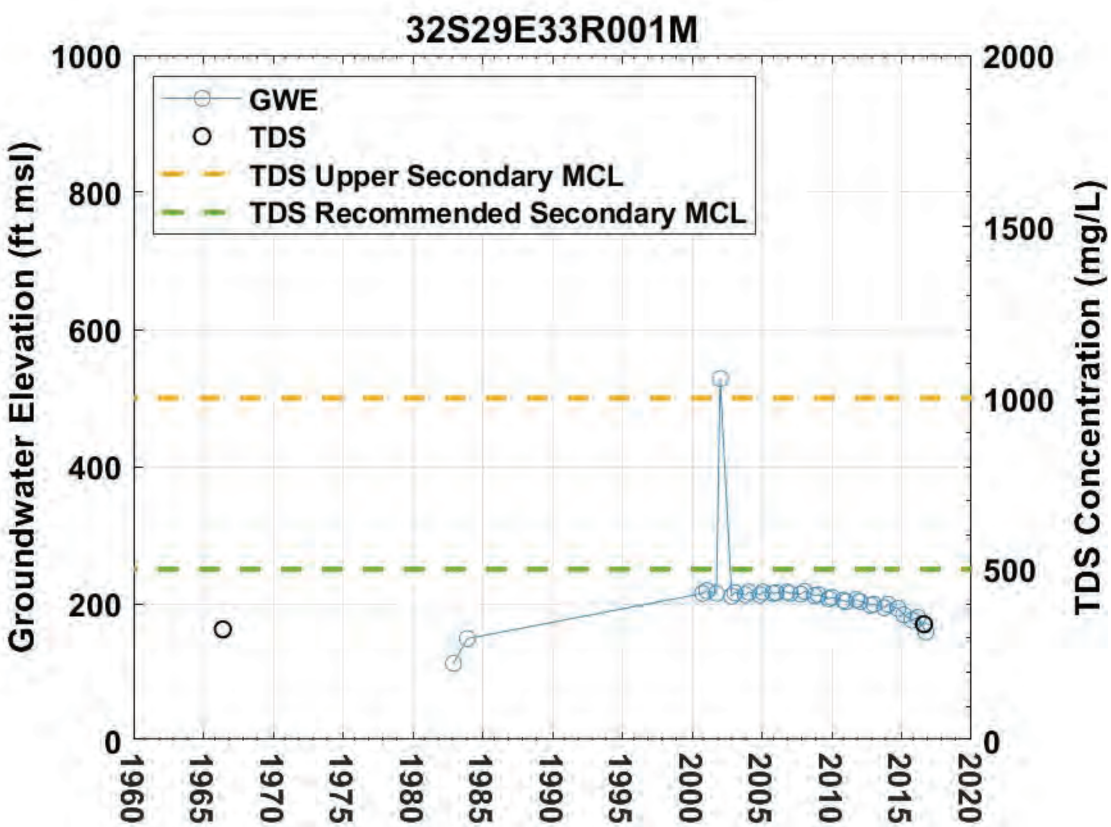

32S29E28R001M
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

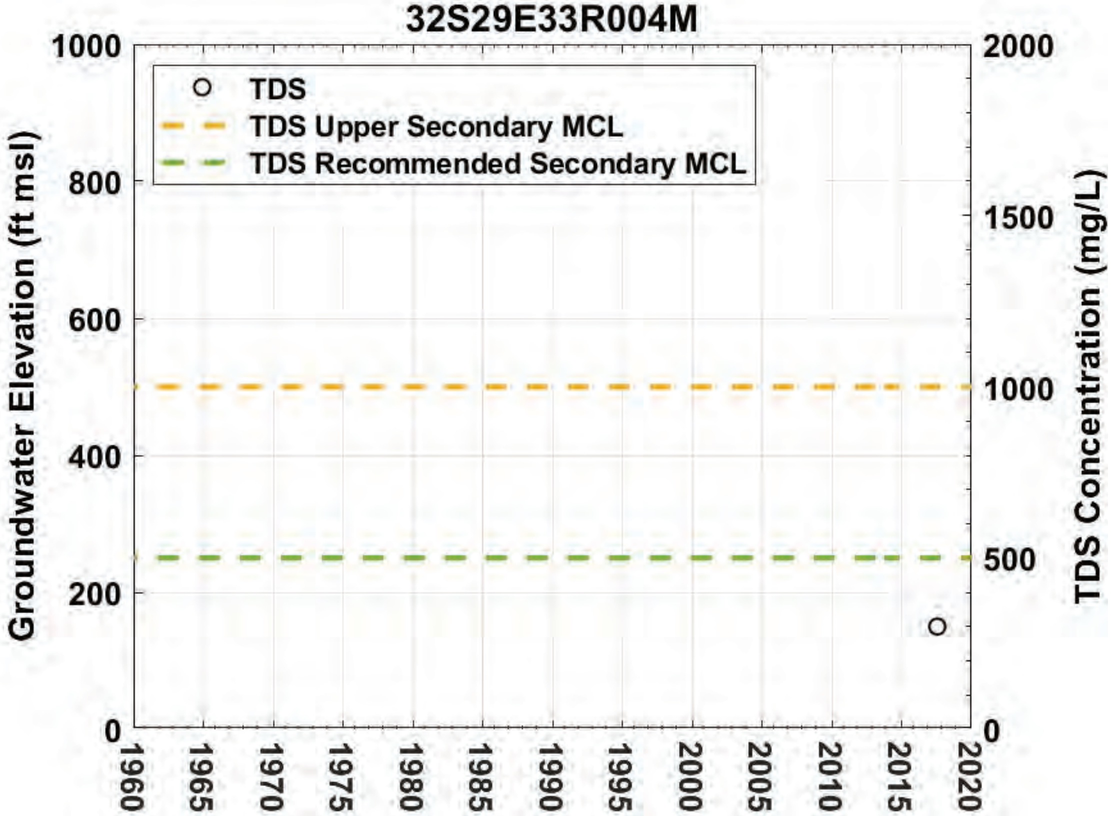

32S29E32R002M
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

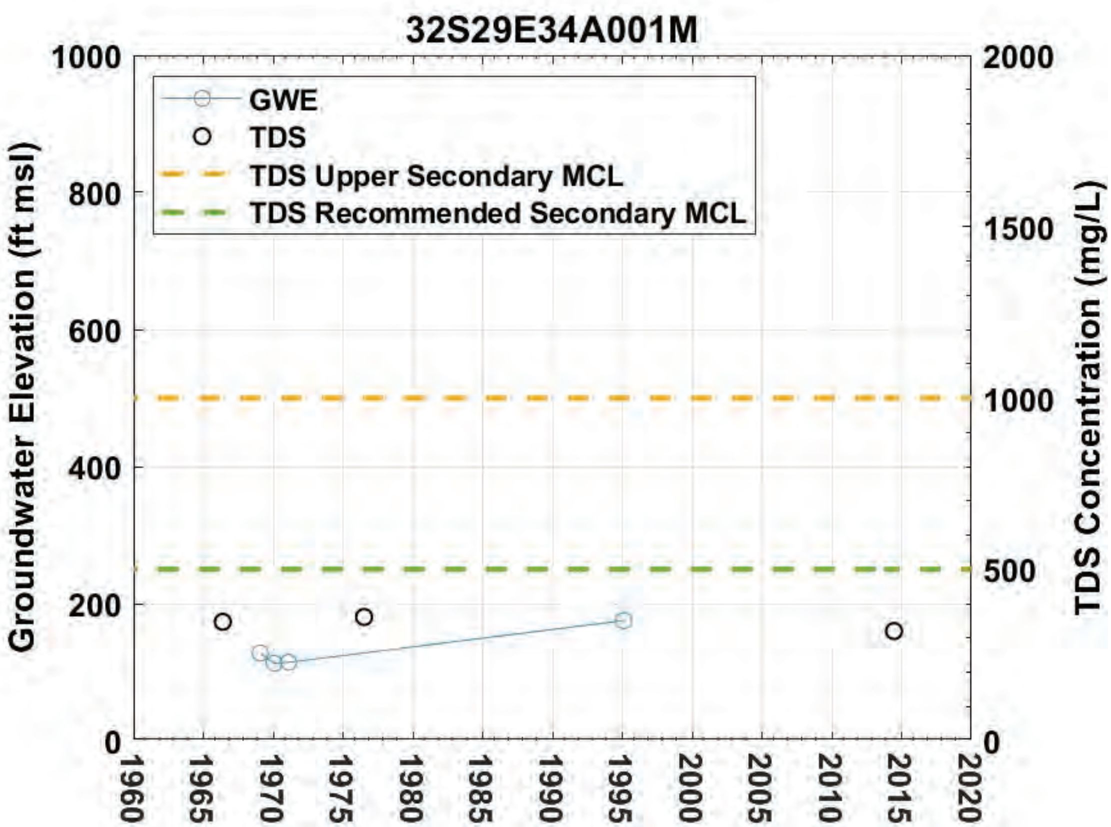

32S29E33B001M
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

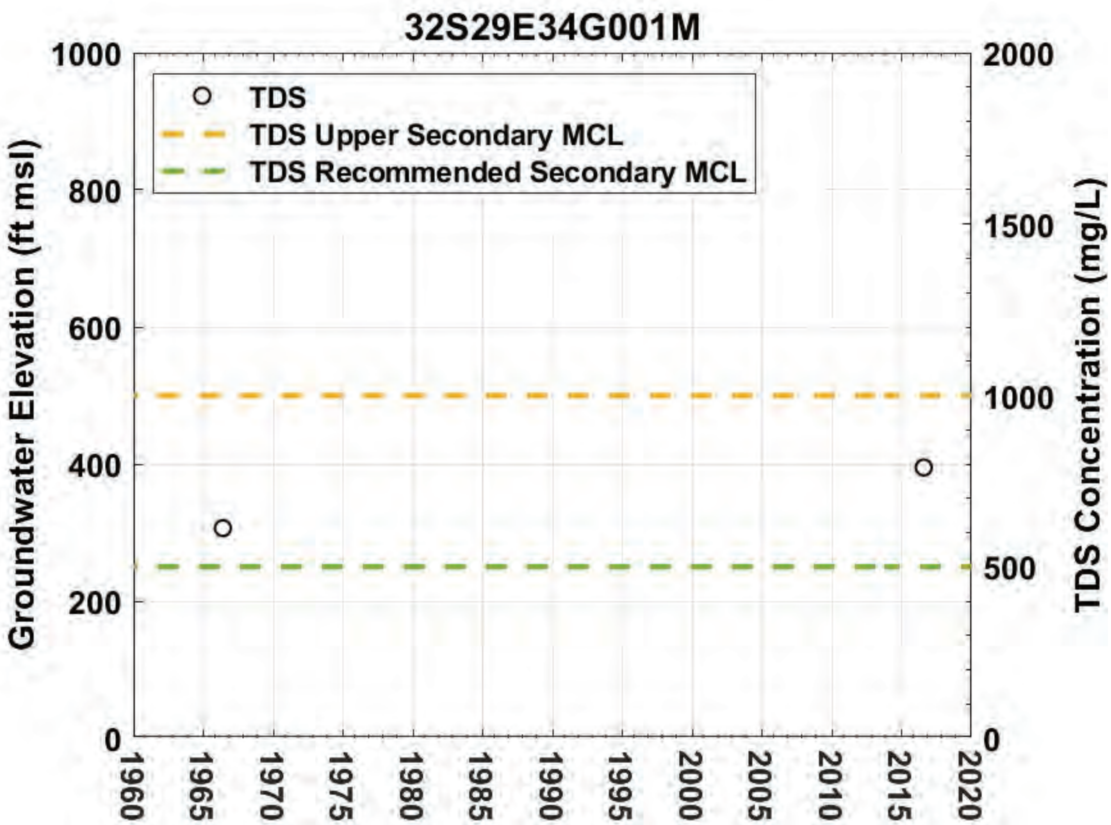

32S29E33F001M
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

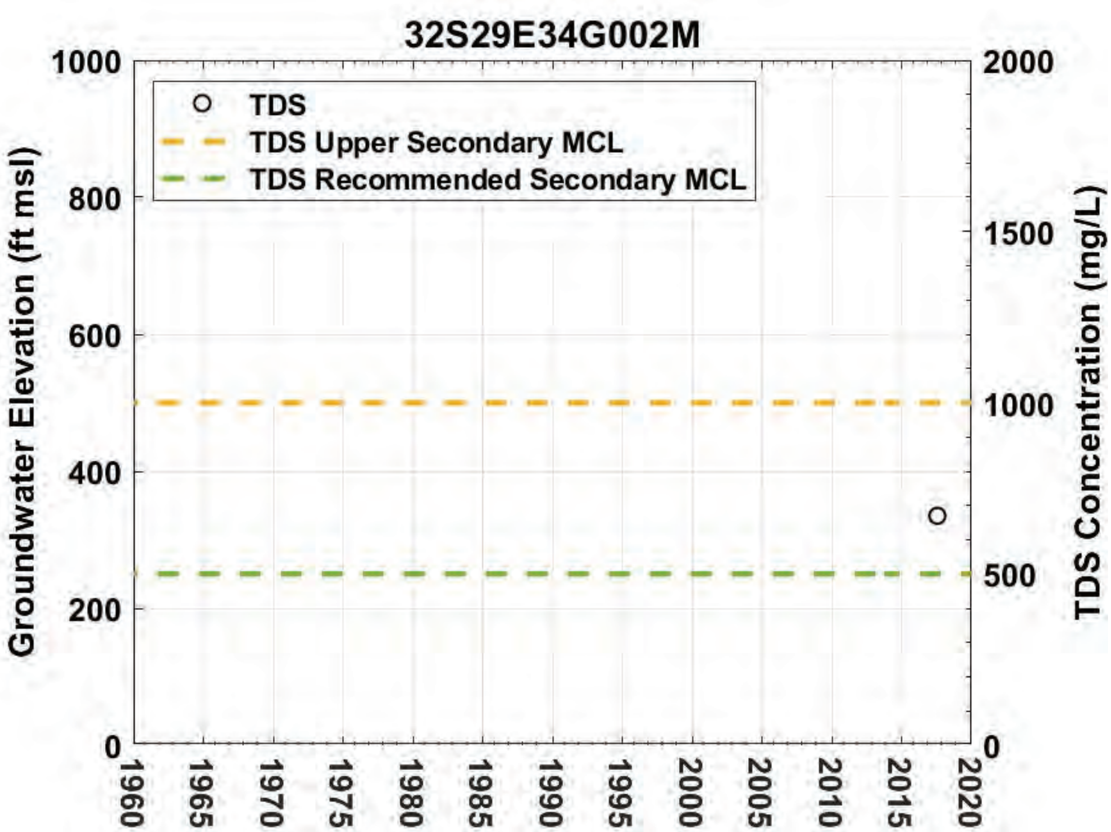

32S29E33N001M
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

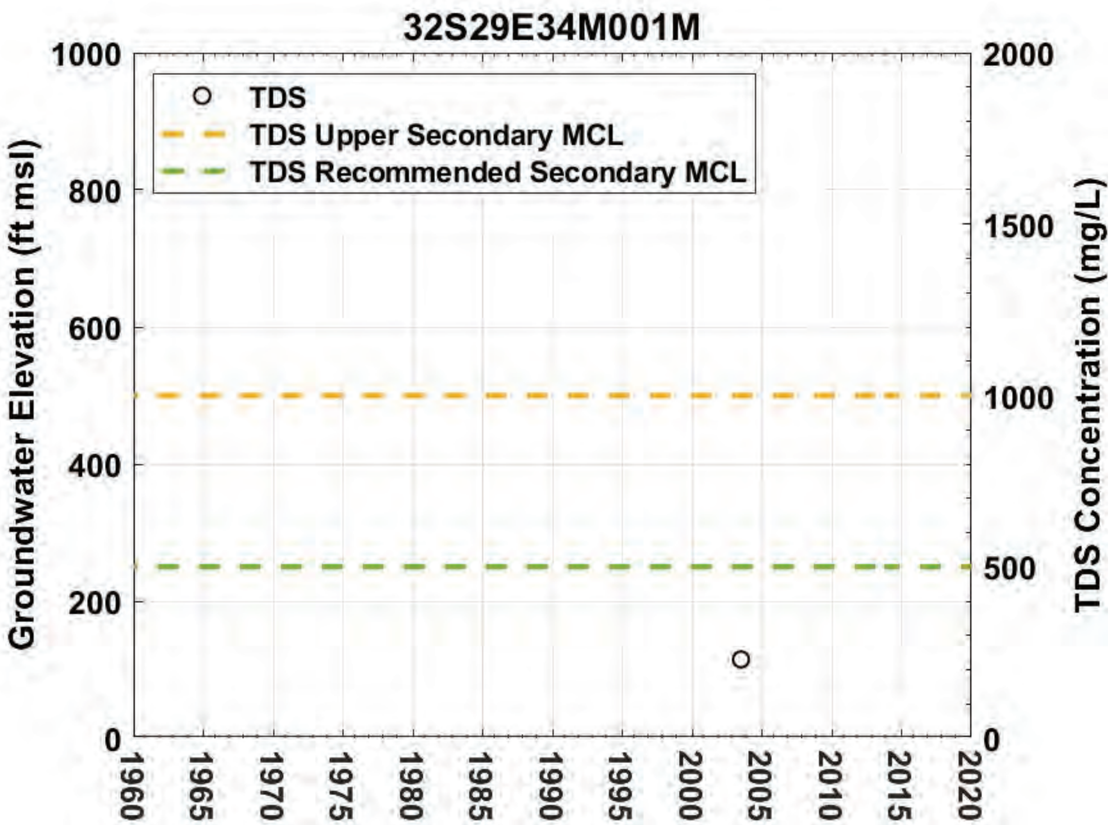

32S29E33R001M
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

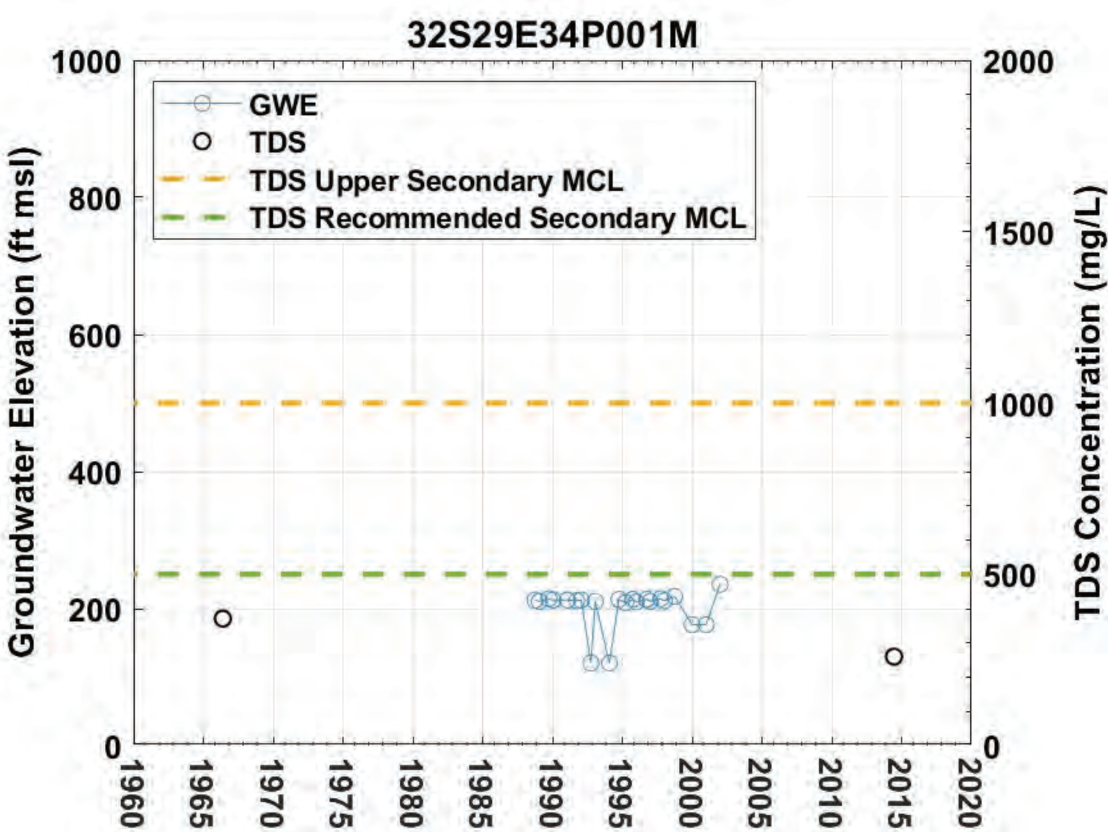

32S29E33R004M
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

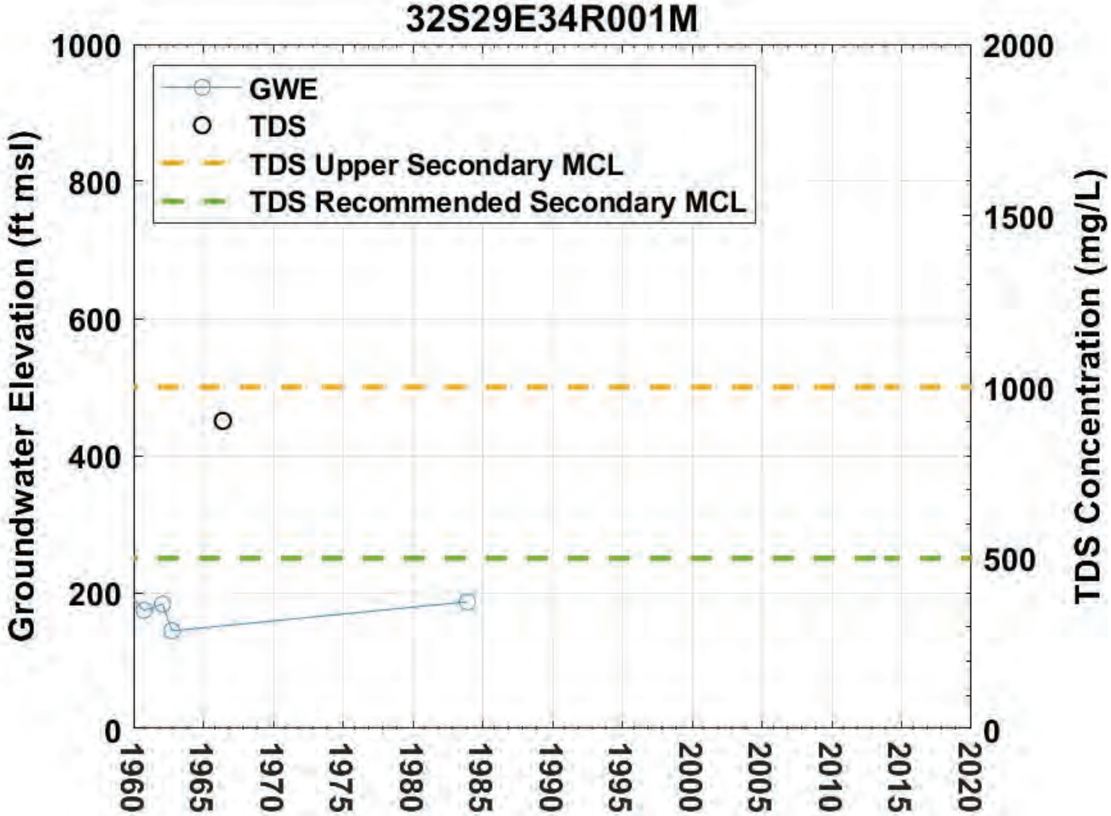

32S29E34A001M
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

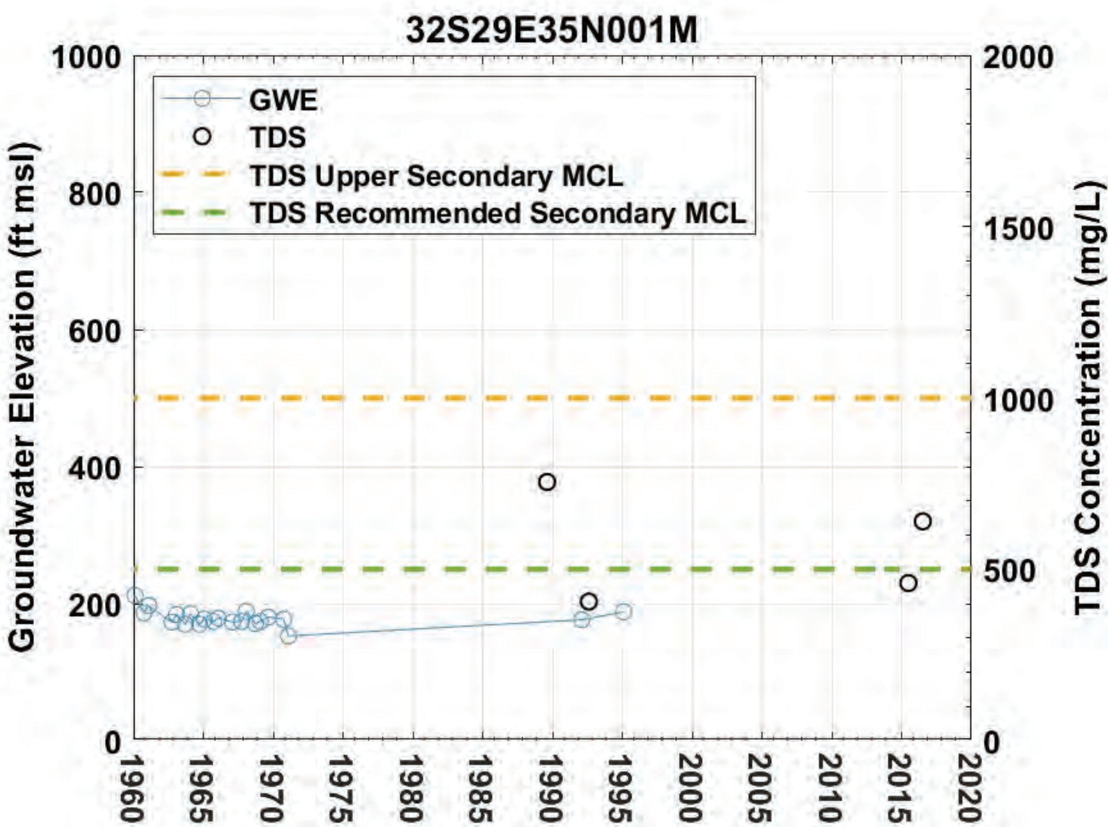

32S29E34G001M
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

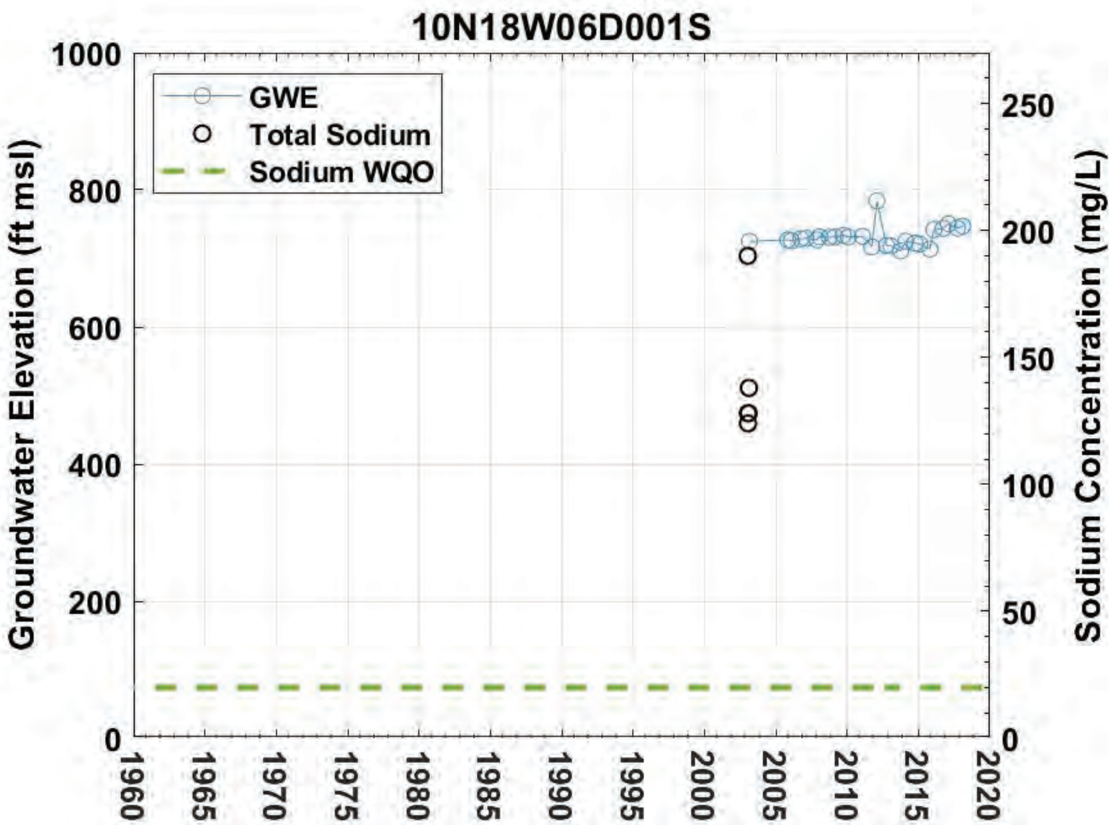

32S29E34G002M
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
1000
800
600
400
200
0
2000
1500
1000
500
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


32S29E34M001M
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

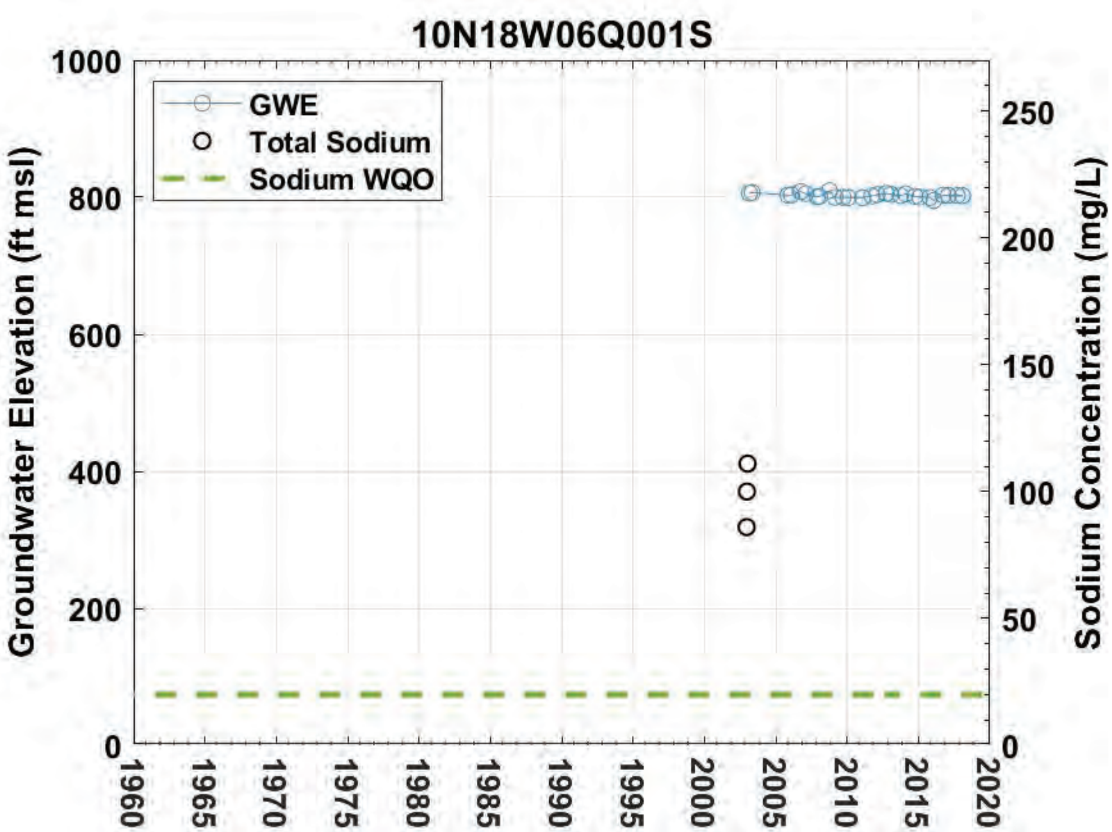

32S29E34P001M
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


32S29E34R001M
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

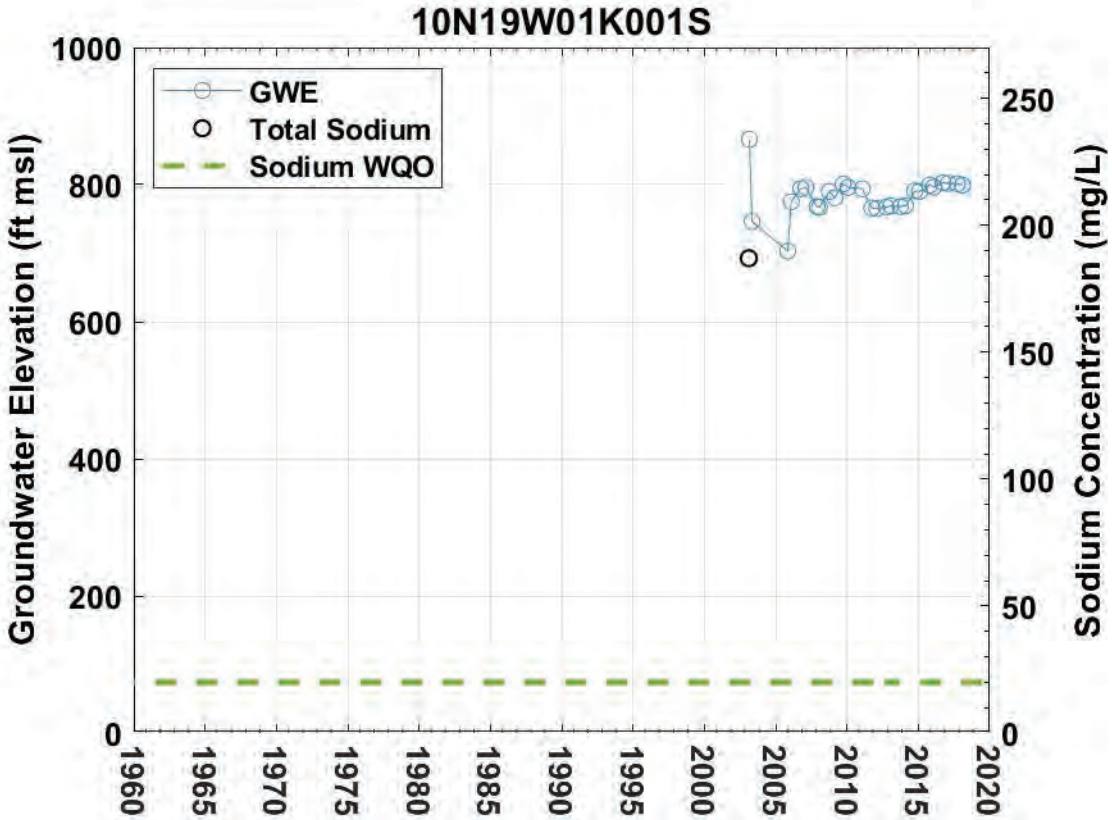

32S29E35N001M
GWE
TDS
TDS Upper Secondary MCL
TDS Recommended Secondary MCL
Groundwater Elevation (ft msl)
TDS Concentration (mg/L)
0
200
400
600
800
1000
0
500
1000
1500
2000
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

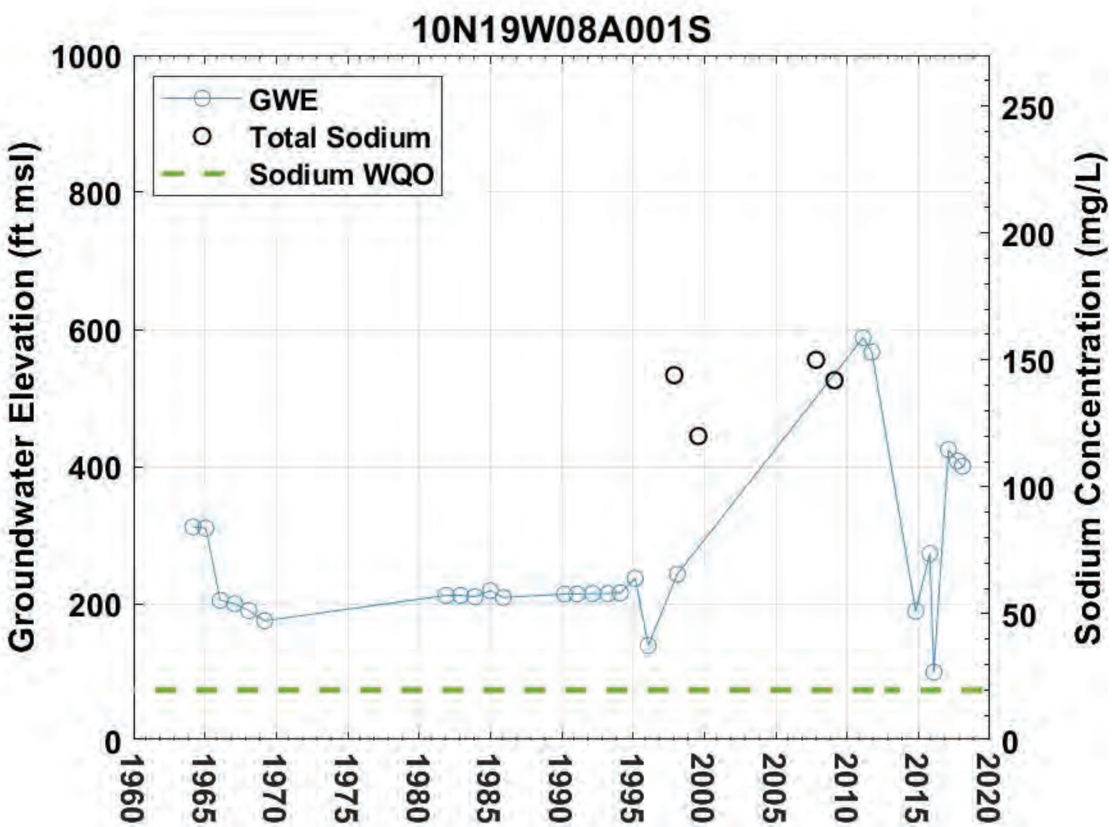


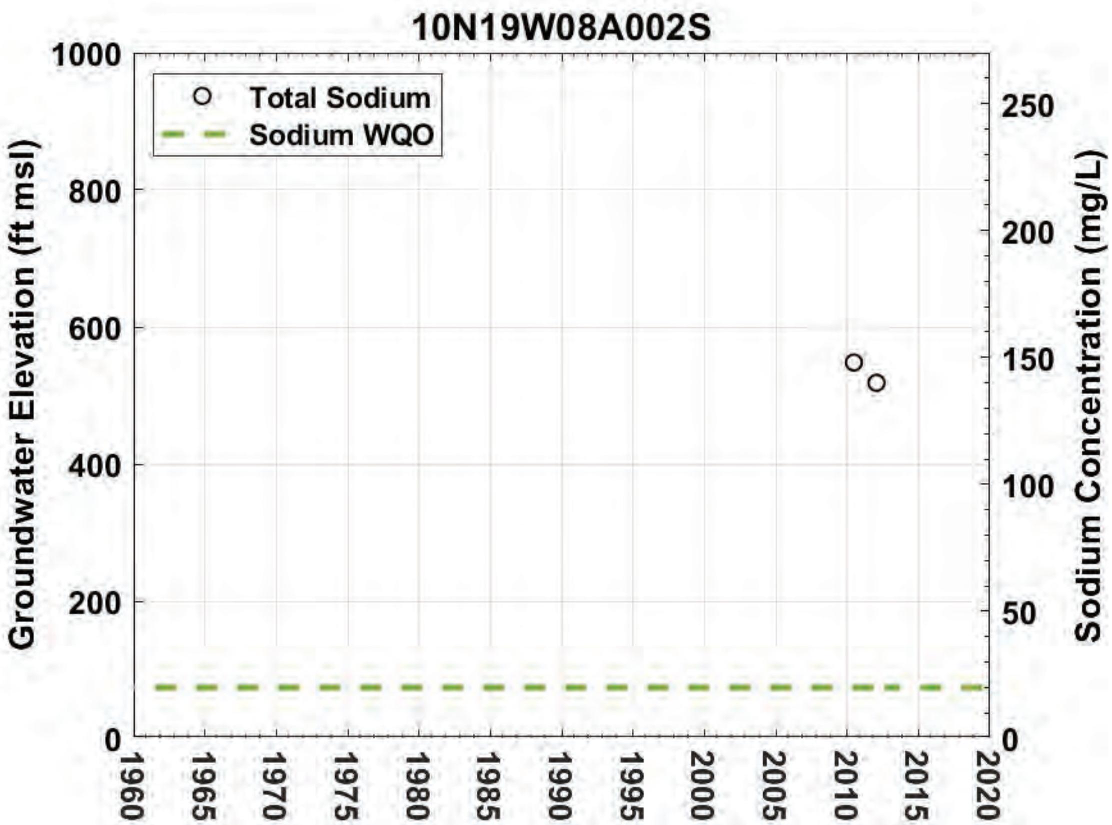
10N18W06D001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

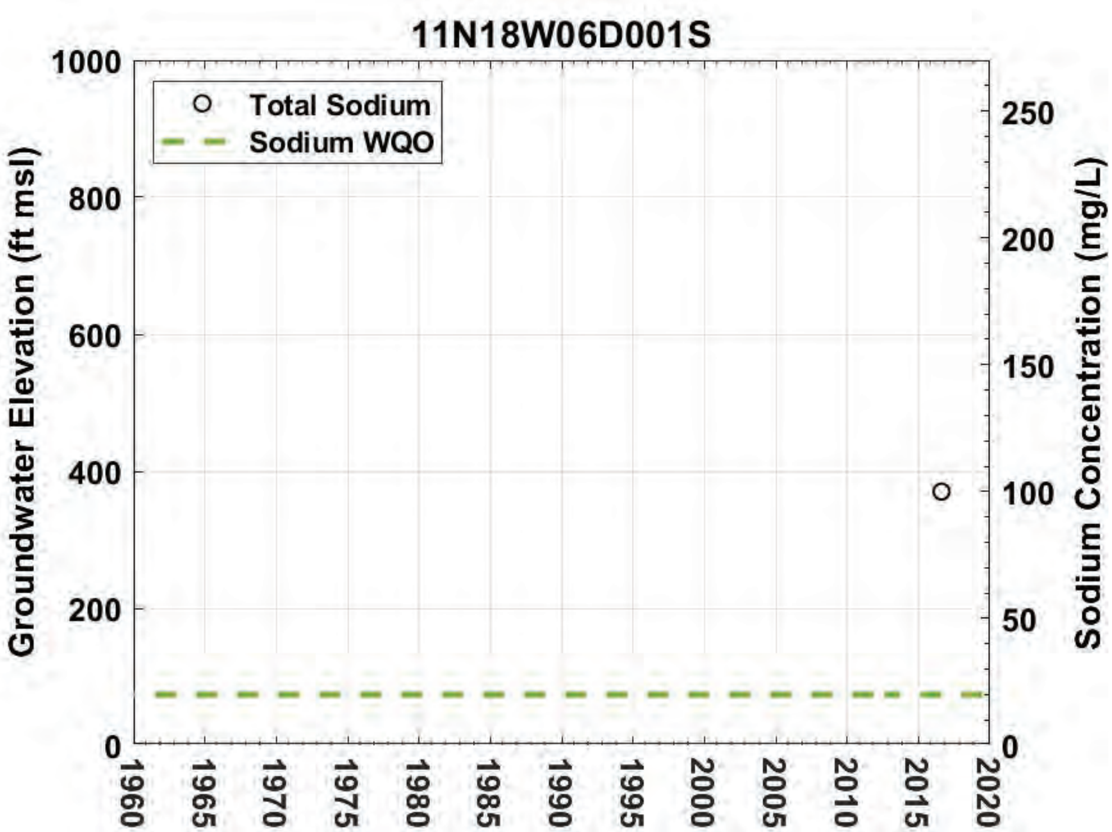


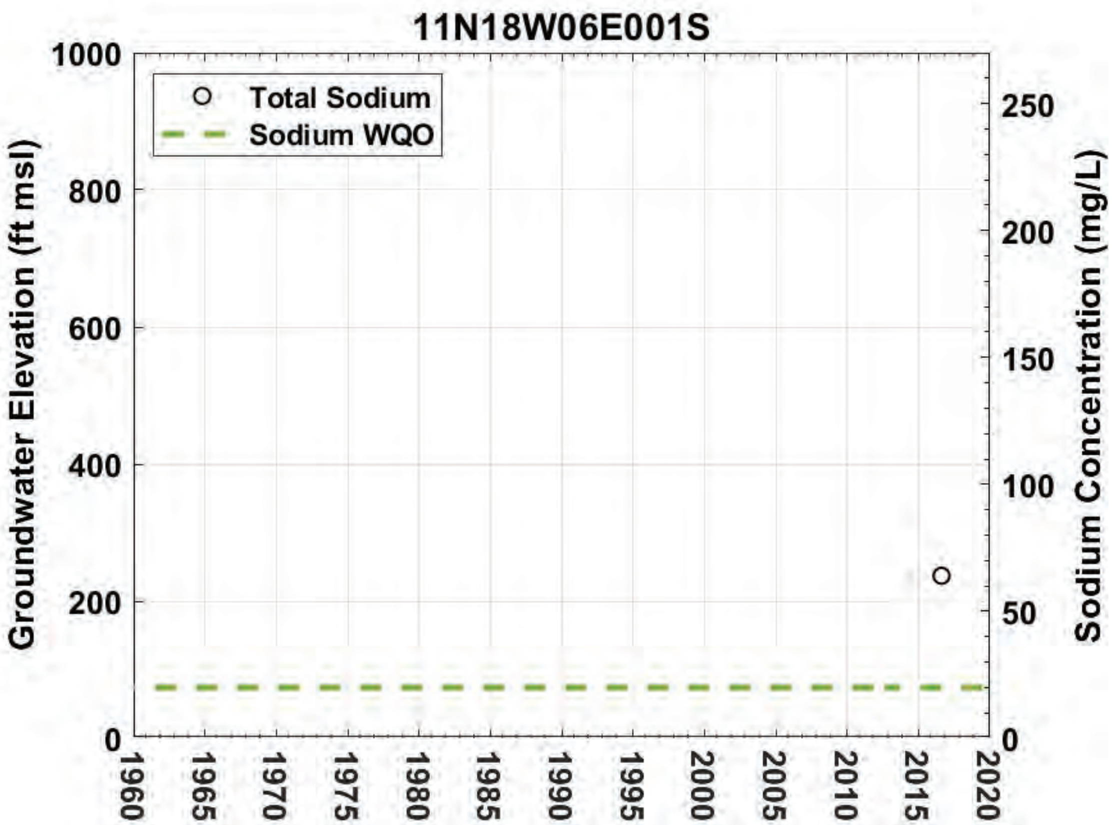
10N18W06Q001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

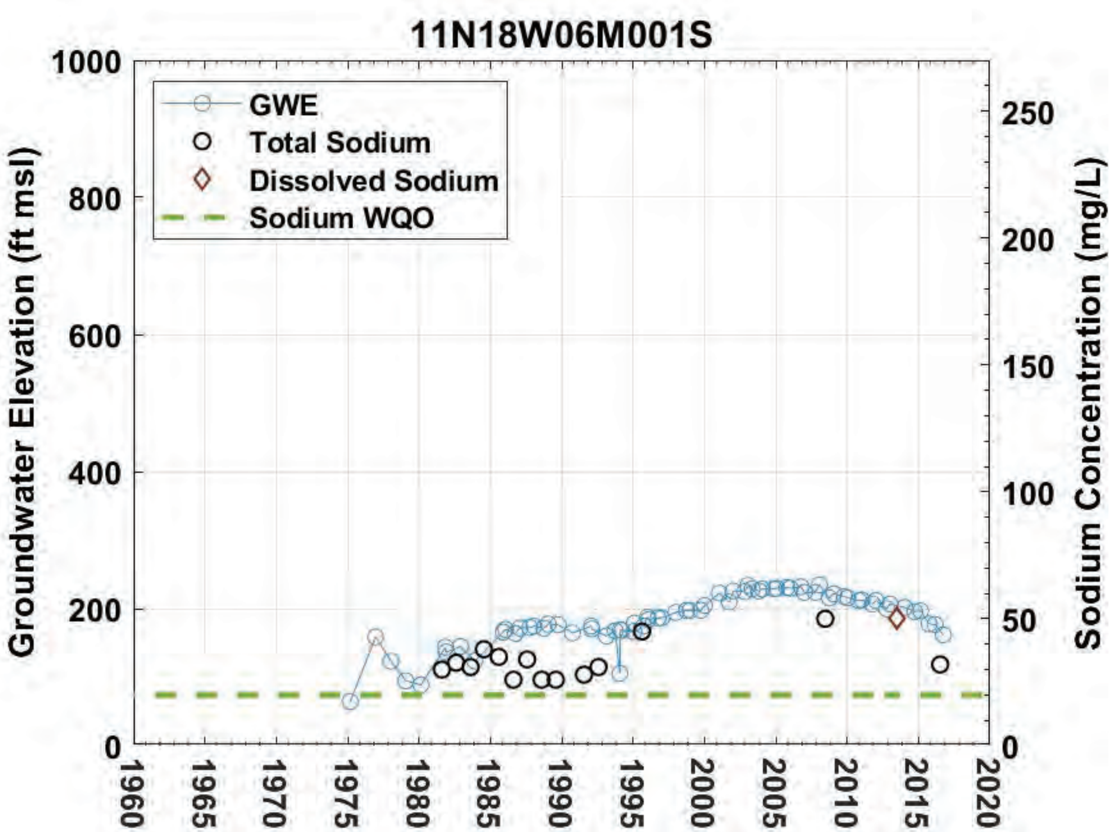

10N19W01K001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

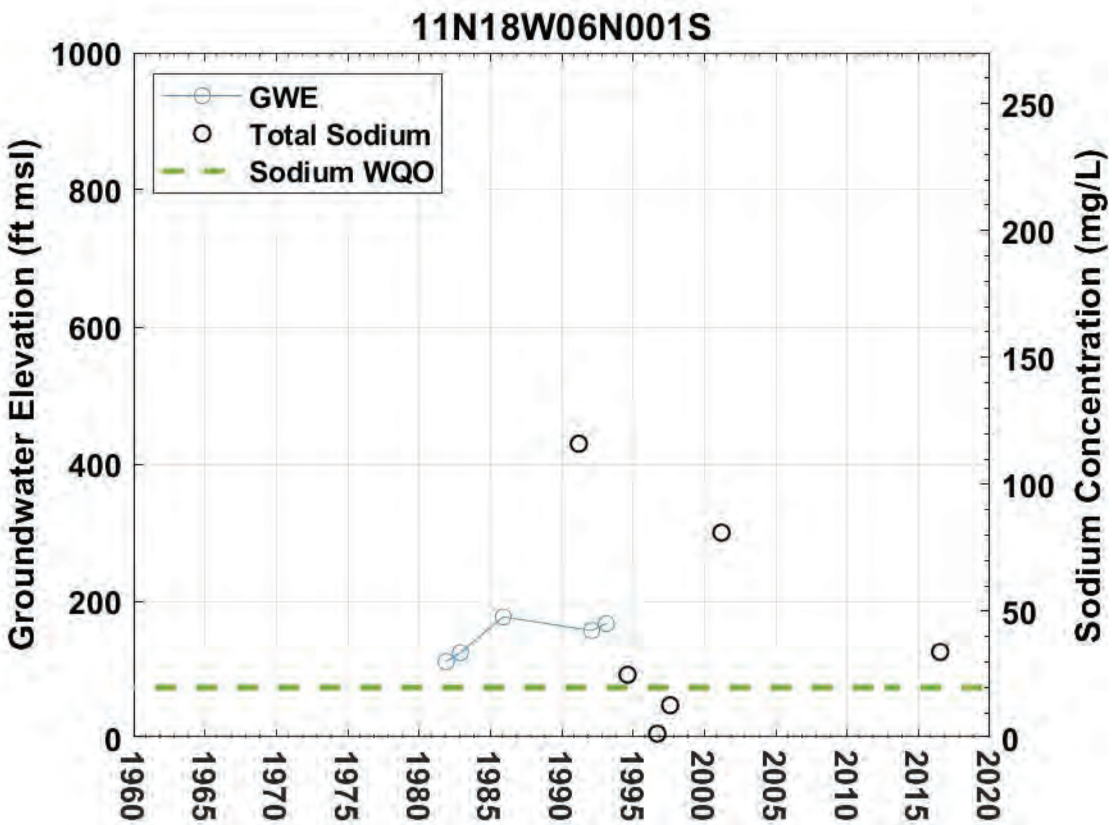

10N19W08A001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


10N19W08A002S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

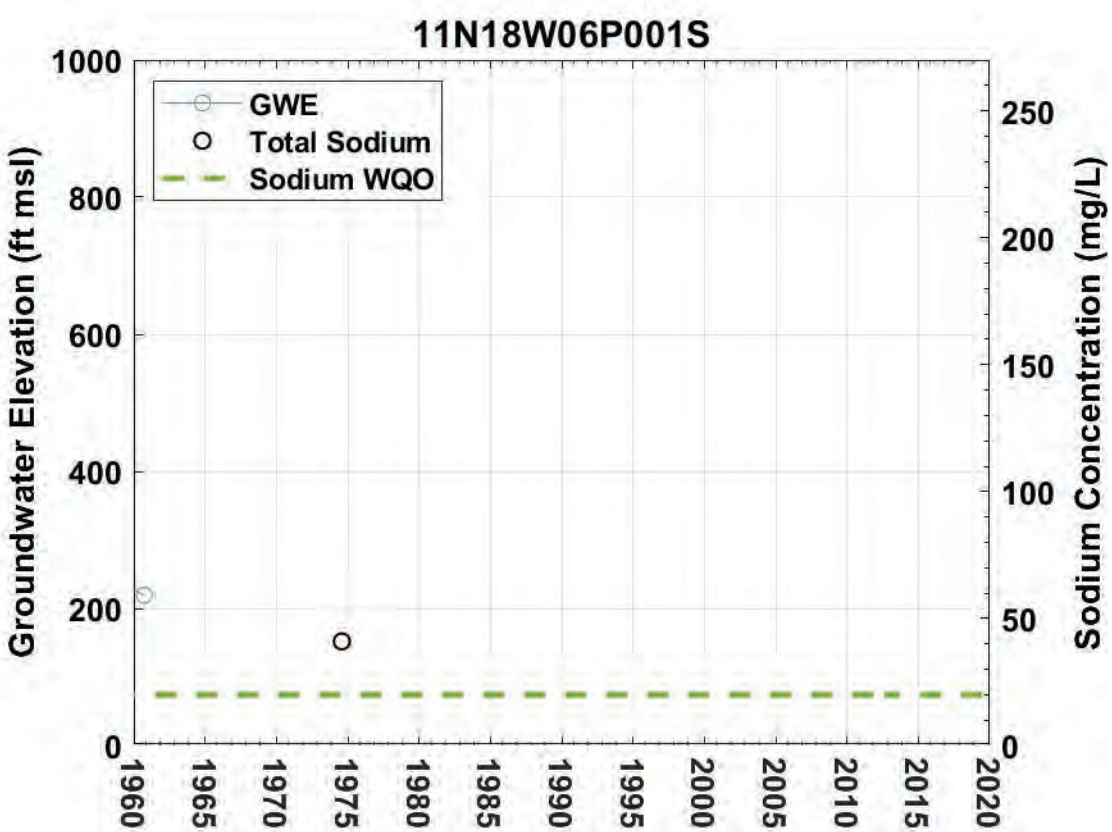

11N18W06D001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N18W06E001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

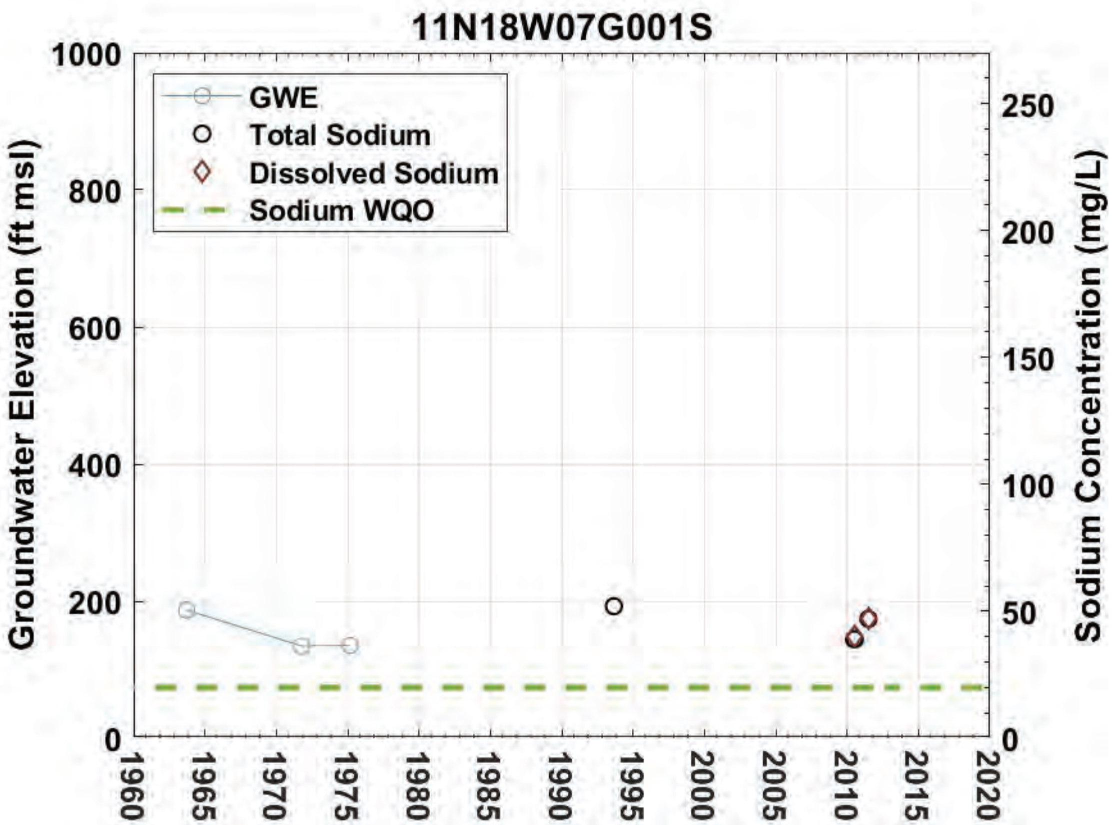

11N18W06M001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



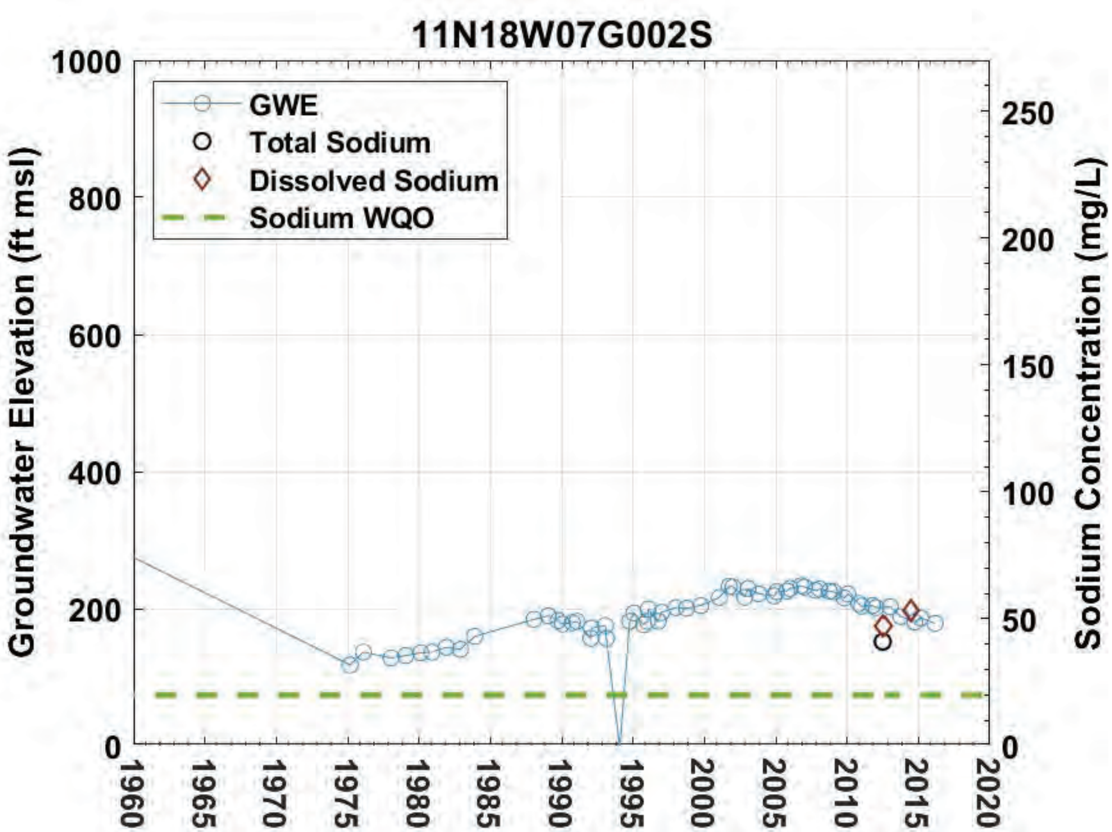
11N18W06N001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
GWE
Total Sodium
Sodium WQO
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



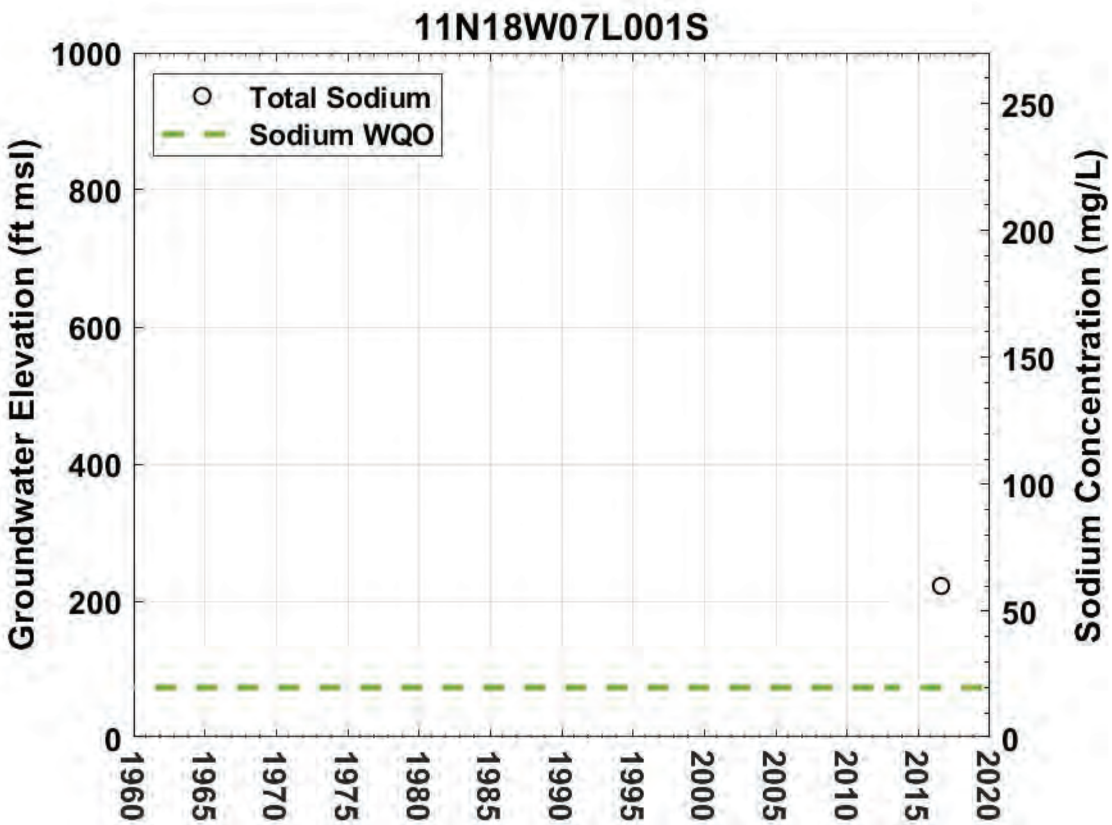
11N18W06P001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
GWE
Total Sodium
Sodium WQO
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

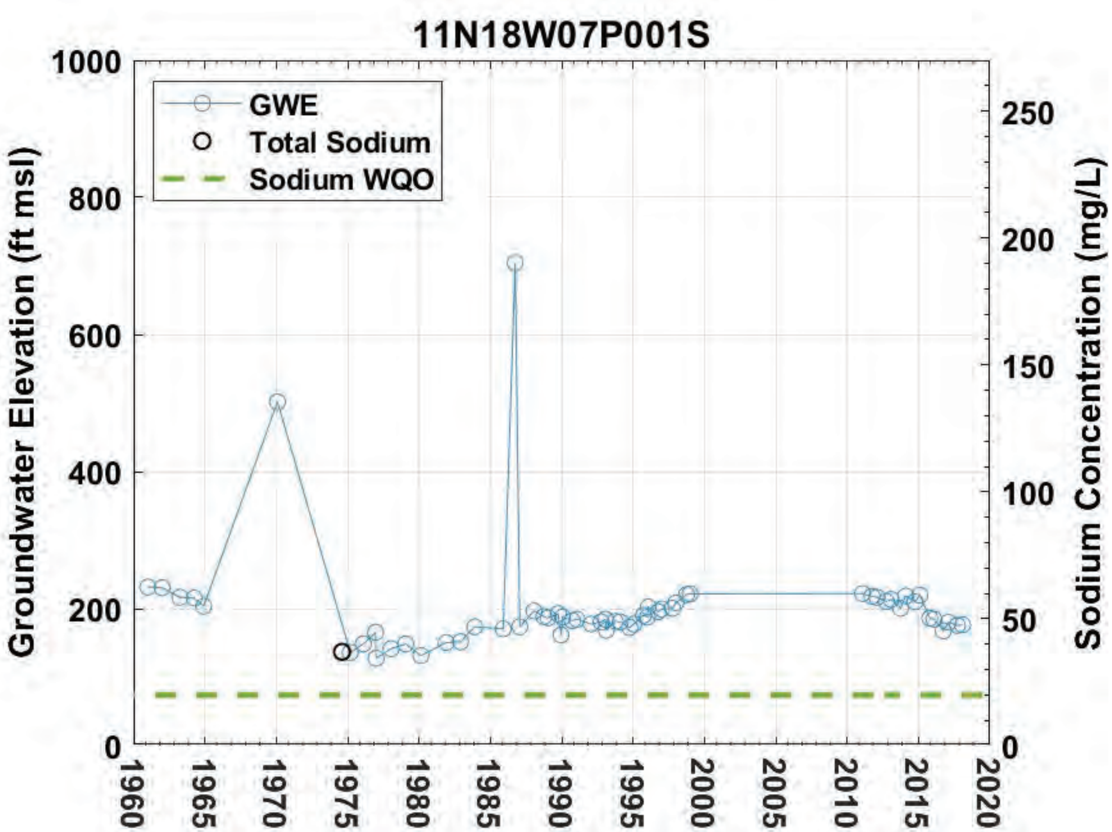


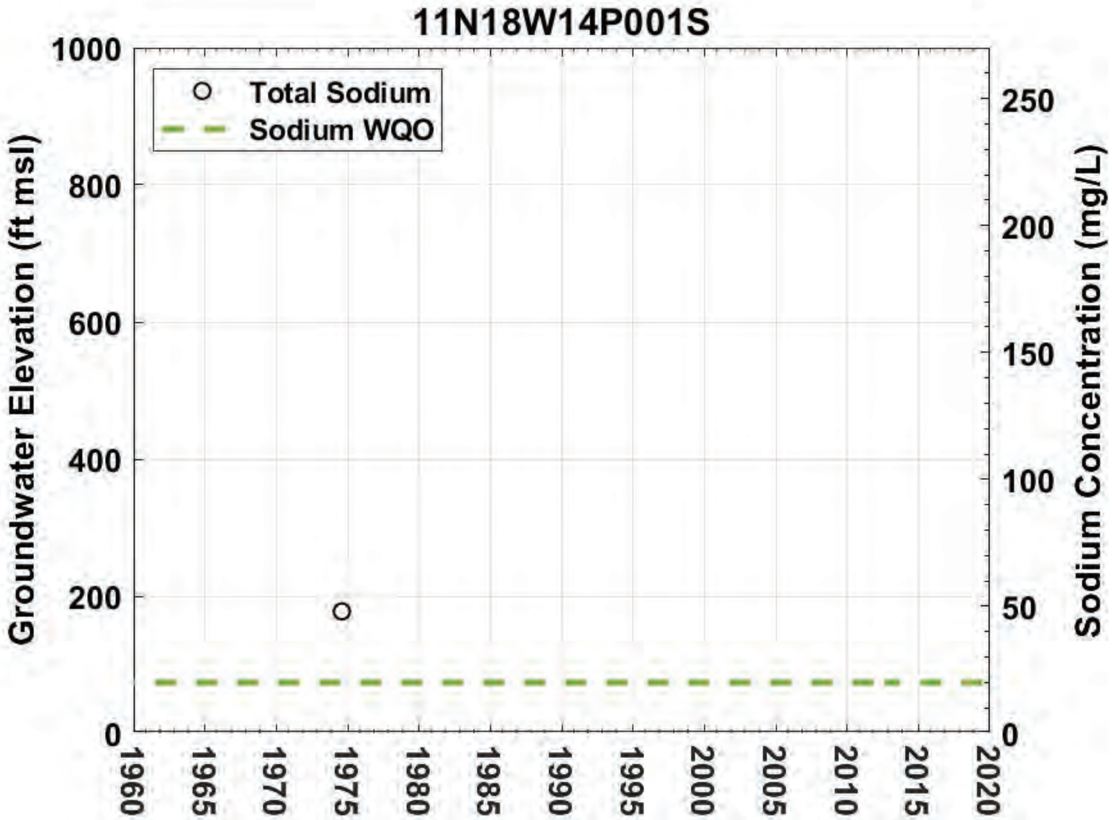
11N18W07G001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

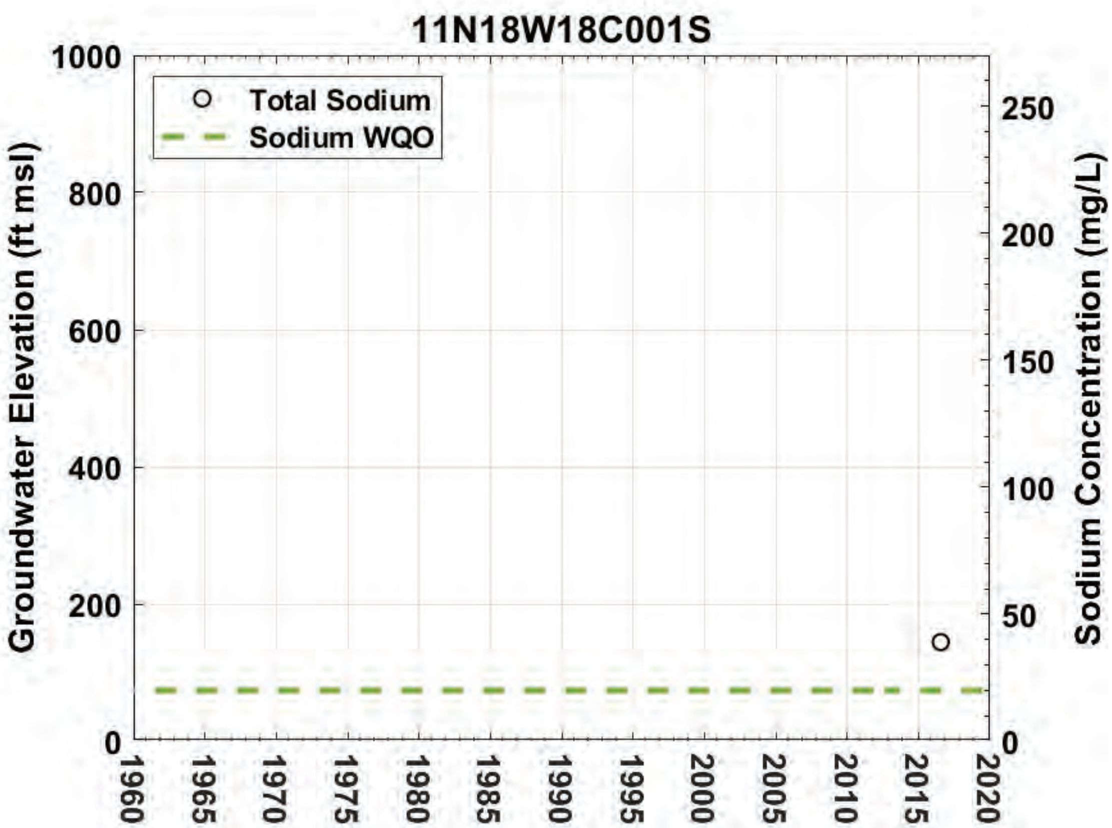


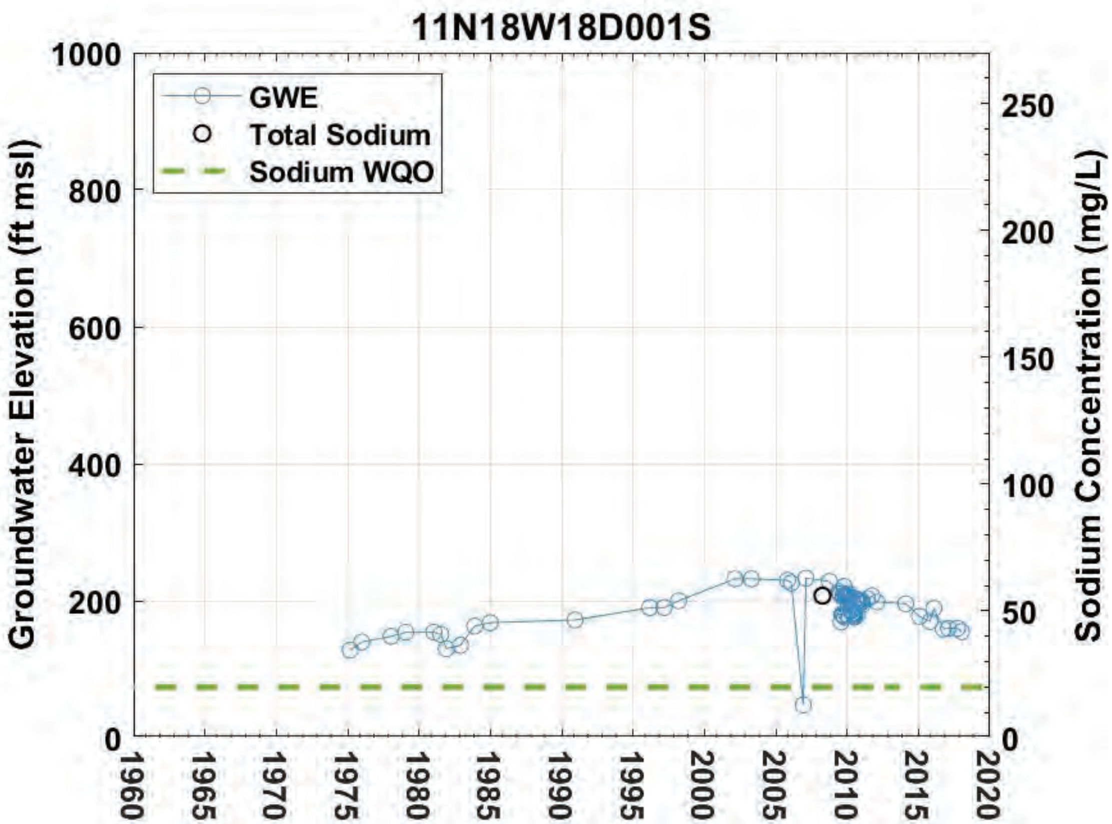
11N18W07G002S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

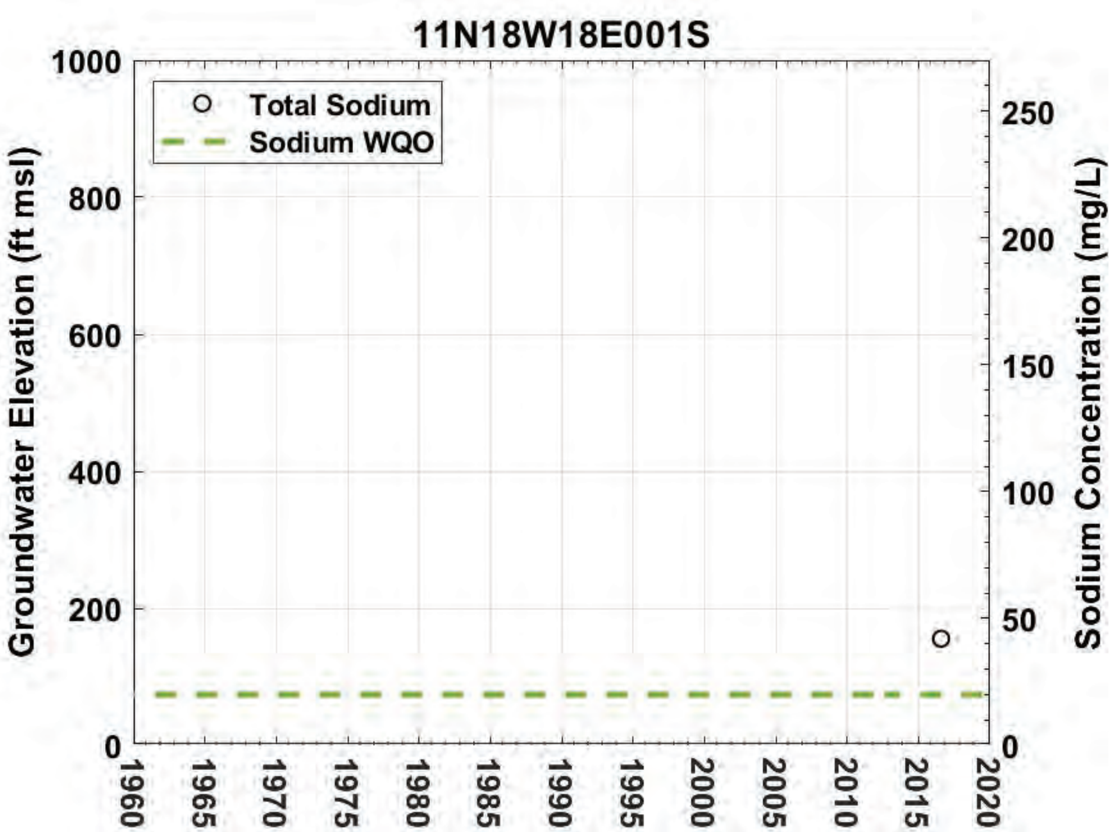

11N18W07L001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

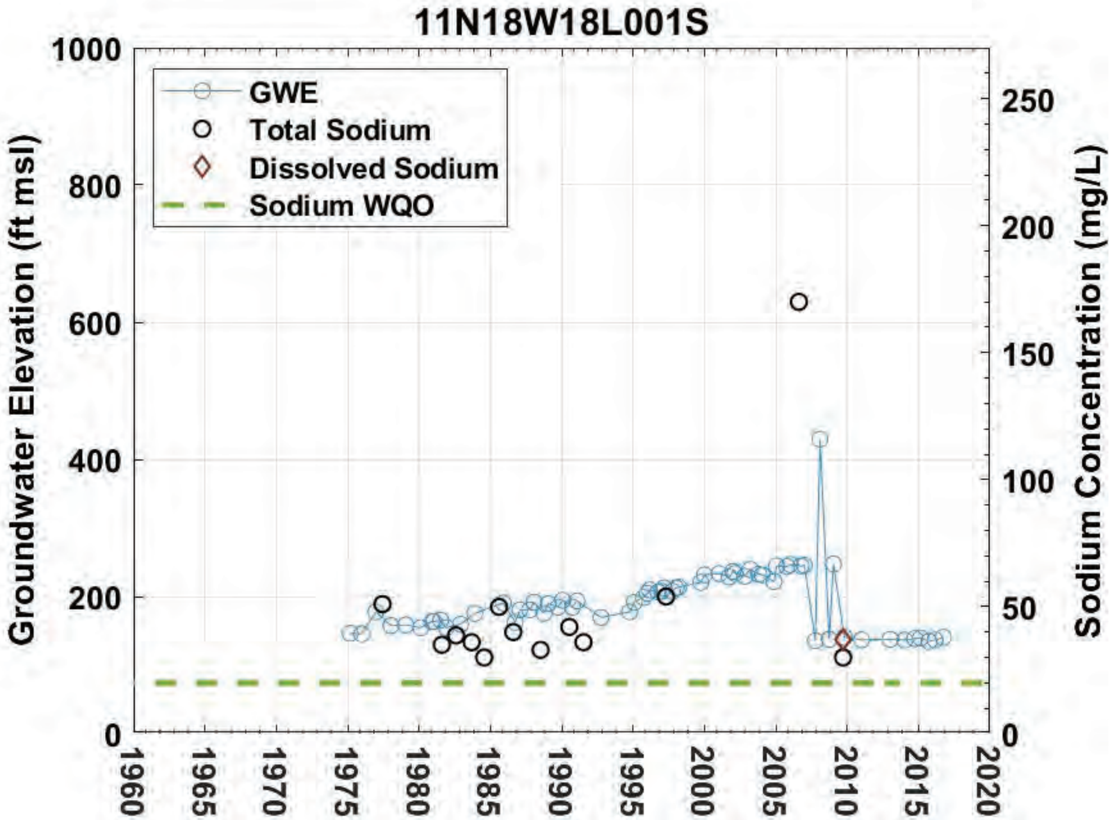

11N18W07P001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

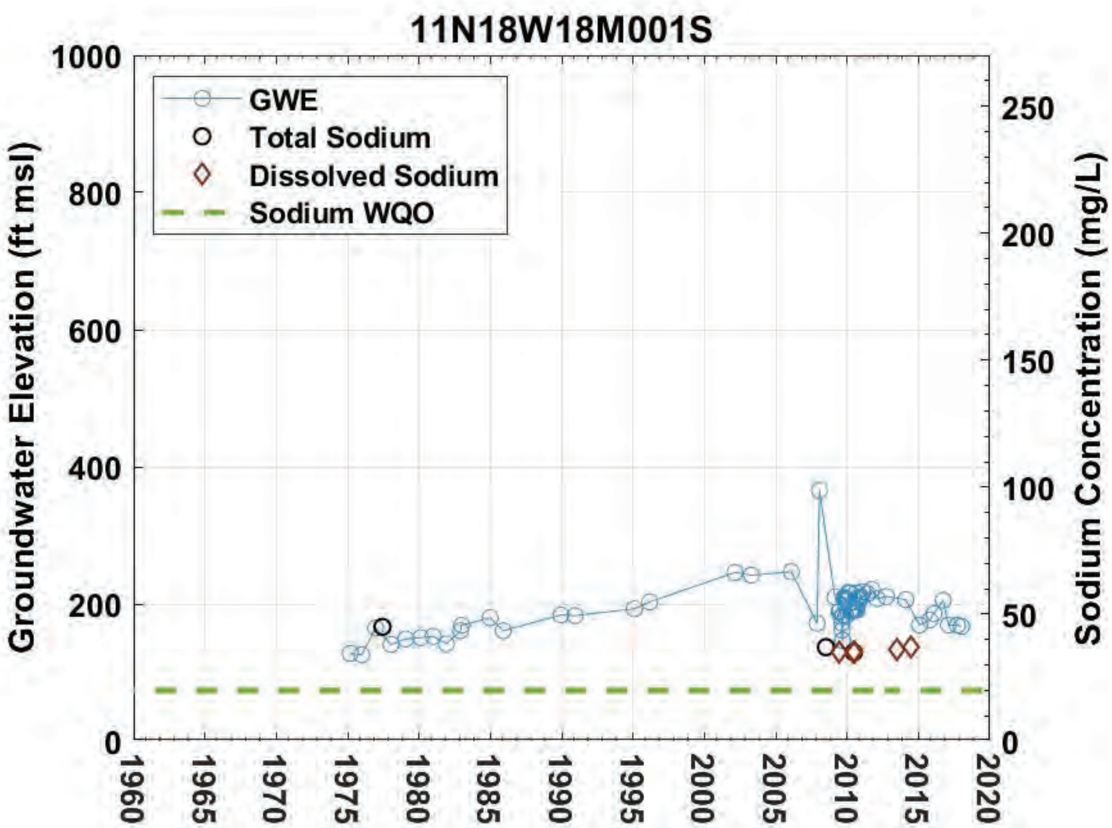

11N18W14P001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

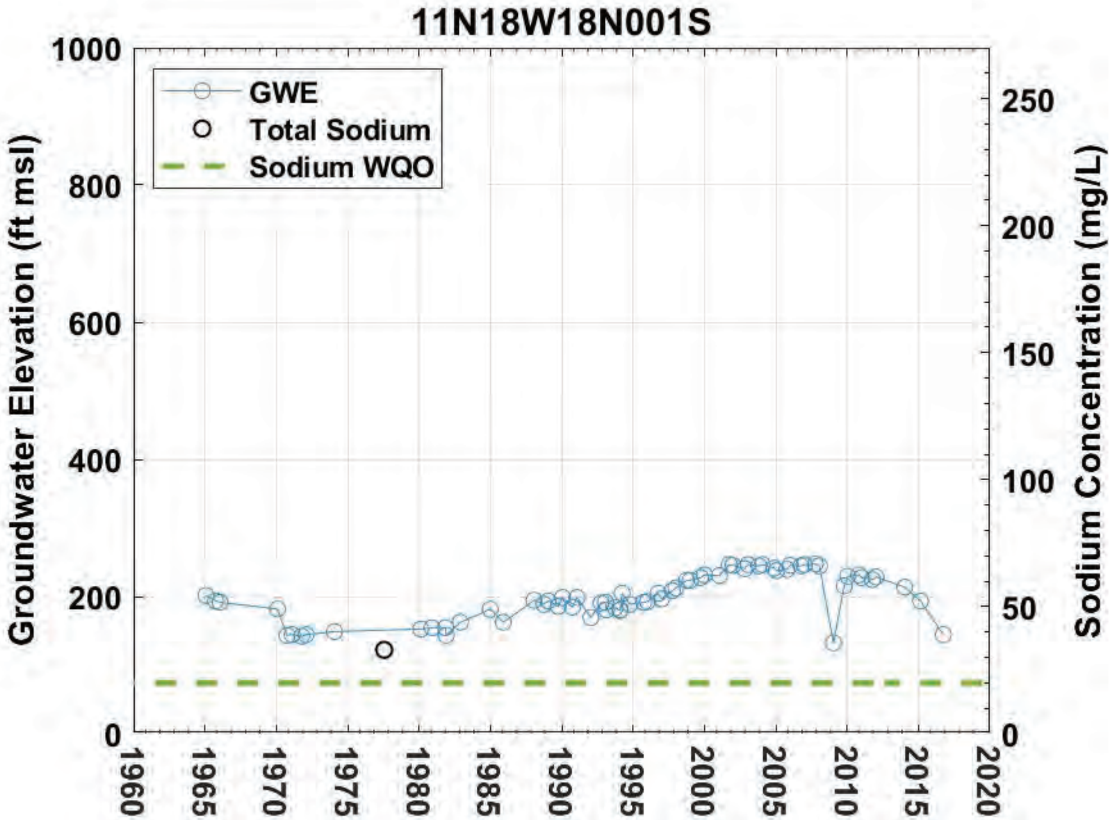

11N18W18C001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

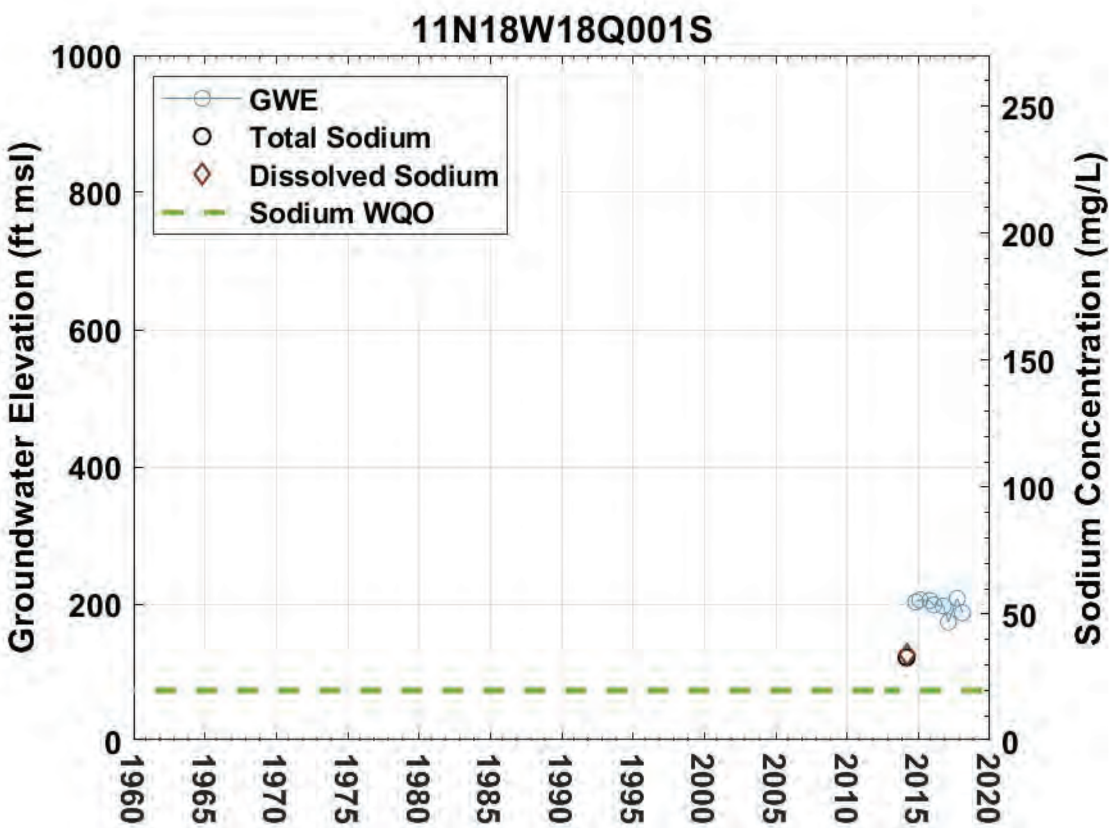

11N18W18D001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

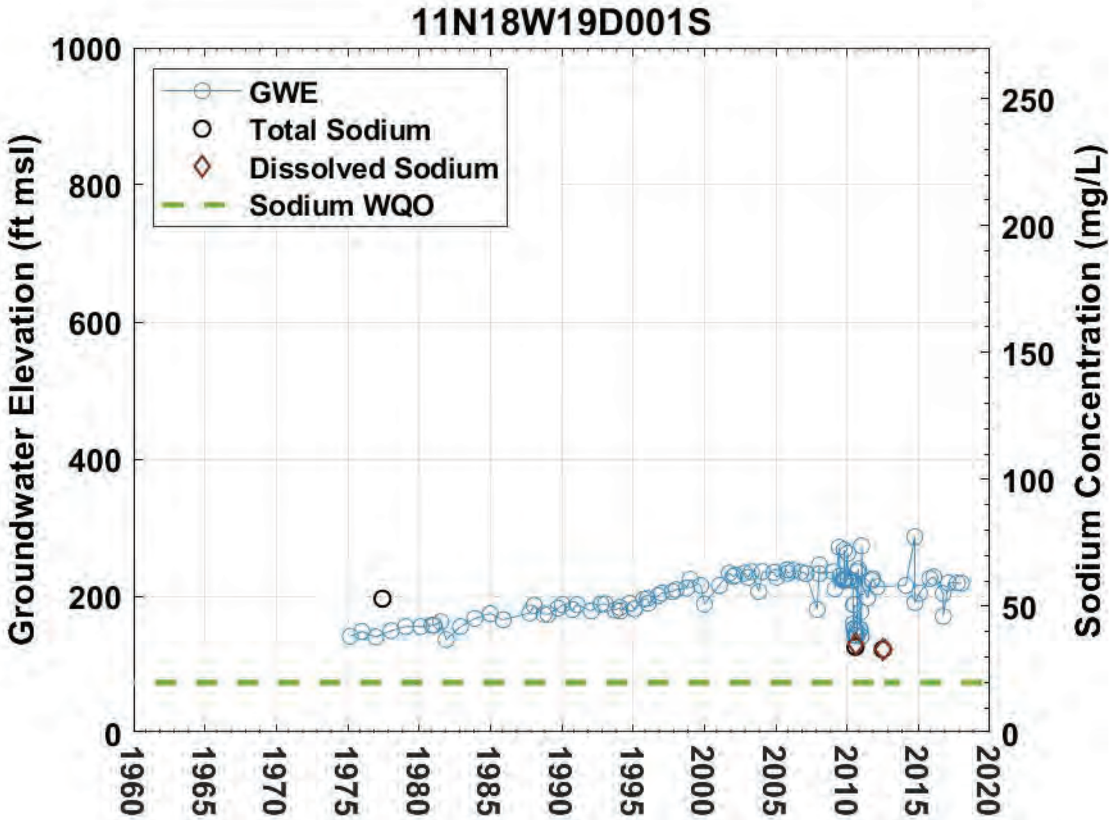

11N18W18E001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

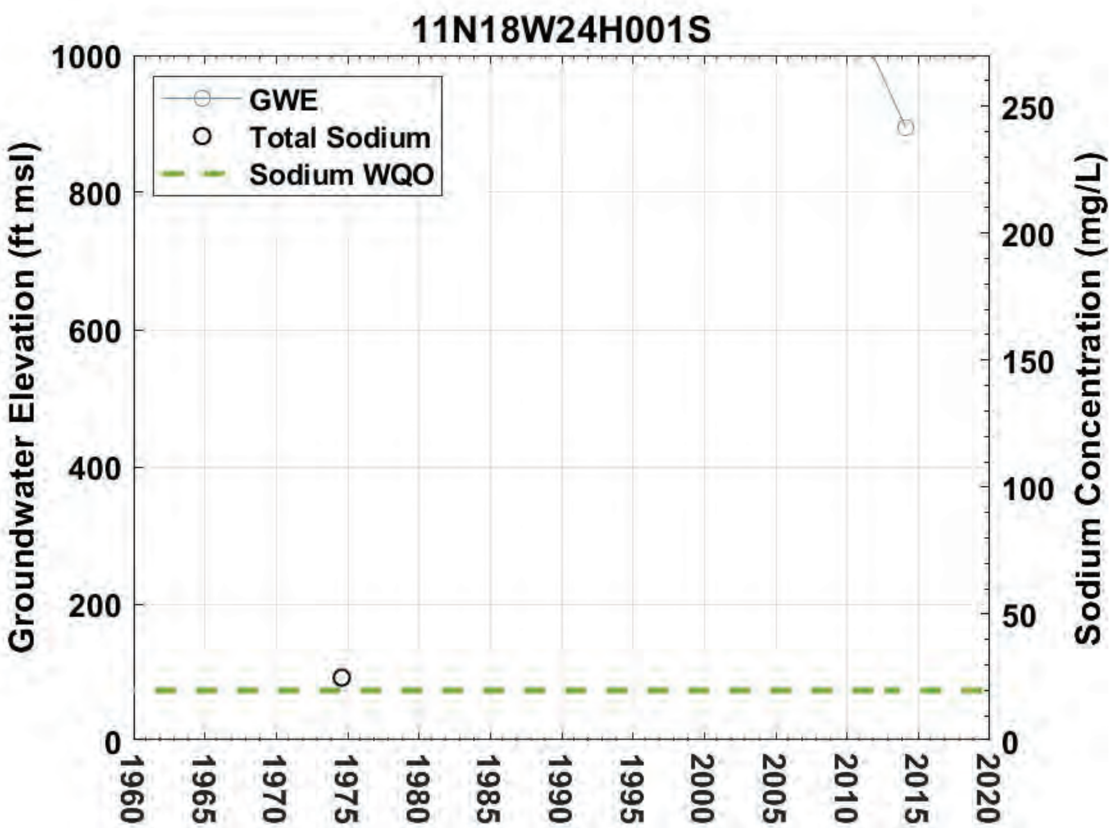

11N18W18L001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

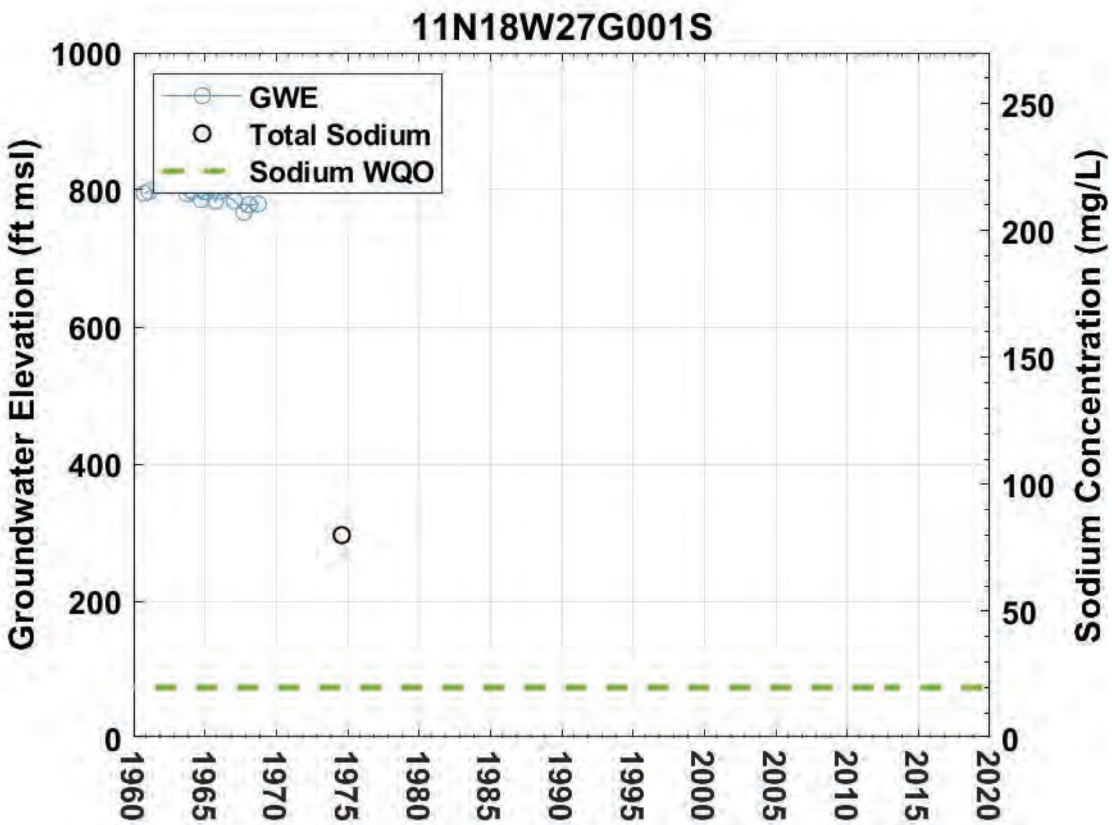

11N18W18M001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N18W18N001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

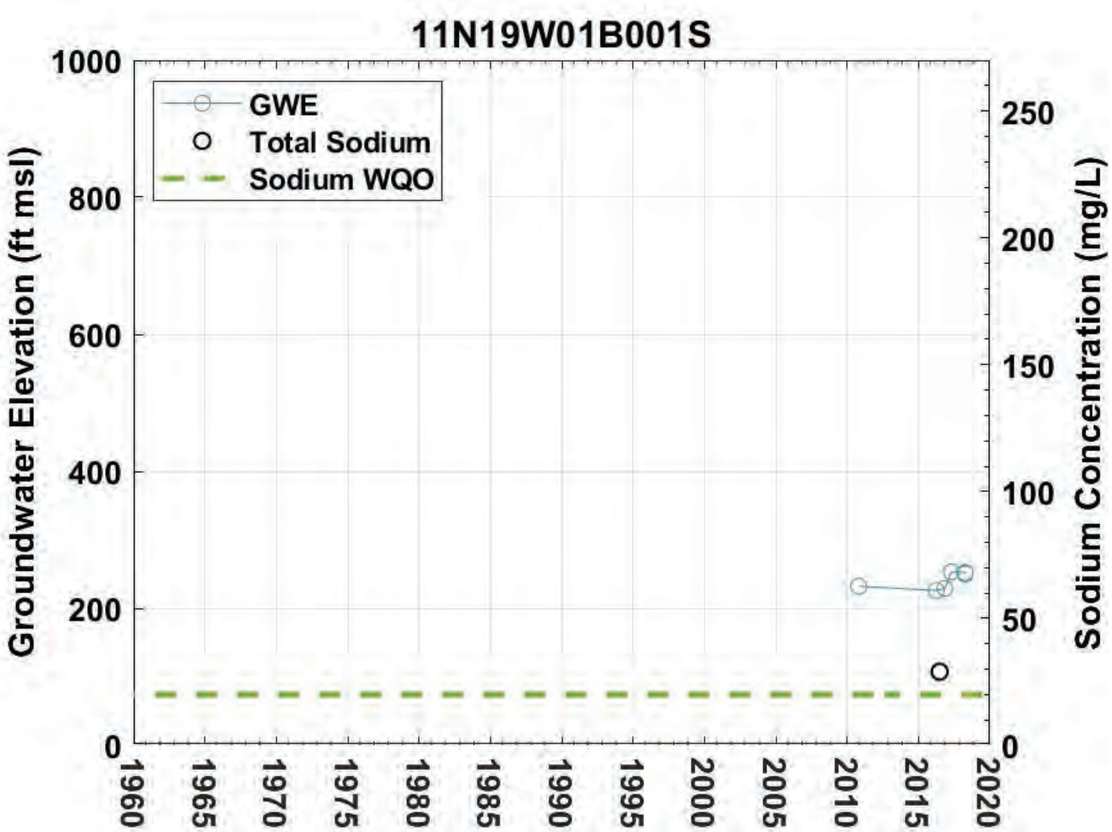

11N18W18Q001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N18W19D001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

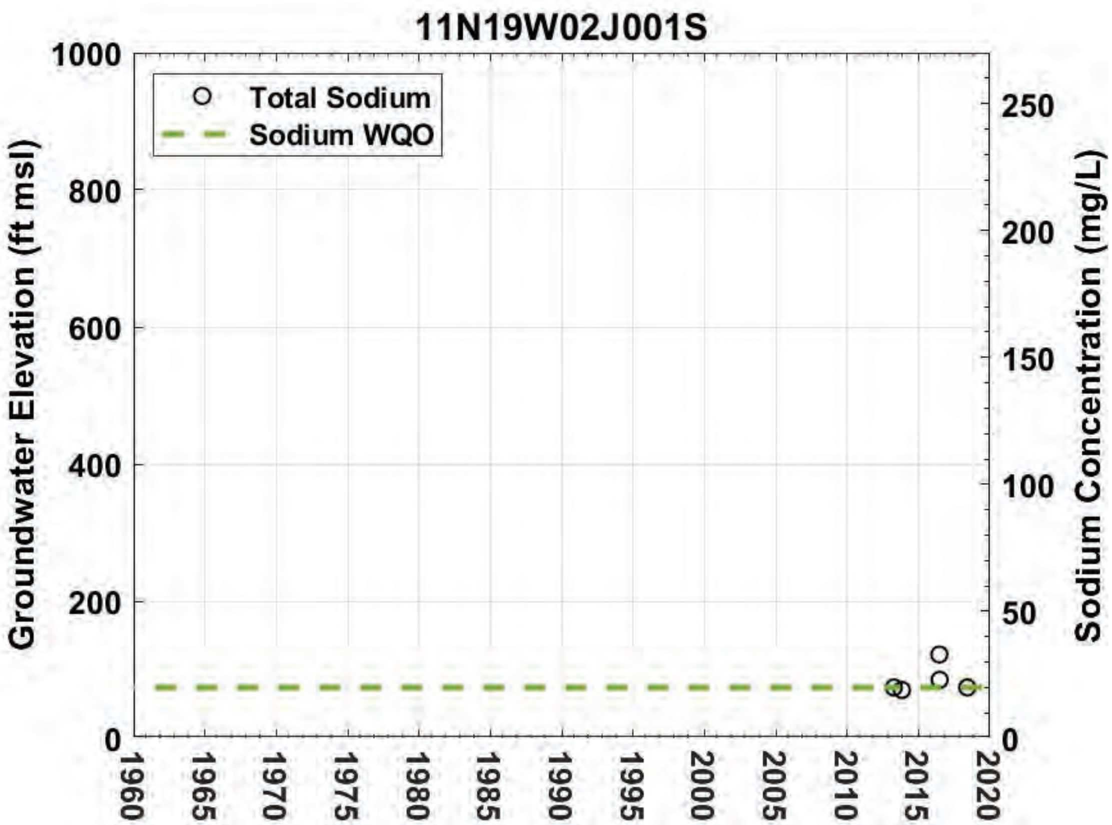

11N18W24H001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
GWE
Total Sodium
Sodium WQO
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

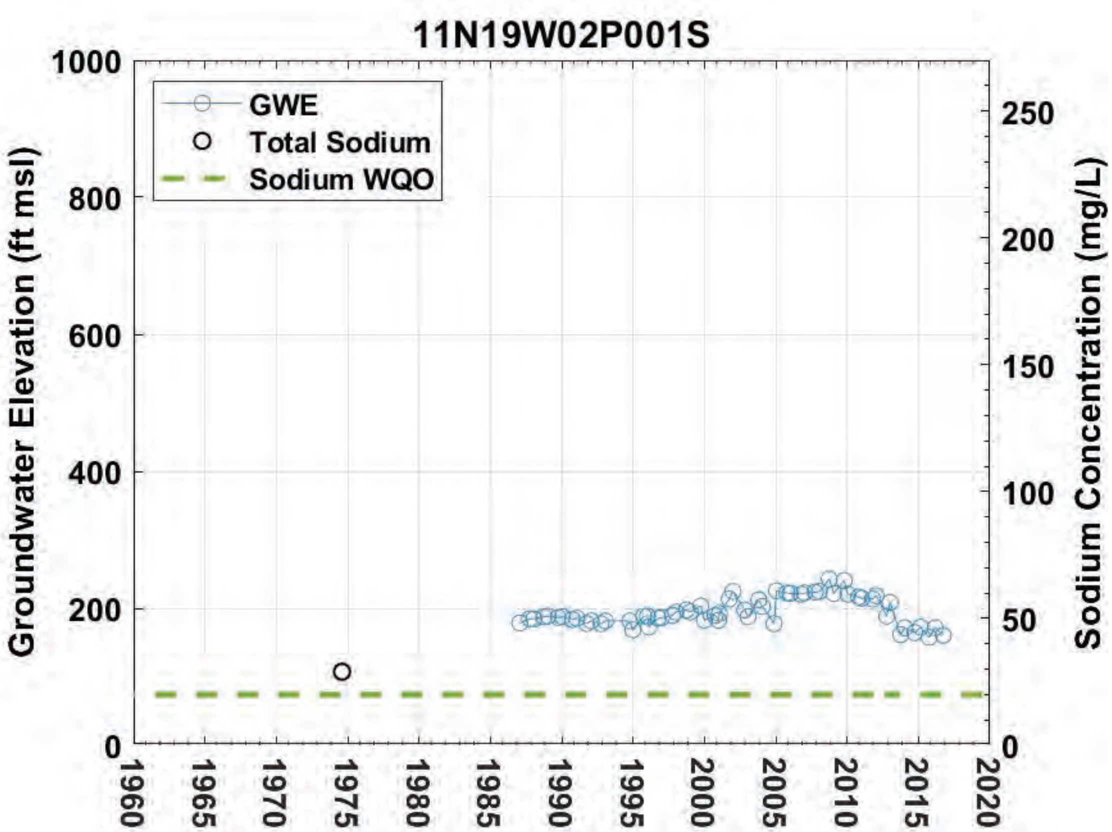


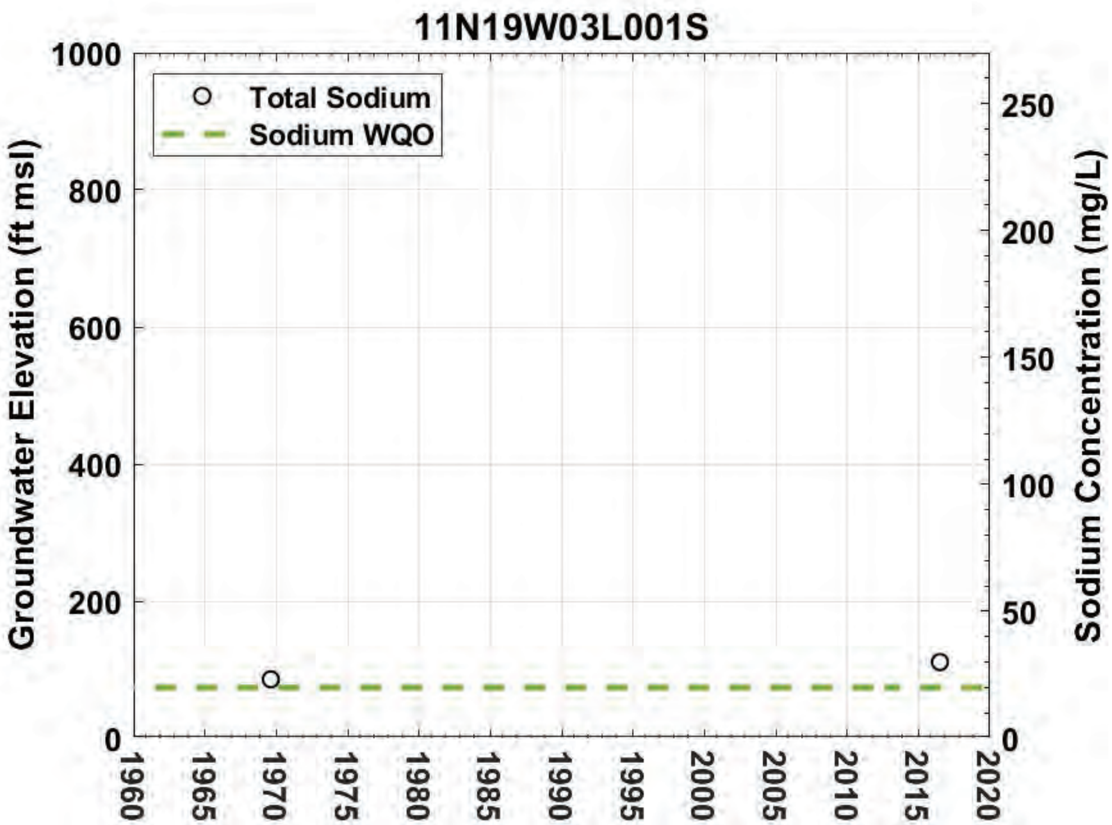
11N18W27G001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

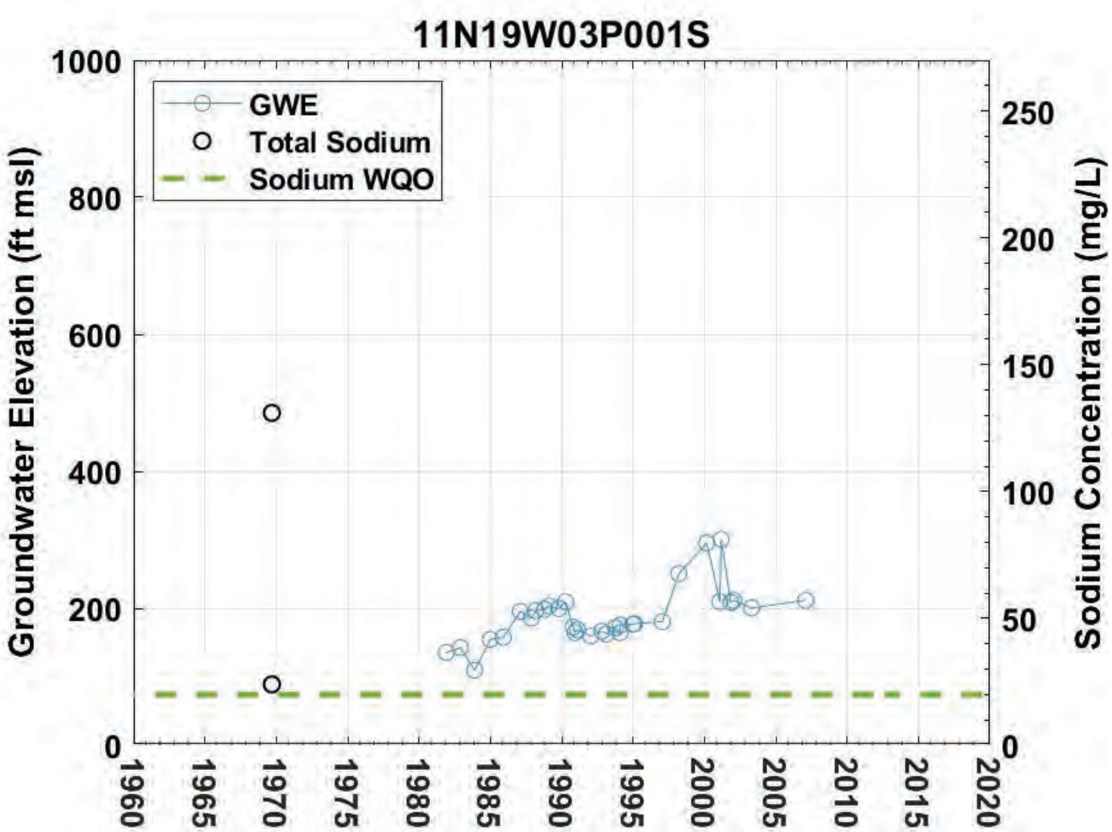


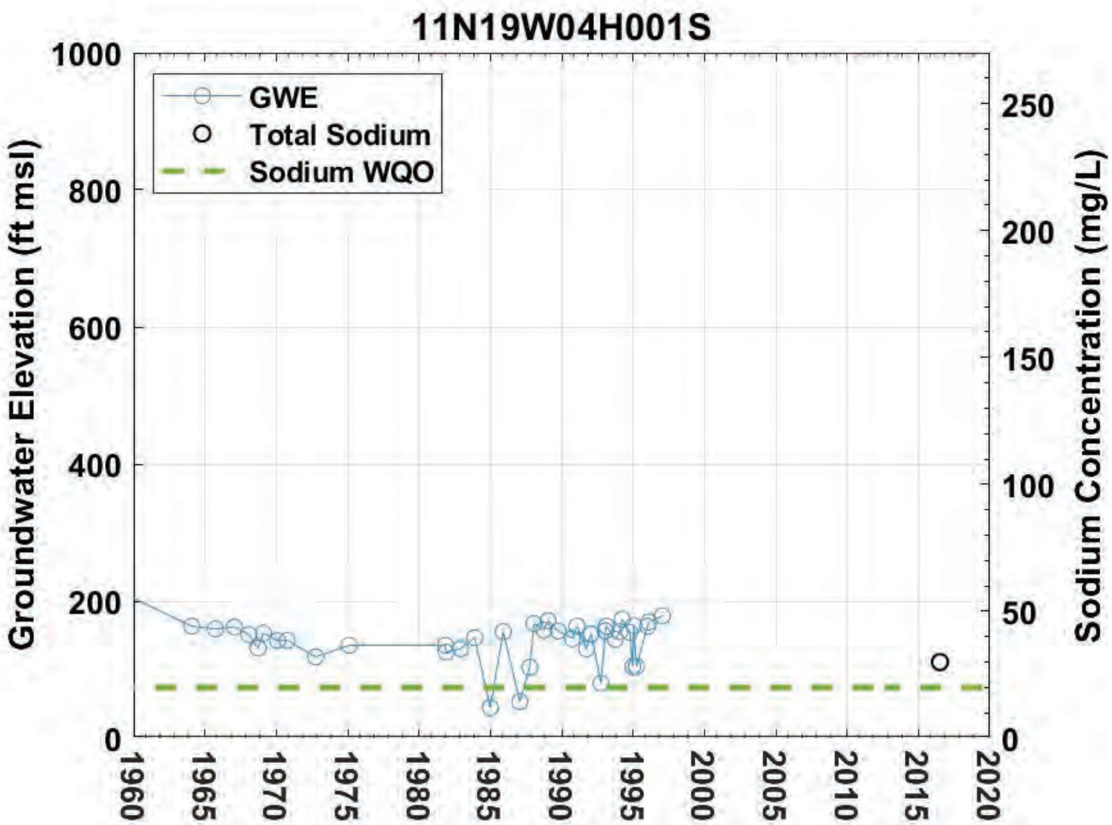
11N19W01B001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

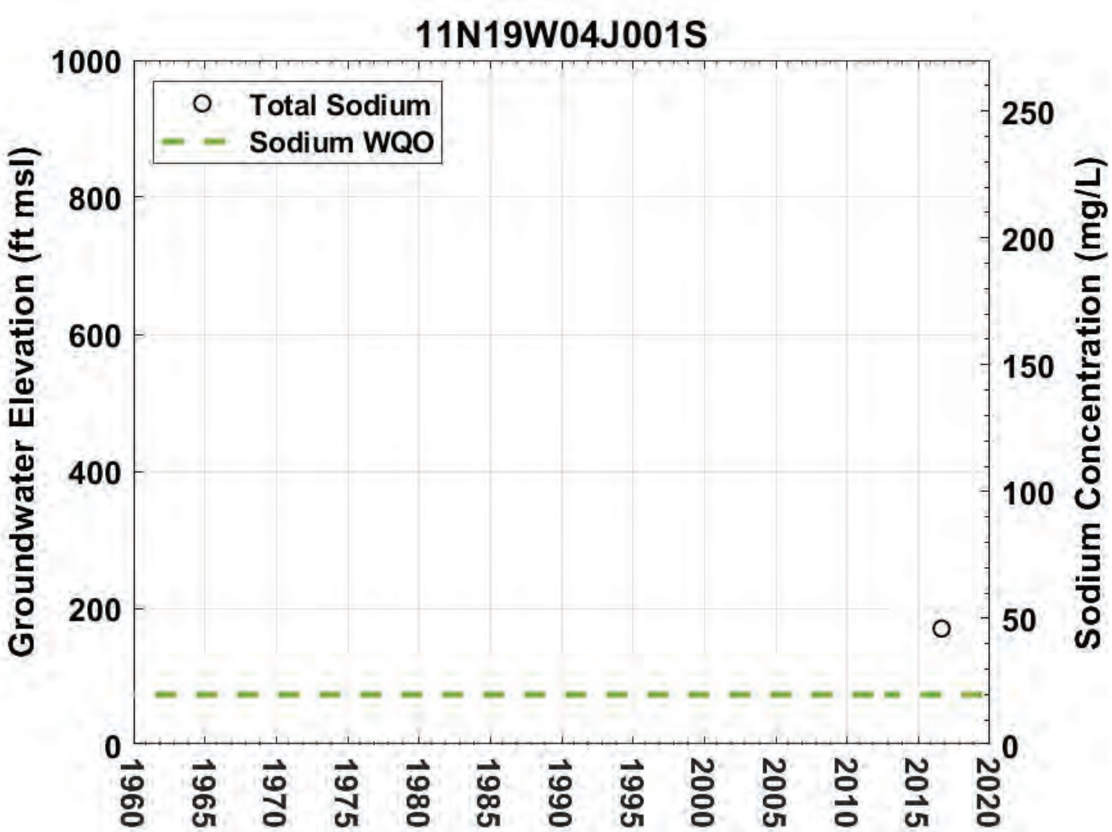

11N19W02J001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

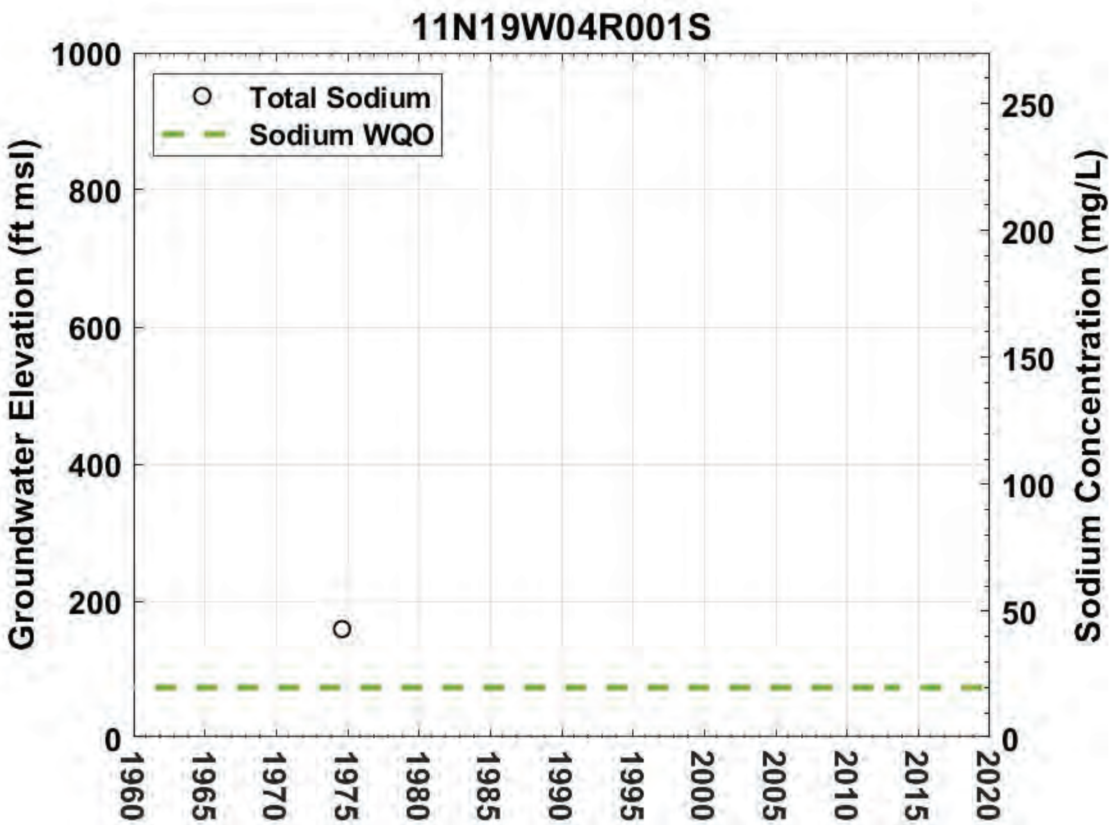

11N19W02P001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

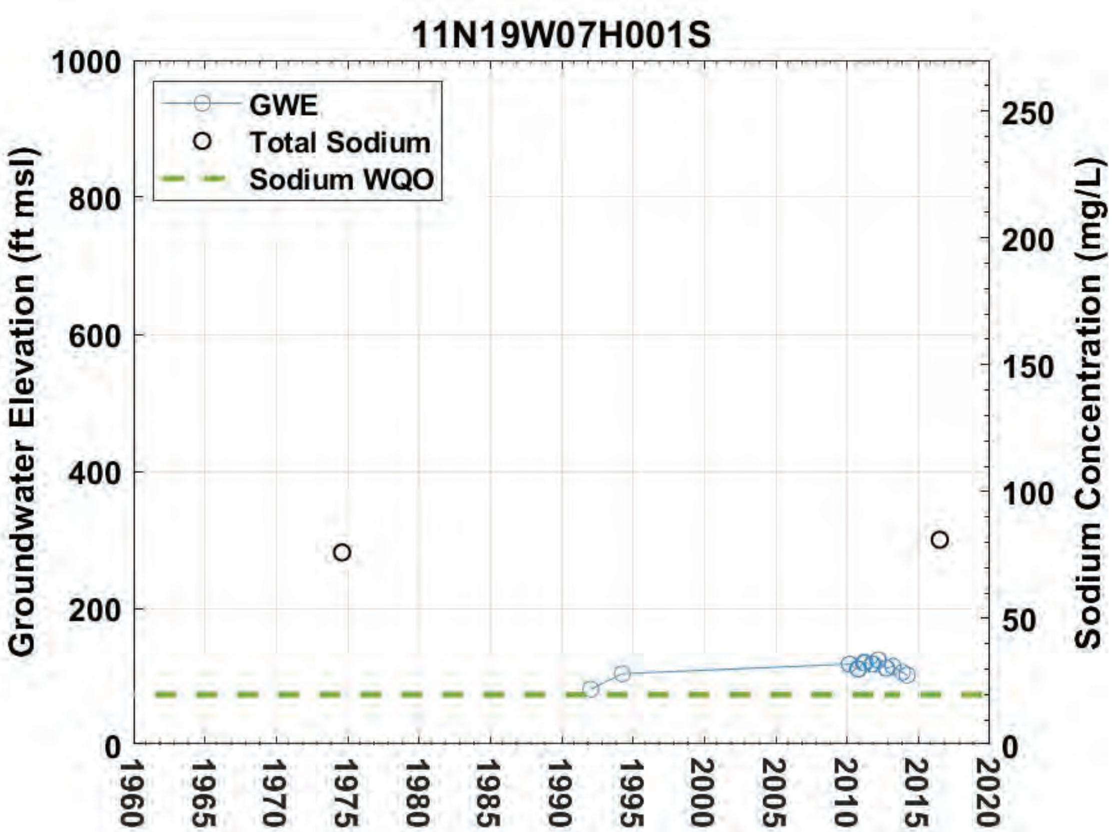

11N19W03L001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

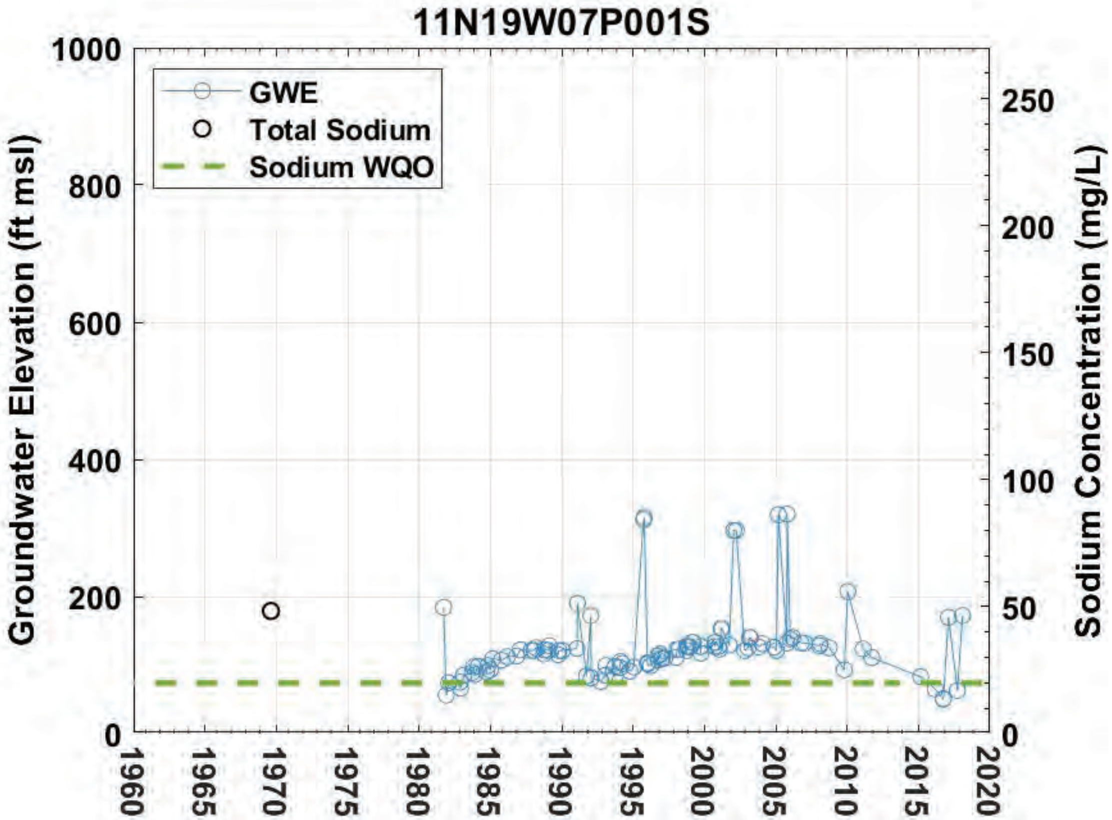

11N19W03P001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

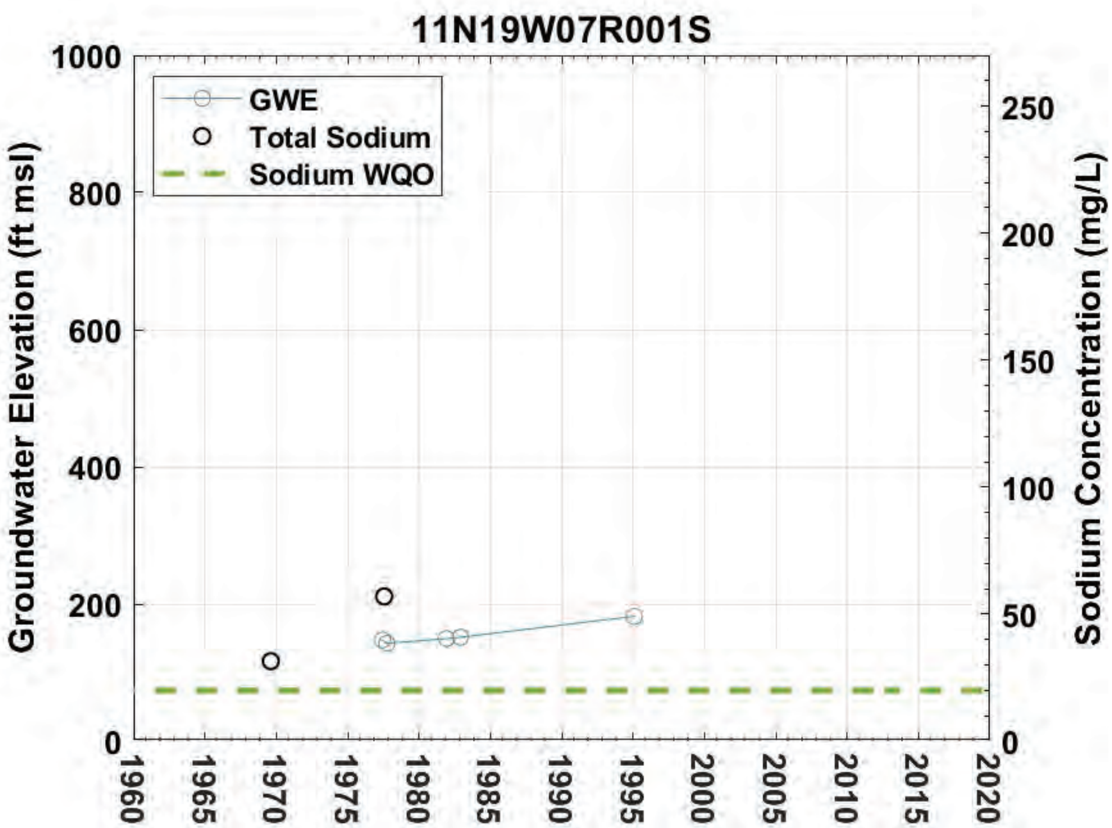

11N19W04H001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

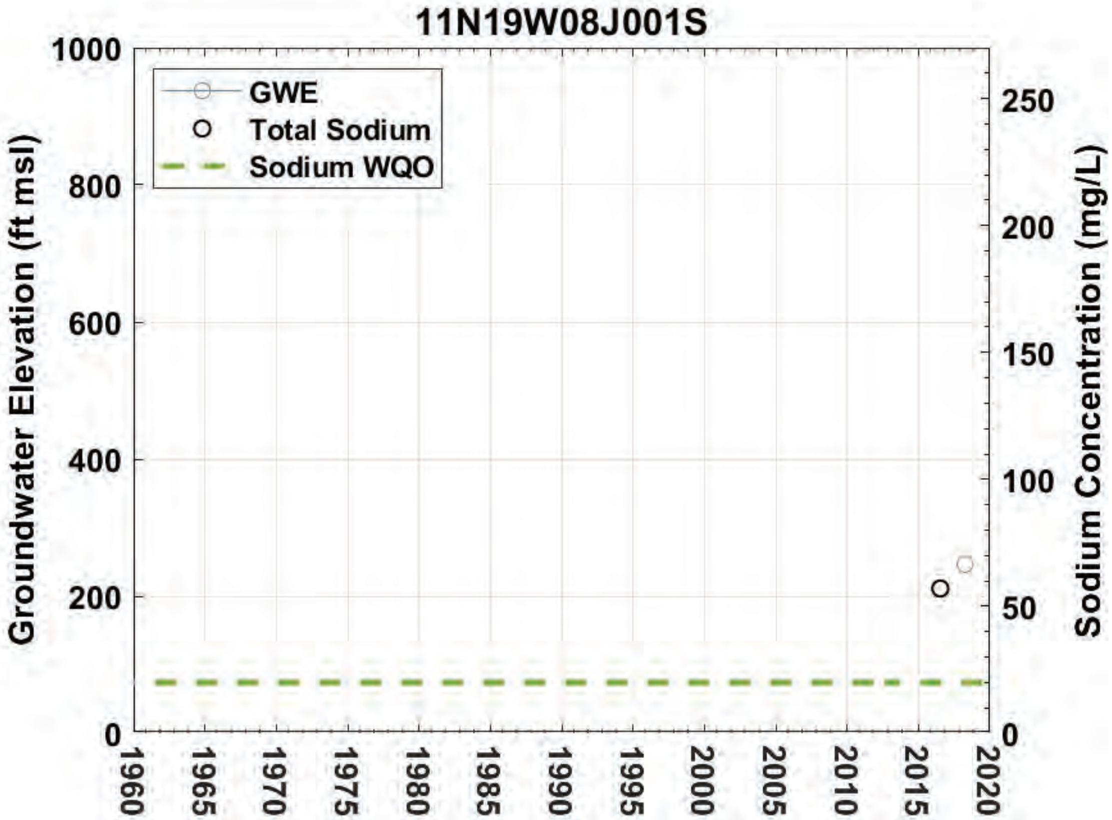

11N19W04J001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

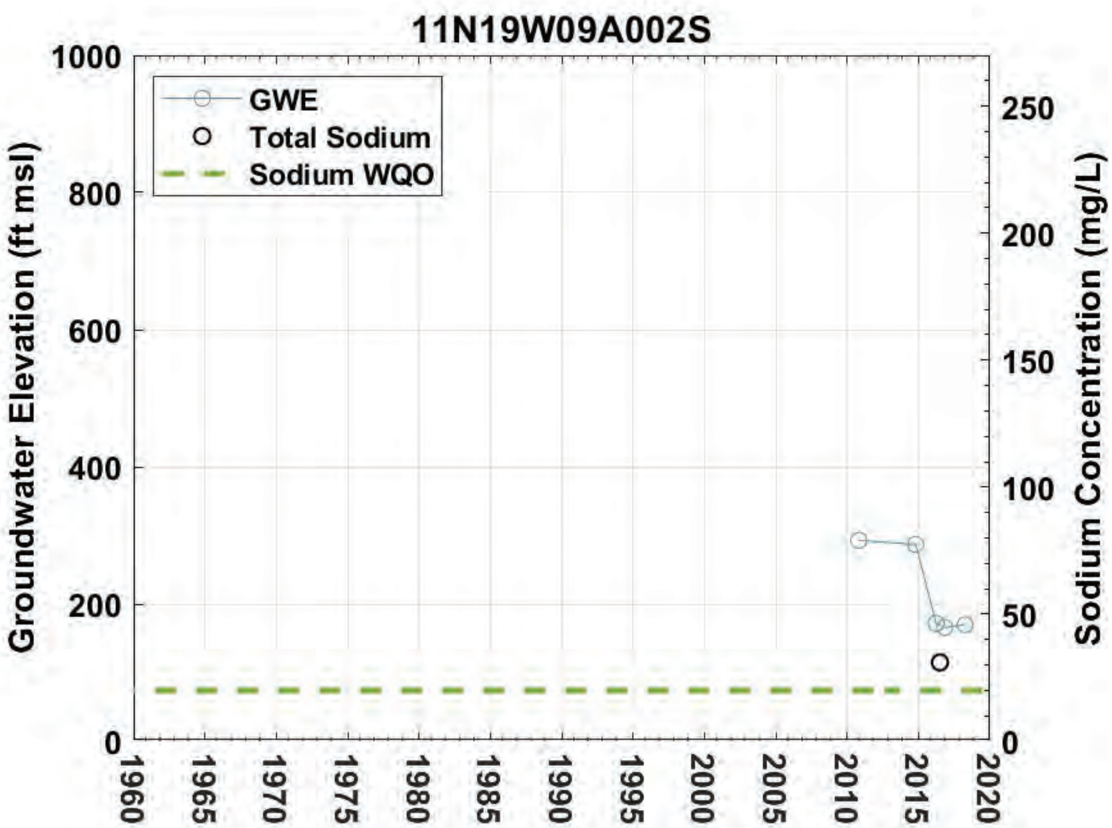

11N19W04R001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

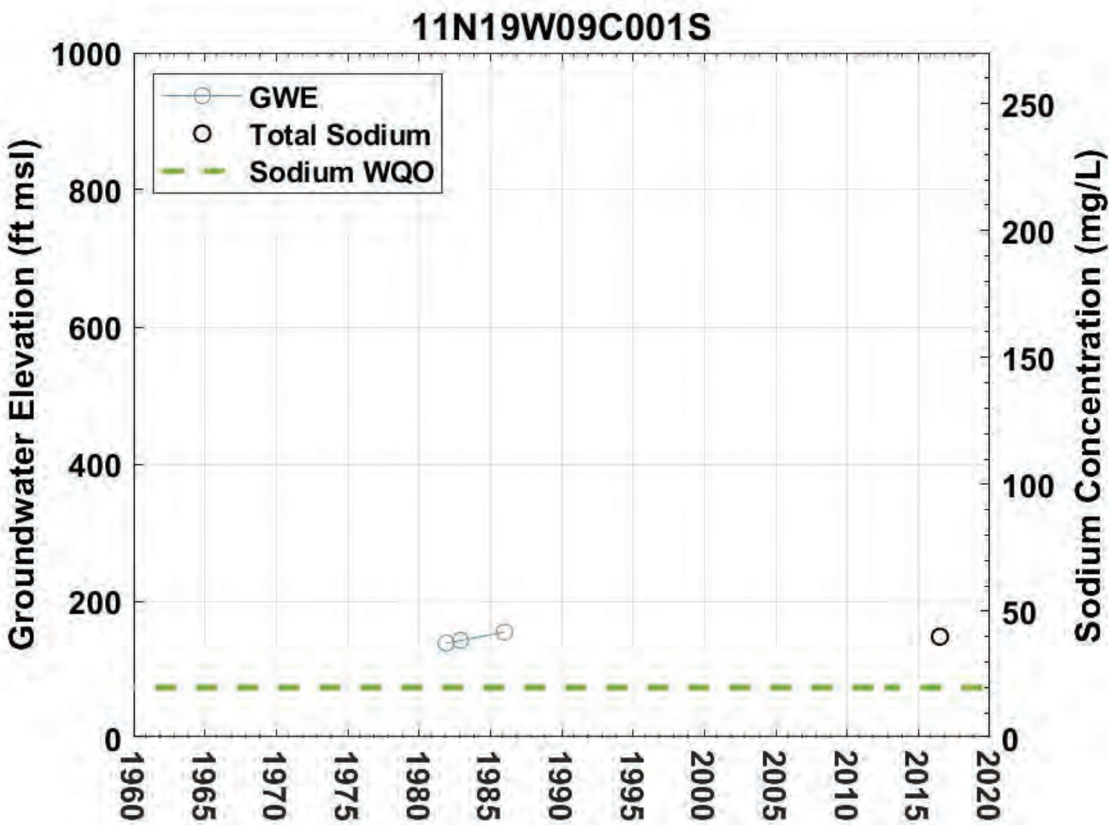

11N19W07H001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W07P001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
GWE
Total Sodium
Sodium WQO
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

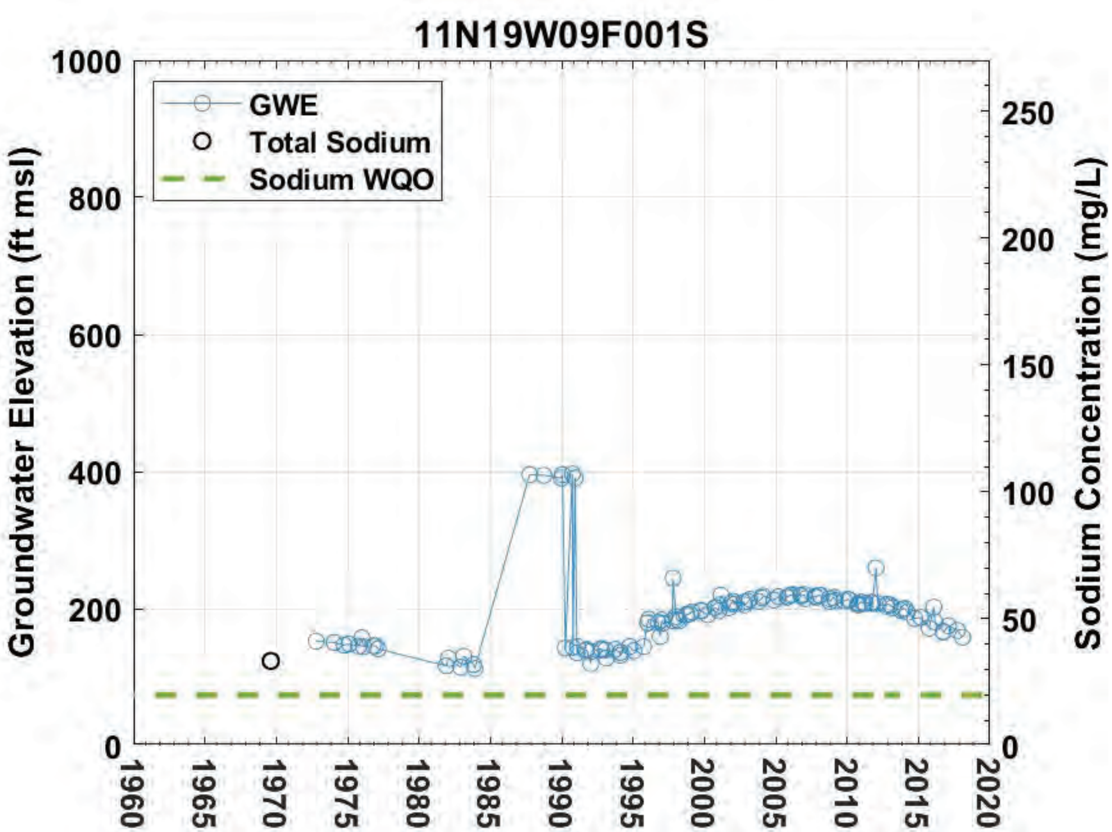

11N19W07R001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
GWE
Total Sodium
Sodium WQO
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W08J001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

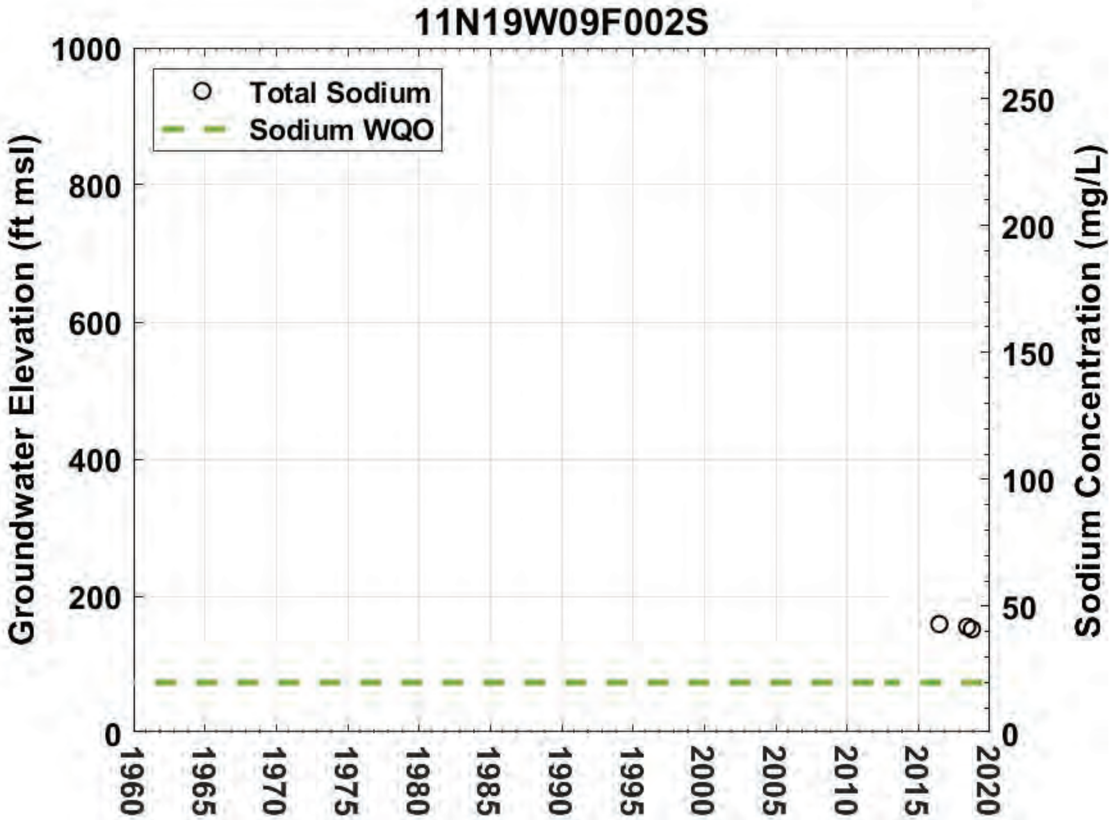

11N19W09A002S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

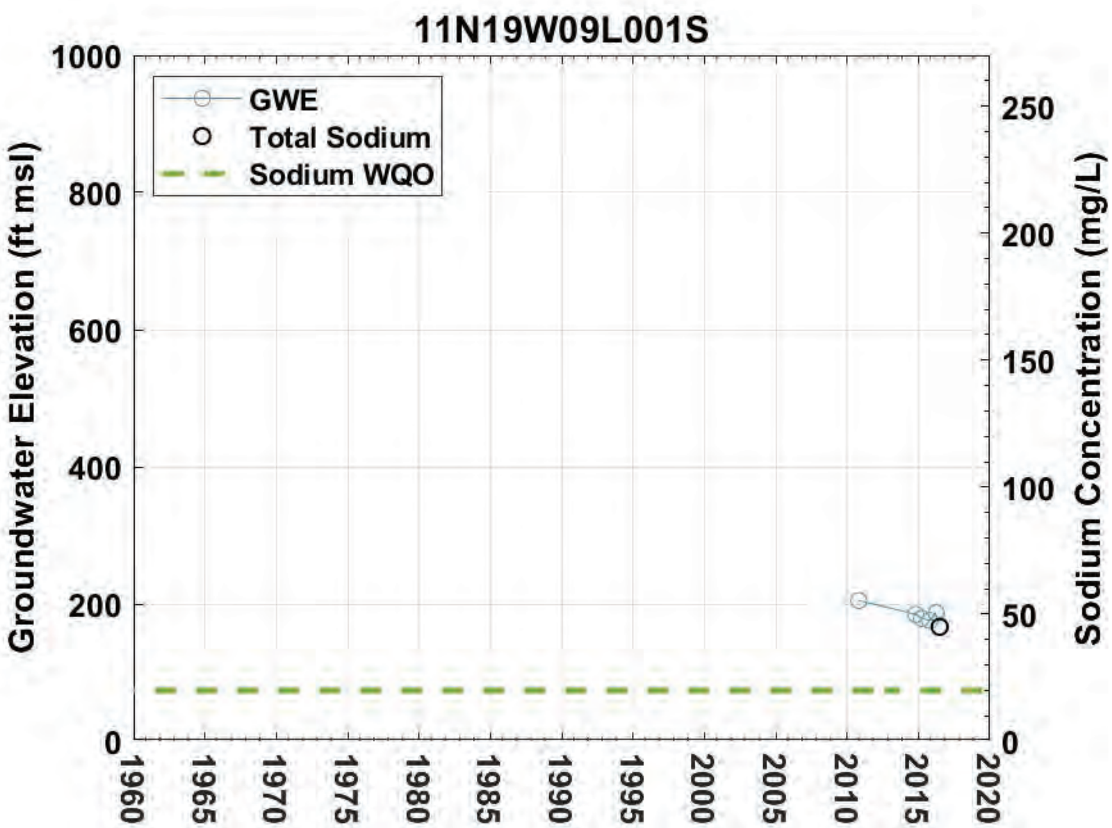


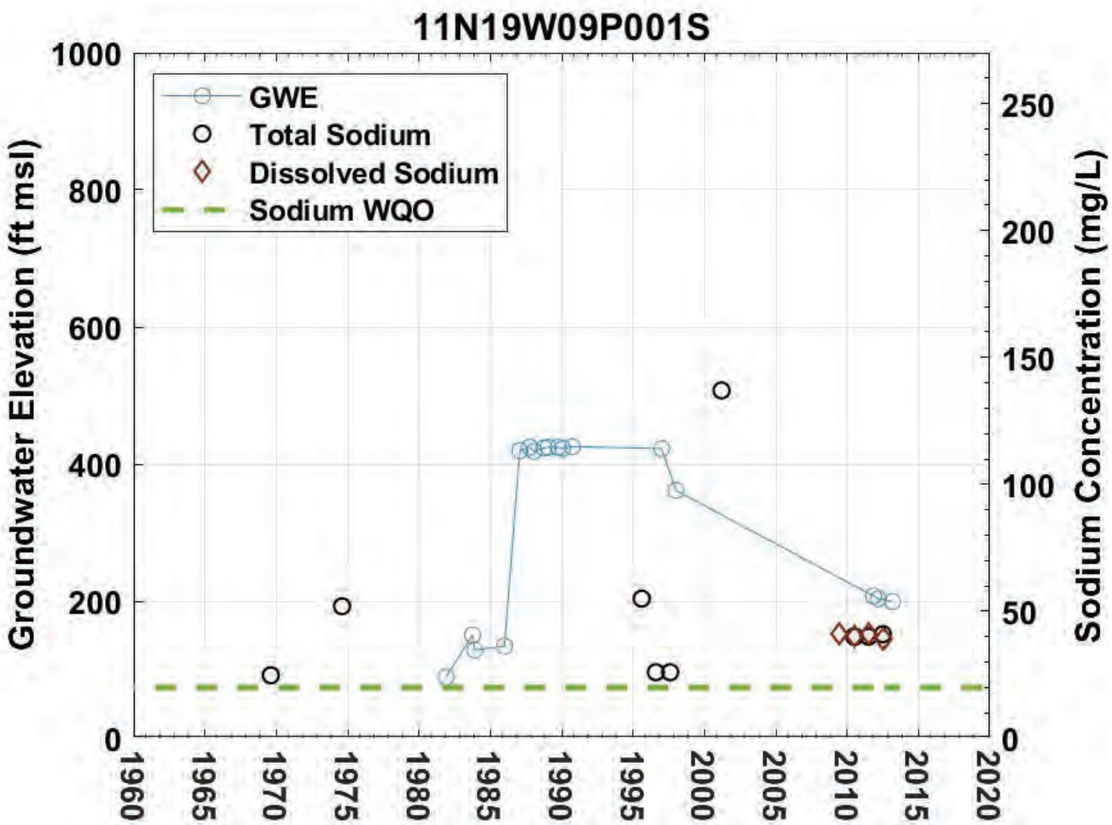
11N19W09C001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

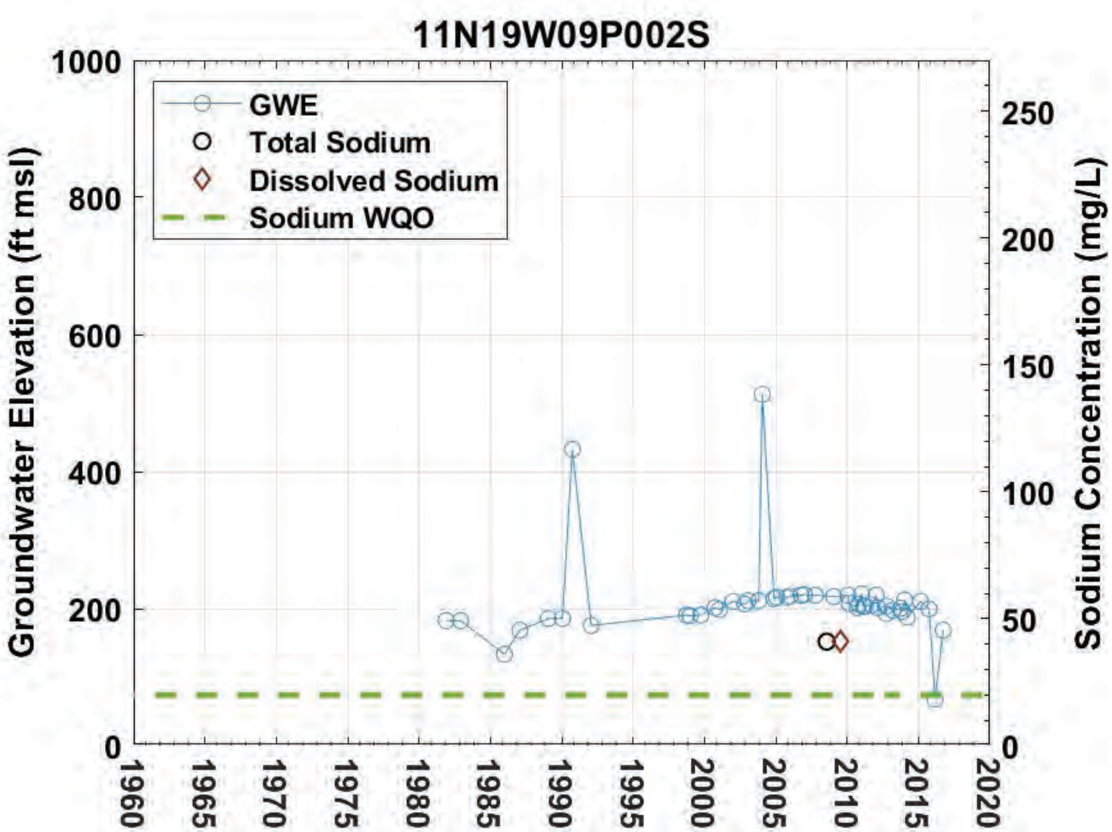


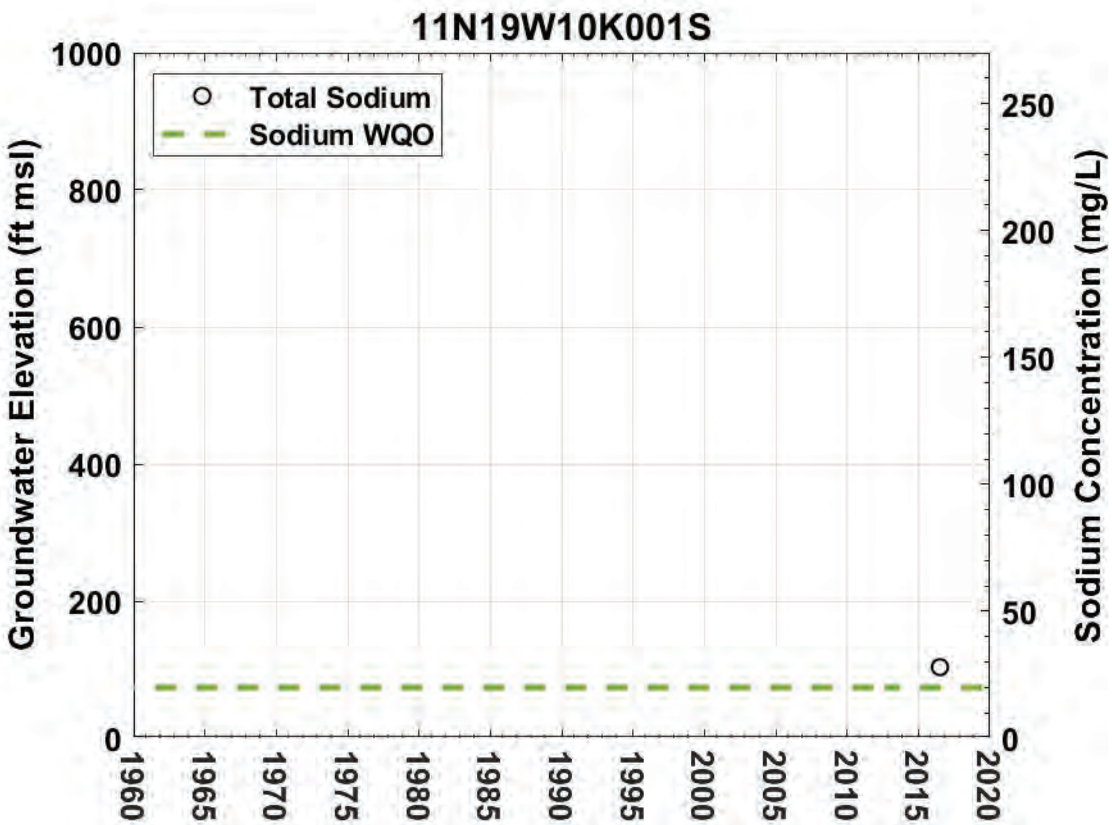
11N19W09F001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

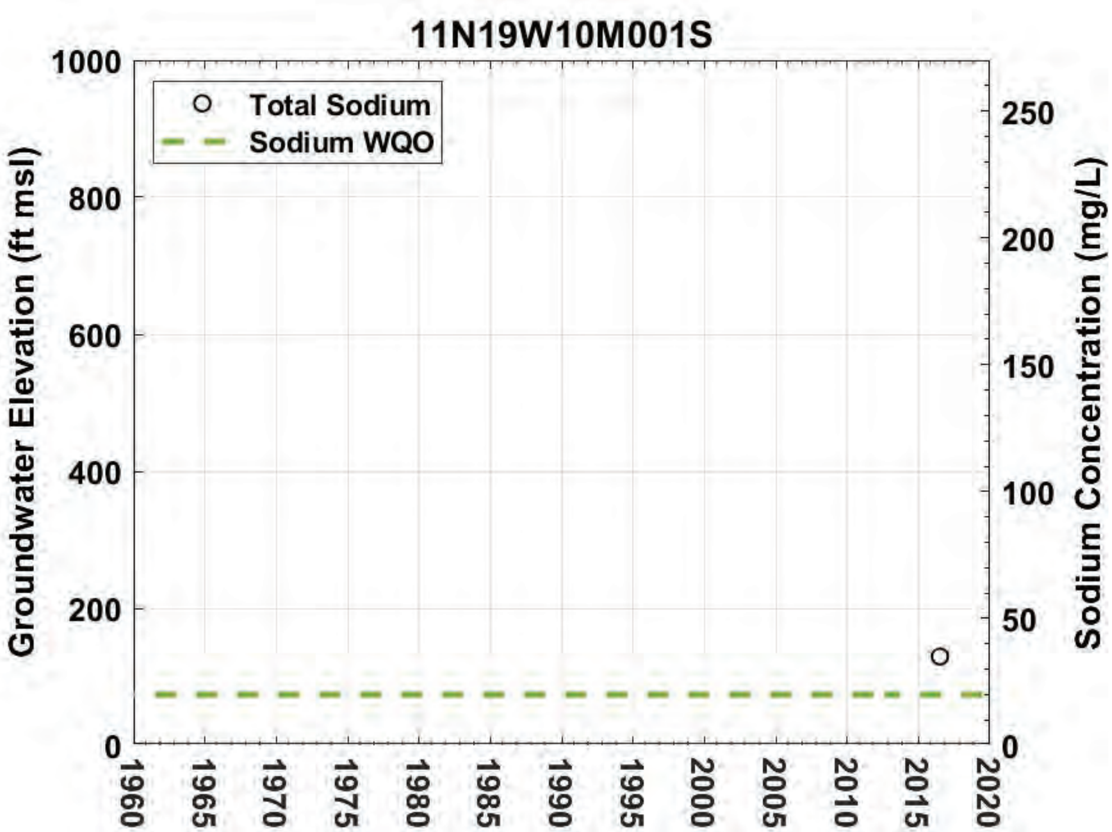

11N19W09F002S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

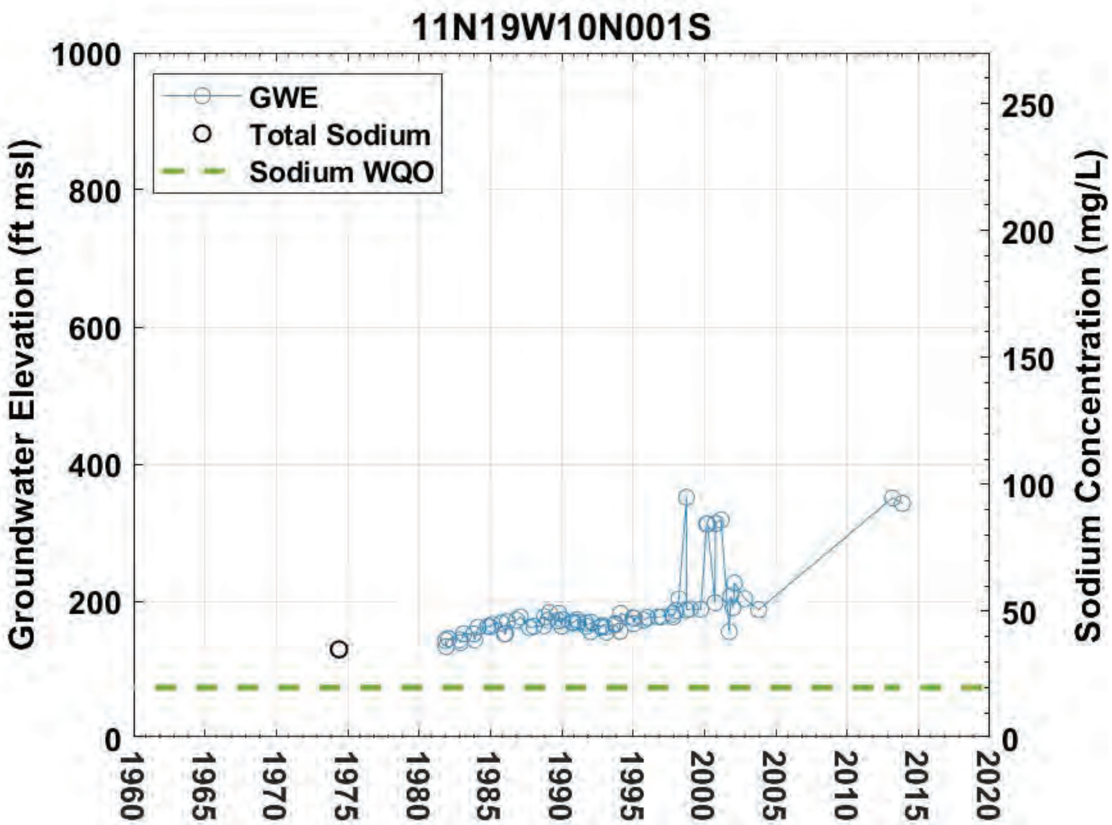

11N19W09L001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

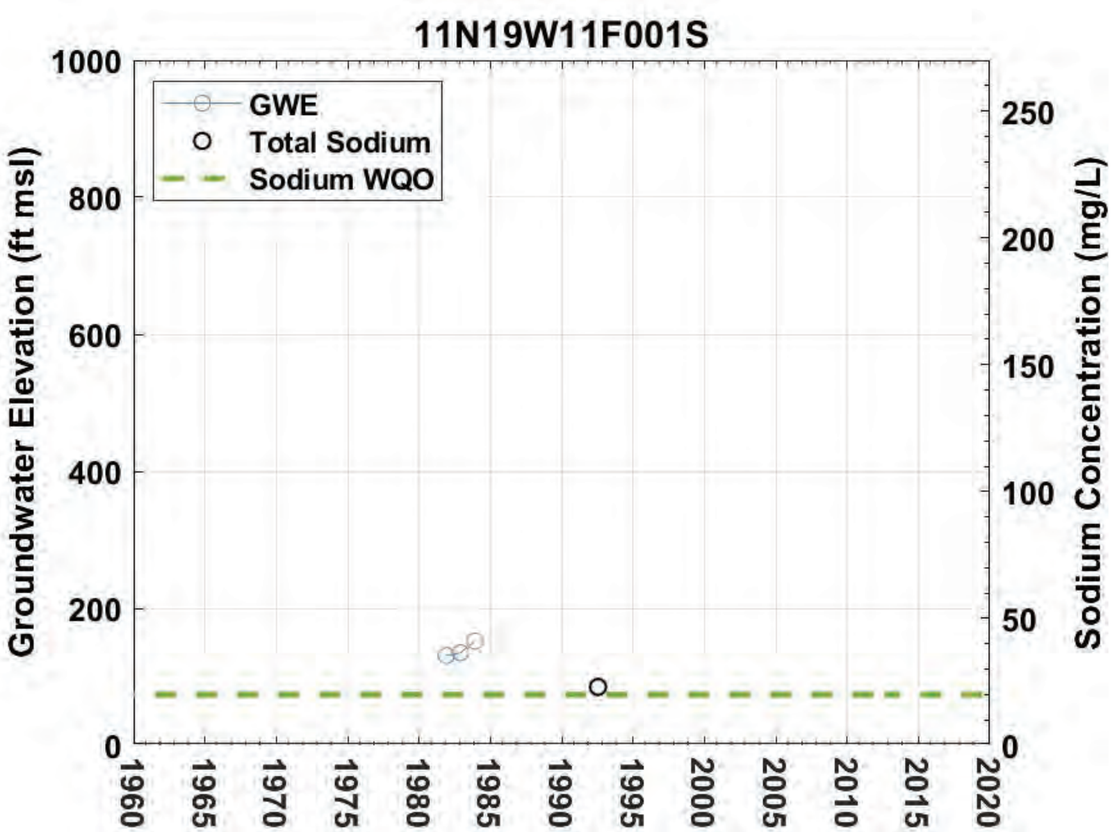

11N19W09P001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

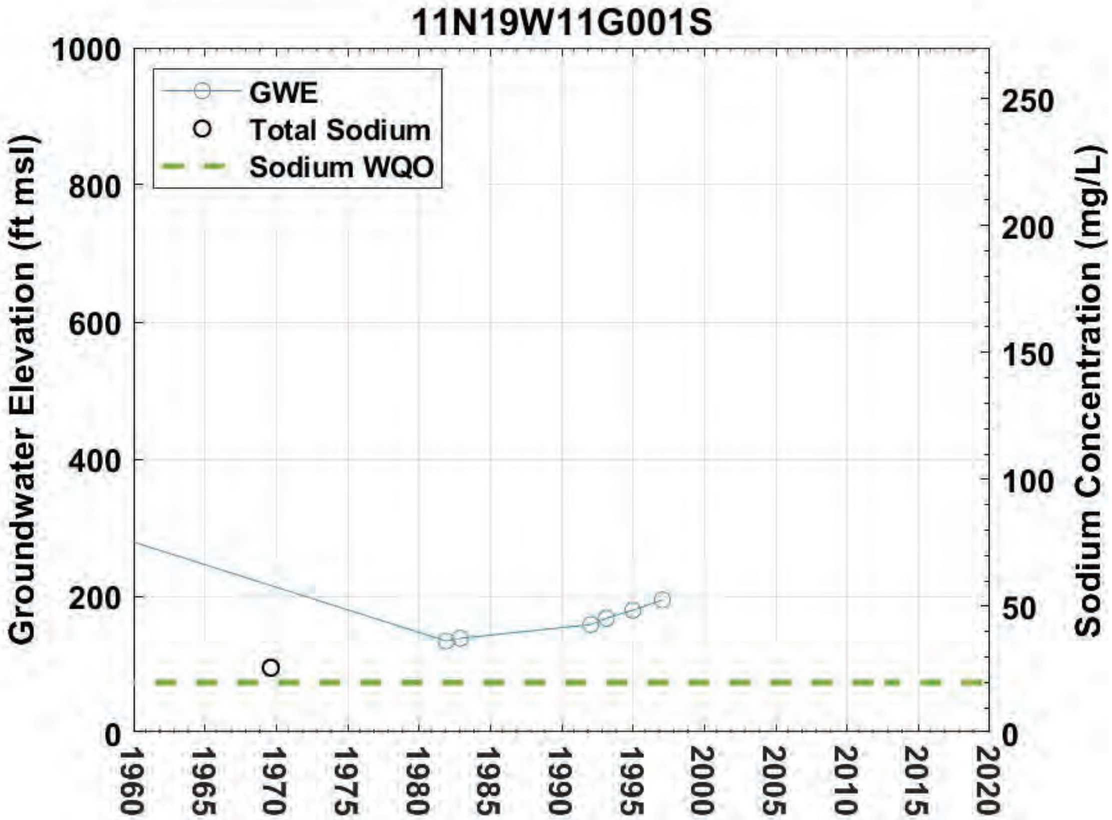

11N19W09P002S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

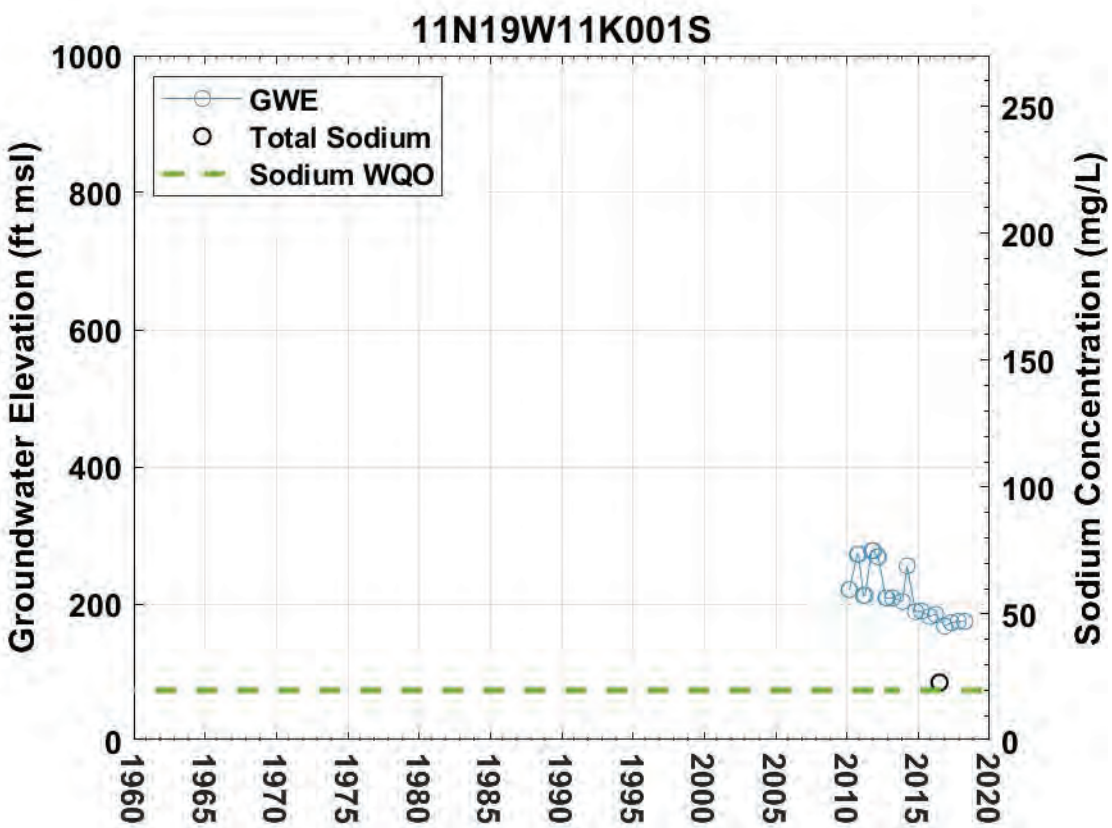

11N19W10K001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

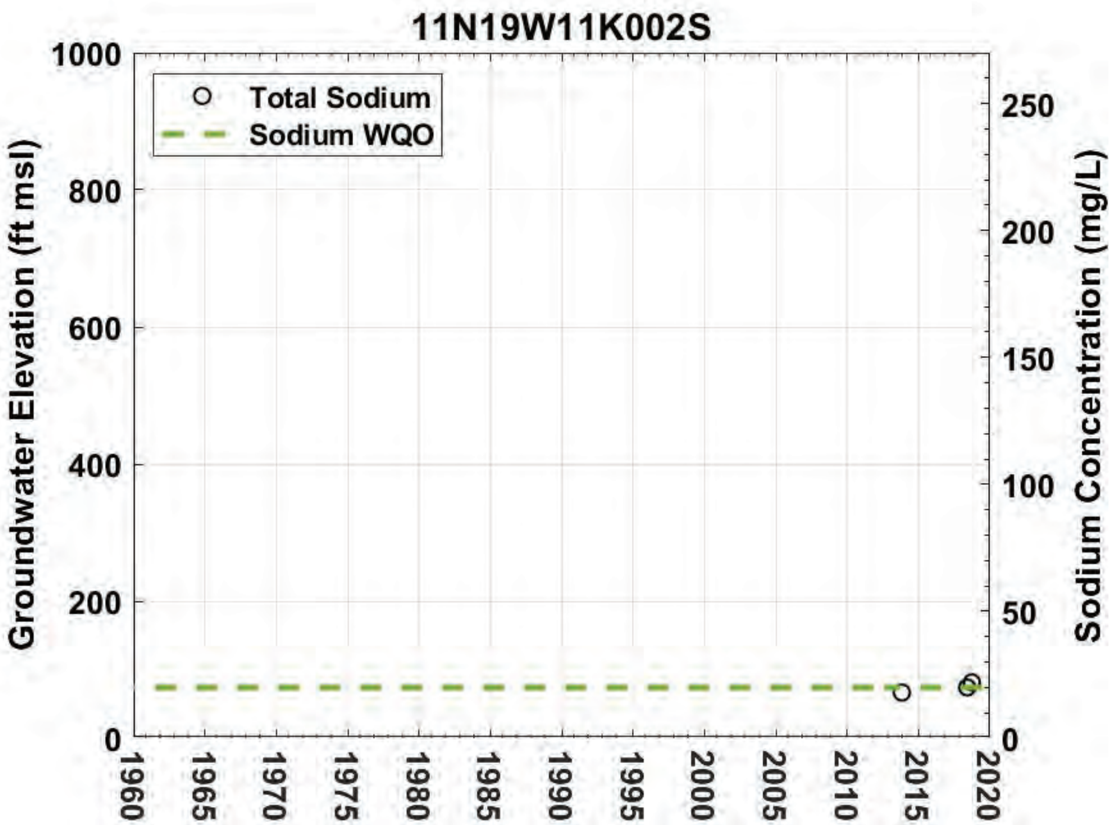

11N19W10M001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

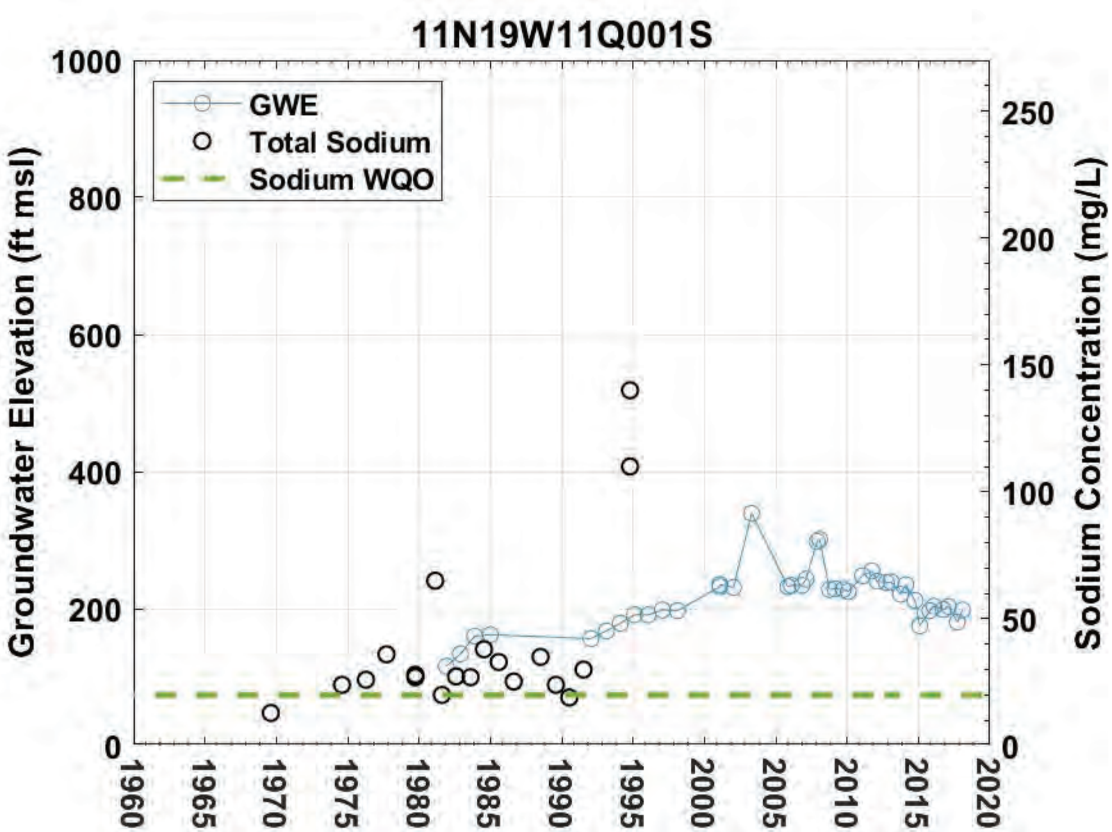

11N19W10N001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

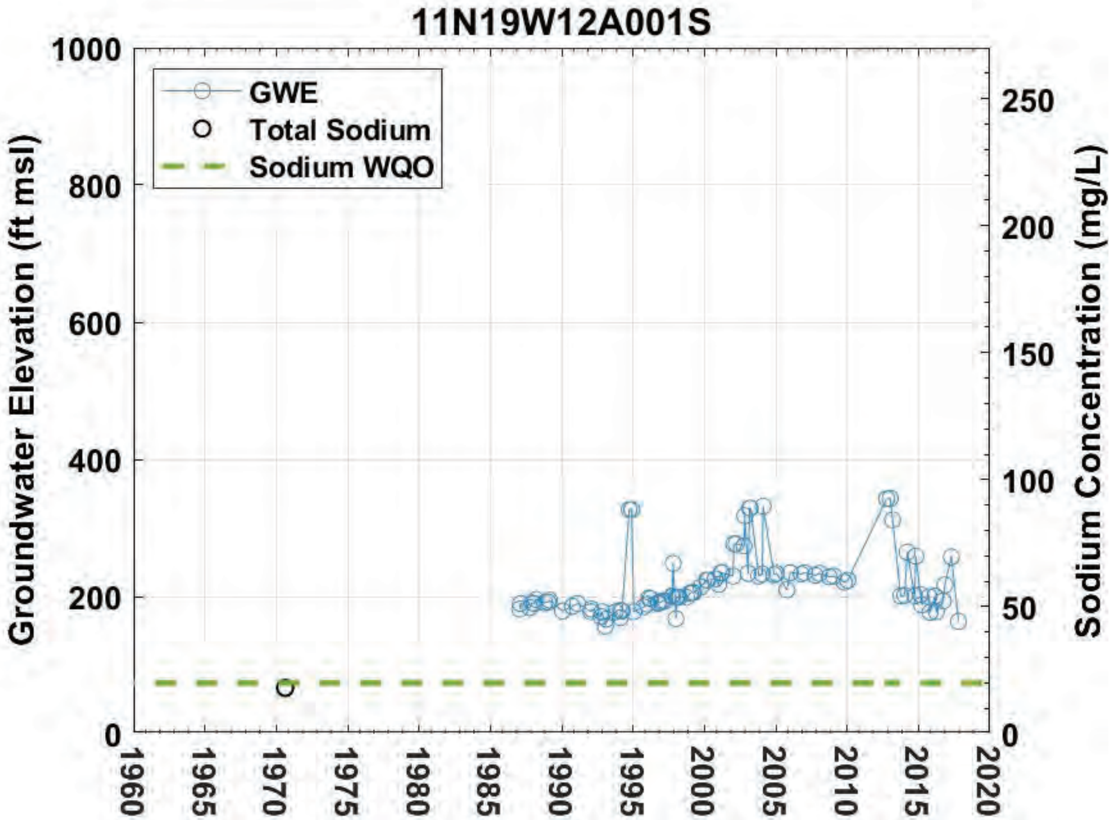

11N19W11F001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

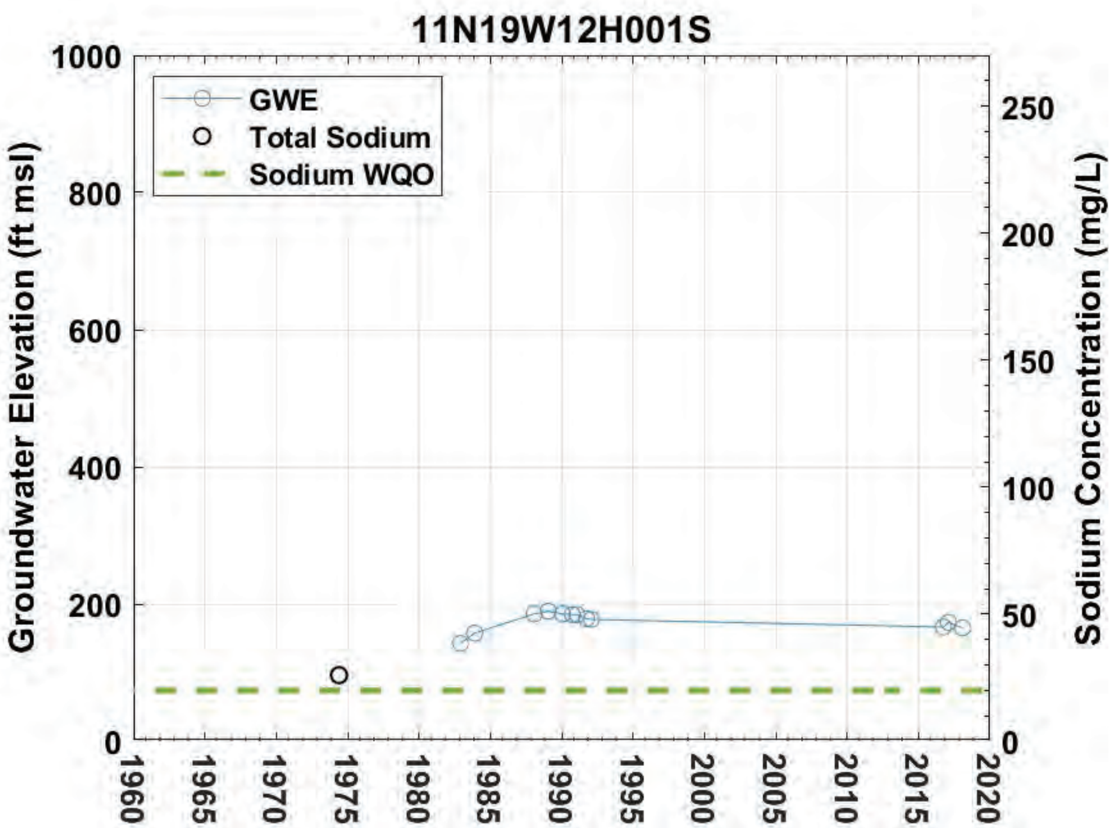

11N19W11G001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
GWE
Total Sodium
Sodium WQO
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

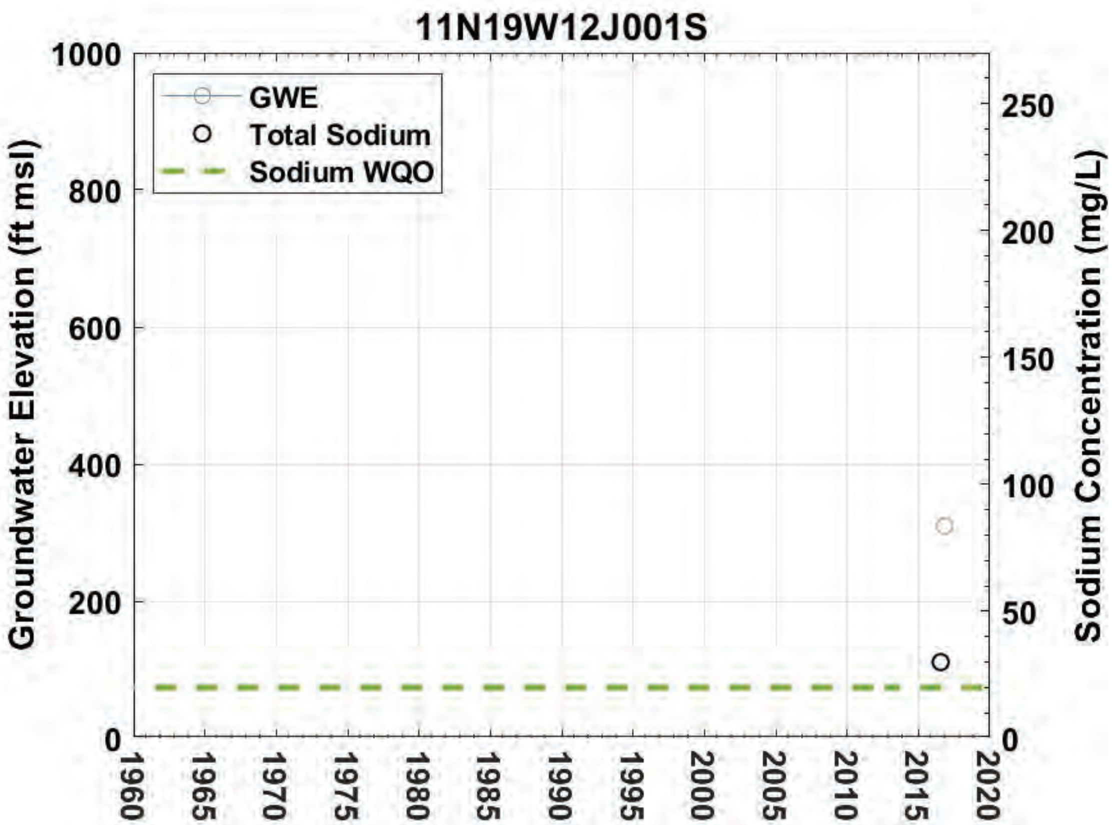

11N19W11K001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
GWE
Total Sodium
Sodium WQO
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

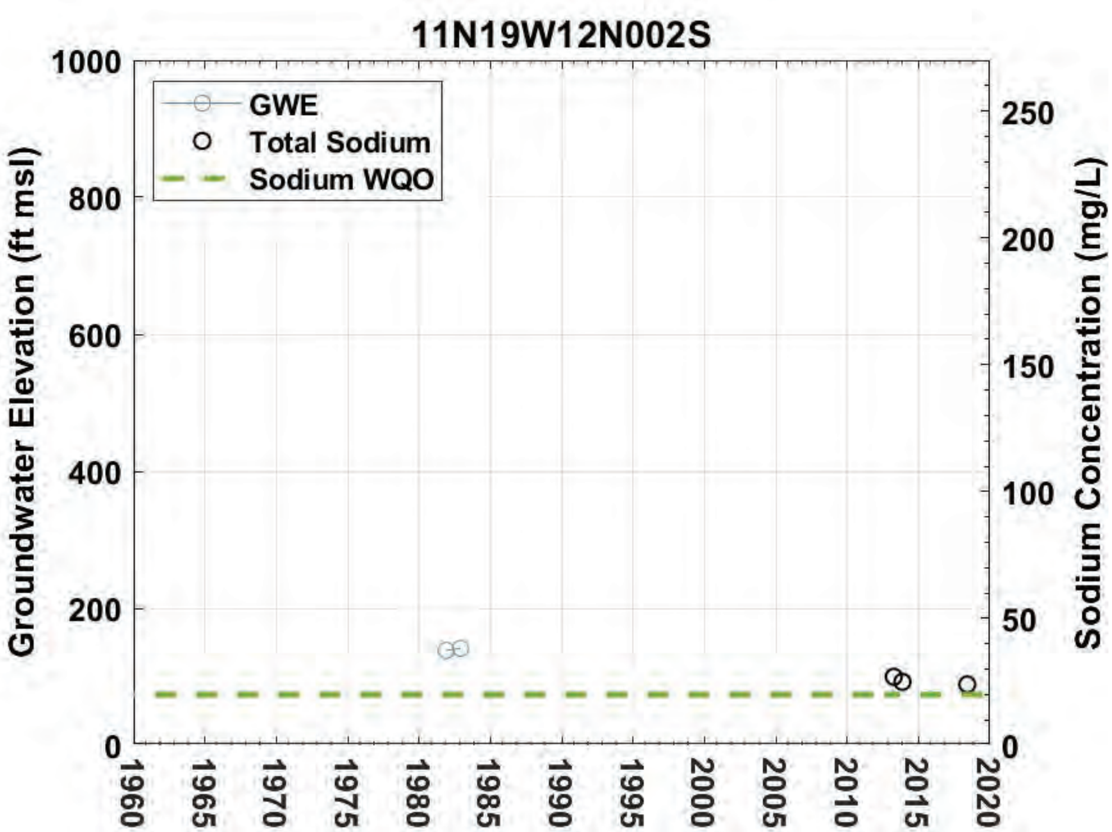

11N19W11K002S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

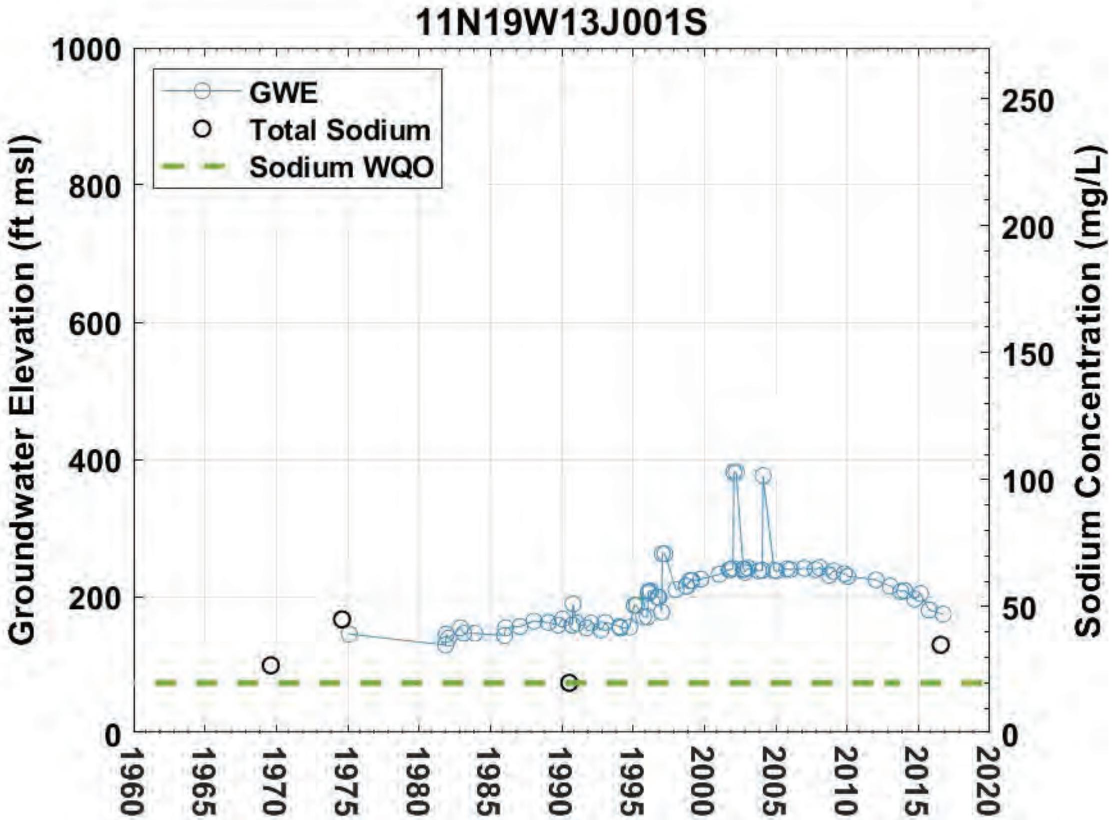

11N19W11Q001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

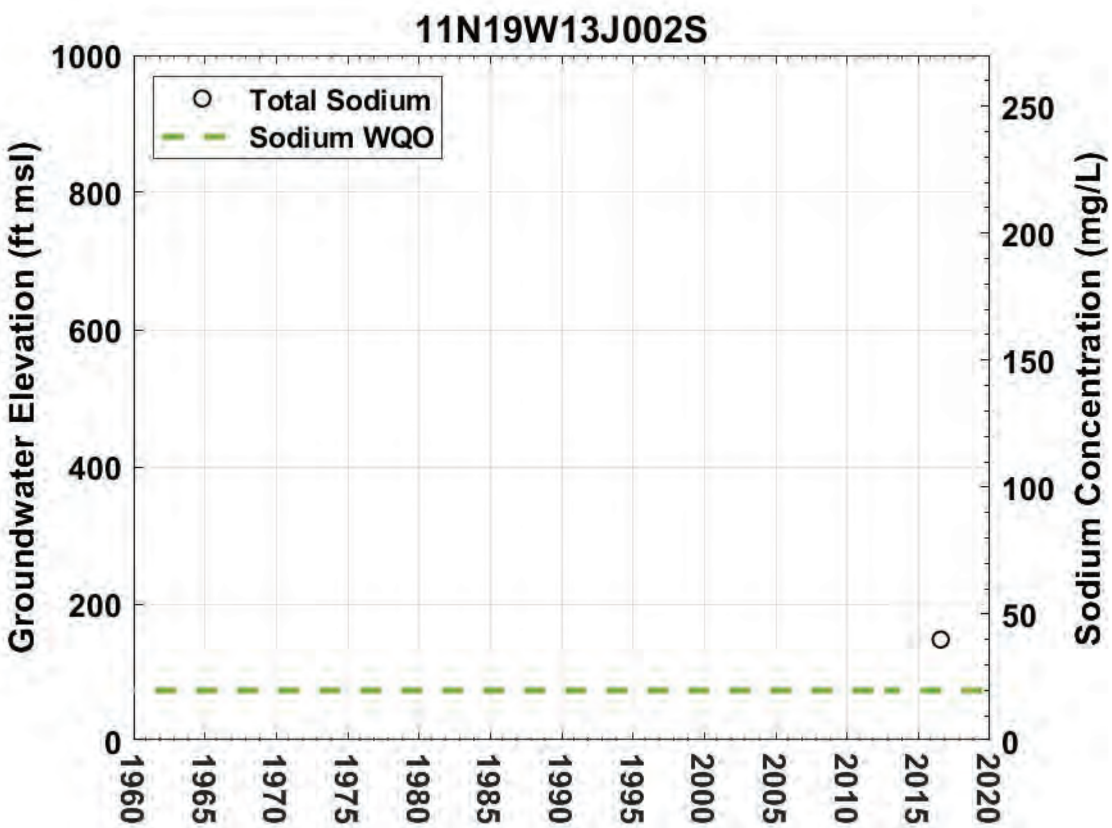

11N19W12A001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

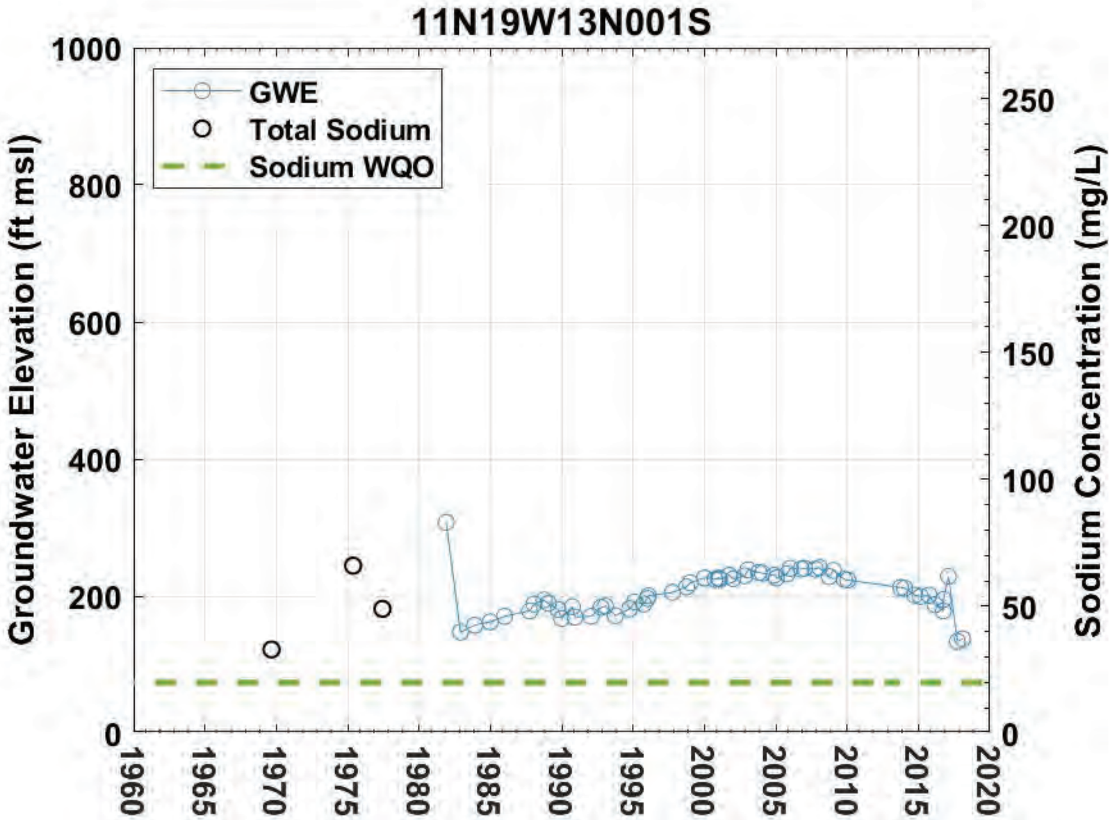

11N19W12H001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

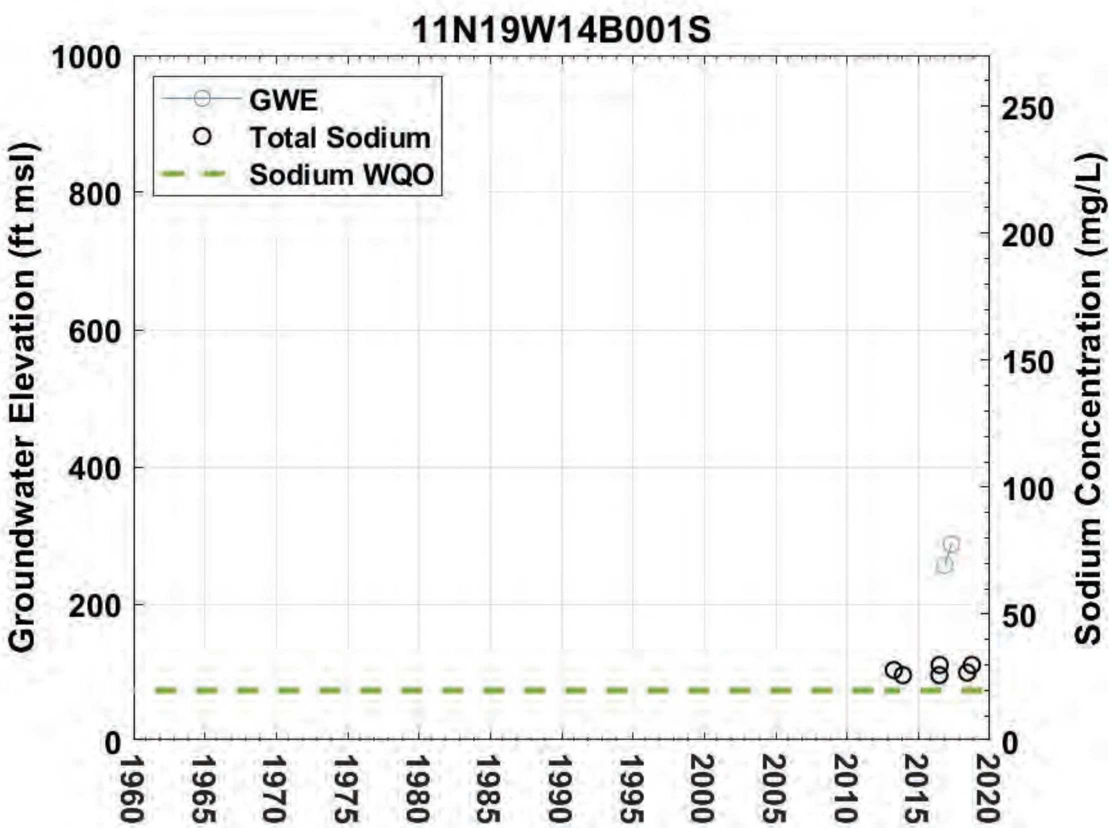

11N19W12J001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

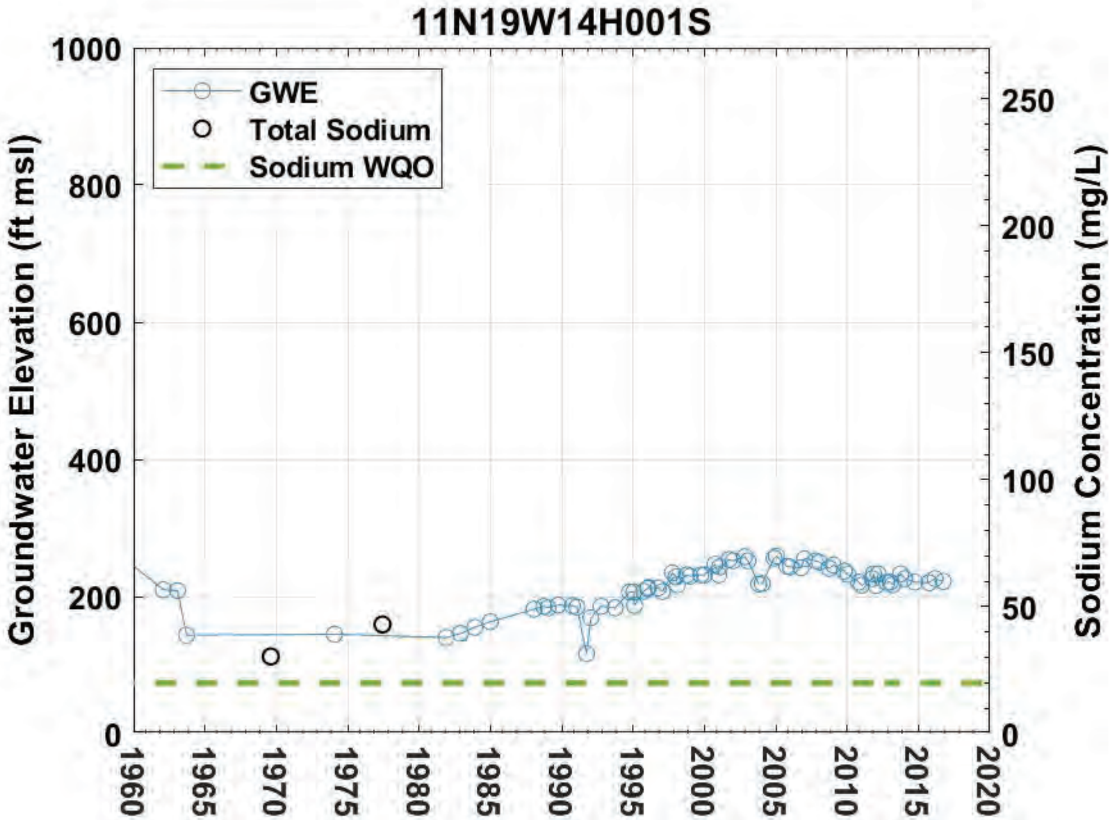

11N19W12N002S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

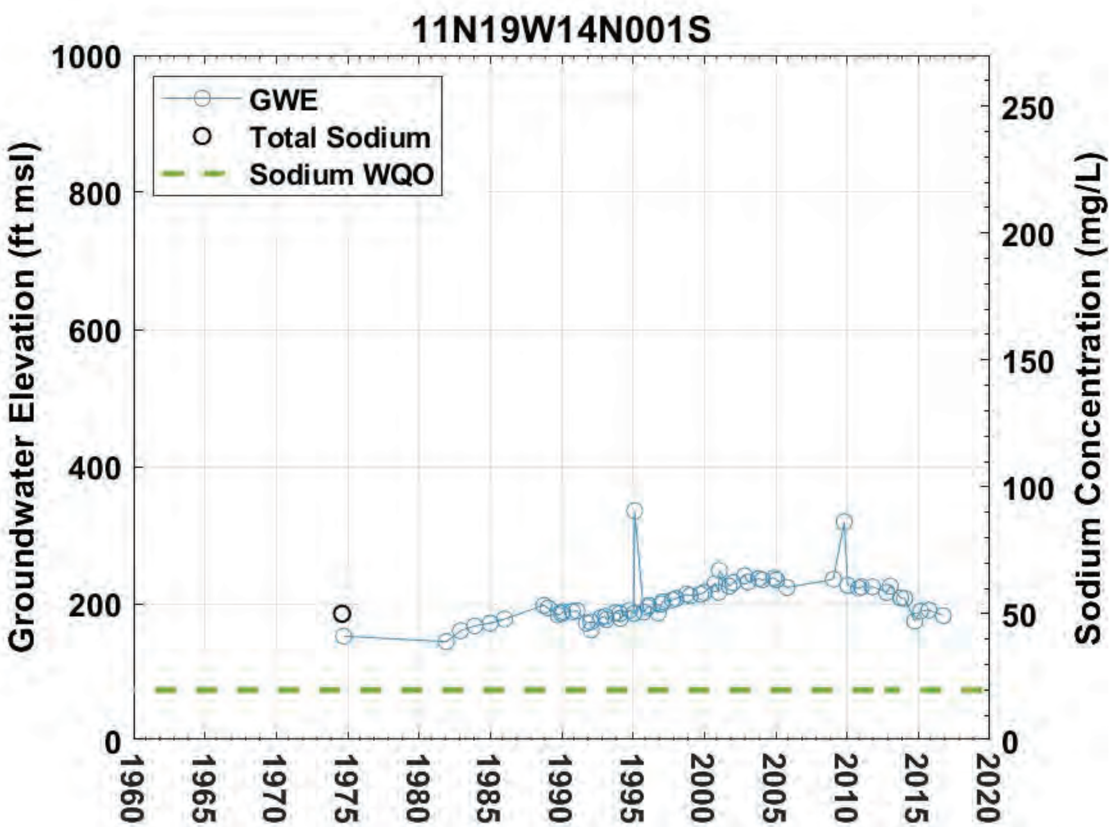

11N19W13J001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

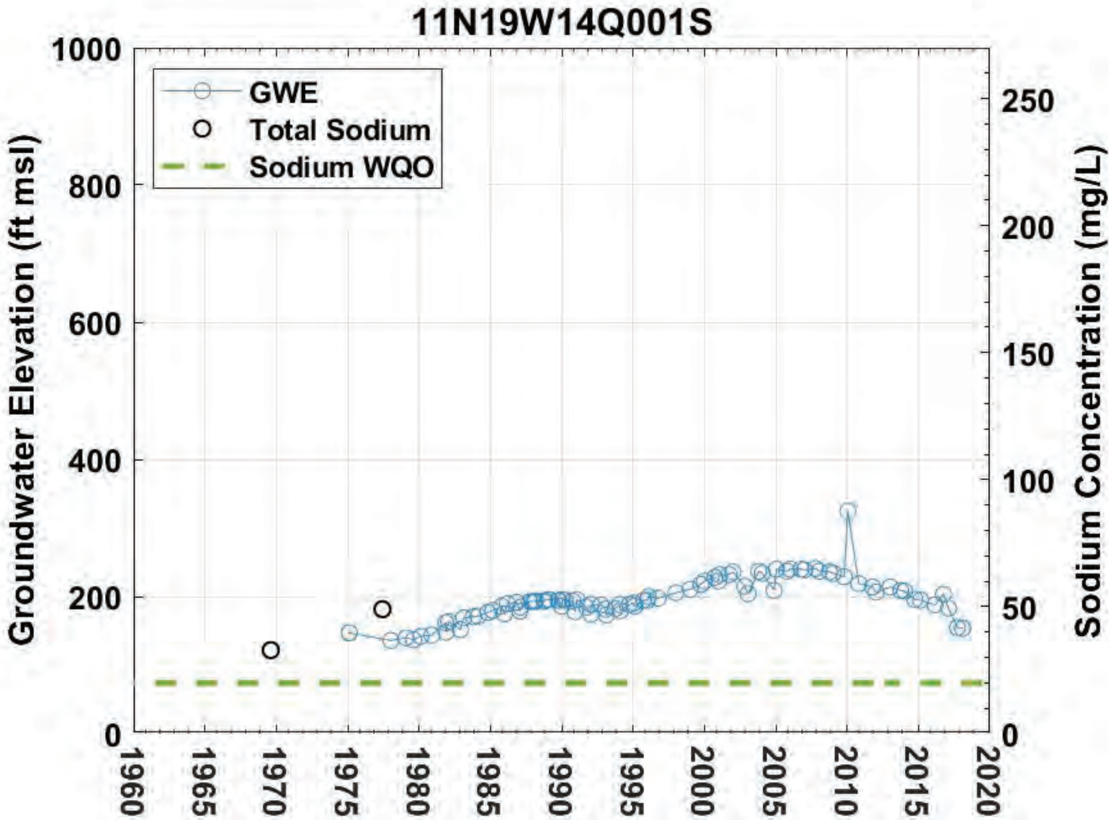

11N19W13J002S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

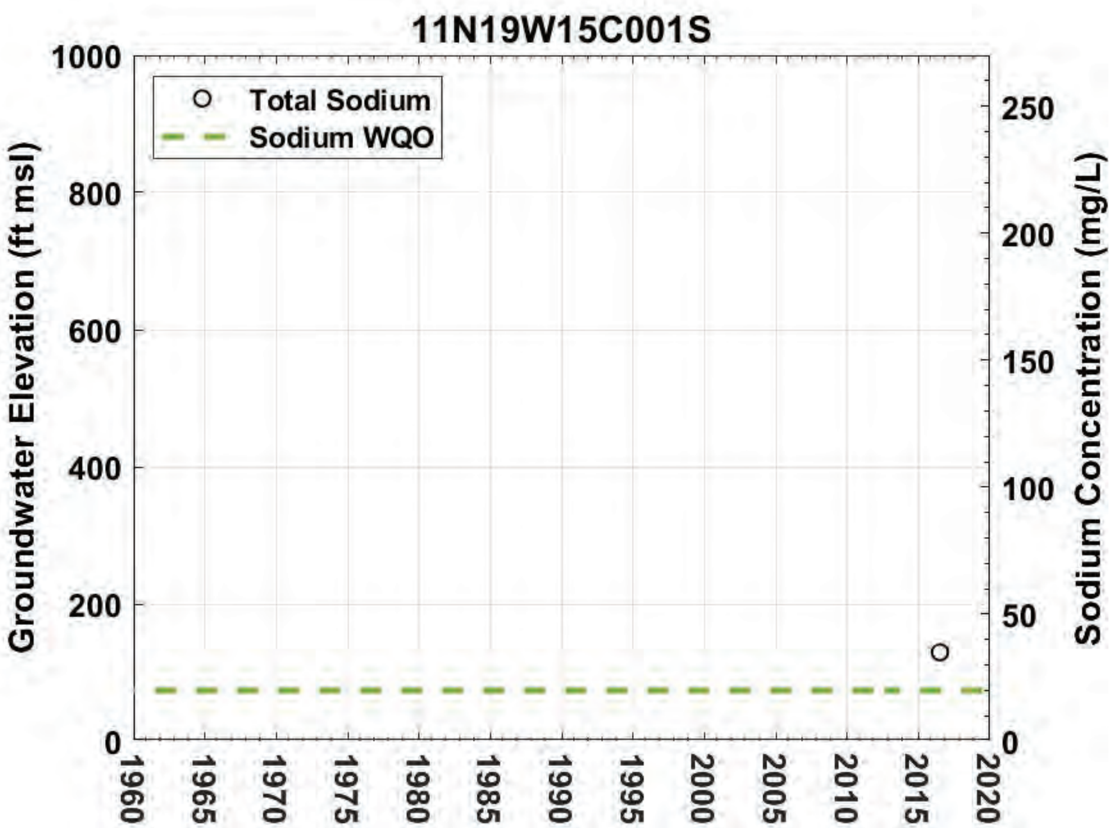

11N19W13N001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

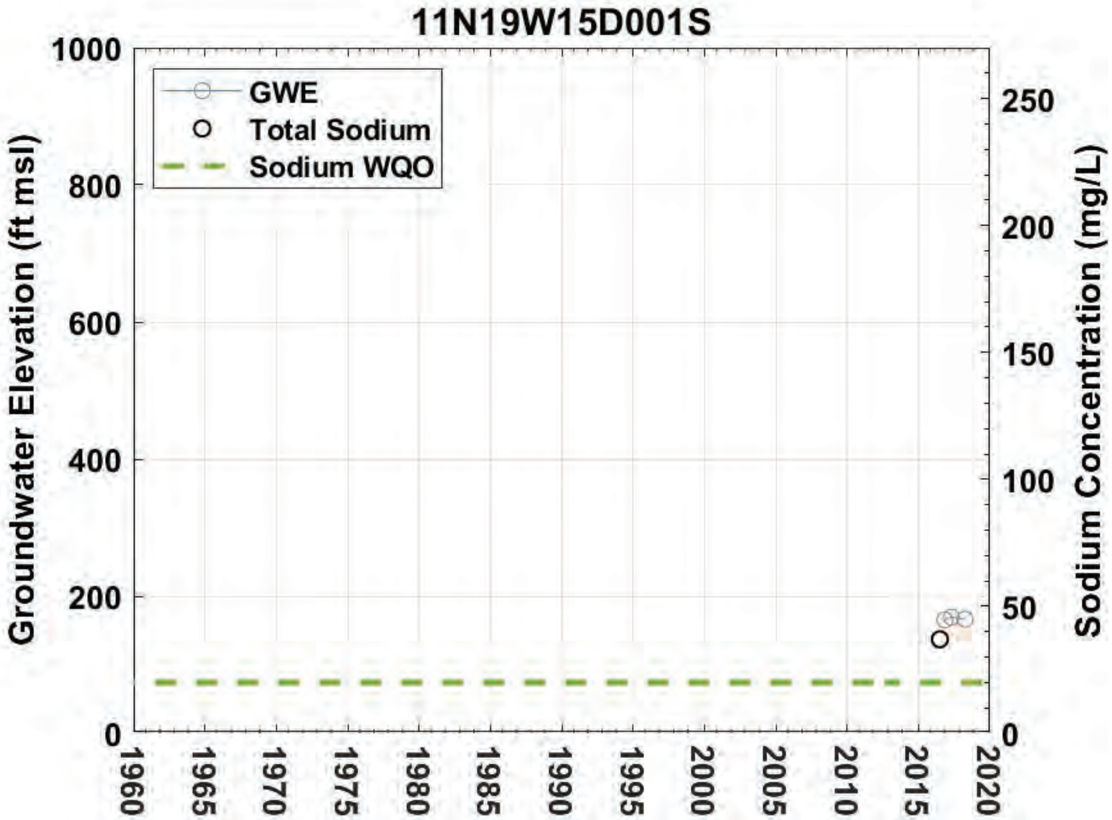

11N19W14B001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

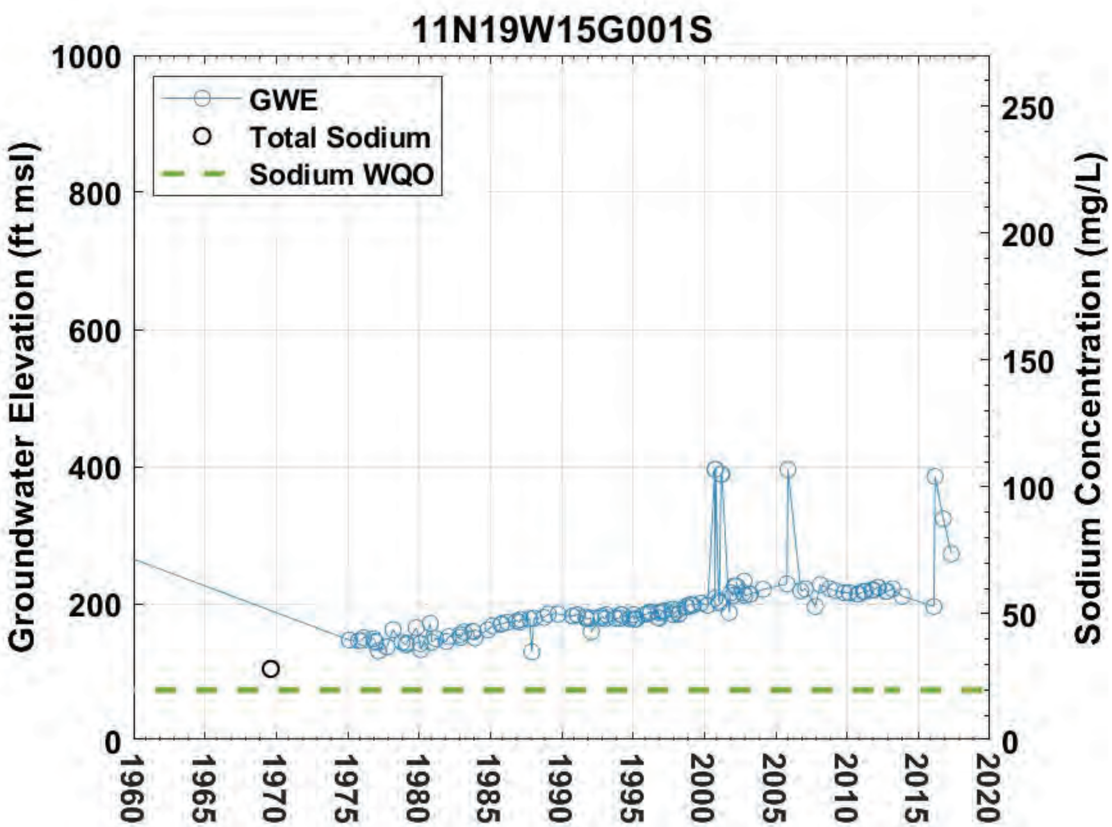

11N19W14H001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

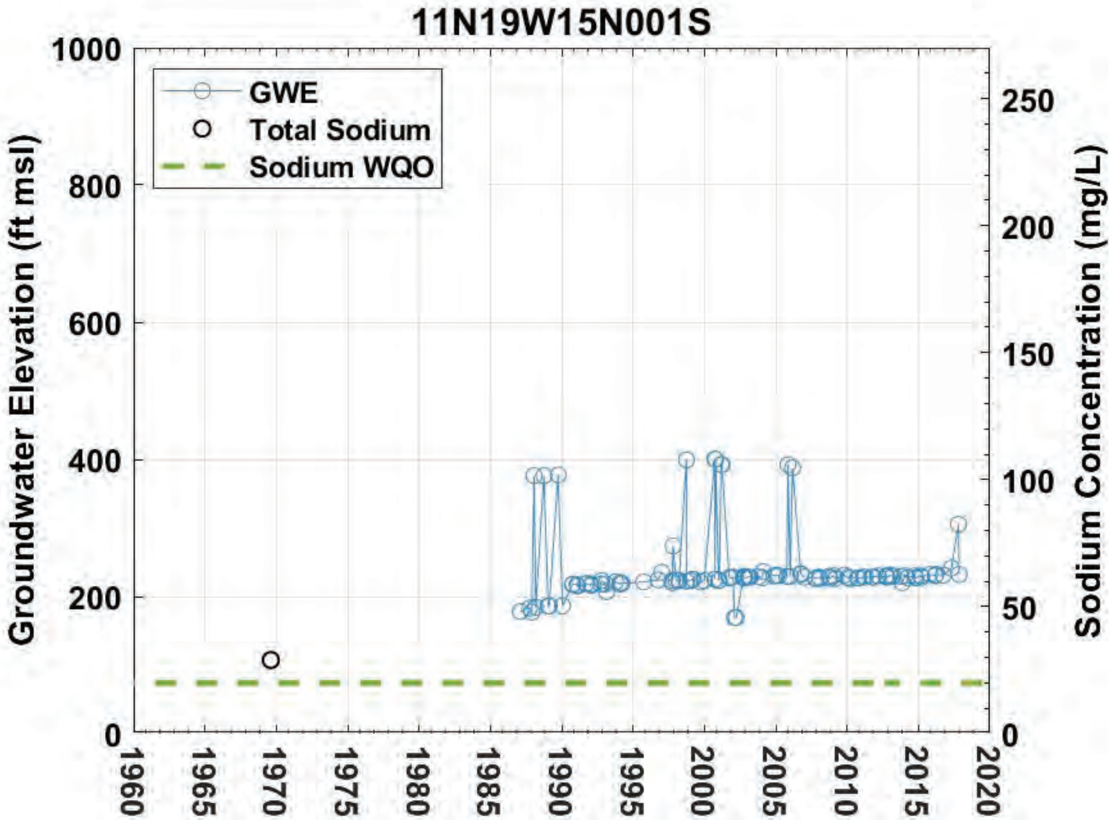

11N19W14N001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

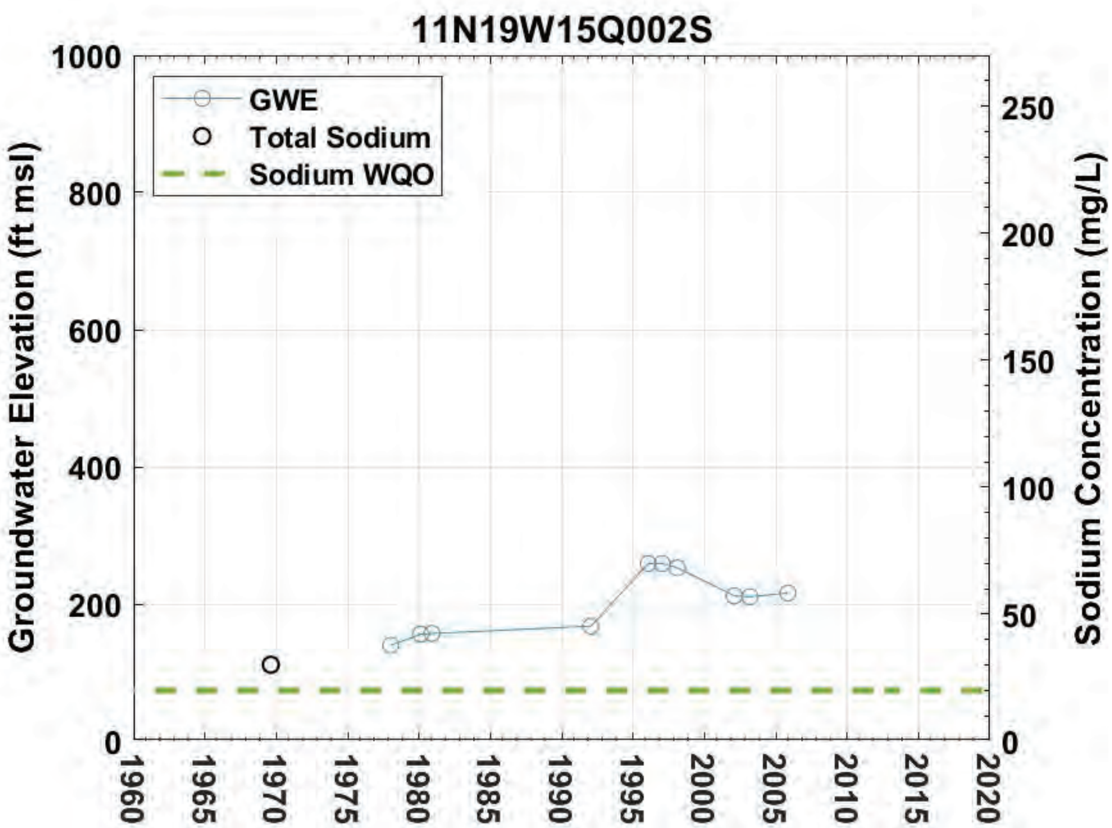

11N19W14Q001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

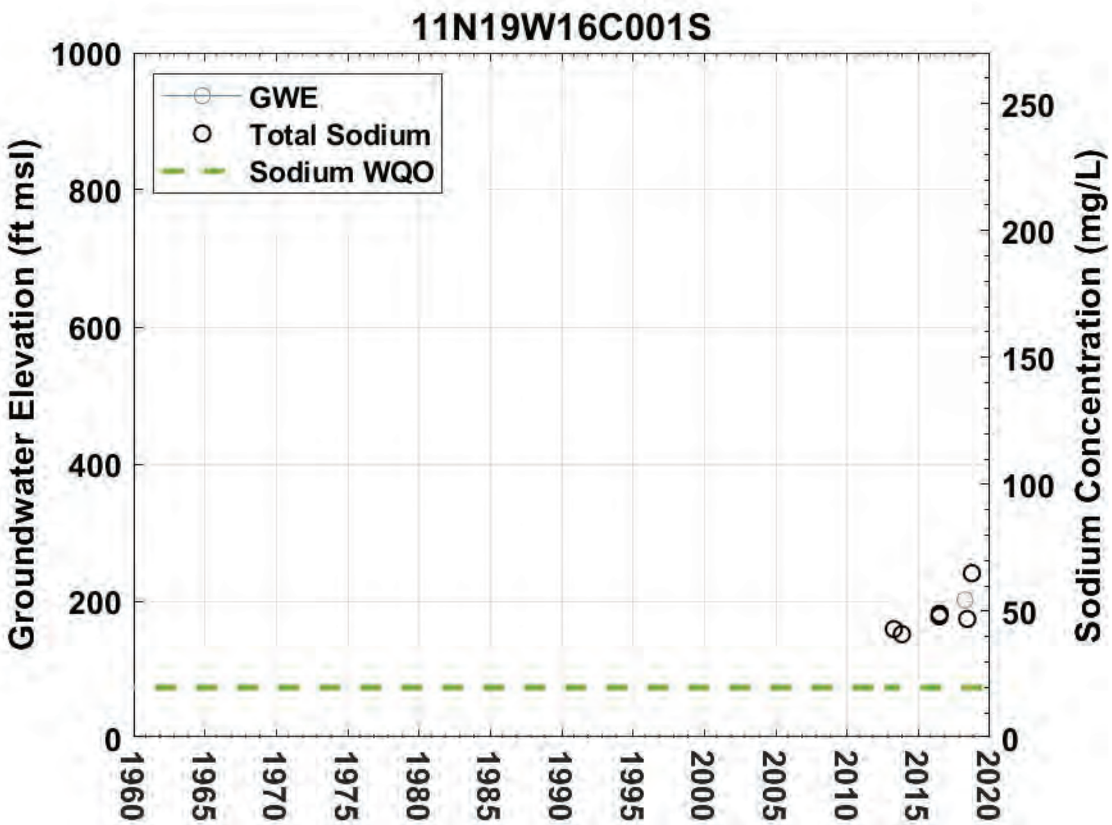

11N19W15C001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

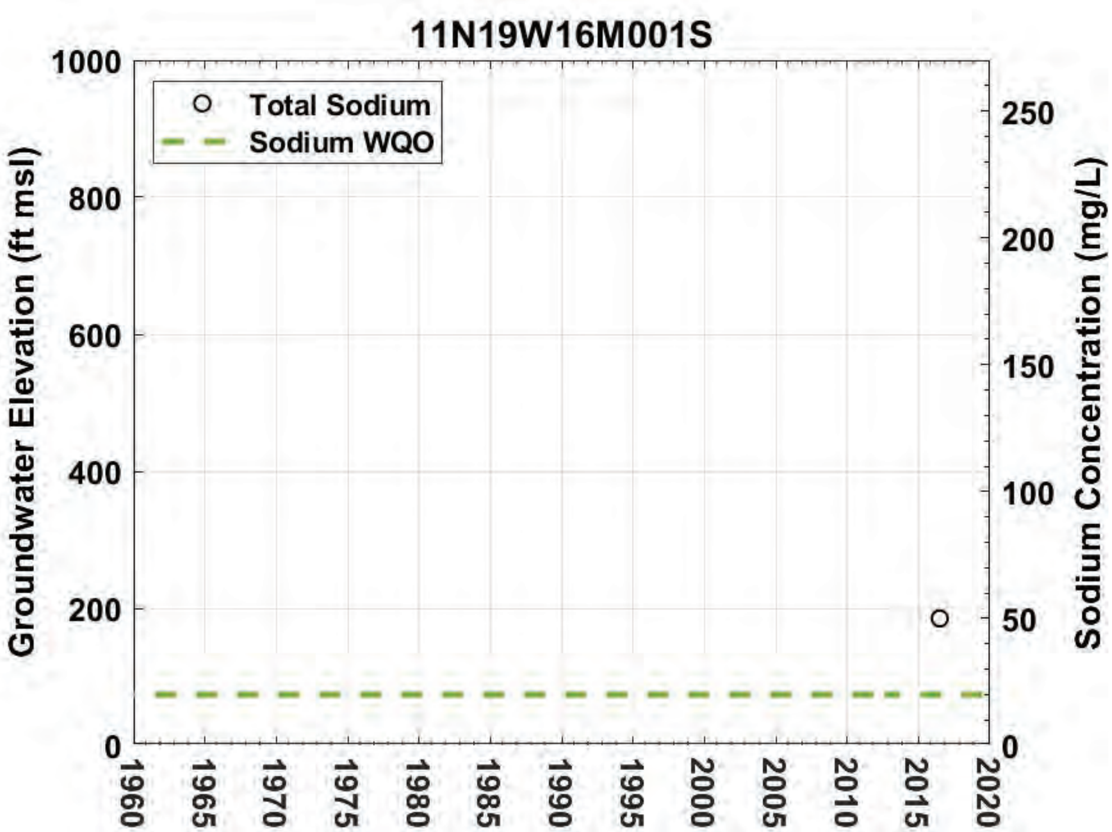

11N19W15D001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

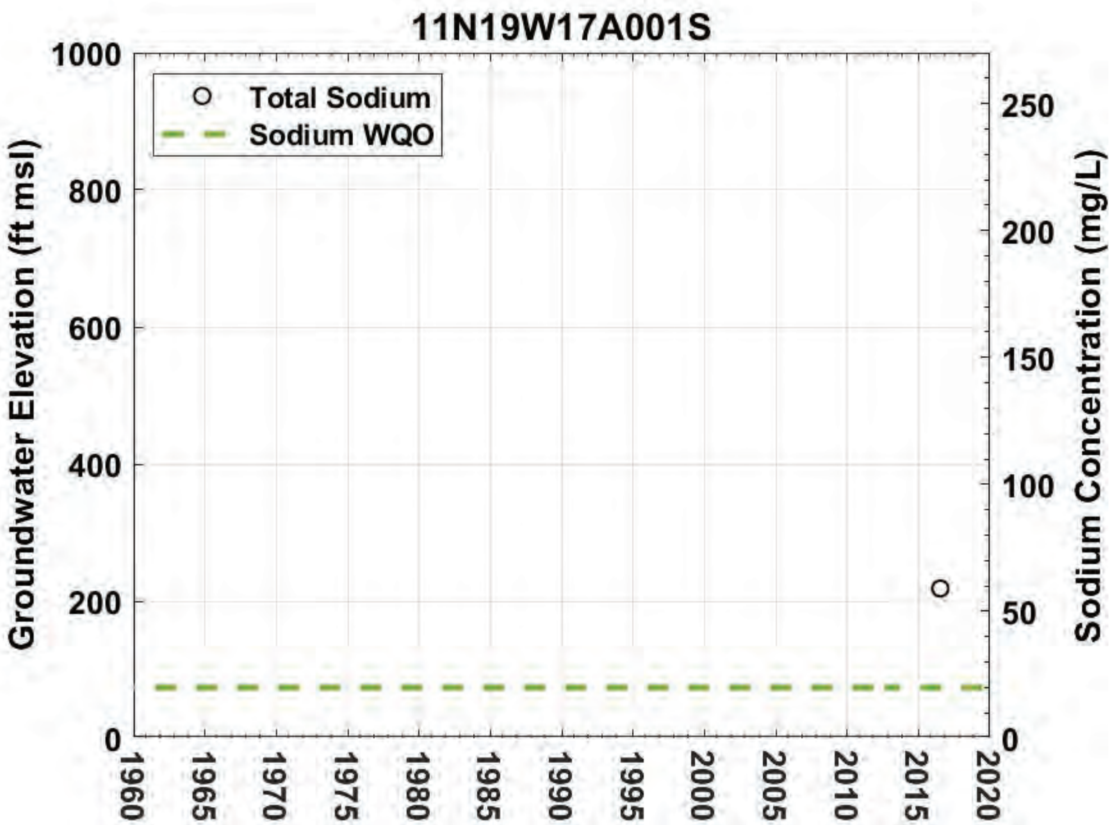

11N19W15G001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

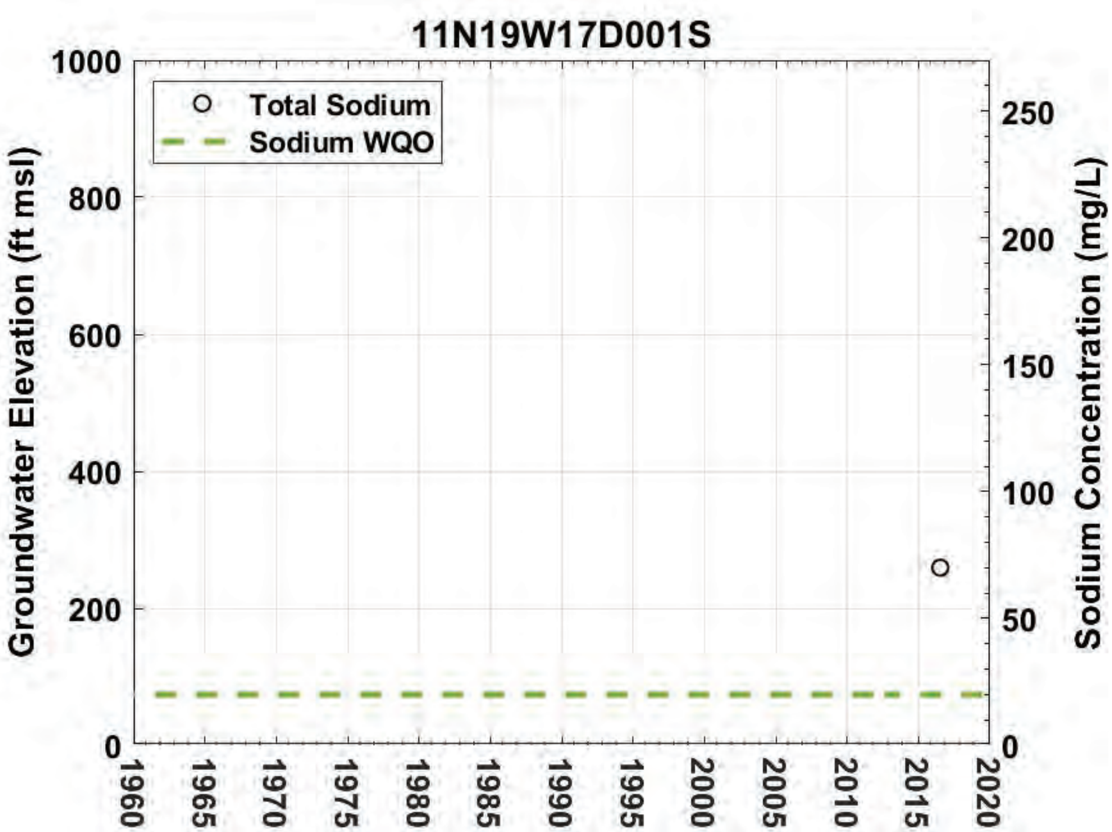

11N19W15N001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

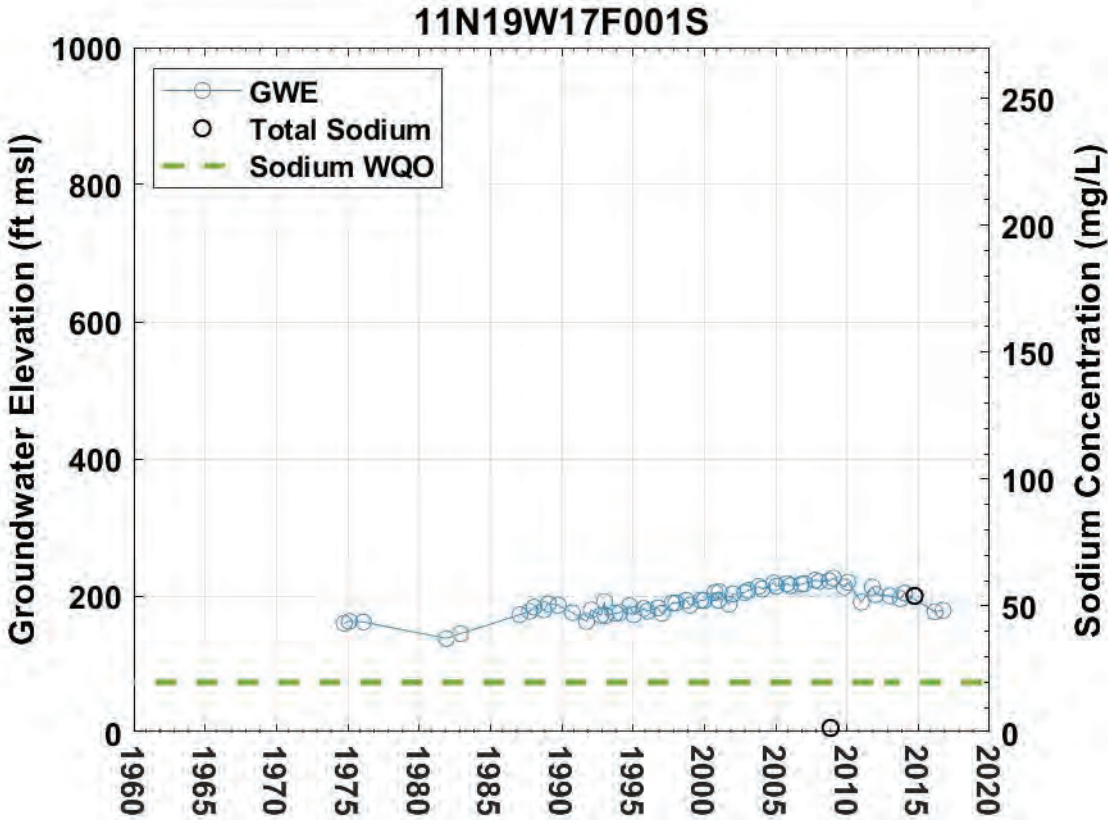

11N19W15Q002S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

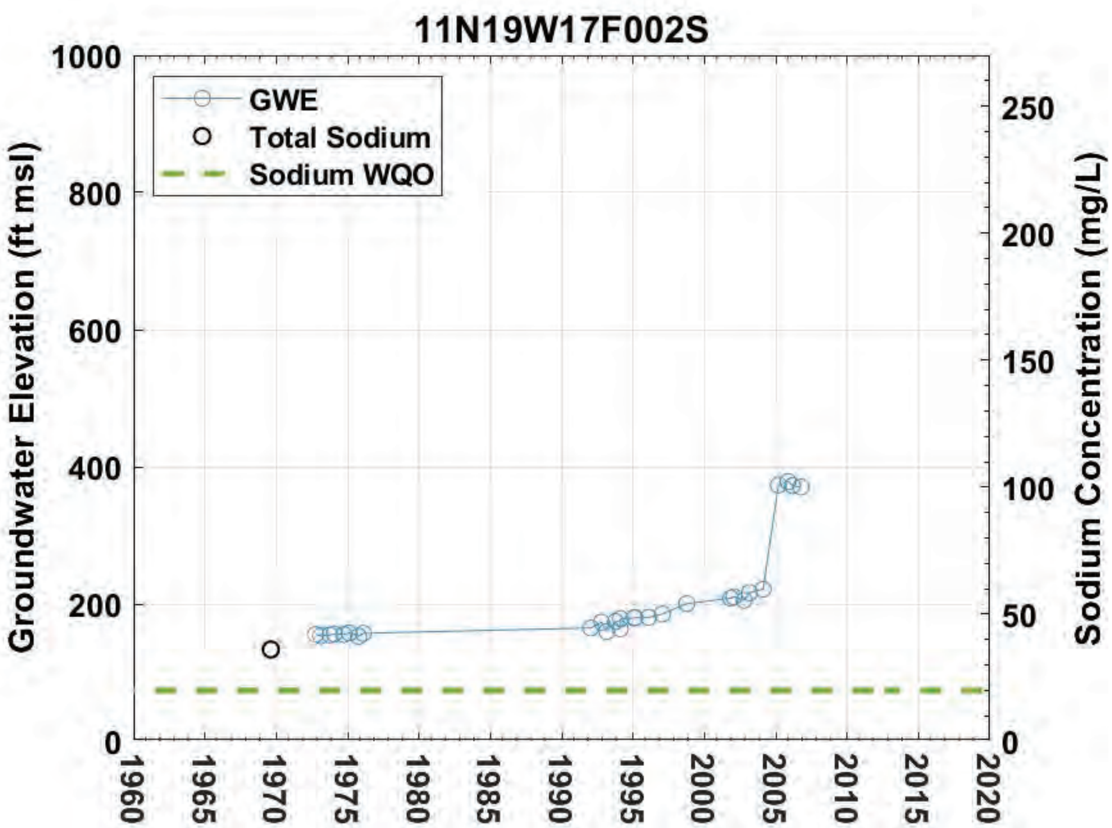

11N19W16C001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

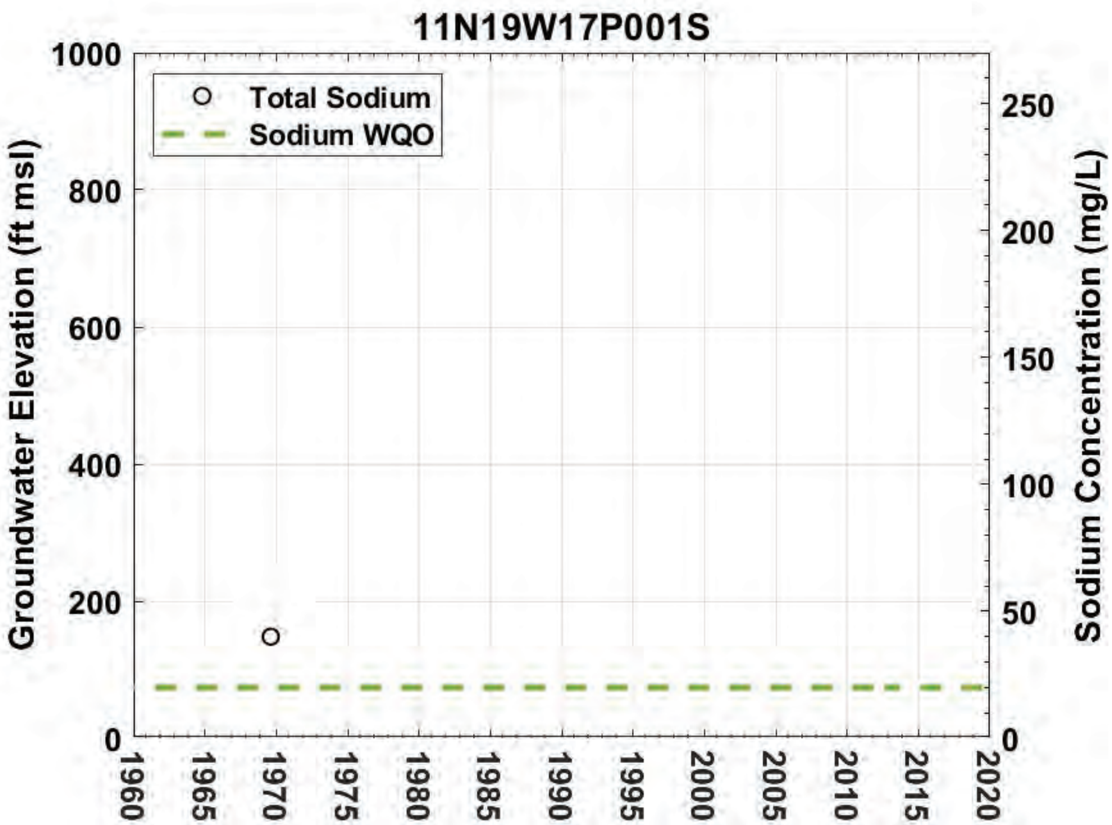

11N19W16M001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

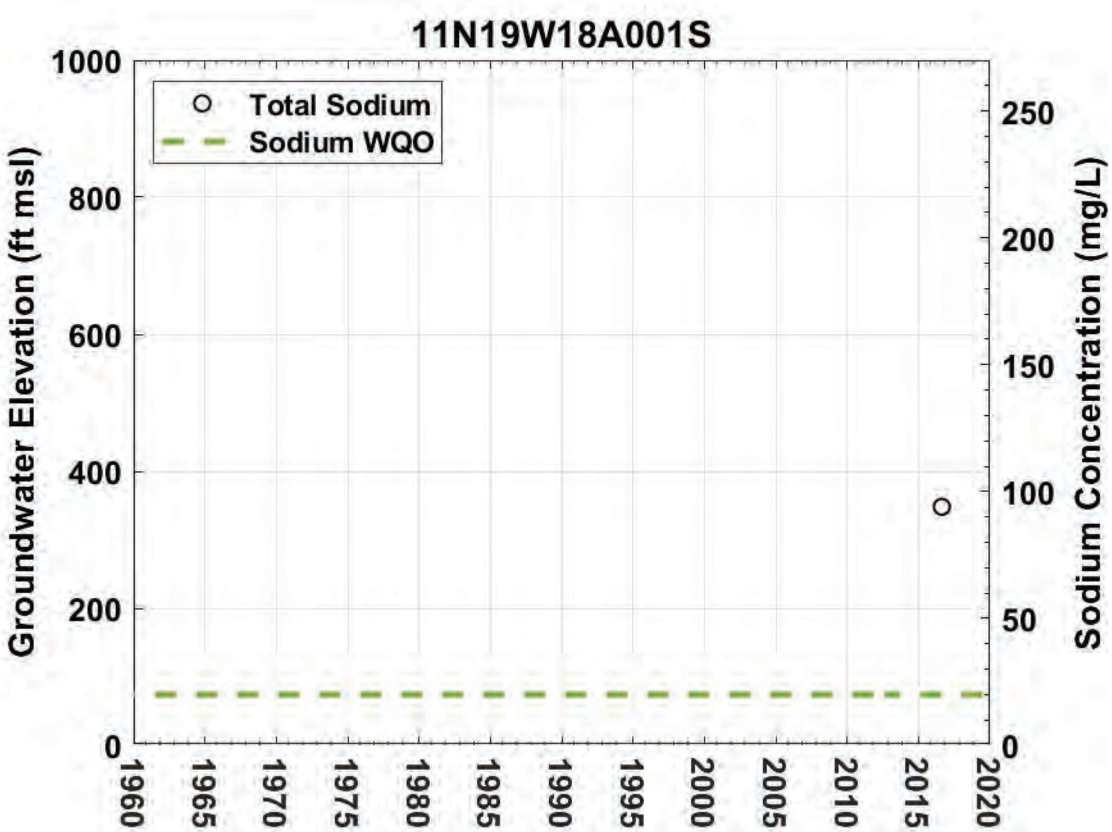

11N19W17A001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

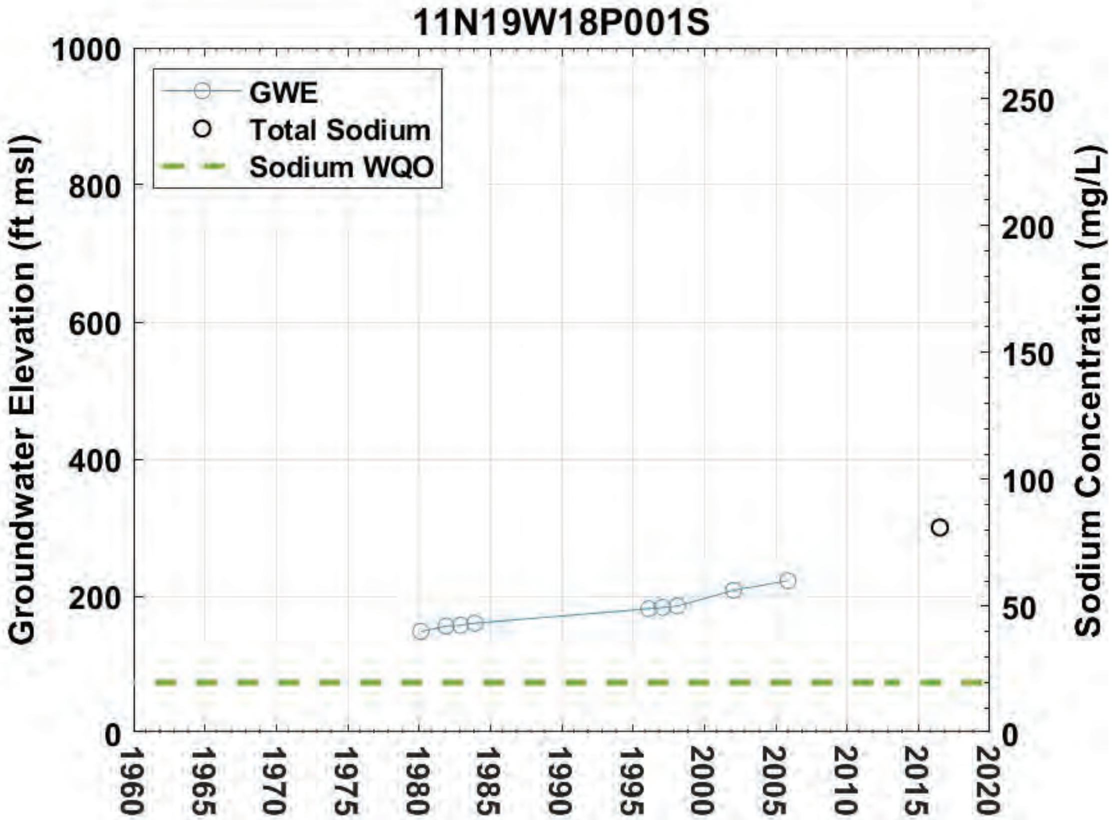

11N19W17D001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W17F001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

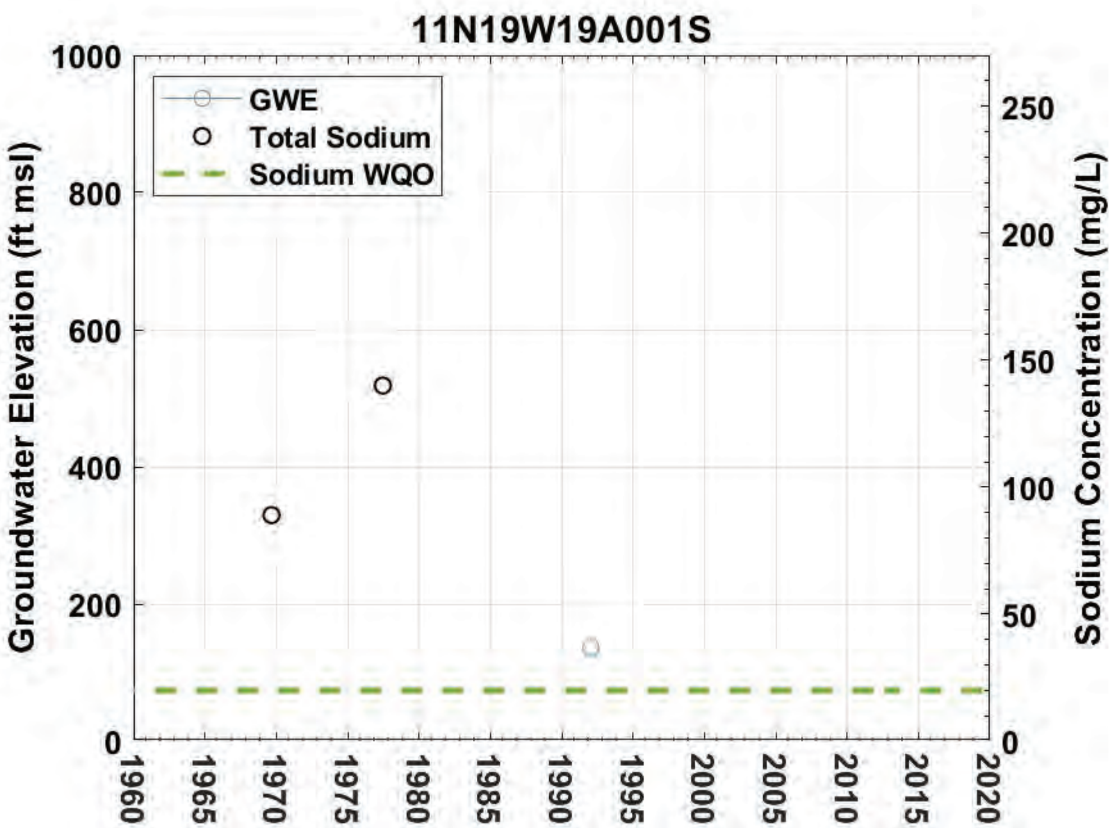

11N19W17F002S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W17P001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

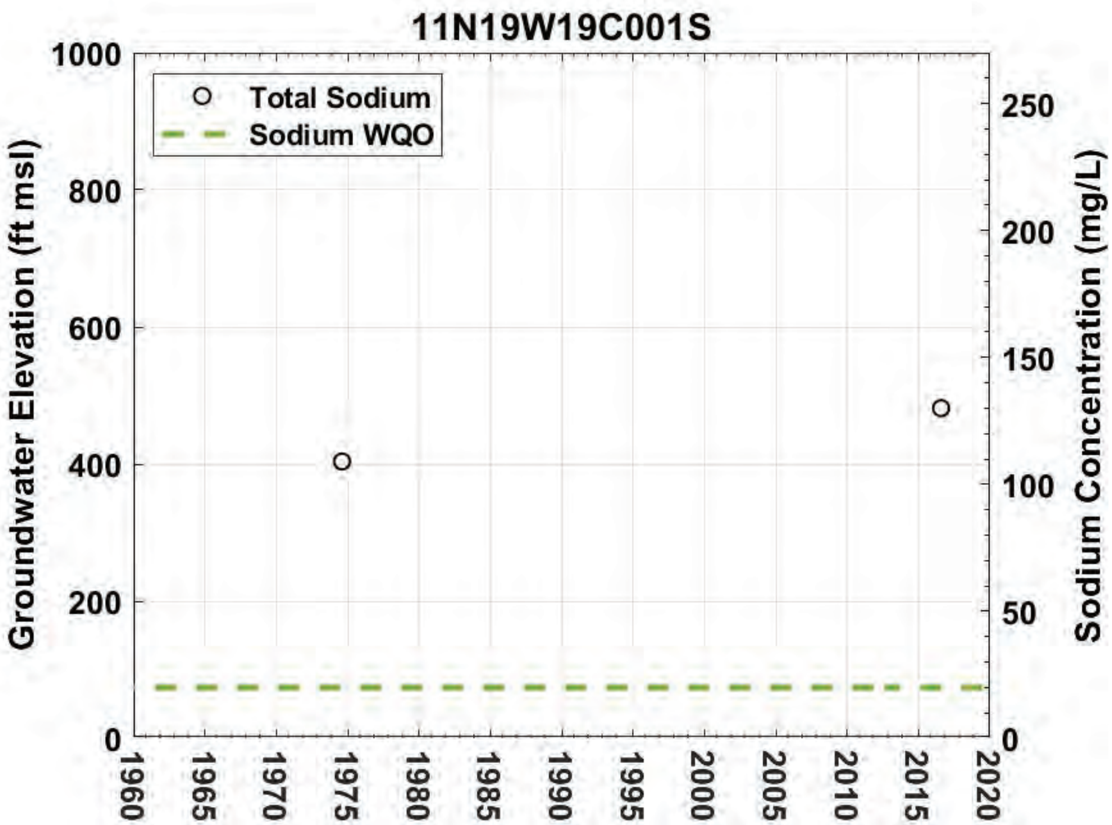

11N19W18A001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

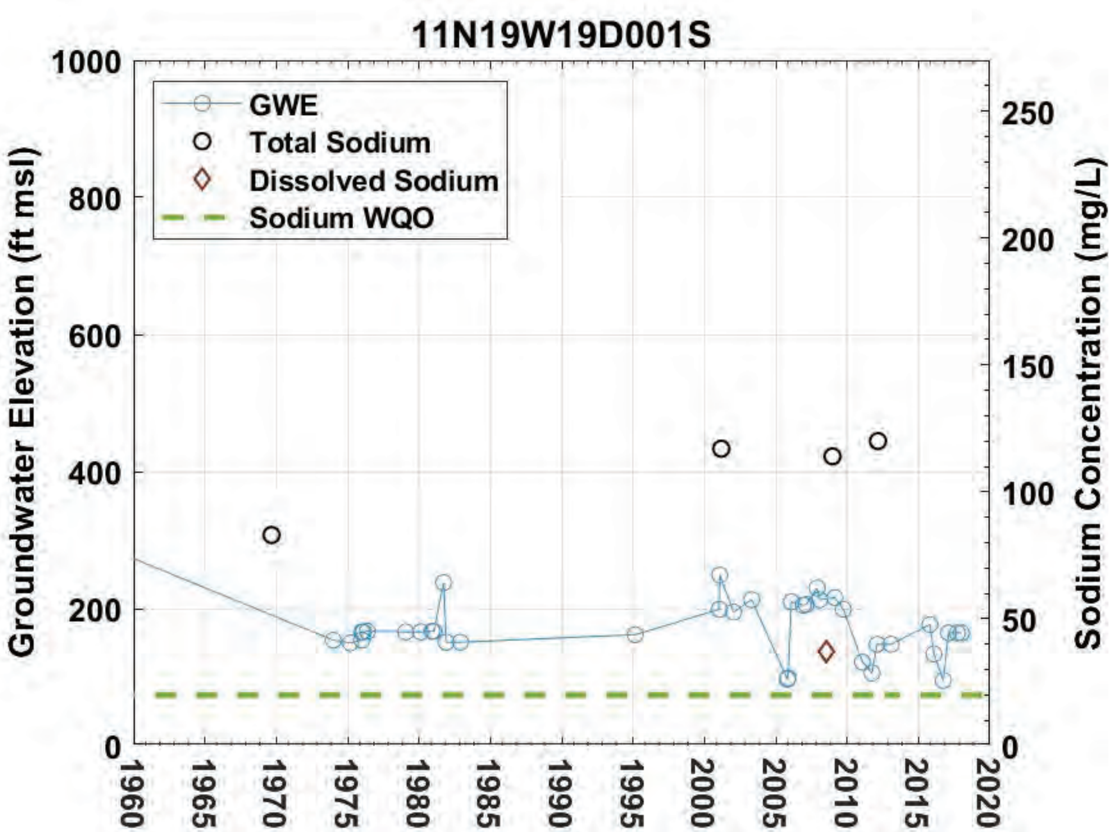


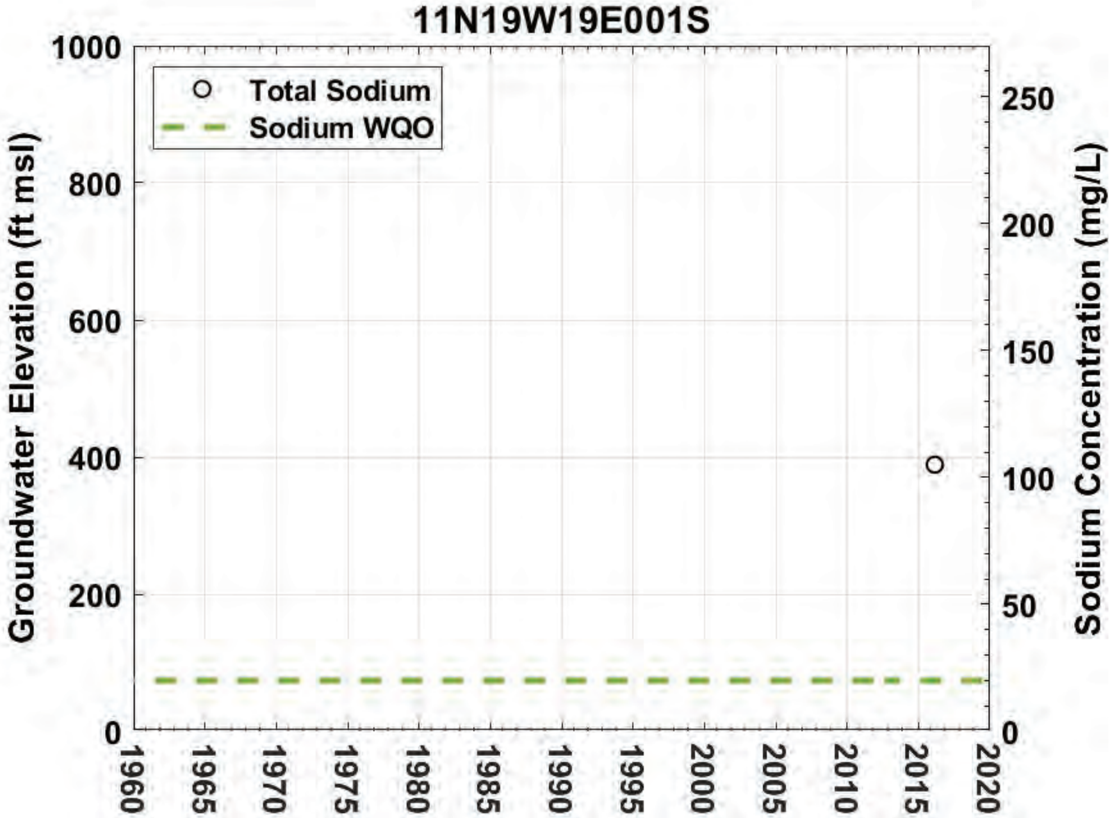
11N19W18P001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



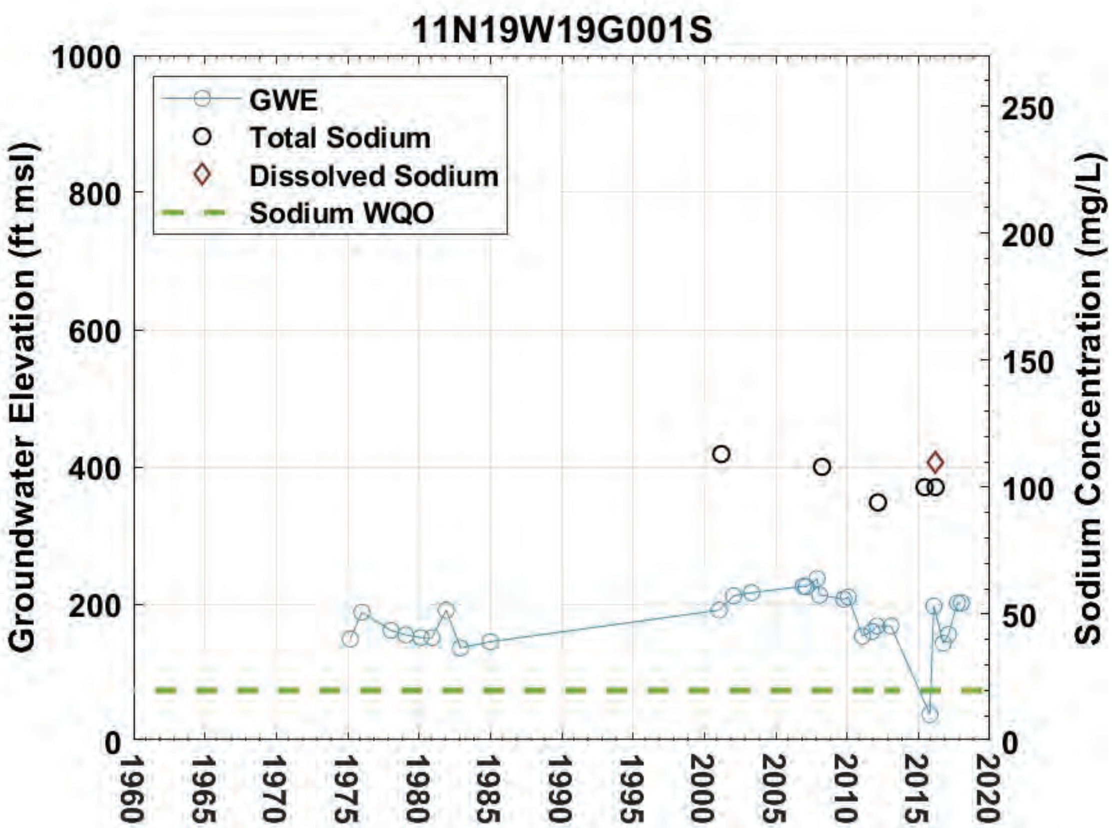
11N19W19A001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W19C001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

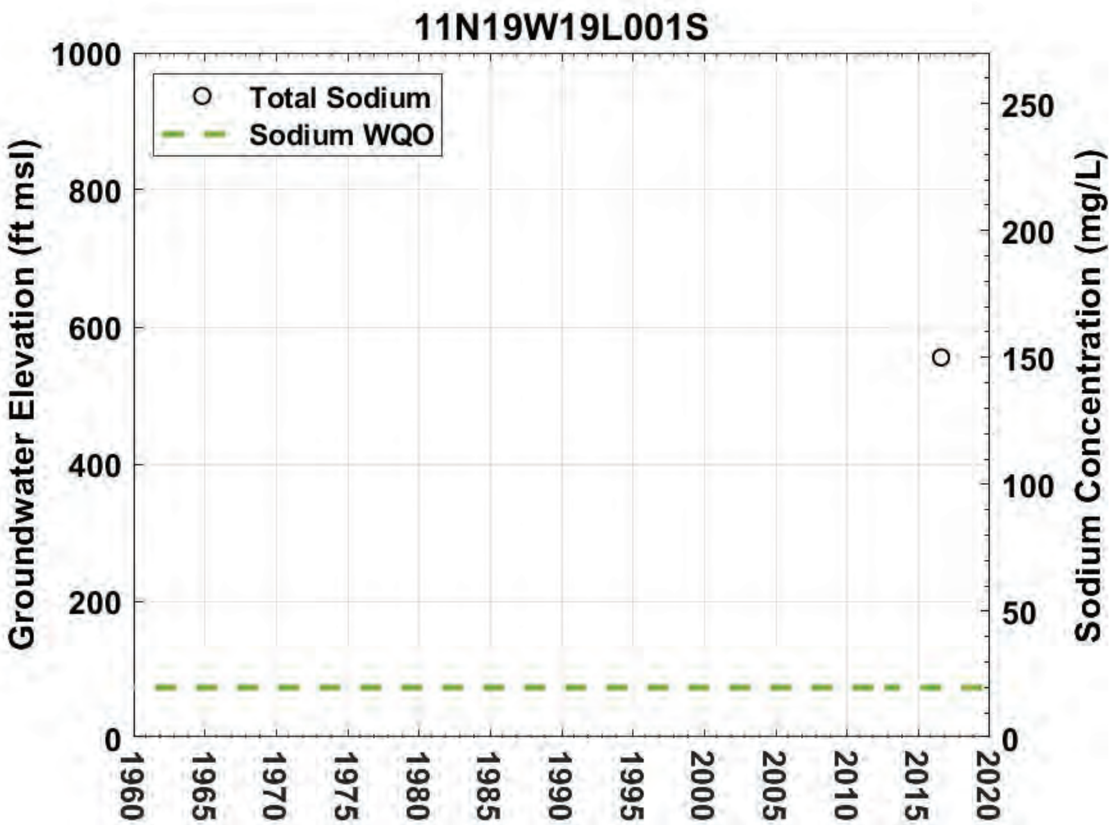

11N19W19D001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

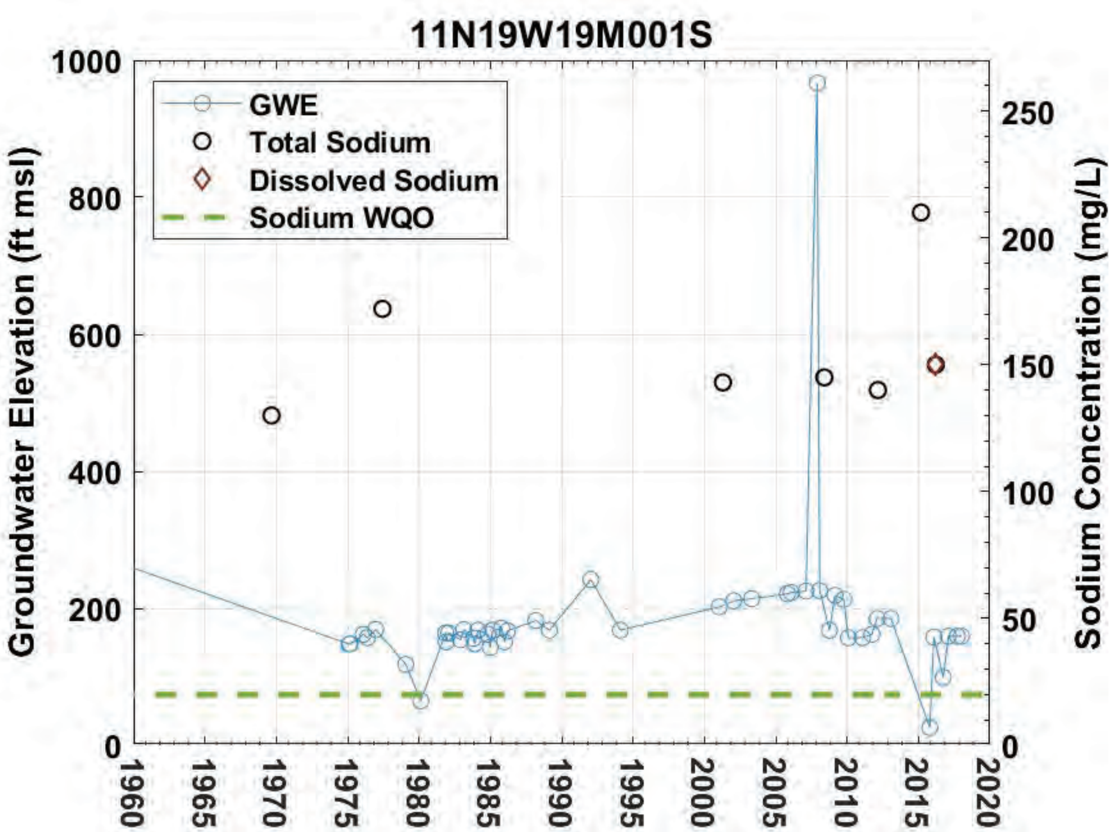


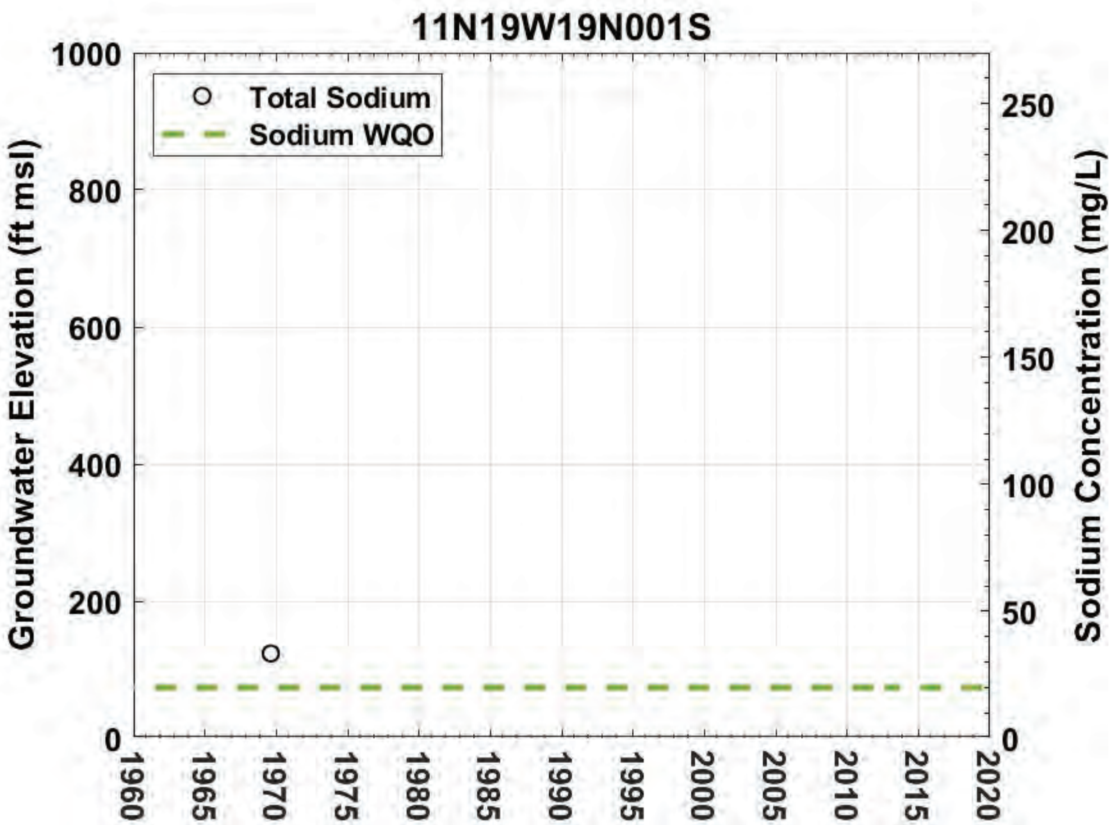
11N19W19E001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)

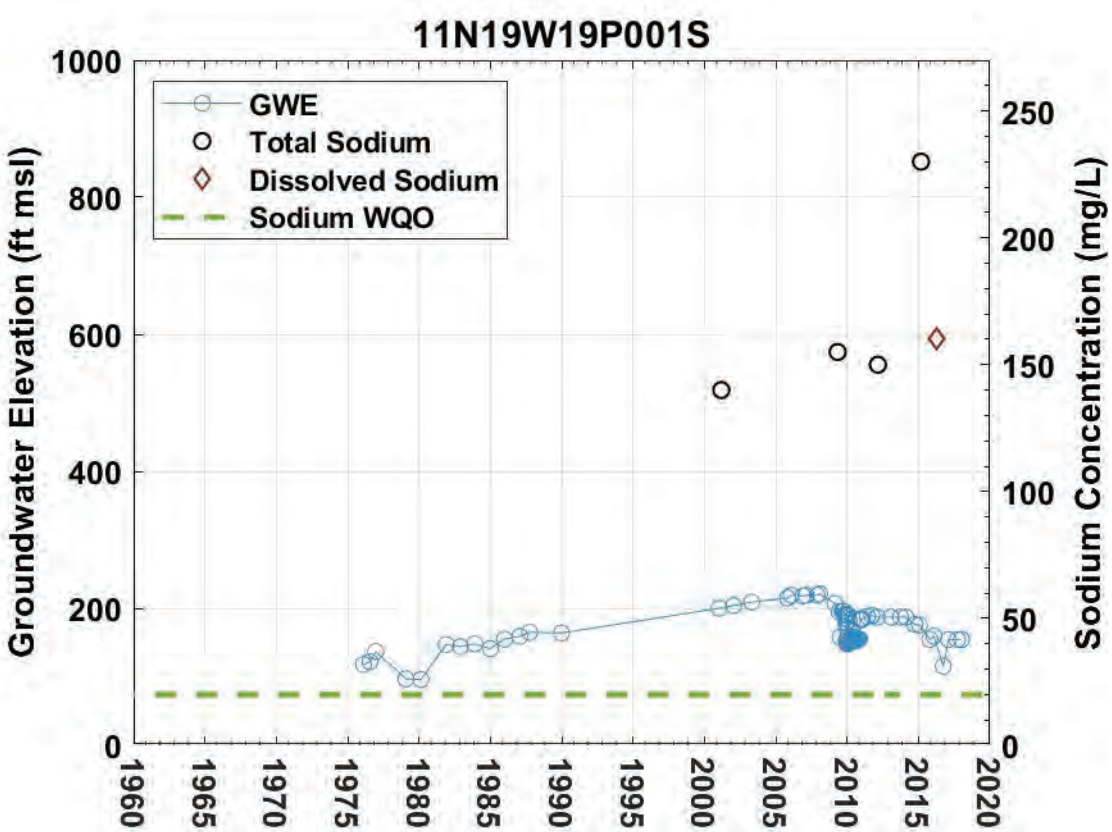


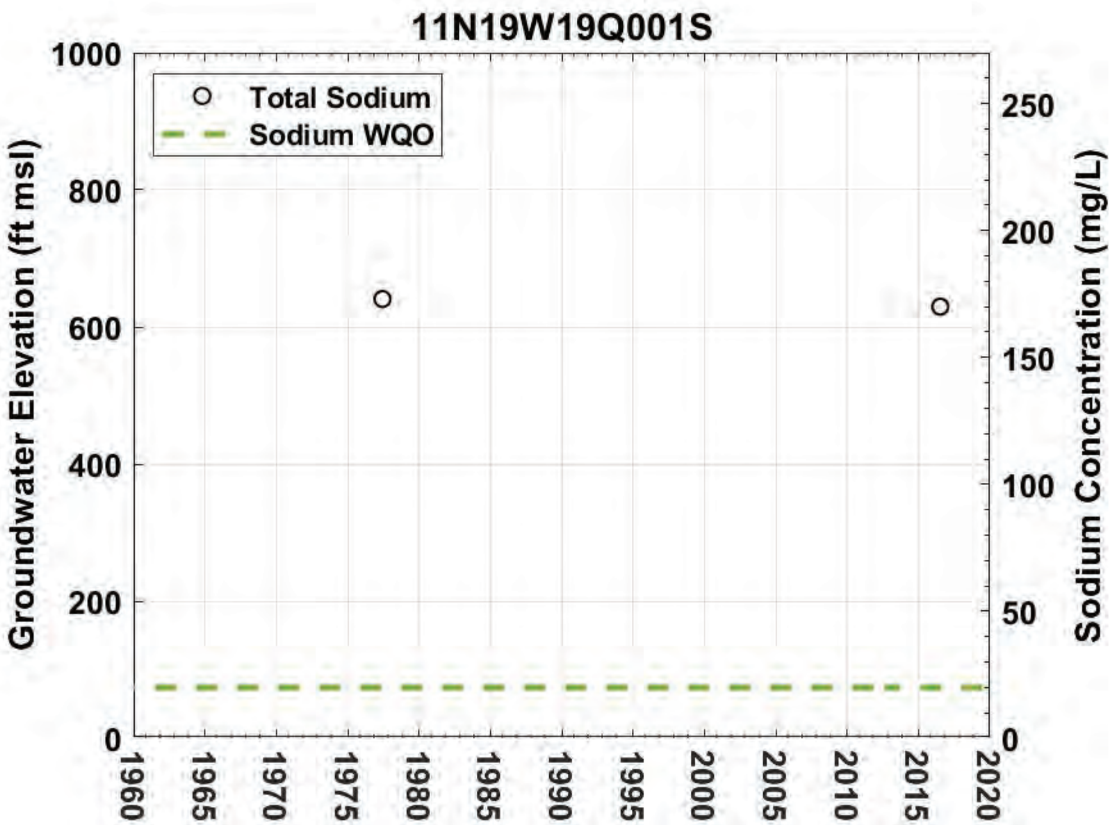
11N19W19G001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)

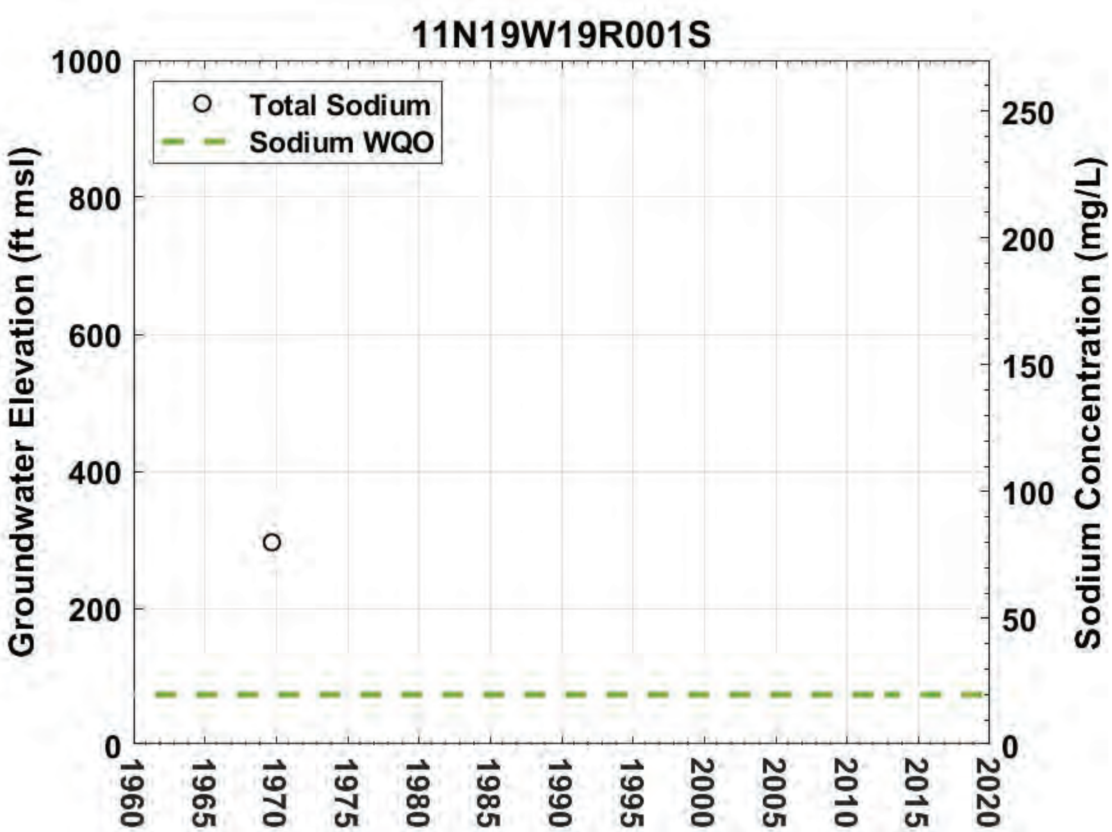

11N19W19L001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)

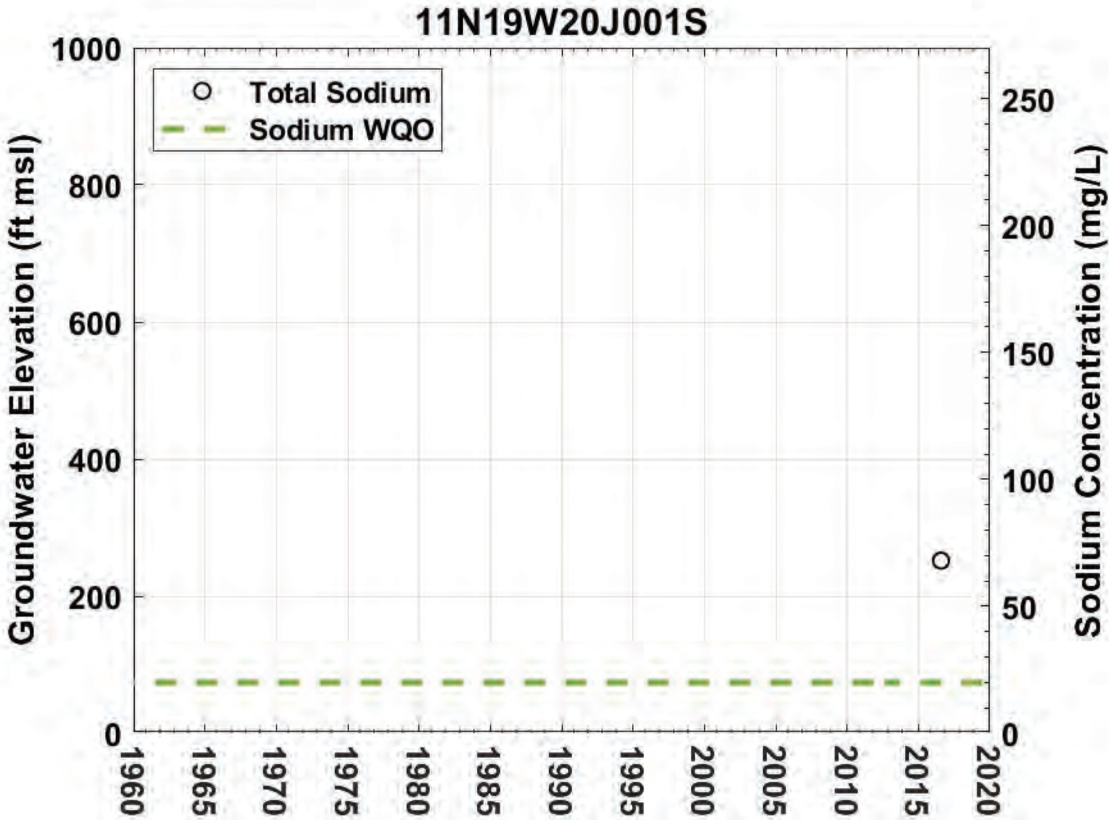

11N19W19M001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)


11N19W19N001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

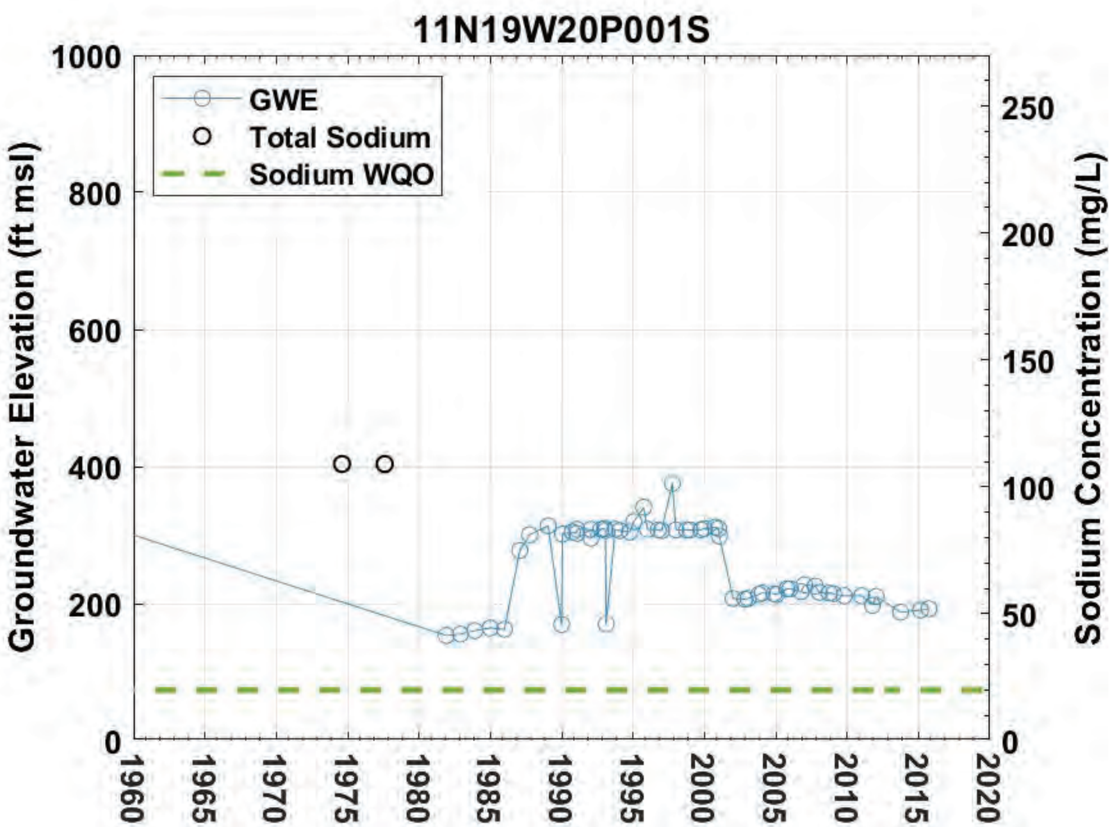

11N19W19P001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W19Q001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

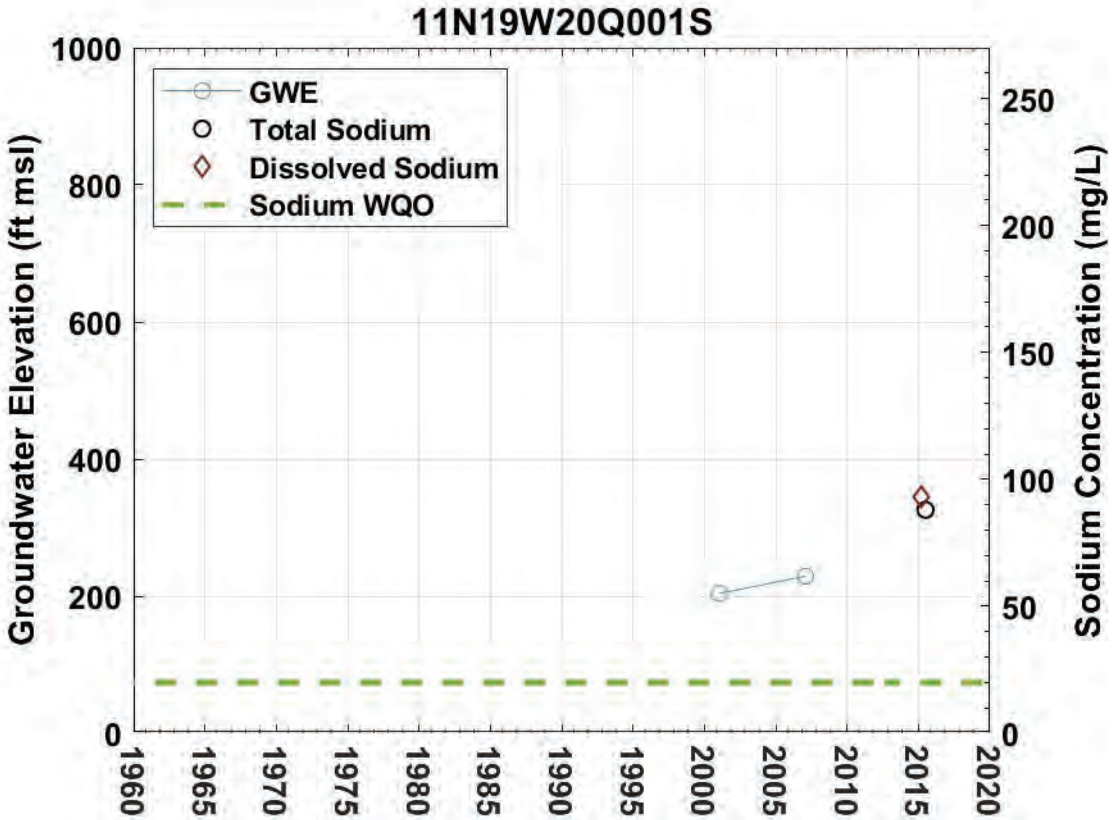

11N19W19R001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



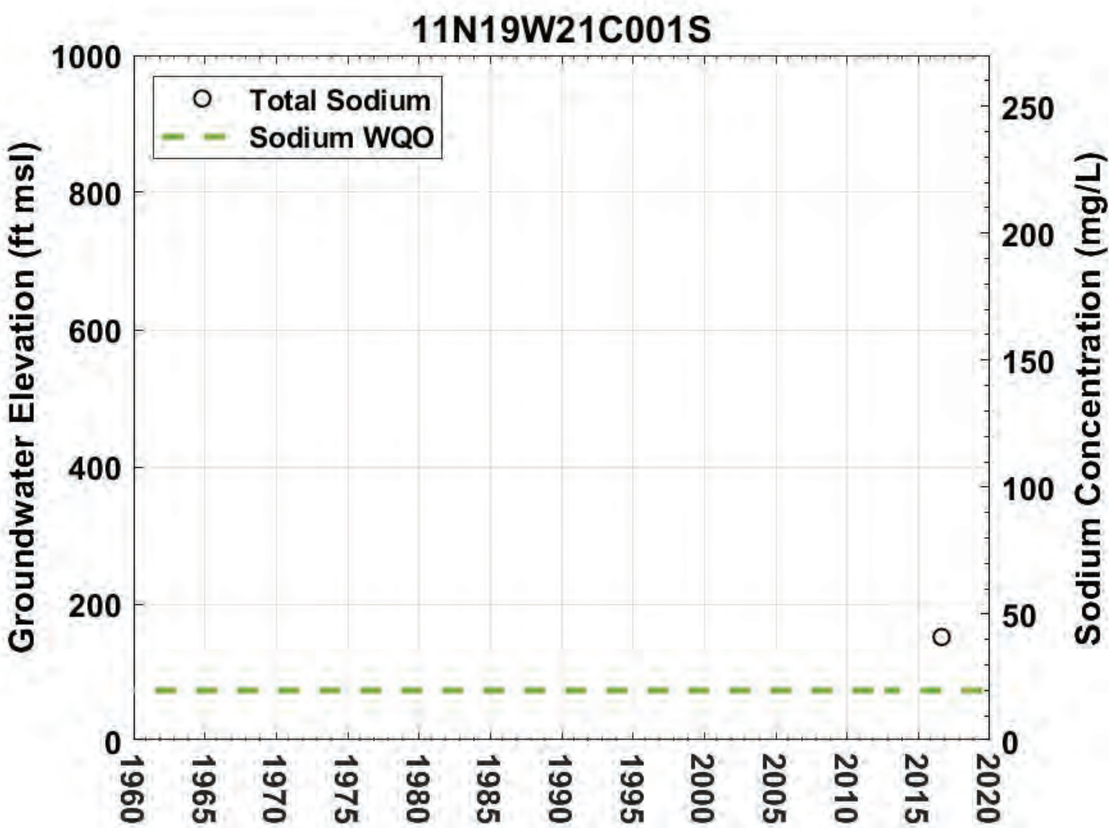
11N19W20J001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



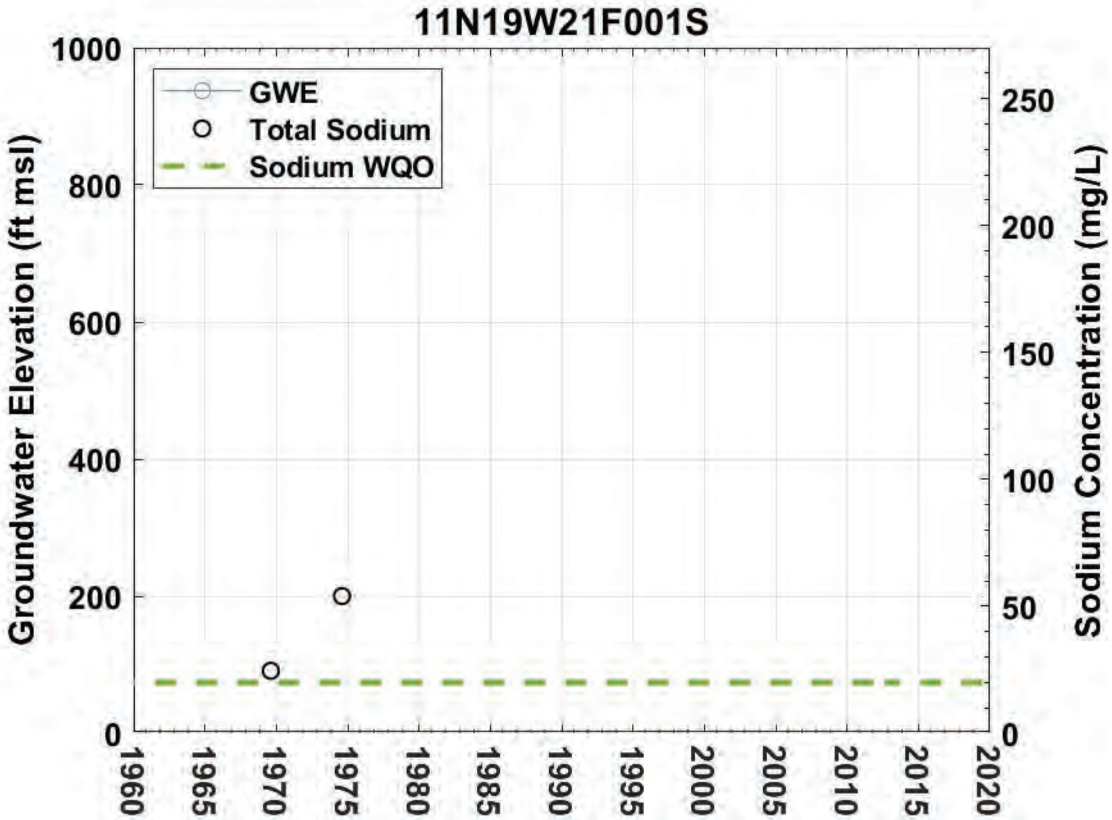
11N19W20P001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



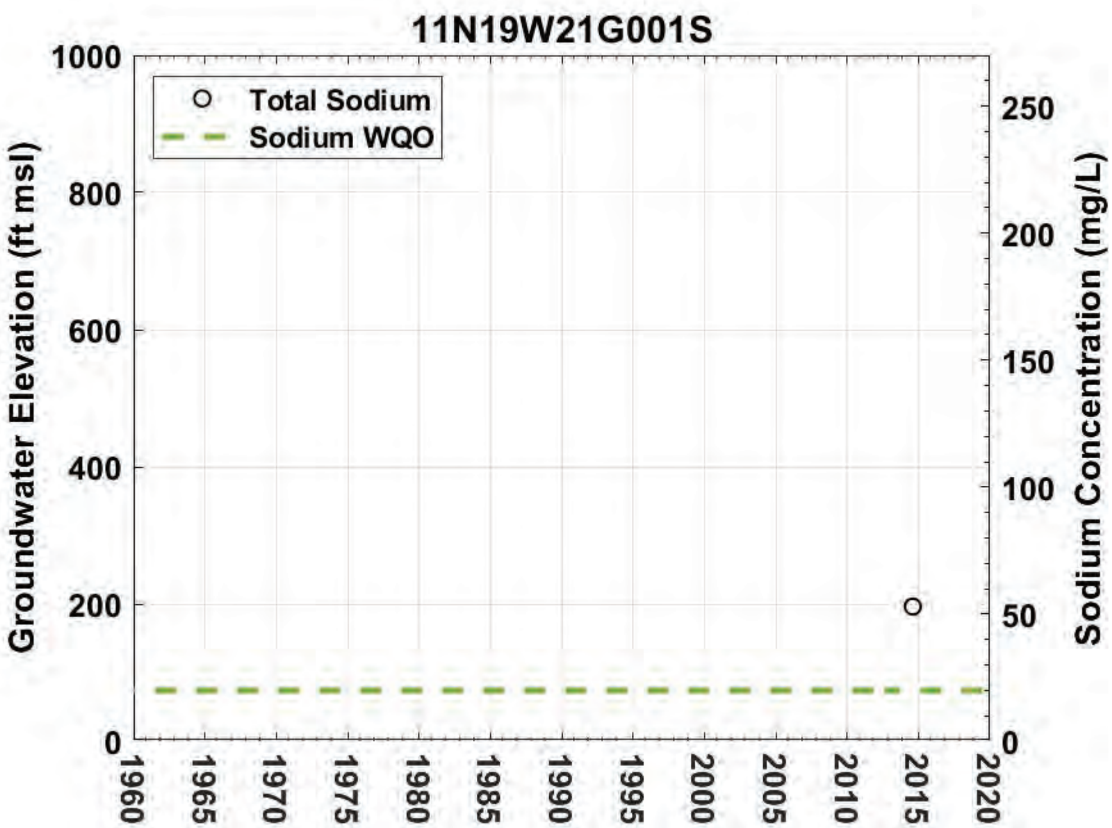
11N19W20Q001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



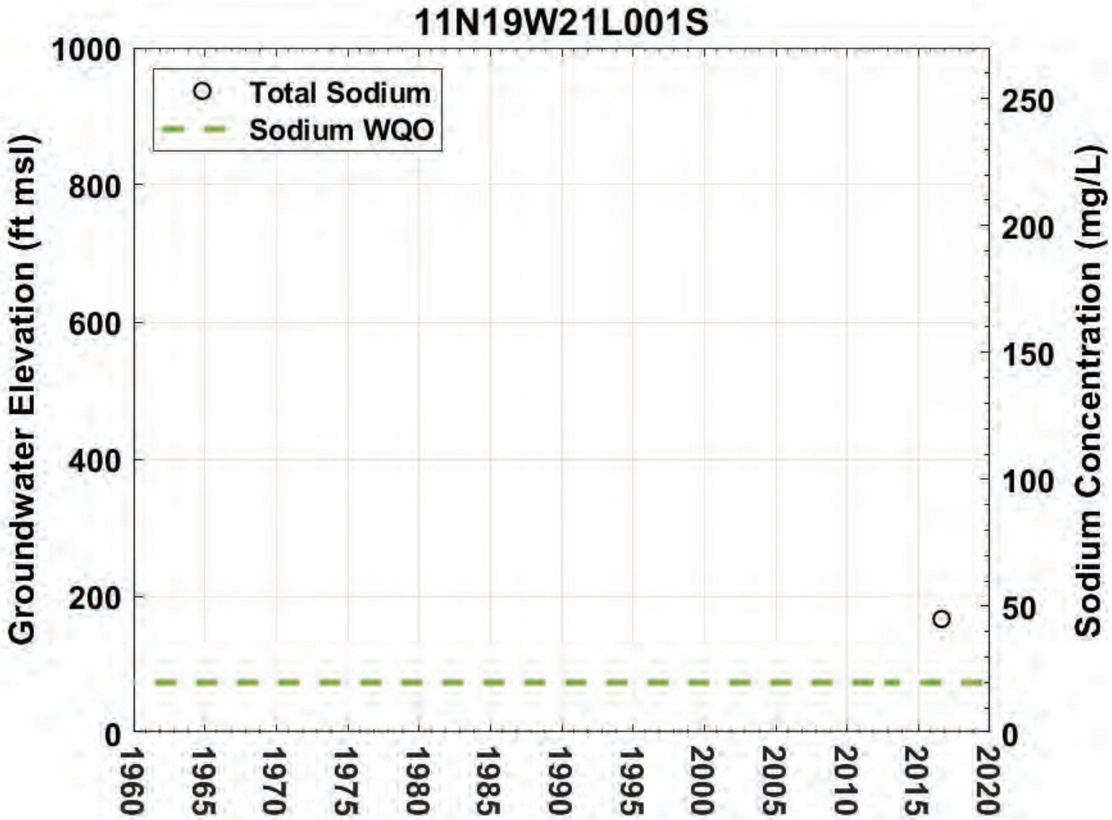
11N19W21C001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

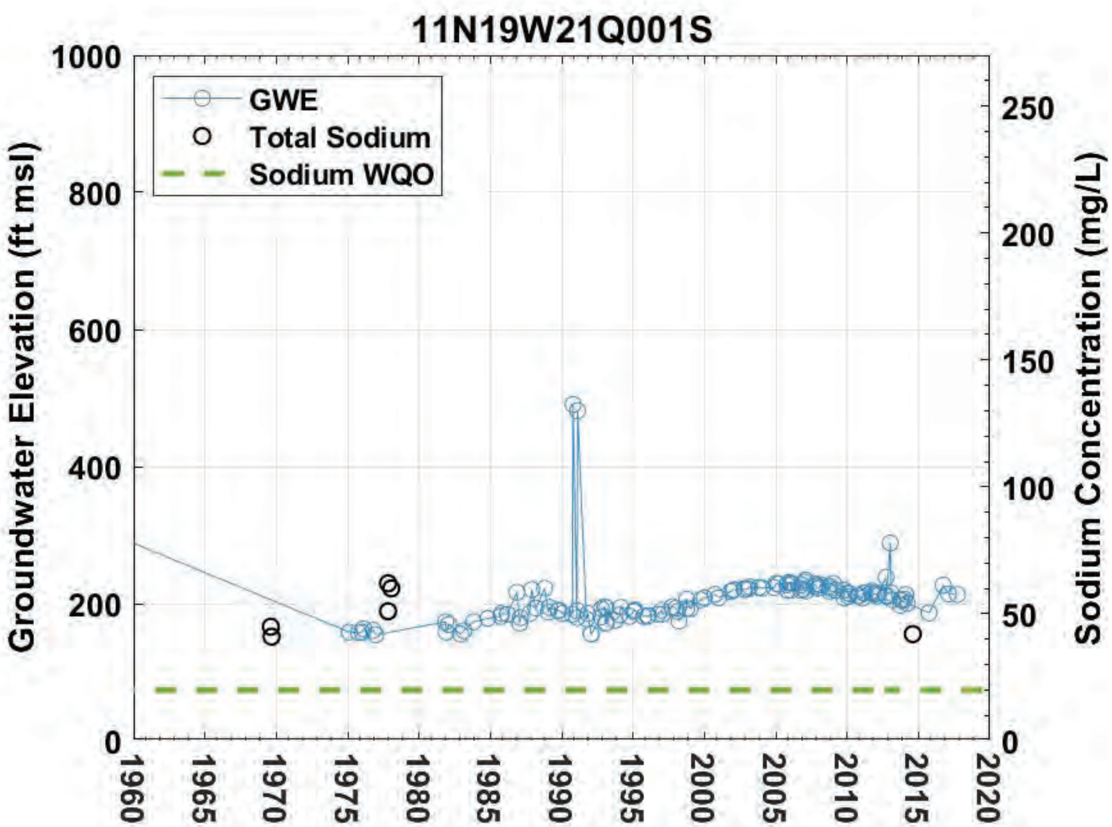


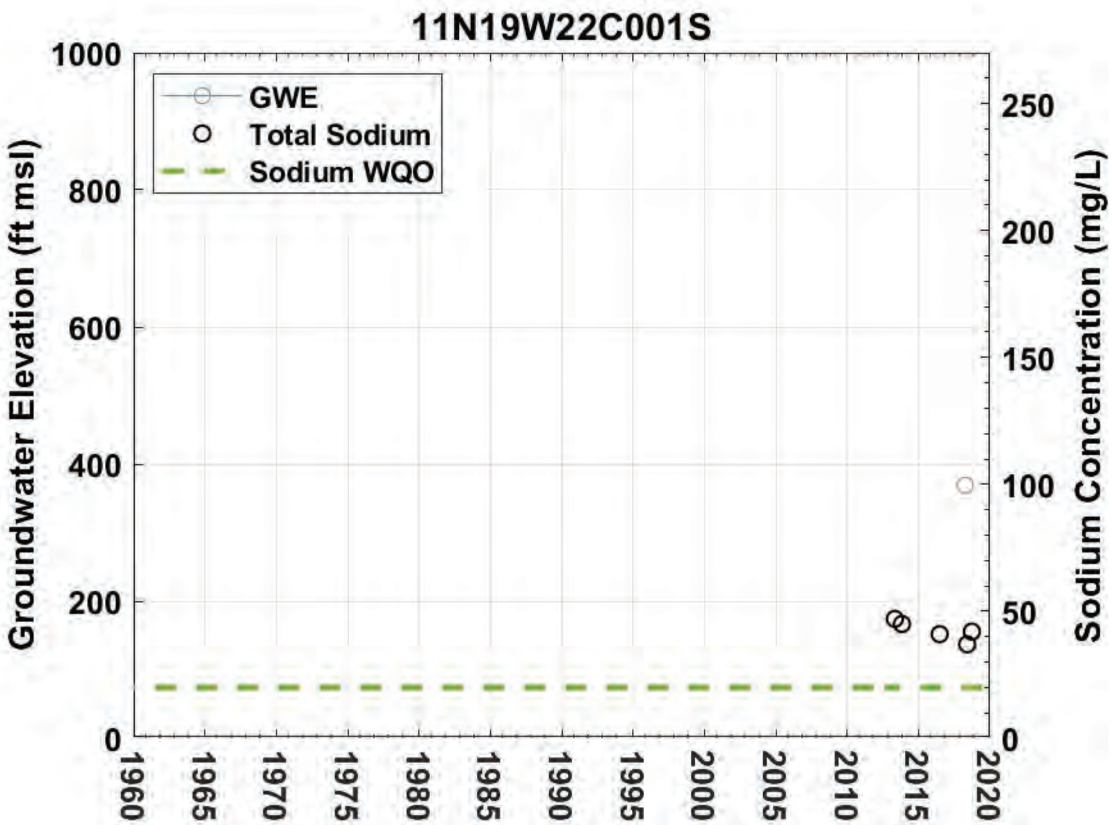
11N19W21F001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)

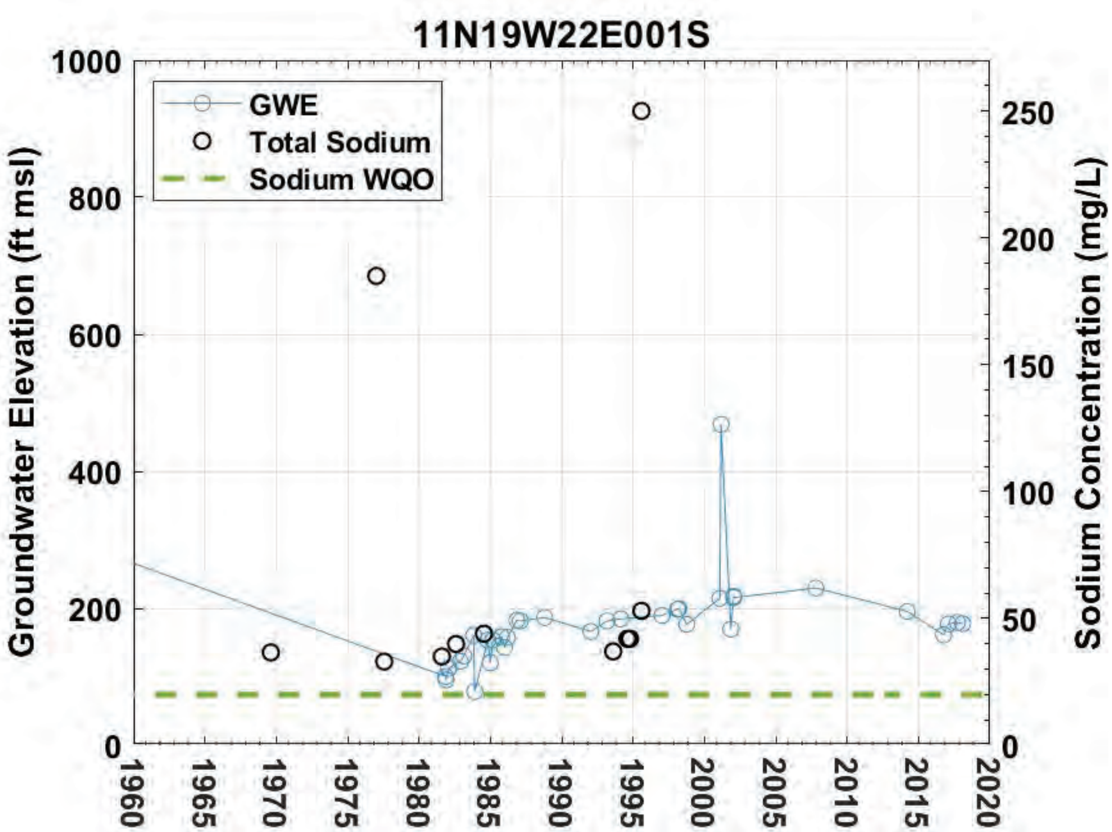


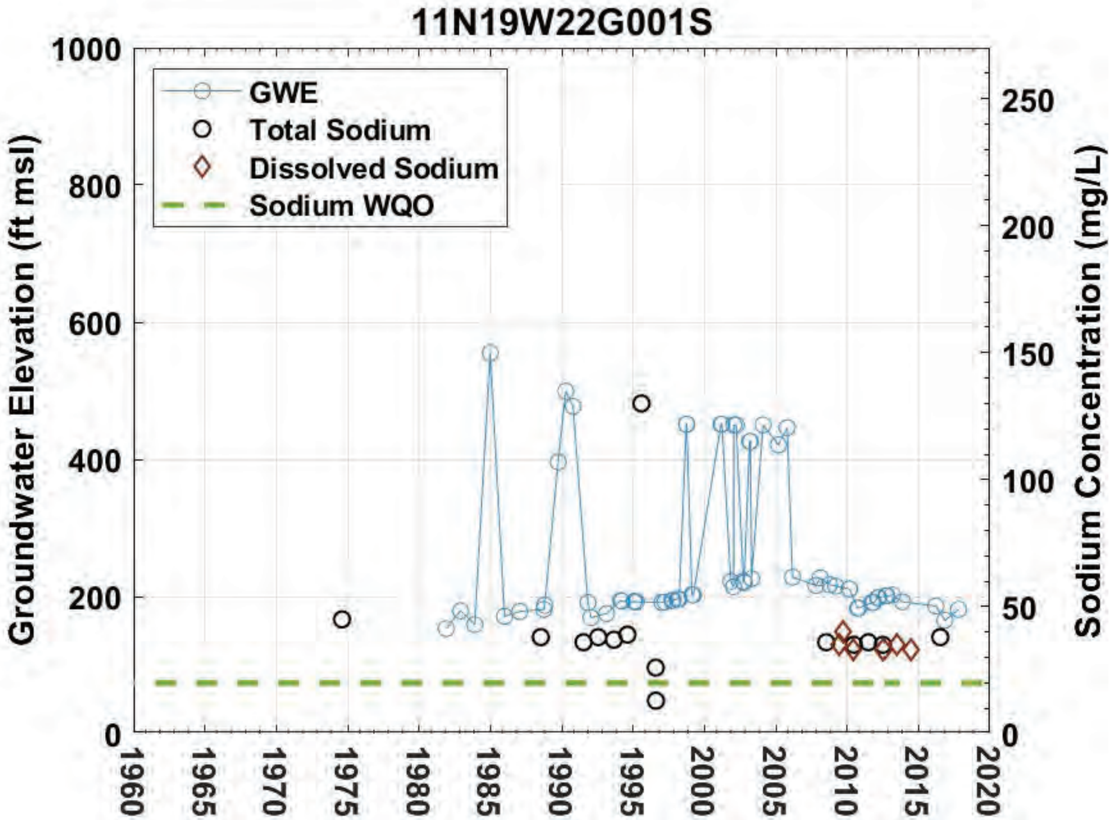
11N19W21G001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)

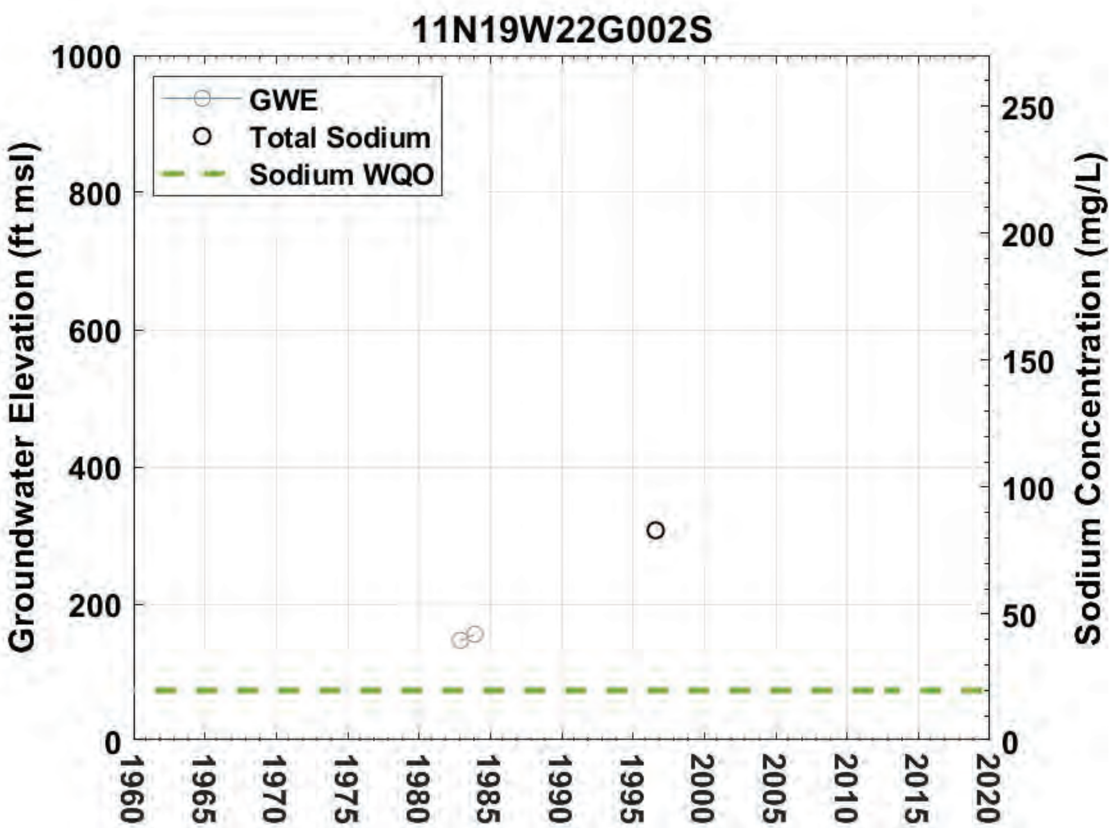

11N19W21L001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

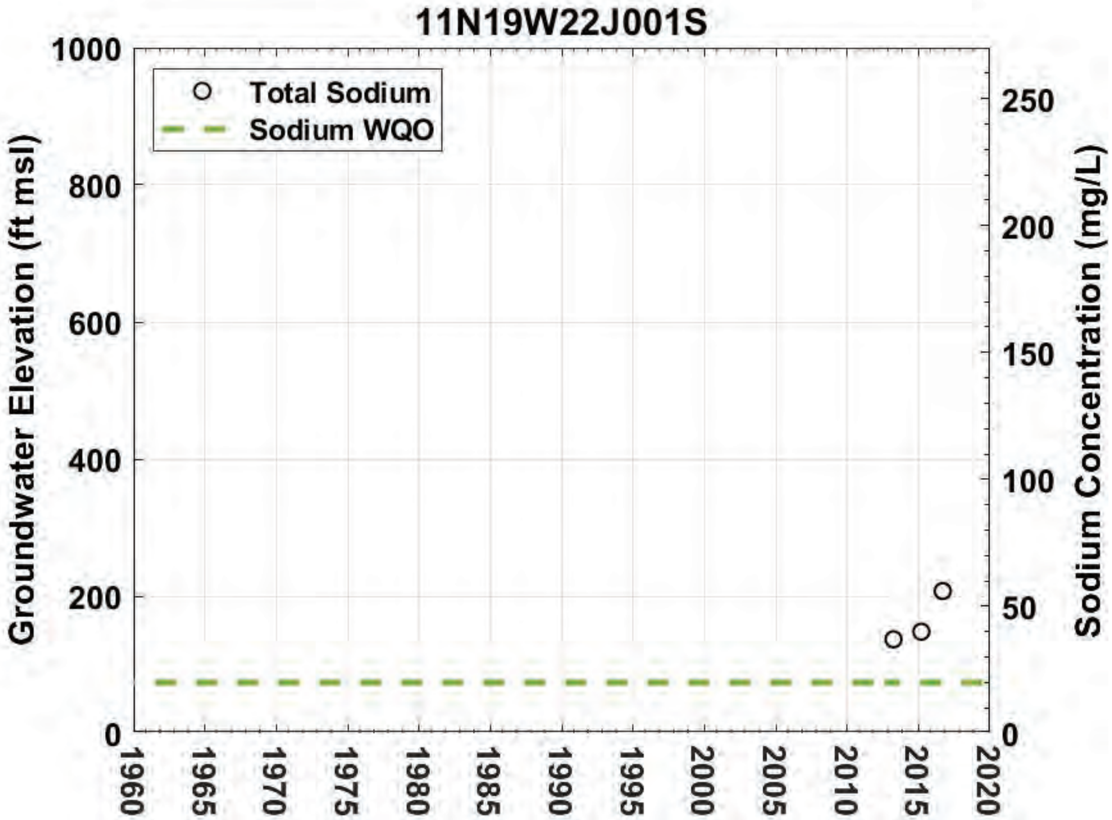

11N19W21Q001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W22C001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
GWE
Total Sodium
Sodium WQO
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

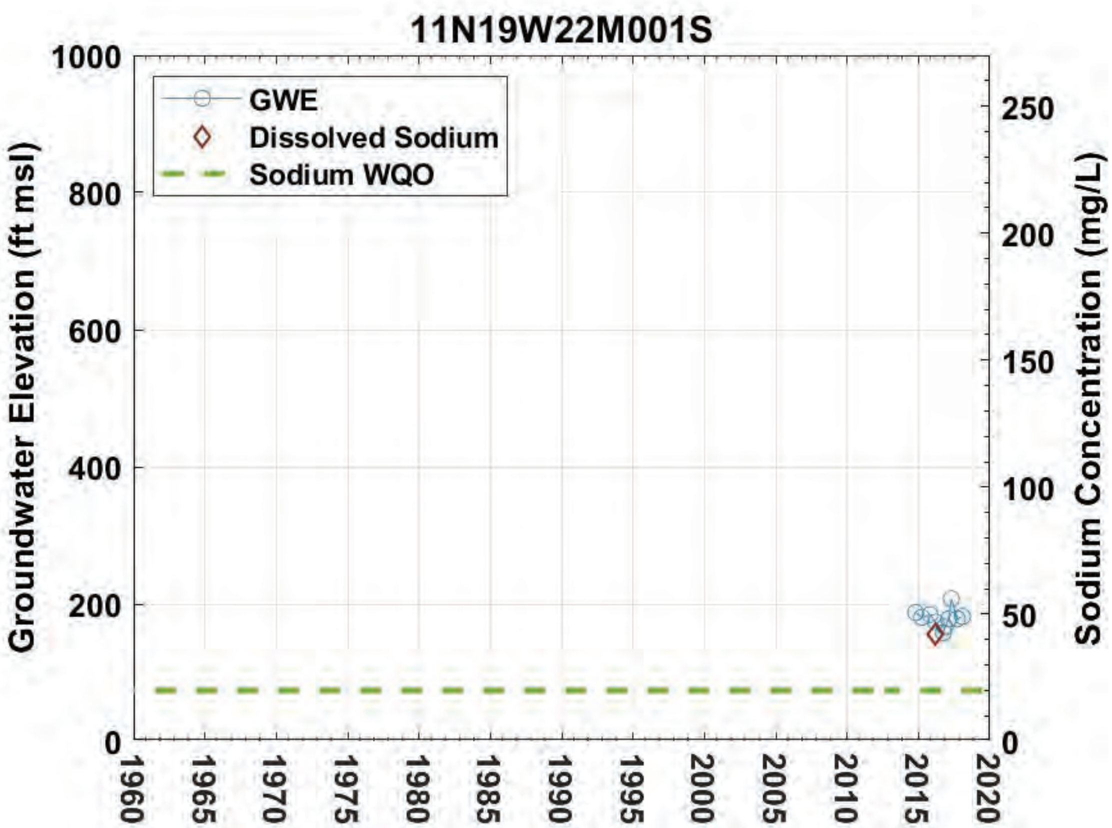

11N19W22E001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
GWE
Total Sodium
Sodium WQO
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W22G001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

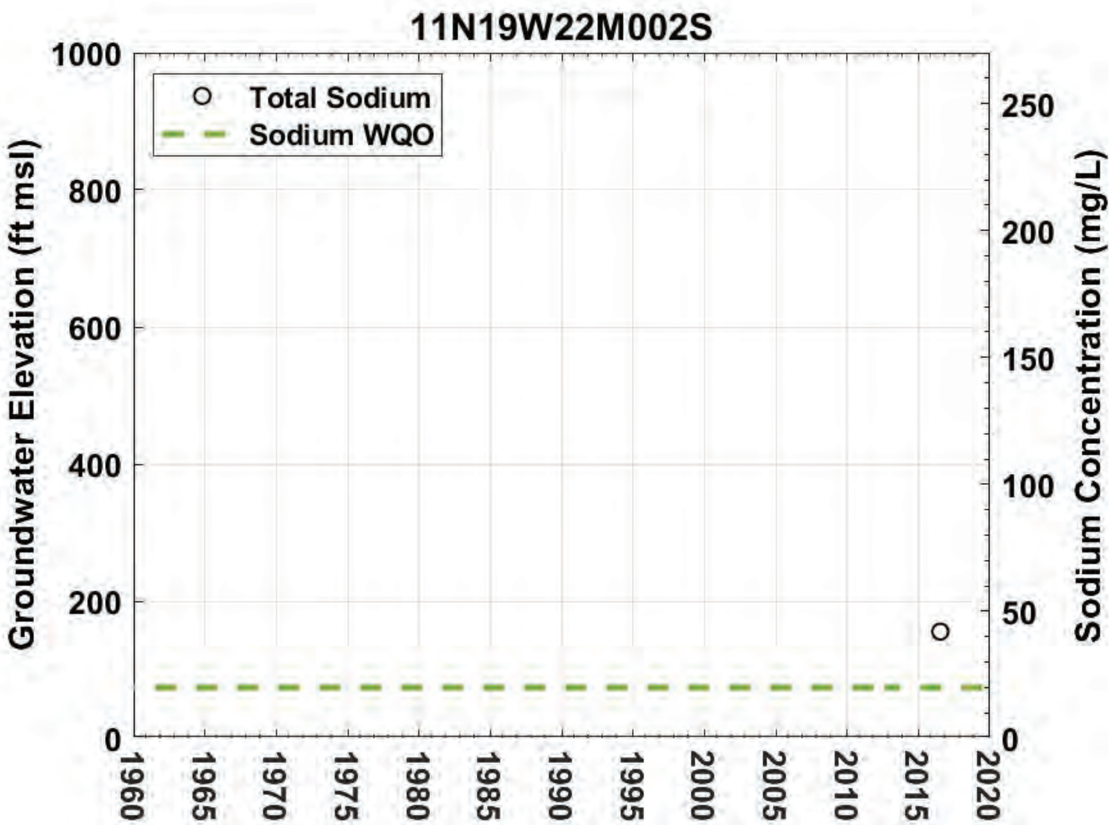

11N19W22G002S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

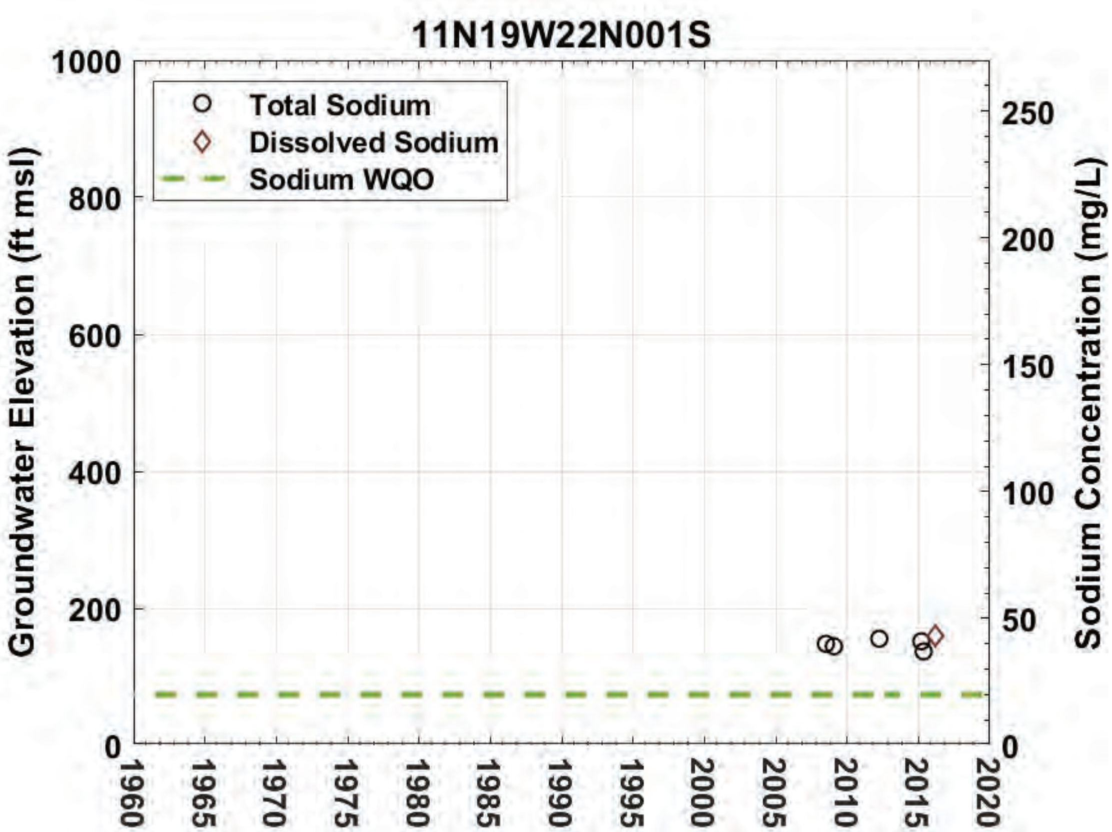


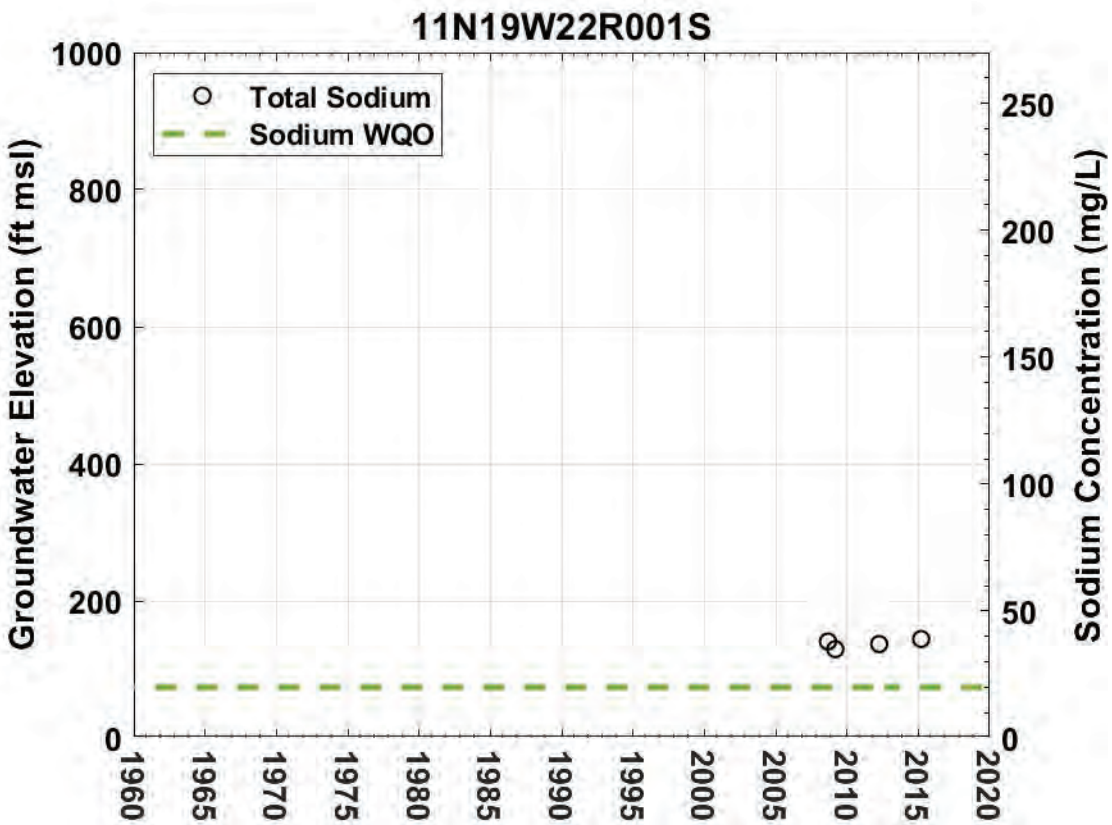
11N19W22J001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

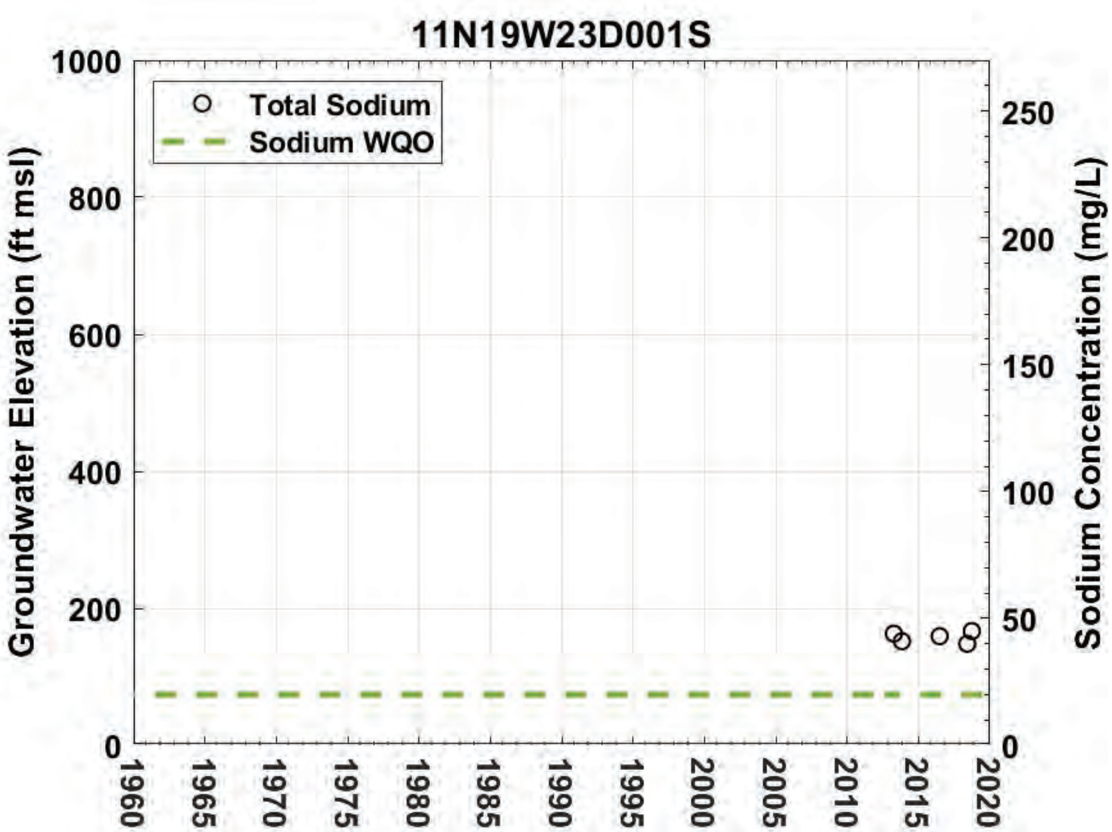


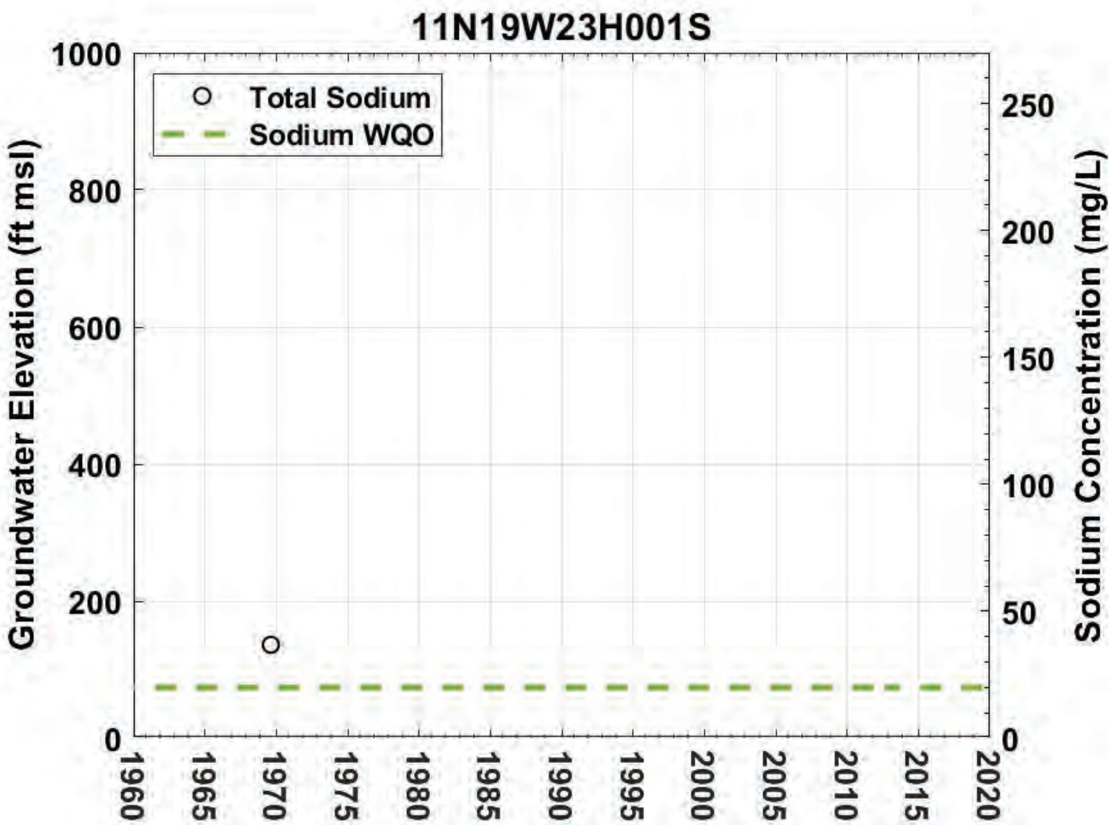
11N19W22M001S
GWE
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

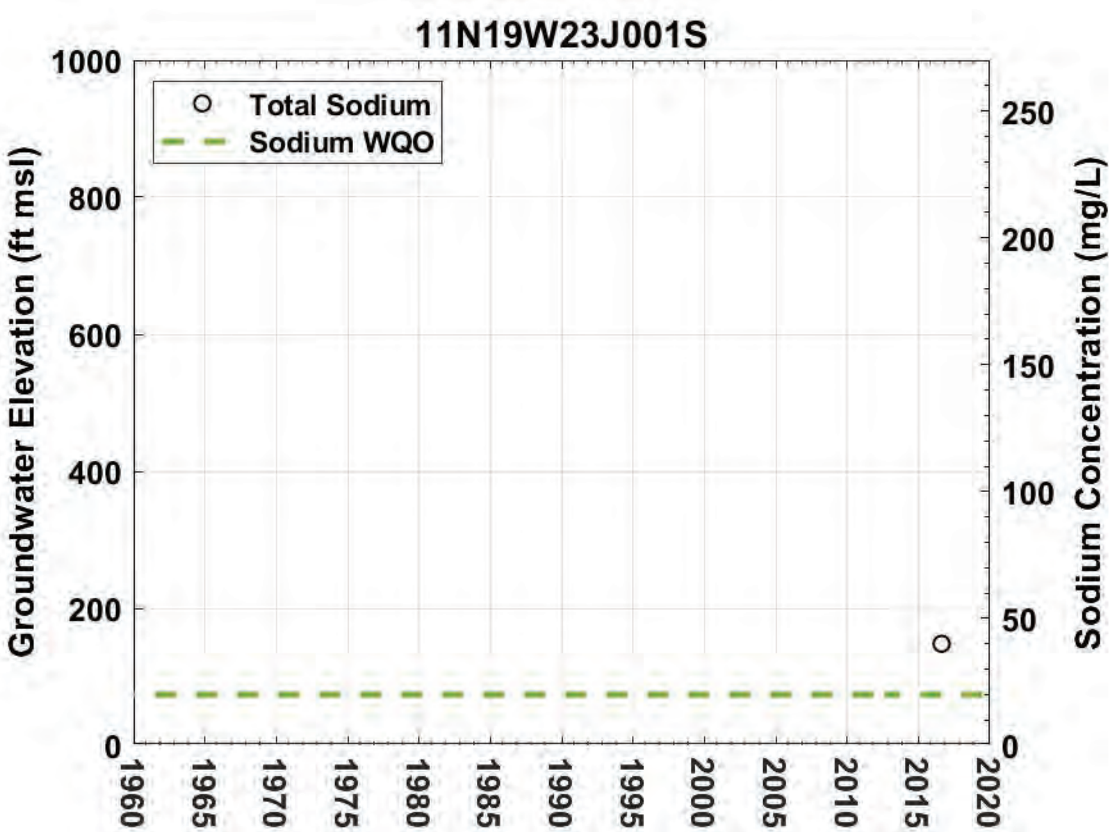

11N19W22M002S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

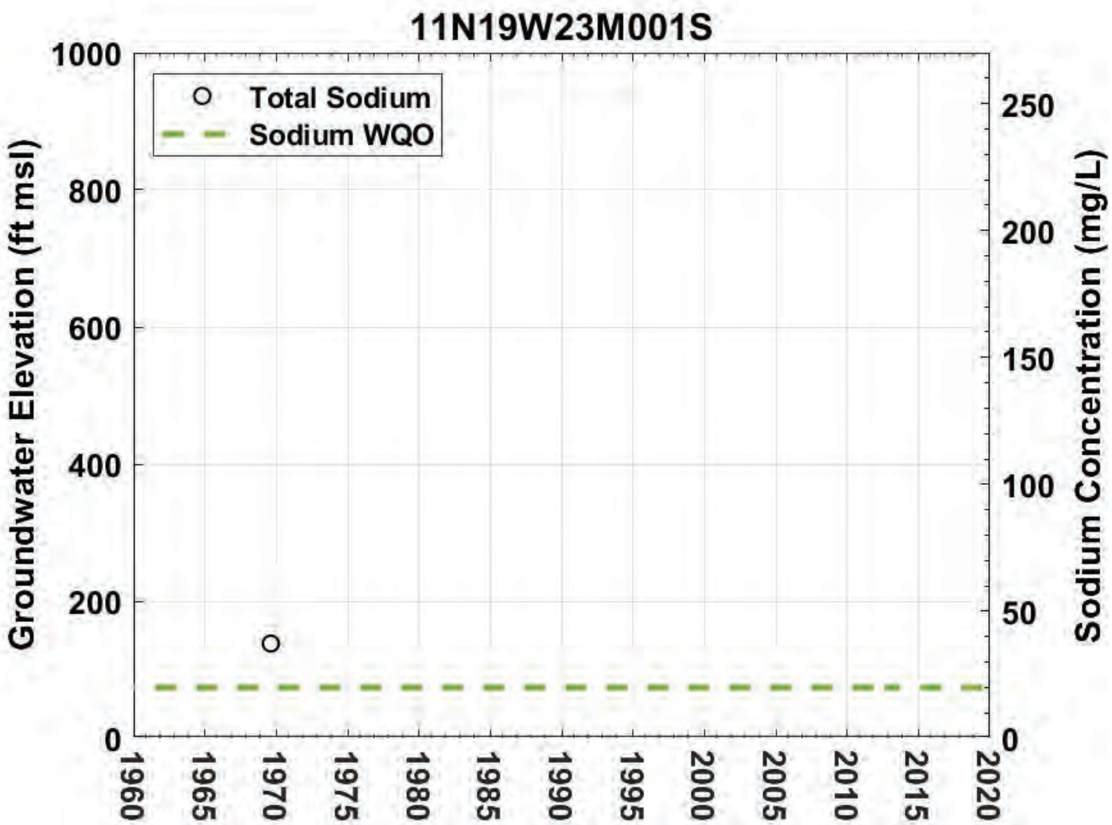

11N19W22N001S
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

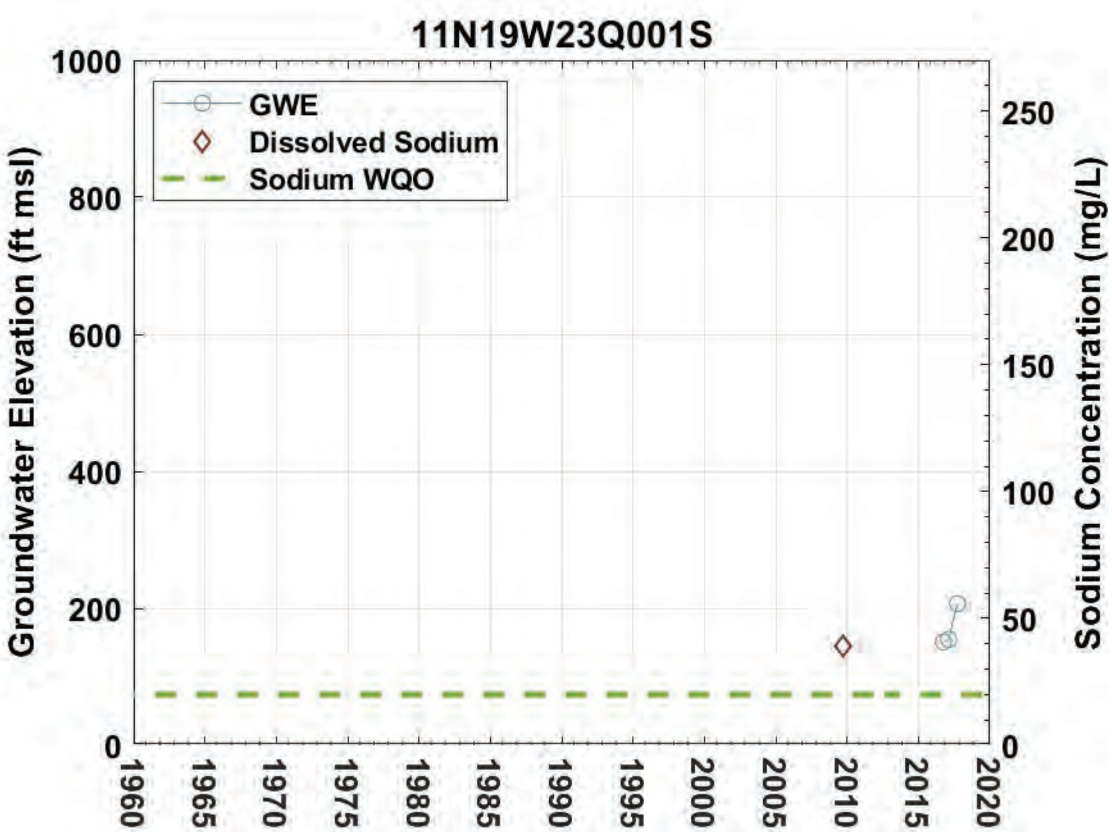

11N19W22R001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

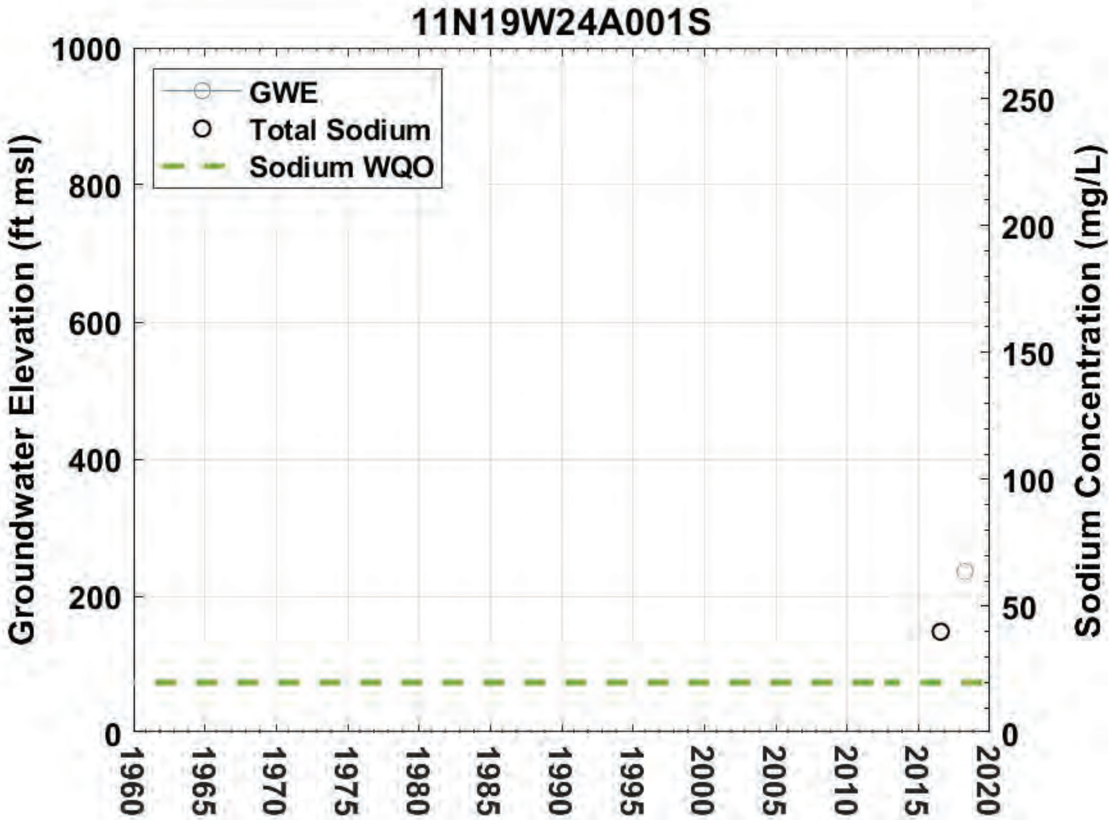

11N19W23D001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

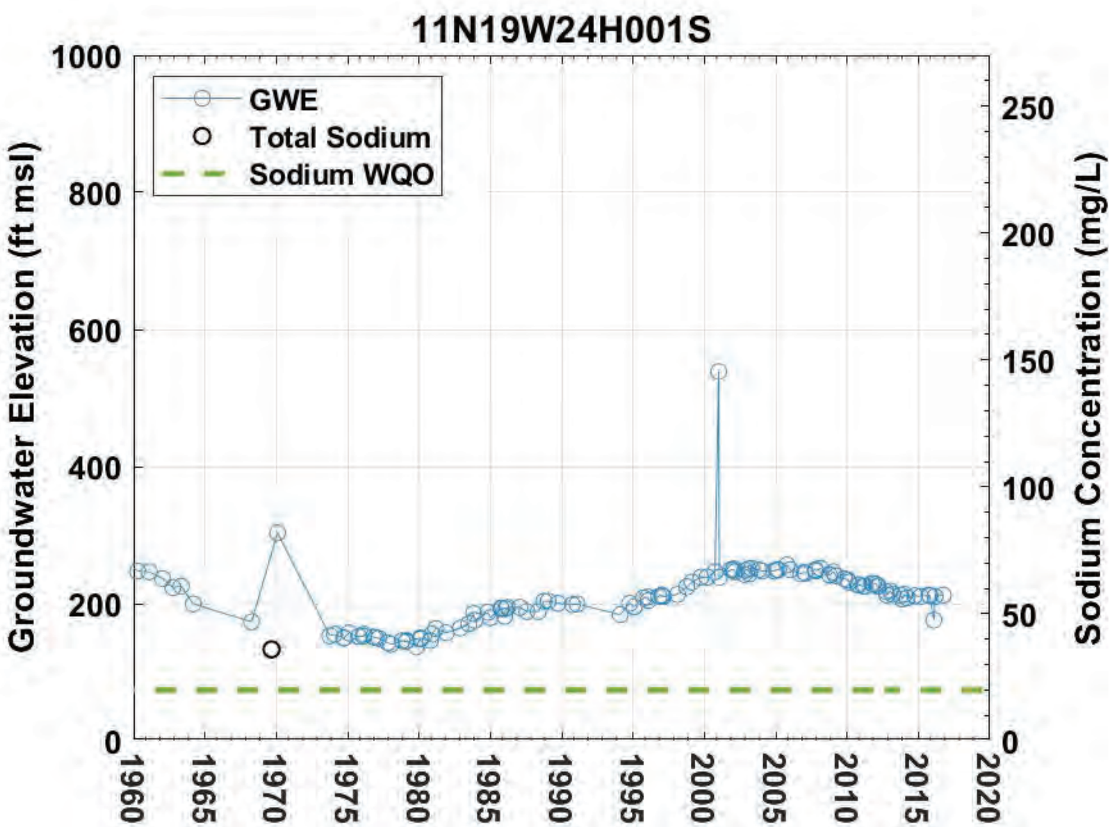

11N19W23H001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

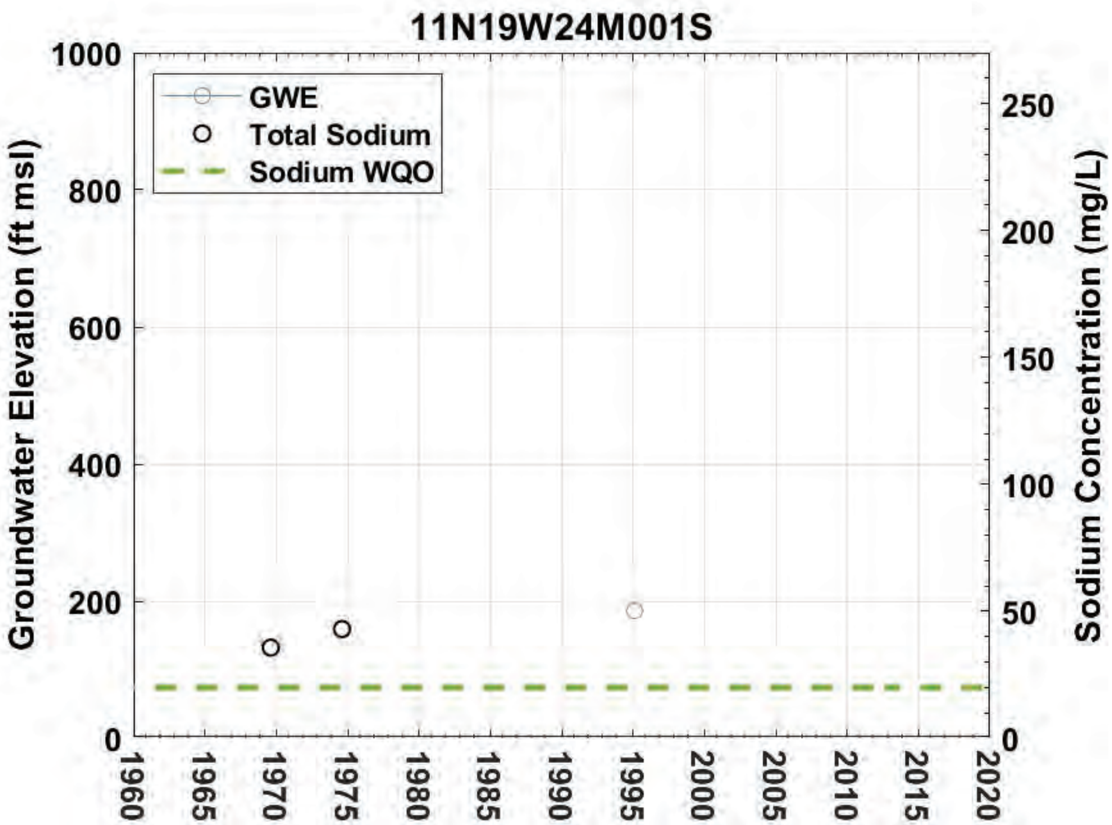

11N19W23J001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

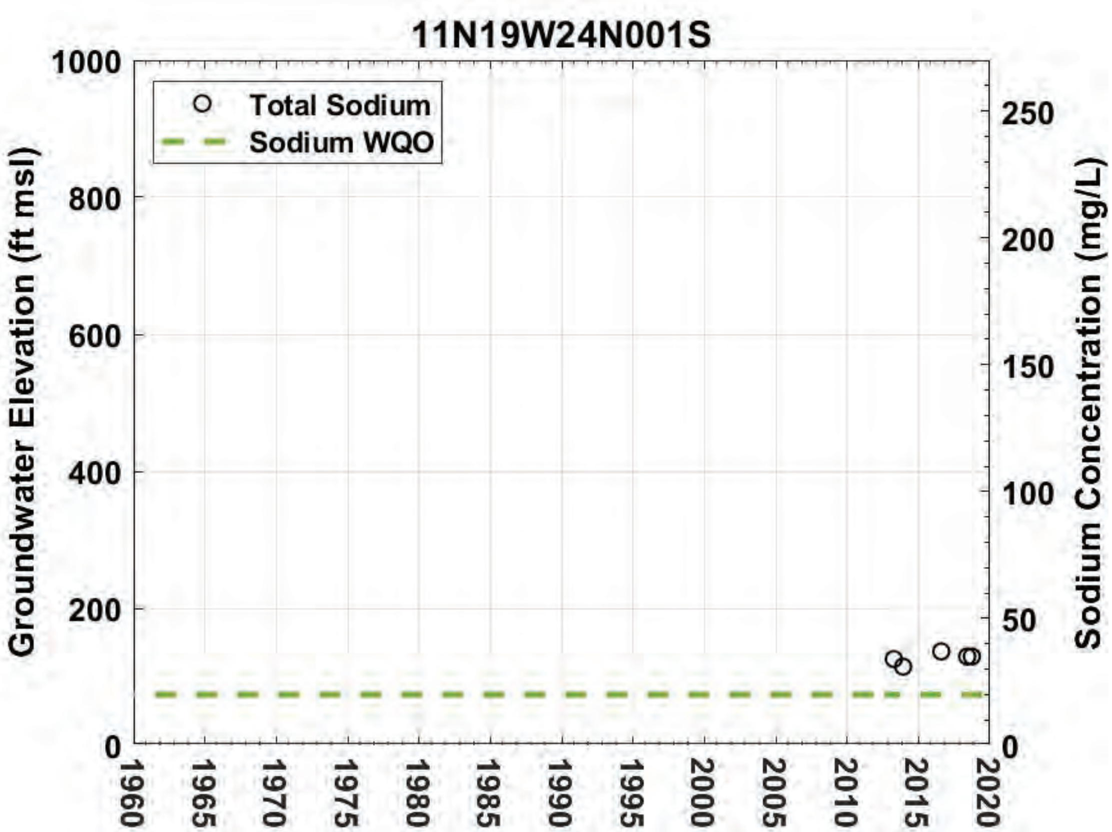

11N19W23M001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

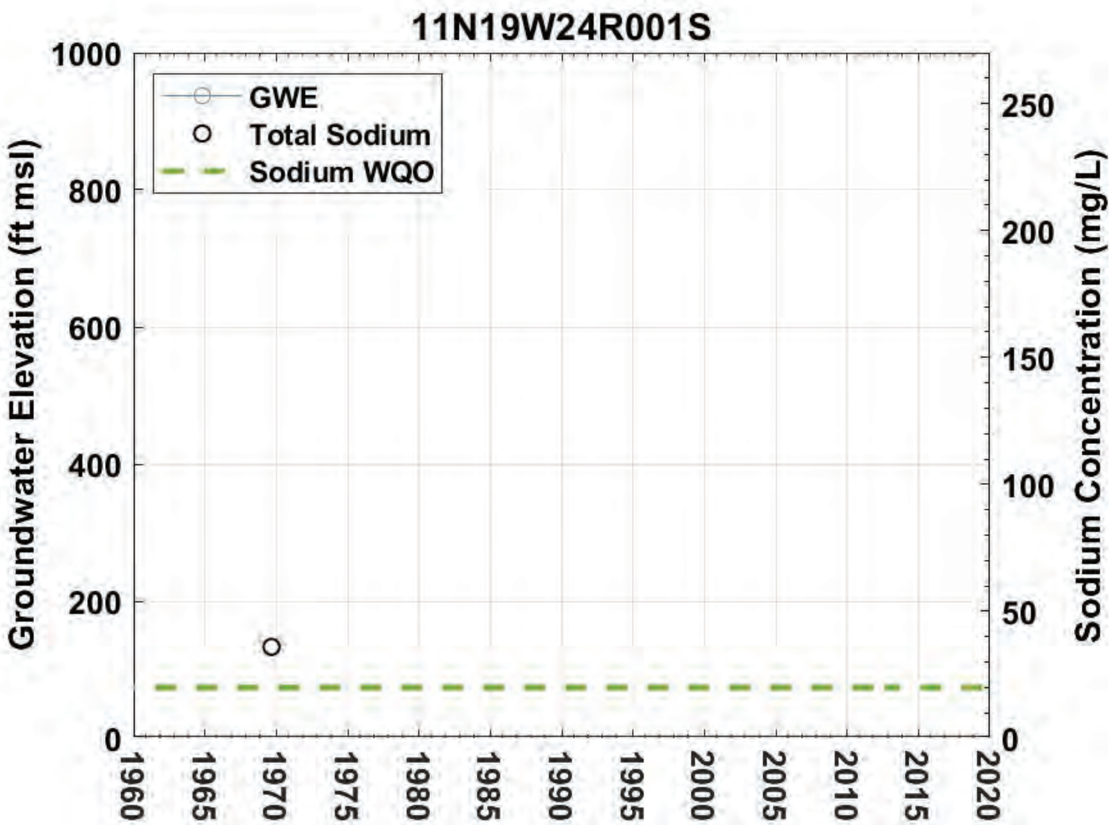

11N19W23Q001S
GWE
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

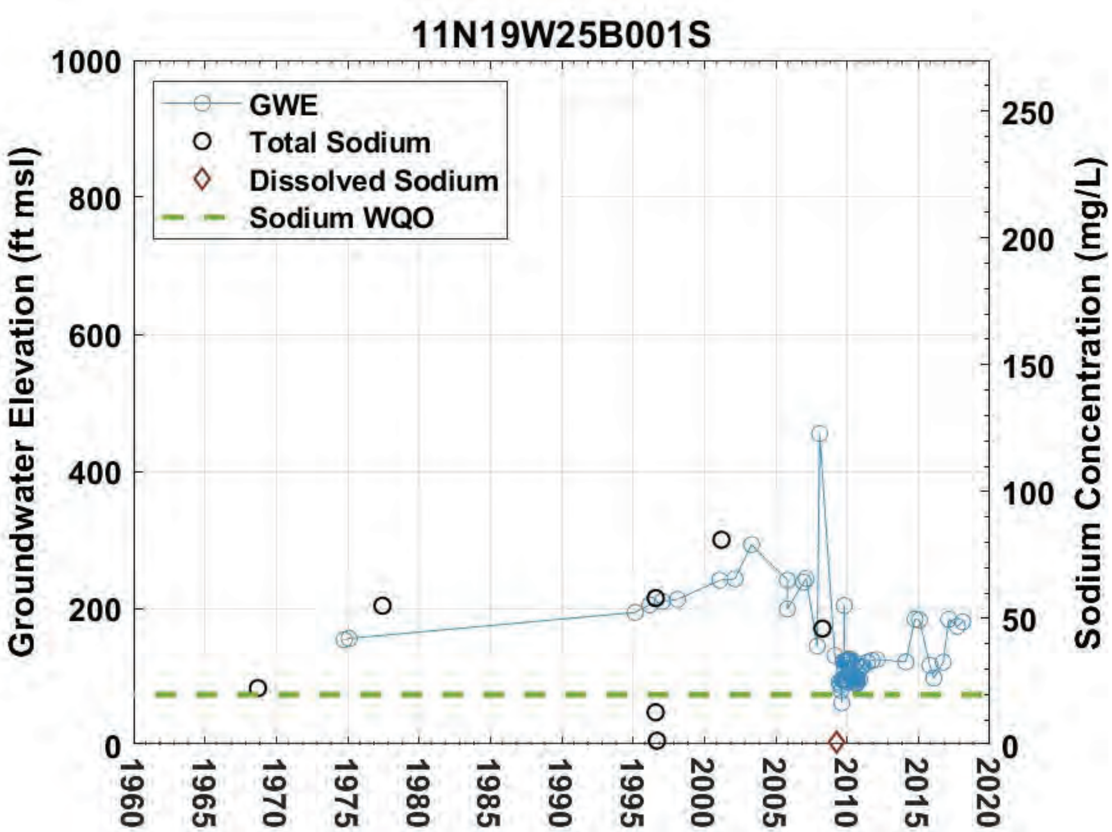

11N19W24A001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

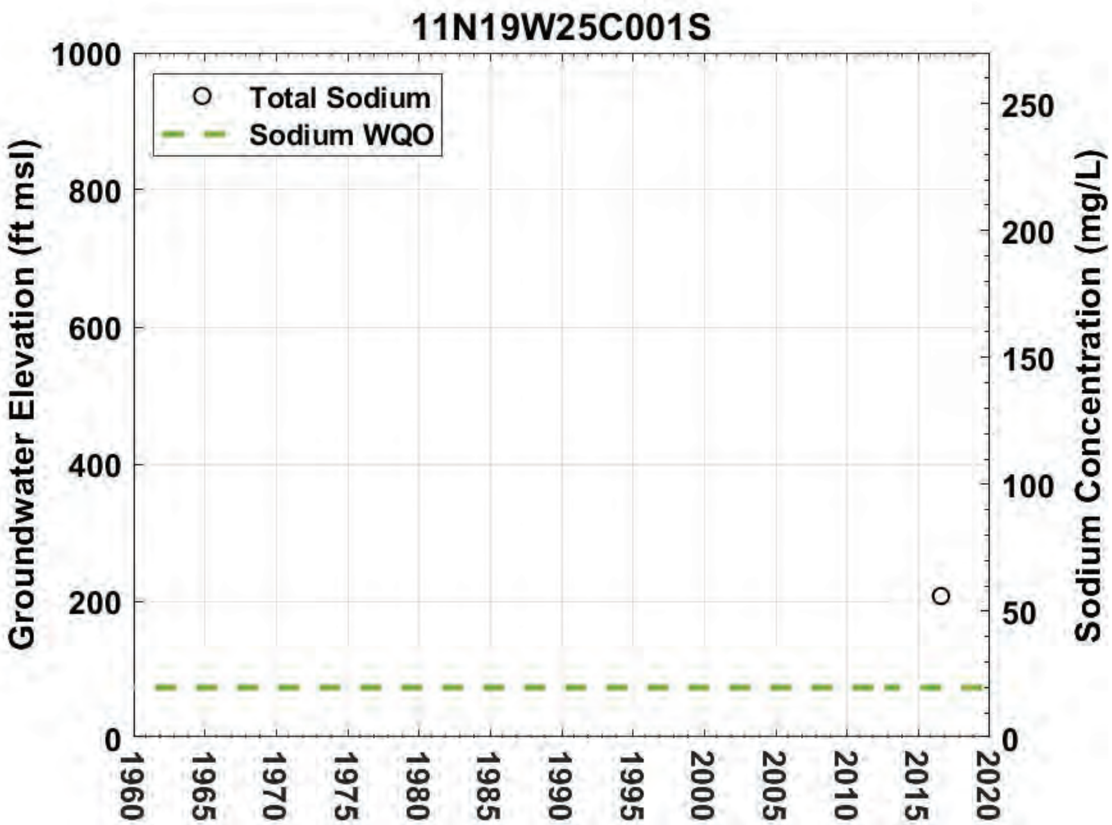

11N19W24H001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

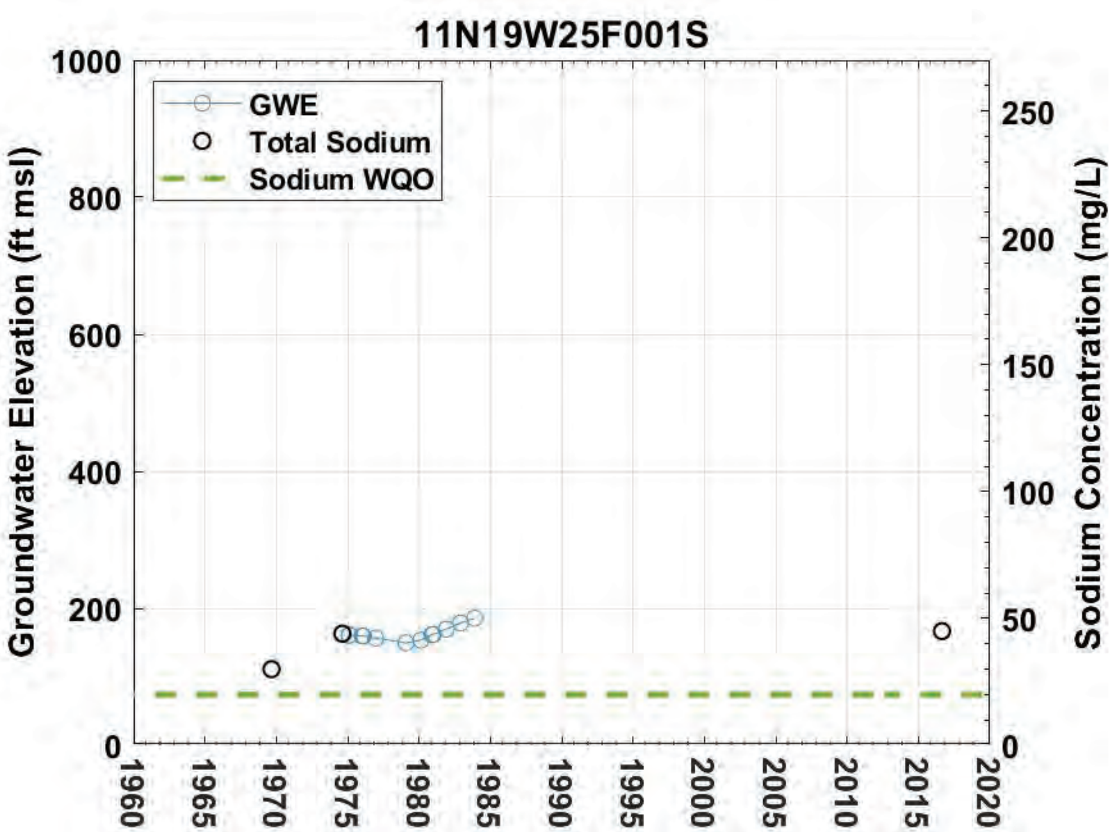

11N19W24M001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

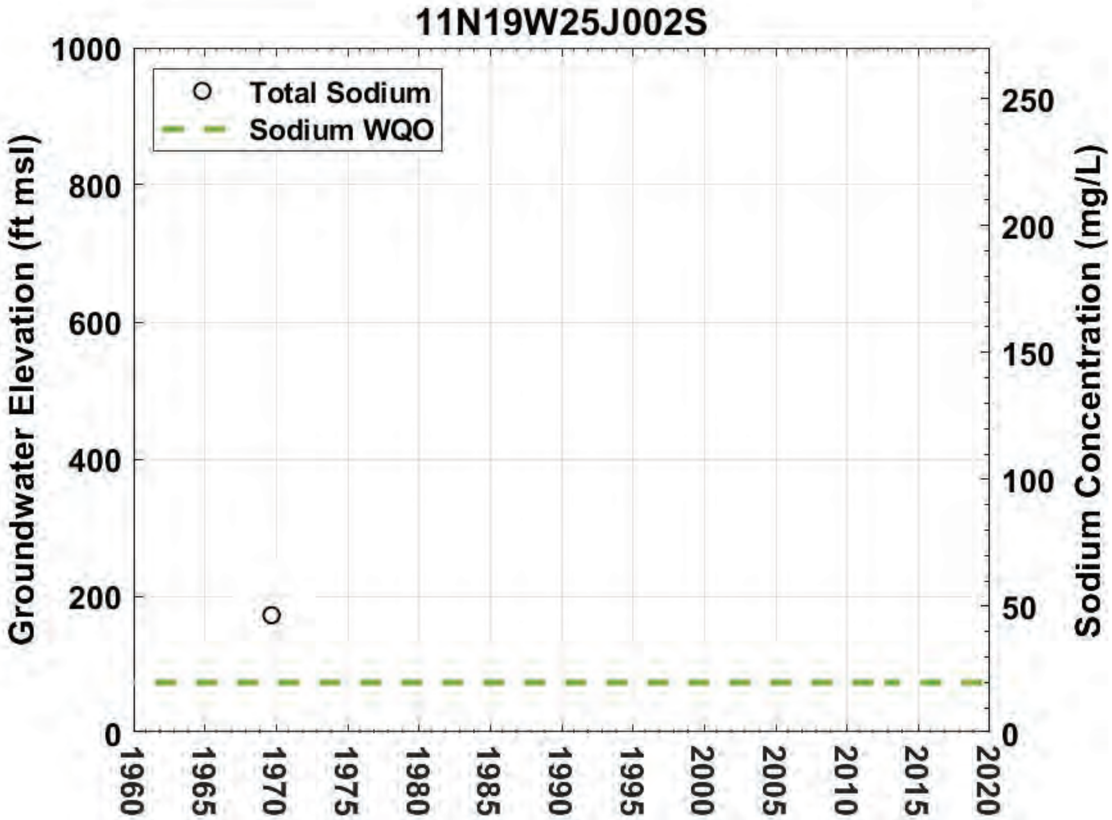

11N19W24N001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

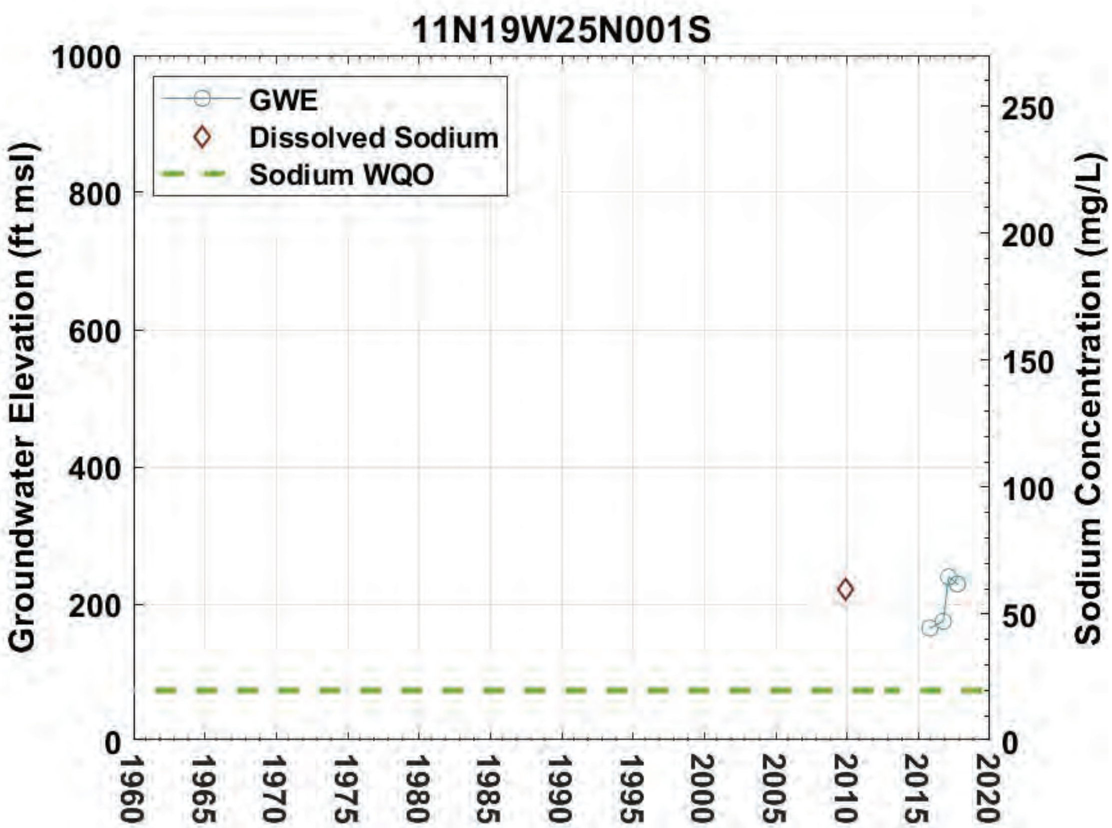

11N19W24R001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

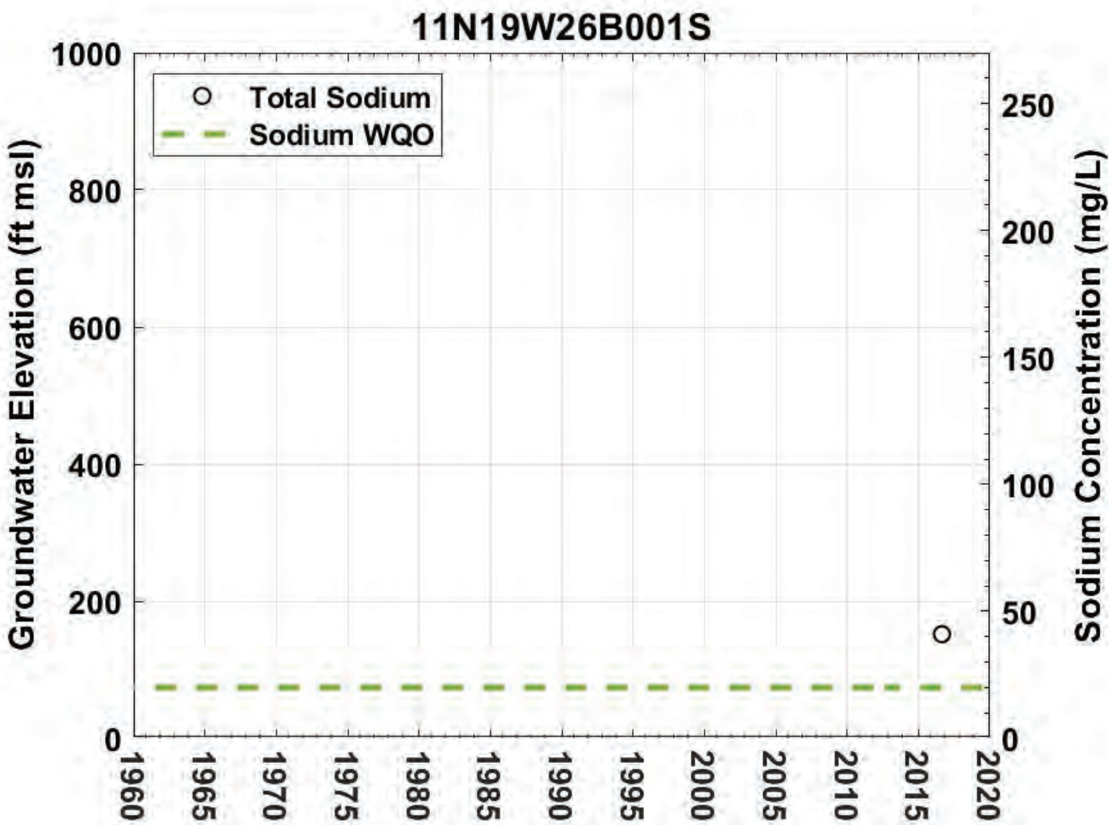

11N19W25B001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

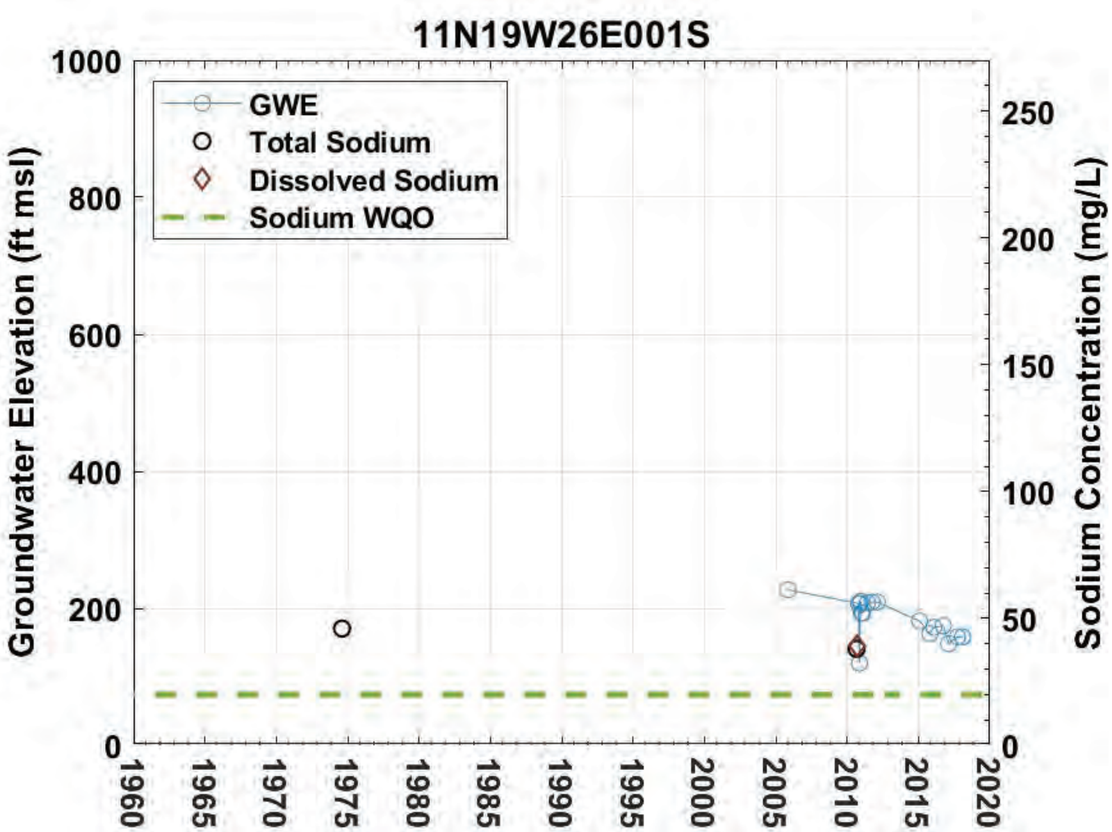

11N19W25C001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
Total Sodium
Sodium WQO
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

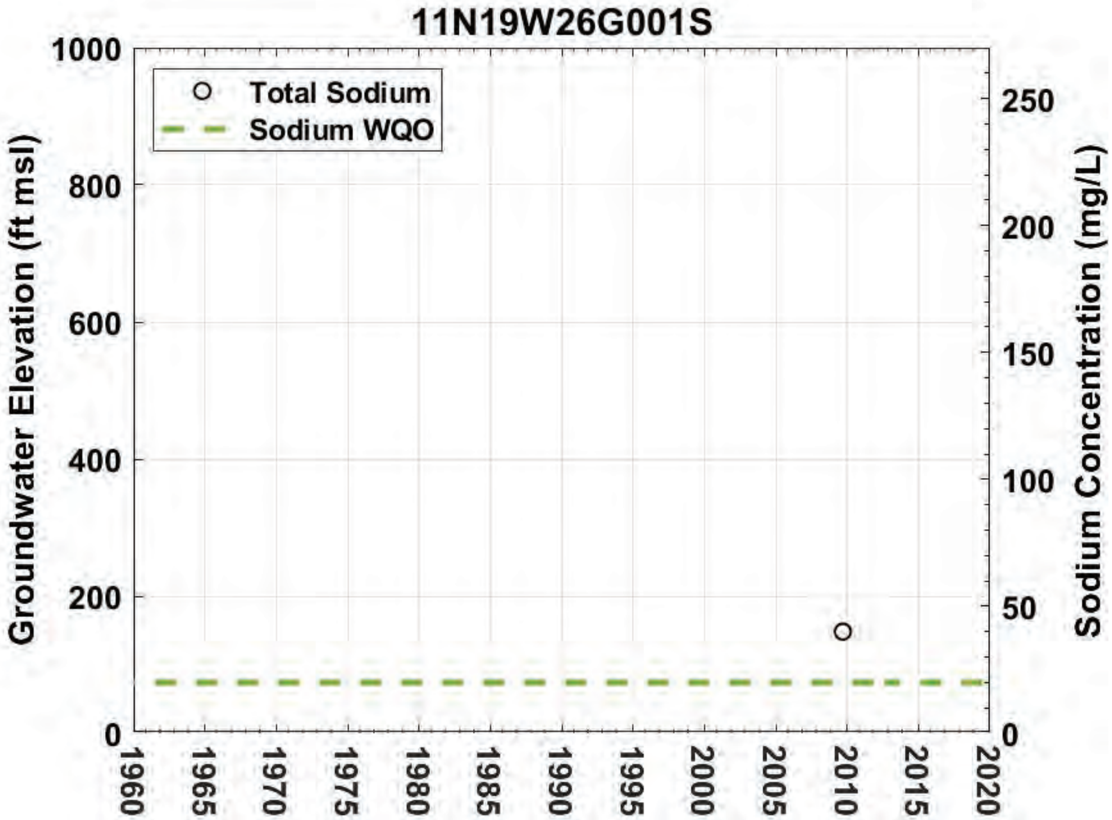

11N19W25F001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
GWE
Total Sodium
Sodium WQO
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

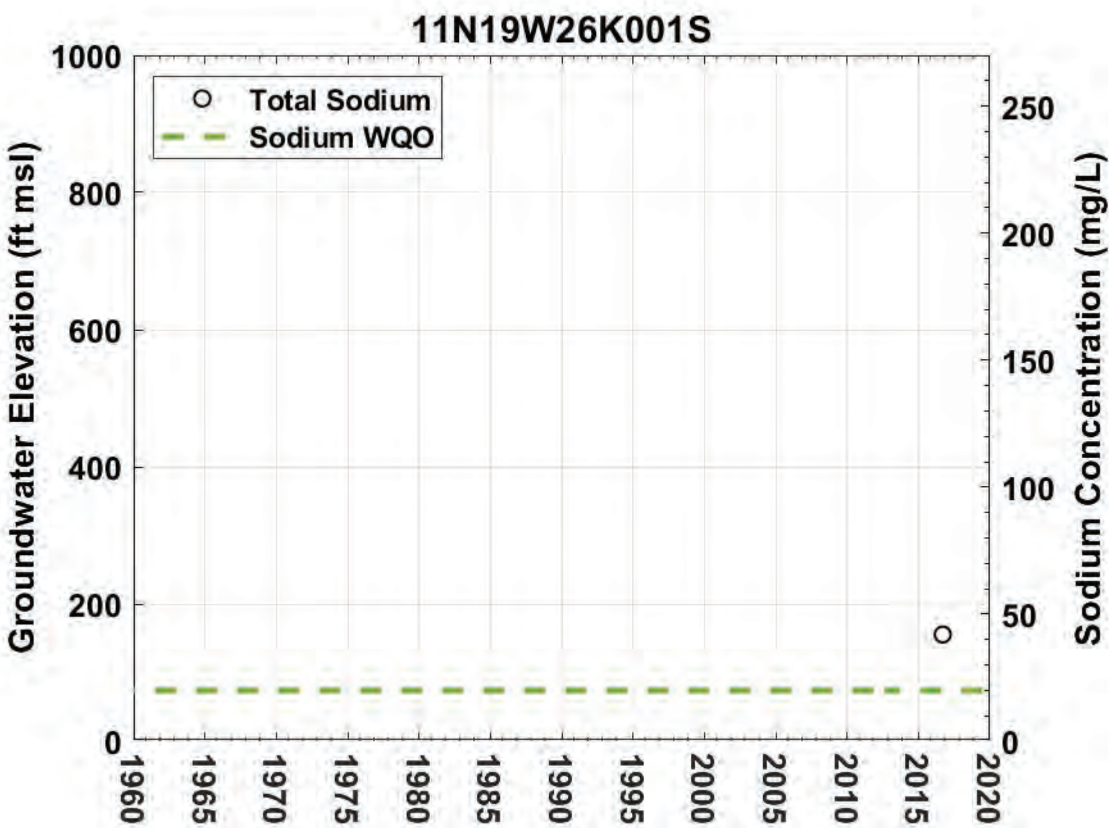

11N19W25J002S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

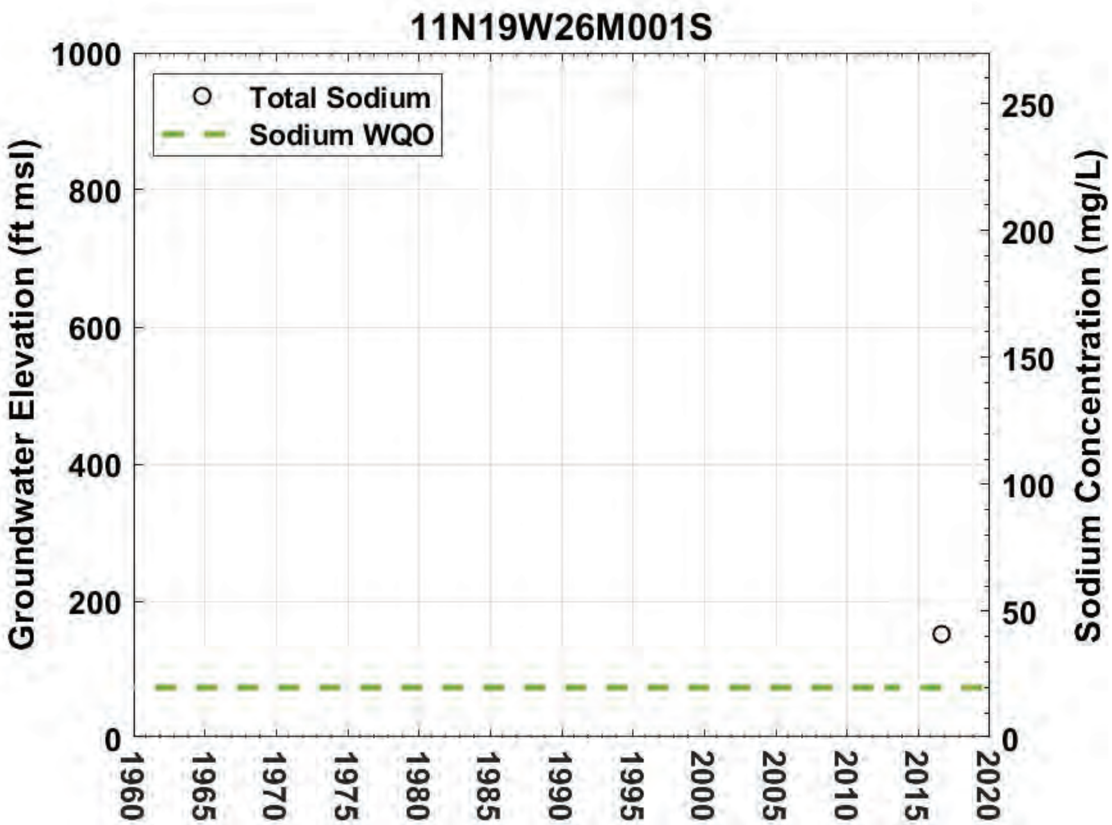

11N19W25N001S
GWE
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

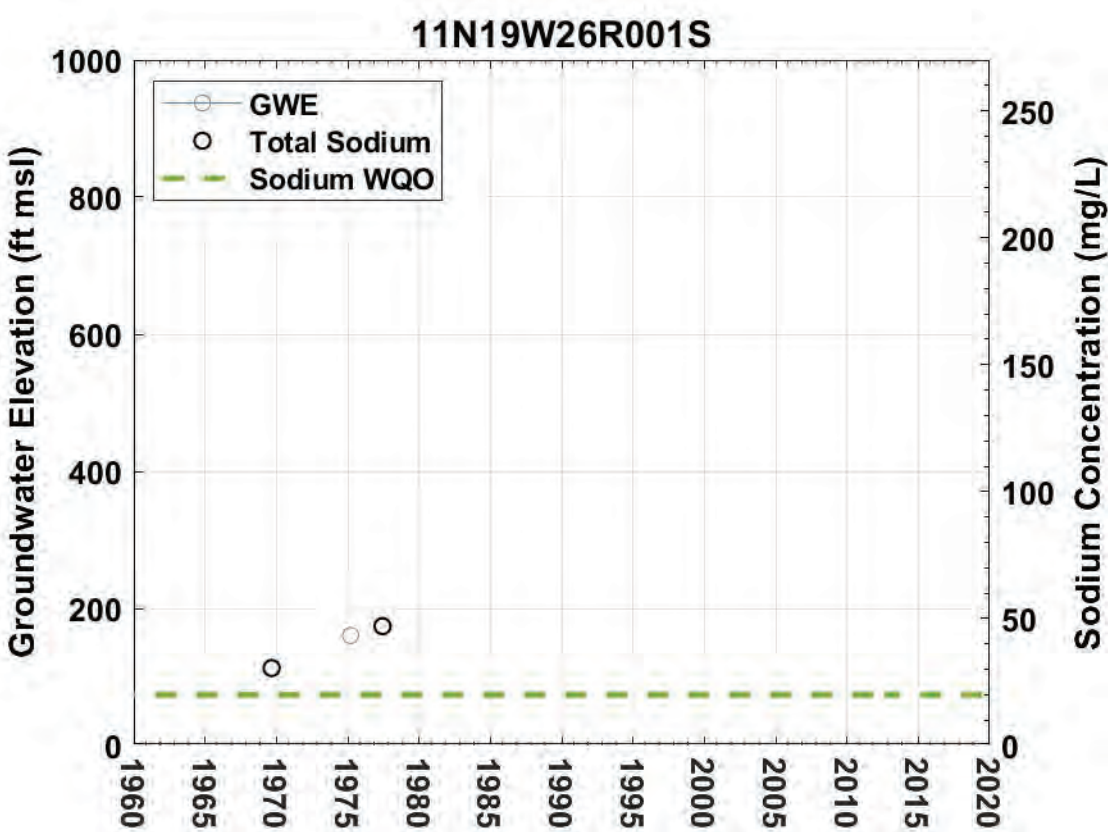

11N19W26B001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

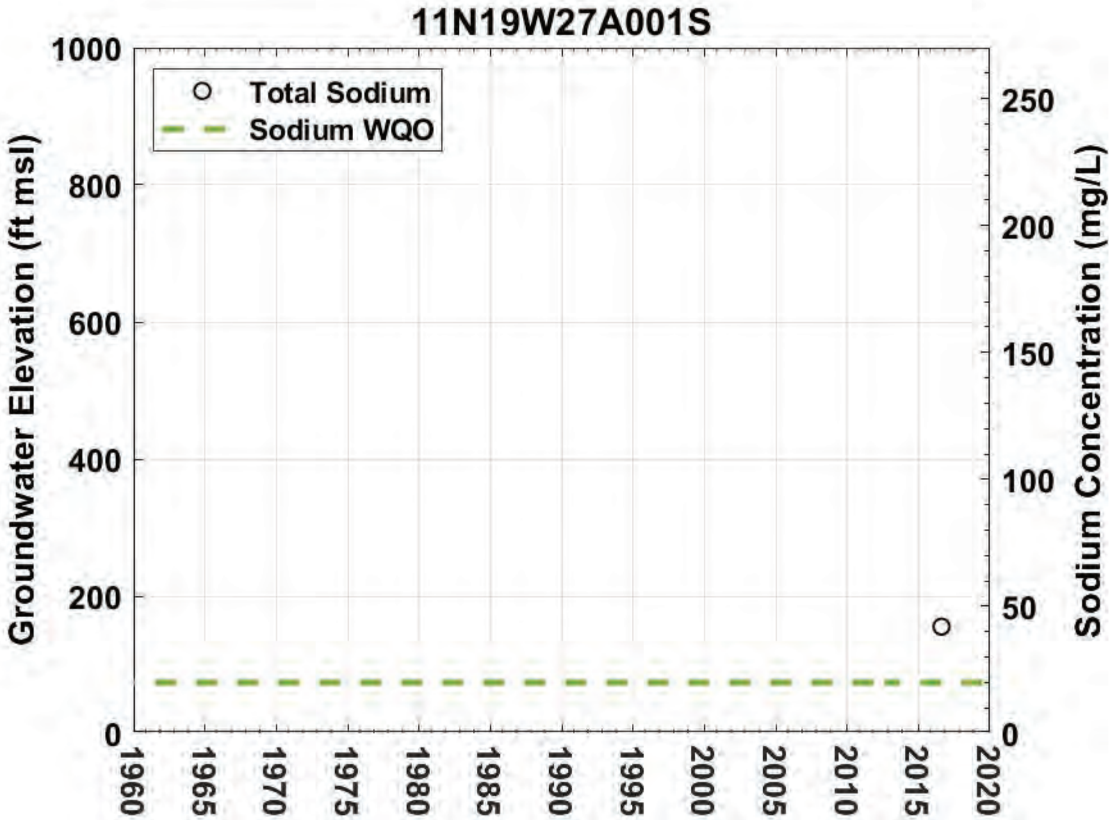

11N19W26E001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W26G001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

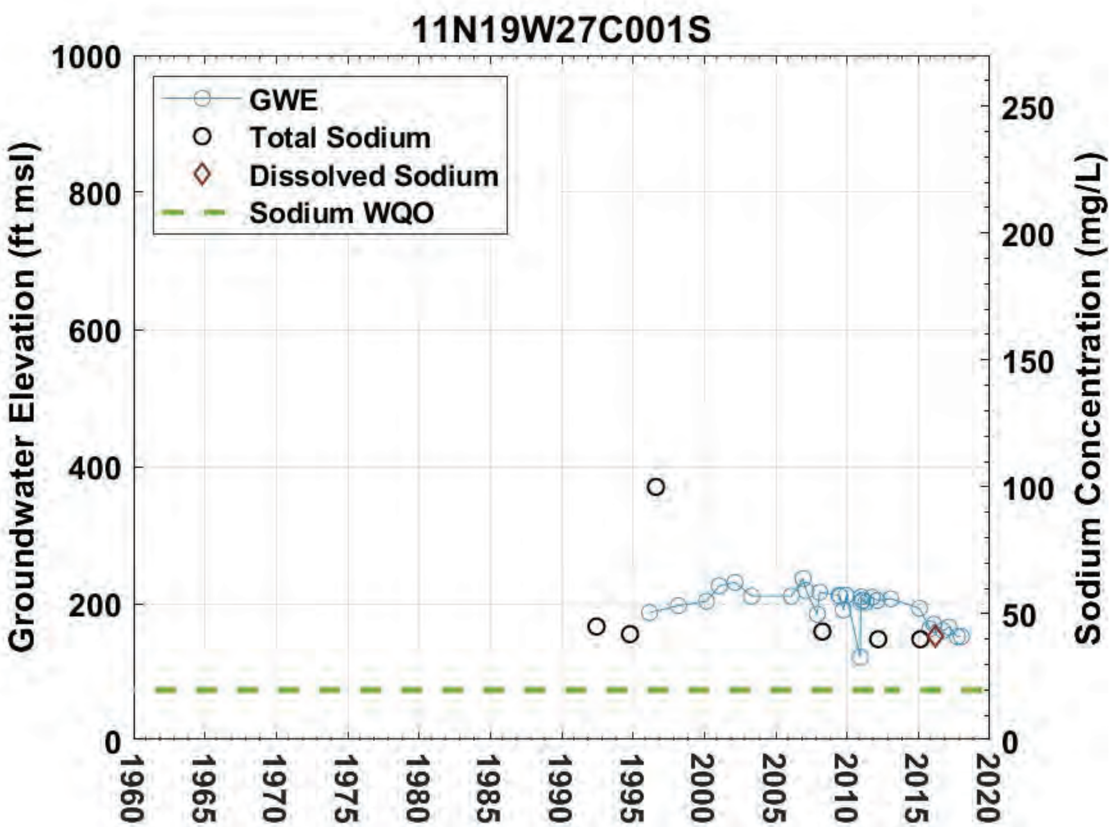

11N19W26K001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W26M001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

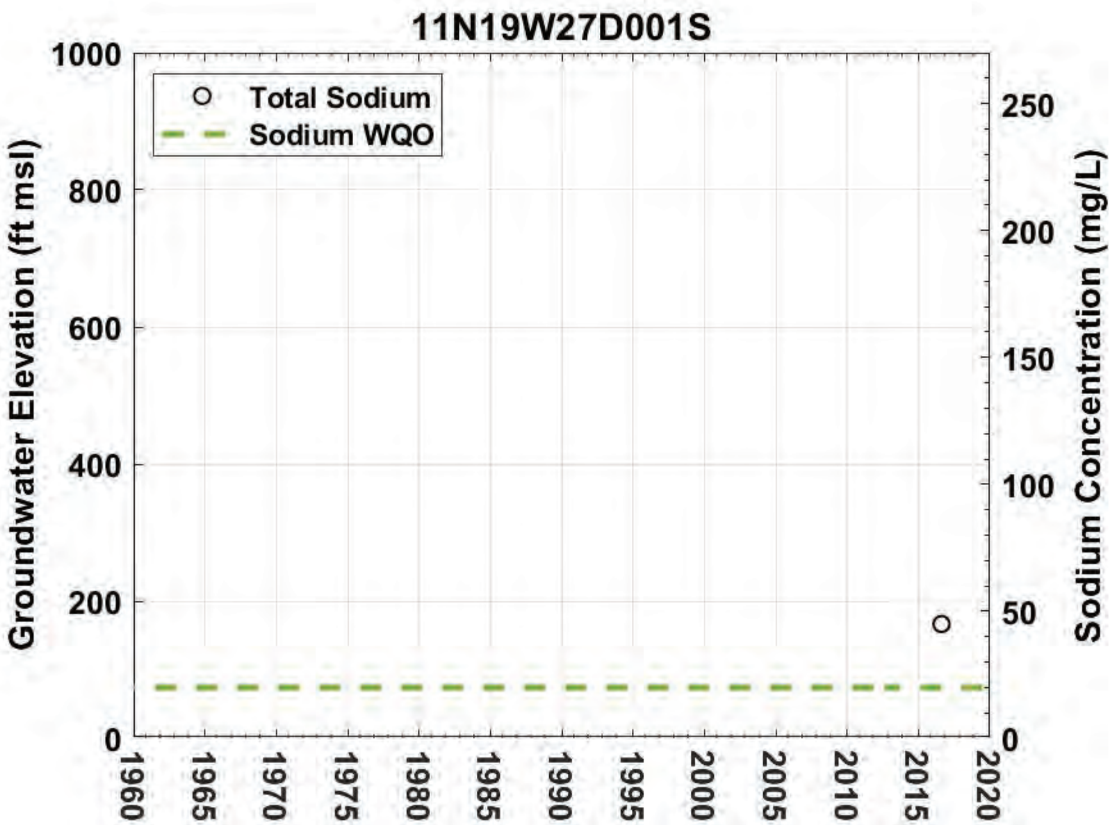

11N19W26R001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

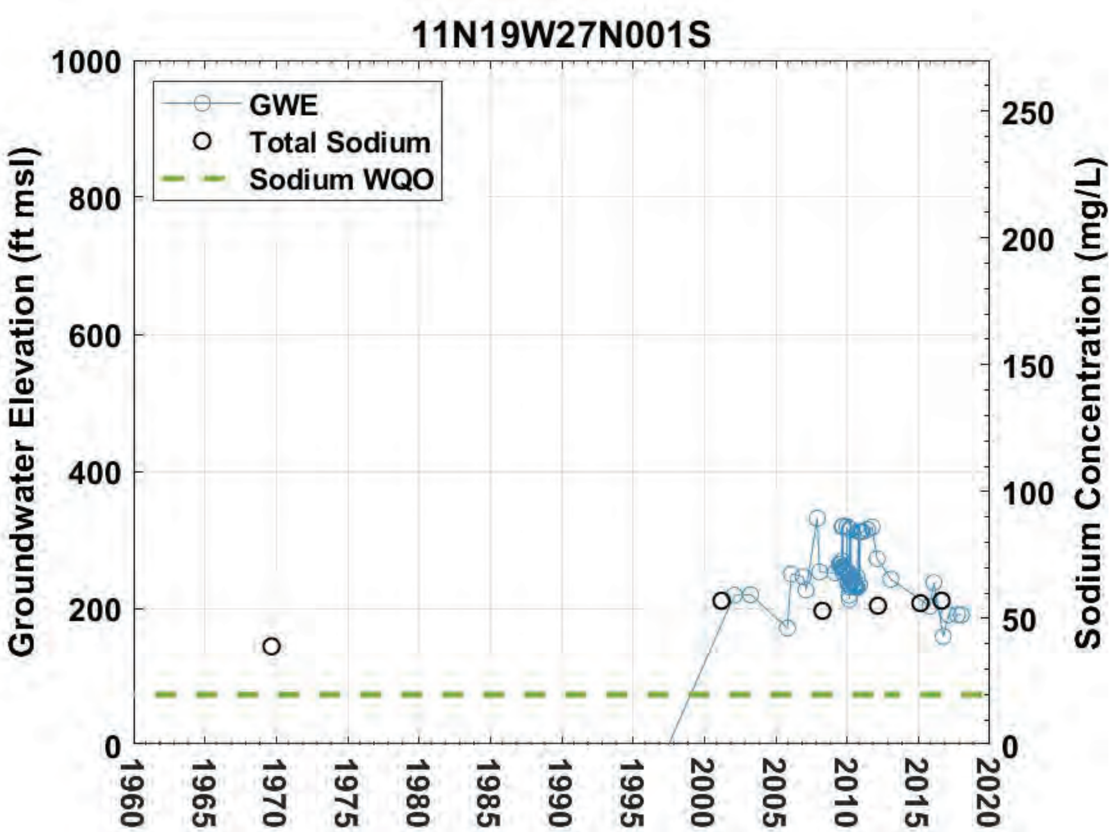


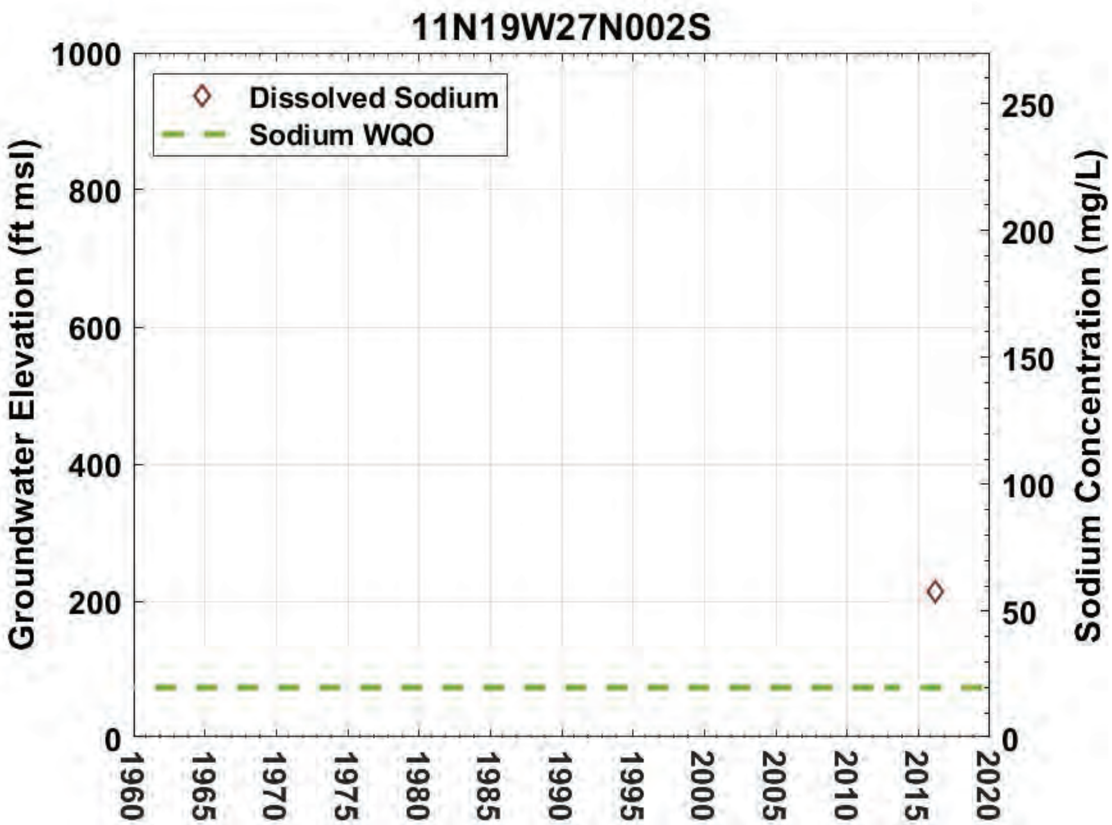
11N19W27A001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



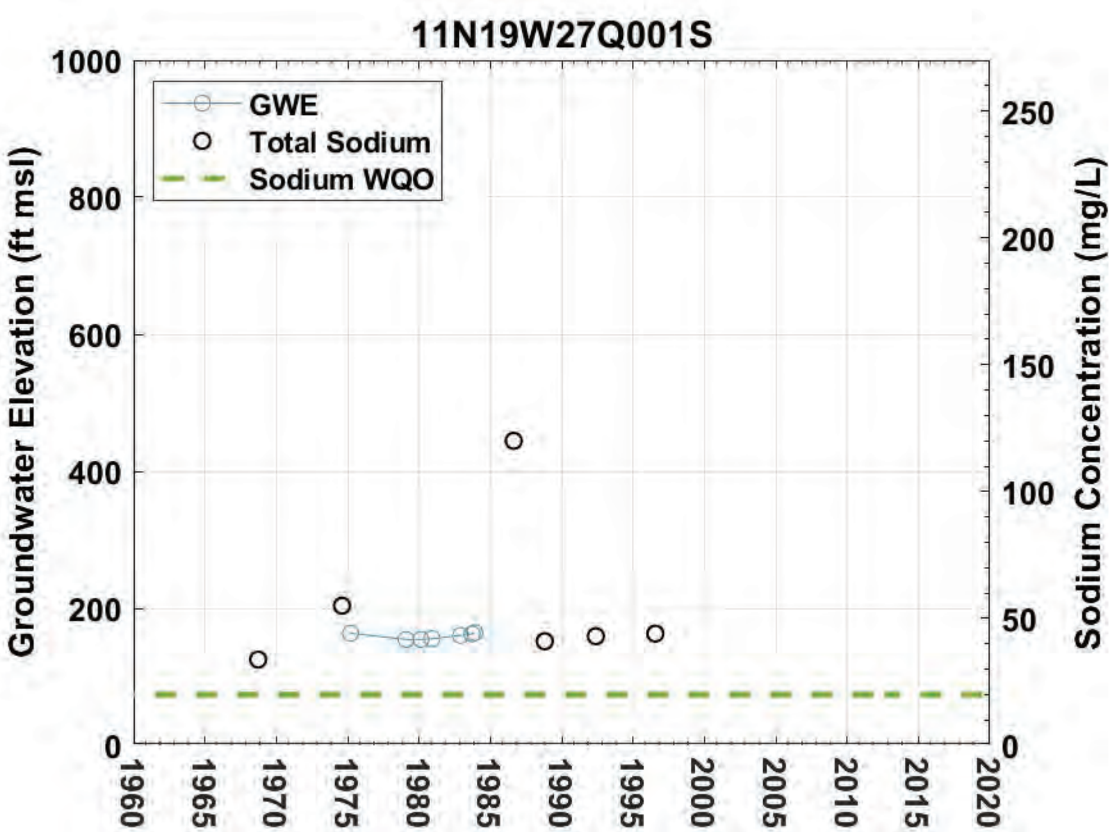
11N19W27C001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W27D001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

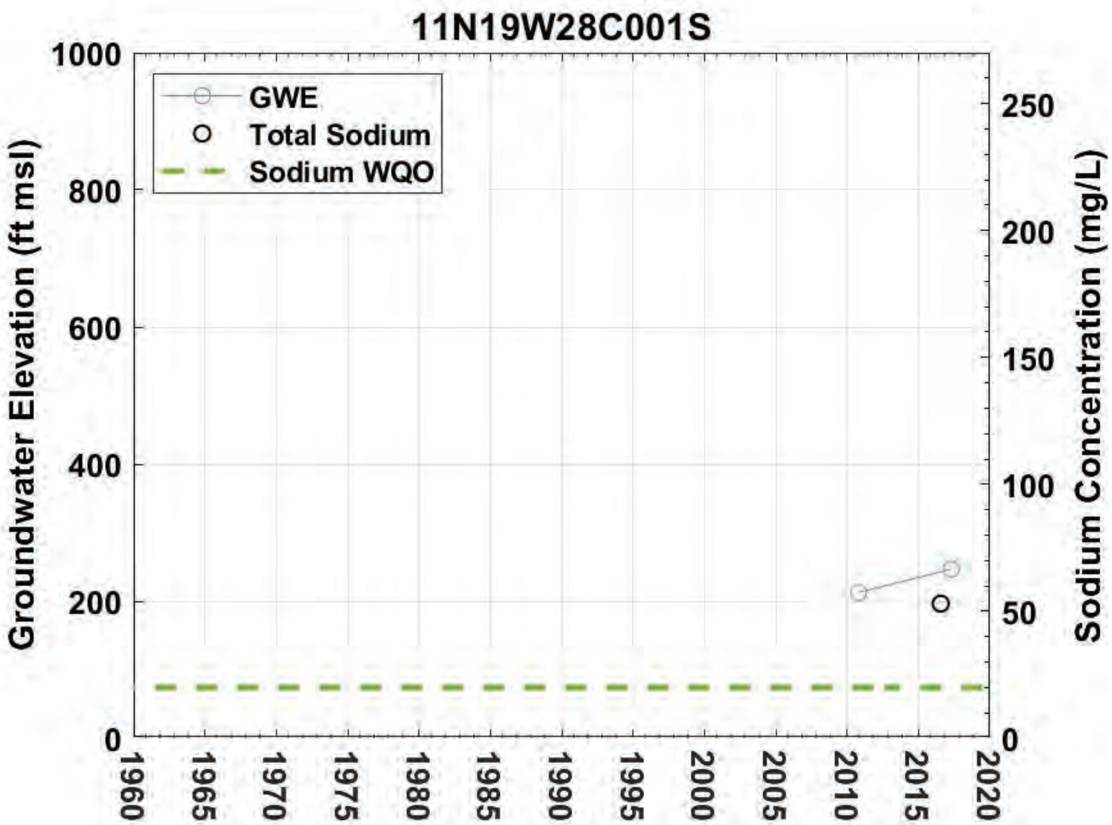

11N19W27N001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

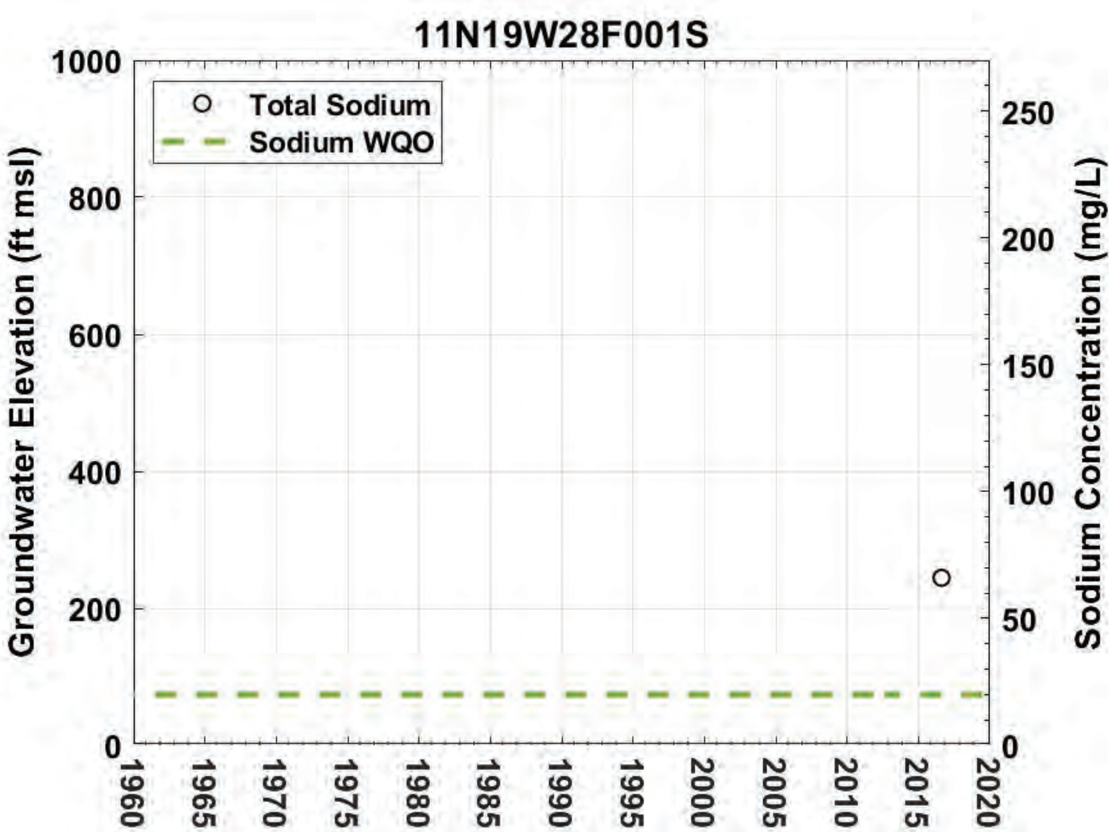


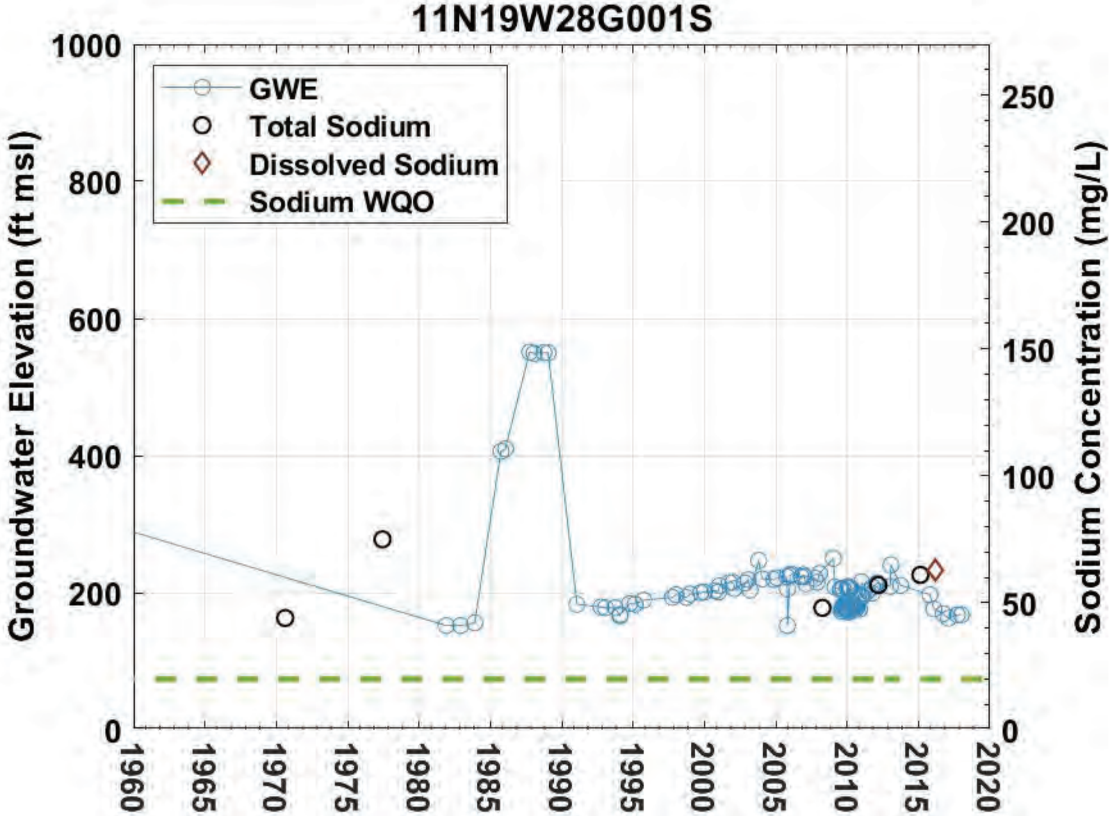
11N19W27N002S
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

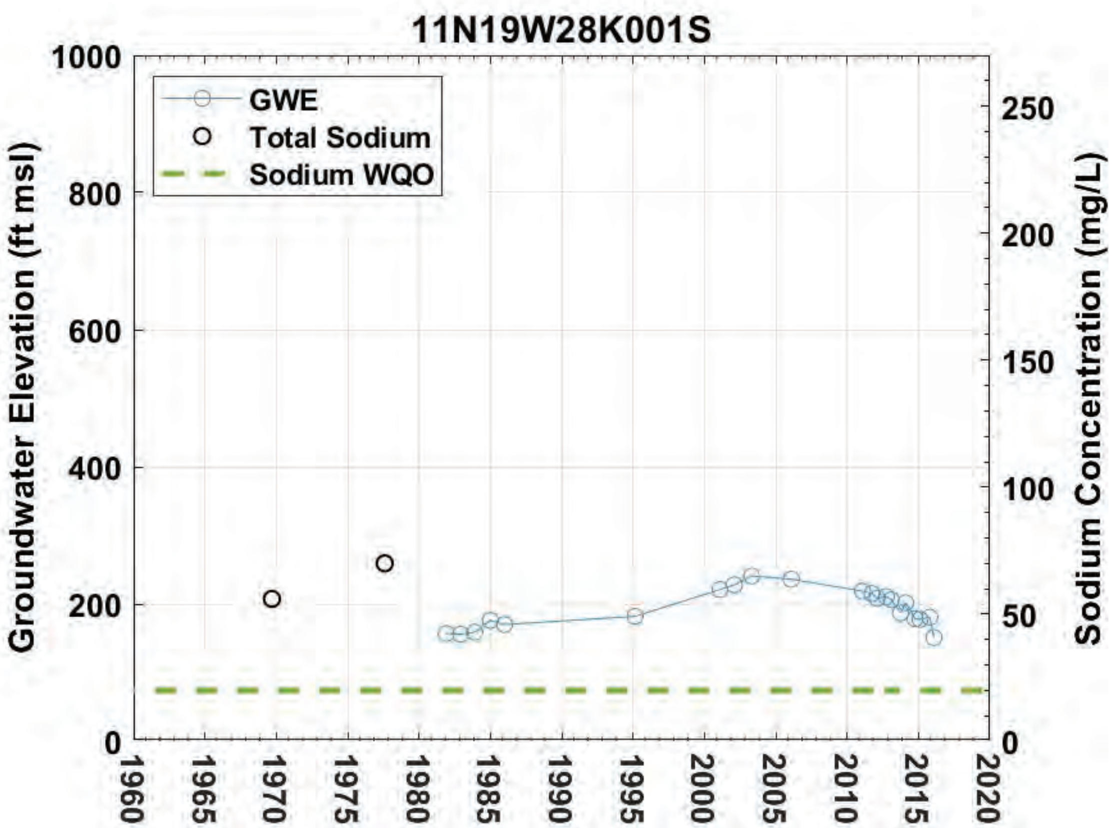


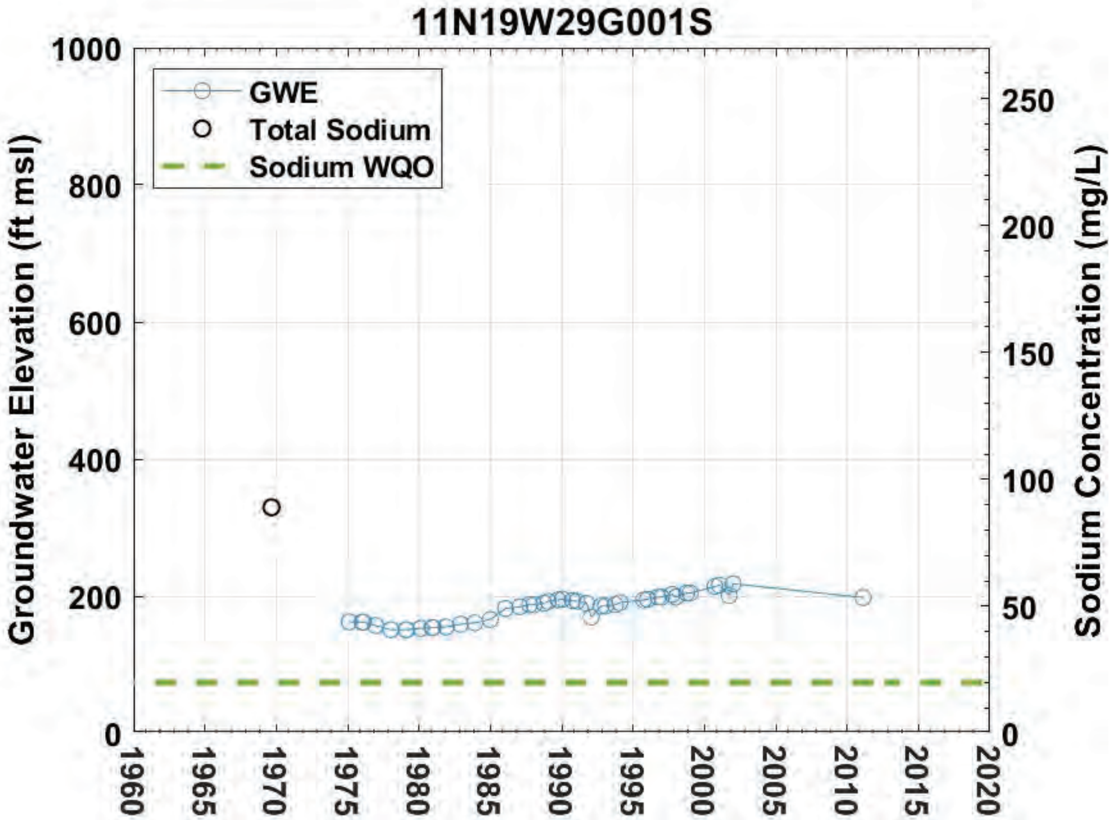
11N19W27Q001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

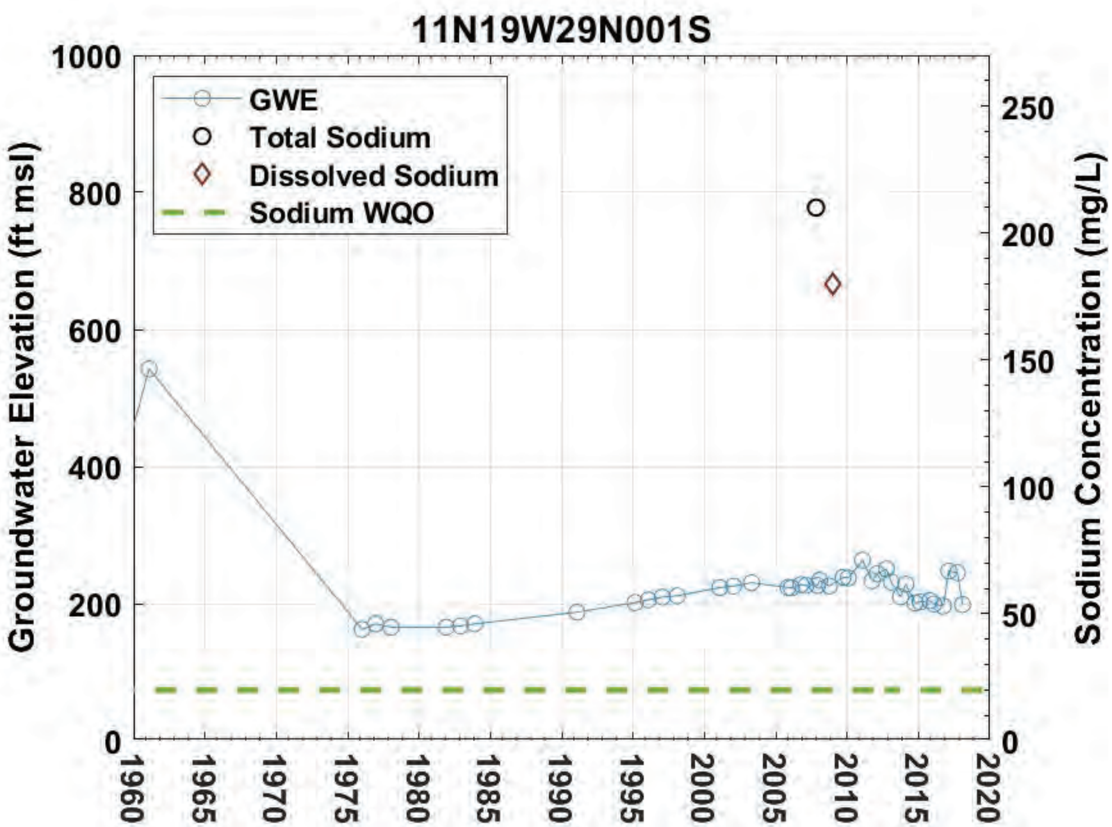

11N19W28C001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

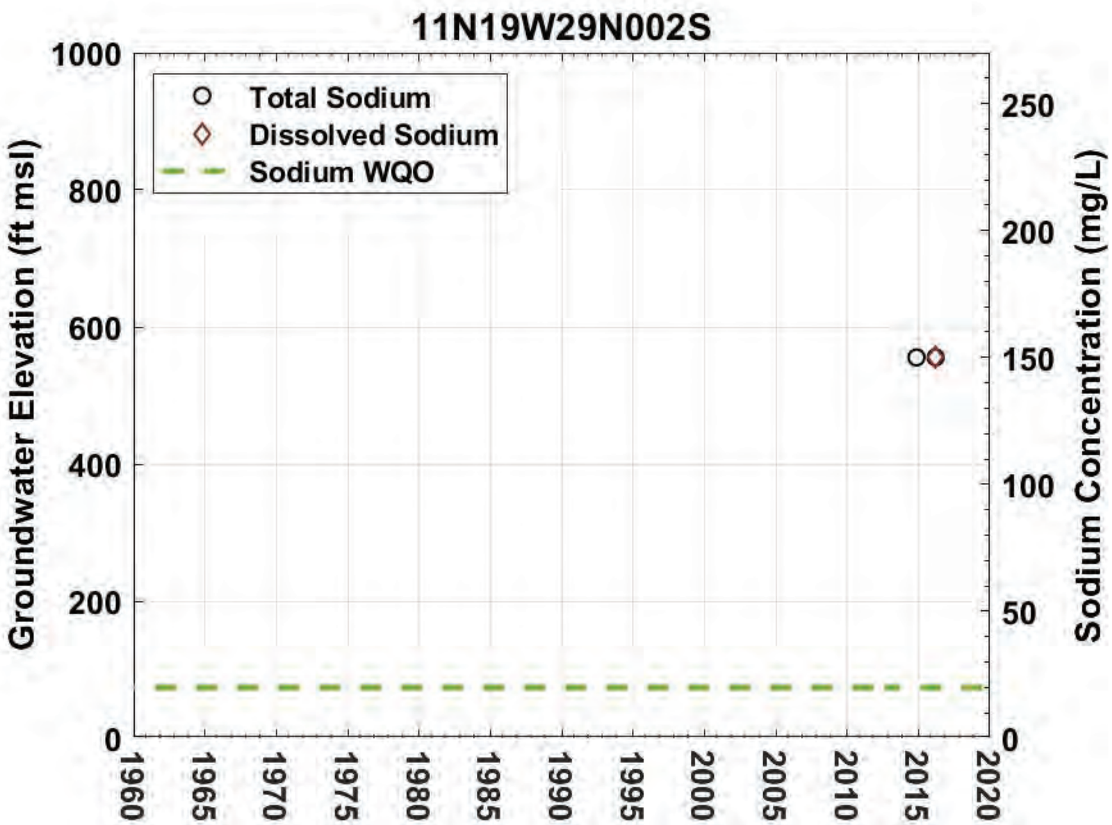

11N19W28F001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

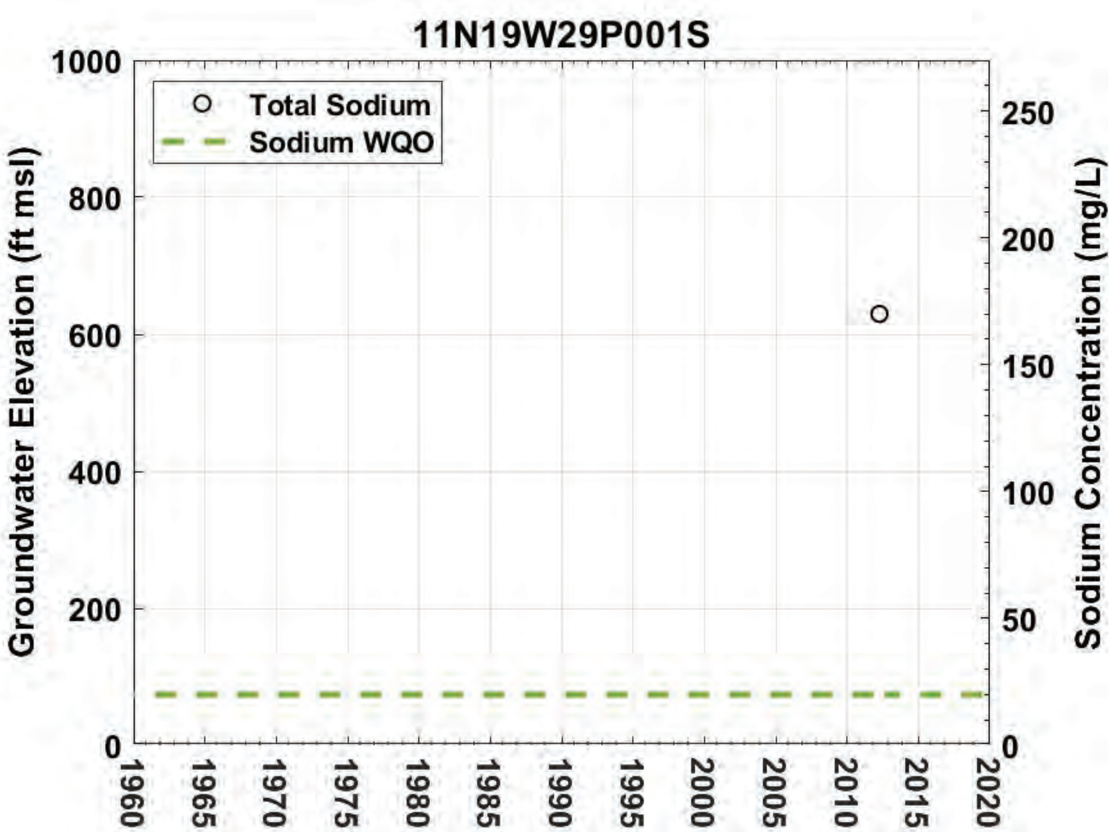

11N19W28G001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

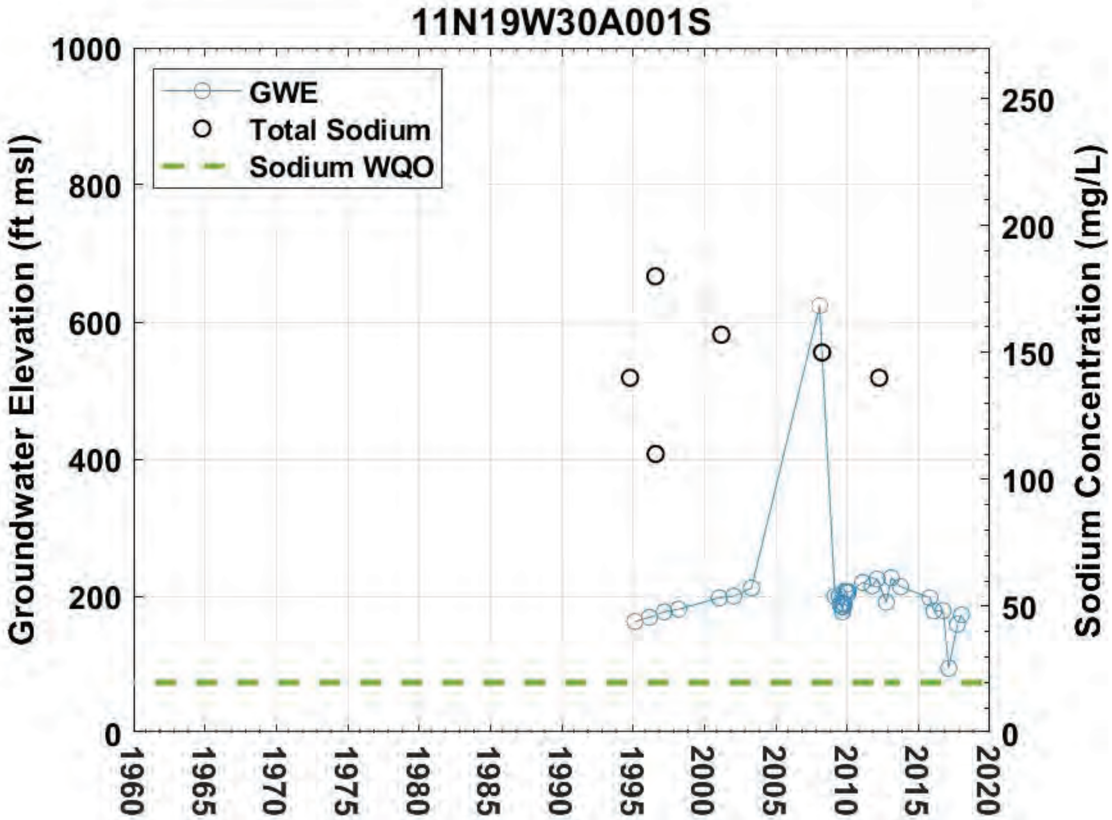

11N19W28K001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

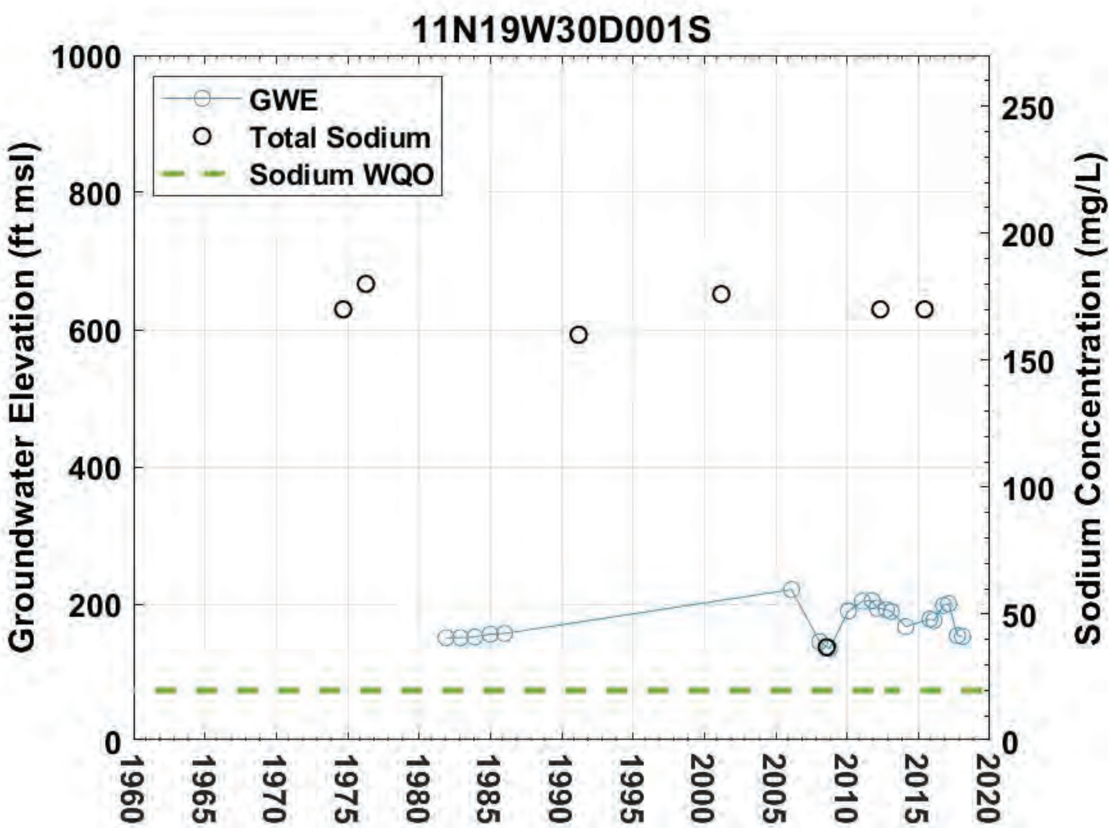

11N19W29G001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

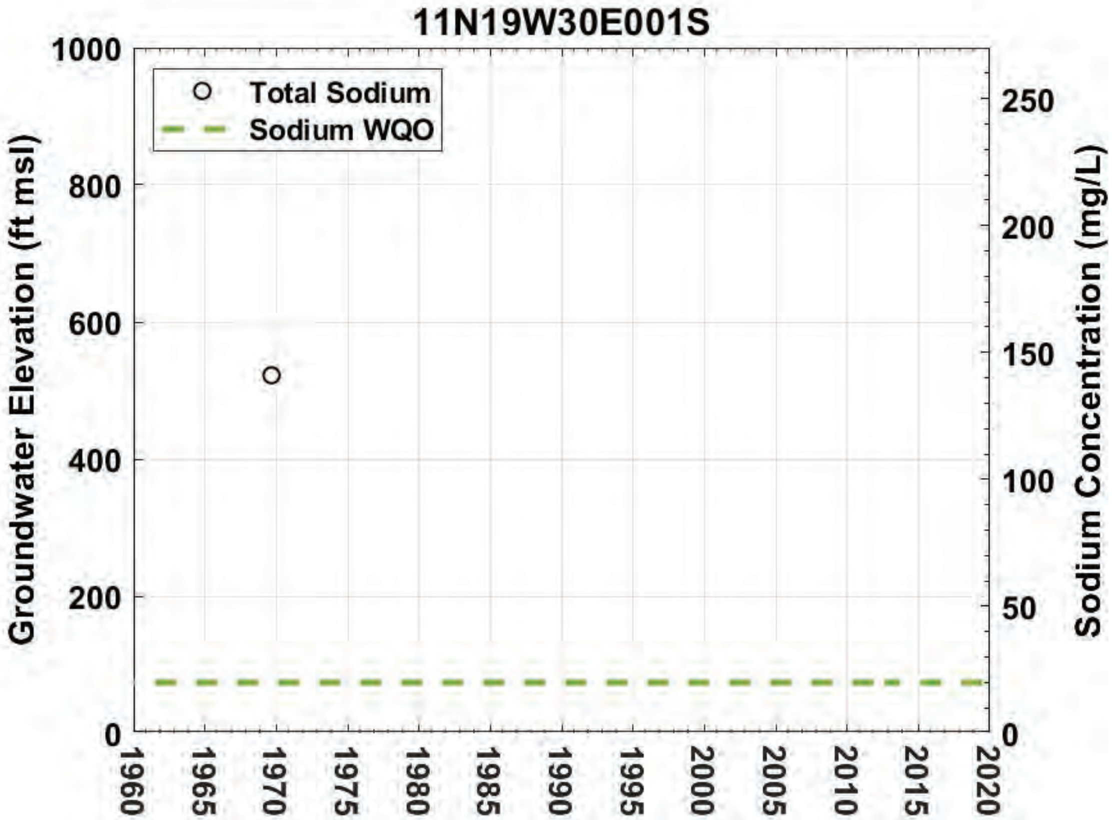

11N19W29N001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

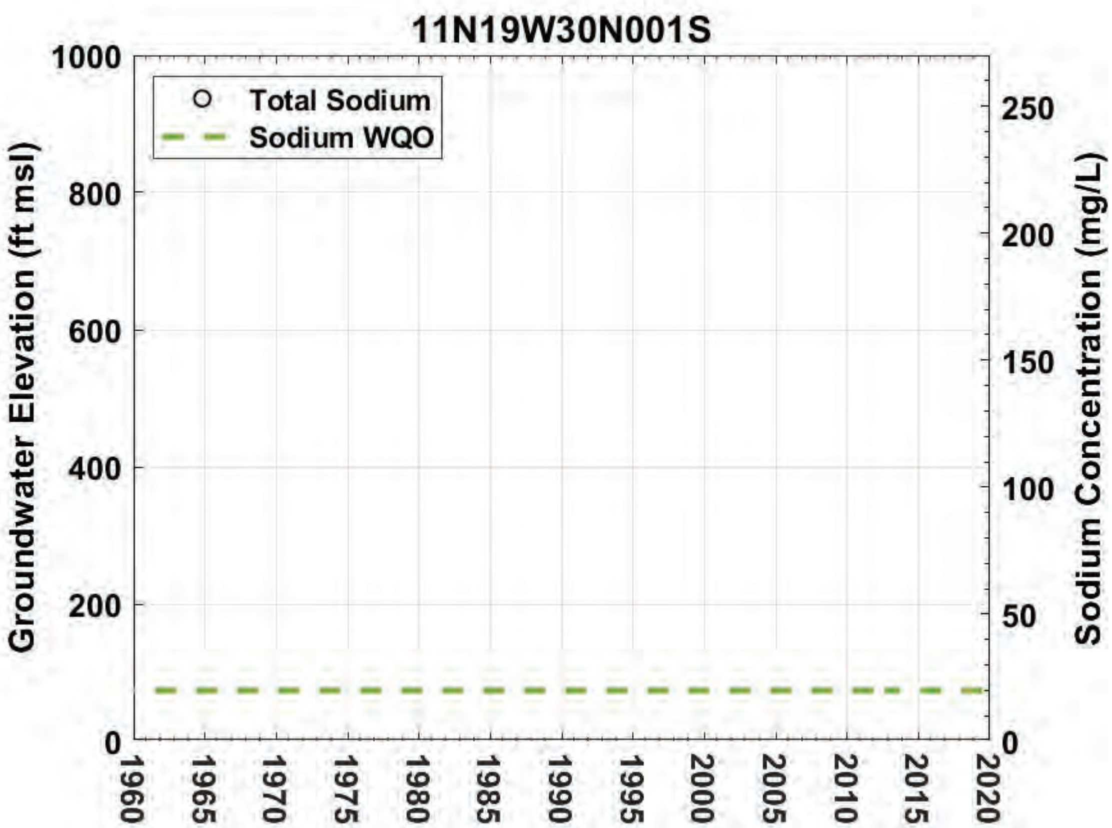

11N19W29N002S
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

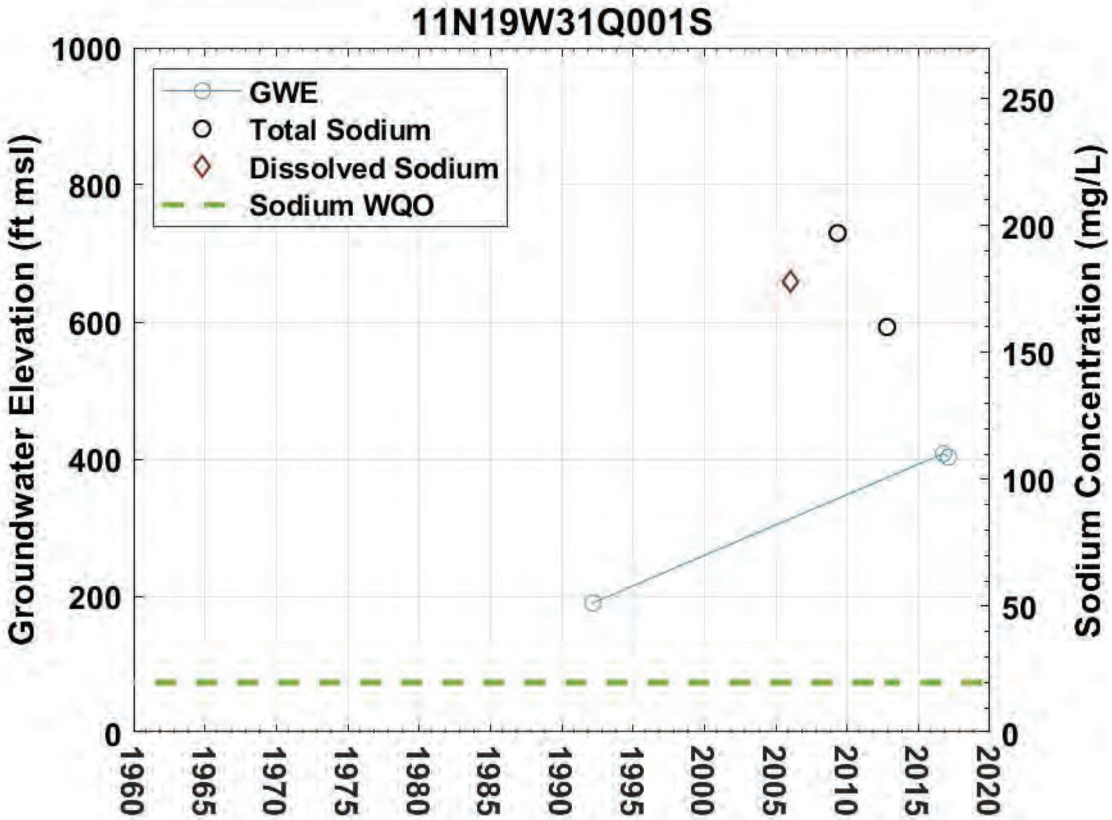

11N19W29P001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

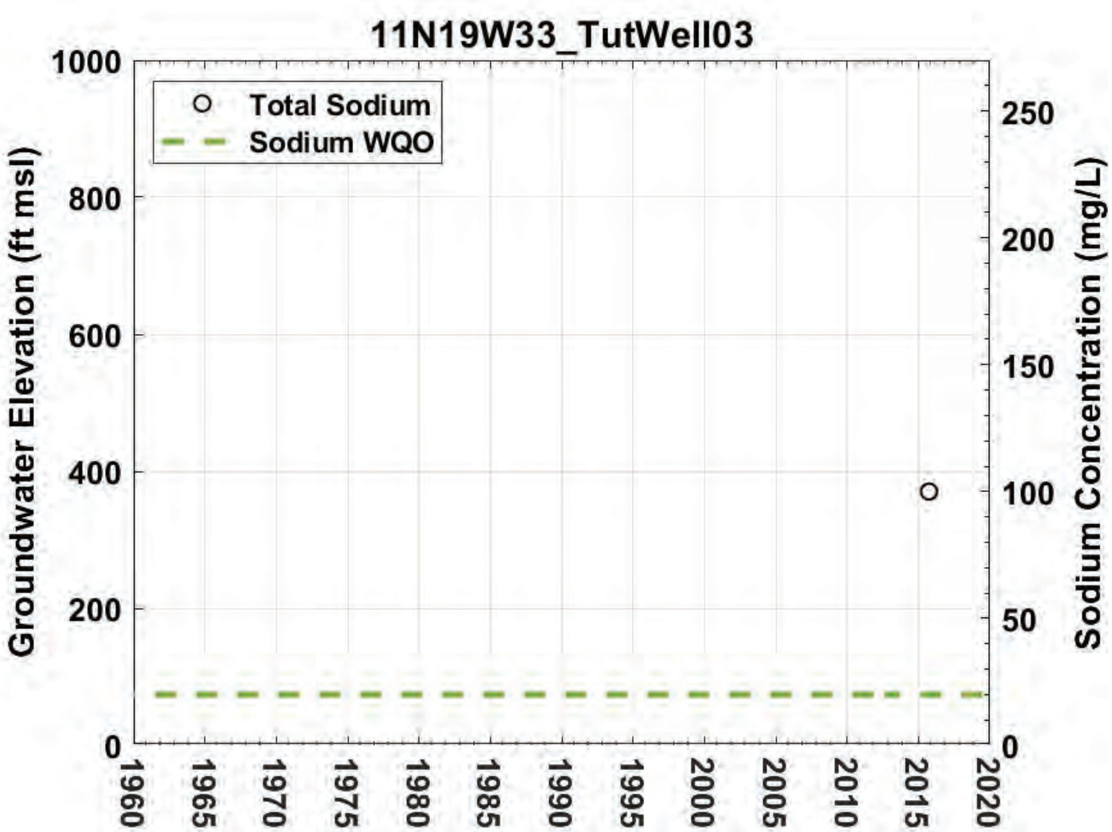

11N19W30A001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
GWE
Total Sodium
Sodium WQO
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

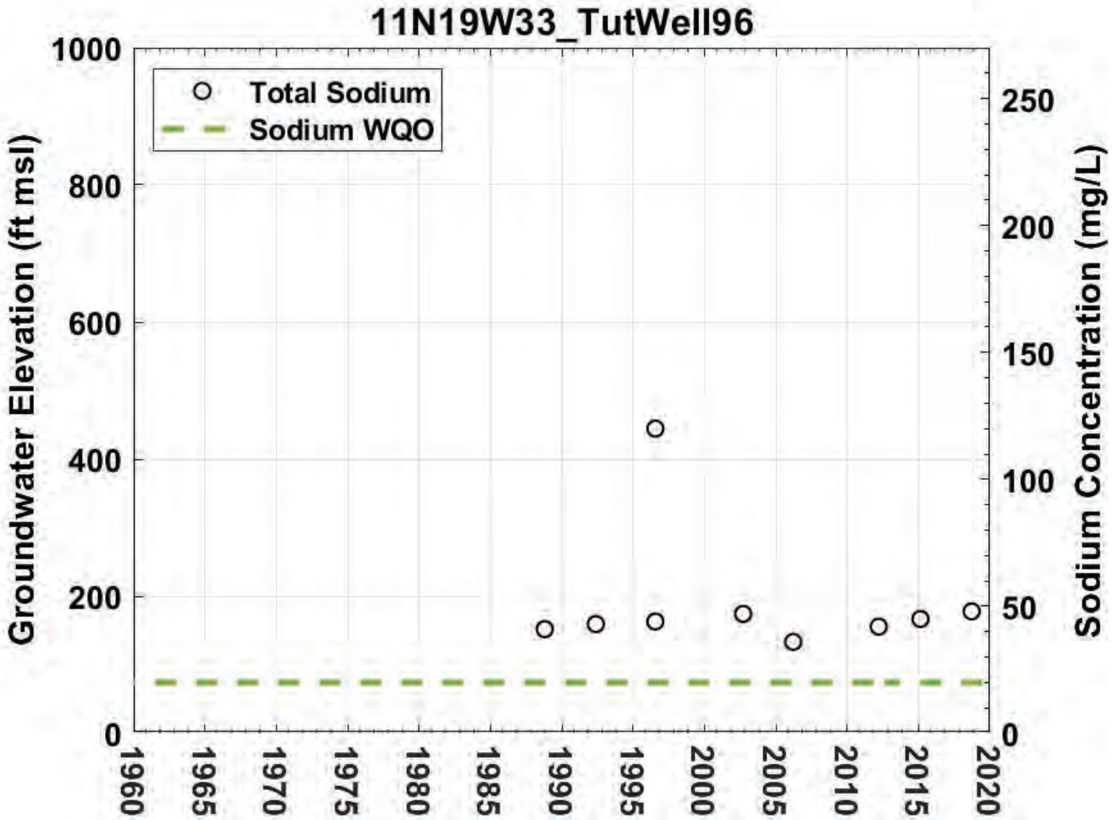

11N19W30D001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
GWE
Total Sodium
Sodium WQO
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

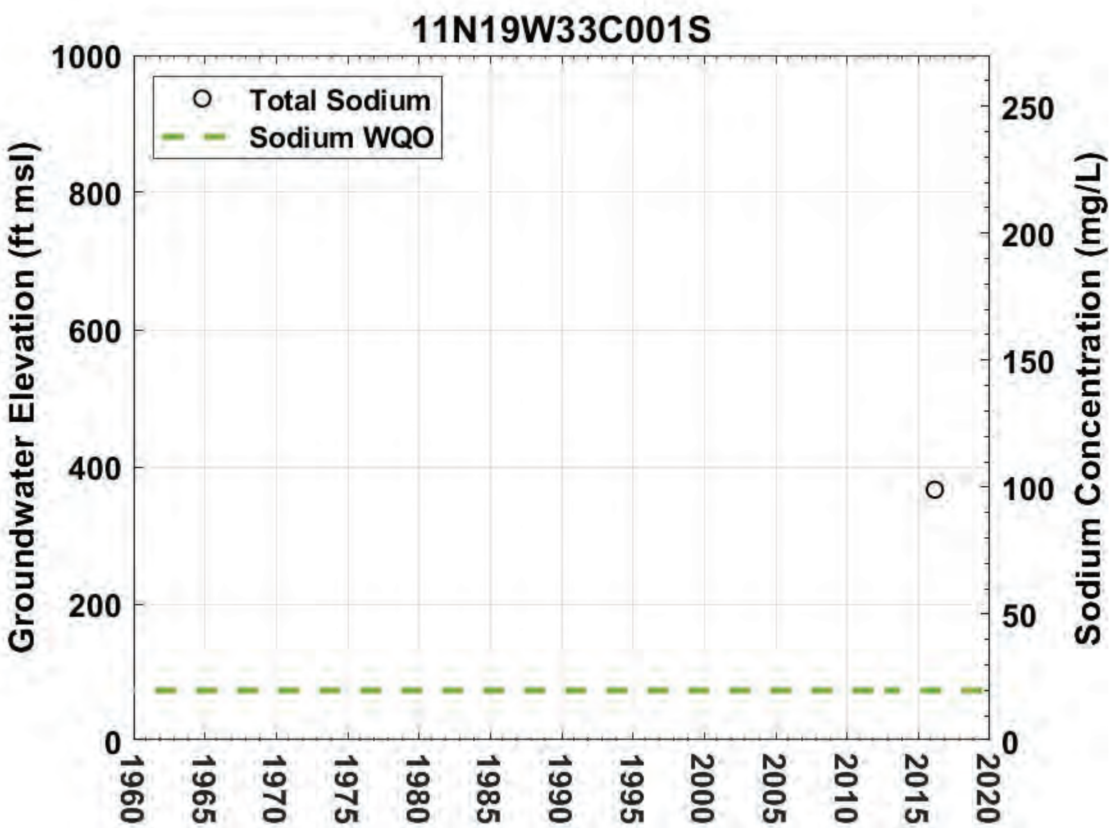

11N19W30E001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

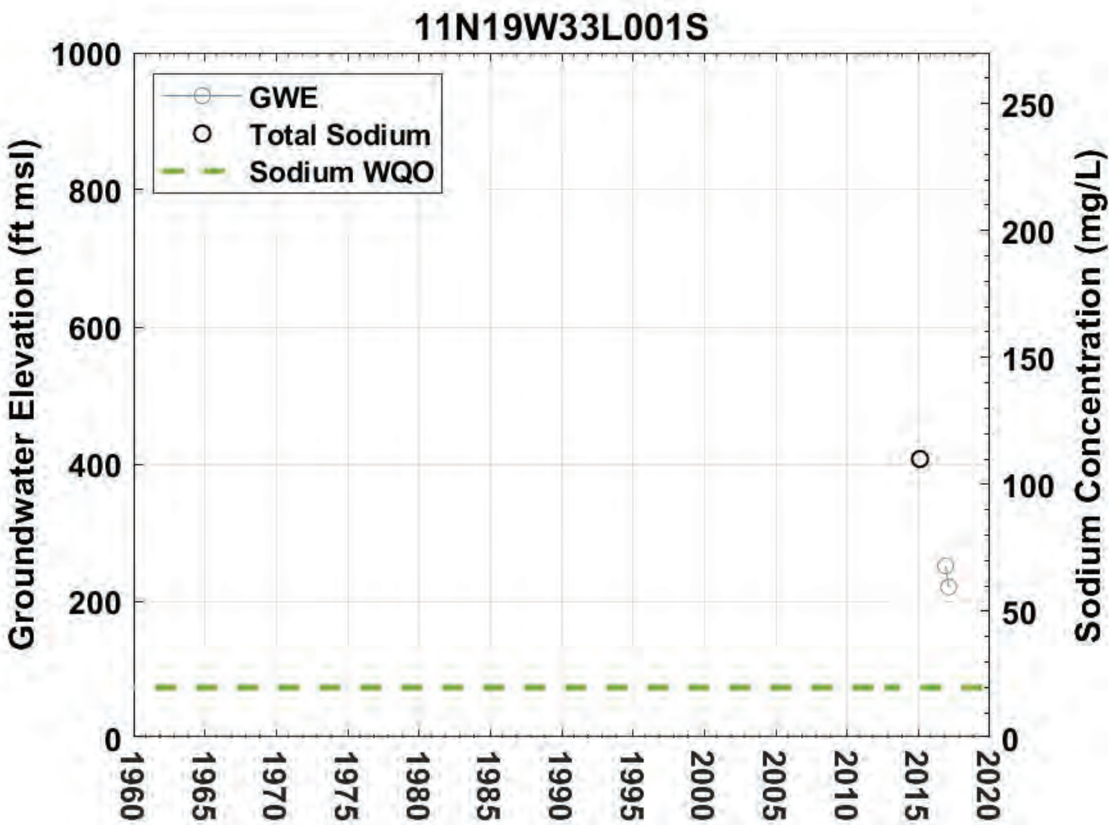

11N19W30N001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

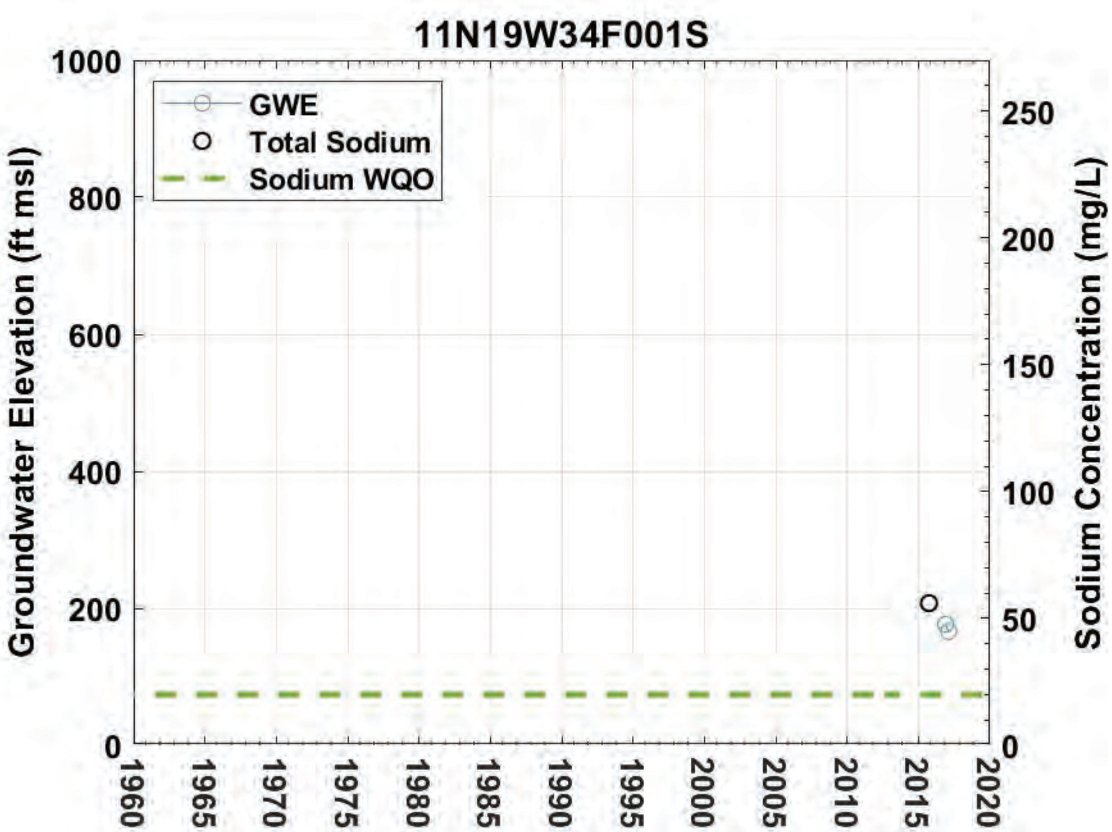

11N19W31Q001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

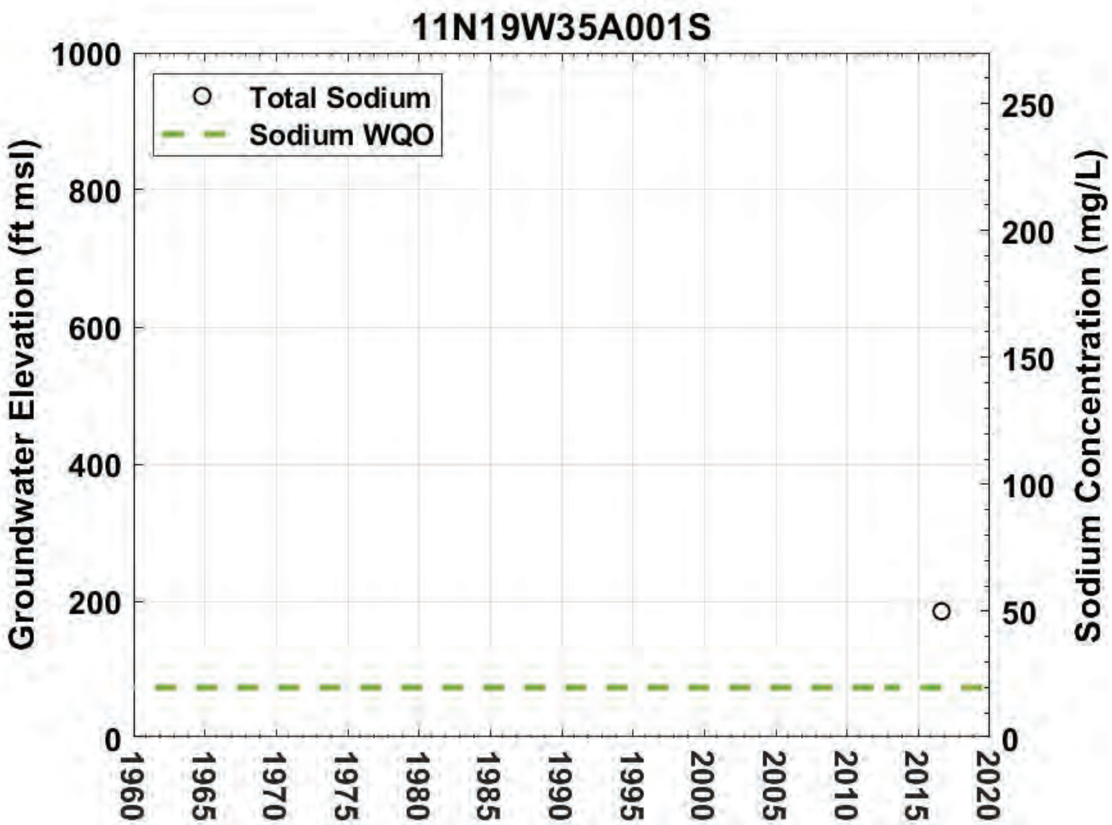

11N19W33_TutWell03
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

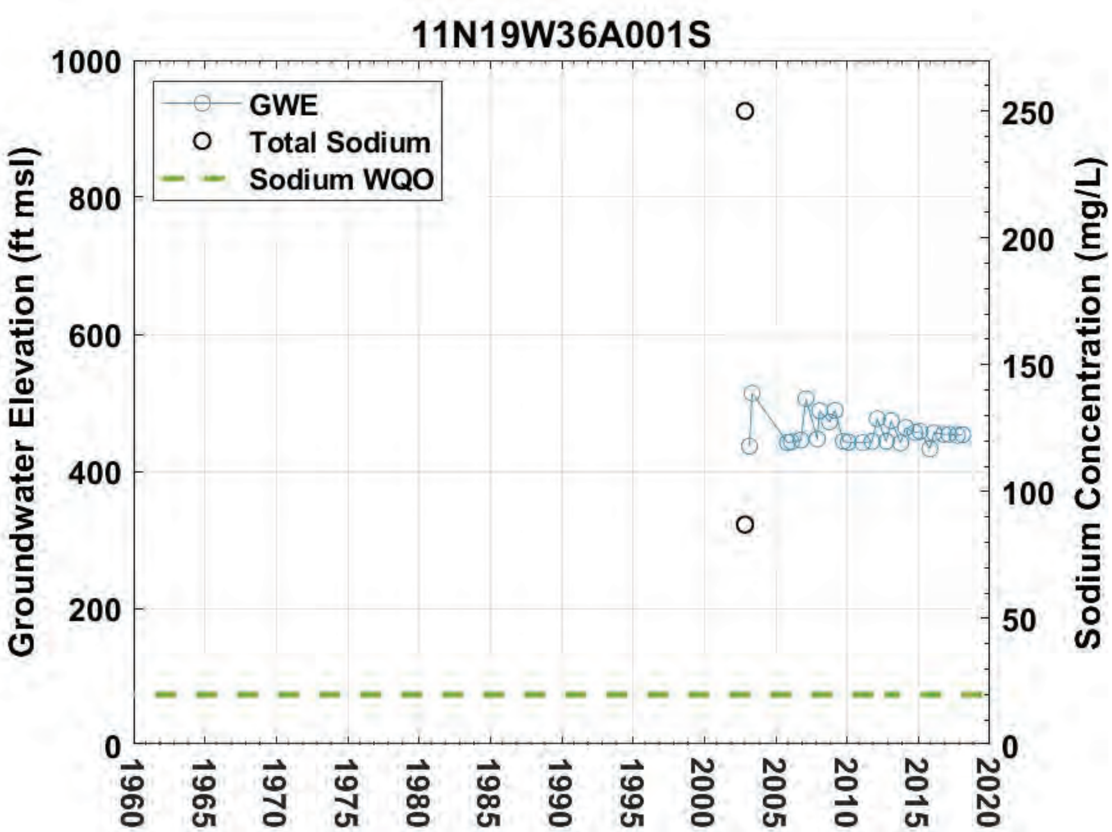

11N19W33_TutWell96
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

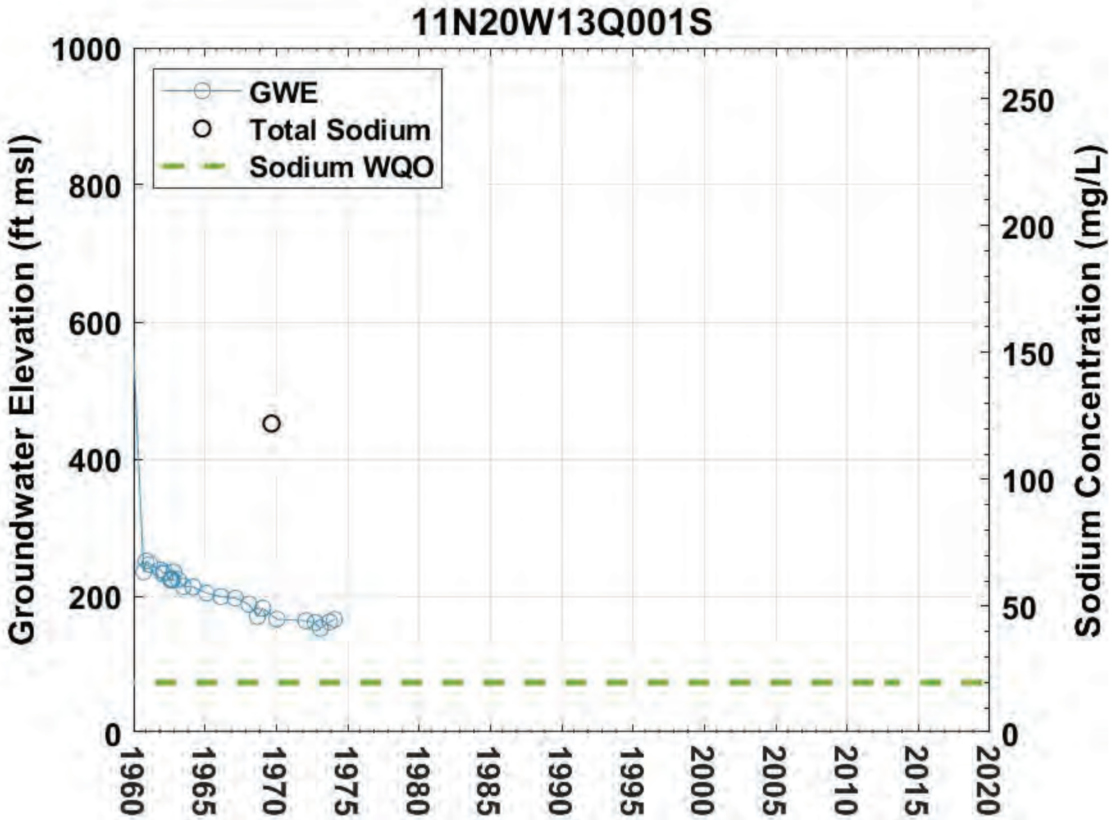

11N19W33C001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W33L001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

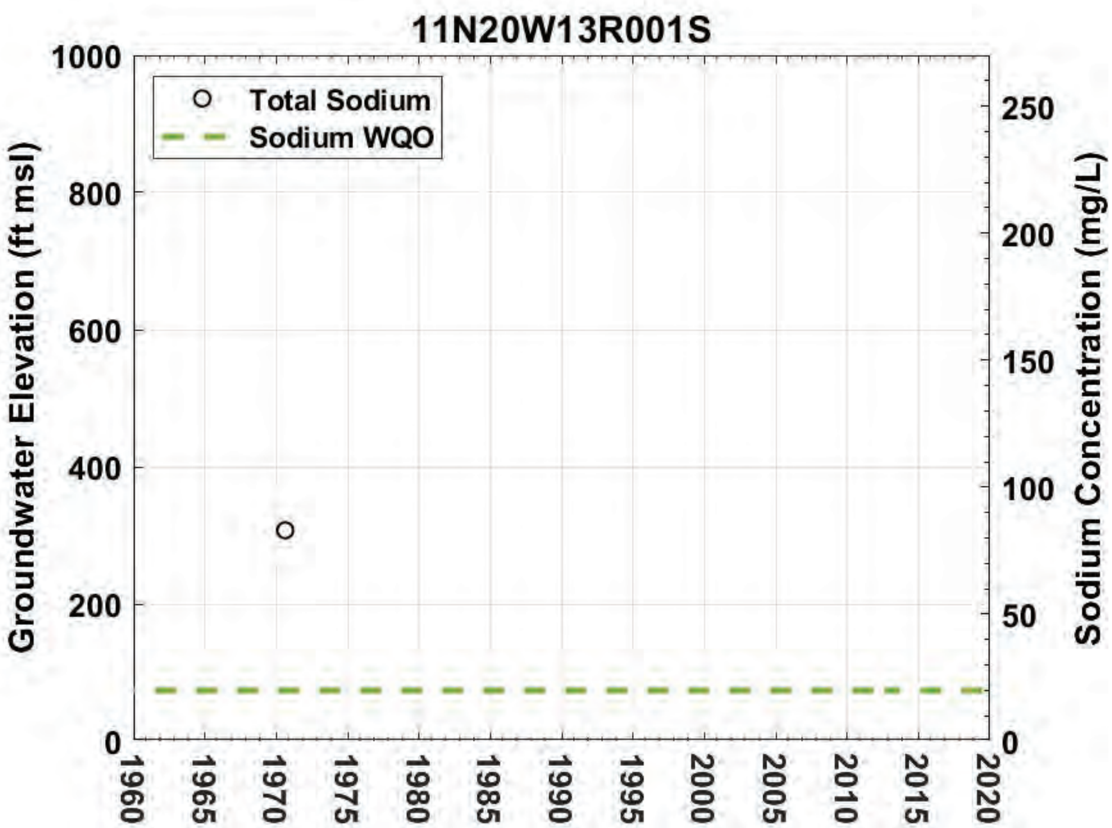

11N19W34F001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


11N19W35A001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

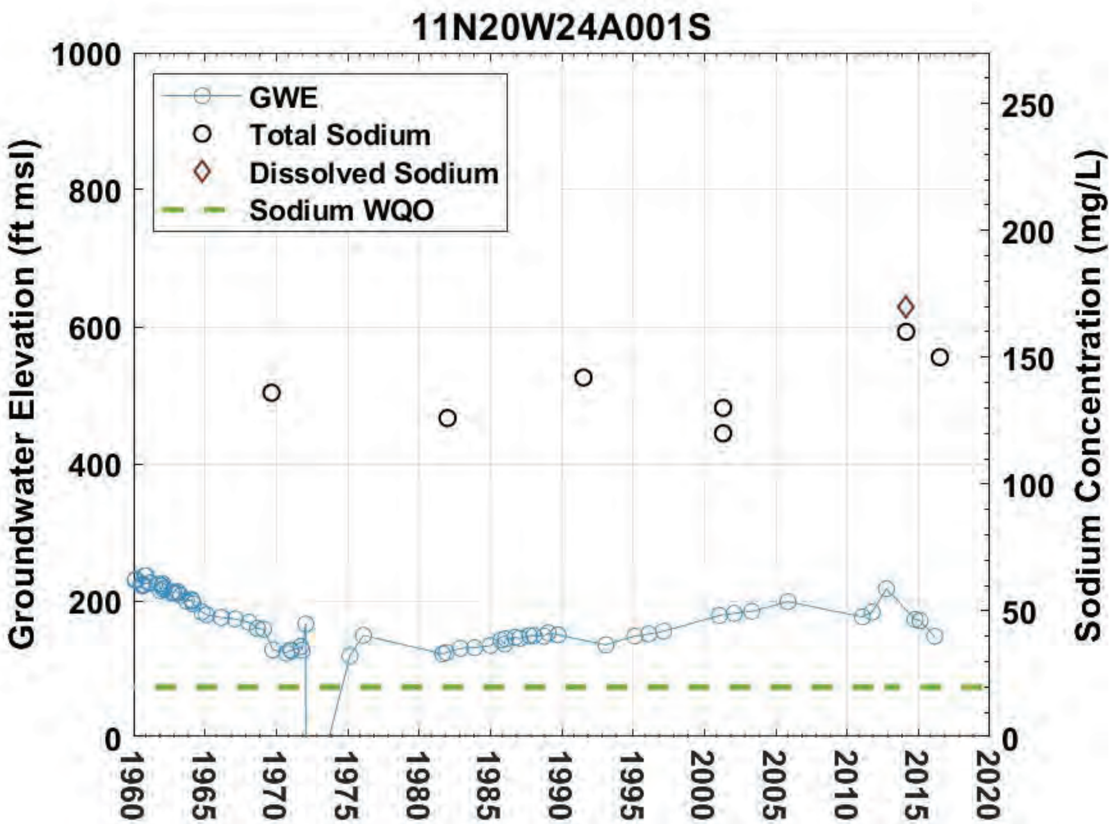

11N19W36A001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

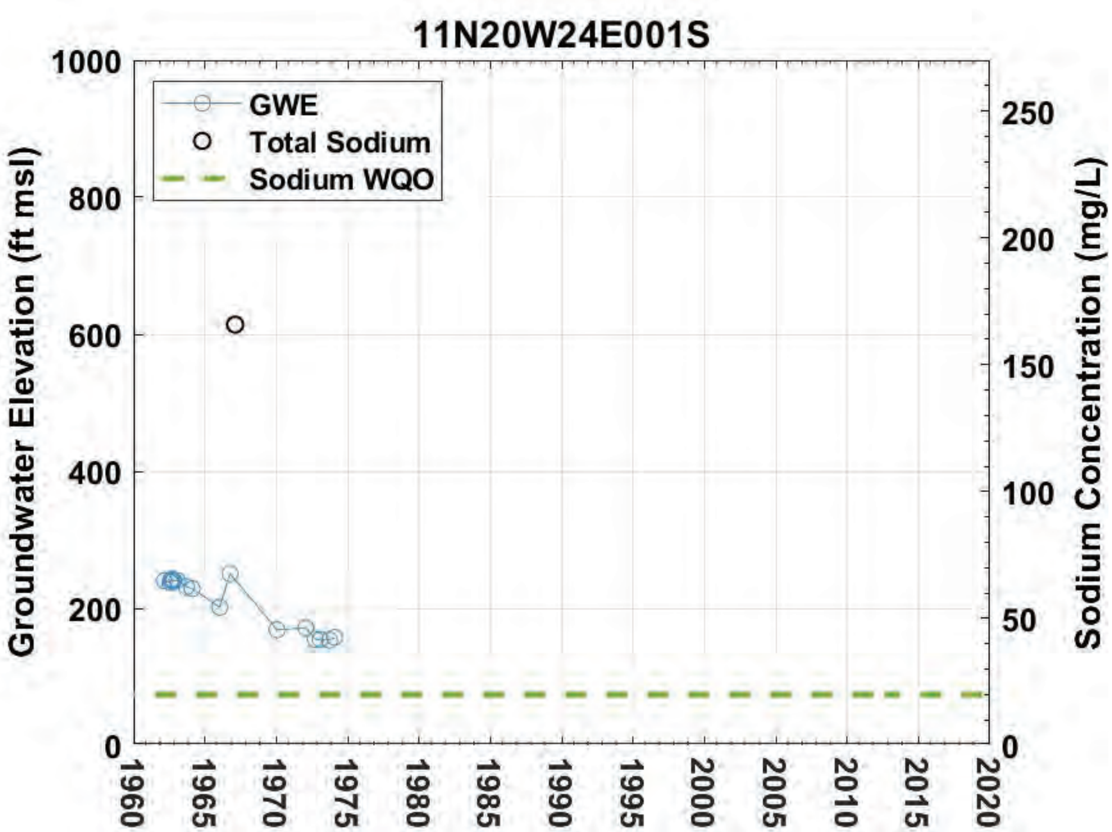


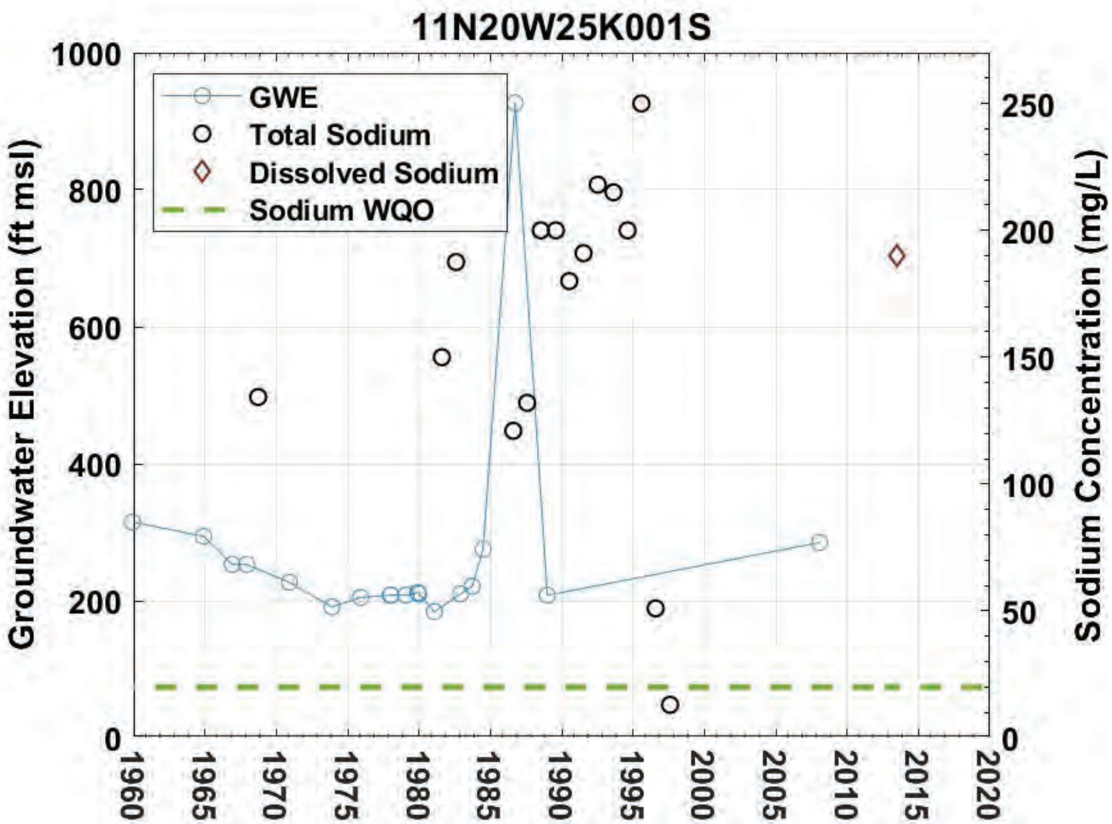
11N20W13Q001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

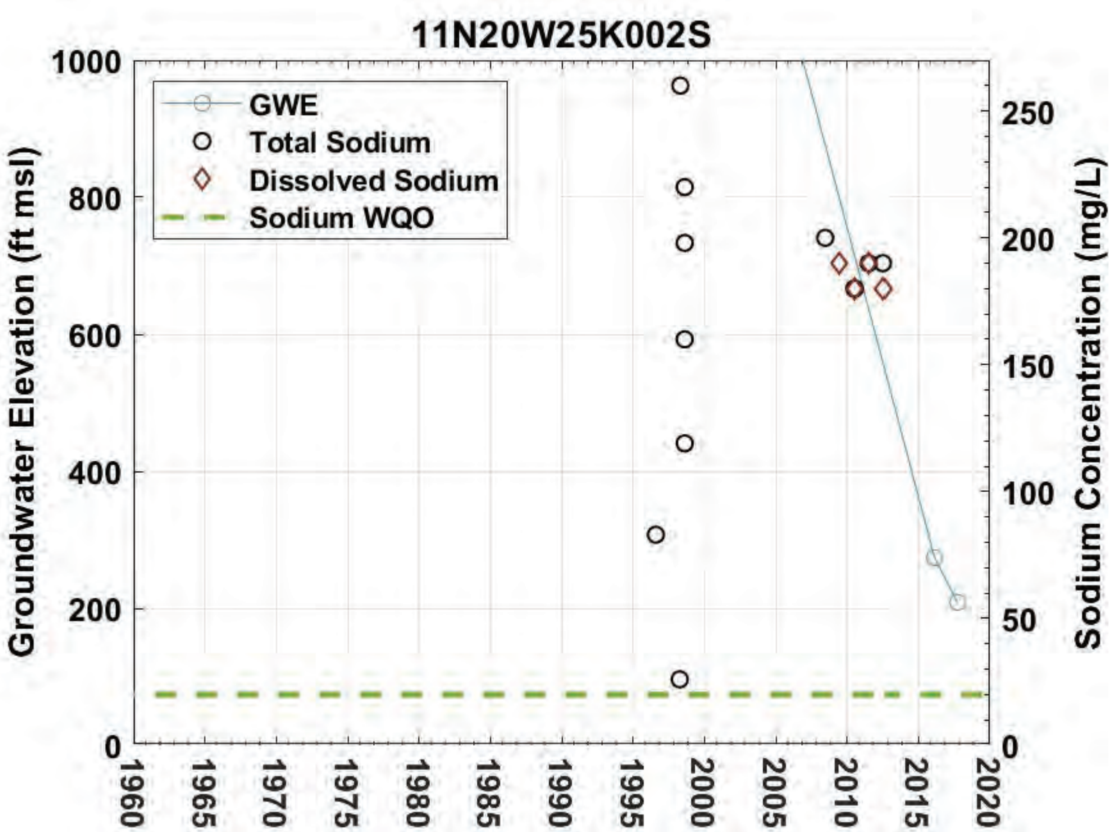


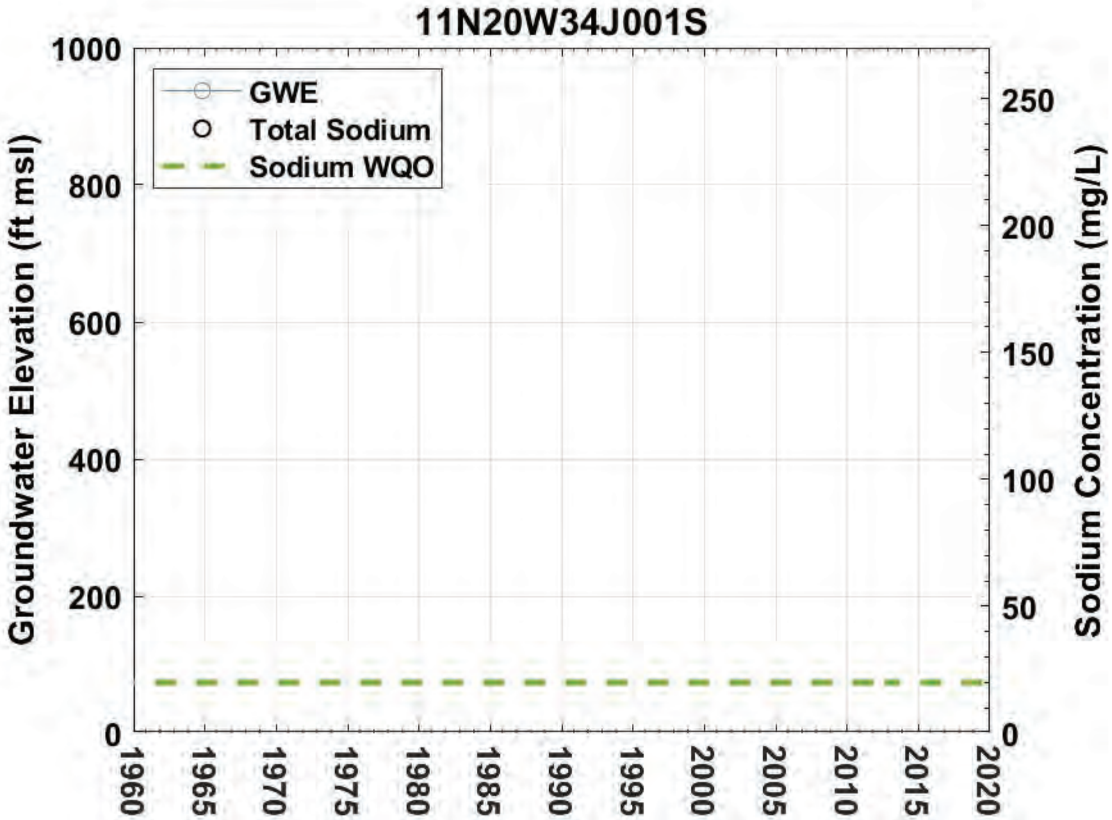
11N20W13R001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

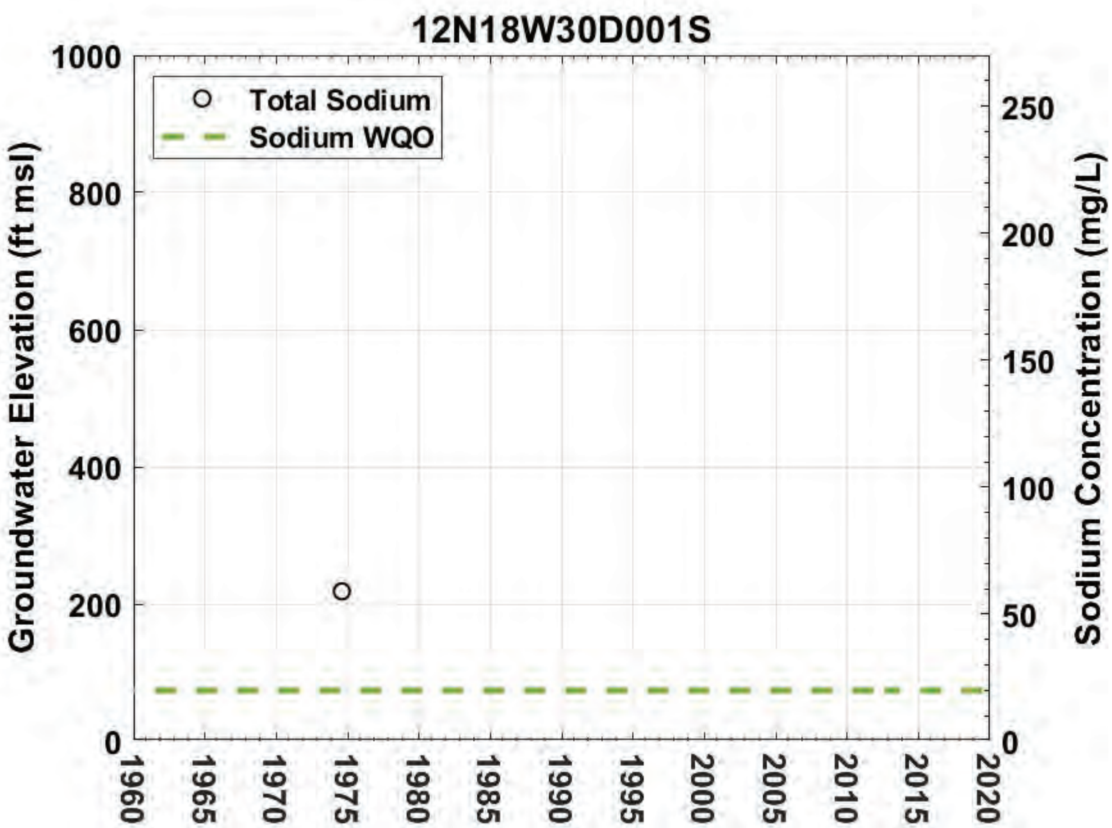

11N20W24A001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

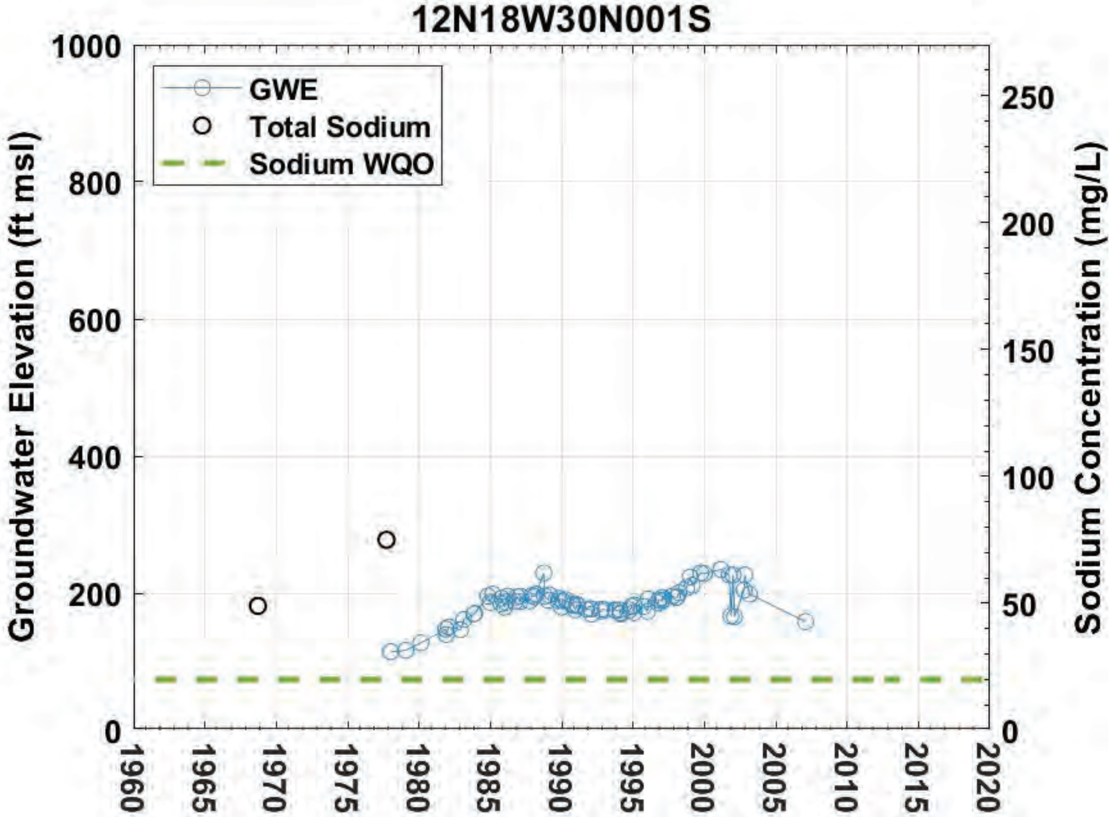

11N20W24E001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

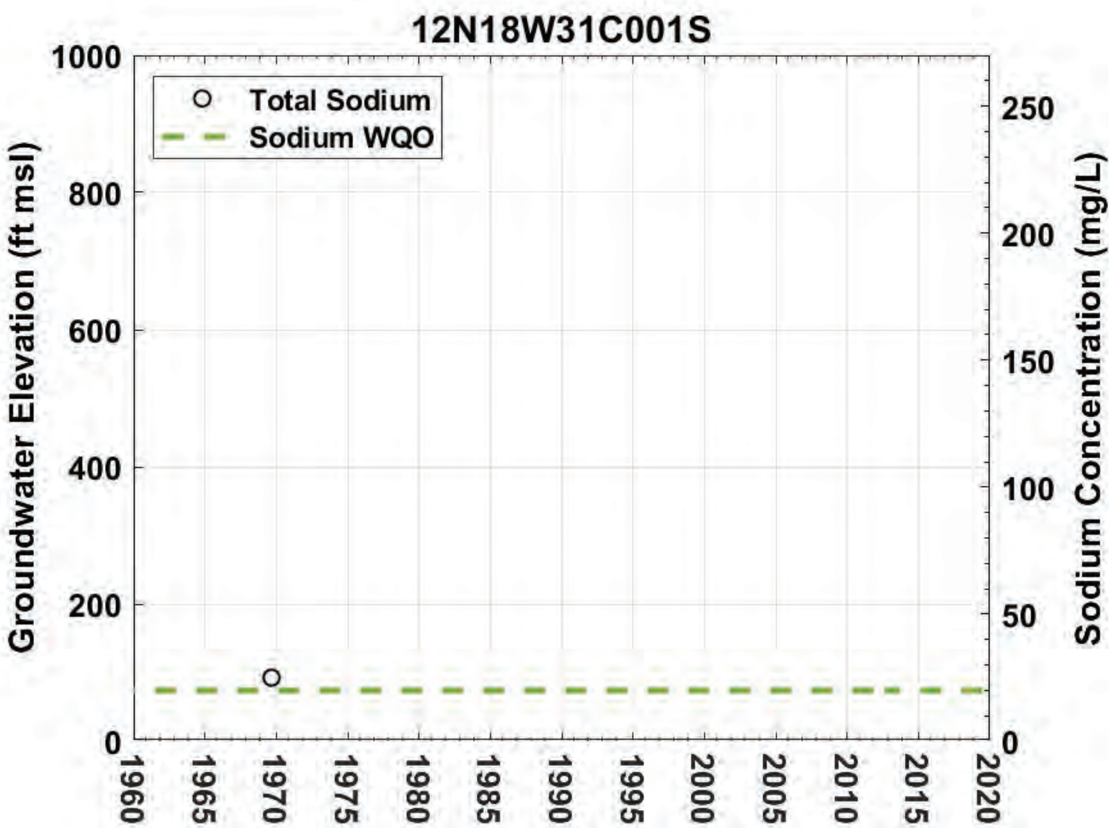

11N20W25K001S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

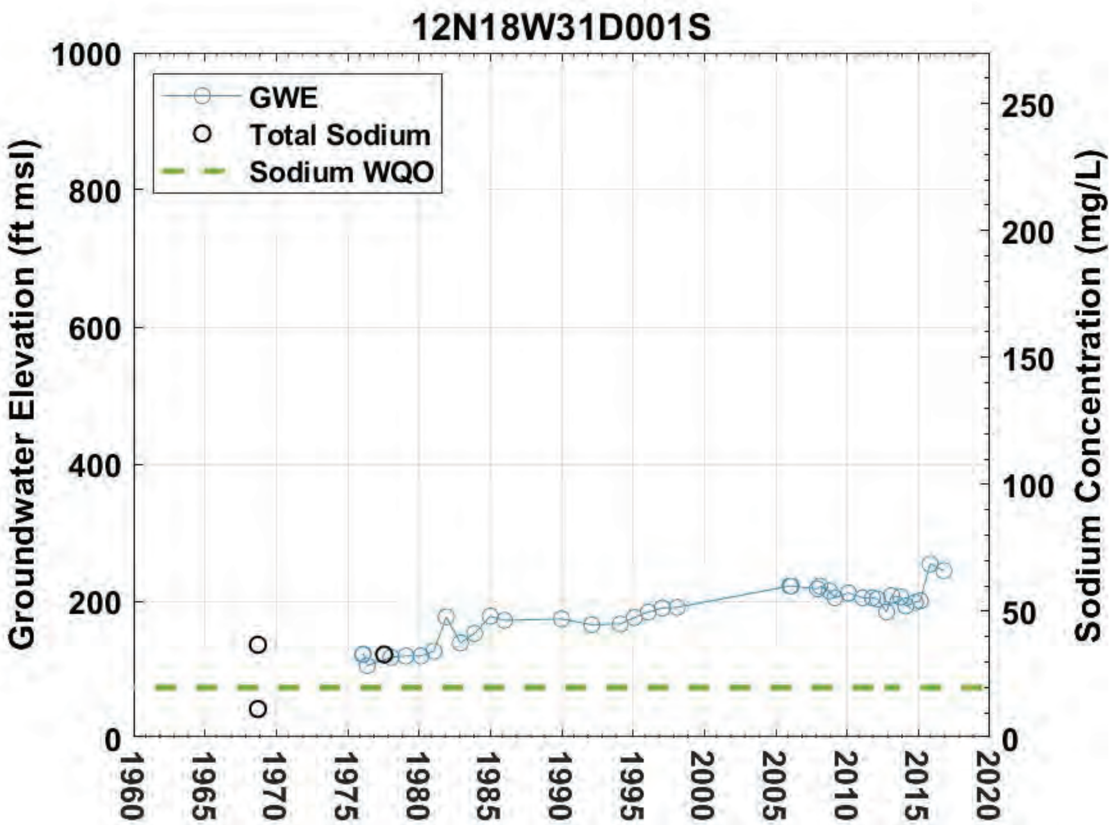

11N20W25K002S
GWE
Total Sodium
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

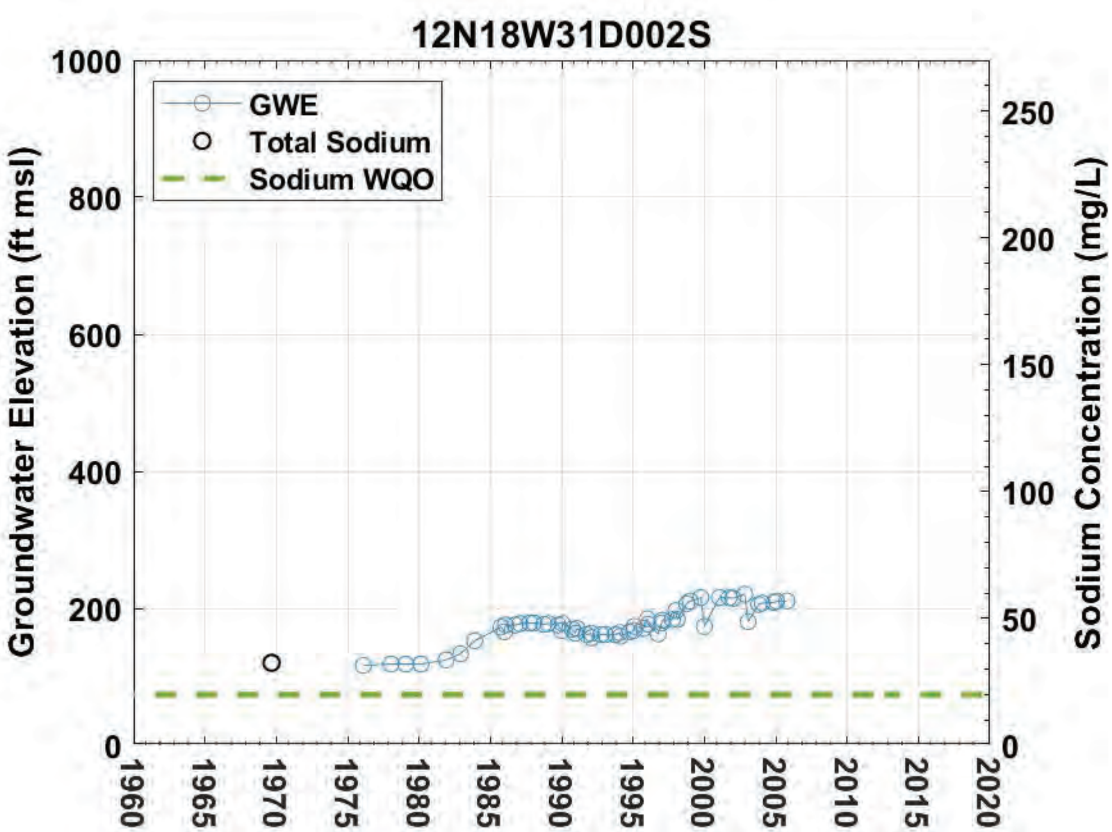

11N20W34J001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

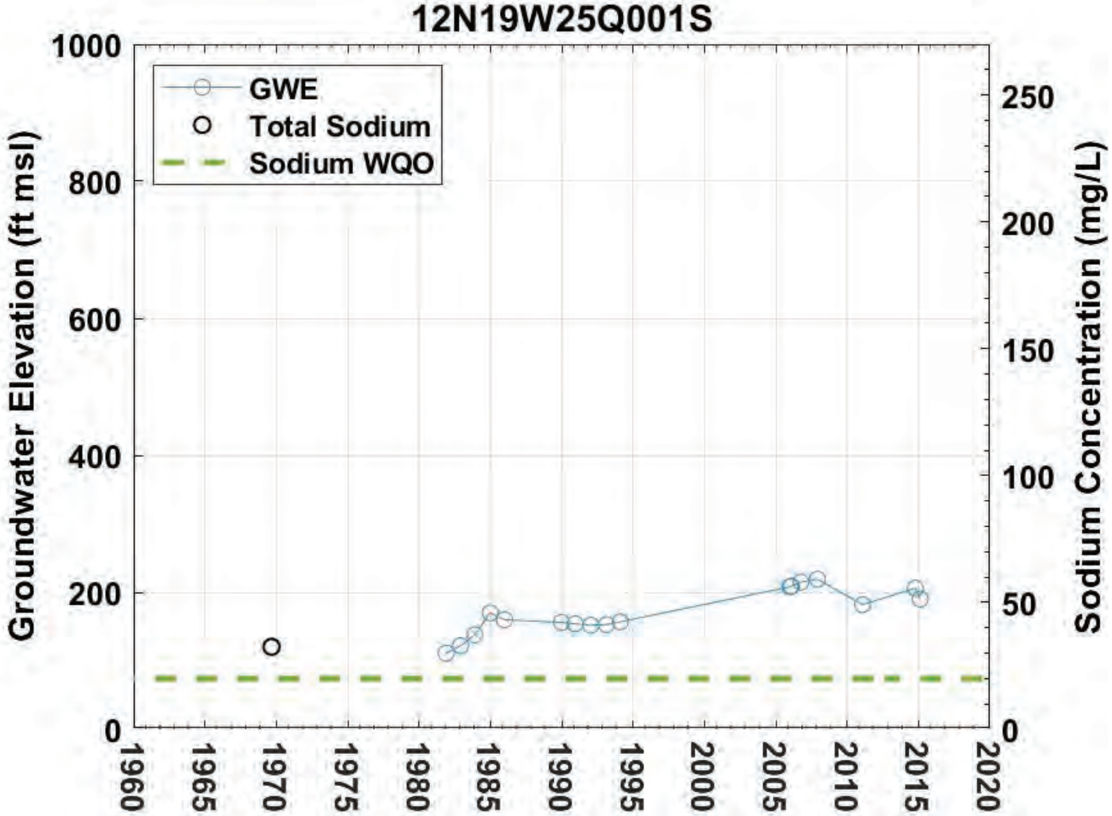

12N18W30D001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


12N18W30N001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

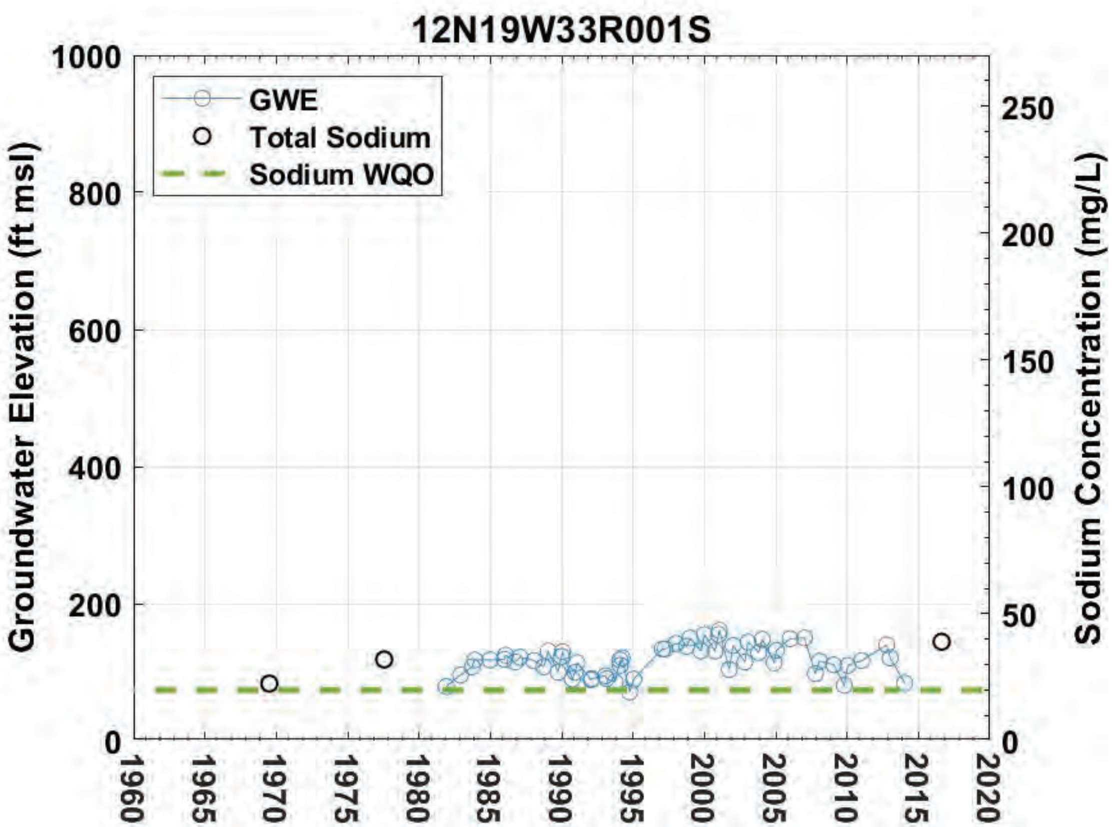

12N18W31C001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


12N18W31D001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

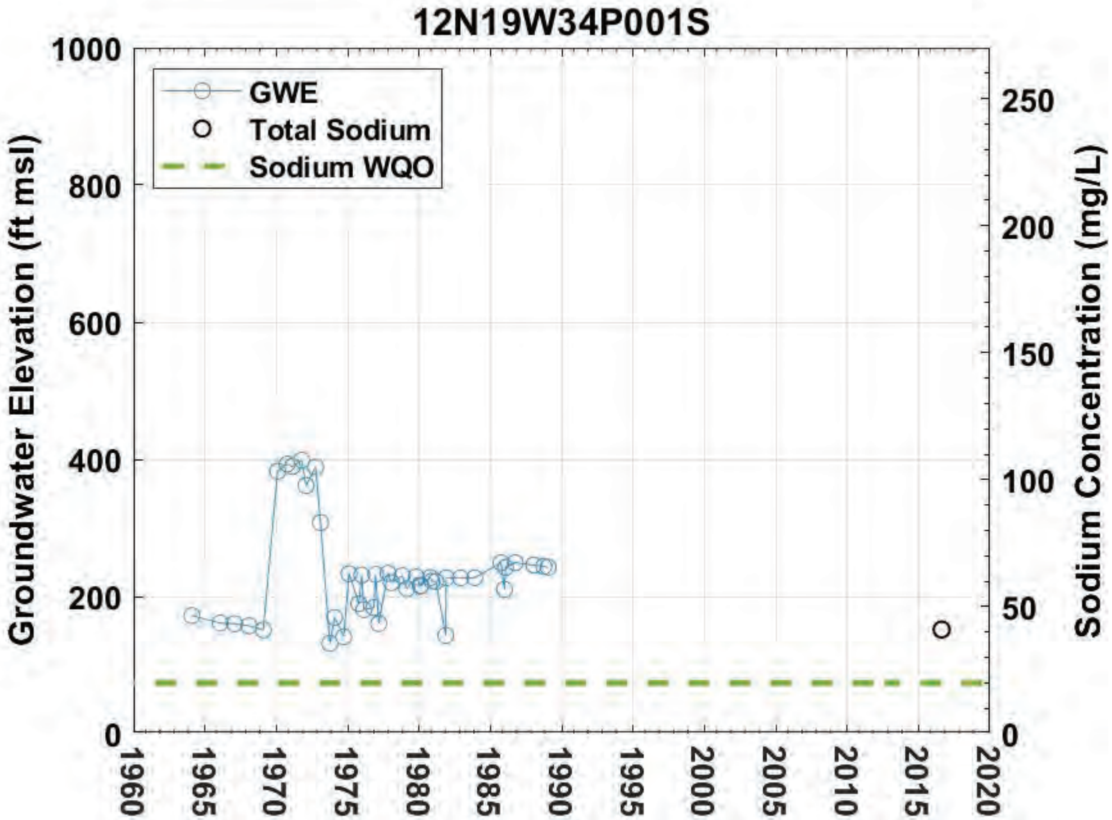

12N18W31D002S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

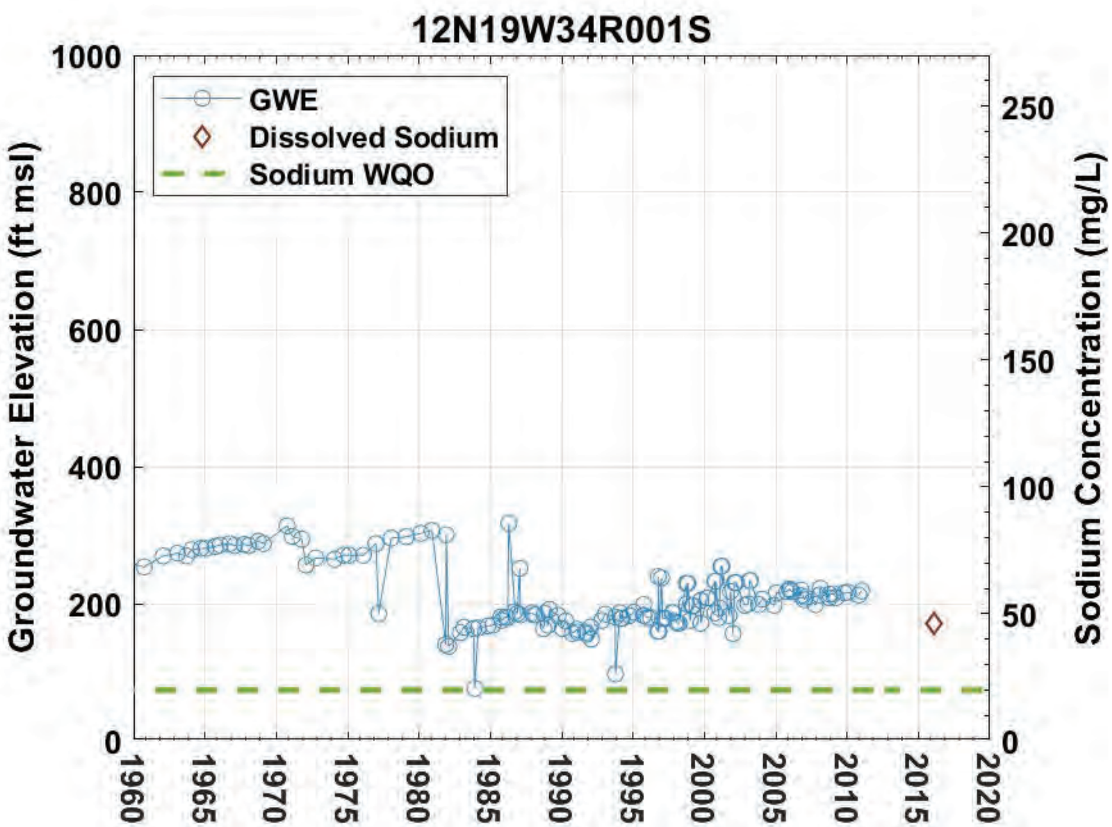


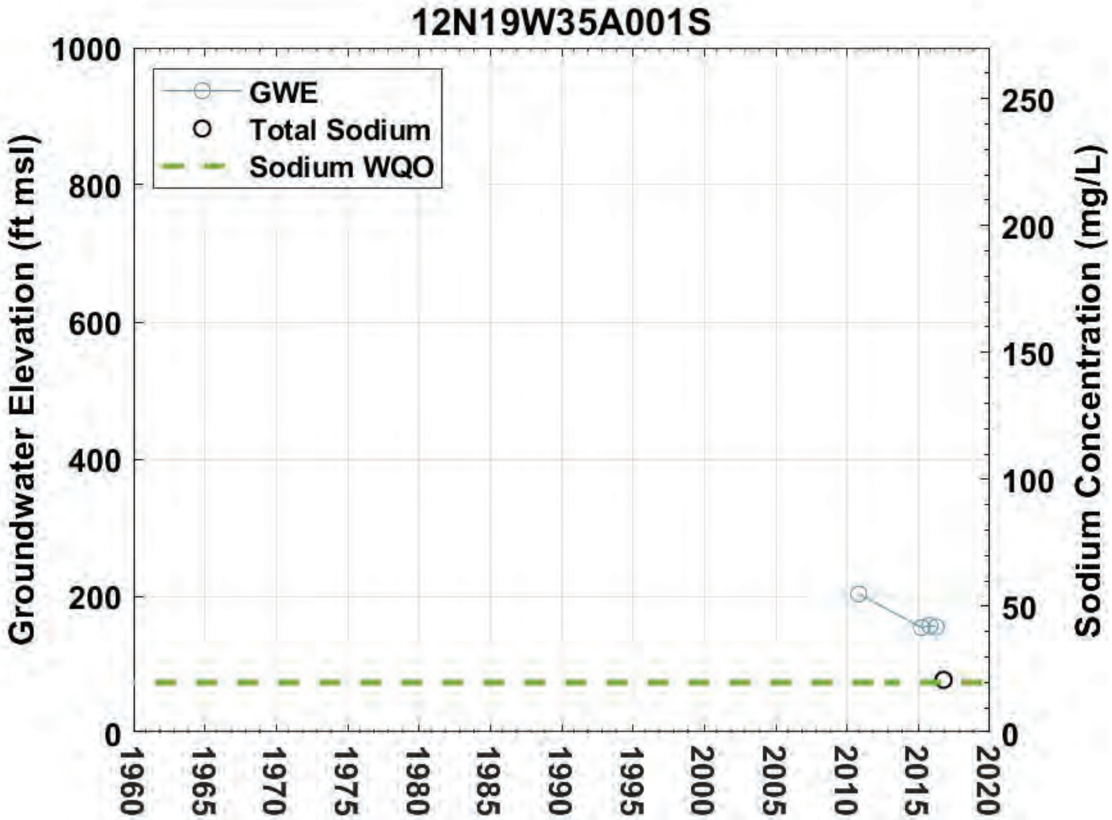
12N19W25Q001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



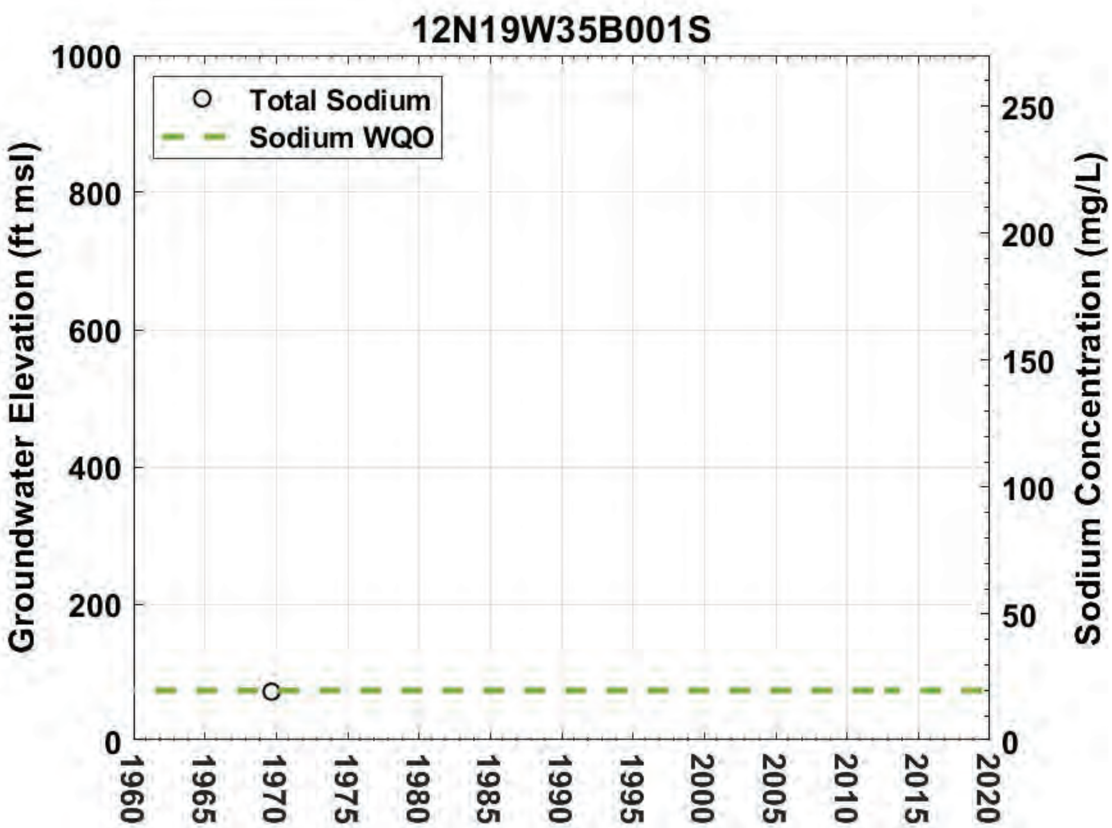
12N19W33R001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


12N19W34P001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

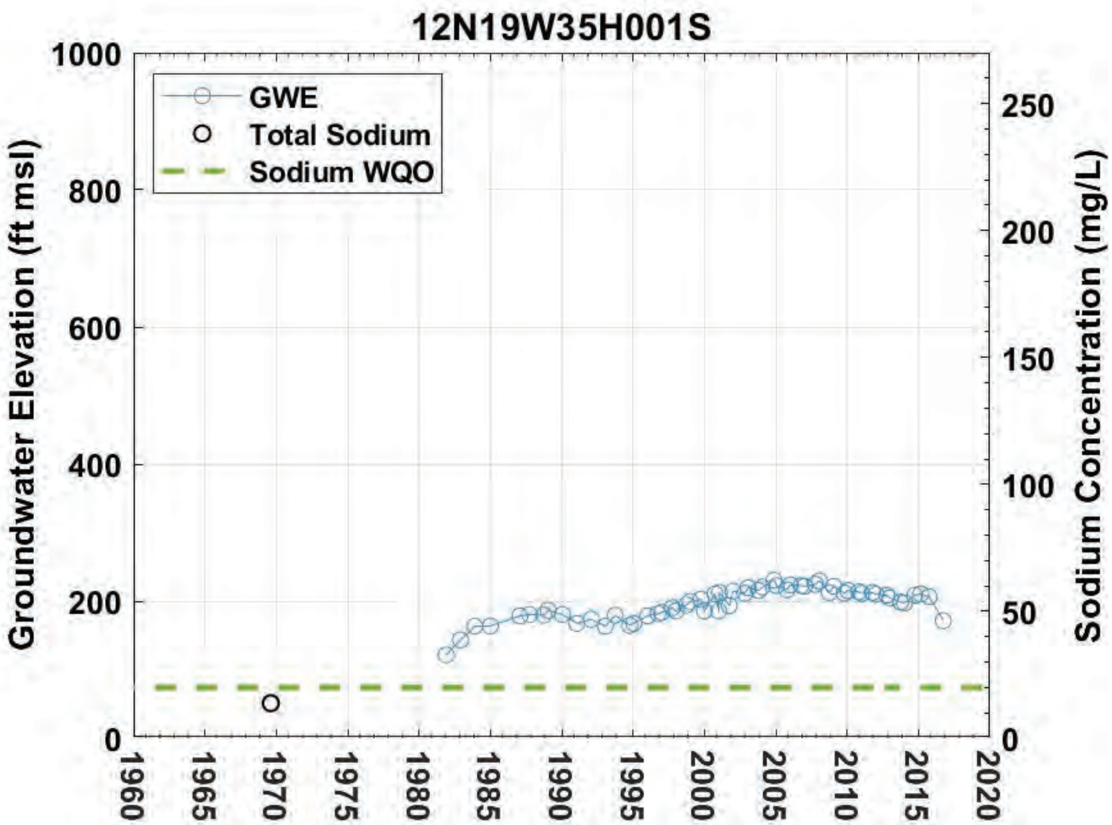

12N19W34R001S
GWE
Dissolved Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



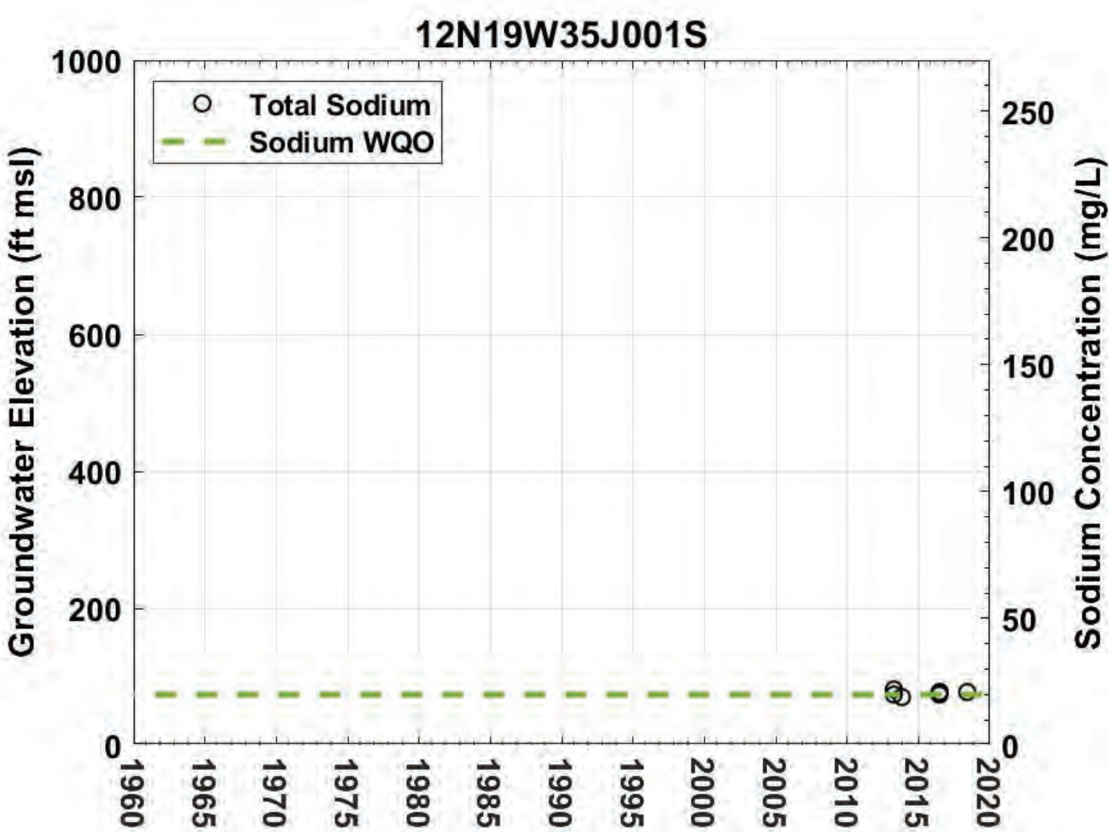
12N19W35A001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020



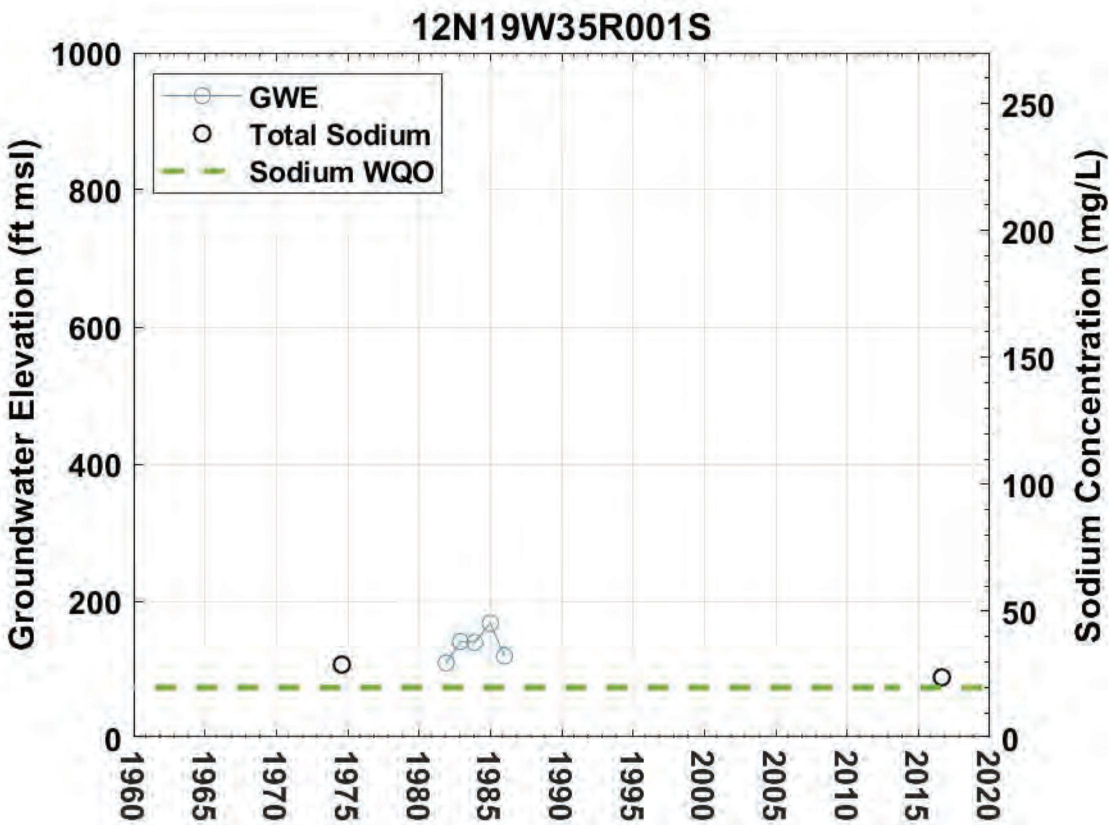
12N19W35B001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

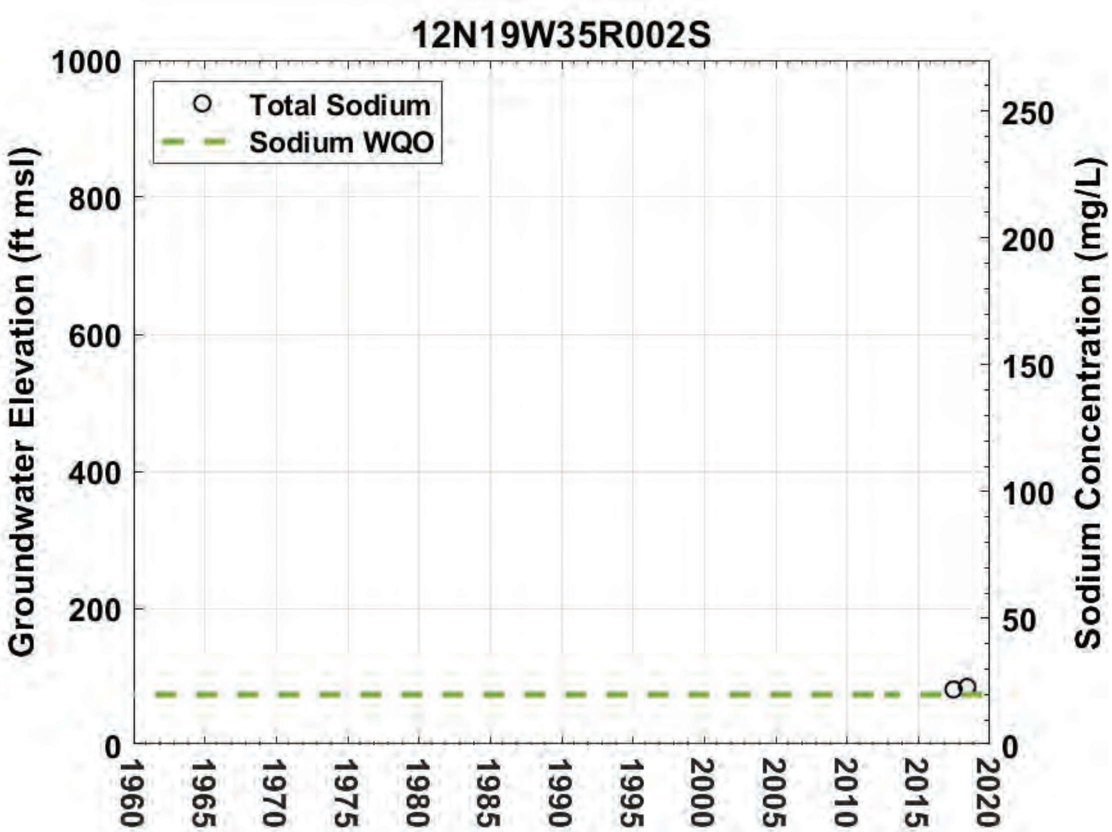


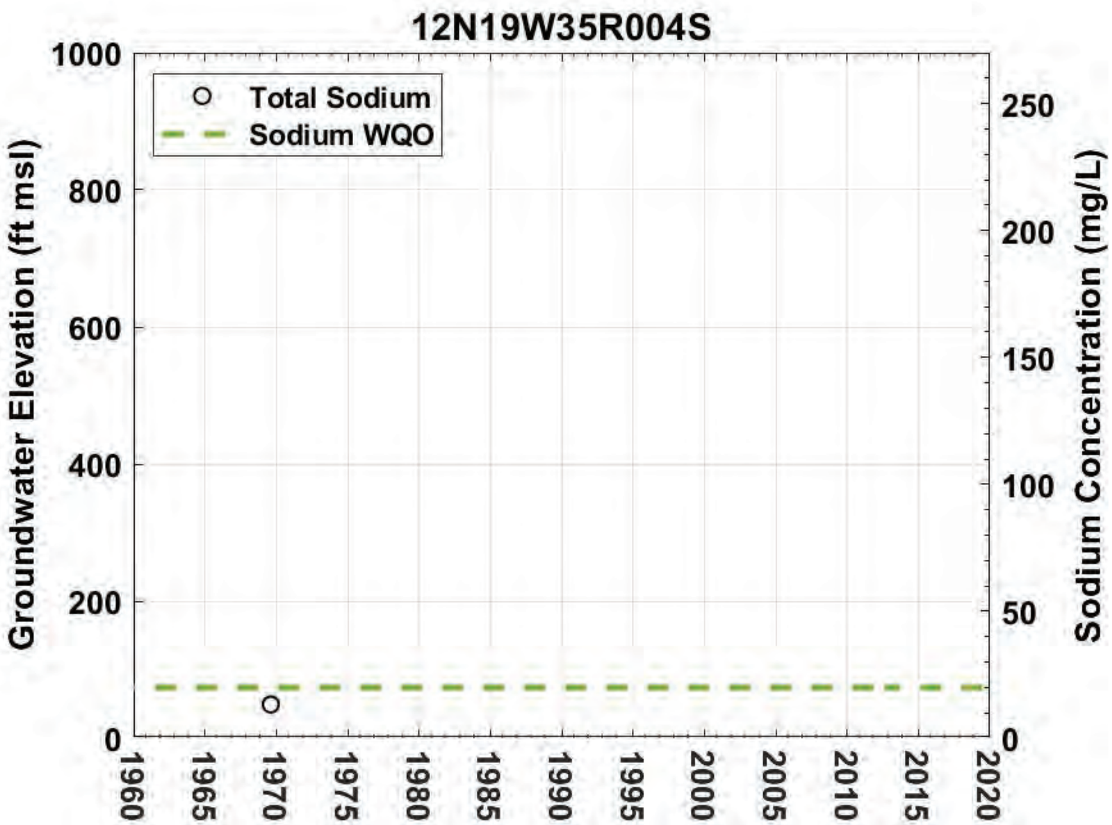
12N19W35H001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

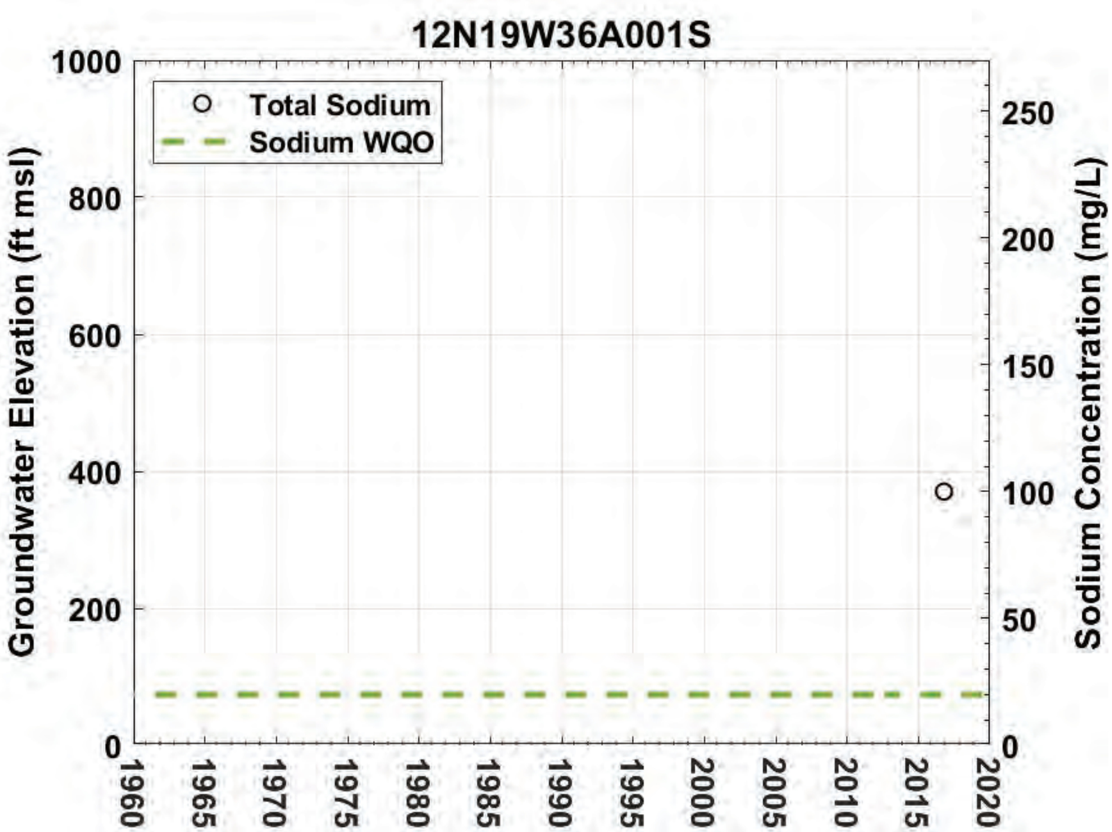


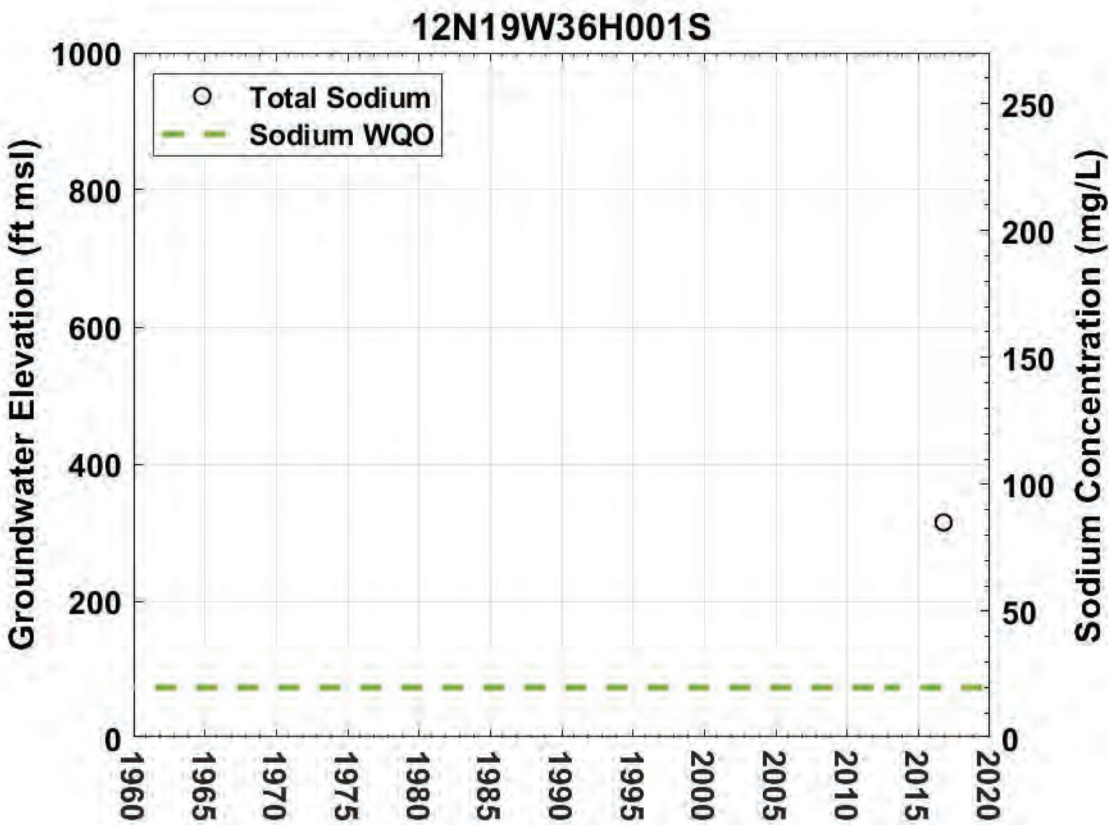
12N19W35J001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

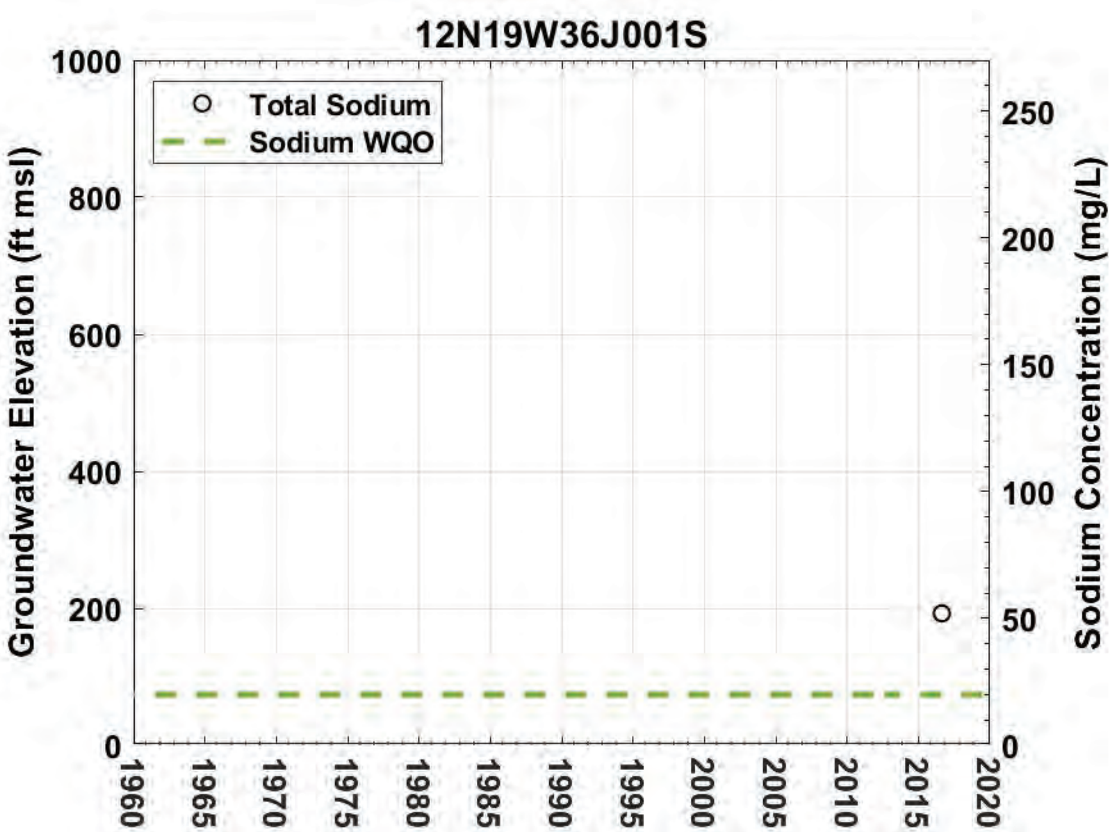

12N19W35R001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
GWE
Total Sodium
Sodium WQO
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

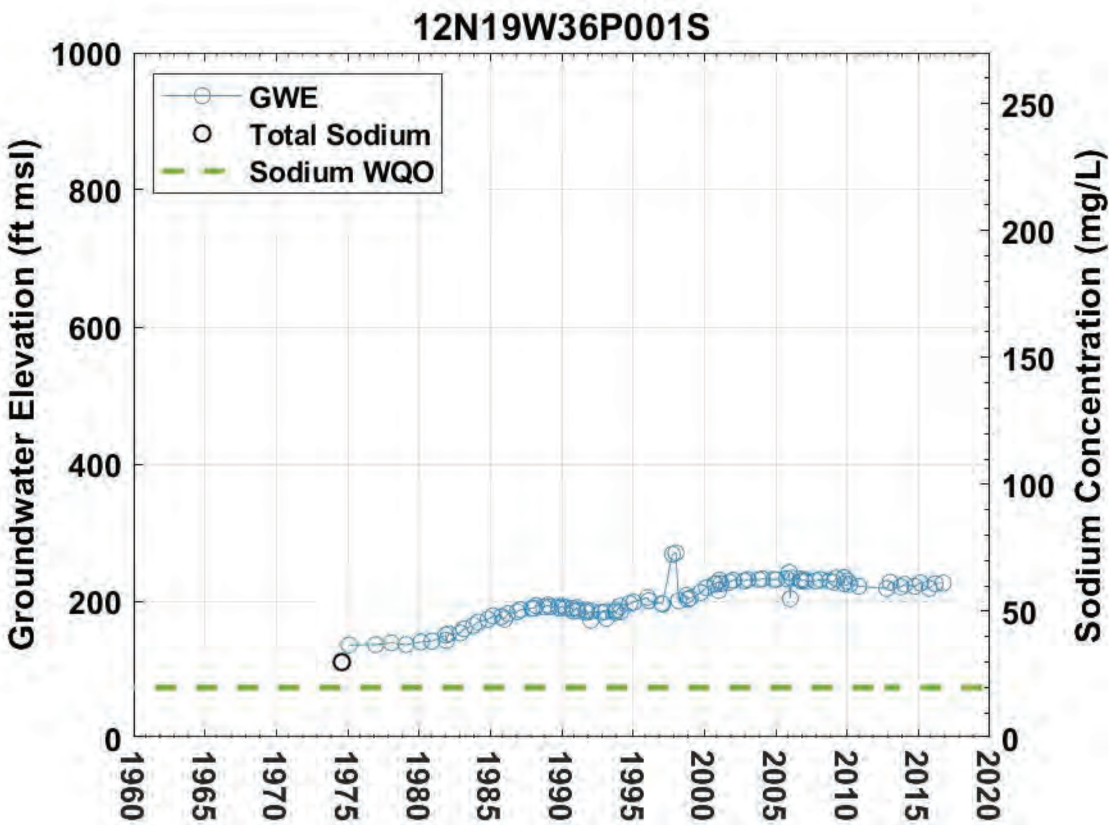

12N19W35R002S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
Total Sodium
Sodium WQO
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

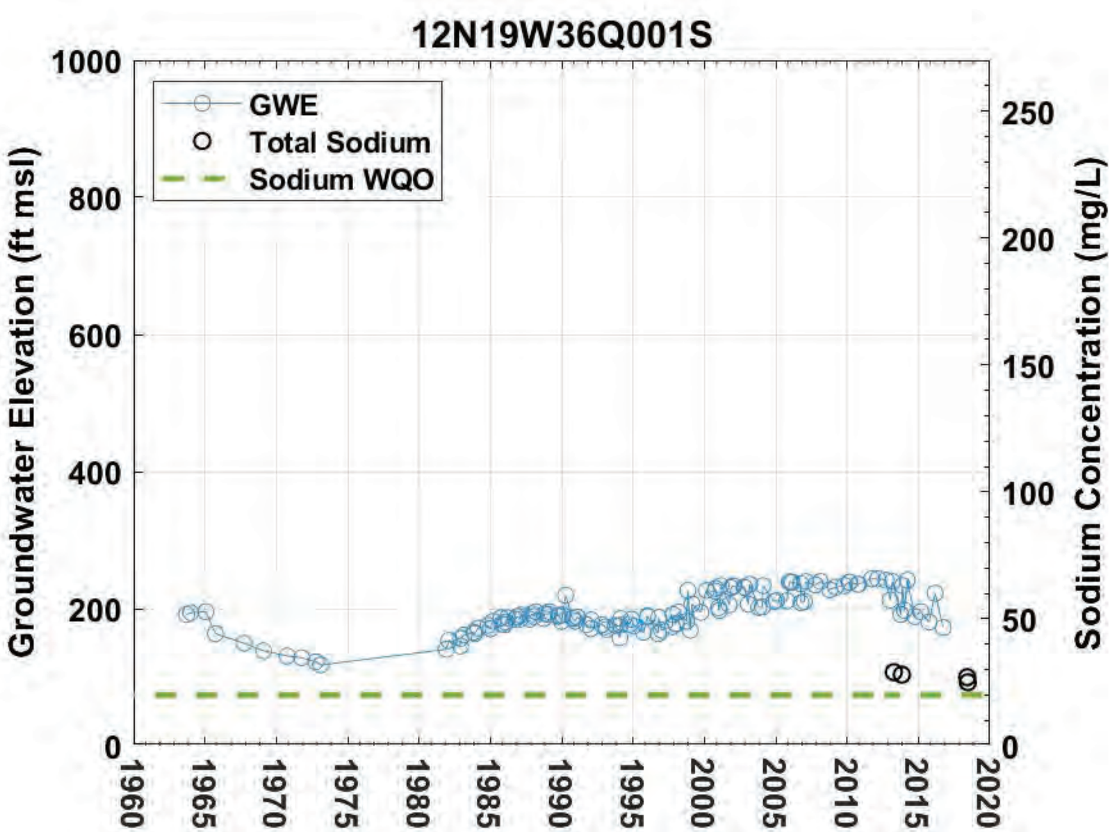

12N19W35R004S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

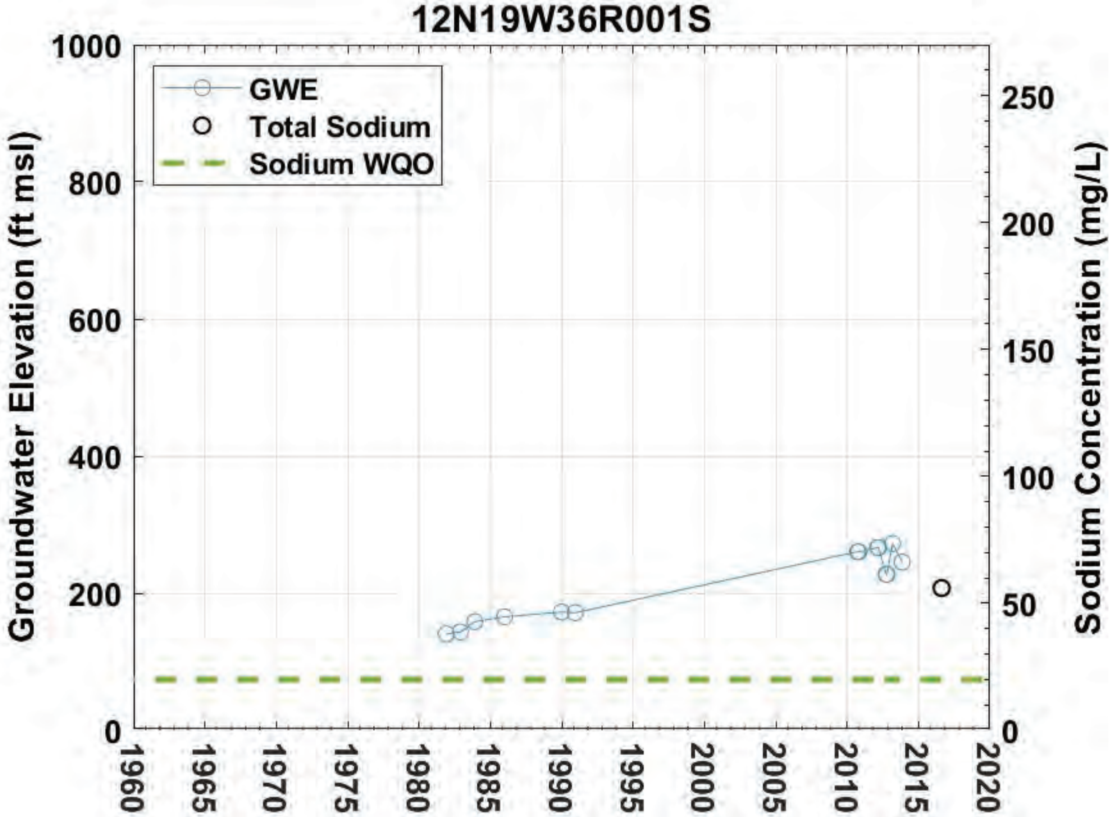

12N19W36A001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

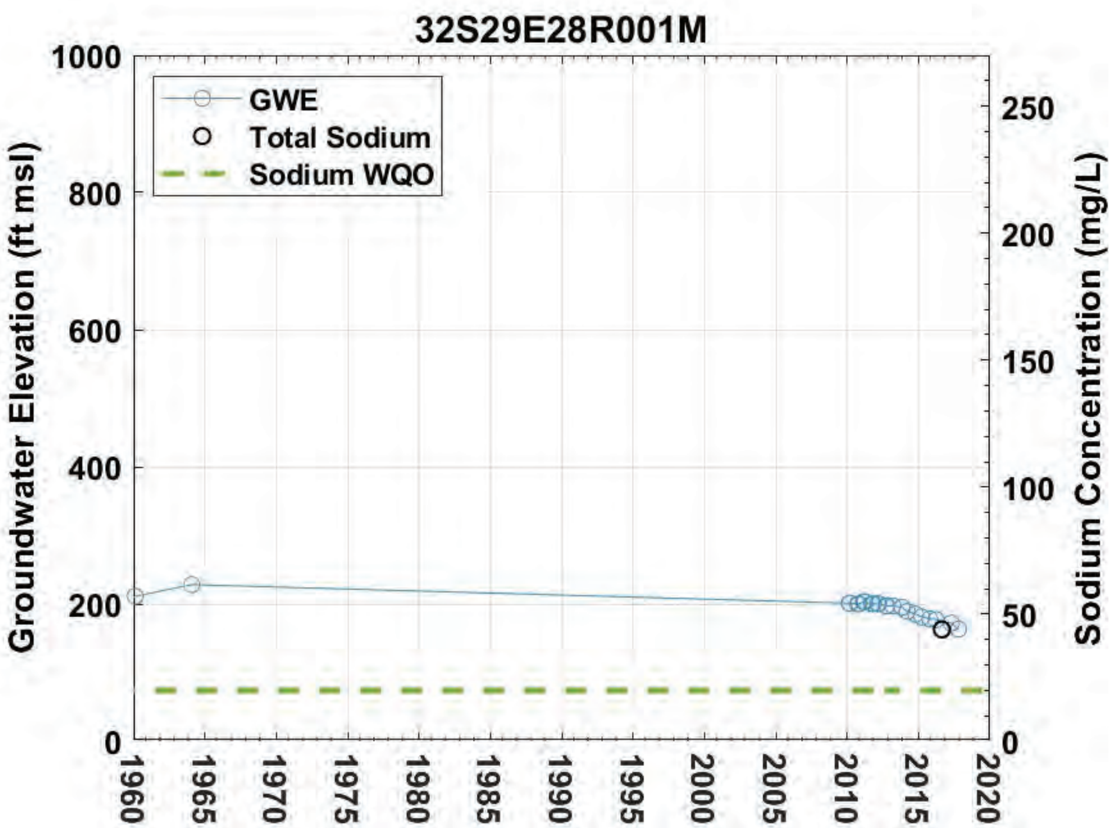

12N19W36H001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

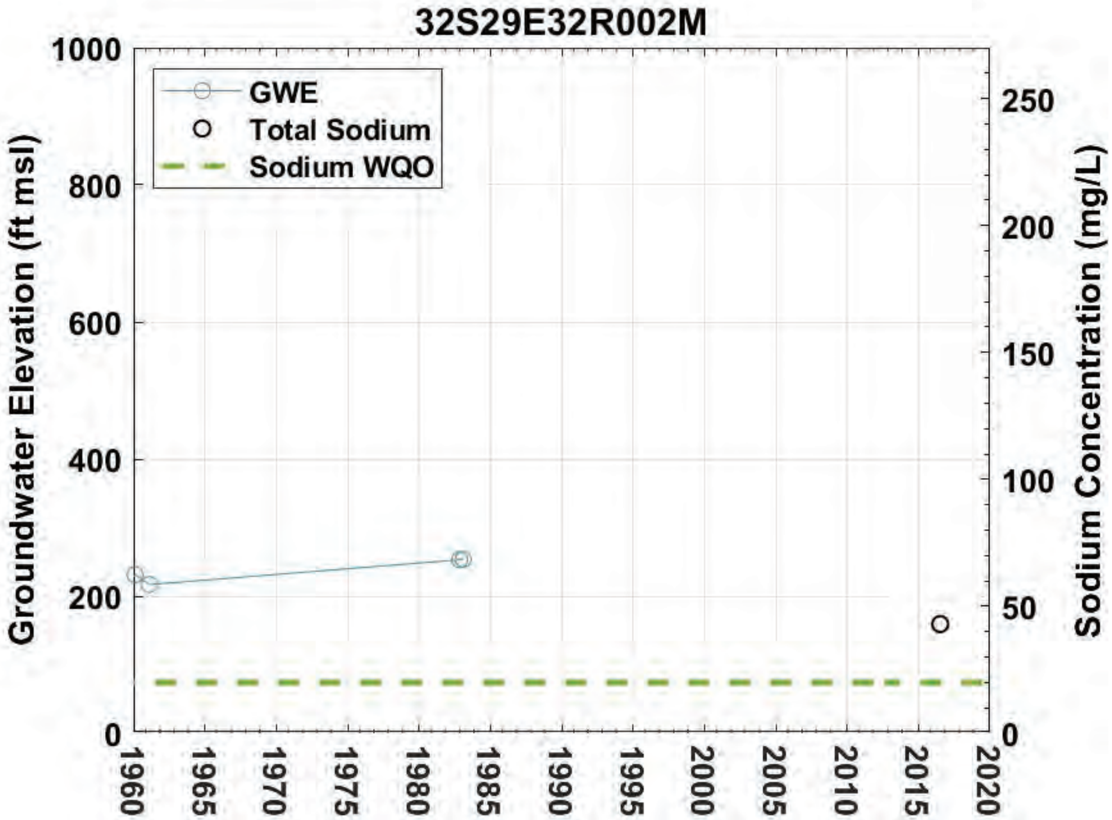

12N19W36J001S
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

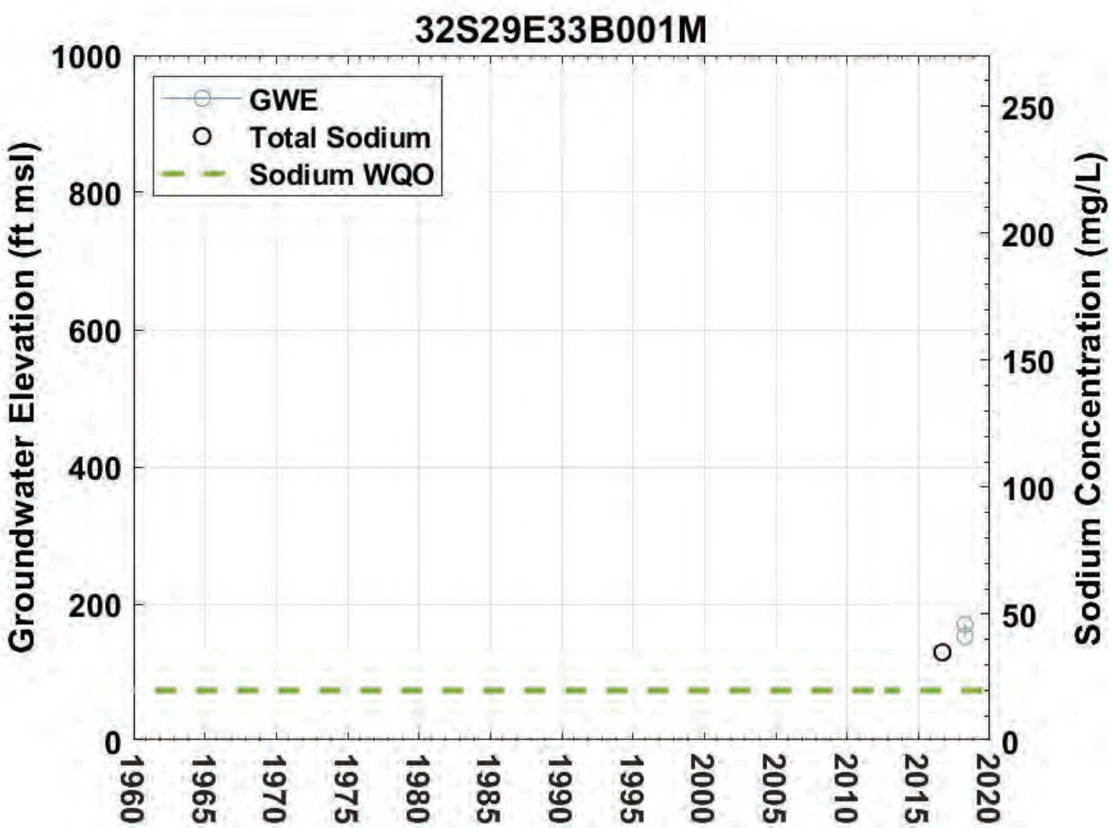

12N19W36P001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
GWE
Total Sodium
Sodium WQO
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

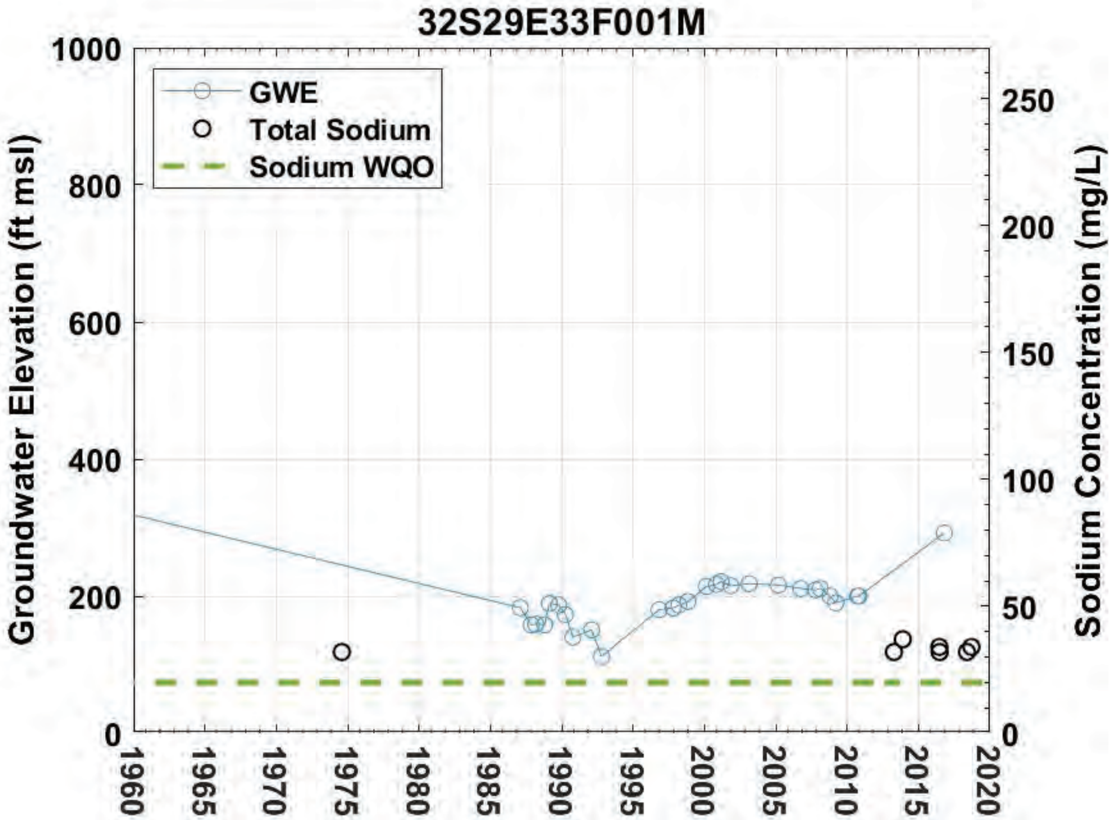

12N19W36Q001S
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
GWE
Total Sodium
Sodium WQO
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

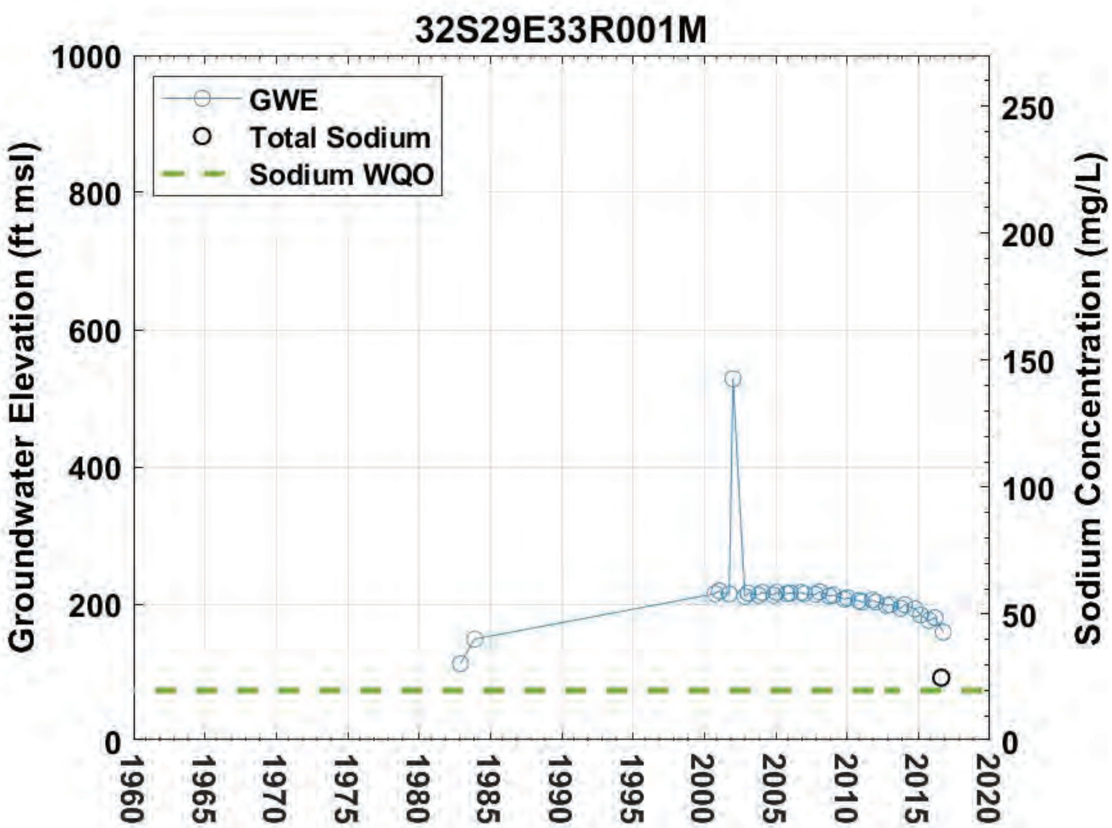

12N19W36R001S
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

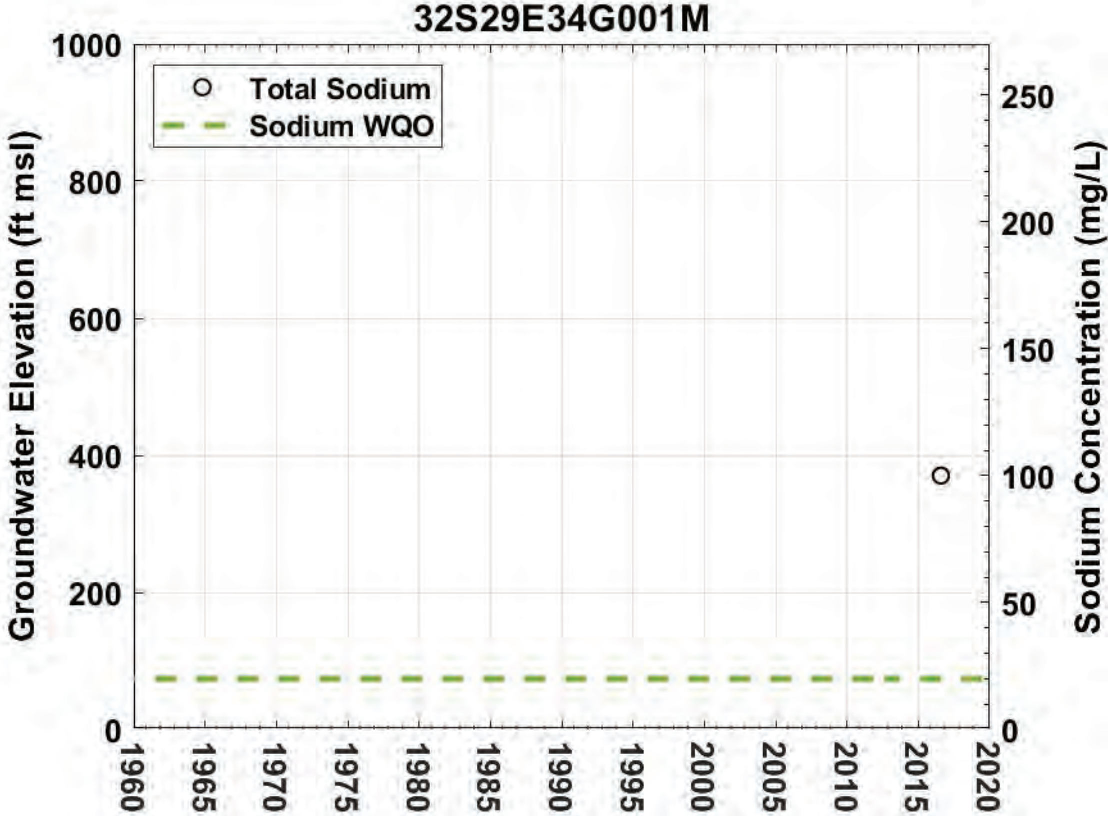

32S29E28R001M
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
1000
800
600
400
200
0
250
200
150
100
50
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

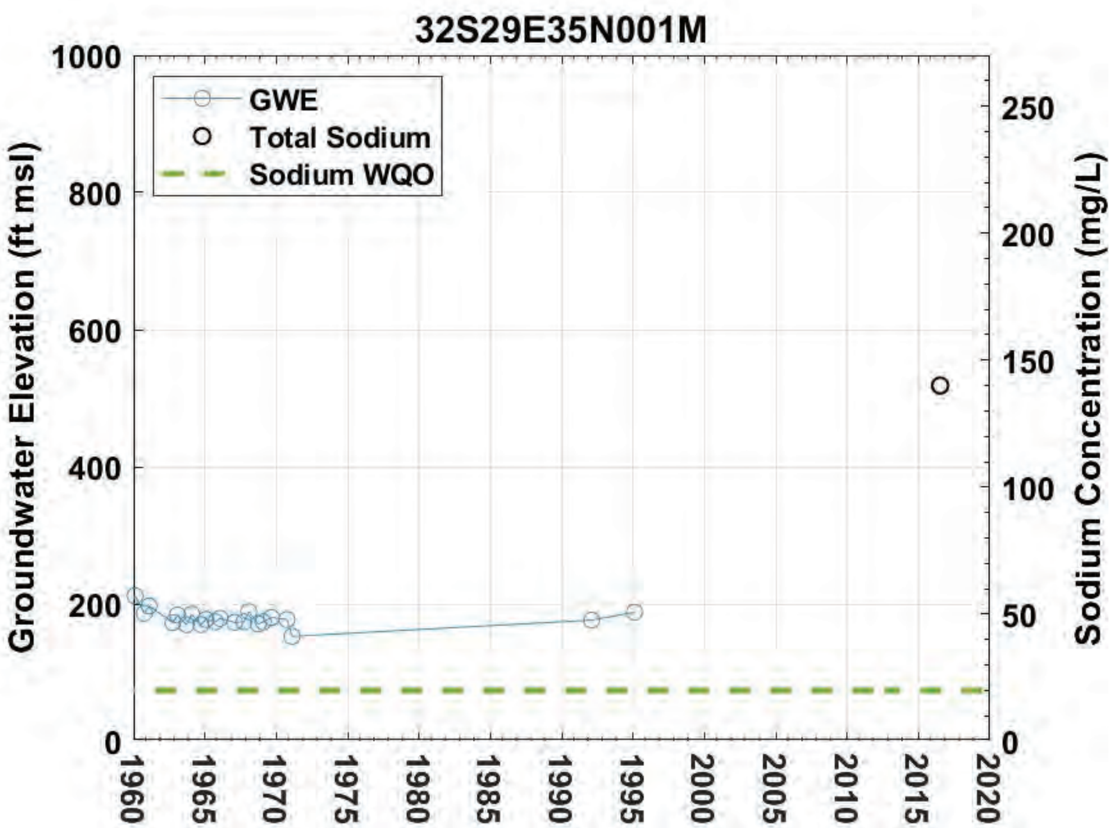

32S29E32R002M
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


32S29E33B001M
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


32S29E33F001M
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


32S29E33R001M
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


32S29E34G001M
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020


32S29E35N001M
GWE
Total Sodium
Sodium WQO
Groundwater Elevation (ft msl)
Sodium Concentration (mg/L)
0
200
400
600
800
1000
0
50
100
150
200
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

Appendix G

Statistical Cross-Correlation Analysis between Water Quality and Groundwater Levels for Selected Constituents

Water Quality Correlation Summary Table

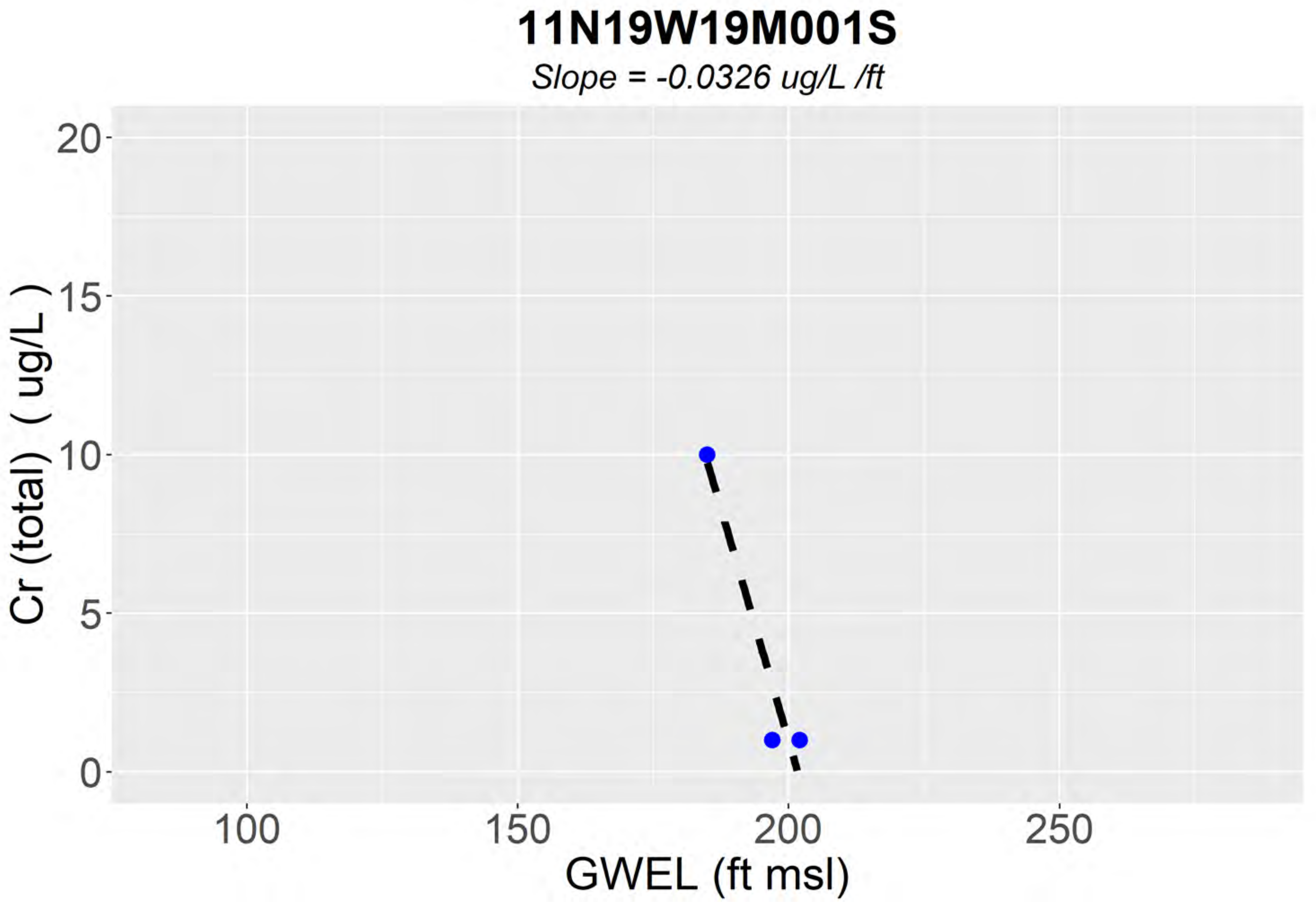
Well ID	Cr (total) (mg/L)		Na (total) (mg/L)		NO3 as N (mg/L)		TDS (mg/L)	
	p-value	slope	p-value	slope	p-value	slope	p-value	slope
11N18W06M001S	NA	NA	0.061	0.166	0.112	0.101	0.009	2.14
11N18W07G002S	NA	NA	NA	NA	0.982	0.006	0.538	1.72
11N18W18L001S	NA	NA	0.003	1.29	0.077	0.073	0.004	12.2
11N18W18N001S	NA	NA	NA	NA	0.225	-0.043	0.634	0.466
11N19W09P002S	NA	NA	NA	NA	NA	NA	0.167	-113
11N19W11Q001S	NA	NA	0.388	0.840	0.319	-0.028	0.357	3.48
11N19W13J001S	NA	NA	NA	NA	0.070	-0.018	0.708	-0.155
11N19W19G001S	NA	NA	0.492	0.045	NA	NA	0.514	-0.350
11N19W19M001S	0.397	-0.033	0.014	-0.378	0.0005	-0.451	0.0001	-5.92
11N19W19P001S	NA	NA	NA	NA	0.372	-1.10	0.425	-12.9
11N19W22E001S	NA	NA	0.461	0.042	0.609	-0.002	0.356	-0.583
11N19W22G001S	NA	NA	0.933	0.056	0.846	0.006	0.987	-0.103
11N19W27C001S	NA	NA	NA	NA	0.883	-0.001	0.874	-2.43
11N19W28G001S	NA	NA	NA	NA	0.368	-0.040	NA	NA
11N20W24A001S	NA	NA	0.675	0.195	0.579	0.367	0.450	5.60
11N20W25K001S	NA	NA	0.137	0.539	0.890	0.086	0.302	3.03

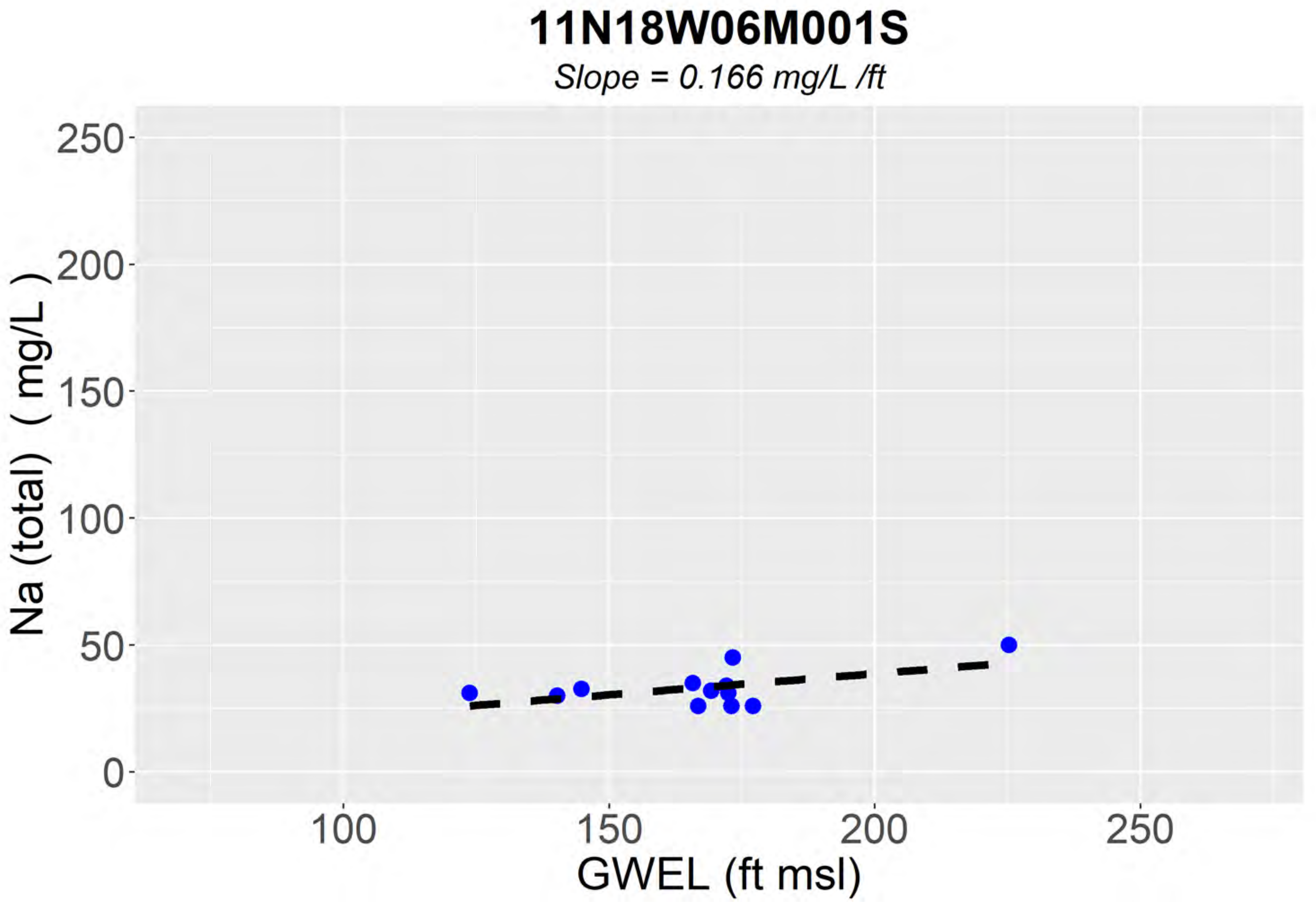
Abbreviations:

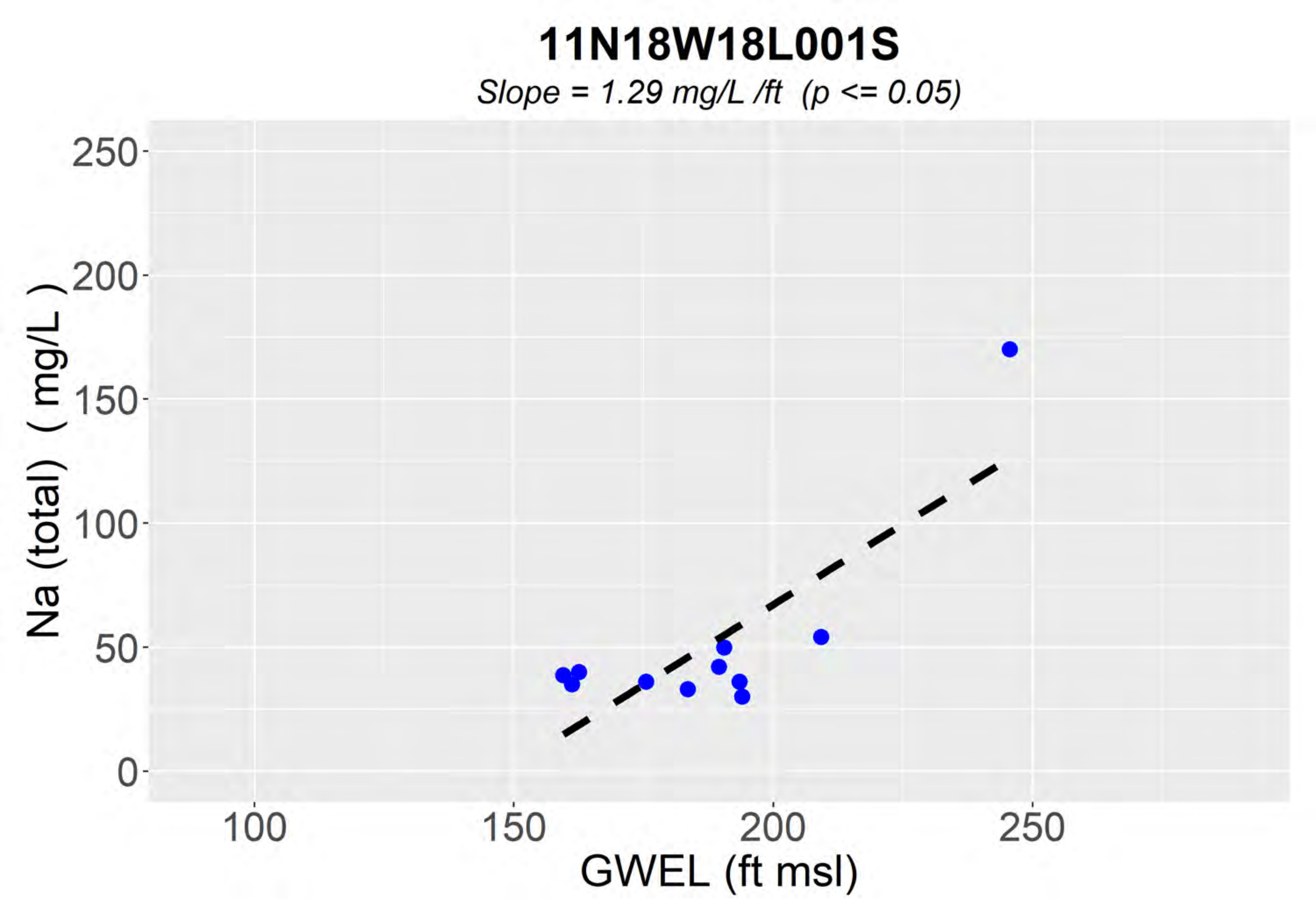
Cr = chromium
Na = sodium
mg/L = milligram per liter
NA = not applicable
NO3 as N = nitrate as nitrogen
TDS = total dissolved solids

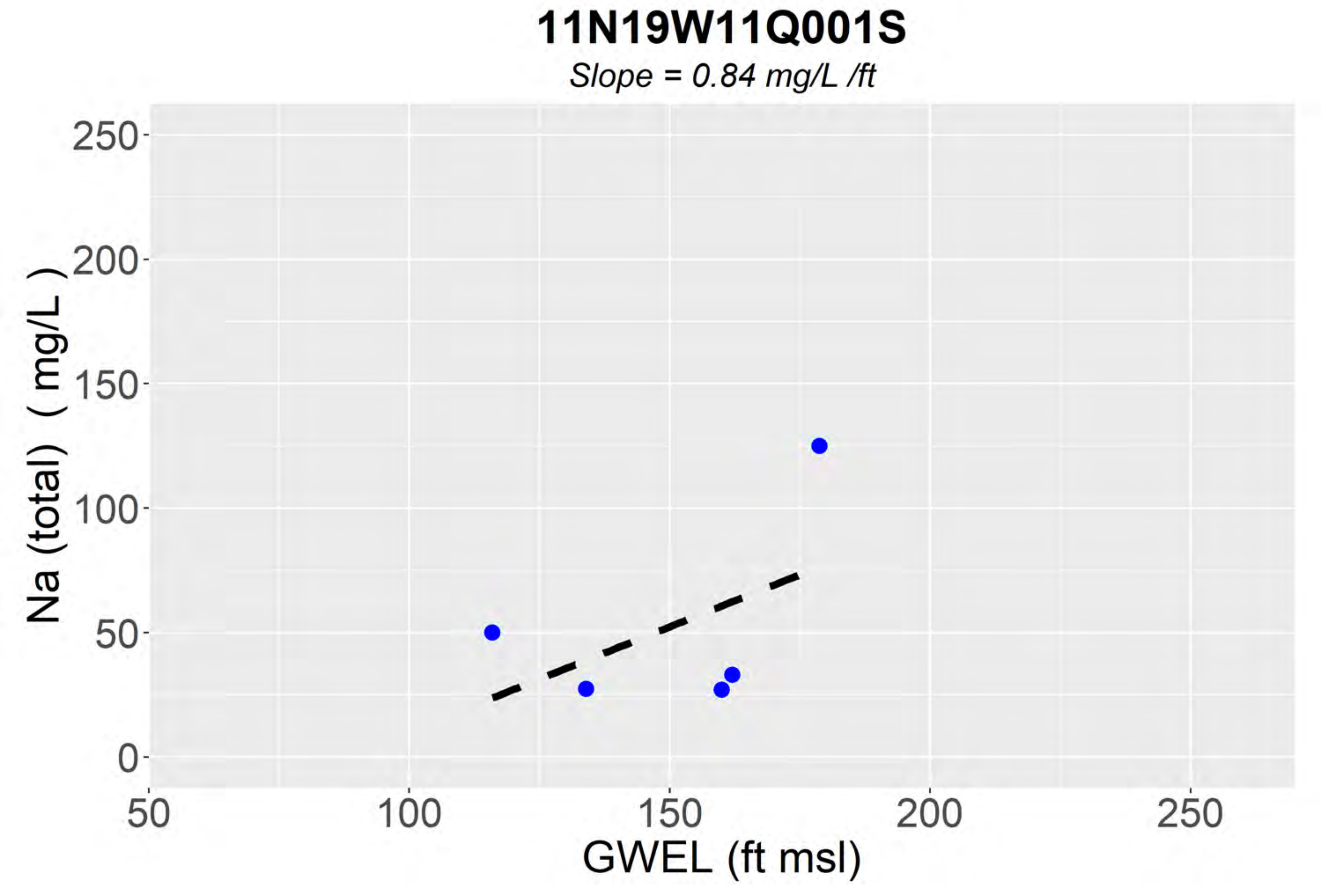
Notes:

(1) Cross-correlation analysis was completed on wells with water quality and water level measurements occurring in the same year, and cells shaded in grey were not statistically significant. Wells without available data were labeled as "NA" and shaded in grey.

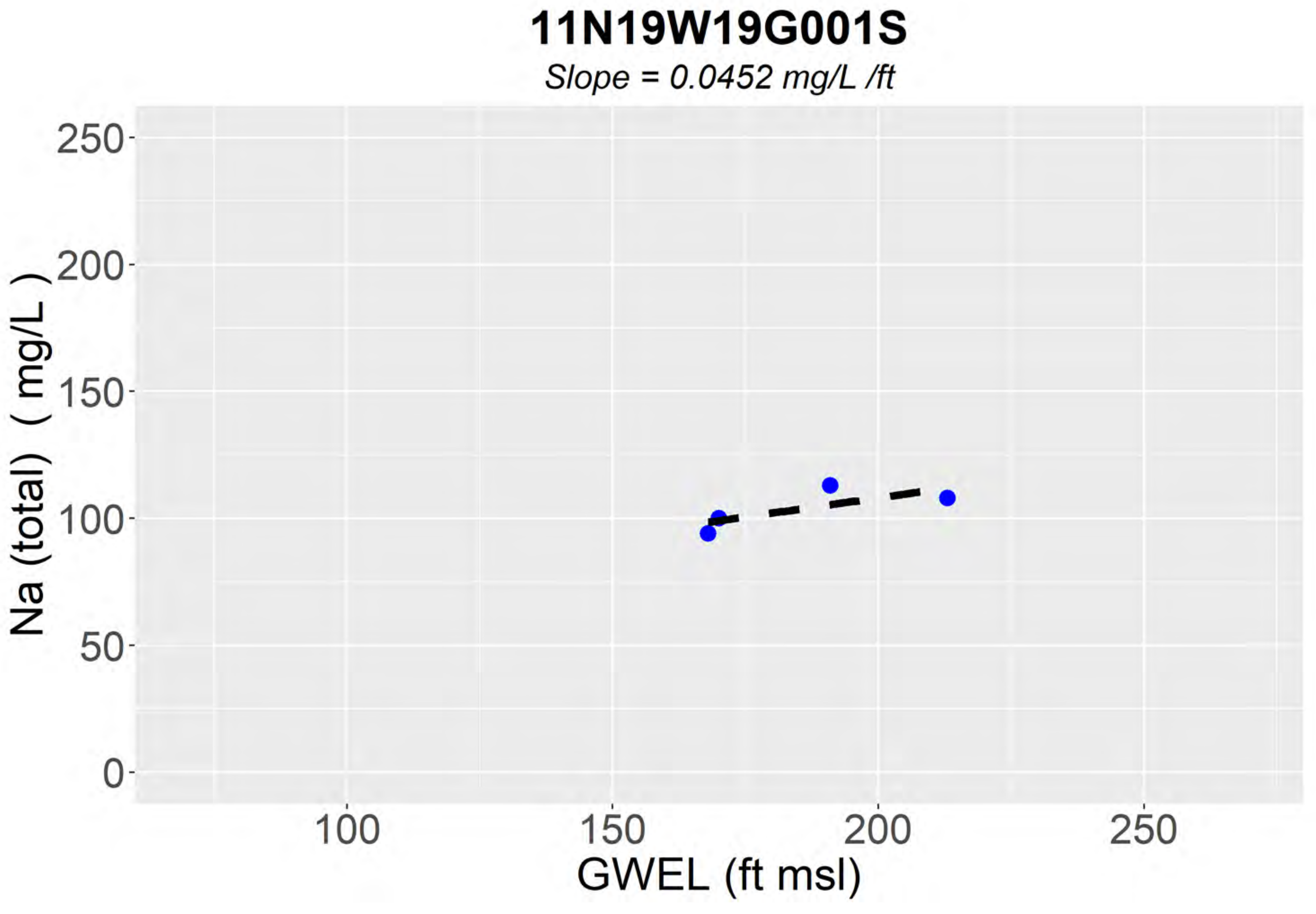

11N19W19M001S
Slope = -0.0326 ug/L /ft
Cr (total) (ug/L)
0
5
10
15
20
100
150
200
250
GWEL (ft msl)

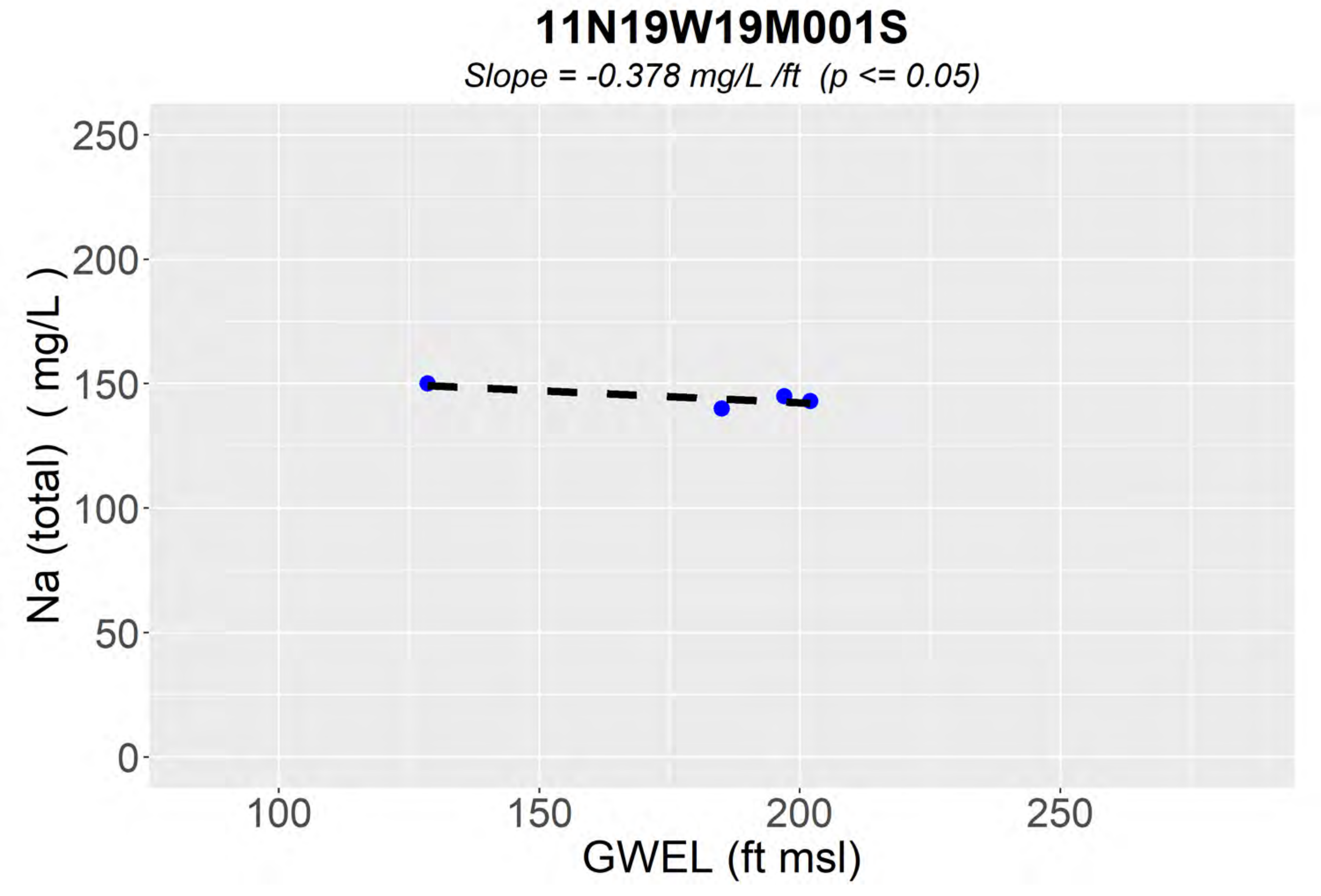

11N18W06M001S
Slope = 0.166 mg/L /ft
Na (total) (mg/L)
250
200
150
100
50
0
100
150
200
250
GWEL (ft msl)

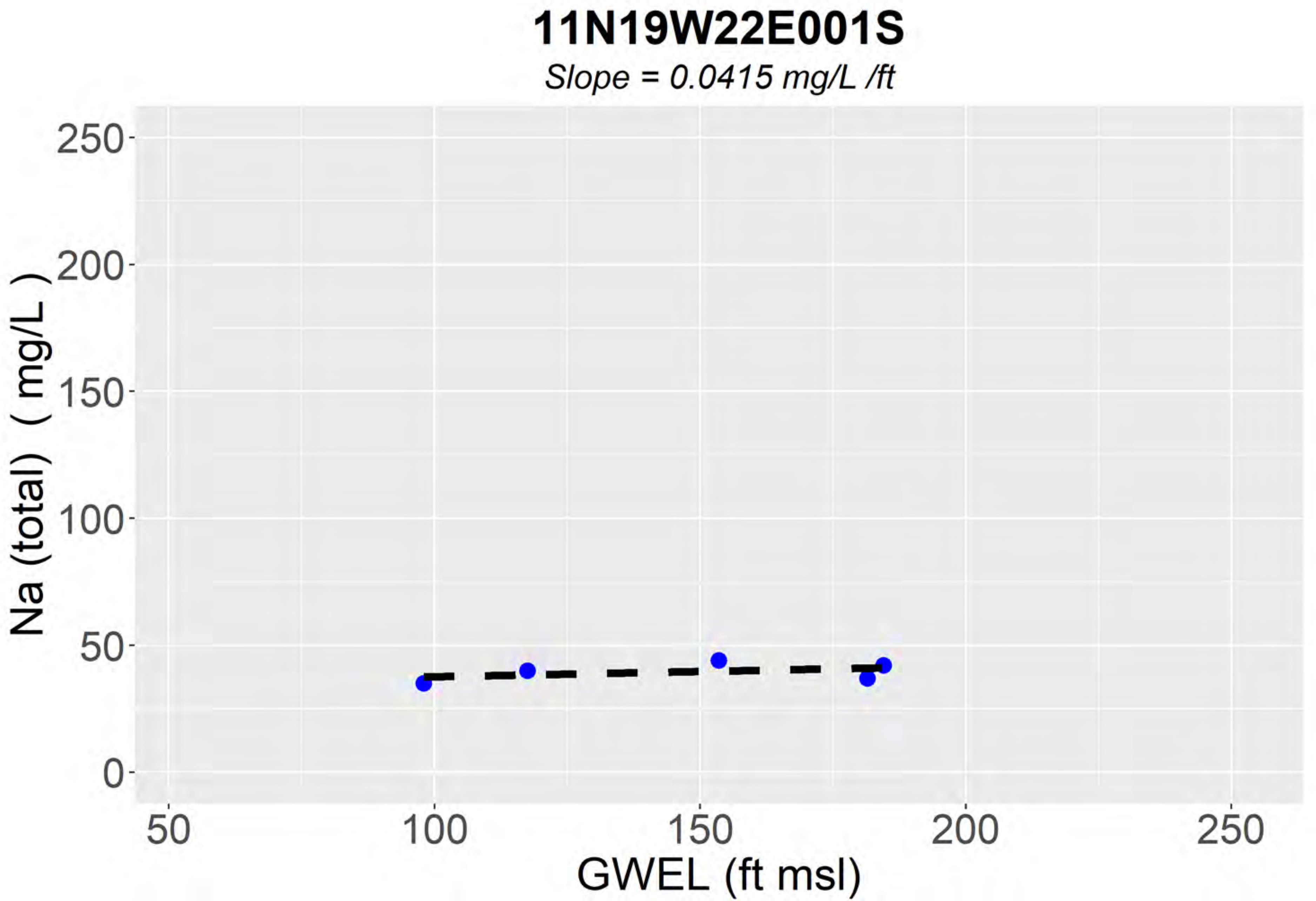

11N18W18L001S
Slope = 1.29 mg/L /ft (p <= 0.05)
Na (total) (mg/L)
GWEL (ft msl)
0
50
100
150
200
250
100
150
200
250



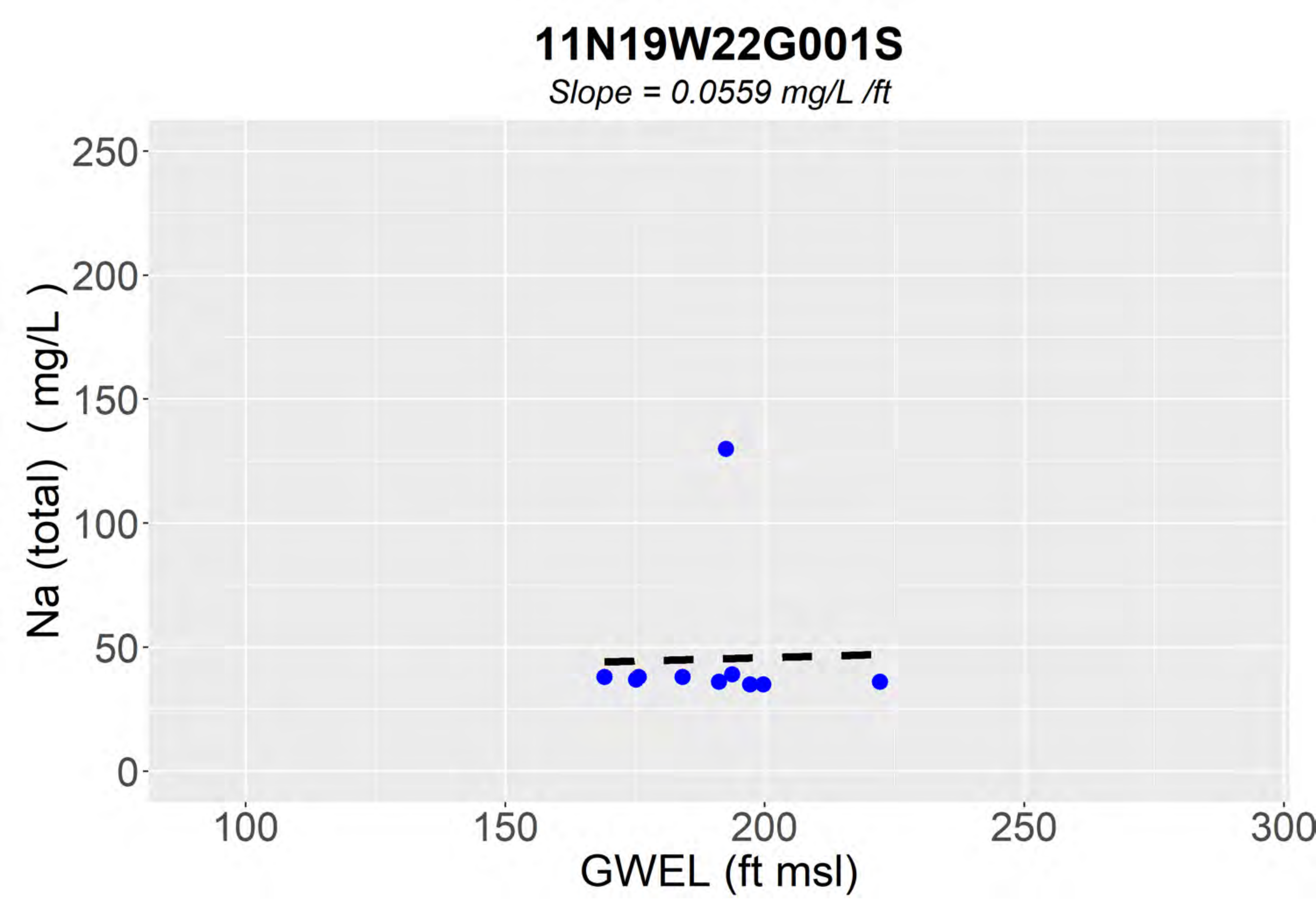
11N19W11Q001S
Slope = 0.84 mg/L /ft
Na (total) (mg/L)
GWEL (ft msl)
0
50
100
150
200
250
50
100
150
200
250


11N19W19G001S
Slope = 0.0452 mg/L /ft
Na (total) (mg/L)
250
200
150
100
50
0
100
150
200
250
GWEL (ft msl)

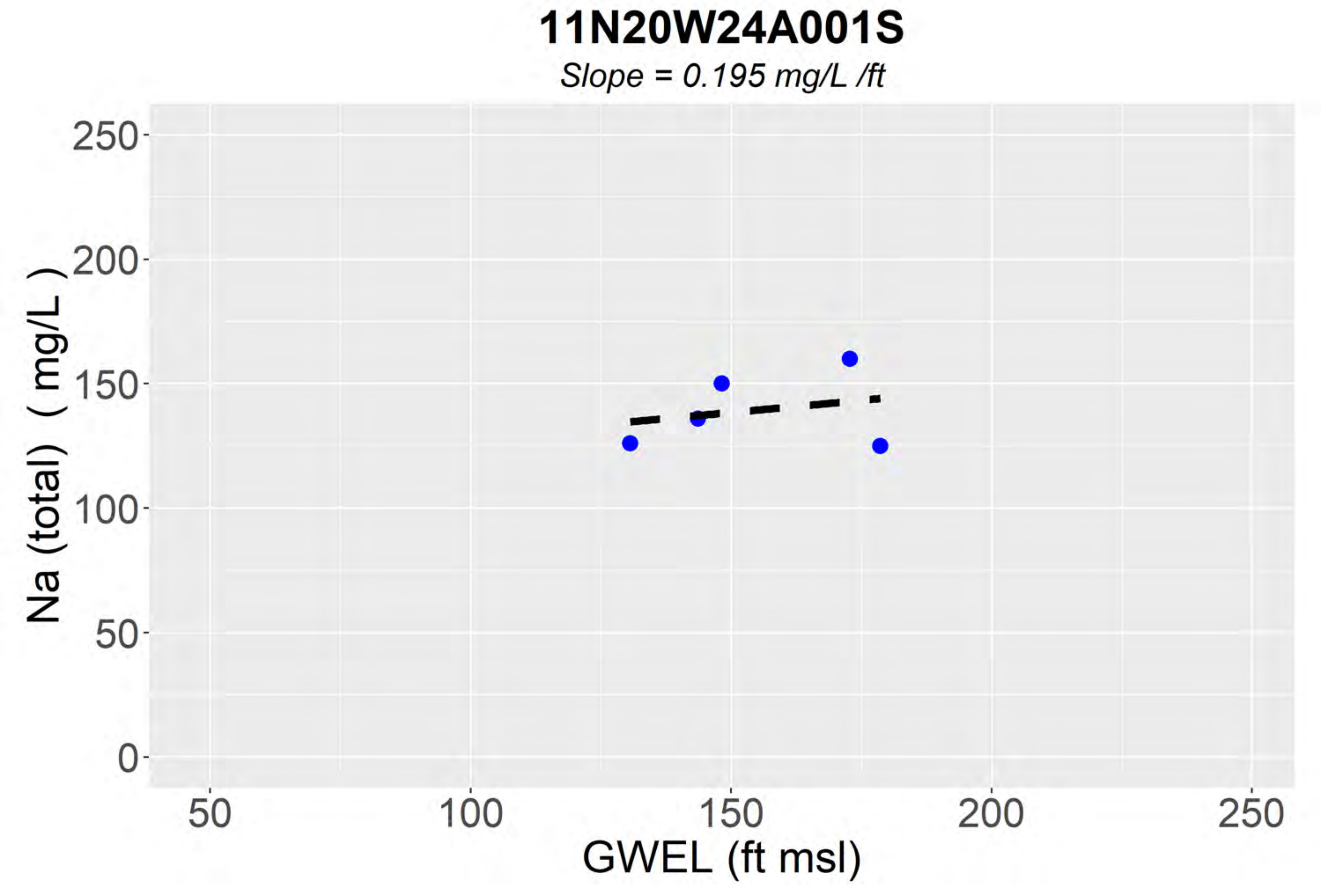

11N19W19M001S
Slope = -0.378 mg/L /ft (p <= 0.05)
Na (total) (mg/L)
250
200
150
100
50
0
100
150
200
250
GWEL (ft msl)

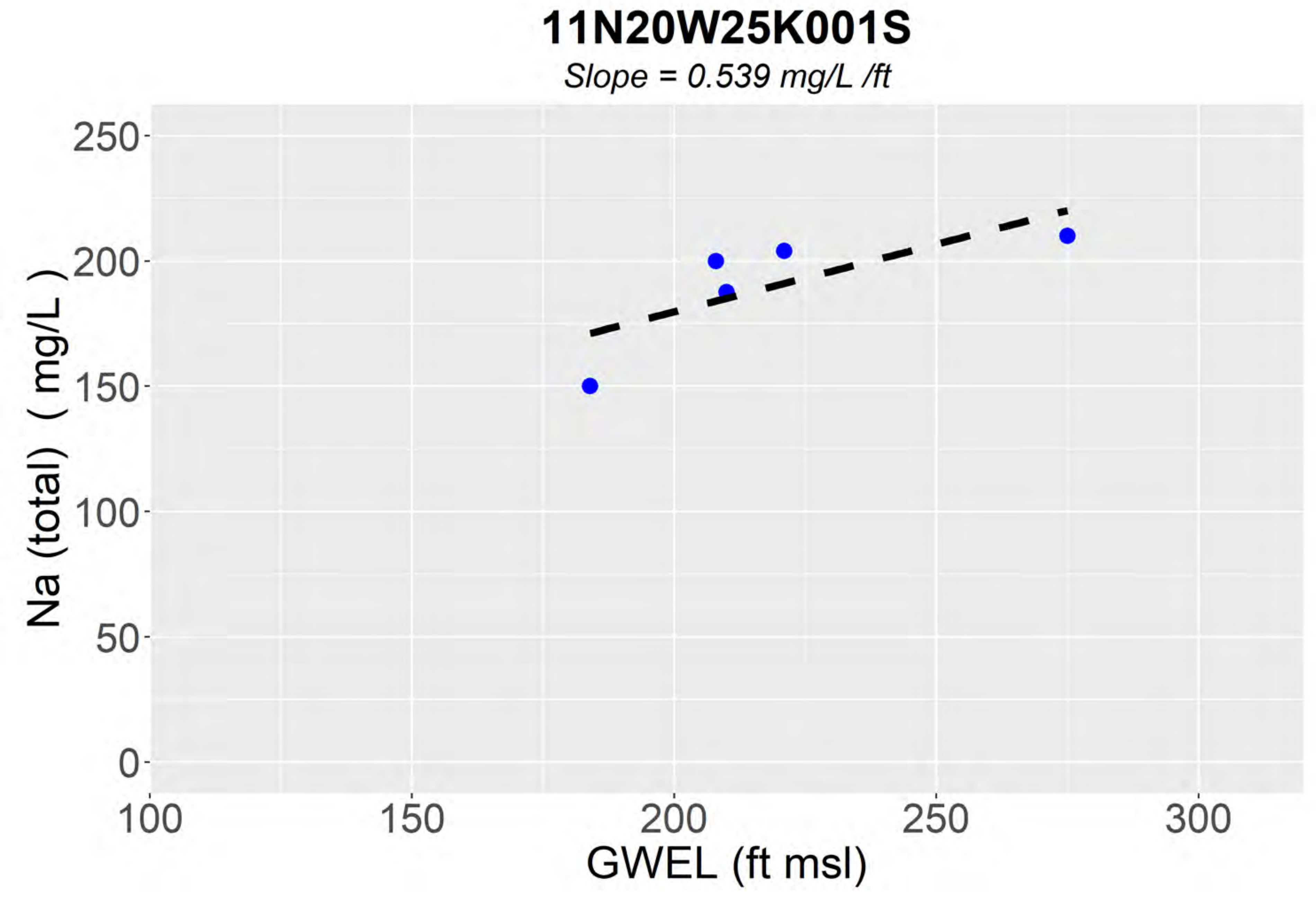


11N19W22E001S
Slope = 0.0415 mg/L /ft
Na (total) (mg/L)
GWEL (ft msl)
0
50
100
150
200
250
50
100
150
200
250

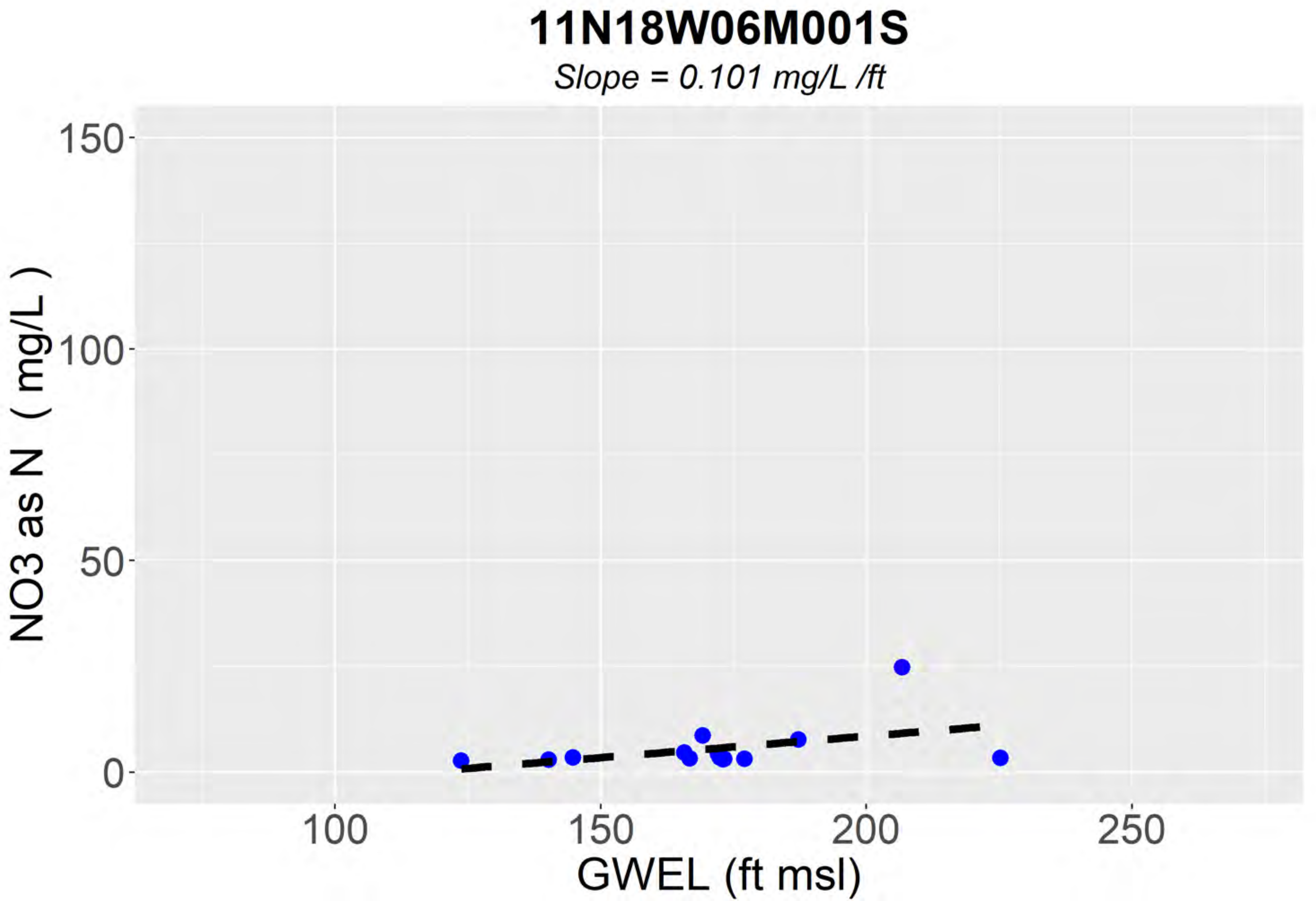


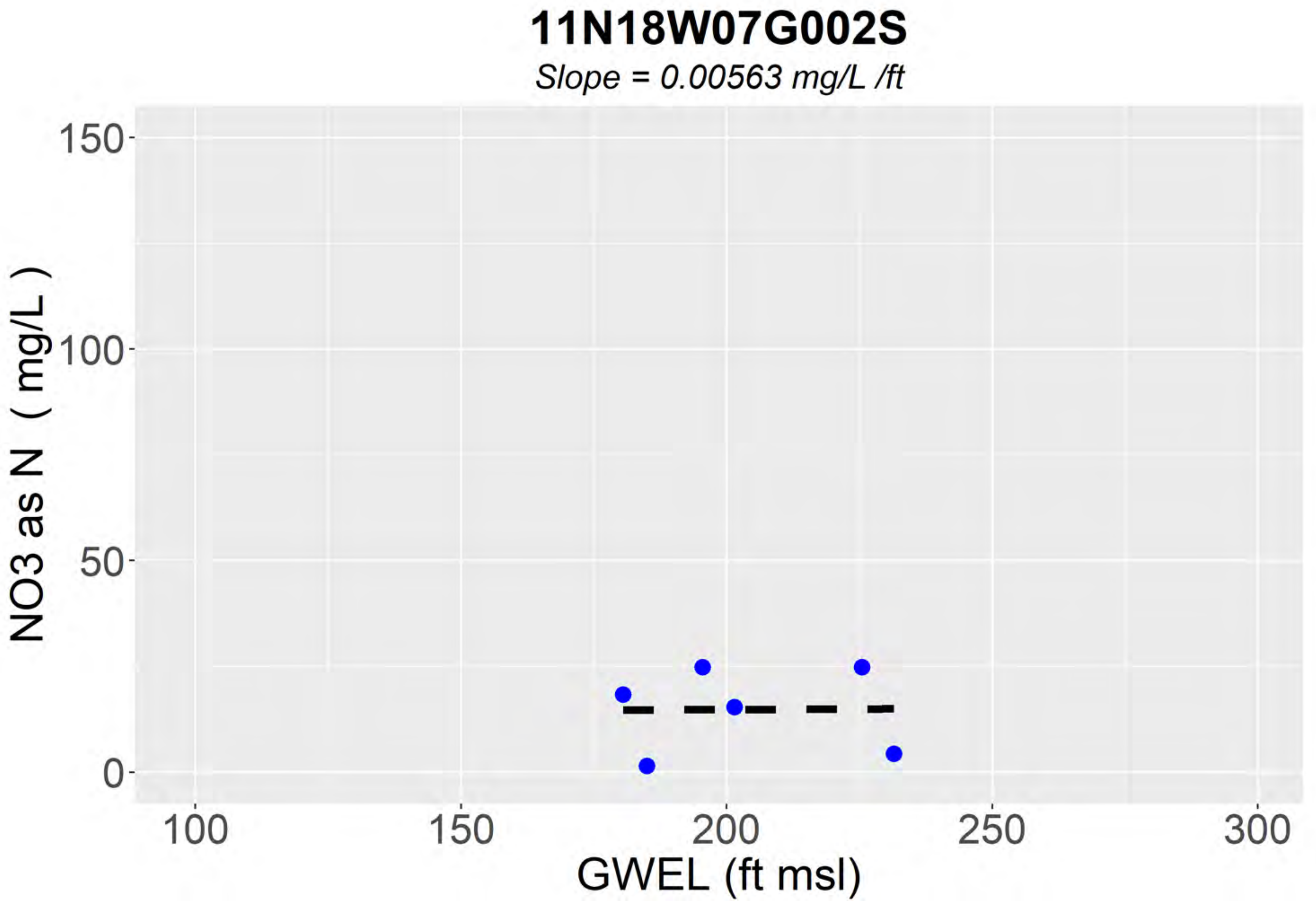
11N19W22G001S
Slope = 0.0559 mg/L /ft
Na (total) (mg/L)
GWEL (ft msl)
0
50
100
150
200
250
100
150
200
250
300

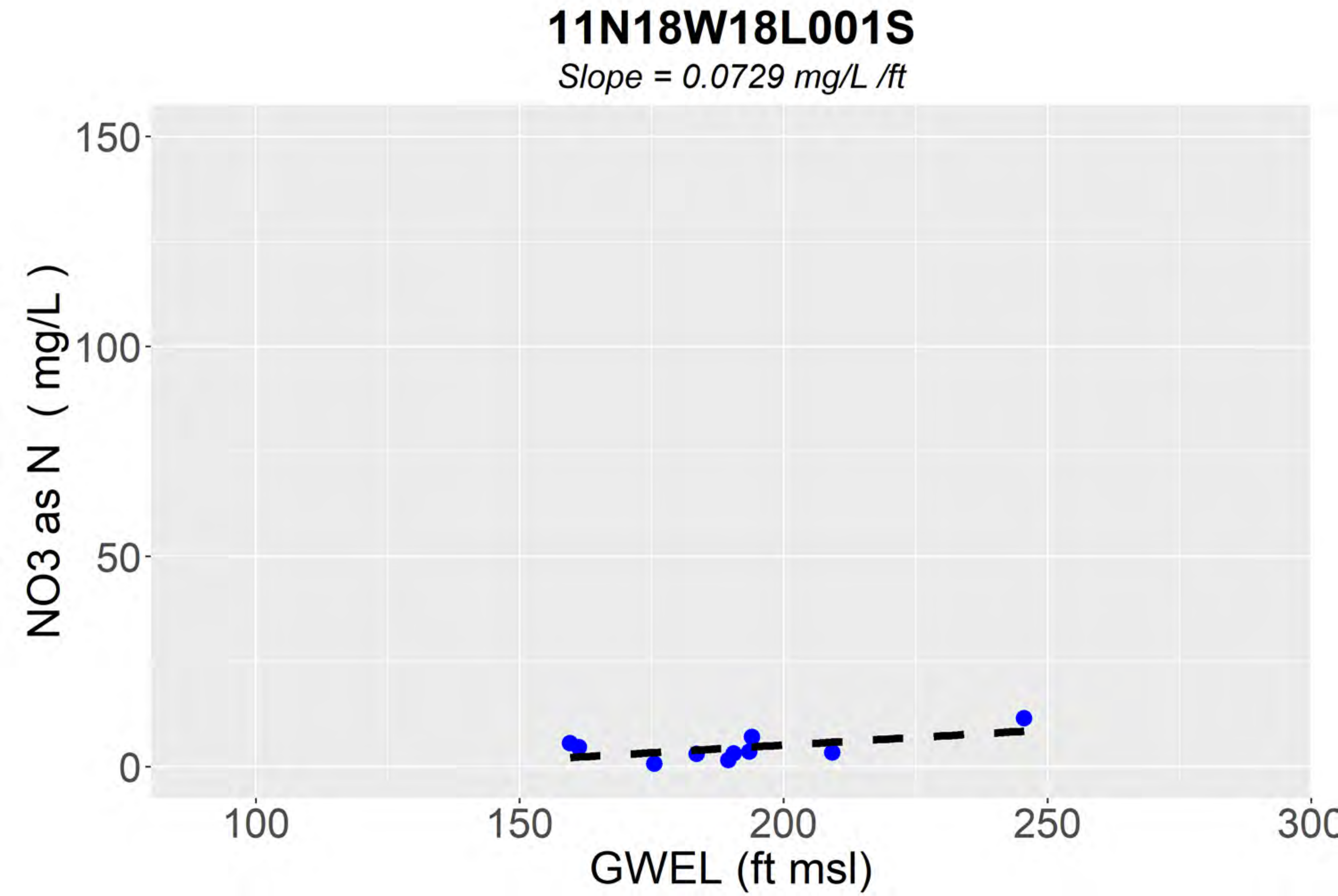

11N20W24A001S
Slope = 0.195 mg/L /ft
250
200
150
100
50
0
Na (total) (mg/L)
50
100
150
200
250
GWEL (ft msl)



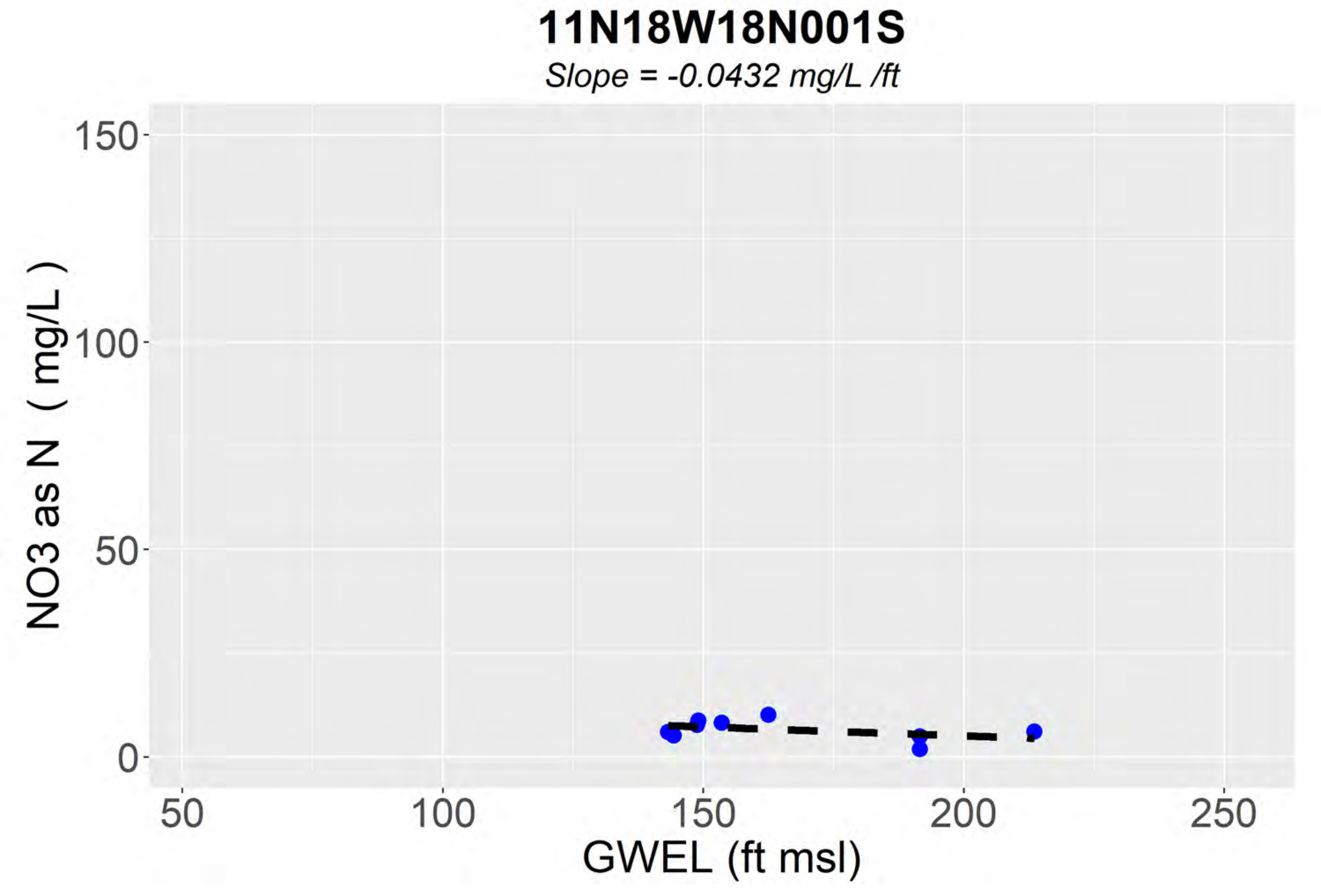
11N20W25K001S
Slope = 0.539 mg/L /ft
Na (total) (mg/L)
250
200
150
100
50
0
100
150
200
250
300
GWEL (ft msl)

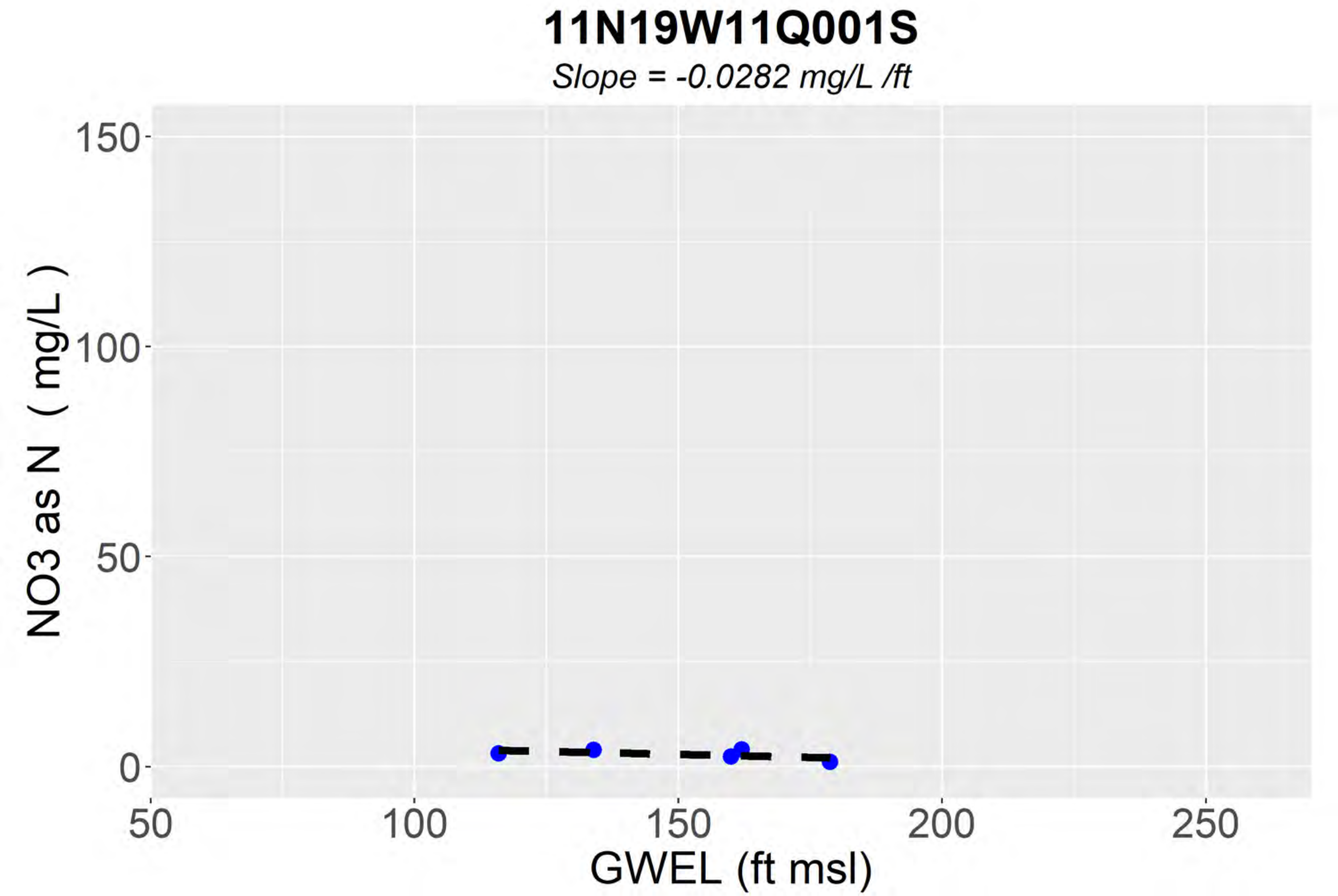

11N18W06M001S
Slope = 0.101 mg/L /ft
150
100
50
0
NO3 as N (mg/L)
100
150
200
250
GWEL (ft msl)

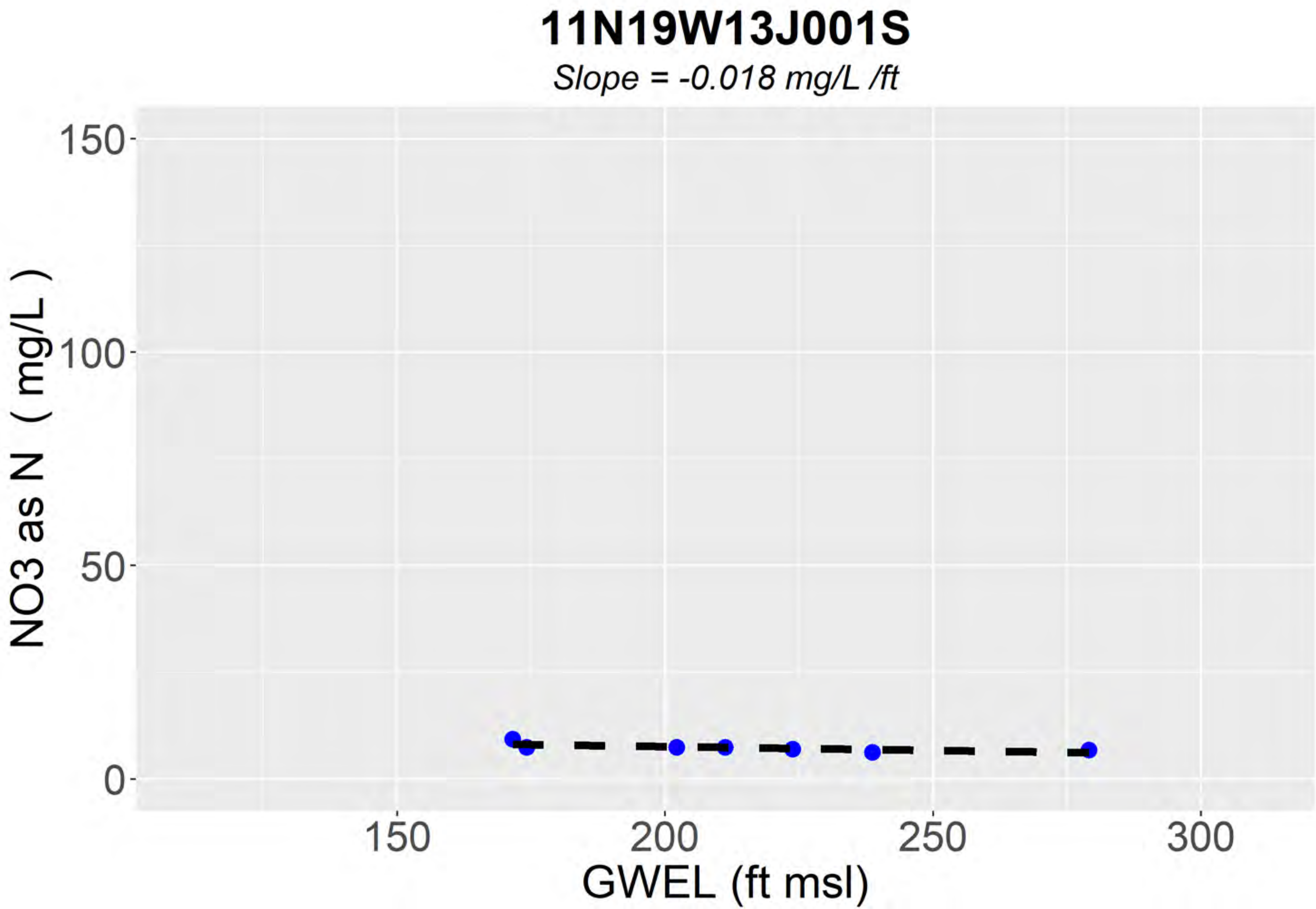

11N18W07G002S
Slope = 0.00563 mg/L /ft
NO3 as N (mg/L)
GWEL (ft msl)
150
100
50
0
100
150
200
250
300

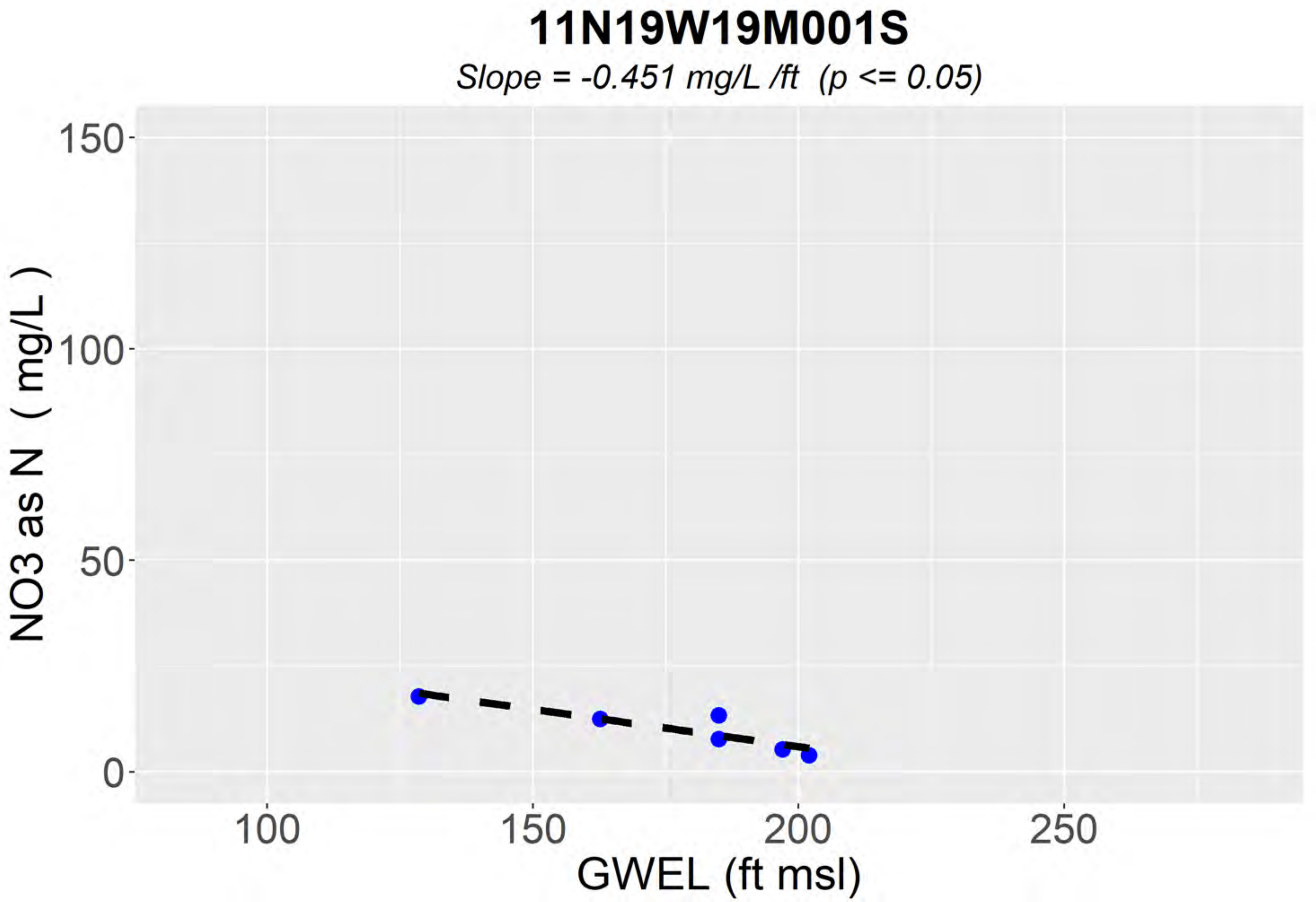


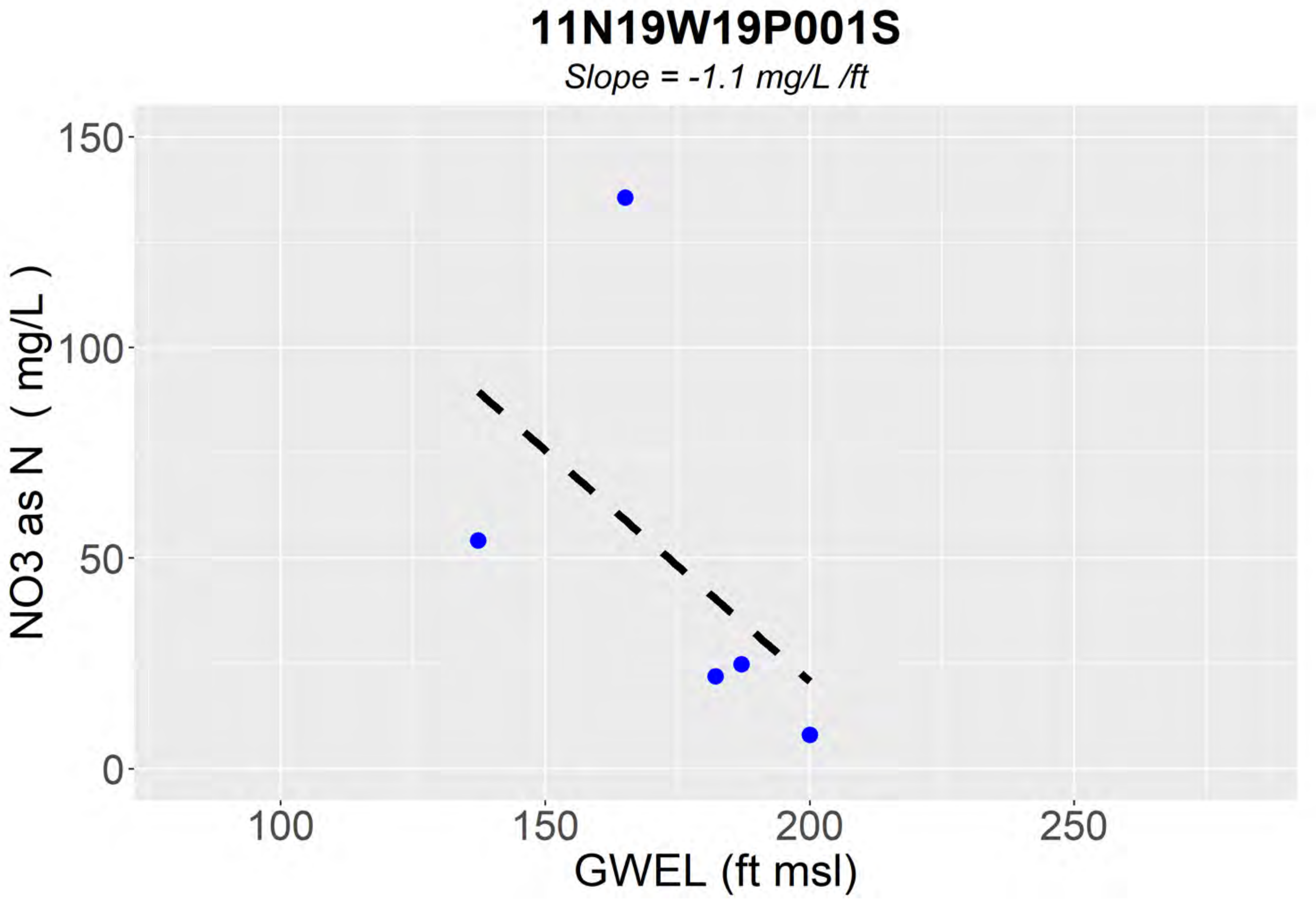
11N18W18L001S
Slope = 0.0729 mg/L /ft
150
100
50
0
NO3 as N (mg/L)
100
150
200
250
300
GWEL (ft msl)


11N18W18N001S
Slope = -0.0432 mg/L /ft
NO3 as N (mg/L)
150
100
50
0
50
100
150
200
250
GWEL (ft msl)

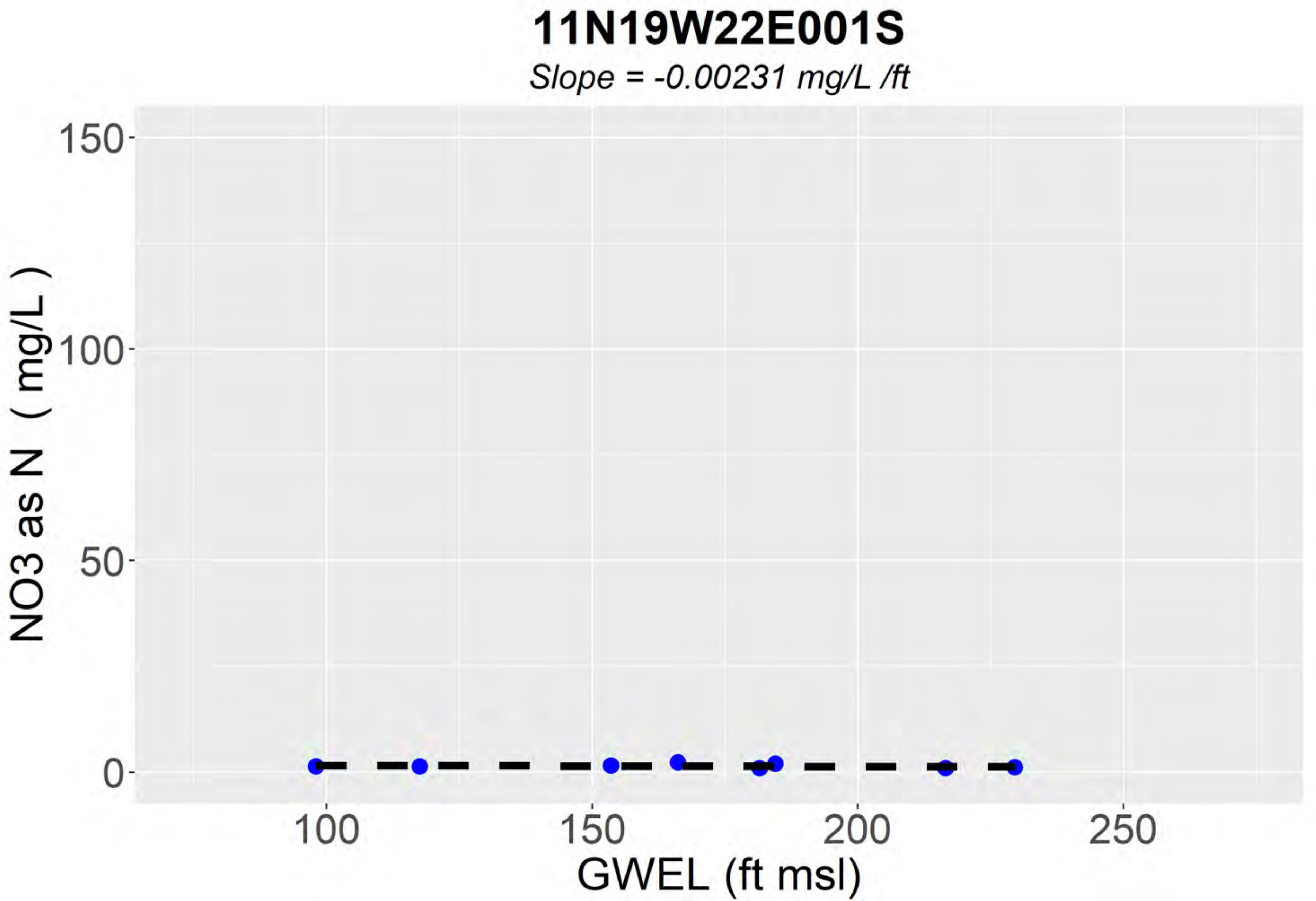

11N19W11Q001S
Slope = -0.0282 mg/L /ft
150
100
50
0
NO3 as N (mg/L)
50
100
150
200
250
GWEL (ft msl)

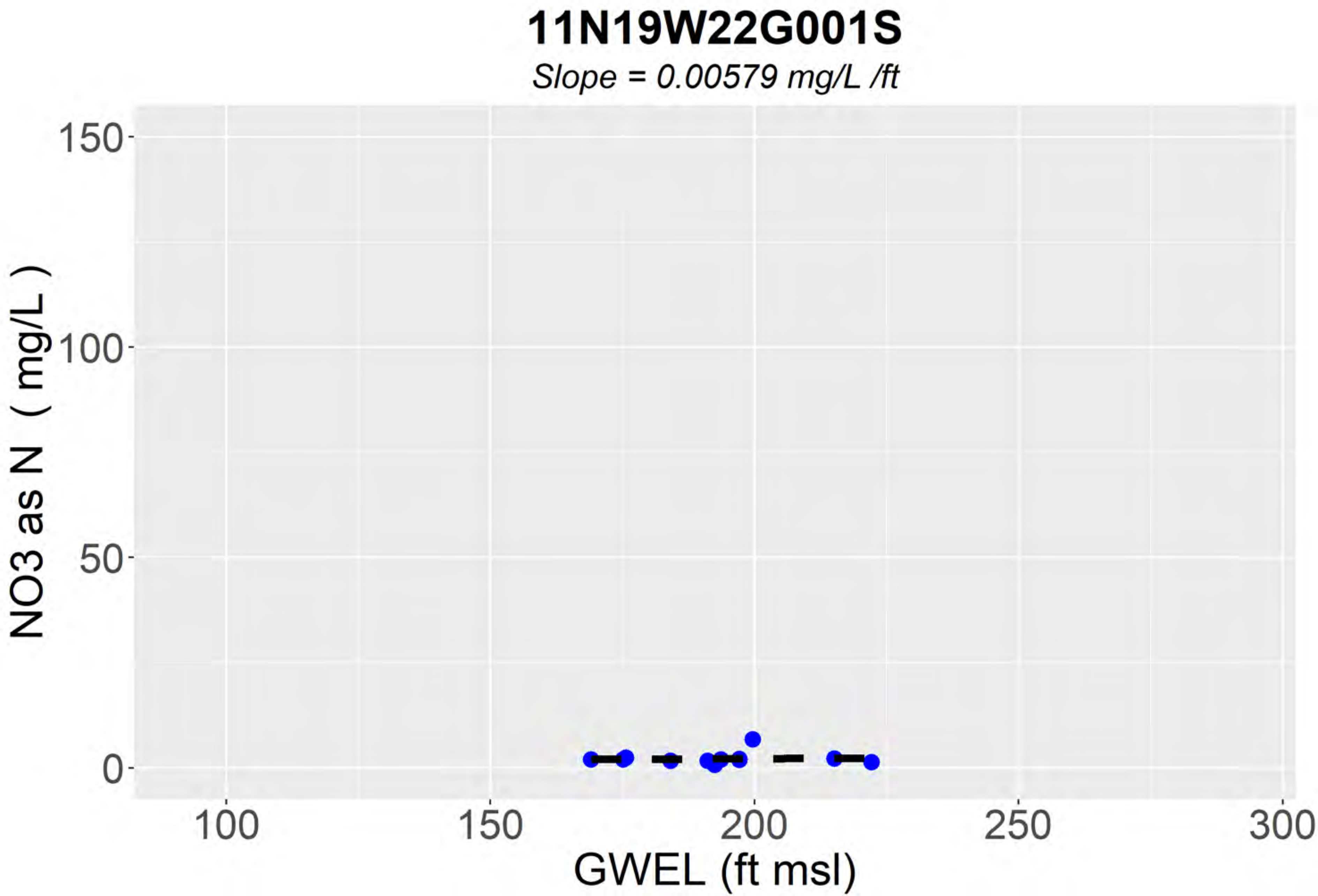

11N19W13J001S
Slope = -0.018 mg/L /ft
150
100
50
0
NO3 as N (mg/L)
150
200
250
300
GWEL (ft msl)

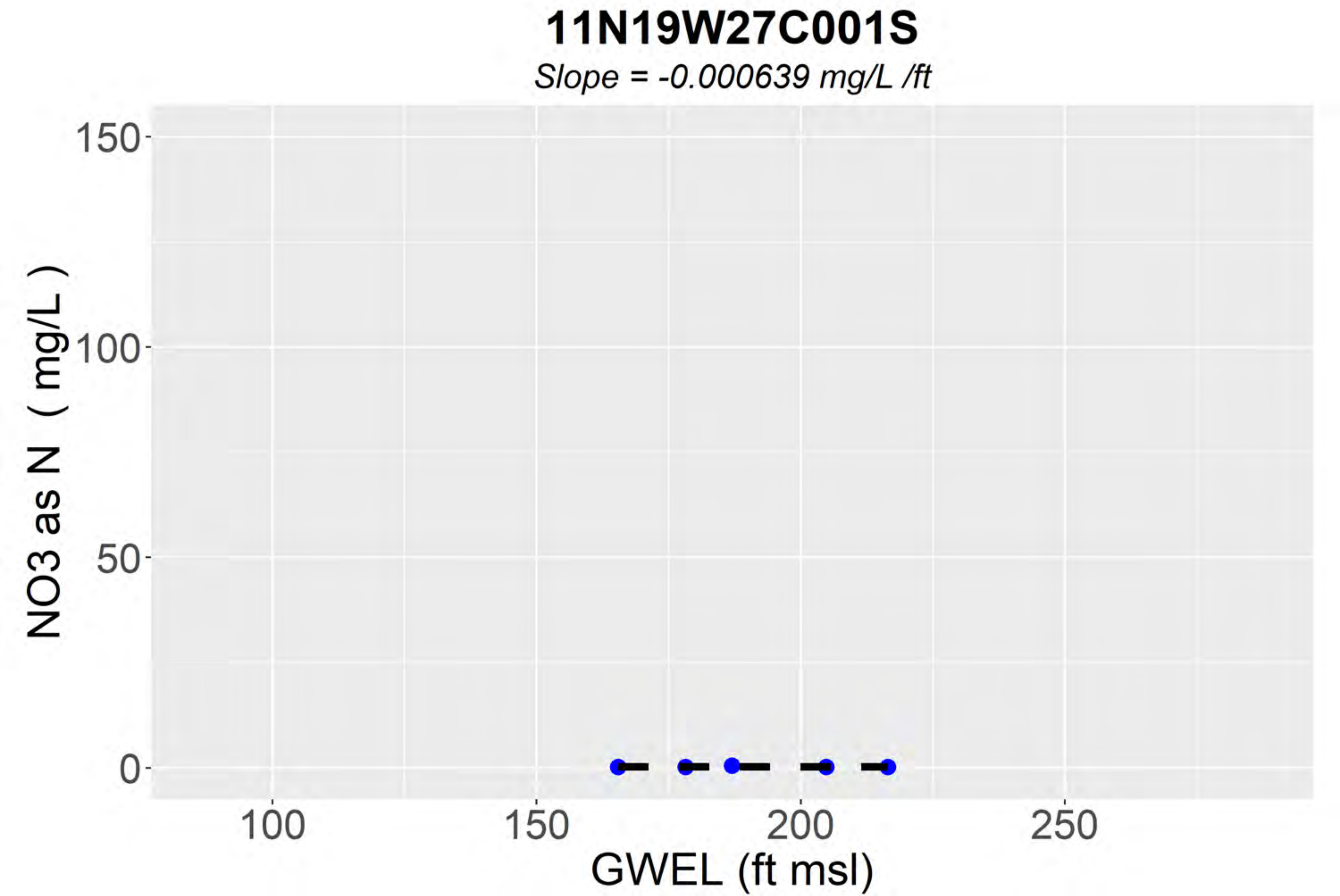

11N19W19M001S
Slope = -0.451 mg/L /ft (p <= 0.05)
NO3 as N (mg/L)
150
100
50
0
100
150
200
250
GWEL (ft msl)



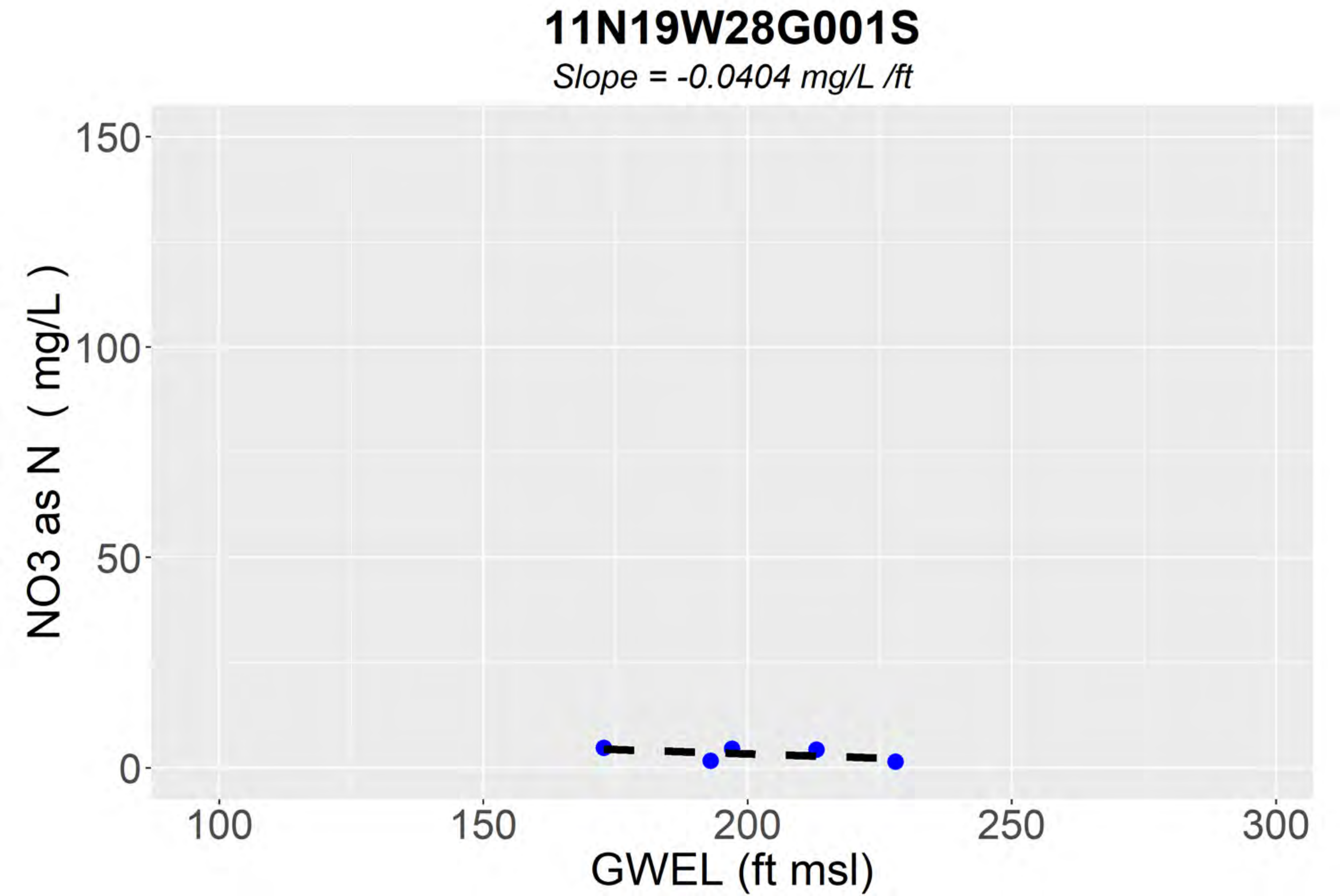
11N19W19P001S
Slope = -1.1 mg/L /ft
NO3 as N (mg/L)
150
100
50
0
100
150
200
250
GWEL (ft msl)

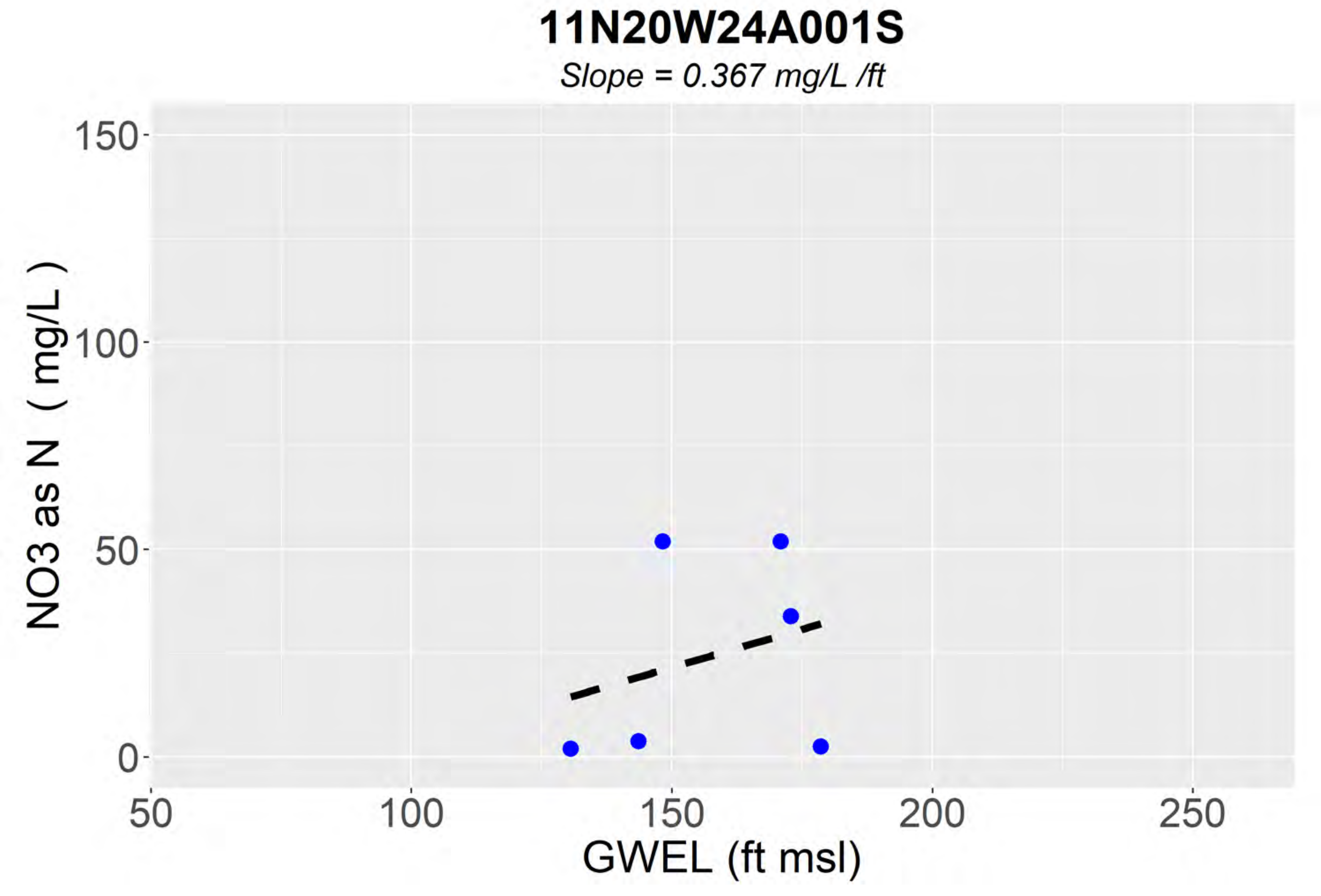

11N19W22E001S
Slope = -0.00231 mg/L /ft
150
100
50
0
NO3 as N (mg/L)
100
150
200
250
GWEL (ft msl)


11N19W22G001S
Slope = 0.00579 mg/L /ft
NO3 as N (mg/L)
150
100
50
0
100
150
200
250
300
GWEL (ft msl)

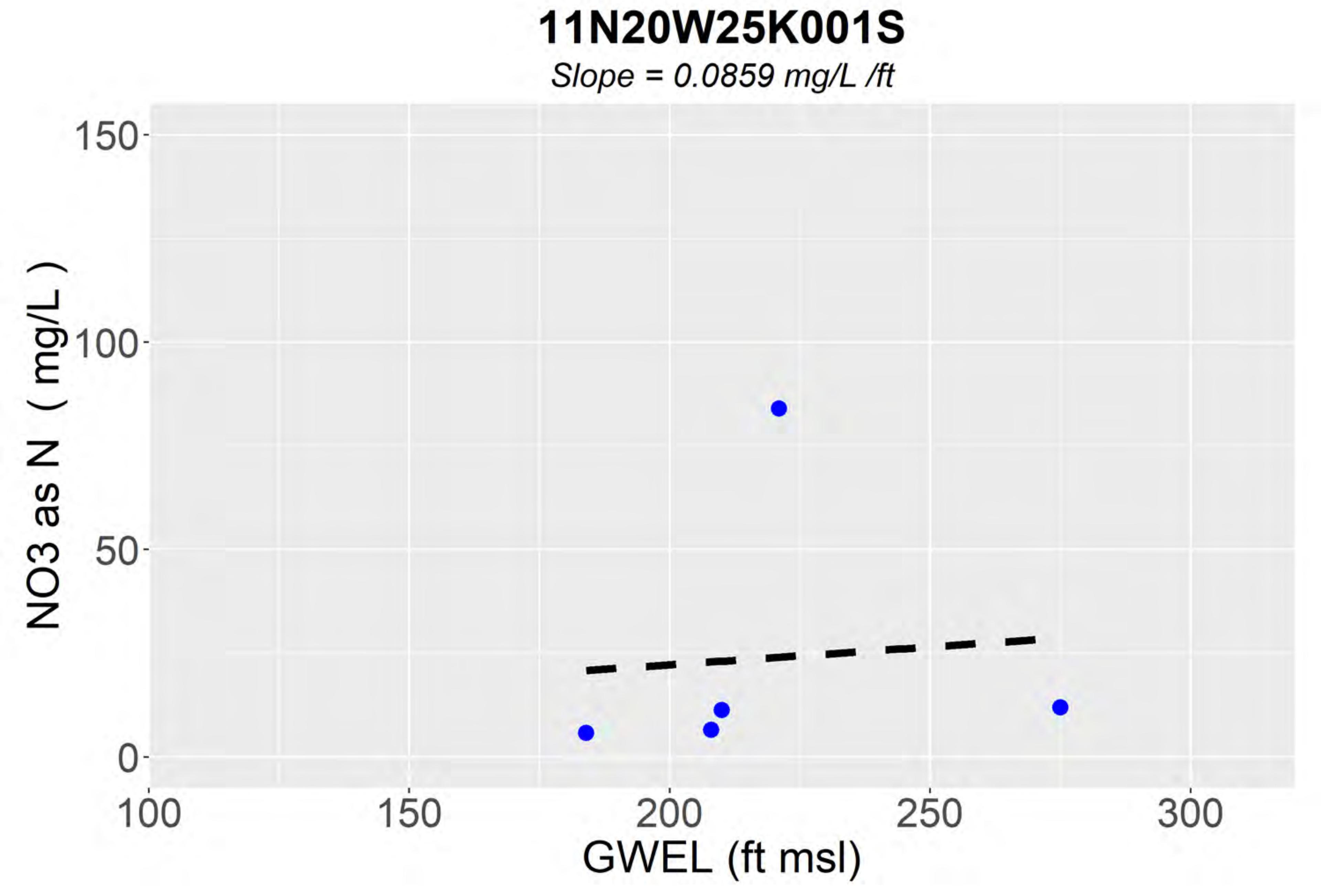


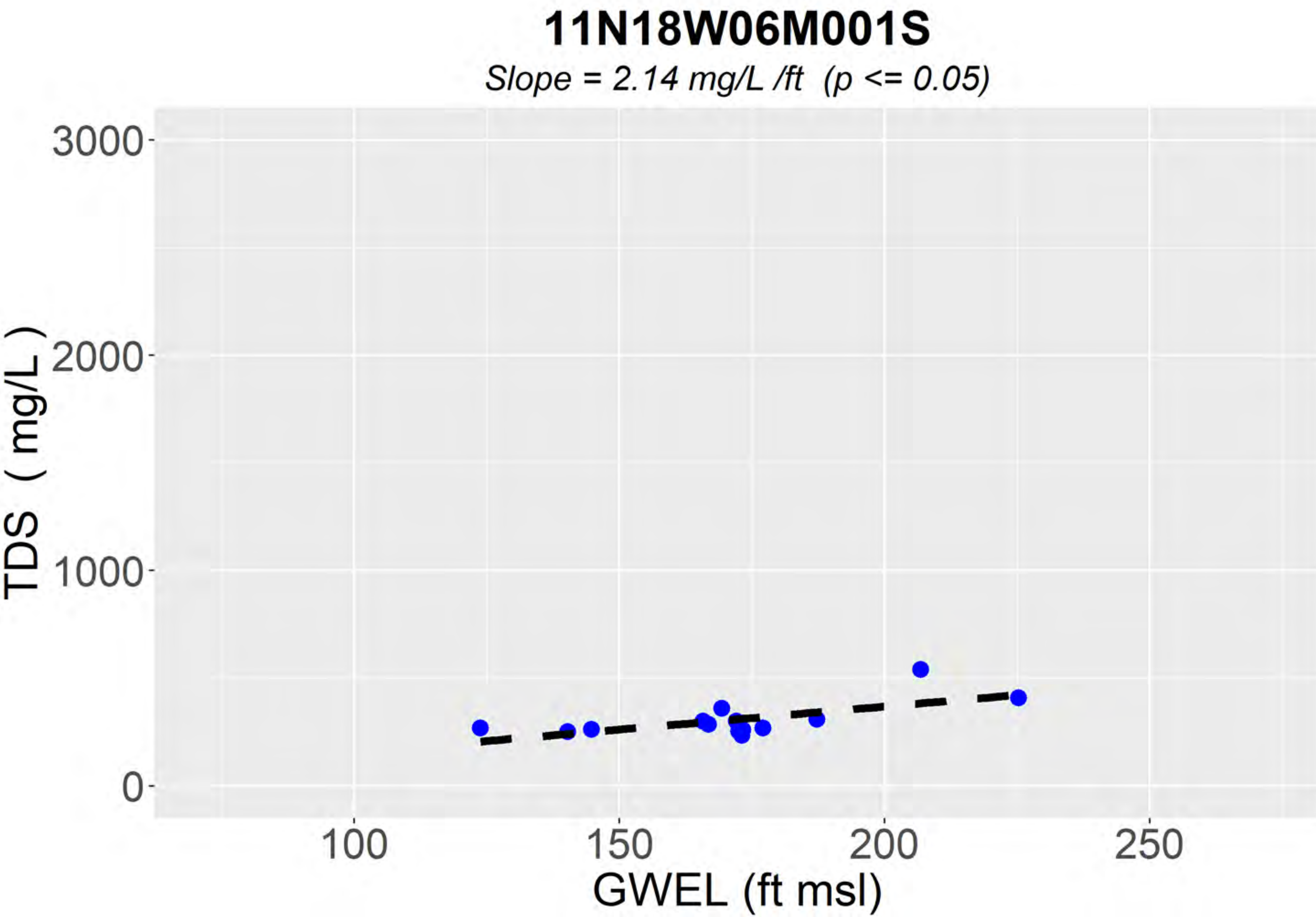
11N19W27C001S
Slope = -0.000639 mg/L /ft
NO3 as N (mg/L)
150
100
50
0
100
150
200
250
GWEL (ft msl)


11N19W28G001S
Slope = -0.0404 mg/L /ft
150
100
50
0
NO3 as N (mg/L)
100
150
200
250
300
GWEL (ft msl)

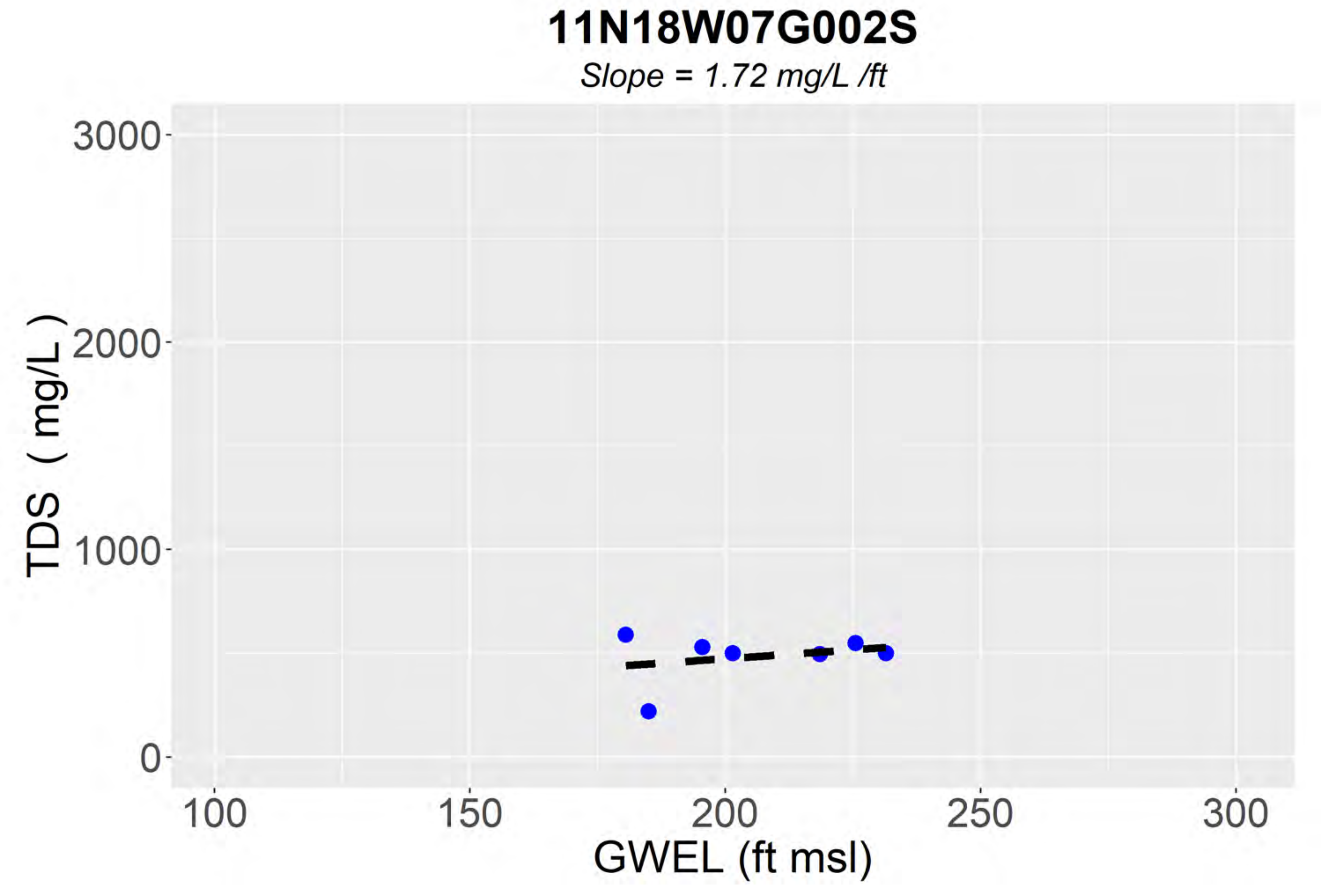


11N20W24A001S
Slope = 0.367 mg/L /ft
NO3 as N (mg/L)
GWEL (ft msl)
150
100
50
0
50
100
150
200
250

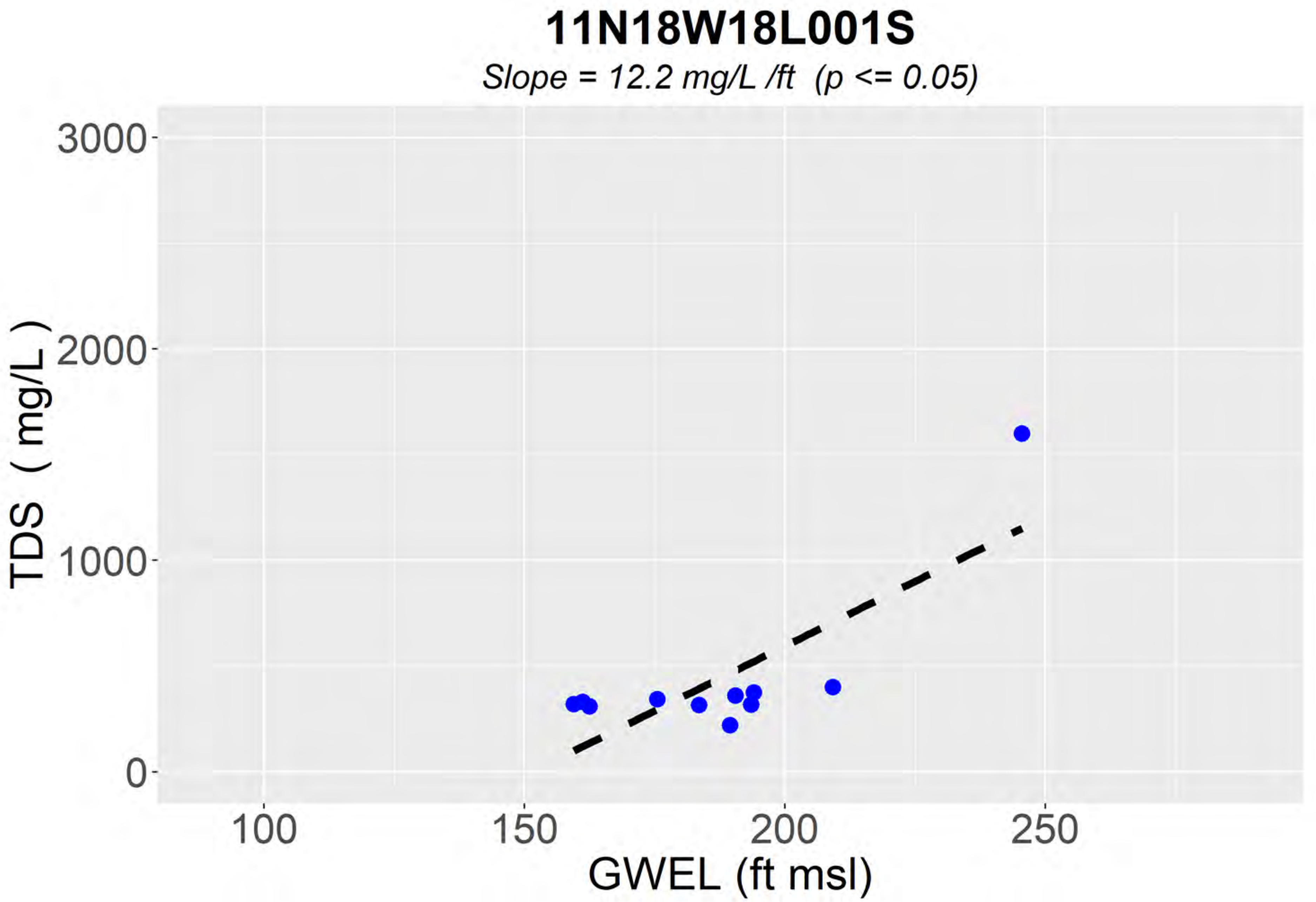

11N20W25K001S
Slope = 0.0859 mg/L /ft
NO3 as N (mg/L)
150
100
50
0
100
150
200
250
300
GWEL (ft msl)

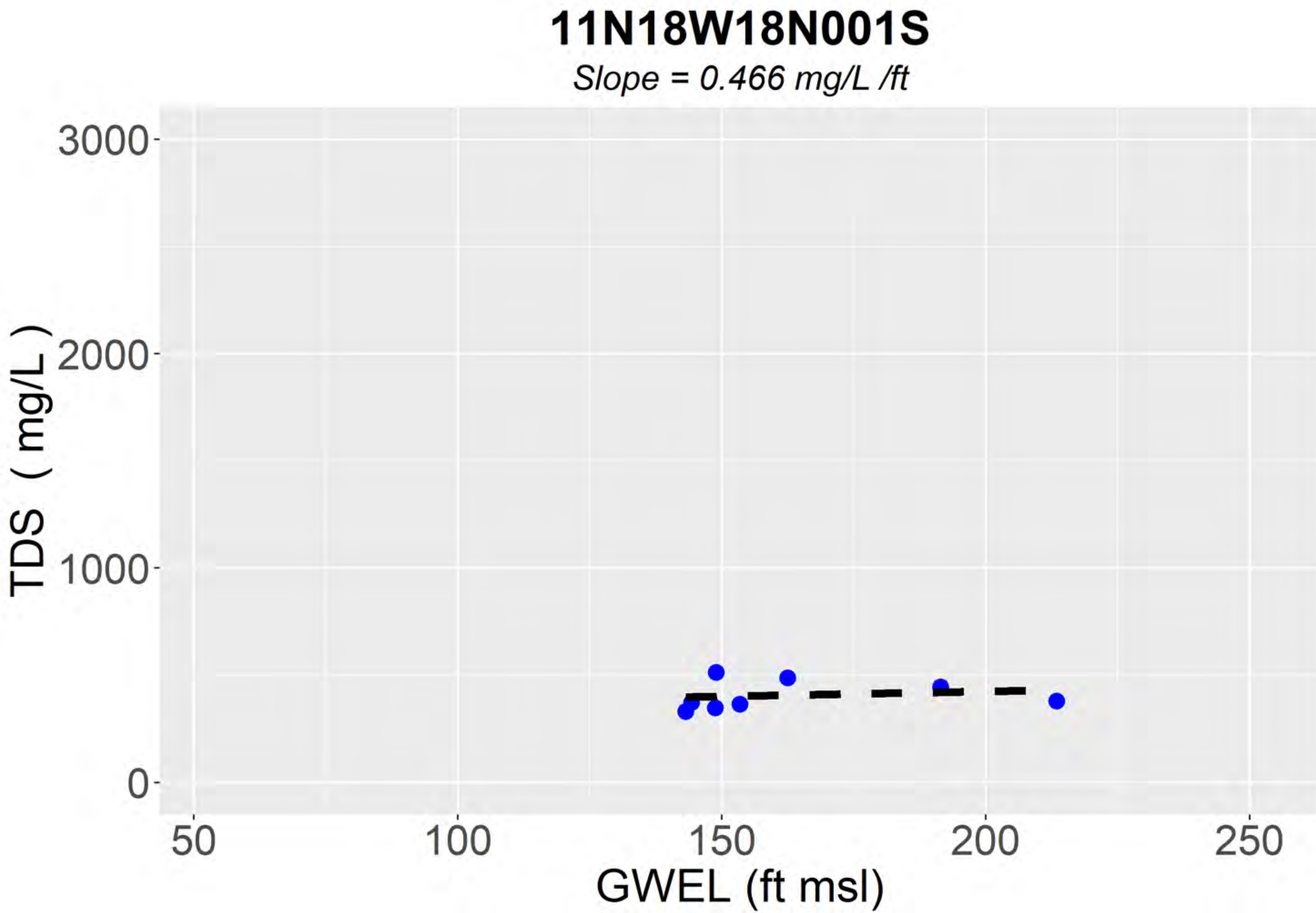


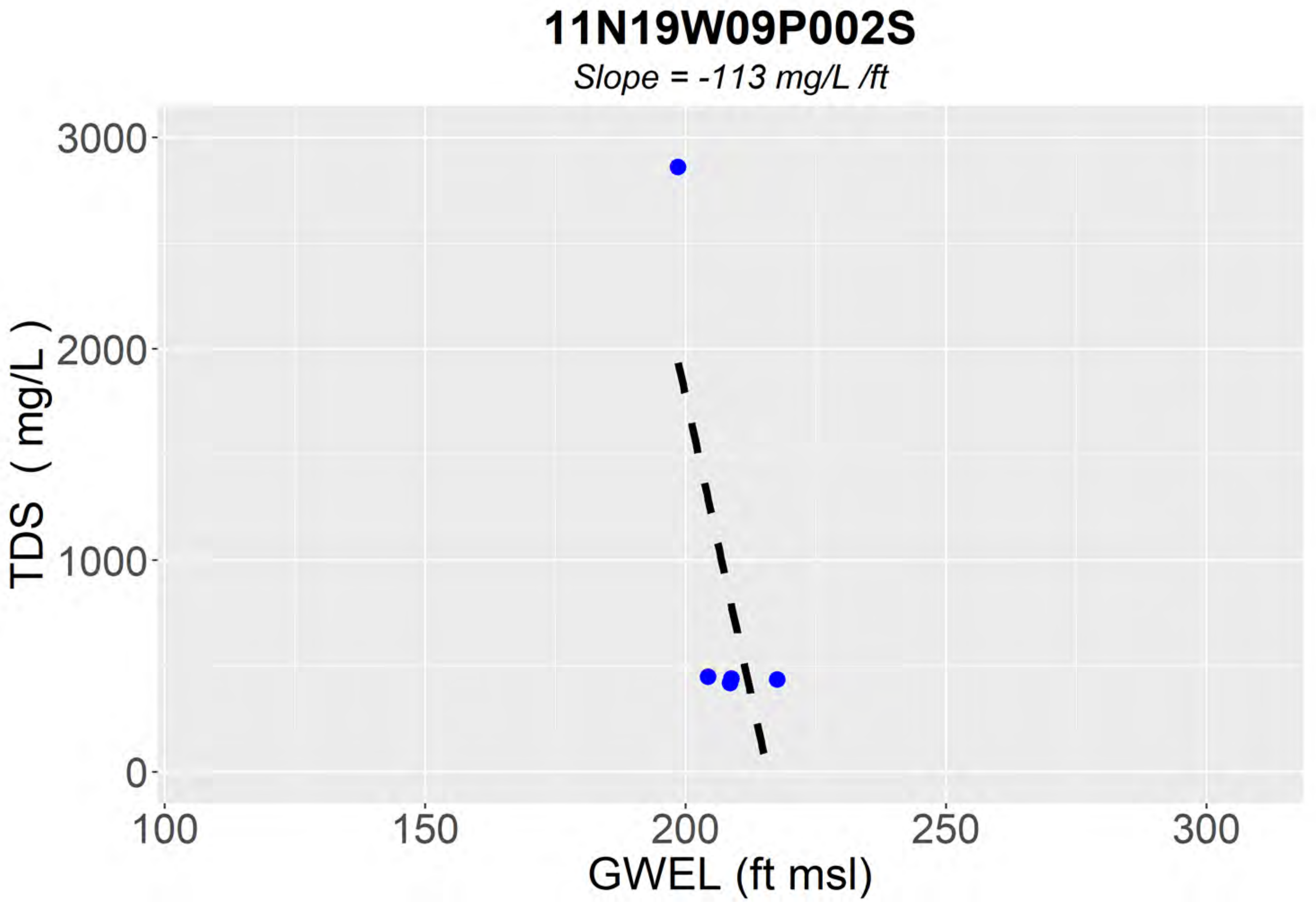
11N18W06M001S
Slope = 2.14 mg/L /ft (p <= 0.05)
3000
2000
1000
0
TDS (mg/L)
100
150
200
250
GWEL (ft msl)



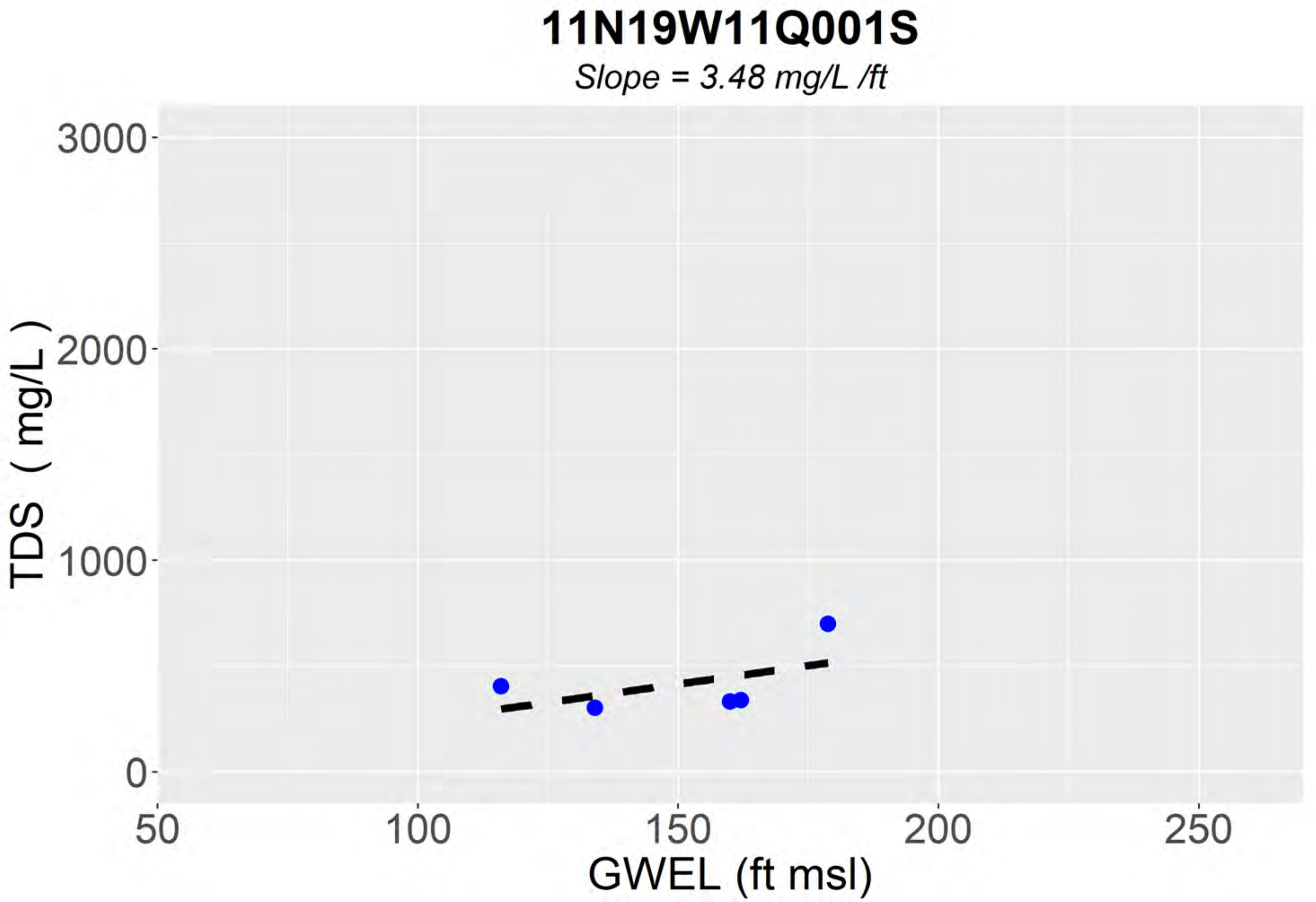
11N18W07G002S
Slope = 1.72 mg/L /ft
TDS (mg/L)
3000
2000
1000
0
100
150
200
250
300
GWEL (ft msl)

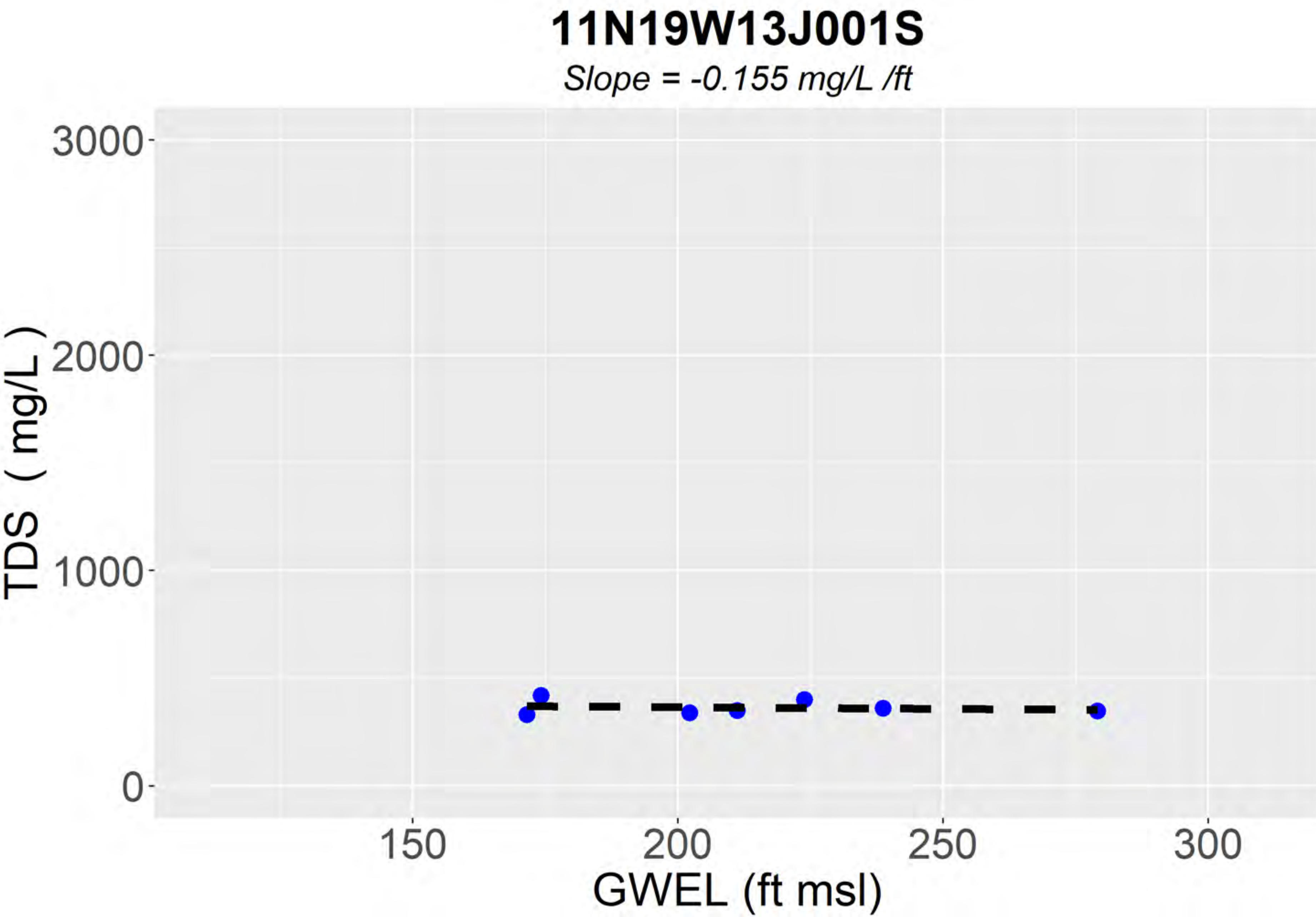

11N18W18L001S
Slope = 12.2 mg/L /ft (p <= 0.05)
3000
2000
1000
0
TDS (mg/L)
100
150
200
250
GWEL (ft msl)

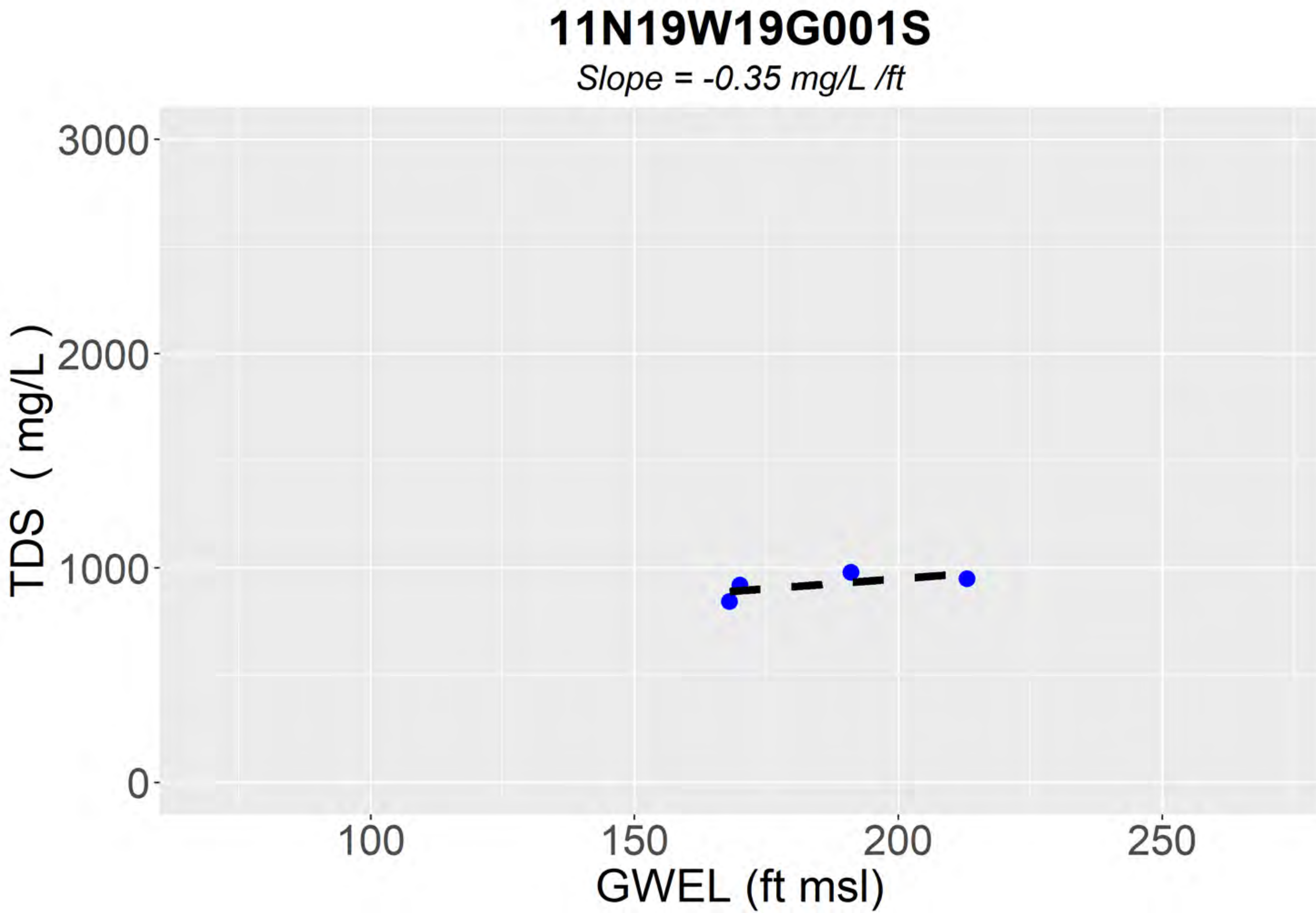

11N18W18N001S
Slope = 0.466 mg/L /ft
TDS (mg/L)
3000
2000
1000
0
50
100
150
200
250
GWEL (ft msl)

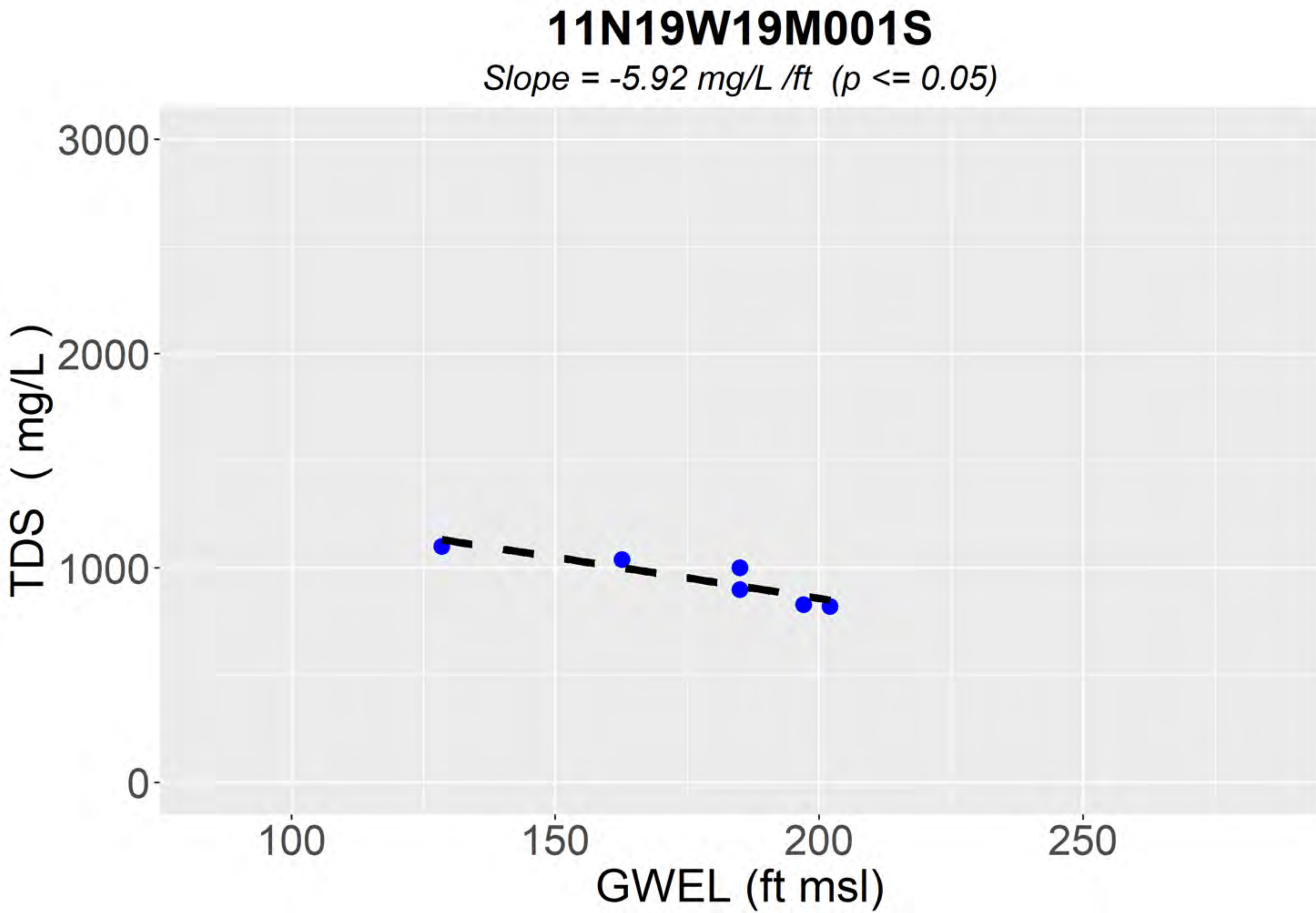


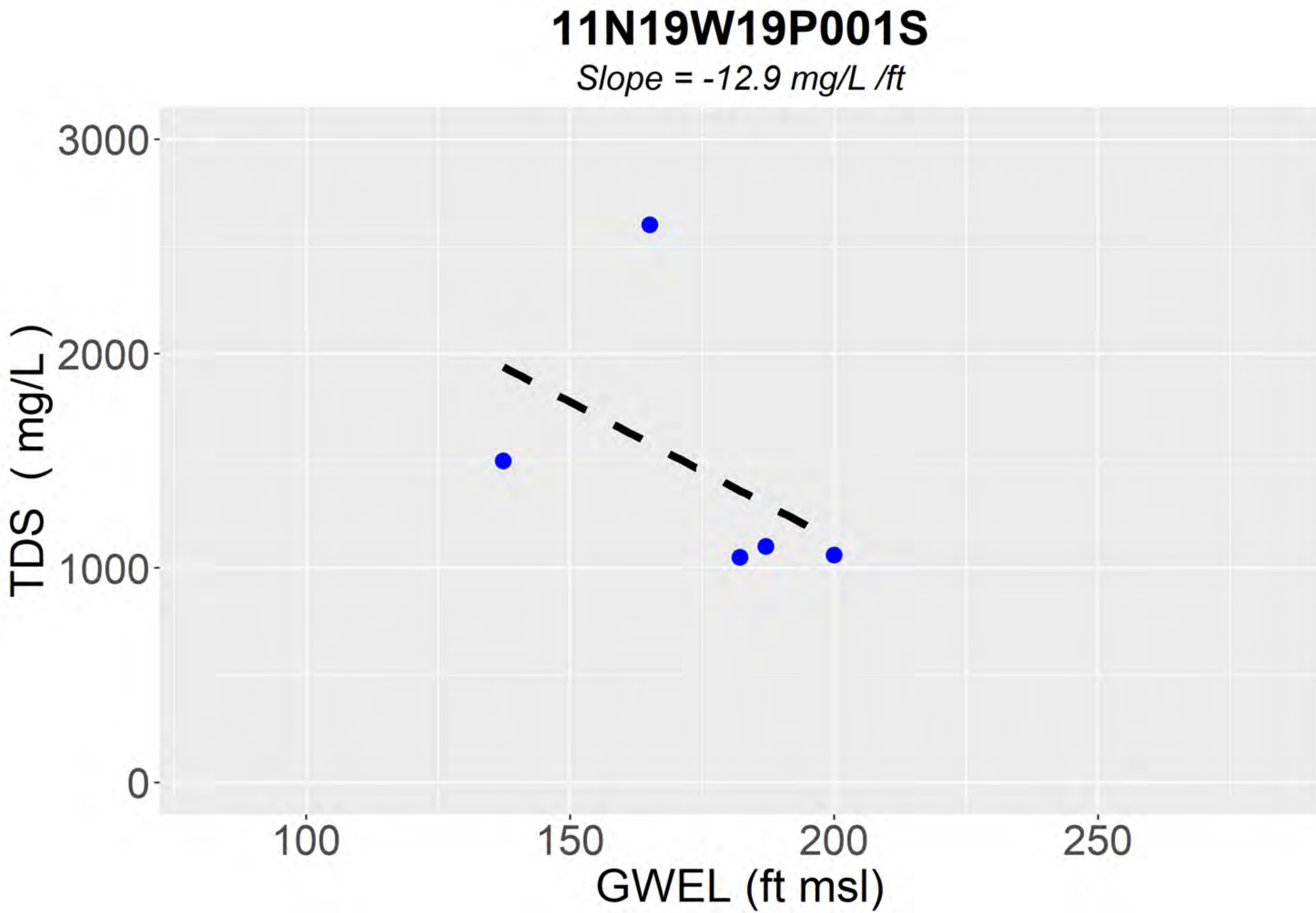
11N19W09P002S
Slope = -113 mg/L /ft
TDS (mg/L)
3000
2000
1000
0
100
150
200
250
300
GWEL (ft msl)

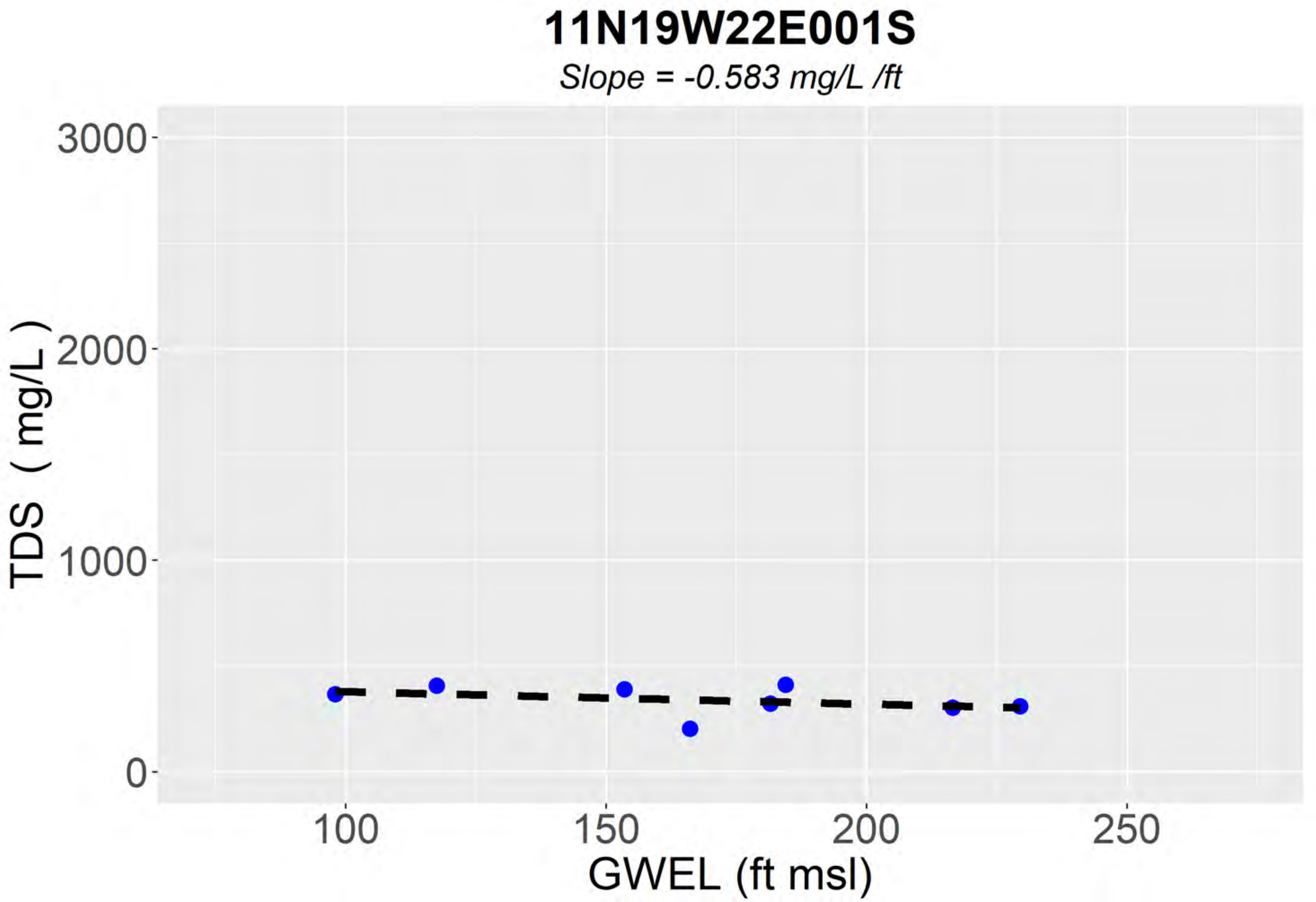

11N19W11Q001S
Slope = 3.48 mg/L /ft
3000
2000
1000
0
TDS (mg/L)
50
100
150
200
250
GWEL (ft msl)

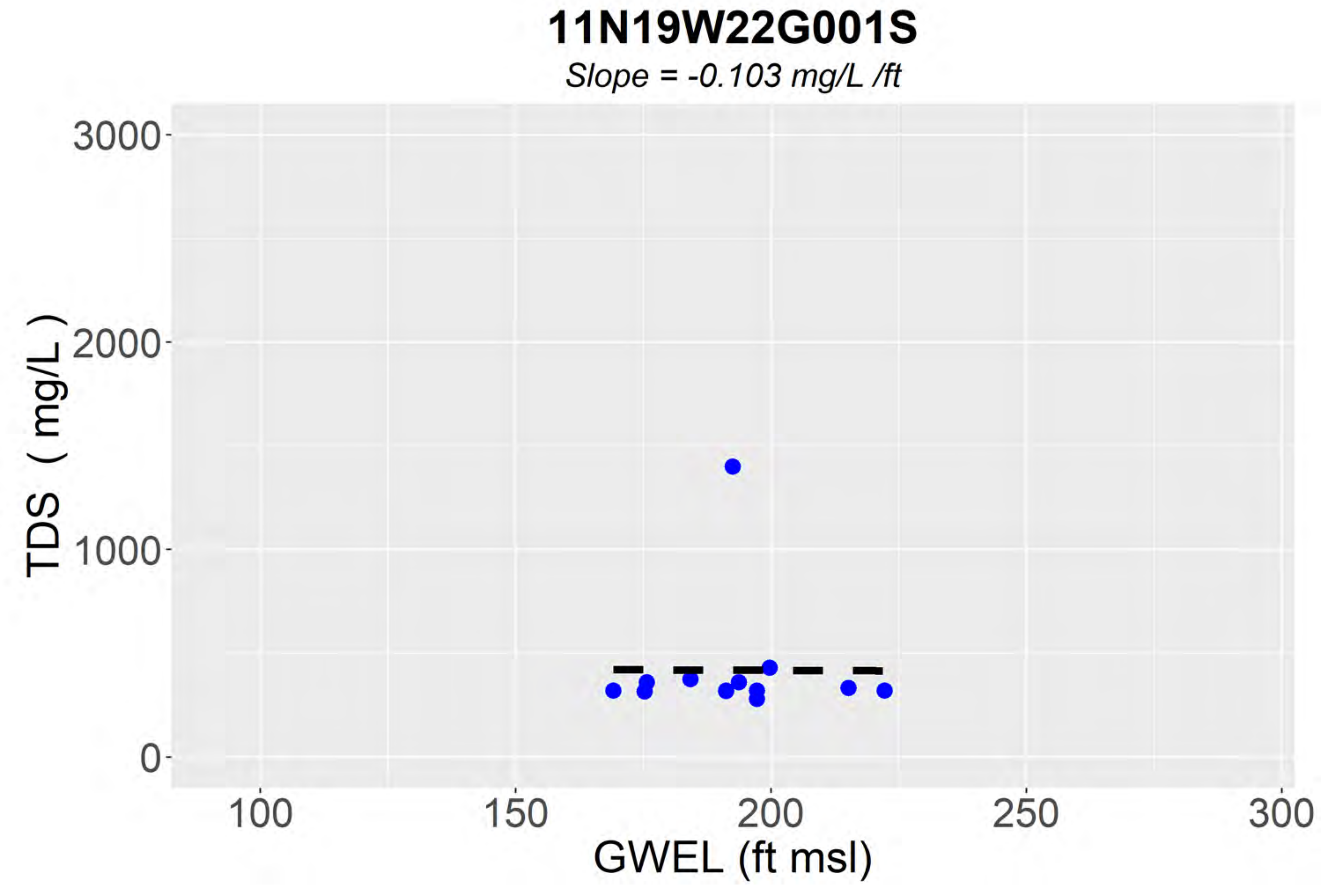

11N19W13J001S
Slope = -0.155 mg/L /ft
3000
2000
1000
0
TDS (mg/L)
150
200
250
300
GWEL (ft msl)

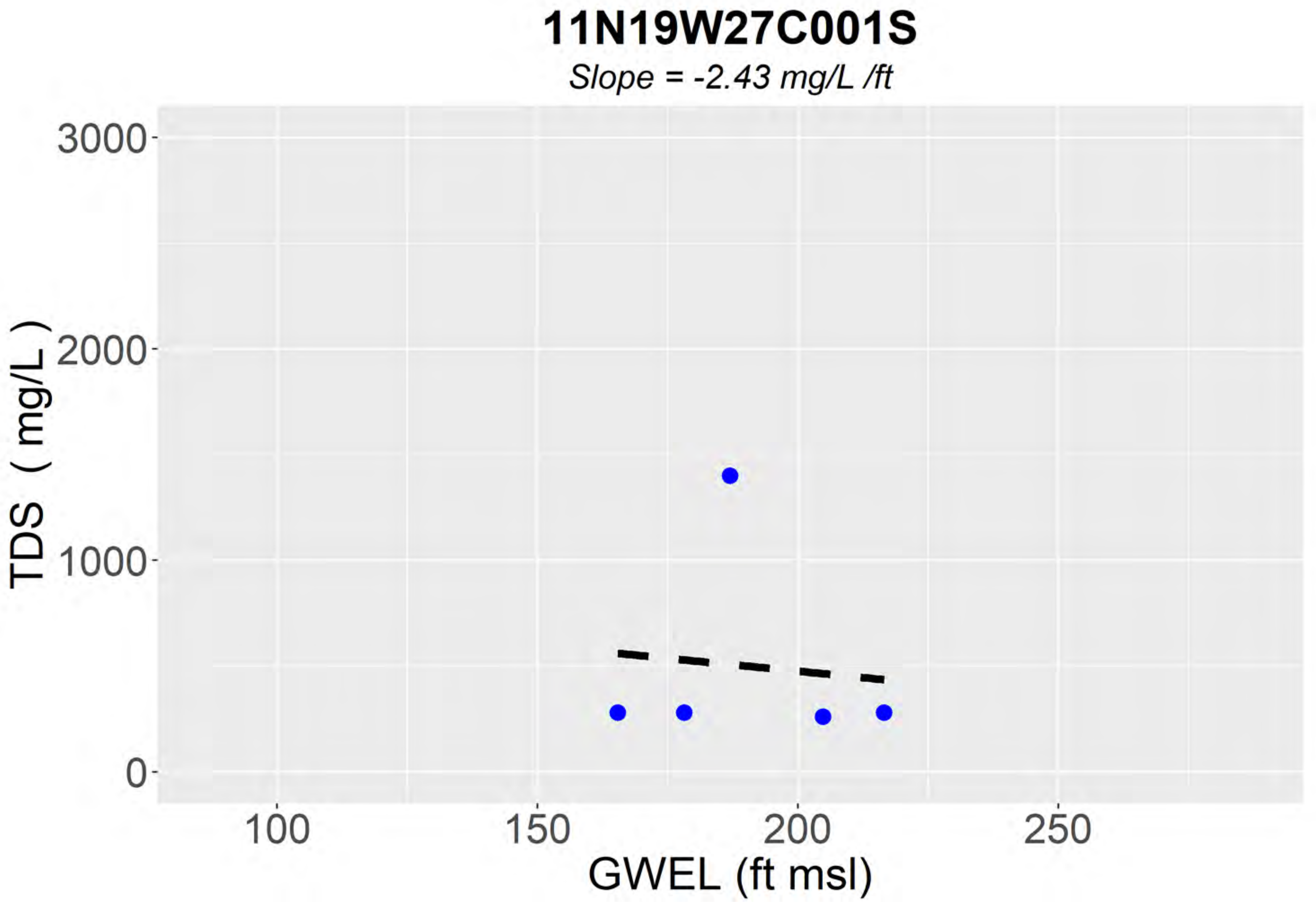

11N19W19G001S
Slope = -0.35 mg/L /ft
3000
2000
1000
0
TDS (mg/L)
100
150
200
250
GWEL (ft msl)

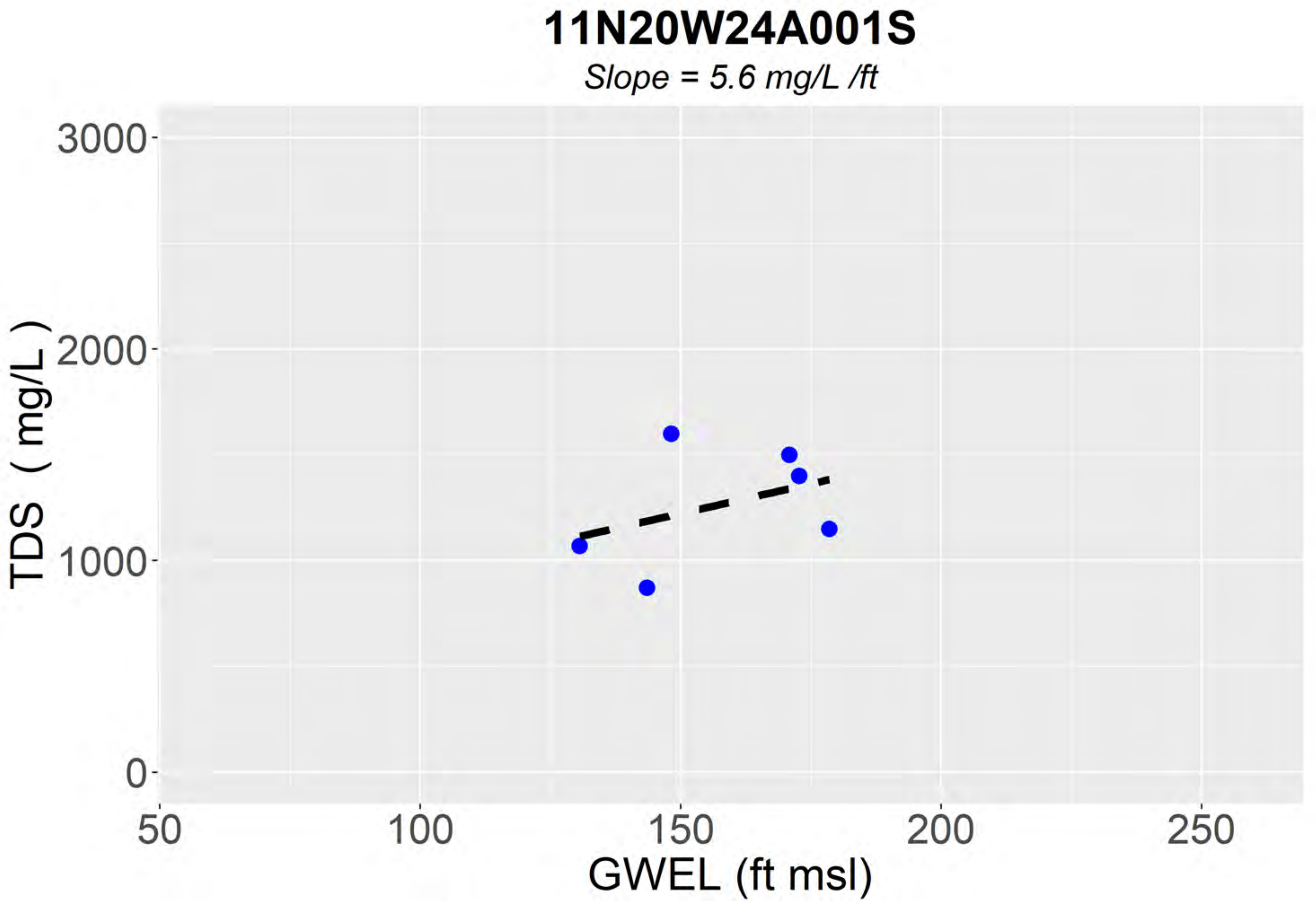

11N19W19M001S
Slope = -5.92 mg/L /ft (p <= 0.05)
TDS (mg/L)
3000
2000
1000
0
100
150
200
250
GWEL (ft msl)


11N19W19P001S
Slope = -12.9 mg/L /ft
3000
2000
1000
0
TDS (mg/L)
100
150
200
250
GWEL (ft msl)

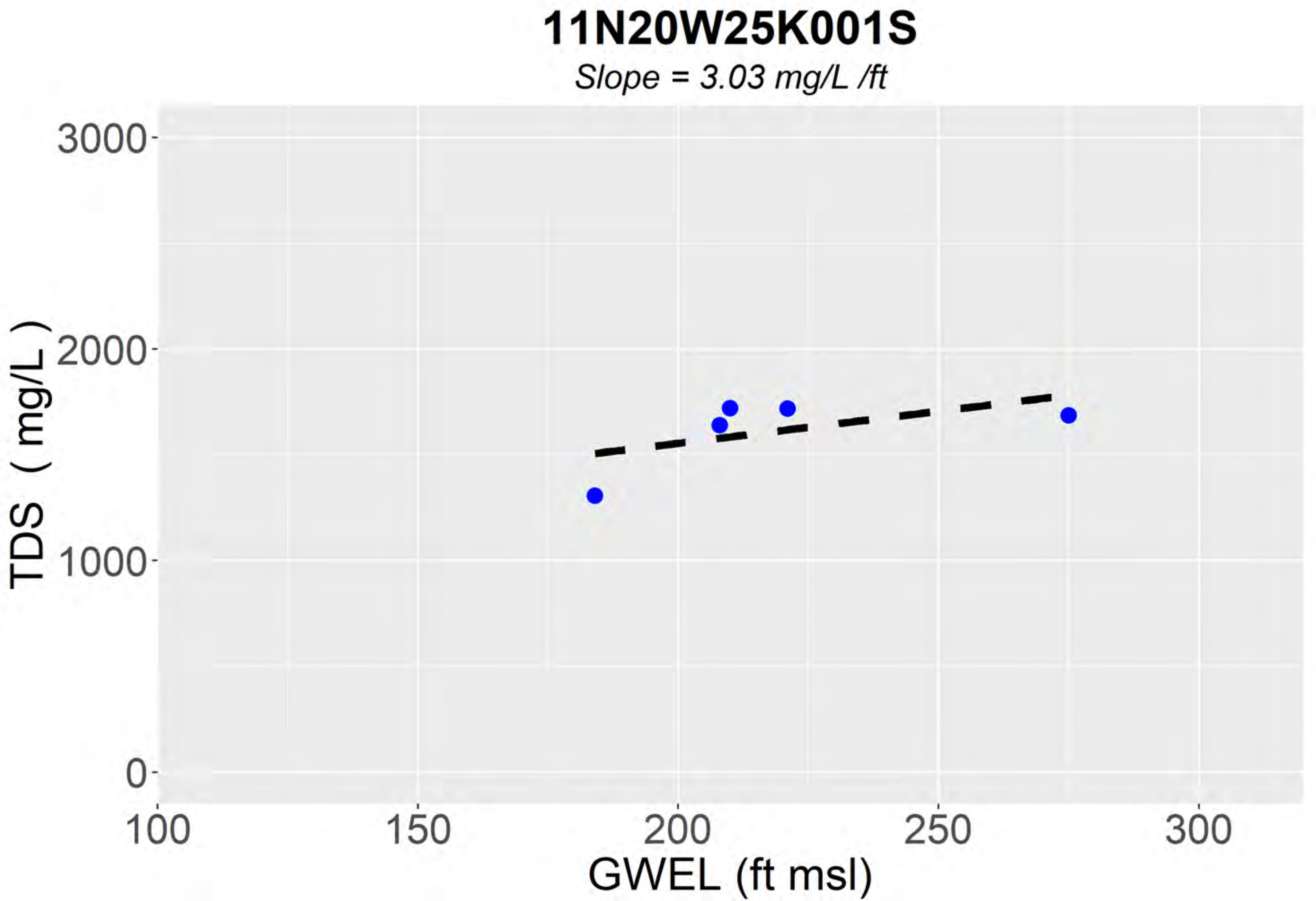

11N19W22E001S
Slope = -0.583 mg/L /ft
3000
2000
1000
0
TDS (mg/L)
100
150
200
250
GWEL (ft msl)


11N19W22G001S
Slope = -0.103 mg/L /ft
TDS (mg/L)
3000
2000
1000
0
100
150
200
250
300
GWEL (ft msl)


11N19W27C001S
Slope = -2.43 mg/L /ft
3000
2000
1000
0
TDS (mg/L)
100
150
200
250
GWEL (ft msl)



11N20W24A001S
Slope = 5.6 mg/L /ft
3000
2000
1000
0
TDS （ mg/L ）
50
100
150
200
250
GWEL (ft msl)



11N20W25K001S
Slope = 3.03 mg/L /ft
3000
2000
1000
0
TDS (mg/L)
100
150
200
250
300
GWEL (ft msl)

Appendix H

An Evaluation and Determination of Groundwater Dependent Ecosystems in the White Wolf Sub-Basin

An Evaluation and Determination of Groundwater Dependent Ecosystems in the White Wolf Sub-Basin (DWR 5-022.18)

Prepared for:
EKI Environment and Water
2827 Spafford Street
Davis, CA 95618

Prepared by:
GeoSystems Analysis
3150 Carlisle Blvd. NE, Ste 203
Albuquerque, NM 87110
www.gsanalysis.com

THIS PAGE INTENTIONALLY BLANK

DOCUMENT CONTROL SUMMARY

Title:	An Evaluation and Determination of Groundwater Dependent Ecosystems in the White Wolf Sub-Basin (DWR 5-022.18)		
Client Company:	EKI Environment and Water		
Client Contact:	Anona Dutton, Christina Lucero		
Status:	Revised Draft Report		
GeoSystems Analysis Job #:	2013		
Project Manager:	Chad McKenna		
Author(s):	Chad McKenna, Mike Milczarek		
Revision Number:	1		
Notes:	A Proposition 68 Sustainable Groundwater Management grant awarded to the White Wolf Groundwater Sustainability Agency (GSA) provided funding for this effort. Comments received by EKI on 9/14/20 were addressed in this version.		
Date:	October 21, 2020		
Checked By:	Meg Buchanan (GSA); Christina Lucero (EKI), Anona Dutton (EKI)		
Distribution	Client	Other	GSA Library
(Number of Copies):	Electronic		

THIS PAGE INTENTIONALLY BLANK

An Evaluation and Determination of Groundwater Dependent Ecosystems in the White Wolf Sub-Basin (DWR 5-022.18)

GeoSystems Analysis 2020

Name	Affiliation	Role
Chad McKenna	GeoSystems Analysis, Inc.	Ecologist/Geographic Information System (GIS) Analyst
Mike Milczarek	GeoSystems Analysis, Inc.	Program Director
William Widener	GeoSystems Analysis, Inc,	Botanist

THIS PAGE INTENTIONALLY BLANK

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

Appendix A. GDE Maps Scaled to Tejon Ranch and Wind Wolves Preserve

Appendix B. Field App Design and Domains

EXECUTIVE SUMMARY

GeoSystems Analysis, Inc. conducted a field and desktop assessment between May and September 2020 to determine the extent and distribution of GDEs in the White Wolf Sub-basin. Numerous existing datasets were compiled and reviewed to identify GDE locations and conditions, to include NCCAG data, monitoring well locations, groundwater monitoring data, springs, artesian wells, production wells, imagery, groundwater elevation contours, streams, alternative vegetation mapping to the NCCAG data, rooting depth databases, surficial geology, the proximity of key geologic features (including faults). The field assessment consisted of mapping probable GDE areas for dominant vegetation species, determining GDE presence or absence; as well as, capturing information related to soil moisture, hydrologic, and manmade hydrologic alterations (i.e. well, impoundment, diversion, etc.). The field mapping was conducted at two intensities: a “full” assessment and a “rapid” assessment. Both approaches involved traversing the NCAAG feature in the field and recording information with sufficient detail to determine whether or not the site met GDE criteria; however, the “full” assessment involved capture of more detailed site attributes via a GDE assessment field application developed for this project.

For the purpose of assigning a representative and consistent GDE class, a classification schema was developed that considers the relative moisture class (apparent frequency and persistence of surface water plus presence/absence of hydrophilic plant spp.), probable source aquifer, and presence of human alterations. A total of 722 acres (or 74% of the land mass identified in the NCCAG dataset) were formally assessed in the field (485 acres with full assessment and 238 acres with rapid assessment). In addition, GDE Pulse data were used to inform and validate our assessment of GDEs in the project area. The GDE classification framework and site assessment approach used in this project substantially exceeds requirements under SGMA and GDE guidance documents (e.g. TNC 2018).

Based on our assessment, the White Wolf sub-basin currently supports a mosaic of diverse, healthy GDEs, particularly in locations upgradient of the Spring Fault. GDEs currently span about 881-acres in the White Wolf sub-basin and most (~91%) of these areas are also identified in the NCCAG data, with an additional 9% added per field observations and image interpretation. Thus, while the NCCAG frequently assigned an incorrect dominant vegetation species to a GDE feature, the NCCAG dataset reasonably predicted GDE presence or absence. The habitat mosaic created by GDEs in the White Wolf sub-basin includes open water, riparian forests and shrublands, wet meadows, and marshes. Common woody riparian species dominating the GDEs are Fremont cottonwood, valley oak, Goodding’s willow, red willow, elderberry, nettle, saltcedar, and seep willow. Surface water presence and persistence varies by GDE location. Current rooting depth databases (TNC, 2018) indicate that the field verified GDE species require shallow groundwater to sustain their existence at the locations where they are currently found.

The majority of classified GDE areas appear to be supported by shallow alluvial aquifer systems do not appear to be in direction connection with the deeper regional aquifer that is used for groundwater extraction. Nonetheless, there is a paucity of groundwater data within the shallow alluvium aquifer upgradient of the Springs Fault and the effect of long-term regional groundwater pumping on GDEs in this area is currently unknown. Most of the GDEs (79%), appear to occur in natural areas rather than sites created/supported by a manmade hydrologic alteration. The GDE Pulse tool was used to provide remote sensing derived NDVI and NDWI ratios that can be related to GDE vegetation cover and vegetation canopy moisture, respectively. According to GDE Pulse data, vegetation cover for the entire

White Wolf sub-basin has been on a slightly increasing trend (13%) from 1985 to 2018, and while vegetation canopy moisture values demonstrate less consistency and more inter-annual variation, the long-term values have been stable. These data indicate that current water management practices within the White Wolf sub-basin have not adversely affected the areal extent or relative health of GDEs.

Recommendations include installing shallow groundwater monitoring wells within each of the larger GDE areas upgradient of the Springs Fault. If groundwater elevation data indicate water table conditions that do not support GDEs (i.e. > 30 feet below the ground surface), stream channel monitoring may be desired to quantify surface water conditions that support GDEs. All monitoring systems should be instrumented with automated devices to evaluate surface water and aquifer system response to climate conditions. Remote sensing via a variety of potential techniques and spanning a range of technical sophistication from simply digitizing the wetted extent off multiband, high resolution imagery up to automated identification and extraction of surface water and soil moisture may also be used to monitor surface water frequency in the GDEs identified under this study. Regardless of the specific technique, remote sensing monitoring should be conducted in a manner that captures seasonal and interannual variability. Finally, GDE Pulse data should be analyzed periodically (e.g. every 3-5 years), to track NDVI and NDWI trends for the project area.

1.0 INTRODUCTION AND BACKGROUND

EKI Environment and Water (EKI) was contracted by Tejon-Castac Water District (TCWD) to provide technical support to the White Wolf Groundwater Sustainability Agency (GSA). The Sustainable Groundwater Management Act of 2014 (SGMA) includes specific requirements for GSAs to identify Groundwater Dependent Ecosystem (GDEs) in their basins plus analyze impacts to GDEs to inform groundwater management decisions and to monitor the long-term health of the GDEs. A Proposition 68 Sustainable Groundwater Management grant awarded to the White Wolf GSA by the California Department of Water Resources (DWR) specifically funds analyses and refinement of GDE classifications in the project area. EKI has sub-contracted GeoSystems Analysis, Inc. (GeoSystems) to assist them with the GDE analyses. This technical memorandum summarizes the methods and results of work conducted by GeoSystems on this project.

The White Wolf Subbasin project area (DWR 5-022.18) spans approximately 108,000 acres near Grapevine, CA and Wheeler Ridge, CA. The project area is ecologically unique because it lies near the convergence of the four major ecoregions in CA: Desert, Coastal, Forest, and Mediterranean. The area also supports a diverse agricultural economy that produces an abundance of nuts (pistachios, almonds, etc.), vegetables, and fruit. Surface water in the project area is supplied by numerous creeks draining from mountain and foothill areas, which notably include, Comanche, Tejon, Grapevine, Tunis, Winters Canyon-El Paso, and Salt Creeks. The CA aqueduct also bisects the project site.

White Wolf Subbasin GSA constituents include three water districts: TWCD, Arvin-Edison Water Storage District (AEWSD), and Wheeler Ridge Maricopa Water Storage District (WRMWSD); plus, Kern County, with the county primarily filling in gaps between the official jurisdictional areas of the water districts (for more info, see http://whitewolfgsa.org/). At the request of the water districts within the GSA, the Kern County Subbasin of the San Joaquin Valley Groundwater Basin (DWR 5-22.14) was divided into two separate subbasins by DWR: the Kern County Subbasin and; the White Wolf Subbasin. This delineation was supported by data demonstrating that the White Wolf Fault significantly impedes groundwater flow in the Kern County Subbasin. The final Basin boundaries were published in October 2018 and the White Wolf Subbasin was formally created.

To identify and diagnose GDEs throughout the project area, GeoSystems staff utilized a combined field and desktop process as described in the following section. The process primarily involved:

- Compilation, review, and analysis of numerous existing datasets to develop an initial GDE map
- Field verification of 74% percent of the GDE polygons within the project area
- Development of a custom field app for assessing GDEs on site
- Development of a preliminary GDE mapping classification framework
- Revision of the GDE map for the White Wolf Subbasin
- Assessment of GDE sustainability and vigor with support from the GDE Pulse tool

2.0 METHODS

2.1 Data gathering and review

With assistance from EKI, GeoSystems staff assembled and reviewed numerous existing datasets including Natural Communities Commonly Associated with Groundwater (NCCAG) data, monitoring well locations and associated measurement data, springs, artesian wells, production wells, satellite imagery, orthophotography, groundwater elevation contours, land ownership, streams, sub-watershed boundaries, alternative vegetation mapping to the NCCAG data, rooting depth databases, surficial geology, proximity of key geologic features (including faults), and GDE Pulse data. These datasets were used to inform and validate our assessment of GDEs in the project area.

Additionally, the California Vegetation Classification and Mapping Program (VegCAMP) creates, maintains, and distributes California's expression of the Nation Vegetation Classification System (NVC; CDFW, 2019), which is a widely used, standard, hierarchal vegetation classification protocol that can be applied to and scaled for a multitude of ecological applications. VegCAMP distributes project-level, oftentimes high resolution, remote sensing-based vegetation datasets. GeoSystems staff downloaded available vegetation mapping products from VegCAMP, as alternatives to the NCCAG data, in case fieldwork revealed that the specific vegetation and wetland types assigned within the NCCAG data are not representative of current field conditions.

2.2 Natural Communities Commonly Associated with Groundwater (NCCAG) data

The DWR has developed (in partnership with CDFW and TNC) and distributes a GIS-ready dataset that specifies NCCAG areas (polygons). Per the DWR, the "*NCCAG dataset can be used as a starting point to investigate and identify GDEs within a groundwater basin. Identifying GDEs requires detailed understanding of the land use, groundwater levels, hydrology, and geology of a location. This comprehensive understanding of geology, hydrology, and biology is not available at the statewide scale. Further investigation and verification of the connection and dependence between groundwater and mapped vegetation and wetlands at a local scale may be needed for water managers in sustainable groundwater management planning*." The NWI wetlands dataset and various, unspecified vegetation mapping products are the primary sources compiled in the NCCAG database in the project area, these source data were produced between 1985 and 2014.

The DWR NCCAG data identifies approximately 1,029 acres of potential GDEs in the project area. Within these areas, the NCCAG data differentiates "vegetation" communities dominated by phreatophytic riparian species versus "wetland" communities, which include emergent and shrub-scrub palustrine wetlands and riverine types. Geodatabase attributes within "vegetation" types assign a (typically monospecific) dominant woody plant composition for an individual polygon while "wetland" types list the NWI type per Cowardin 1979. The existing NCCAG data for the project area is not distributed with clean topology, and 53 acres of wetland and vegetation types overlap (basically the acreage in overlapping segments is double-counted unless data are algorithmically cleaned beforehand). Thus, the total actual land mass inhabited by NCCAGs is 976 acres. Within the Draft White Wolf Groundwater Sustainability Plan (GSP; WWGSA, 2020), EKI identified approximately 665 acres of priority GDE "vegetation" types and 125 acres of priority "wetlands" in in the project area for further evaluation. The remaining 244 acres (18 acres of wetland, 227 acres of vegetation types) of GDEs were downgraded in priority during this process based on their downstream/downslope proximity to the Springs Fault and per nearby monitoring well data which demonstrates that groundwater elevations are far too deep (e.g. hundreds of feet deep) to sustain GDEs. Figure 1 shows the GDE areas identified within the Draft White Wolf GSP as not connected to groundwater (WWGSA, 2020).

Prior to fieldwork, each “vegetation” and “wetland” type characterized in the NCCAG data was assigned a simplified unique identifier (e.g. V1, V2, W1, W2, etc., etc.) to guide map interpretation. GPS-enabled pdf files were created for individual map frames within the project area at 1:5,000 scale so field staff could readily align themselves with individual GDEs delineated throughout the project area and navigate to specific locations during the site assessment.

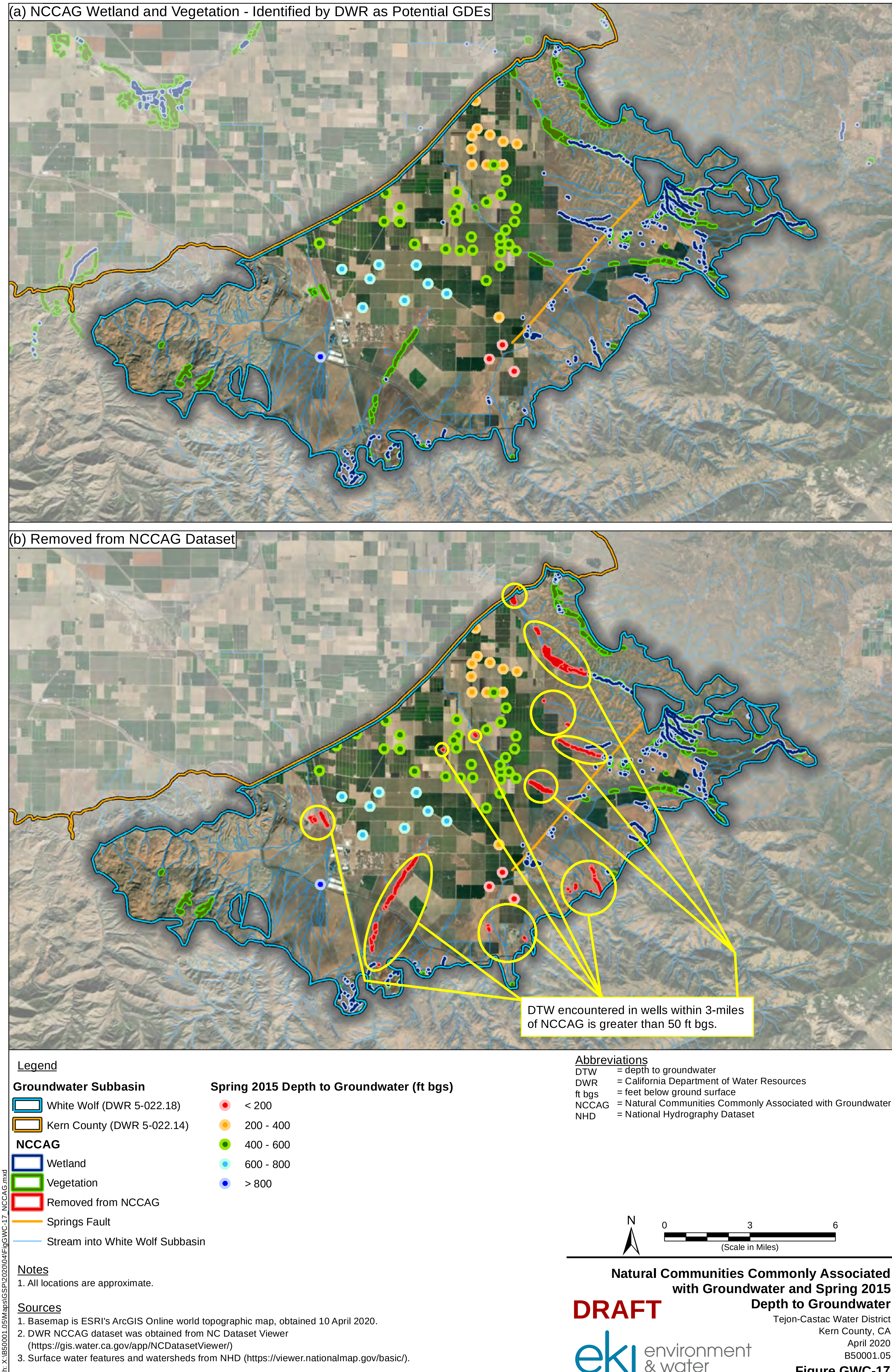


Figure 1. Map showing GDEs removed from NCCAG dataset by EKI. Used with permission (WWGSA 2020)

2.3 Field app development

To streamline, guide, and normalize GDE identification and assessment, several field guides have been developed. The primary references that GeoSystems staff used to support our field analysis, include:

- The Nature Conservancy, 2018. Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans.
- The Nature Conservancy, 2019. Identifying GDEs under SGMA. Best Practices for Using the NC Dataset.
- US Forest Service, 2012. Groundwater Dependent Ecosystems: Level II Inventory Field Guide: Inventory Methods for Project Design and Analysis. Technical Report 86-b.

In support of the White Wolf field effort, GeoSystems developed a custom smartphone/tablet application to log GDE-related field attributes efficiently and consistently across multiple observers, sites, and GDE types. This tool expands and synthesizes recommended survey techniques within the current GDE guidance documents (TNC 2018, TNC 2019, USFS 2012). An initial proof of concept was developed prior to the site visit, and the tool was refined and improved during the field effort.

A data dictionary that specifies the key variables and data domains captured in the custom field application is included as Appendix B at the end of this document. Key components of the field application include:

- Visible evidence of groundwater
- GDE type (cave, exposure, helocrene, hypocrene, hillslope, etc. per USFS 2012)
- Current vegetation
  - Accuracy of the vegetation community described in the NCCAG database
  - Dominant vegetation species
  - Subdominant woody vegetation species
  - Aerial vegetation cover class: graminoids, weeds
  - List of weed species observed
  - Indications of moisture stress
- Ground cover class: Bare ground, rock, litter, cobble, basal vegetation
- Soils
  - Surface soil texture
  - Surface soil moisture
  - Redox indicators in top 6 inches
- Surface water
  - Presence/absence of surface water and surface water indicators
  - Apparent flow consistency
  - Channel dynamics
  - Surface water fate (if applicable)
  - Erosion indicators
- Human influence and disturbance
  - Manmade structures
  - Animal effects
  - Soil disturbance indicators

   - Water diversion observations
- General notes
- Geotagged field photos

2.4 Field Verification of GDEs

With support from Tejon Ranch and Wind Wolves Preserve staff, fieldwork was conducted by Chad McKenna and William Widener between May 19 and May 24, 2020. During the site visit, a representative subset of all the GDE types described in the NCCAG data were assessed. Field assessment was completed at two different intensities: 1) a “full” assessment where each attribute within the field app was logged using ocular estimates of cover were assessed and information was logged for a polygon by traversing the feature until the observer felt they confidently assessed and recorded each required field in the app, and; 2) a “rapid” assessment where the dominant vegetation species, GDE presence/absence, soil moisture, hydrologic, manmade observations, and general field notes were recorded. A total of 722 acres (or 74% of the land mass identified in the NCCAG dataset) were formally assessed in the field (485 acres with full assessment and 238 acres with rapid assessment). A geo-tagged field photograph was also captured for most of the sites evaluated and these spatially referenced photos are incorporated into the project geodatabase described below. These photos could become an asset during future trend monitoring, if desired.

2.5 Post fieldwork GDE Classification

GeoSystems developed a classification system for coding specific types of GDEs and this framework was applied to GDEs identified in the project area. Note that this framework substantially exceeds requirements under SGMA and GDE guidance documents (e.g. TNC 2018) where GDEs are classified as “removed”, “added”, and “retained” but little information related to their specific attributes is characterized. The GeoSystems GDE classification system is intended to normalize and streamline the characteristics of different types of GDEs and support further evaluations on potential impacts to GDEs via groundwater pumping or other potential land use scenarios. This GDE classification schema describes three key attributes for each GDE:

1) “Wetness” as determined by the presence or absence of surface water; and/or phreatophytic/hydrophilic species during the survey and via remote sensing analysis, and: predicted surface water persistence (e.g. ephemeral/intermittent vs. perennial/near-perennial).
2) “Suspected source aquifer” as determined by whether a GDE appears to be supported by the shallow (e.g. alluvial) aquifer, the regional aquifer, or both.
3) “Man-made modifier” distinguishes naturally occurring GDEs from GDEs that are (at least partially) supported by a surface water diversion, groundwater extraction (e.g. well), or a stock tank/impoundment.

During post-processing, data gathered during the field effort were extrapolated to refine and improve the GDE dataset with cross-analysis with alternative vegetation mapping data, satellite imagery, the TNC rooting depth database (TNC 2018b), and available geologic, groundwater, and surface water related information. As described in the following section, vegetation types described within the NCCAG did not accurately reflect field conditions in portions of the project site. Alternative mapping data was extracted from Great Valley Ecoregion (GVE) alliance-level NVCS data originally created by the Geographic Information Center at CSU Chico (GIC 2018). This vegetation map was produced in phases between 2009-

2012 via a combination of manual digitization over four-band imagery and partial field verification. The published accuracy of this product is about 90% (GIC).

Additionally, the GVE vegetation map was utilized as a supplement to the NCCAG data to predict vegetation types in areas not field verified and to identify other suspected GDEs not included in the NCCAG data. Following fieldwork, additional areas suspected to meet GDE criteria were added into the project GDE geodatabase per TNC guidelines. Recent satellite imagery and orthophotography was then used to evaluate for presence/absence of key environmental variables that are diagnostic of GDEs to include visible evidence of surface water, increased soil moisture, manmade modifications, disturbance, etc.; appropriate GDE Type were then assigned per our GDE classification schema.

3.0 RESULTS

3.1 Original NCCAG vegetation types

A list of the vegetation and wetland communities described in the DWR NCCAG dataset is shown in (Table 1) and their distribution is illustrated on Figure 1. Fremont cottonwood (*Populus fremontii*) dominated communities are the most prominent vegetation type described in NCCAG data for the project area, followed by saltcedar (*Tamarix* spp). Valley oak (*Quercus lobata*) dominated types and emergent wetlands are also common within the NCCAG data, along with various types of willow-dominated communities, grasslands, marshes, and shrublands. Note that the acreages shown in Table 1, were computed after transforming NCCAG "wetland" types into NCCAG "vegetation" types where they overlapped in the raw data, to better reflect the actual vegetation described within the NCCAG dataset. Per field observations, the overlapping sites were more typically woody dominated riparian communities when NCCAG riparian "vegetation" types overlapped with emergent "wetland" types.

Table 1. Vegetation and wetland types described in the DWR NCCAG within the project area

NCCAG Vegetation/Wetland Communities	Acres
Fremont Cottonwood	336.7
Tamarix spp.	161.4
Quercus lobate (Valley Oak)	150.8
Emergent Wetland	71.9
Riparian Mixed Hardwood	35.7
Atriplex lentiformis	35.5
Lepidospartum squamatum	33.7
Sporobolus airoides	32
Salix laevigata	25.6
Vitis californica - provisional	19
Willow	16
Sambucus nigra	10
Scrub-shrub Wetland	9.2
Isocoma acradenia	6.9
California Warm Temperate Marsh/Seep	5.6
Anemopsis californica	5.4
Riparian Introduced Scrub	4.8
Riverine Wetland	4.2
Salix gooddingii	3.3
Baccharis salicifolia	3.1
Typha (angustifolia, domingensis, latifolia)	2.9
Seep or Spring	1.4
Platanus racemosa	1.2
Grand Total	**976.3**

3.2 GDE classification framework

As described in the methods section of this report, GeoSystems staff created a classification schema to describe potential types of GDEs within the project site. A specific breakdown of the coding structure used within this schema is presented in (Table 2). Essentially, the classification system assigns a moisture class, probable source aquifer, and man-made modifier to each GDE polygon in the project site based on information gathered during the field assessment and supplemented by orthophoto/satellite image interpretation. Sites without GDE indicator vegetation or hydrologic conditions are simply classified as "0". This information is presented here, to assist with interpreting the results in subsequent sub-sections of this report. Photos showing typical conditions within different types of GDEs described within this framework are also shown later in this report (Figure 7 through Figure 11).

Examples of the GDE classification system are:

- **3Ai** --- Site dominated by hydrophilic plants, water suspected to be perennial or near perennial; appears to be completely supported by the alluvial aquifer; site also a manmade impoundment
- **0** --- Not a GDE
- **3BE** --- Site dominated by hydrophilic plants, water suspected to be perennial or near perennial; appears to be completely supported by the alluvial aquifer but supplemented by the regional aquifer; receives supplemental water from a manmade well

Table 2 . GDE classification schema developed in support of this project

Moisture Class	**0**	**1**	**2**	**3**
	No visual evidence of surface water or groundwater; not dominated by phreatophytic/ hydrophilic plants	No visual evidence of surface water or groundwater; however, site is dominated by phreatophytic/ hydrophilic plants	Visual evidence of surface and/or groundwater, site is dominated by phreatophytic/ hydrophilic plants; however, surface water suspected to be ephemeral or intermittent	Visual evidence of surface and/or groundwater, site is dominated by phreatophytic/ hydrophilic plants; and, surface water suspected to be perennial or near perennial
Probable Source Aquifer	**A**	**B**	**S**	**R**
	Site appears to be supported by shallow aquifer and/or surface water separate from regional aquifer	Site appears to be supported by shallow alluvial aquifer upgradient of the Springs Fault	Site appears to be supported by bedrock springs or shallow alluvium over low permeability sediments or rocks	Site appears to be supported by the regional aquifer
Man-Made Modifier	**n**	**I**	**d**	**E**
	Naturally occurring GDE	Created/supported by a man-made impoundment	Created/supported by a man-made diversion	Created/supported by a man-made extraction feature (e.g. a well)

3.3 GDE "wetness index"

Amongst the GDEs classified for the project area, the most extensive area by "wetness index" is Class 1 (386 acres, Table 3). Their distribution is illustrated on Figure 2. We commonly designated these areas as dominated by phreatophytic trees and shrubs growing in locations with no visual evidence of surface water or groundwater. A total of 319.5 acres of the GDEs assigned in the project area received a "wetness index" score of 2 while 175.6 acres of GDEs received a 3. Sites receiving a 3 are concentrated in creek bottoms, surrounding springs and artesian wells, or adjacent to reservoirs and stock tanks, or proximal to the Springs Fault. Areas receiving a "wetness index" of 3 often grade into locations with a "wetness index" of 2. The "wetness index" 3 score is particularly common in the upper portions of El Paso Creek, the convergence of the primary drainages that form Tejon Creek, and the lower segments of Comanche Creek. GDE maps zoomed to Tejon Ranch and Wind Wolves Preserve are included in Appendix A.

Table 3. GDE wetness index acreage summary

Wetness Index Class		Acres
0	Not a GDE	174.5
1	No visual evidence of surface water or groundwater; however, site is dominated by hydrophilic plants	386.3
2	Visual evidence of surface and/or groundwater, site is dominated by hydrophilic plants; however, surface water suspected to be ephemeral or intermittent	319.5
3	Visual evidence of surface and/or groundwater, site is dominated by hydrophilic plants; and surface water suspected to be perennial or near perennial	175.6
Total Acreage of GDEs		**881.3**
Total Acreage Assessed		**1,055.8**

3.4 Probable GDE source aquifers

Groundwater in the White Wolf Sub-basin is contained in four potentially water-bearing units (WW GSA, 2020): 1) Quaternary/Recent fan, terrace, and alluvial deposits (Shallow Alluvium); 2) the Kern River Formation; 3) the Chanac Formation, and; 4) the Santa Margarita Formation. Shallow alluvium is considered the primary aquifer accessible to GDEs, whereas the overwhelming majority of groundwater extraction wells are completed in the undifferentiated sediments of the Kern River and Chanac Formations which are typically deeper than 200 feet below ground surface. As discussed below, GDEs supported by groundwater in the shallow alluvium maybe disconnected from the primary regional (undifferentiated Kern/Chanac Formations) aquifer system.

Depth to groundwater in areas north of the Springs Fault can exceed 500 feet (WW GSA, 2020), therefore GDEs located north of the Springs Fault are likely supported by surface water flows and/or shallow aquifer conditions that are separate from the regional aquifer. Limited groundwater data indicates shallow groundwater conditions in the Quaternary alluvial aquifer south (upgradient) of the Springs Fault, therefore GDEs upgradient of the Springs fault are likely supported by the Shallow Alluvium. Figure 3 shows the geologic units in the vicinity of the Spring Fault and available groundwater elevation data; wells proximal to identified GDEs show groundwater elevations less than 30 feet below ground surface (bgs), whereas other wells within one mile of the GDEs show groundwater elevations can exceed 200 feet bgs. Along the fringes and particularly in the eastern portion of the White Wolf Sub-basin there are surface expressions of the deeper water bearing geologic units, however the sediments/rocks in these areas generally have low permeability and low specific yield values (i.e. the Chanac Formation, geologic unit PMLC in Figure 3). Of note, there is a north-south trending ridge of PLMC on the western edge of the Springs Fault that may also act as a barrier to groundwater flow from the area upgradient of the Springs Fault (Figure 3). GDEs found within low permeability sediment/rock areas are most likely supported by overlying shallow alluvium (i.e. stringer aquifers).

Potential GDE source aquifers are classified into the categories specified in Table 4 and Figure 4. Based on available groundwater monitoring data and geologic mapping data, the majority of the GDEs mapped in the project site appear to be supported by the shallow Quaternary alluvial aquifer upgradient of the Springs Fault (sites coded "B") or by springs or shallow alluvium over low permeability sediments or rocks (sites coded "S"). The remaining GDEs appear to be supported by surface water or perched water conditions separate from the regional aquifer (sites coded "A"), with a small minority of acreage classified as "R" (Table 4).

Table 4. GDE source aquifer acreage summary

Source Aquifer		Acres
0	Not a GDE	174.5
A	Site appears to be supported by shallow aquifer and/or surface water separate from regional aquifer	123.0
B	Site appears to be supported by shallow alluvial aquifer upgradient of the Springs Fault	435.1
S	Site appears to be supported by bedrock springs or shallow alluvium over low permeability sediments or rocks	323.0
R	Site appears to be supported by the regional aquifer	0.2
Total Acreage of GDEs		**881.3**
Total Acreage Assessed		**1,055.8**

GDE locations coded as "A" under our schema may not technically qualify as GDEs of concern under current SGMA guidance because they are sustained by groundwater/surface water that is not in direct connection with the much deeper regional aquifer. Although "S" type GDEs may overlie sediments that are considered part of the regional aquifer system, their occurrence in shallow alluvium overlying low permeability/low yield sediments/rocks also indicates they may not be directly influenced by the pumping from the regional aquifer. Consequently, GDEs in "B" and "R" locations should be the focus for SGMA-related monitoring and management. Although the Spring Fault and the ridge of low permeability PMLC (Figure 3) appear to act as barriers to flow, GDEs located in "B" sites upgradient of the Spring Fault may at some time in the future be affected by regional groundwater extraction. There is a paucity of groundwater data upgradient of the Springs Fault, consequently a determination of whether GDEs in "B" locations will be affected by long-term regional groundwater pumping is unknown and groundwater monitoring in selected GDE areas is recommended.

3.5 Manmade modifier

While numerous GDE features are entirely created or partially enhanced by human-caused hydrologic modifications or improvements (e.g. wells, impoundments, diversions, etc.), the majority of the GDEs characterized in the White Wolf Subbasin (Table 5) appear to be naturally occurring (about 698 acres or 79%). A subset of the GDEs, however, are sustained by manmade features as shown in Table 5.

Table 5. GDE manmade modifier acreage summary

Manmade Modifier		Acres
0	Not a GDE	174.5
d	Created/supported by a manmade diversion	7.7
e	Created/supported by manmade extraction feature (e.g. a well)	82.5
i	Created/supported by a manmade impoundment	93.5
n	Naturally occurring GDE	697.6
Total Acreage of GDEs		**881.3**
Total Acreage Assessed		**1,055.8**

The total acreage of each GDE class is indicated in Table 6. The most common class assigned, by acreage was type 1Bn, followed by type 2Sn . The distribution of each type is shown on Figure 6.

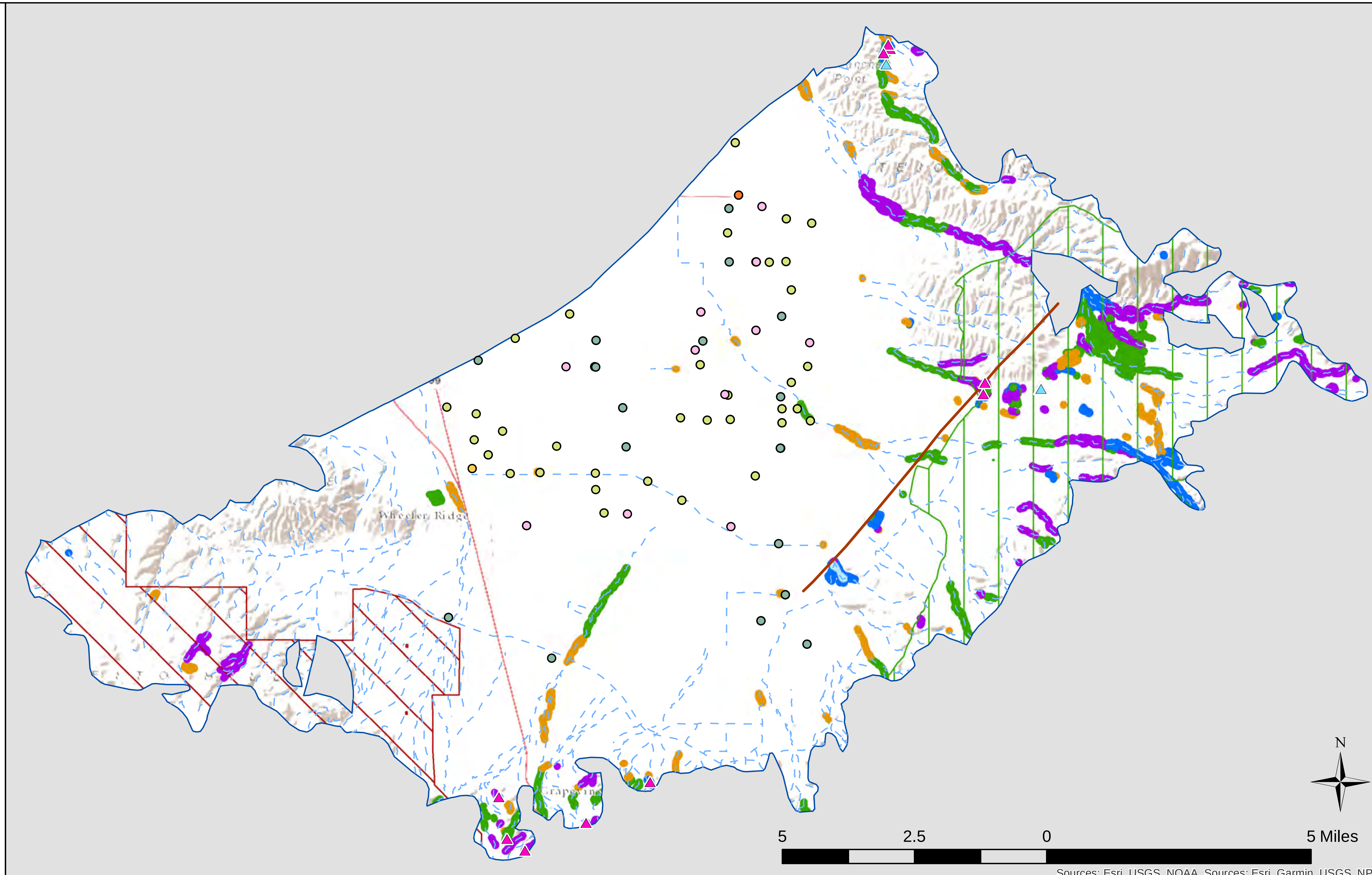
Wetness Score

0 - No visual evidence of surface water or groundwater; not dominated by hydrophilic plants

1 - No visual evidence of surface water or groundwater; however, site is dominated by hydrophilic plants

2 - Visual evidence of surface and/or groundwater, site is dominated by hydrophilic plants; however, surface water suspected to be ephemeral or intermittent

3 - Visual evidence of surface and/or groundwater, site is dominated by hydrophilic plants; and, surface water suspected to be perennial or near perennial



Legend

White Wolf sub-basin
Tejon Ranch
Wind Wolves Preserve
Surface water drainage
Spring Fault
Artesian well
National Hydrography Dataset springs

Wells
Dom/M&I
Domestic
Irr/Dom
Irrigation
Monitoring
Unknown

Wetness Score
0 1 2 3

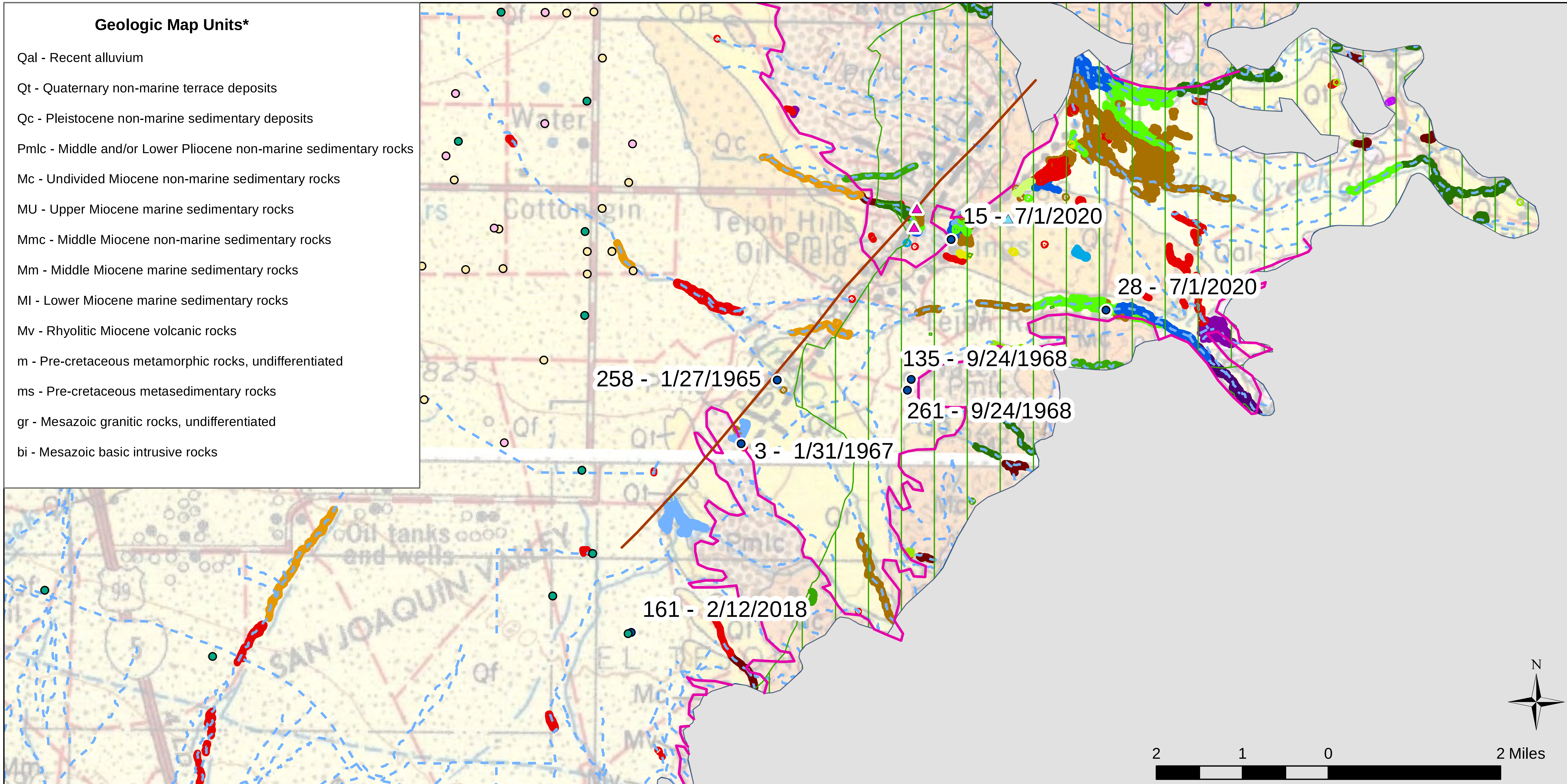
GDEs are not drawn to scale. Their size was enlarged to improve visibility at map scale.

GeoSystems Analysis, Inc.
Innovations and Solutions

EKI Environment & Water, Inc.
Burlingame, CA

GSA Proj. No. 2013

Figure 2. Map showing the GDE wetness score



Legend

White Wolf sub-basin
Tejon Ranch
Surface drainages
Artesian well
National Hydrography Dataset springs
Spring Fault
Boundary between consolidated rock and alluvial sediments
Wells with latest depth to water (ft bgs) - measurement date

Wells
Dom/M&I
Irr/Dom
Irrigation
Monitoring
Unknown

Full GDE type

000, 1Ad, 1An, 1Bn, 1Sd, 1Sn, 2Ae, 2Be, 2Bi, 2Bn, 2Se, 2Si, 2Sn, 3An, 3Be, 3Bi, 3Bn, 3Re, 3Ri, 3Se, 3Si, 3Sn

GDE areas are not drawn to scale. Their size was enlarged to improve visibilty at map scale.

* Basemap: California Division of Mines and Geology, Geological Map of California, Olaf P. Jenkins ed., Bakersfield Sheet, 1964 and Los Angeles Sheet, 1969.

GSA GeoSystems Analysis, Inc. Innovations and Solutions

EKI Environment & Water, Inc.
Burlingame, CA

GSA Proj. No. 2013

Figure 3. Map showing the well locations, surficial geology, and GDE type near Spring Faultt

Probable Source Aquifer

0 - No visual evidence of surface water or groundwater; not dominated by hydrophylic plants

A - Site appears to be supported by shallow aquifer and/or surface water separate from regional aquifer

B - Site appears to be supported by shallow alluvial aquifer upgradient of the Springs Fault

S - Site appears to be supported by bedrock springs or shallow alluvium over low permeability sediments or rocks

R - Site appears to be supported by the regional aquifer

Geologic Map Units*

Qal - Recent alluvium

Qt - Quaternary non-marine terrace deposits

Qc - Pleistocene non-marine sedimentary deposits

Pmlc - Middle and/or Lower Pliocene non-marine sedimentary rocks

Mc - Undivided Miocene non-marine sedimentary rocks

MU - Upper Miocene marine sedimentary rocks

Mmc - Middle Miocene non-marine sedimentary rocks

Mm - Middle Miocene marine sedimentary rocks

Ml - Lower Miocene marine sedimentary rocks

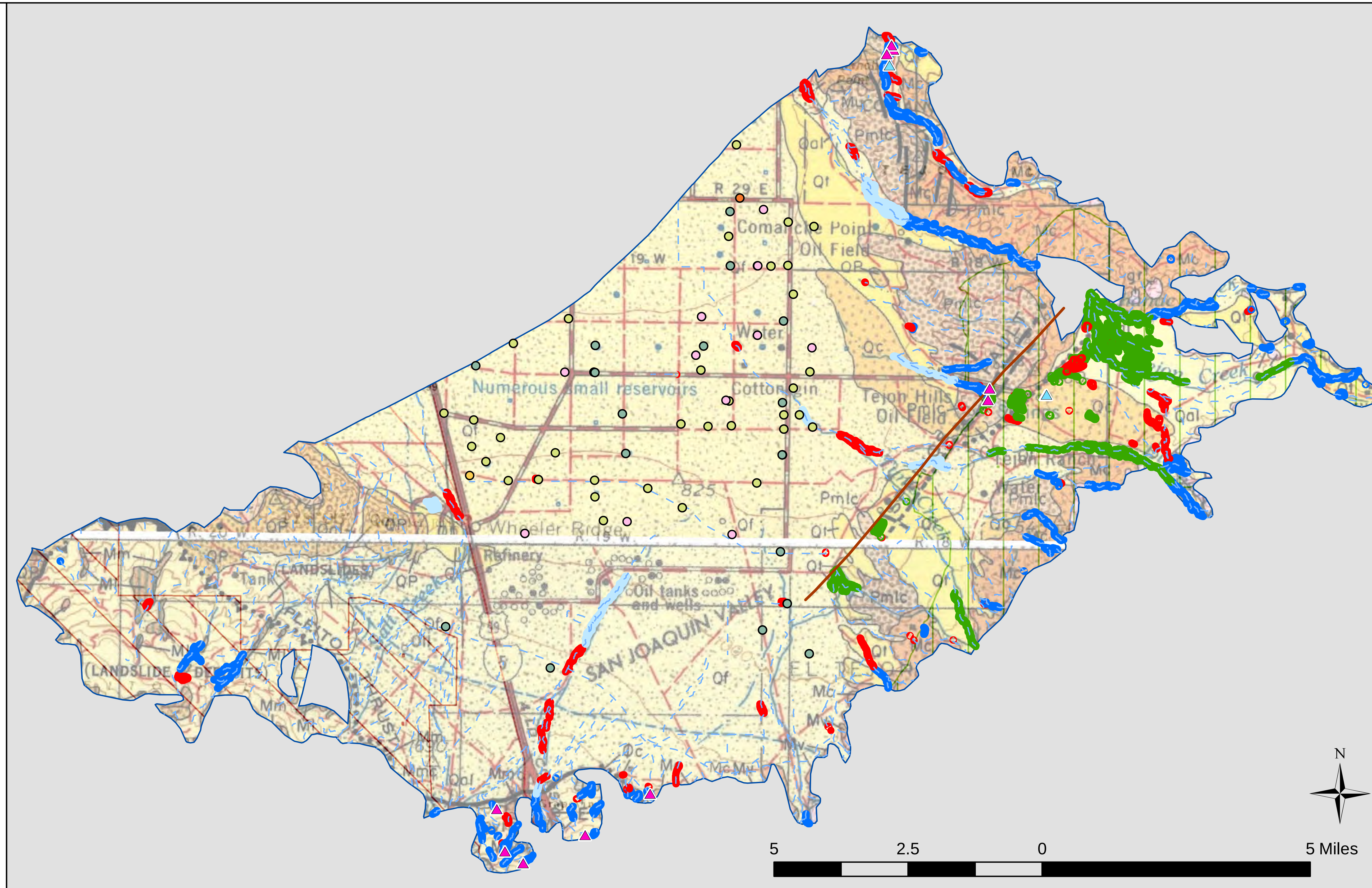
Mv - Rhyolitic Miocene volcanic rocks

m - Pre-cretaceous metamorphic rocks, undifferentiated

ms - Pre-cretaceous metasedimentary rocks

gr - Mesazoic granitic rocks, undifferentiated

bi - Mesazoic basic intrusive rocks



Legend

Artesian well

National Hydrography Dataset springs

Probable source aquifer: 0, A, B, S, R

Wells: Dom/M&I, Domestic, Irr/Dom, Irrigation, Monitoring, Unknown

Surface water drainage

Spring Fault

White Wolf sub-basin

Tejon Ranch

Wind Wolves Preserve

GDEs are not drawn to scale. Their size was enlarged to improve visibility at map scale.

* Basemap: California Division of Mines and Geology, Geological Map of California, Olaf P. Jenkins ed., Bakersfield Sheet, 1964 and Los Angeles Sheet, 1969.

GSA GeoSystems Analysis, Inc. Innovations and Solutions

EKI Environment & Water, Inc.
Burlingame, CA

GSA Proj. No. 2013

Figure 4. Map showing the probable source aquifer

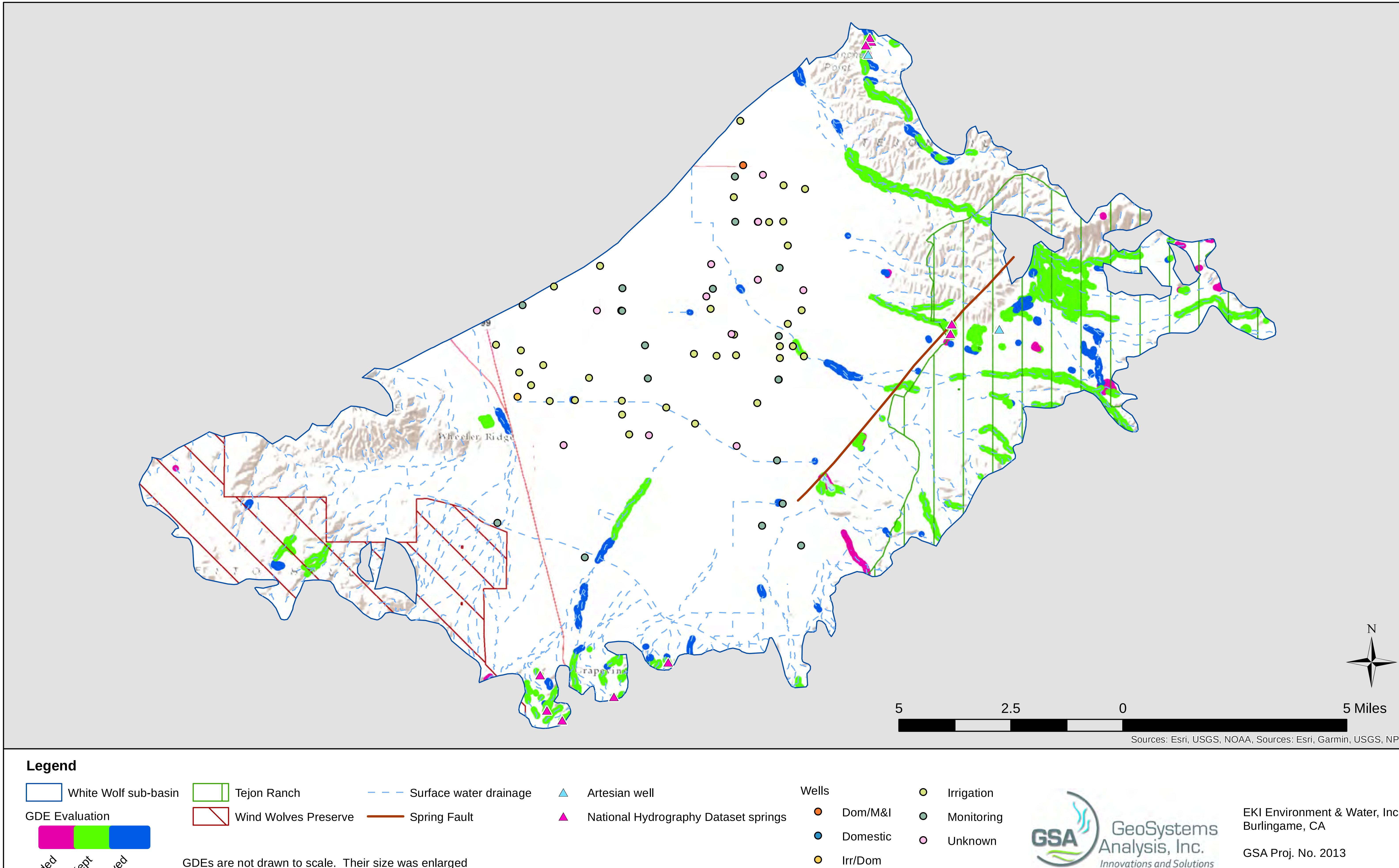


Figure 5. Map showing the GDE retention status

Full GDE Type

Moisture Class

0 - No visual evidence of surface water or groundwater; not dominated by hydrophilic plants

1 - No visual evidence of surface water or groundwater; however, site is dominated by hydrophilic plants

2 - Visual evidence of surface and/or groundwater, site is dominated by hydrophilic plants; however, surface water suspected to be ephemeral or intermittent

3 - Visual evidence of surface and/or groundwater, site is dominated by hydrophilic plants; and, surface water suspected to be perennial or near perennial

Probable Source Aquifer

0 - No visual evidence of surface water or groundwater; not dominated by hydrophylic plants

A - Site appears to be supported by shallow aquifer and/or surface water separate from regional aquifer

B - Site appears to be supported by shallow alluvial aquifer upgradient of the Springs Fault

S - Site appears to be supported by bedrock springs or shallow alluvium over low permeability sediments or rocks

R - Site appears to be supported by the regional aquifer

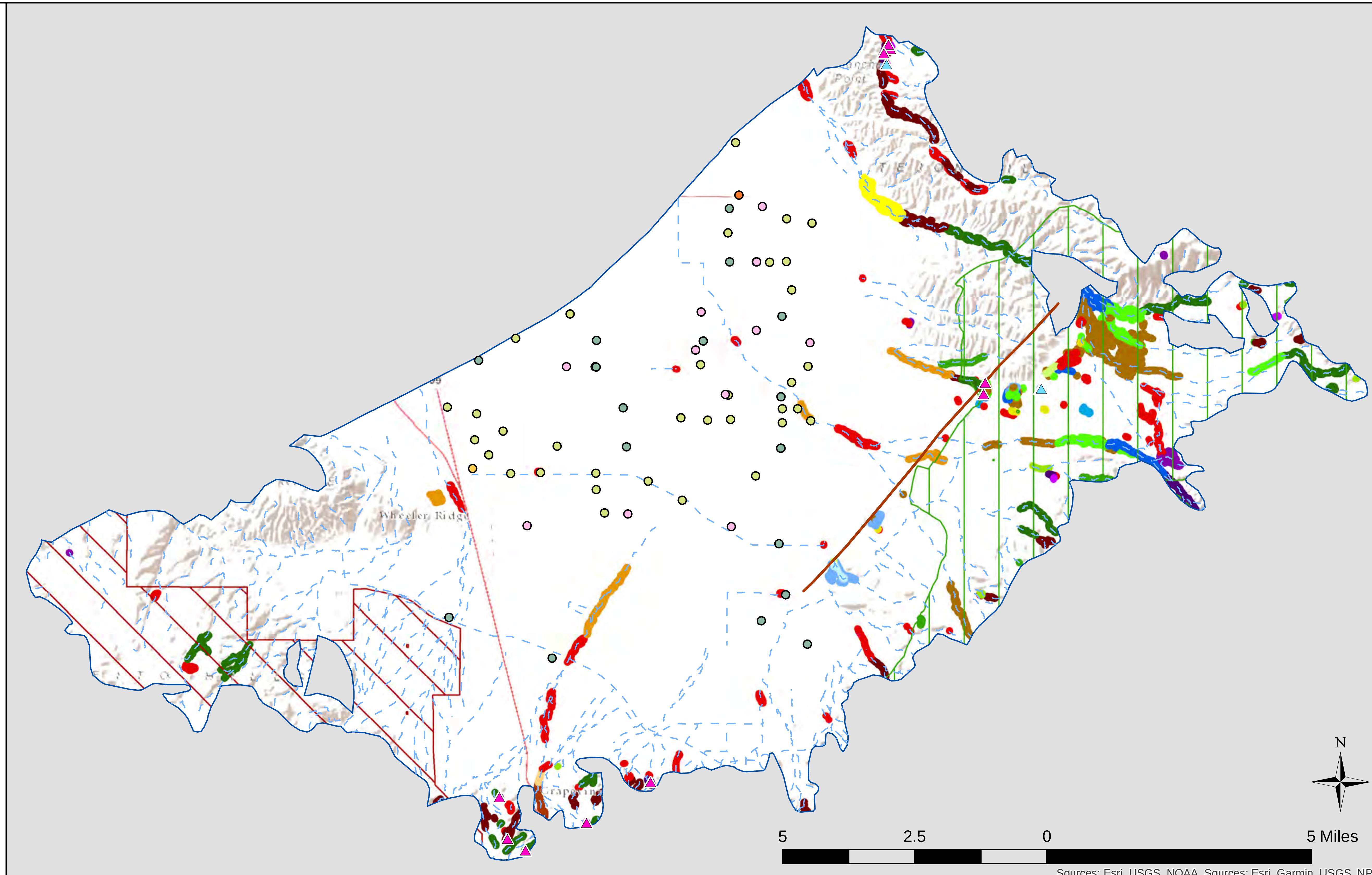
Man-Made Modifier

n - Naturally occurring GDE

i - Created/supported by a man-made impoundment

d - Created/supported by a man-made diversion

e - Created/supported by a man-made extraction feature (e.g. a well)



Legend

White Wolf sub-basin

Tejon Ranch

Wind Wolves Preserve

Surface water drainage

Spring Fault

Artesian well

National Hydrography Dataset springs

Wells

Dom/M&I

Domestic

Irr/Dom

Irrigation

Monitoring

Unknown

Full GDE type

000, 1Ad, 1An, 1Bn, 1Sd, 1Sn, 2Ae, 2Be, 2Bi, 2Bn, 2Se, 2Si, 2Sn, 3An, 3Be, 3Bi, 3Bn, 3Re, 3Ri, 3Se, 3Si, 3Sn

GDEs are not drawn to scale. Their size was enlarged to improve visibility at map scale.

GSA GeoSystems Analysis, Inc. Innovations and Solutions

EKI Environment & Water, Inc.
Burlingame, CA

GSA Proj. No. 2013

Figure 6. Map showing the full GDE type

Table 6. Full GDE class acreage summary

GDE Class		Acres
0	Not a GDE	174.5
1Ad	No visual evidence of surface water or groundwater but dominated by hydrophilic plants, site appears supported by a shallow aquifer and/or surface water separate from regional aquifer, created/supported by a man-made diversion	1.1
1An	No visual evidence of surface water or groundwater but dominated by hydrophilic plants, site appears supported by a shallow aquifer and/or surface water separate from regional aquifer, naturally occurring GDE	52.6
1Bn	No visual evidence of surface water or groundwater but dominated by hydrophilic plants, site appears supported by a shallow alluvial aquifer upgradient of the Springs Fault, naturally occurring GDE	222.3
1Sd	No visual evidence of surface water or groundwater but dominated by hydrophilic plants, site appears to be supported by bedrock springs or shallow alluvium over low permeability sediments or rocks, created/supported by a man-made diversion	6.7
1Sn	No visual evidence of surface water or groundwater but dominated by hydrophilic plants, site appears to be supported by bedrock springs or shallow alluvium over low permeability sediments or rocks, naturally occurring GDE	103.5
2Ae	Visual evidence of surface and/or groundwater with surface water suspected to be ephemeral or intermittent, site appears supported by a shallow aquifer and/or surface water separate from regional aquifer, created/supported by a man-made extraction feature	69.3
2Be	Visual evidence of surface and/or groundwater with surface water suspected to be ephemeral or intermittent, site appears supported by a shallow alluvial aquifer upgradient of the Springs Fault, created/supported by a man-made extraction feature	2.6
2Bi	Visual evidence of surface and/or groundwater with surface water suspected to be ephemeral or intermittent, site appears supported by a shallow alluvial aquifer upgradient of the Springs Fault, created/supported by a man-made impoundment	3.4
2Bn	Visual evidence of surface and/or groundwater with surface water suspected to be ephemeral or intermittent, site appears supported by a shallow alluvial aquifer upgradient of the Springs Fault, naturally occurring GDE	99.5
2Se	Visual evidence of surface and/or groundwater with surface water suspected to be ephemeral or intermittent, site appears to be supported by bedrock springs or shallow alluvium over low permeability sediments or rocks, created/supported by a man-made extraction feature	1.6

GDE Class		Acres
2Si	Visual evidence of surface and/or groundwater with surface water suspected to be ephemeral or intermittent, site appears to be supported by bedrock springs or shallow alluvium over low permeability sediments or rocks, created/supported by a man-made impoundment	4.7
2Sn	Visual evidence of surface and/or groundwater with surface water suspected to be ephemeral or intermittent, site appears to be supported by bedrock springs or shallow alluvium over low permeability sediments or rocks, naturally occurring GDE	129.5
3An	Visual evidence of surface and/or groundwater with site dominated by hydrophilic plants and surface water suspected to be perennial or near perennial, site appears supported by a shallow aquifer and/or surface water separate from regional aquifer, naturally occurring GDE	0.00005
3Be	Visual evidence of surface and/or groundwater with site dominated by hydrophilic plants and surface water suspected to be perennial or near perennial, site appears supported by a shallow alluvial aquifer upgradient of the Springs Fault, created/supported by a man-made extraction feature	4.7
3Bi	Visual evidence of surface and/or groundwater with site dominated by hydrophilic plants and surface water suspected to be perennial or near perennial, site appears supported by a shallow alluvial aquifer upgradient of the Springs Fault, created/supported by a man-made impoundment	44.0
3Bn	Visual evidence of surface and/or groundwater with site dominated by hydrophilic plants and surface water suspected to be perennial or near perennial, site appears supported by a shallow alluvial aquifer upgradient of the Springs Fault, naturally occurring GDE	58.6
3Re	Visual evidence of surface and/or groundwater with site dominated by hydrophilic plants and surface water suspected to be perennial or near perennial, site appears to be supported by the regional aquifer, created/supported by a man-made extraction feature	0.2
3Ri	Visual evidence of surface and/or groundwater with site dominated by hydrophilic plants and surface water suspected to be perennial or near perennial, site appears to be supported by the regional aquifer, created/supported by a man-made impoundment	0.03
3Se	Visual evidence of surface and/or groundwater with site dominated by hydrophilic plants and surface water suspected to be perennial or near perennial, site appears to be supported by bedrock springs or shallow alluvium over low permeability sediments or rocks, created/supported by a man-made extraction feature	4.0

GDE Class		Acres
3Si	Visual evidence of surface and/or groundwater with site dominated by hydrophilic plants and surface water suspected to be perennial or near perennial, site appears to be supported by bedrock springs or shallow alluvium over low permeability sediments or rocks, created/supported by a man-made impoundment	41.4
3Sn	Visual evidence of surface and/or groundwater with site dominated by hydrophilic plants and surface water suspected to be perennial or near perennial, site appears to be supported by bedrock springs or shallow alluvium over low permeability sediments or rocks, naturally occurring GDE	31.6
	Grand Total	**1055.8**

3.6 GDE retention status

TNC guidelines (TNC 2018) suggest illustrating which GDEs are "added" to, "kept", or "removed" from the NCCAG dataset as a method to communicate the evaluation process and the original source for a GDE feature. For the purpose of this report, we refer to this type of evaluation as "retention status". A total of 801.8 acres of GDEs described in the original NCCAG data created for the site were "kept" (Table 7) because our analysis substantiated these sites meet GDE criteria (Figure 6). This represents 82% of the total acreage included in the DWR NCCAG data (Table 1). Thus, while the NCCAG often did not assign a correct dominant vegetation species to a polygon (as discussed in this report), the dataset is a reasonably reliable indicator for predicting where GDEs occurred within the project area. A total of 174.5 acres within the NCCAG data were "removed" from the GDE dataset (or 17% of the original NCCAG area). Many of the sites excluded as GDEs are incorrectly described emergent wetland types dominated by annual grasses or woody riparian species in the field. Additionally, we added a total of 79.5 acres of GDEs based on types classified in the GVE map, air photo interpretation, and image greenness for a total GDE area of 884.6 acres.

Table 7. GDE retention status acreage table

Retention Status	Acres
Added	79.5
Kept	801.8
Total GDE Area	**881.3**
Removed	174.5
Total GDE Acreage Assessed	**1,055.8**

3.7 Dominant plant species and vegetation communities within the GDEs

Based on our site assessment, various forms of riparian forest are the most dominant general vegetation type within GDEs mapped within the project area (Table 8), spanning about 652 acres (or ~74% of the total GDE area). The prominent trees in these communities are Fremont cottonwood and valley oak. Eucalyptus, Goodding's willow (*Salix gooddingii*), and red willow (*Salix laevigata*) also dominate some of the forested communities and often co-dominate with cottonwood and oak. Numerous shrub species including nettle (Urtica dioica), saltcedar (*Tamarix spp*), elderberry (*Sambucus nigra*), seep willow (*Baccharis salicifolia*), saltbushes (*Atriplex spp*), and canyon grape (*Vitis californica*) also dominate certain GDEs and frequently formed a shrub understory below the riparian trees. Wetland herbaceous communities in the project area included yerba mansa (*Anemopsis californica*), cattail (*Typha spp*), saltgrass (*Distichlis spicata*), alkali sacaton (*Sporobolus airoides*), and winter wheatgrass (*Pascopyrum smithii*). Photo plates to illustrate the common vegetation communities encountered at the site are shown in Figure 7 through Figure 11.

A total of 33 plant species were mapped as (co-)dominants during the site assessment (Table 9). As previously mentioned, annual grass species frequently dominate sites incorrectly mapped as emergent wetlands in the NWI/NCCAG mapping. Sites dominated by annual grasses rarely contained any hydrologic/moist soil indicators necessary to be diagnosed as a GDE, so most of these areas are removed from our GDE coverage. As a cross-check on the GDE assessment, rooting depth information (TNC 2018b) demonstrates that many of the species identified within the project area GDEs require shallow groundwater (e.g. within 25 feet from the land surface) to sustainably inhabit the segments where they are currently found.

Table 8. Vegetation types assigned to GDEs based on field verification

General Veg Type	Detailed Veg Type	Acres
Barren	Barren (riverine)	5.3
	Barren Total	**5.3**
Open water	Open water	40.6
	Open water Total	**40.6**
Riparian forest	Cottonwood	25.6
	Cottonwood-Elderberry-Nettle	2.3
	Cottonwood-Saltbush	1
	Cottonwood-Saltcedar	6.2
	Cottonwood-Seep willow	0.2
	Cottonwood-Valley oak	8.2
	Cottonwood-Valley oak-Elderberry	3.8
	Cottonwood-Valley oak-Seep willow	120
	Cottonwood-Willow	10.7
	Cottonwood-Willow-Elderberry	3.7
	Cottonwood-Willow-Nettle	1.5
	Cottonwood-Willow-Seep willow	189.6
	Cottonwood-Willow-Valley oak	8.9
	Cottonwood-Willow-Valley oak-Elderberry	5.8
	Eucalyptus	5.9
	Eucalyptus-Seep willow	30.4
	Valley oak	133.3
	Valley oak-Elderberry	1.4
	Valley oak-Willow	5.7
	Valley oak-Willow-Elderberry	0.4

General Veg Type	Detailed Veg Type	Acres
	Willow	60
	Willow-Elderberry	5.5
	Willow-Nettle	0.1
	Willow-Saltcedar	3.7
	Willow-Seep willow	14.7
	Riparian forest Total	**645.4**
Riparian shrubland	Canyon grape	5.3
	Elderberry	3
	Nettle	25.2
	Nettle-Seep willow	4
	Saltbush	11.5
	Saltbush-Elderberry-Seep willow	0.8
	Saltcedar	32.7
	Saltcedar-Elderberry	67.6
	Seep willow	1.3
	Seep willow-Elderberry	0.7
	Riparian shrubland Total	**152.1**
Wetland herbaceous	Cattail	8
	Wetland herbaceous	30
	Wetland herbaceous Total	**37.9**
Total GDE area		**881.3**

	
Oak, cottonwood, and willow inhabiting a segment classified with a “wetness index” score of 1. No surface water was present in his GDE feature; however, the site was dominated by a healthy stand of phreatophytes.	Nettle dominated GDE in a drainage on Wind Wolves Preserve. This feature did have standing water, but it was classified as a “wetness index” type 2 because surface water was present during the field assessment but presence of flow in the drainage is suspected to be ephemeral.
	
Saltcedar dominated portion of Comanche Creek, this GDE received a “wetness index” score of 1 because the feature was dominated by hydrophilic species but there was no visual evidence of surface water.	Example of a NCCAG identified emergent wetland that is actually an annual, exotic grassland. This location was “removed”, this feature was not considered a GDE.

Figure 7. GDE photo plate 1

	
Another example of a NCCAG identified emergent wetland type that was removed from GDEs.	Willow community with a "wetness index" score of 1.
	
Developed spring along Comanche Creek – "wetness index" score 3, probable aquifer source "S", and manmade modifier "i".	Flowing artesian well along Comanche Creek – "wetness index" score 3, probable aquifer source "S", and manmade modifier "i".

Figure 8. GDE photo plate 2

	
Spring near the fault that is dominated by grape, nettle, and weedy species.	Nettle dominated spring near Spring fault.
	
Willow dominated, undeveloped spring near the Springs Fault - "wetness index" score 3, probable aquifer source "B", and manmade modifier "n".	Natural spring dominated by cattail and bulrush along Comanche Creek- "wetness index" score 3, probable aquifer source "S", and manmade modifier "n".

Figure 9. GDE photo plate 3

	
Example of "wetness index" type 3, Tejon Reservoir.	Willow community along a gaining reach segment of El Paso Creek, also a 3 "wetness index" score. Probable aquifer source in this GDE is "S", but near the transition to source aquifer "B".
	
Manmade wetland impoundment along an unnamed drainage on Tejon Ranch – example of "wetness index" score of 3 with an "I" designated in the GDE type due to the impoundment. Probable aquifer source in this GDE is "S".	Yerba mansa dominated wetland near the location where multiple drainages converge with Tejon Creek, also receiving a "wetness index" of 3. Probable aquifer source in this GDE is "B" because the feature is within a drainage bottom but also near the fault.

Figure 10. GDE photo plate 4

	
Valley oak growing on a terrace above the drainage bottom.	Dead cottonwood in a side drainage of the upper Tejon Creek watershed.

Figure 11. GDE photo plate 5

Table 9. (Co-) Dominant plant species occurring within the mapped project area GDEs

Species Name	Common Name	Rooting Depth (ft)
Anemopsis californica	Yerba mansa	0.4
Atriplex lentiformis	Big saltbush	N/A (phreatophyte)
Atriplex polycarpa	Allscale	N/A (phreatophyte)
Avena fatua	Wild oat	N/A (upland)
Baccharis salicifolia	Seep willow	2
Bassia scoparia	Kochia	N/A (upland)
Brassica nigra	Black mustard	N/A (upland)
Bromus diandrus	Ripgut brome	N/A (upland)
Bromus hordeaceus	Soft brome	N/A (upland)
Bromus madritensis	Red brome	N/A (upland)
Distichlis spicata	Saltgrass	2
Eleocharis sp	Spikerush	N/A (wetland herb)
Elymus triticoides	Wild rye	3.8
Eucalyptus sp	Eucalyptus	5 to 10
Hordeum sp	Barley	N/A (upland)
Juncus sp	Rush	N/A (wetland herb)
Lepidospartum squamatum	Scale broom	N/A (phreatophyte)
Pascopyrum smithii	Western wheatgrass	N/A (often a moist soil indicator)
Peritoma arborea	Shrub bladderpod	N/A
Polypogon monspeliensis	Rabbitfoot grass	N/A
Populus fremontii	Cottonwood	2 to 7
Quercus lobata	Valley oak	24
Rumex sp	Dock	N/A (wetland herb)
Salix goodingii	Gooddings willow	7
Salix laevigata	Red willow	N/A (phreatophyte)
Sambucus nigra	Elderberry	N/A (phreatophyte)
Sporobolus airoides	Alkali sacaton	N/A (often a moist soil indicator)
Tamarix sp	Saltcedar	1 to 71
Typha domingensis	Southern cattail	N/A (wetland herb)
Typha sp	Cattail	N/A (wetland herb)
Urtica dioica	Stinging nettle	N/A (phreatophyte)
Vitis californica	Canyon grape	N/A (phreatophyte)

3.8 GDE Pulse

The health of GDEs is affected by numerous variables including water management, climate, pests, land management, and water quality (TNC, 2020). To provide GSAs with a rapid means of assessing GDE health, the creators of the GDE Pulse tool specifically analyzed 34 years of Landsat satellite data for GDEs in all groundwater basins in California to show how their greenness, or photosynthetic vigor (via

Normalized Difference Vegetation Index (NDVI)), and canopy moisture content (via Normalized Difference Moisture Index (NDMI)), have changed over this period of time. Both NDVI and NDMI are intended to provide an ongoing, quick proxy to monitor GDE health trends.

According to GDE Pulse data, NDVI values for the entire WW basin have been on a slightly increasing trend from 1985 to 2018 (Figure 2), and while NDMI values demonstrate less consistency and more inter-annual variation (Figure 3), the long-term values are stable. NDMI may also correlate with precipitation quantity but that relationship was not explored in detail to support this report. The GDE Pulse data indicate that groundwater pumping from the regional aquifer has not affected the areal extent or relative health of GDEs within the White Wolf Basin. These data are consistent with the source aquifer assessment presented in Section 3.4.

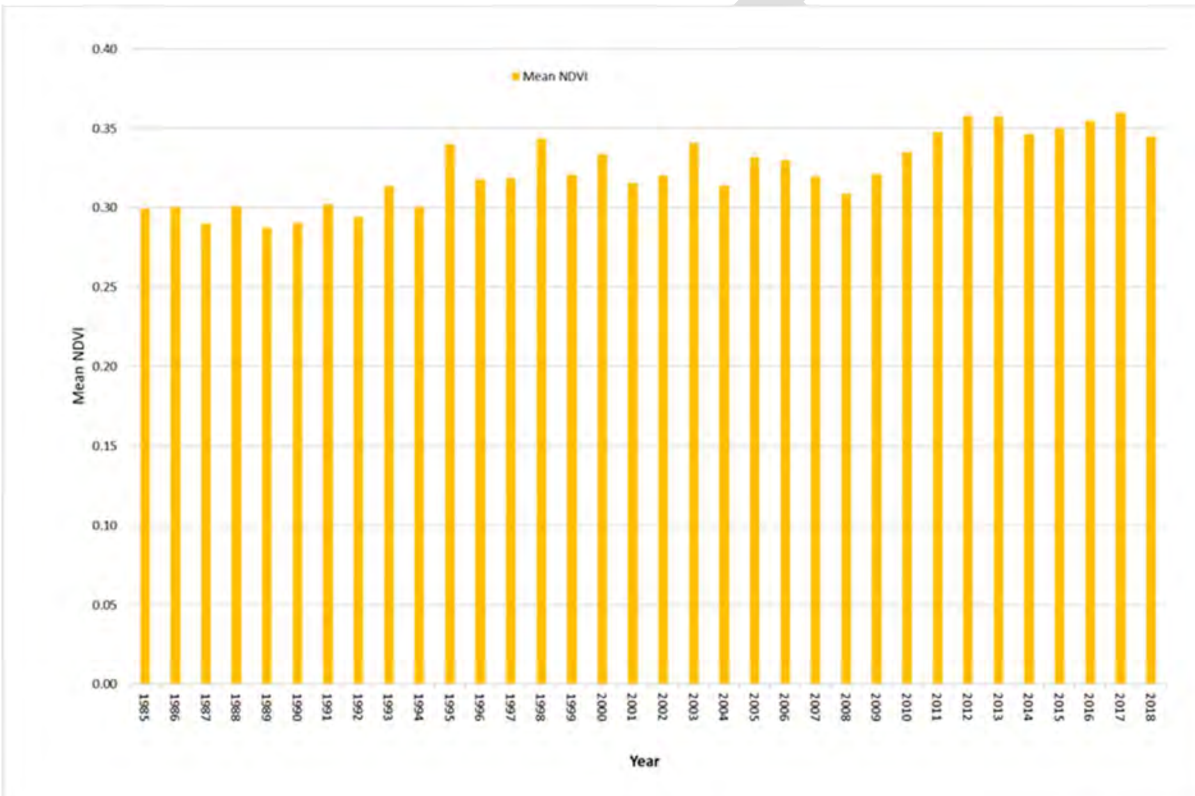


Figure 12. GDE Pulse tool NDVI trends in the White Wolf Sub-basin.

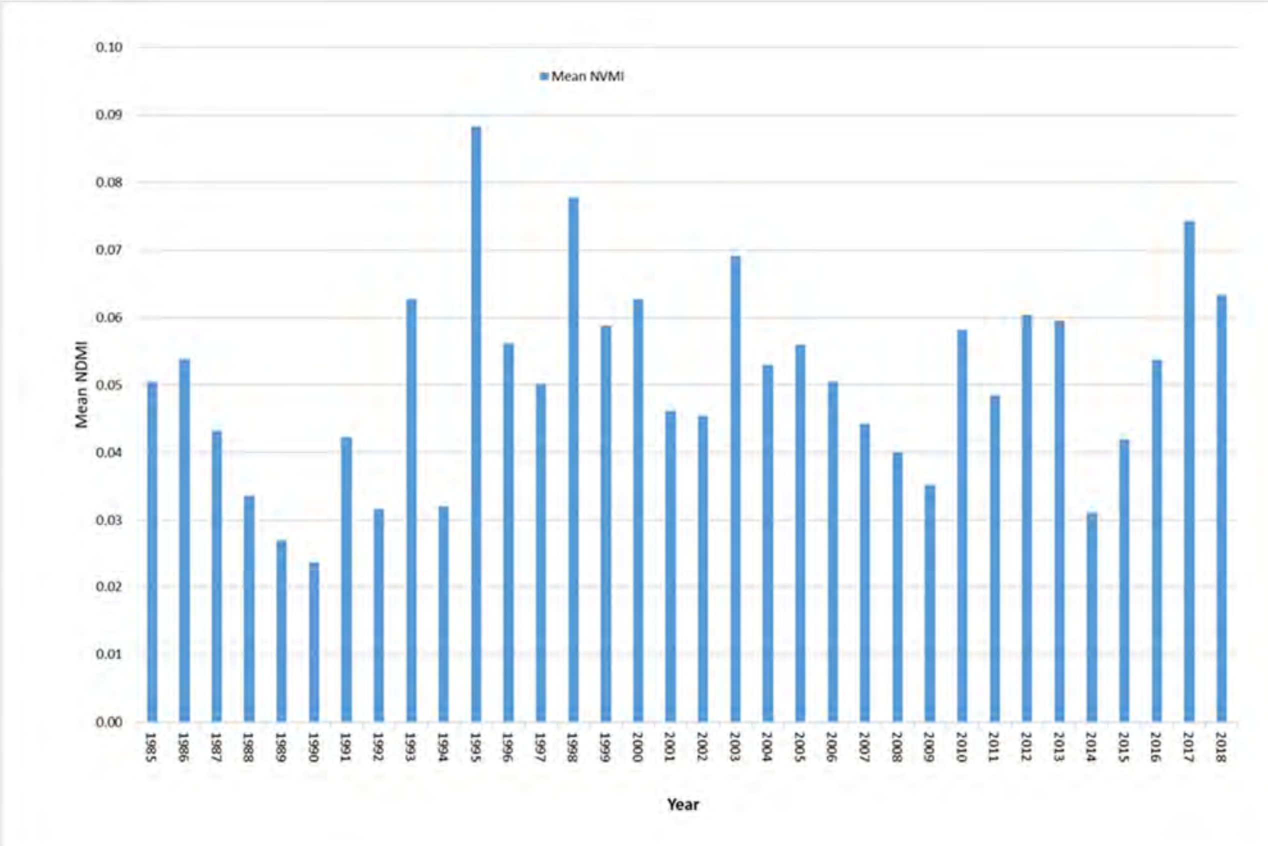


Figure 13. GDE Pulse tool NDMI trends in the White Wolf Sub-basin.

3.9 Other

A tricolored blackbird (*Agelaius tricolor*) exhibiting signs of nest/fledgling protection was encountered within a nettle dominated GDE on the Wind Wolves preserve. According to Cornell Labs (allaboutbirds.org), the population of tricolored blackbirds has declined by more than 50% since 1970, leaving the global breeding population at approximately 300,000 individuals. This species is also a Red Watch List species, with a Continental Concern Score of 18 out of 20 and the International Union for the Conservation of Nature (IUCN) lists tricolored blackbird as endangered. They are being considered for the California Endangered Species List. Population declines are due, in part, to loss of wetlands due to agricultural and urban conversion as well as to draining and diverting water from wetlands.

4.0 CONCLUSIONS AND RECOMMENDATIONS

GeoSystems conducted a field and desktop assessment to determine the extent and distribution of GDEs in the White Wolf Sub-basin between May and September, 2020. A total of 722 acres (or 74% of the land mass identified in the NCCAG dataset) were formally assessed in the field (485 acres with full assessment and 238 acres with rapid assessment). In addition, GDE Pulse data were used to inform and validate our assessment of GDEs in the project area. Based on our assessment, the White Wolf sub-basin currently supports a mosaic of diverse, healthy GDEs, particularly in the upland portions of the project area above the Spring Fault. GDEs currently span about 881-acres in the White Wolf sub-basin and most (~91%) of these areas are also identified in the NCCAG data, with an additional 9% added per field observations and image interpretation.

GDE habitat in the White Wolf sub-basin includes open water, riparian forests and shrublands, wet meadows, and marshes. Common woody riparian species dominating the GDEs are Fremont cottonwood, valley oak, Goodding's willow, red willow, elderberry, nettle, saltcedar, and seep willow. Surface water presence and persistence varies by GDE location. Current rooting depth databases (TNC, 2018) indicate that the field verified GDE species require shallow groundwater to sustain their existence at the locations where they are currently found.

A vast majority of GDE areas appears to be supported by shallow alluvial aquifer conditions rather than the deeper aquifer units that are used for groundwater extraction in the sub-basin. Most of the GDEs appear to occur in natural areas rather than sites created/supported by a manmade hydrologic alteration. According to GDE Pulse data, GDE vegetation cover for the entire White Wolf sub-basin have been on a slightly increasing trend (13%) from 1985 to 2018, and while vegetation canopy moisture values demonstrate less consistency and more inter-annual variation, the long-term values are stable. These data indicate that current water management practices within the White Wolf sub-basin have not adversely affected the areal extent or relative health of GDEs.

Recommendations

- There is a paucity of groundwater monitoring data in the project area upland of the Springs Fault. We recommend installing shallow groundwater monitoring wells within each of the larger GDE areas within the Shallow Alluvium upgradient of the Springs Fault.
- If groundwater elevation data indicate water table conditions that do not support GDEs (i.e. > 30 feet bgs), stream channel monitoring may be desired to quantify surface water conditions that support GDEs.
- Remote sensing via a variety of potential techniques and spanning a range of technical sophistication from simply digitizing the wetted extent off multiband, high resolution imagery up to automated identification and extraction of surface water and soil moisture may also be used to monitor surface water frequency in the GDEs identified under this study. Regardless of the specific technique, remote sensing monitoring should be conducted in a manner that captures seasonal and interannual variability. All monitoring systems should be instrumented with automated devices to evaluate surface water and aquifer system response to climate conditions.
- Periodically (e.g. every 3-5 years) the GDE Pulse data should be analyzed to track NDVI and NDWI trends for the project area.

5.0 REFERENCES

California Department Fish and Wildife (CFDW). 2019. VegCAMP Background Information. Accessed online: https://www.wildlife.ca.gov/Data/VegCAMP/Background

Cowardin, L.M., V. Carter V., F.C. Golet, E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service Report No. FWS/OBS/-79/31.Washington, D.C.

Geographic Information Center (GIC), Chico Research Foundation. 2018. Great Valley Ecoregion Metadata, accessed online from https://map.dfg.ca.gov/metadata/ds2632.html

Klausmeyer, K., Howard J., Keeler-Wolf T., Davis-Fadtke K., Hull R., and Lyons A., 2018. Mapping Indicators of Groundwater dependent ecosystems in California

The Nature Conservancy, 2018. Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans.

The Nature Conservancy, 2018b. Plant Rooting Depth Database (Plant_Rooting_Depth_Database_20180419.xls), obtained online from https://groundwaterresourcehub.org/sgma-tools/gde-rooting-depths-database-for-gdes/

The Nature Conservancy, 2019. Identifying GDEs under SGMA. Best Practices for Using the NC Dataset. 8 pages.

TNC, see The Nature Conservancy

US Forest Service, 2012. Groundwater Dependent Ecosystems: Level II Inventory Field Guide: Inventory Methods for Project Design and Analysis. Technical Report 86-b. 131 pages.

USFS, see US Forest Service

White Wolf Groundwater Sustainability Agency, 2020. Groundwater Sustainability Plan White Wolf Subbasin, Draft May 2020. Prepared by EKI Environment & Water, Inc.

WWGSA, see White Wolf Groundwater Sustainability Agency

Appendix A

GDE Maps Scaled to Tejon Ranch and Wind Wolves Preserve

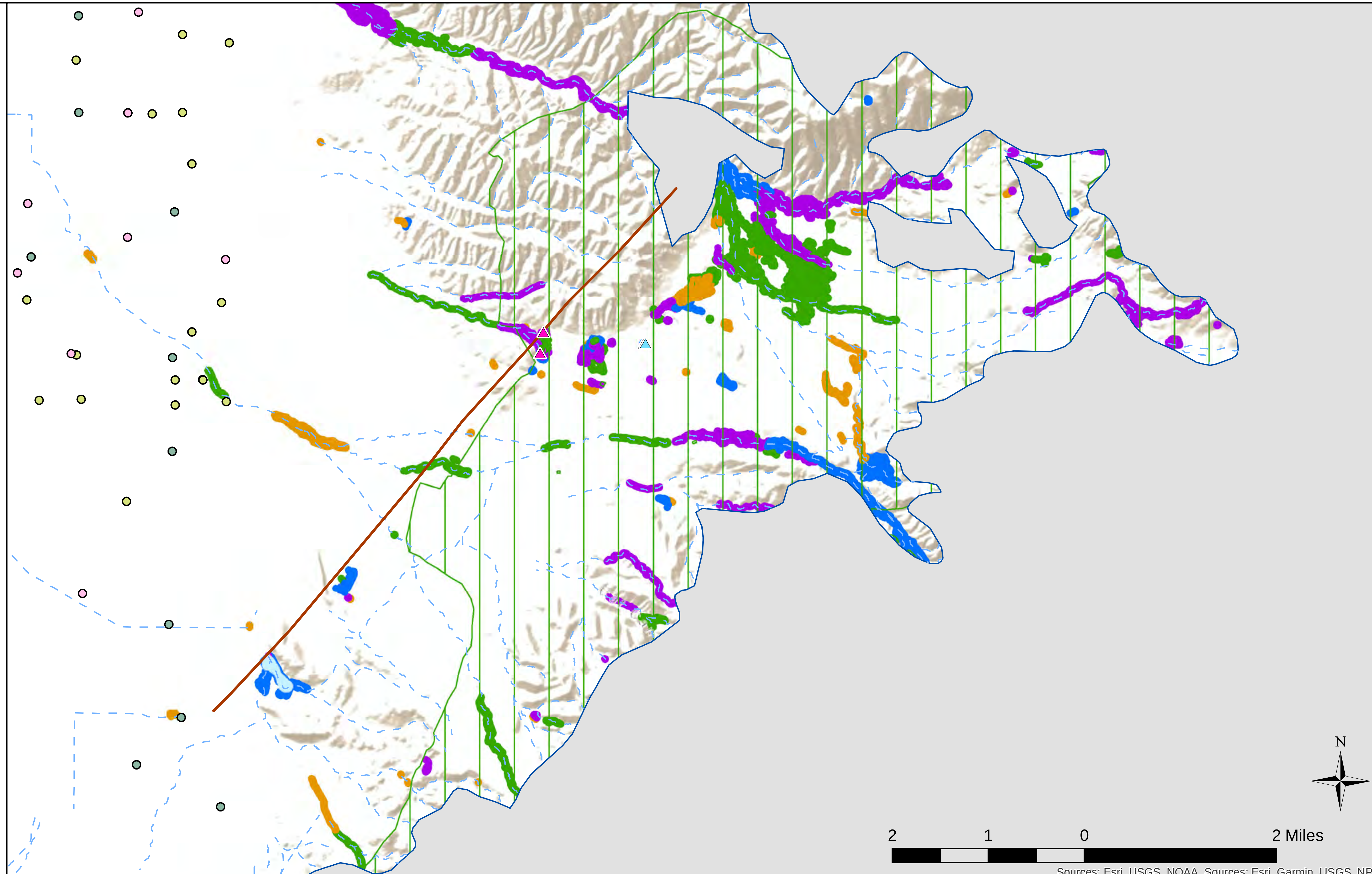
Wetness Score

0 - No visual evidence of surface water or groundwater; not dominated by hydrophilic plants

1 - No visual evidence of surface water or groundwater; however, site is dominated by hydrophilic plants

2 - Visual evidence of surface and/or groundwater, site is dominated by hydrophilic plants; however, surface water suspected to be ephemeral or intermittent

3 - Visual evidence of surface and/or groundwater, site is dominated by hydrophilic plants; and, surface water suspected to be perennial or near perennial



Legend

White Wolf sub-basin
Tejon Ranch
Surface water drainage
Spring Fault
Artesian well
National Hydrography Dataset springs

Wells
Dom/M&I
Domestic
Irr/Dom
Irrigation
Monitoring
Unknown

Wetness Score
0 1 2 3

GDEs are not drawn to scale. Their size was enlarged to improve visibility at map scale.

GSA GeoSystems Analysis, Inc. Innovations and Solutions

EKI Environment & Water, Inc.
Burlingame, CA

GSA Proj. No. 2013

Figure A-1. Map showing the GDE wetness score - Tejon Ranch

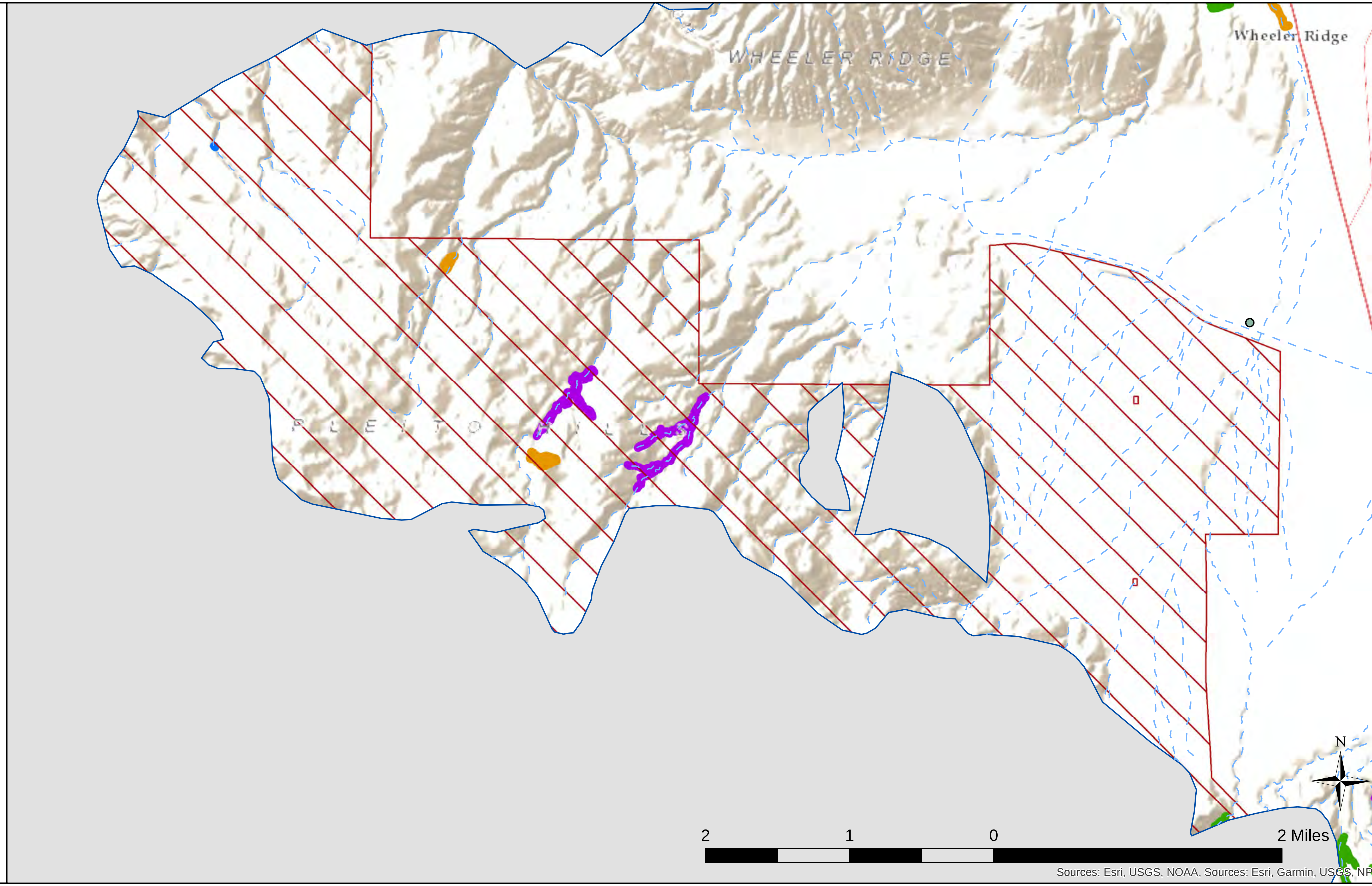
Wetness Score

0 - No visual evidence of surface water or groundwater; not dominated by hydrophilic plants

1 - No visual evidence of surface water or groundwater; however, site is dominated by hydrophilic plants

2 - Visual evidence of surface and/or groundwater, site is dominated by hydrophilic plants; however, surface water suspected to be ephemeral or intermittent

3 - Visual evidence of surface and/or groundwater, site is dominated by hydrophilic plants; and, surface water suspected to be perennial or near perennial



Legend

White Wolf sub-basin

Wind Wolves Preserve

Surface water drainage

Spring Fault

Artesian well

National Hydrography Dataset springs

Wells

- Dom/M&I
- Domestic
- Irr/Dom
- Irrigation
- Monitoring
- Unknown

Wetness Score

0 1 2 3

GDEs are not drawn to scale. Their size was enlarged to improve visibility at map scale.

GSA GeoSystems Analysis, Inc. Innovations and Solutions

EKI Environment & Water, Inc.
Burlingame, CA

GSA Proj. No. 2013

Figure A-2. Map showing the GDE wetness score - Wind Wolves Preserve

Probable Source Aquifer

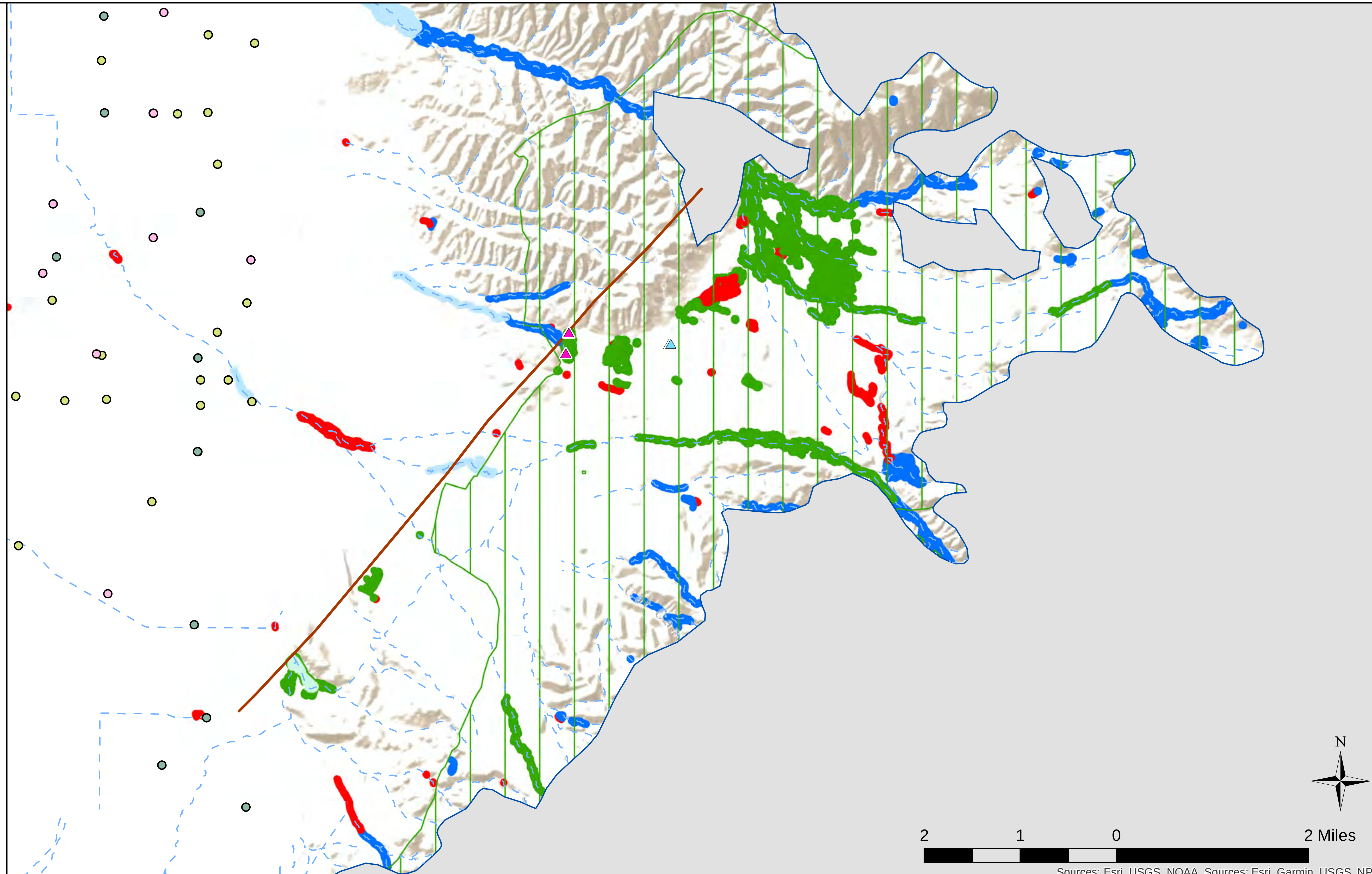
0 - No visual evidence of surface water or groundwater; not dominated by hydrophylic plants

A - Site appears to be supported by shallow aquifer and/or surface water separate from regional aquifer

B - Site appears to be supported by shallow alluvial aquifer upgradient of the Springs Fault

S - Site appears to be supported by bedrock springs or shallow alluvium over low permeability sediments or rocks

R - Site appears to be supported by the regional aquifer



Legend

White Wolf sub-basin

Tejon Ranch

Surface water drainage

Spring Fault

Artesian well

National Hydrography Dataset springs

Wells

Dom/M&I

Domestic

Irr/Dom

Irrigation

Monitoring

Unknown

Probable source aquifer

0 A B S

GDEs are not drawn to scale. Their size was enlarged to improve visibility at map scale.

GSA GeoSystems Analysis, Inc. Innovations and Solutions

EKI Environment & Water, Inc.
Burlingame, CA

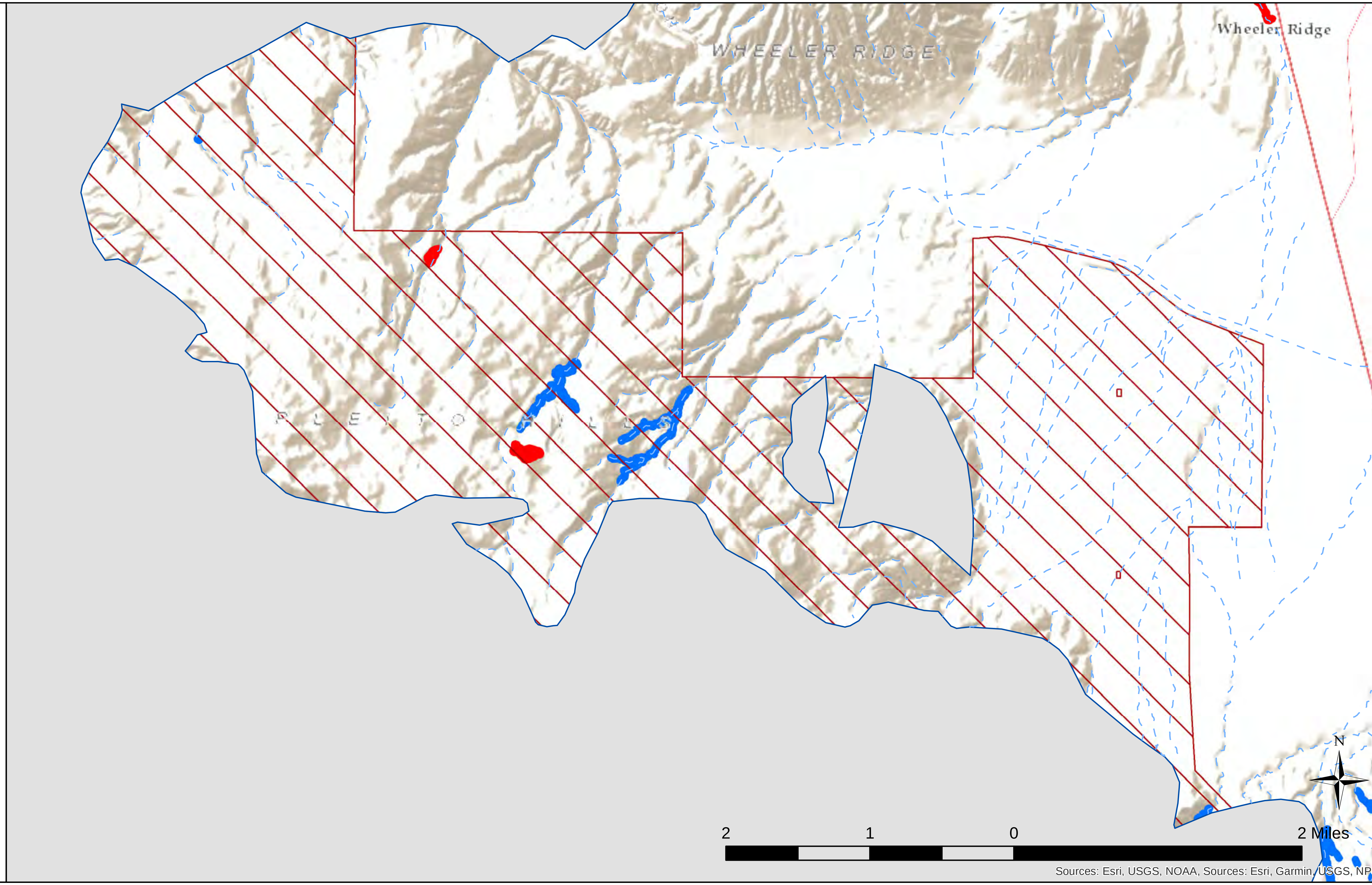
GSA Proj. No. 2013

Figure A-3. Probable source aquifer - Tejon Ranch

Probable Source Aquifer

0 - No visual evidence of surface water or groundwater; not dominated by hydrophylic plants

S - Site appears to be supported by bedrock springs or shallow alluvium over low permeability sediments or rocks



Legend

White Wolf sub-basin
Wind Wolves Preserve
Surface water drainage

Probable source aquifer

0 S

GDEs are not drawn to scale. Their size was enlarged to improve visibility at map scale.

EKI Environment & Water, Inc.
Burlingame, CA

GSA Proj. No. 2013

Figure A-4. Probable source aquifer - Wind Wolves Preserve

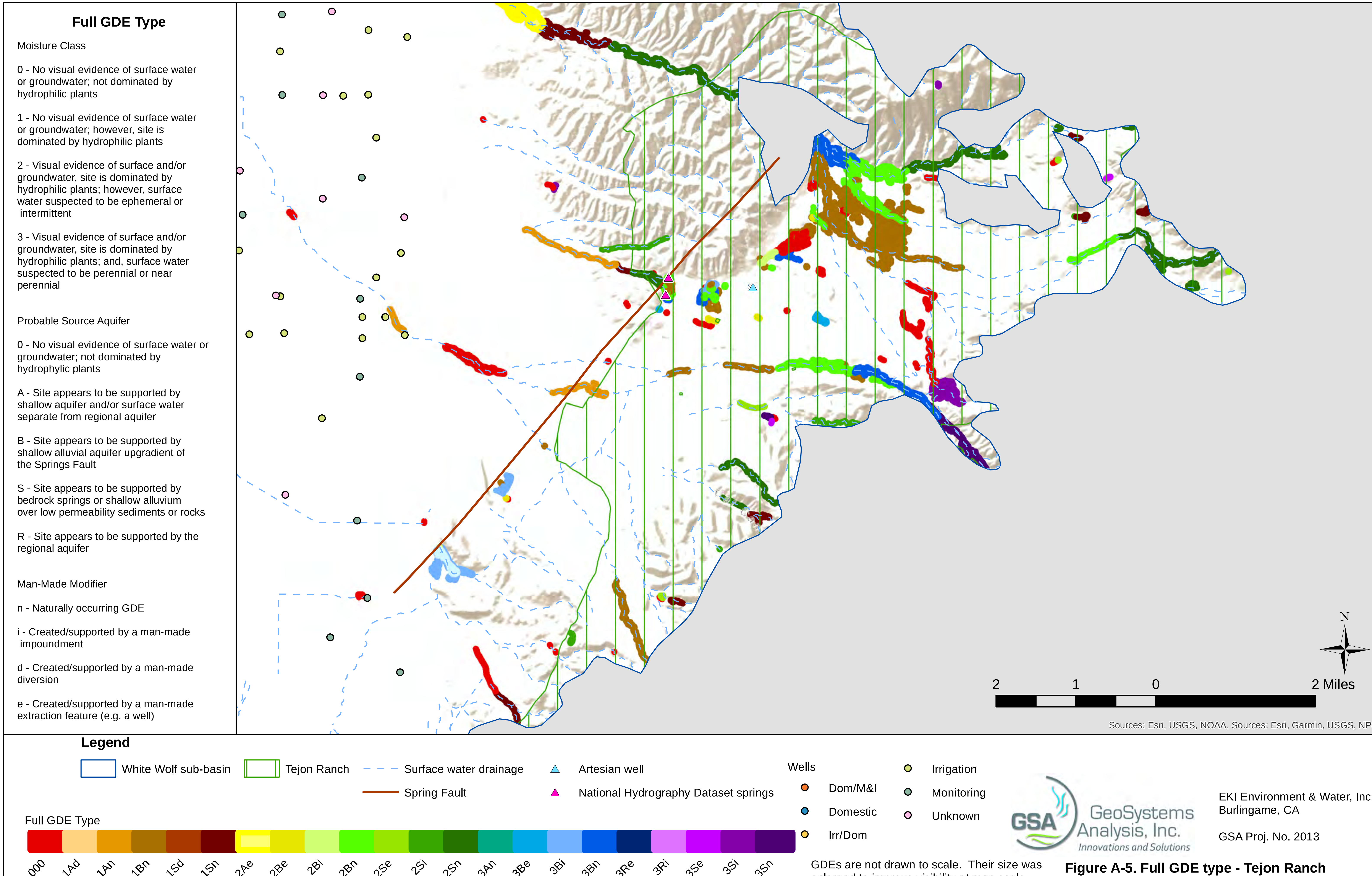


Figure A-5. Full GDE type - Tejon Ranch

Full GDE Type

Moisture Class

0 - No visual evidence of surface water or groundwater; not dominated by hydrophilic plants

1 - No visual evidence of surface water or groundwater; however, site is dominated by hydrophilic plants

2 - Visual evidence of surface and/or groundwater, site is dominated by hydrophilic plants; however, surface water suspected to be ephemeral or intermittent

3 - Visual evidence of surface and/or groundwater, site is dominated by hydrophilic plants; and, surface water suspected to be perennial or near perennial

Probable Source Aquifer

0 - No visual evidence of surface water or groundwater; not dominated by hydrophylic plants

A - Site appears to be supported by shallow aquifer and/or surface water separate from regional aquifer

B - Site appears to be supported by shallow alluvial aquifer upgradient of the Springs Fault

S - Site appears to be supported by bedrock springs or shallow alluvium over low permeability sediments or rocks

R - Site appears to be supported by the regional aquifer

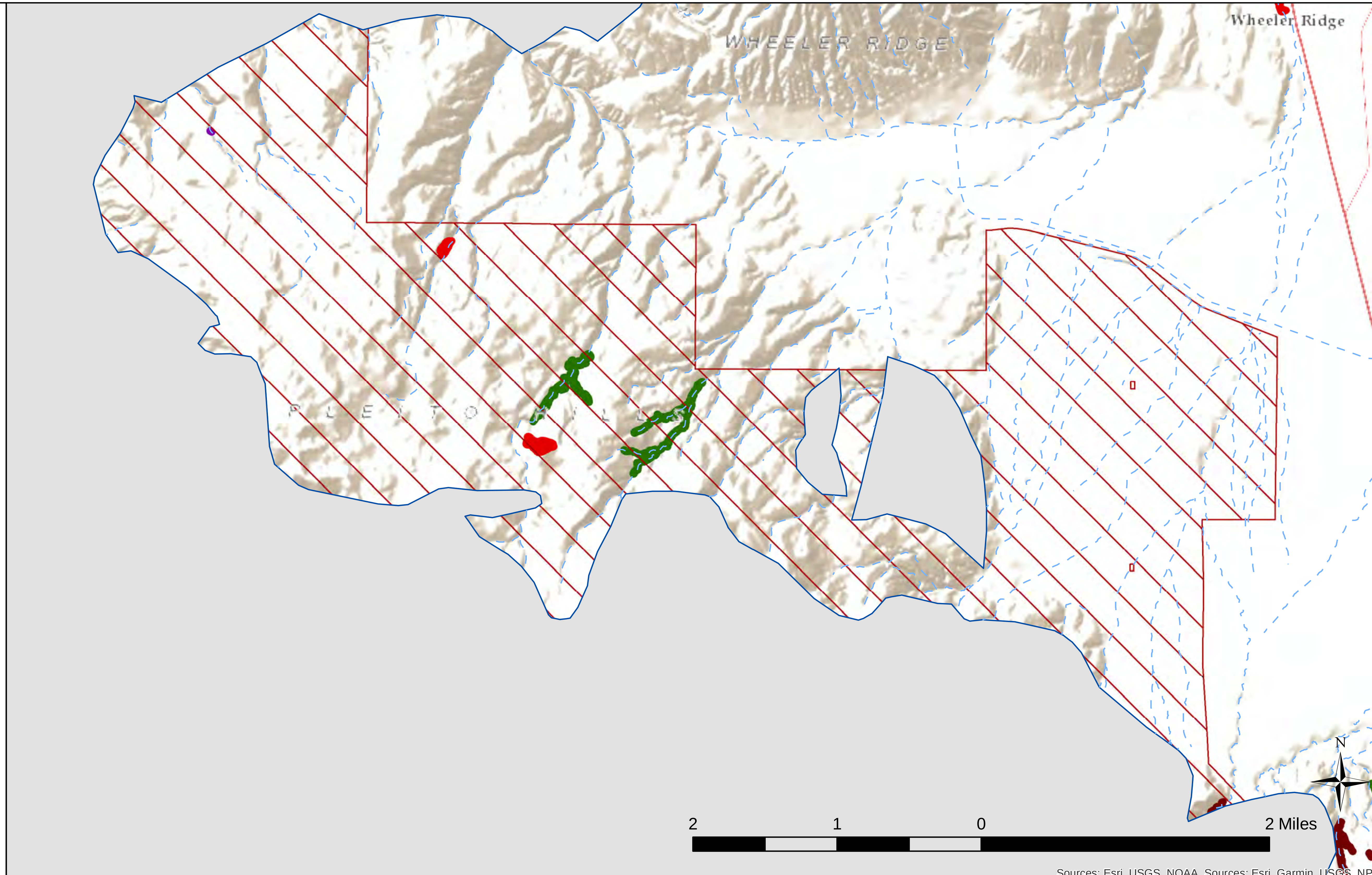
Man-Made Modifier

n - Naturally occurring GDE

i - Created/supported by a man-made impoundment

d - Created/supported by a man-made diversion

e - Created/supported by a man-made extraction feature (e.g. a well)



Legend

White Wolf sub-basin
Wind Wolves Preserve
Surface water drainage

Full GDE type

000 1Sn 2Sn 3Si

GDEs are not drawn to scale. Their size was enlarged to improve visibility at map scale.

GSA GeoSystems Analysis, Inc. Innovations and Solutions

EKI Environment & Water, Inc.
Burlingame, CA

GSA Proj. No. 2013

Figure A-6. Full GDE type - Wind Wolves Preserve

Appendix B

Field App Design and Domains

Field Name	Field Description	Field Type	Domain Values												
Lat	*Latitude (WGS 1984) of the observation*	*Numeric*	*Application logged latitude*												
Long	*Longitude (WGS 1984) of the observation*	*Numeric*	*Application logged longitude*												
Observer	*Name of the observer (s)*	*Multiple choice*	*Values dependent on names of observers*												
SiteID	*Unique name for the map unit being assessed*	*Text*	*Often per NCCAG*												
Date	*Observation date*	*Date*	*Today's date*												
Precip	*Indications of recent precipitation*	*Single choice*	*Recent rain*	*Rain during survey*	*Snow/hail during survey*	*Snow on the ground*	*No recent precipitation*								
Temp	*Approproximate temperature (F) at time of assessment*	*Numeric*	*Typically determined in field via a smart phone app*												
SlopeClass	*Representative slope class for the map unit*	*Single choice*	*<5%*	*5-10%*	*11-25%*	*26-50%*	*>50%*								
VisEvGW	*Visible evidence of groundwater*	*Multiple choice*	*Flowing spring*	*Muck from peat source*	*Standing water*	*Wetland vegetation*	*NONE*								
GDEType	*Type of GDE*	*Single choice*	*Cave*	*Exposure*	*Geyser*	*Gusing*	*Hanging garden*	*Helocrene*	*Hillslope*	*Hypocrene*	*Unknown*				
GeoStrType	*Geologic structure type*	*Single choice*	*Bedding*	*Contact*	*Fault*	*Fracture*	*Lineation*	*Conduit*	*Unknown*						
PrimSurfMat	*Primary surficial geologic material*	*Multiple choice*	*Alluvium*	*Colluvium*	*Eolian deposit*	*Glacial deposit*	*Human caused or constructed*	*Lacustrine sediment*	*Landlide deposit*						
NCCAGVg	*Dominant vegetation type assigned to the map unit within the NCCAG dataset*	*Single choice*	*Per NCCAG database*												

Field Name	**Field Description**	**Field Type**	***Domain Values***												
ActDomVg	*Dominant vegetation type inhabiting map unit per field observations*	*Multiple choice*	*Per actual field conditions*												
SbDomTr	*Sub-dominant tree species field observed in the map unit*	*Multiple choice*	*Per actual field conditions*												
SbDomSh	*Sub-dominant shrub species field observed in the map unit*	*Multiple choice*	*Per actual field conditions*												
MoistStress	*Significant evidence of moisture stress observed during the field survey*	*Single choice*	*Yes*	*No*											
MoistStNts	*Moisture stress related notes*	*Text*	*Relevant moisture stress observations*												
BareGrCvr	*Bare ground cover within the map unit*	*Single choice*	*<5%*	*6-10%*	*11-25%*	*26-50%*	*51-75%*	*76-90%*	*>90%*						
LitterCvr	*Litter cover within the map unit*	*Single choice*	*<5%*	*6-10%*	*11-25%*	*26-50%*	*51-75%*	*76-90%*	*>90%*						
BryoCvr	*Bryophyte cover within the map unit*	*Single choice*	*<5%*	*6-10%*	*11-25%*	*26-50%*	*51-75%*	*76-90%*	*>90%*						
BasVegCvr	*Basal vegetation cover within the map unit*	*Single choice*	*<5%*	*6-10%*	*11-25%*	*26-50%*	*51-75%*	*76-90%*	*>90%*						
GravelCvr	*Gravel cover within the map unit*	*Single choice*	*<5%*	*6-10%*	*11-25%*	*26-50%*	*51-75%*	*76-90%*	*>90%*						

Field Name	Field Description	Field Type	Domain Values												
CobbleCvr	*Cobble cover within the map unit*	*Single choice*	*<5%*	*6-10%*	*11-25%*	*26-50%*	*51-75%*	*76-90%*	*>90%*						
RockCvr	*Rock cover within the map unit*	*Single choice*	*<5%*	*6-10%*	*11-25%*	*26-50%*	*51-75%*	*76-90%*	*>90%*						
PerGraCvr	*Perennial grass cover within the map unit*	*Single choice*	*<5%*	*6-10%*	*11-25%*	*26-50%*	*51-75%*	*76-90%*	*>90%*						
DomGrSpp	*Dominant graminoid spp observed within the map unit during the field survey*	*Multiple choice*	*Pre-populate with graminoid spp known to occur, include editable OTHER (editable) in list*												
PerFbCvr	*Perennial forb cover within the map unit*	*Single choice*	*<5%*	*6-10%*	*11-25%*	*26-50%*	*51-75%*	*76-90%*	*>90%*						
WeedCvr	*Weed coveer within the map unit*	*Single choice*	*<5%*	*6-10%*	*11-25%*	*26-50%*	*51-75%*	*76-90%*	*>90%*						
NoxWeSpp	*Noxious weed species observed within the map unit*	*Multiple choice*	*Pre-populate with weed spp known to occur, include editable OTHER (editable) in list*												
DpOgLyr	*Depth (in) of the organic layer within the map unit*	*Numeric*	*Field determined depth (in)*												
SoilTxt	*Composite soil texture within the top 6 inches from the surface*	*Single choice*	*Sand/loamy sand*	*Loamy*	*Clayey loam*	*Clay*									

Field Name	Field Description	Field Type	Domain Values												
SoilMoistCnt	*Soil moisture content within the top 6 inches from the surface*	*Single choice*	*Dry*	*Slightly moist*	*Moist*	*Wet*	*Saturated*								
RedoxInd	*Redox indicators observed in the top 6 inches from the surface*	*Single choice*	*Yes*	*No*	*Unknown*										
AugerYN	*Did you auger within this map unit to determine current depth to groundwater?*	*Single choice*	*Yes*	*No*											
MeasDpGW	*Measured depth to groundwater*	*Numeric*	*Field determined depth (in)*												
SMNotes	*Notes on soil moisture with depth*	*Text*	*Field logged notes, if applicable*												
NonPrWtr	*Is non-precipitation caused surface water present within the map unit?*	*Single choice*	*Yes*	*No*	*Unknown*										
SurfWtrFeat	*Basic type of surface water feature present within the map unit?*	*Single choice*	*Spring/seep*	*Channel*	*NONE*										
SurfWtrInd	*Specific surface water indicators observed within the map unit*	*Multiple choice*	*NONE*	*Moist soil*	*Surface water present*	*Debris in vegetation*	*Watermarks on vegetation*	*Sediment deposits*	*Drainage patterns*	*Groundwater surfacing*	*Overbank flooding*				
ChanDyn	*Channel dynamics*	*Single choice*	*Mixed runoff/spring dominated*	*Runoff dominated*	*Spring dominated*	*Subaqueous*									

Field Name	Field Description	Field Type	*Domain Values*												
FlowCons	*Apparent flow consistency*	*Single choice*	*Dry intermittent*	*Erattic intermittent*	*Regular intermittent*	*Perennial*									
CFS	*Approximate discharge (cfs) flowing in the channel during the time of the survey, if applicable*	*Numeric*	*Field estimated flow volume (cubic feet per second)*												
ObsFtSW	*Observable fate of surface water within the map unit*	*Multiple choice*	*Disappears underground*	*Continues as far as can be seen*	*Confined to pool*	*Flows into anOTHER (editable) water feature*	*Unknown*	*Diverted*	*Becomes intermittent*	*NOT applicable*	*OTHER (editable)*				
HydAlt	*Basic types of hydrologica alterations within the map unit*	*Multiple choice*	*Downgradient capture*	*Extraction from a spring source*	*Extraction of water from within a wetland*	*NONE*	*Pollution*	*Regulated flow by impoundm ent*	*Upgradient extraction*	*Water diversion*	*Wells*	*OTHER (editable)*			
PctDiv	*Percent of the water diverted from the map unit*	*Numeric*	*Field estimated percentage*												
EroInd	*Types of erosion indicators observed within the map unit*	*Multiple choice*	*Gully erosion*	*Mass wasting*	*NONE*	*Pedestals*	*Rills*	*Sheet erosion*	*Wind erosion*	*OTHER (editable)*					
SoilDist	*Types of soil disturbance within the map unit*	*Multiple choice*	*Compaction*	*Debris flow*	*Deposition*	*Displacement of soil*	*General ground disturbance*	*Mining*	*NONE*	*Pipes*	*Ruts (vehicle tires)*	*Soil mining (e.g. peat)*	*OTHER (editable)*		
HydStru	*Manmade structures observed within the map unit*	*Multiple choice*	*Buried utility corridors*	*Enclosure fence*	*Erosion control structures*	*NONE*	*Oil/gas well*	*Pipeline*	*Point source pollution*	*Powerlines*	*Road*	*Stock tank*	*Well*	*Trails (human or animal)*	*OTHER (editable)*
RedImp	*Recreation impacts observed within the map unit*	*Multiple choice*	*Camp sites*	*Trails*	*Horseback*	*Vehicle (including off road)*	*NONE*	*OTHER (editable)*							

Field Name	Field Description	Field Type	Domain Values												
AnEff	*Types of animal effects observed within the map unit*	*Multiple choice*	*Ferel animals*	*Livestock grazing*	*Beaver activity*	*Wildlife browsing*	*Trampling*	*NONE*	*OTHER (editable)*						
MiscDist	*Miscellaneous disturbance observations within the map unit*	*Multiple choice*	*Fire*	*Tree cutting*	*Refuse disposal*	*NONE*	*OTHER (editable)*								
GenNotes	*General notes*	*Text*	*Relevant notes*												
Photos	*Photos*	*Text*	*Application logged file names*												

Appendix I

GDE Pulse Interactive Map Analysis

GDE PULSE ANALYSIS FOR WHITE WOLF SUBBASIN

White Wolf GSA
Kern County, CA

September 2021
EKI B50001.05

EKI ENVIRONMENT & WATER, INC.

www.ekiconsult.com
2001 Junipero Serra Blvd, Suite 300 • Daly City, CA 94014

GDE Pulse Analysis for White Wolf Subbasin

White Wolf Subbasin

TABLE OF CONTENTS

TABLES

FIGURES

ABBREVIATIONS

AOI	Area of Interest
GDE	Groundwater Dependent Ecosystem
ID	Identification
NDMI	Normalized Derived Moisture Index
NDVI	Normalized Derived Vegetation Index
TNC	The Nature Conservancy

1 INTRODUCTION

The GDE Pulse Interactive Map[1] developed by The Nature Conservancy (TNC), which uses remote sensing data from satellites to monitor the health of vegetation, can be used to assess long-term temporal trends of vegetation metrics in the Basin (Klausmeyer et al., 2019). The vegetation metrics include Normalized Derived Vegetation Index (NDVI) which estimates vegetation greenness and Normalized Derived Moisture Index (NDMI) which estimates vegetation moisture. Both NDVI and NDMI are used to indicate vegetation health for Groundwater Dependent Ecosystems (GDEs) through their relationship to photosynthetic chlorophyll and moisture, respectively. NDVI is measured as the ratio difference between reflectance of visible red and near-infrared wavelengths (Gandhi et al, 2015). A high NDVI value is indicative of lower visible red light reflectance, an overall greater amount of photosynthetic chlorophyll content, and therefore greener, healthier vegetation[2]. NDMI is calculated as the ratio difference of near-infrared and shortwave-infrared wavelengths (SWIR). Positive values of NDMI indicate lower reflectance of SWIR, higher leaf water content, and adequate access to water while negative values indicate higher reflectance of SWIR, decreased leaf water content, and increased water stress (Gao, 1996).

2 STUDY AREA AND ANALYSIS

Figure 1 shows selected polygons that are spatially distributed in the GDE area of interest (AOI) located upgradient of the Springs Fault. Two to three GDE polygons were selected in each AOI where sparse depth to groundwater data was available and/or near the new shallow monitoring well locations and encompass different vegetation classes.[3] AOI-1 through AOI-3 encompass the selected GDE polygons of interest nearest monitoring well sites 1 through 3 while AOI-4 and AOI-5 encompass the selected GDE polygons of interest near well sites 11N18W14M001S and 11N18W24H001S, respectively.

Figures 2 through **Figure 6** include plots of NDVI and NDMI metrics for each GDE AOI. Additionally, the cumulative departure from average rainfall was plotted against the NDVI and NDMI metrics to compare vegetation metrics against long-term precipitation trends.

Because the NDMI and NDVI indices can quantify changes in the rates and patterns of vegetation growth and moisture levels in plants over time, the relationship between these two indices and the depth to shallow groundwater can be evaluated to examine whether these measures of GDE “health” have a relationship to shallow groundwater conditions. This relationship is the premise of the TNC GDE Pulse tool. As previously mentioned, depth to water measurements are sparse for recent years in the Basin; however, depth to water measurements are available for well 11N18W24H001S. A correlation analysis between depth to water and the two vegetation metrics (NDVI and NDMI) was evaluated for the three GDE polygons nearest well 11N18W24H001S [GDE identification (ID) 136410, 140049, and 140050; see **Figure 6**].

[1] https://gde.codefornature.org/#/map, accessed on 12 October 2020.
[2] https://gde.codefornature.org/#/map, accessed on 12 October 2020
[3] In some instances, the GDE polygon extent as mapped in the GDE Pulse Interactive Map does not match that of the field verified GDE of interest. In these instances, the closest available GDE polygon extent was used.

3 RESULTS AND DISCUSSION

In general, over the long term (i.e., 1985 - 2018), NDVI and NDMI trends generally have been mostly stable, with local or short-term declines and increases, and trends generally align with long-term trends in precipitation. Specific observations for each AOI are described below.

For GDE polygons in AOI-1, NDVI and NDMI trends align with trends in precipitation (**Figure 2**). Though both GDEs are classified as red willow, GDE ID 138172 experienced greater stress as indicated by lower NDVI and NDMI values during the recent (i.e., 2012-2016) California drought than GDE ID 138170.

Trends in NDVI and NDMI for GDE polygons in AOI-2 generally show a slight lagged response to precipitation with brief and minor exceptions before 2004. For both NDVI and NDMI this lagged response is more consistent, and exaggerated, after 2004. A reversal of this lagged response is seen in both NDVI and NDMI post 2017 for Valley Oak (GDE IDs 138223 and 137220) (**Figure 3**). California grape (GDE ID 140053) exhibited less stress compared to Valley Oak (GDE IDs 138223 and 137220), as indicated by comparatively higher and more stable NDVI and NDMI values. An exception to this occurred during 1996 and 2011 where all GDEs experienced similar decreases in greenness and increased moisture stress. Over the period of record (1985-2018) the NDMI remained positive for all three GDEs for most years.

For all GDE polygons in AOI-3, trends in NDVI have remained near constant and have a very muted response to precipitation trends (**Figure 4**). Trends in NDMI show greater variability over time in comparison to trends of NDVI. Specifically, common elderberry (GDE ID 138236) and Fremont cottonwood (GDE ID 136442) showed a greater negative response in NDMI to precipitation in comparison to Valley oak (GDE ID 137270). Trends for all GDEs show decreasing NDMI suggesting decreases in chlorophyll and declining vegetation health.

For GDE polygons in AOI-4, trends in NDVI and NDMI for Valley oak (GDE ID 137218) are generally constant over time with slight variation aligning with trends in precipitation (**Figure 5**). The trends of NDVI and NDMI for Fremont cottonwood (GDE ID 136415) are slightly greater than Valley oak, and generally have a delayed response to trends in precipitation. A recent (i.e., 2020) measurement from a nearby domestic well indicates the depth to water is approximately 30 feet below ground surface near the southern area of the mapped GDE units.

Trends in both NDVI and NDMI align with trends in precipitation for all GDE polygons in AOI-5 (**Figure 6**). California grape (GDE ID 140050) has more variation in both NDVI and NDMI over time and is generally "healthier," while Valley oak (GDE IDs 136410 and 140049) show less variation over time. Measurements from a nearby domestic well (11N18W24H001S) indicate the depth to water ranges from 15 to 100 feet below ground surface near the confluence of the three mapped GDE units. However, AOI-5 is immediately adjacent to El Paso Creek, whose stream inflows from the surrounding watersheds may have an impact on overall GDE health.

Time series data of these two vegetation metrics and the depth to water data for well 11N18W24H001S were plotted for each retained GDE polygon, as shown on **Figure 7, Figure 8,** and **Figure 9**. A linear correlation between the two metrics and the depth to water was then evaluated for each polygon. A negative correlation shows when the depth to water increases, the NDMI and NDVI metrics decrease, indicating that the GDEs are less healthy when local groundwater elevations decrease, and vice versa.

All three GDEs' vegetation metrics have a negative correlation with depth to water from well 11N18W24H001S; however, only the correlation between GDE 140049 NDMI and depth to water was statistically significant ($p < 0.05$) (**Table 1**). Given limitations on current depth to water data available, future depth to water data collected from newly installed shallow monitoring wells will allow for a more robust assessment of the relationship between the two vegetation metrics and groundwater depths across the Basin.

Table 1. Correlation between Depth to Water and Vegetation Indices

Polygon ID	DTW and NDVI (r)	DTW and NDMI (r)
136410	-0.522	-0.814
140049	-0.267	-0.956[a]
140050	-0.415	-0.541

Abbreviations:
DTW= Depth to Water
ID= identification
NDMI = Normalized Derived Moisture Index
NDVI = Normalized Derived Vegetation Index
r= Pearson's correlation coefficient

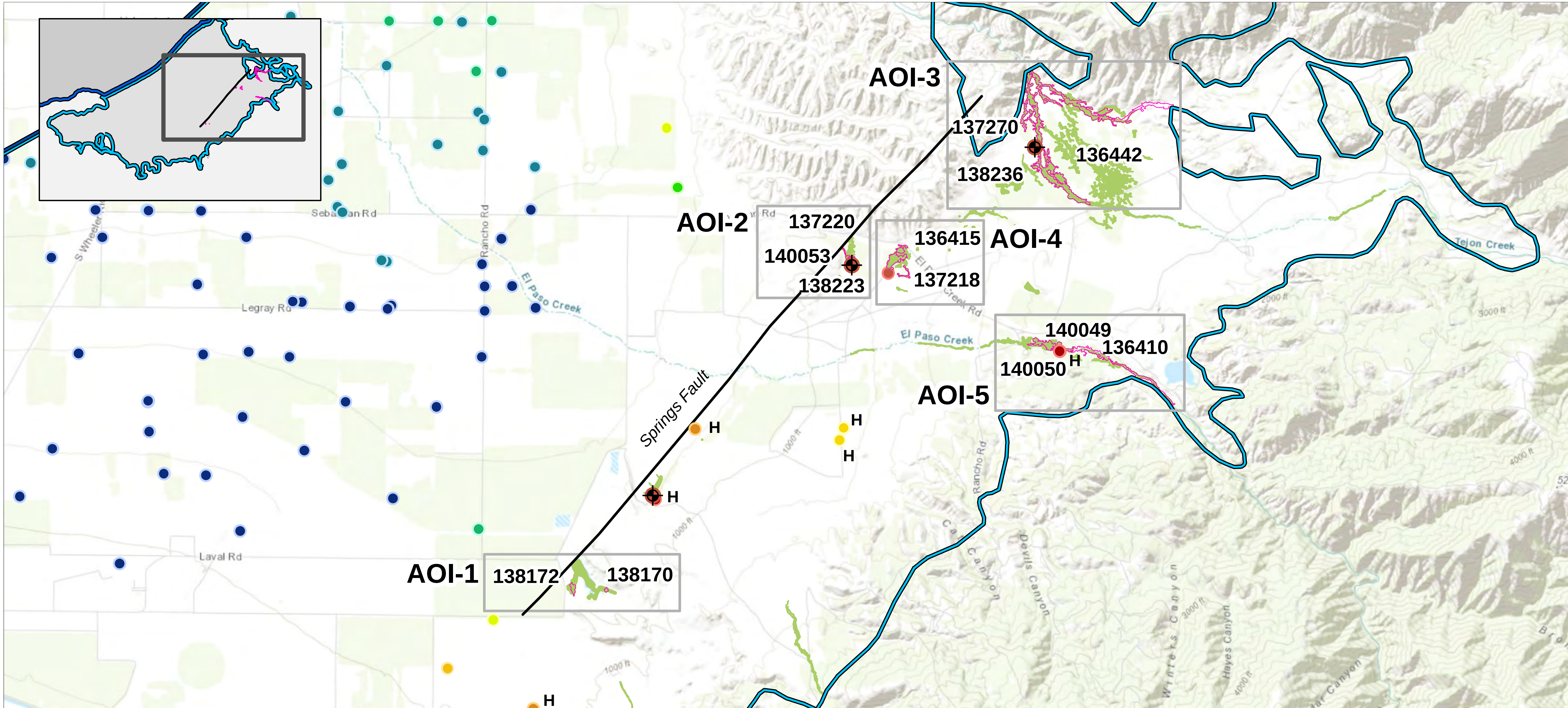
Notes:
(a) Coefficient is statistically significant ($p < 0.05$).

4 REFERENCES

Gandhi, M. G., Parthiban, S., Thummalu, N., Chrisy, A. (2015) Ndvi: Vegetation change detection using remote sensing and gis- A case study of Vellore District. Procedia Computer Science 57: 1199-1210

Gao, B.C. (1996) NDWI: A normalized difference water index for remote sensing of vegetation liquid water from space. Remote Sensing of Environment 58: 257-266

Klausmeyer, Kirk R., Tanushree Biswas, Melissa M. Rohde, Falk Schuetzenmeister, Nathaniel Rindlaub, Ian Housman, and Jeanette K. Howard. (2019) GDE Pulse: Taking the Pulse of Groundwater Dependent Ecosystems with Satellite Data. San Francisco, California. Available online at https://gde.codefornature.org/assets/GDE-Pulse-Methods-Report.pdf



Legend

- Shallow Monitoring Wells
- Springs Fault
- Area of Interest

Groundwater Subbasin

- White Wolf (DWR 5-022.18)
- Kern County (DWR 5-022.14)
- Selected Vegetation NCCAG polygon
- GDE's of Interest

Average Depth to Groundwater (ft bgs)

- < 25
- 25 - 50
- 50 - 100
- 100 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- > 500

Abbreviations

AOI- Area of Interest
DWR - California Department of Water Resources
ft bgs- feet below ground surface
GDE- Groundwater Dependant Ecosystems
NCCAG - Natural Communities Commonly Associated with Groundwater

Notes

1. All locations are approximate
2. Numeric labels indicate unique polygon ID for selected Vegetation NCCAG polygons in which vegetation indexes were downloaded from the GDE Pulse Interactive Map.
3. Average depth to water measured between 2015 & 2018 except for historic average whose measurements were obtained between 1957 and 2014. Furthermore, two wells located near El Paso Creek were measured in 2020 and the shallow monitoring wells were sampled in 2021. "H" denotes historic average depth to water measurements.
4. In some instances, the available NCCAG polygon extent does not match that of the field verified GDE of interest. GDEs of interest include those characterized as "B", site appears to be supported by shallow alluvial aquifer upgradient of the Springs Fault, or "R", site appears to be supported by the regional aquifer.

Sources

1. GDEs of interest shapefile provided by GeoSystems Analysis, Inc., 7 October 2020
2. DWR NCCAG dataset was obtained from NC Dataset from The Nature Conservancy (https://gis.water.ca.gov/app/NCDatasetViewer/)

N

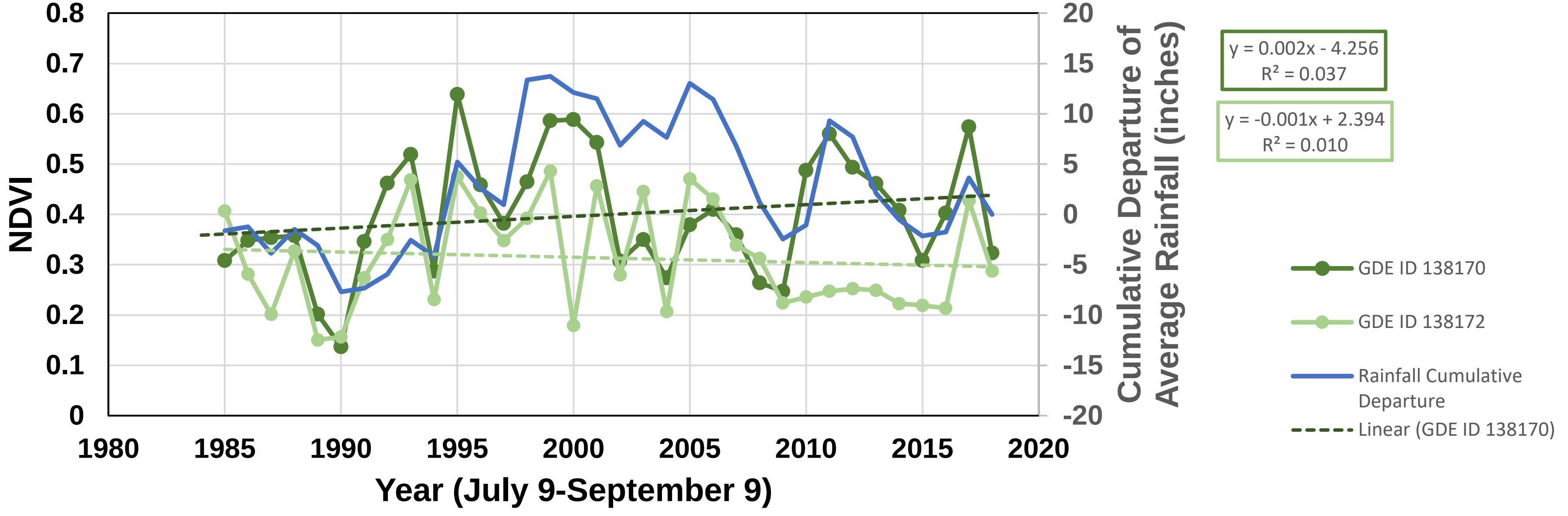
0 1 2
(Scale in Miles)

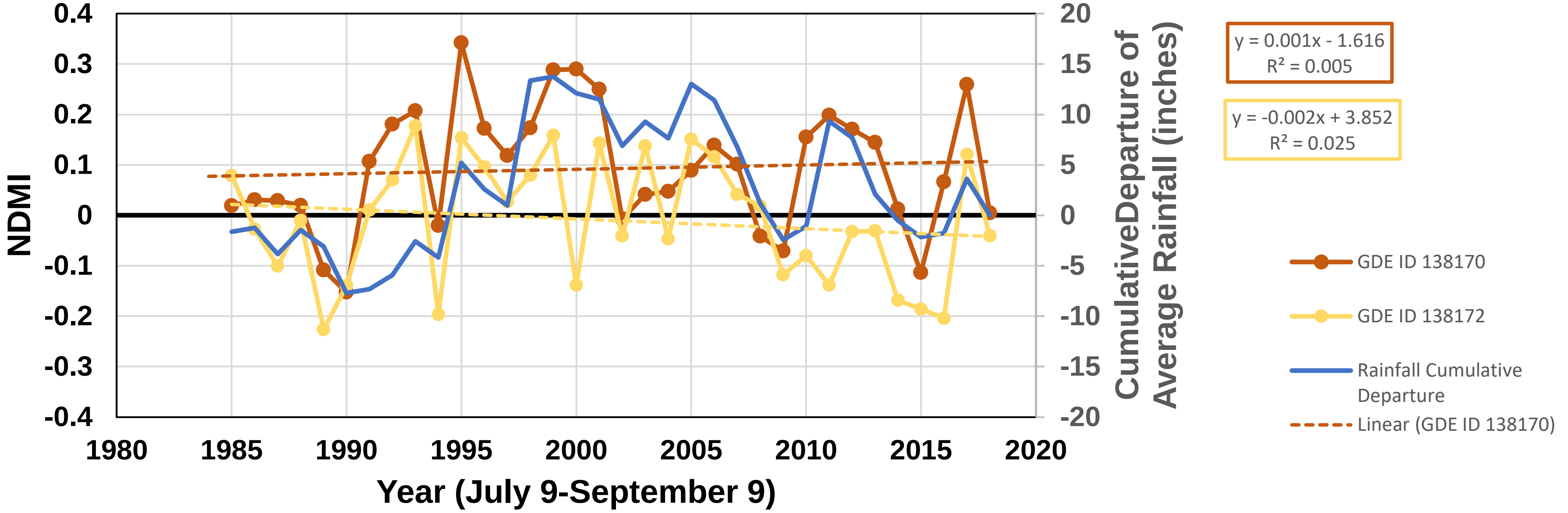
GDE Areas of Interest for GDE Pulse Analysis

eki environment & water

White Wolf GSA
Kern County. California
May 2021
B50001.06
Figure 1

Path: X:\B50001.05\Maps\2021\04\GDEPulse_NMW.mxd

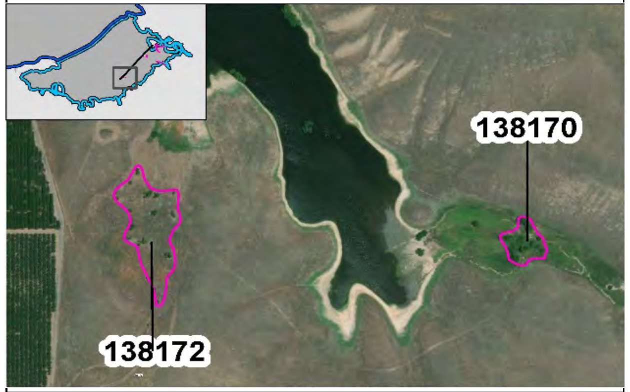




Abbreviations:
AOI = Area of Interest
GDE = Groundwater Dependent Ecosystem
ID = Identification number
NDMI = Normalized Difference Moisture Index
NDVI = Normalized Difference Vegetation Index

Notes:
1. Cumulative departure of average rainfall calculated over the available period of record (i.e., 1985-2018).
2. The field study undertaken in May 2020 classified GDE ID 138170 and GDE ID 138172 as Red Willow.

Sources:
1. GDE Pulse polygons of interest from TNC (https://gde.codefornature.org)

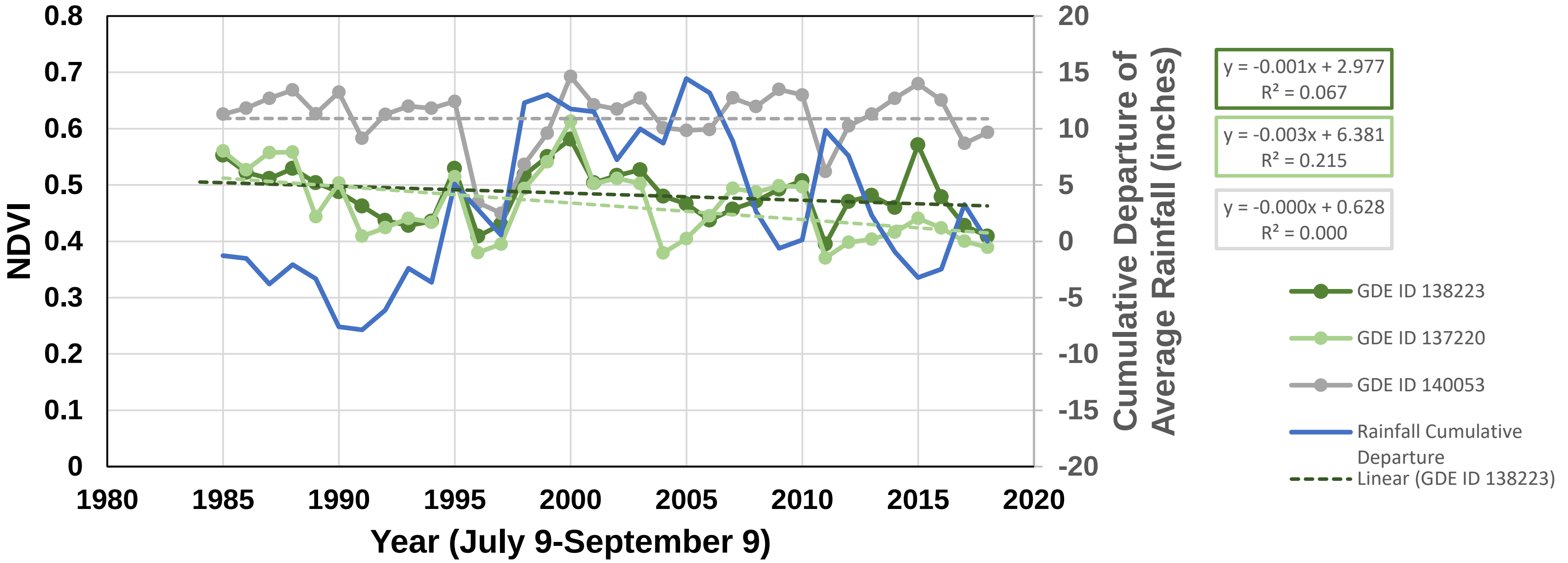


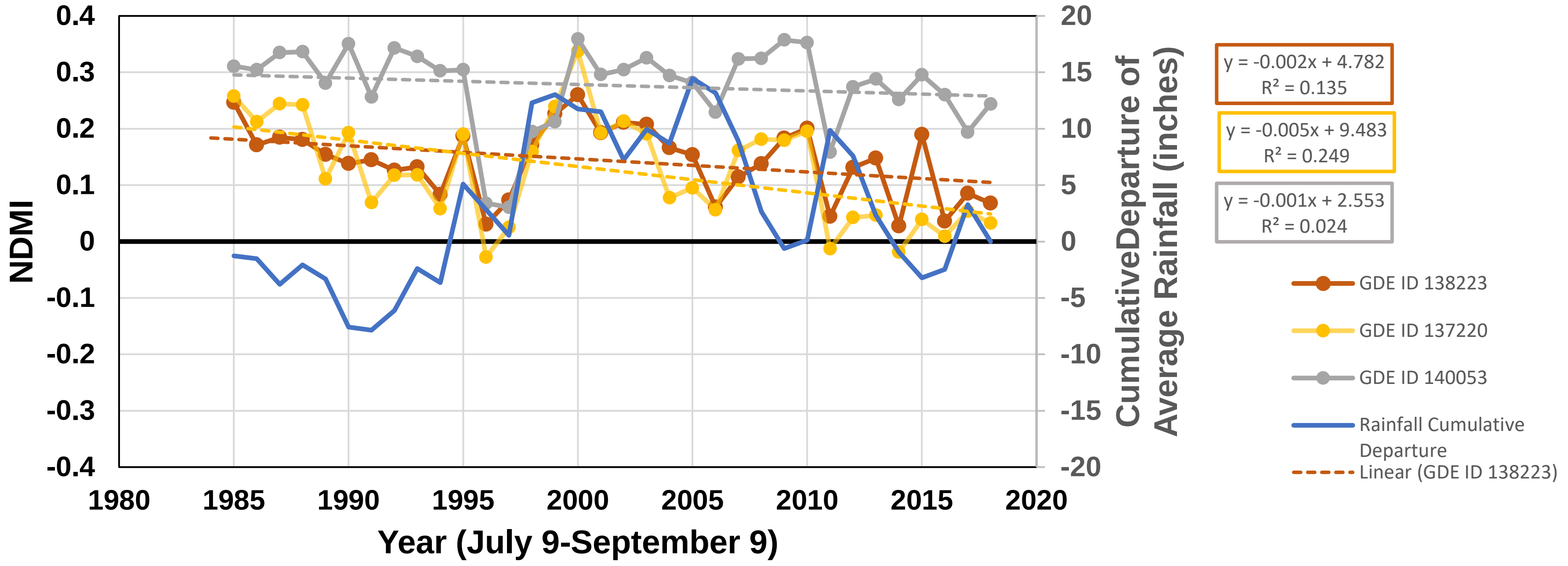
GDE AOI-1

White Wolf GSA
Kern County, California
May 2021
B50001.06

eki environment & water

Figure 2

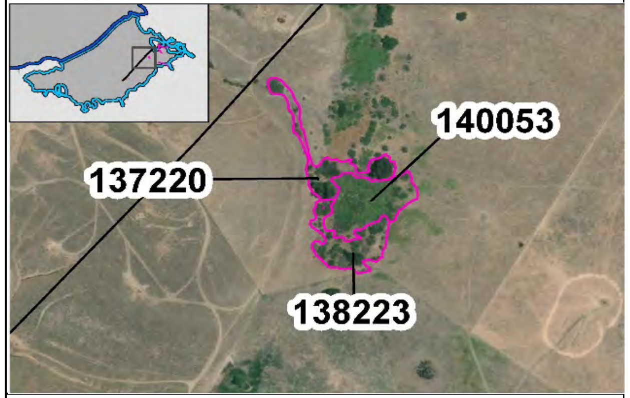




Abbreviations:
AOI= Area of Interest
GDE = Groundwater Dependent Ecosystem
ID = Identification number
NDMI = Normalized Difference Moisture Index
NDVI = Normalized Difference Vegetation Index

Notes:
1. Cumulative departure of average rainfall calculated over the available period of record (i.e., 1985-2018).
2. The field study undertaken in May 2020 classified GDE ID 137220 and GDE ID 138223 as Valley Oak and GDE ID 140053 as California Grape.

Sources:
1. GDE Pulse polygons of interest from TNC (https://gde.codefornature.org)

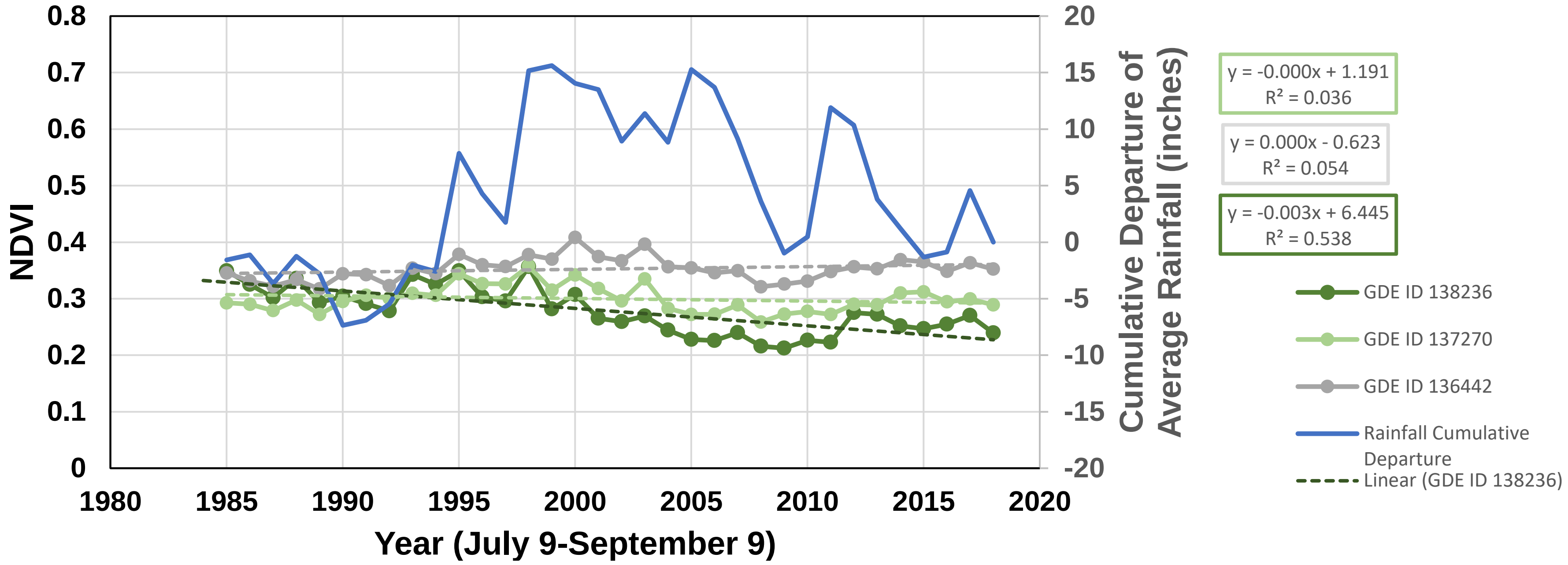


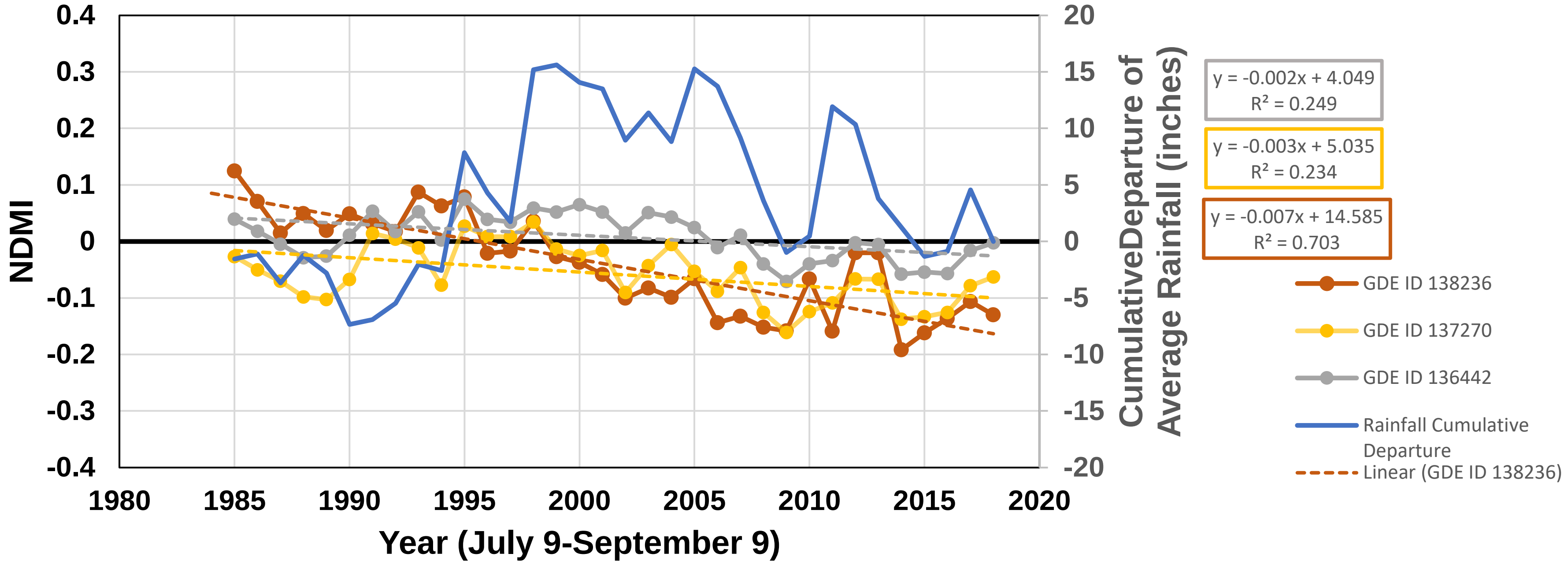
GDE AOI-2

eki environment & water

White Wolf GSA
Kern County, California
May 2021
B50001.06

Figure 3

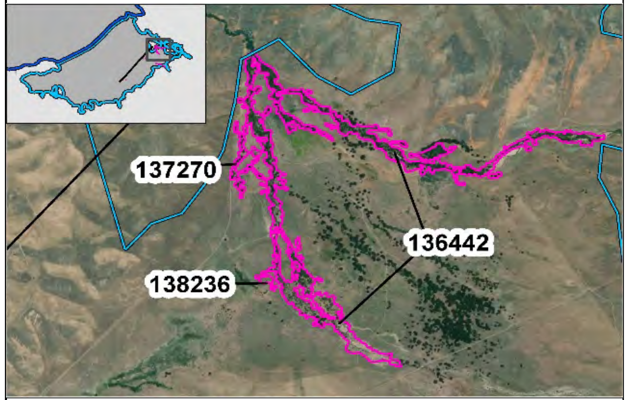




Abbreviations:
AOI= Area of Interest
GDE = Groundwater Dependent Ecosystem
ID = Identification number
NDMI = Normalized Difference Moisture Index
NDVI = Normalized Difference Vegetation Index

Notes:
1. Cumulative departure of average rainfall calculated over the available period of record (i.e., 1985-2018).
2. The field study undertaken in May 2020 classified GDE ID 138236 as common elderberry, GDE ID 137270 as Valley Oak and GDE ID 136442 as Fremont Cottonwood.

Sources:
1. GDE Pulse polygons of interest from TNC (https://gde.codefornature.org)

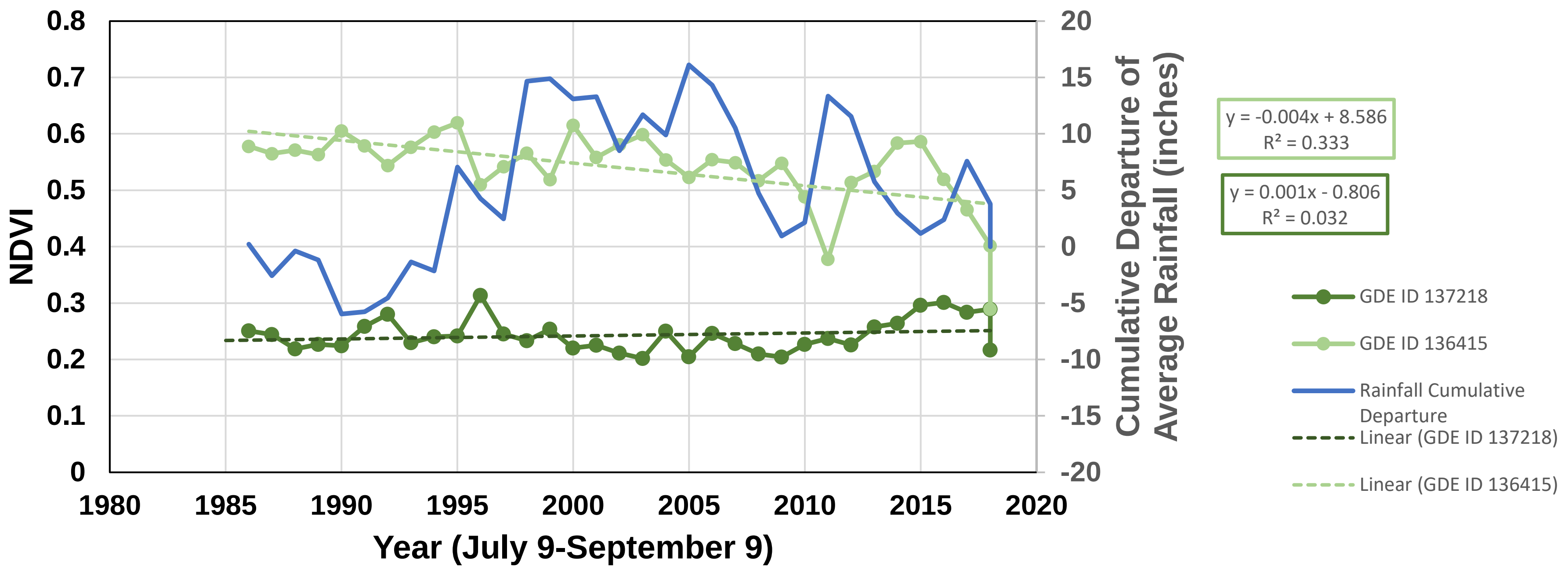


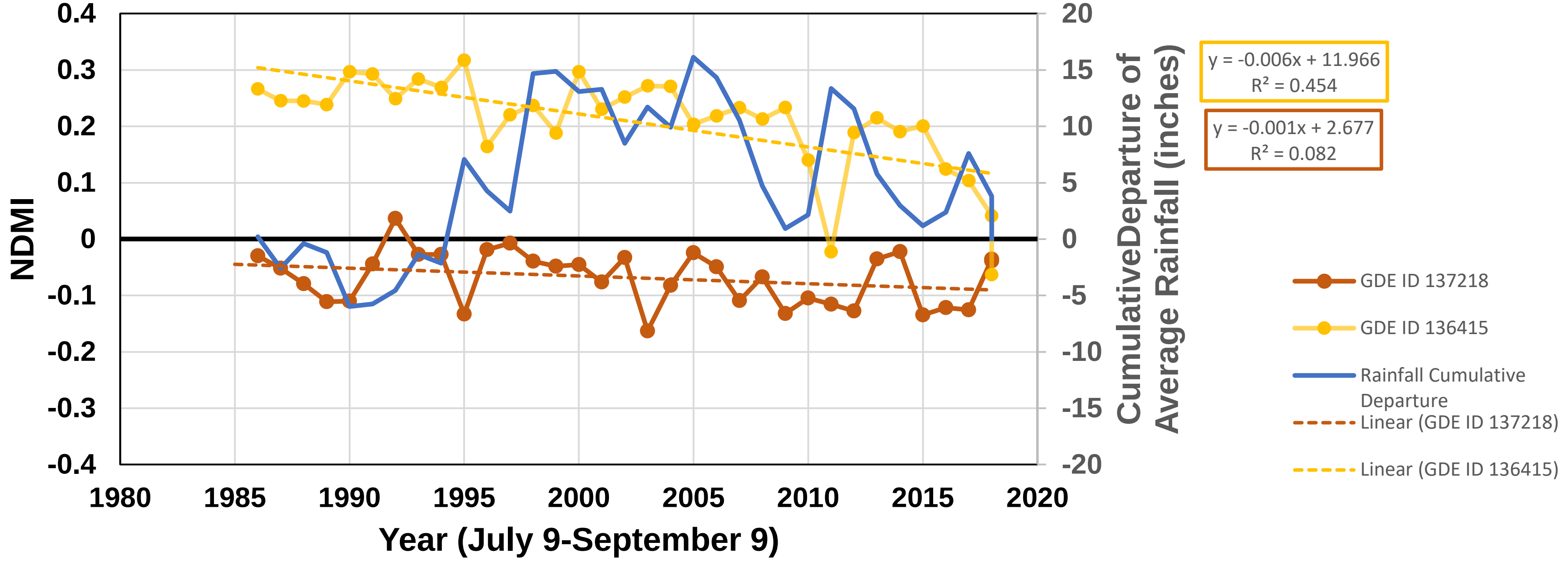
GDE AOI-3

White Wolf GSA
Kern County, California
May 2021
B50001.06

eki environment & water

Figure 4





Abbreviations:

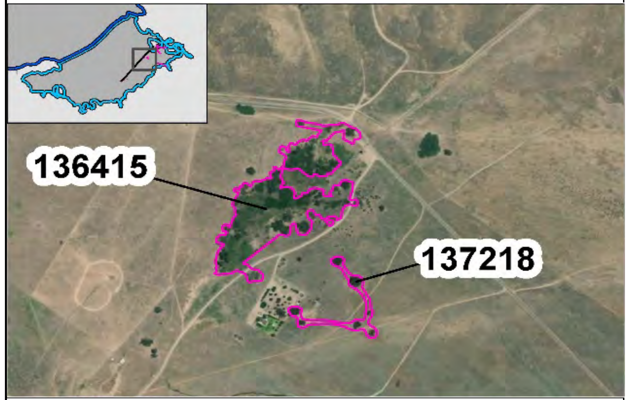
AOI= Area of Interest
GDE = Groundwater Dependent Ecosystem
ID = Identification number
NDMI = Normalized Difference Moisture Index
NDVI = Normalized Difference Vegetation Index

Notes:

1. Cumulative departure of average rainfall calculated over the available period of record (i.e., 1985-2018).
2. The field study undertaken in May 2020 classified GDE ID 137218 as Valley Oak and GDE ID 136415 as Fremont Cottonwood.

Sources:

1. GDE Pulse polygons of interest from TNC (https://gde.codefornature.org)

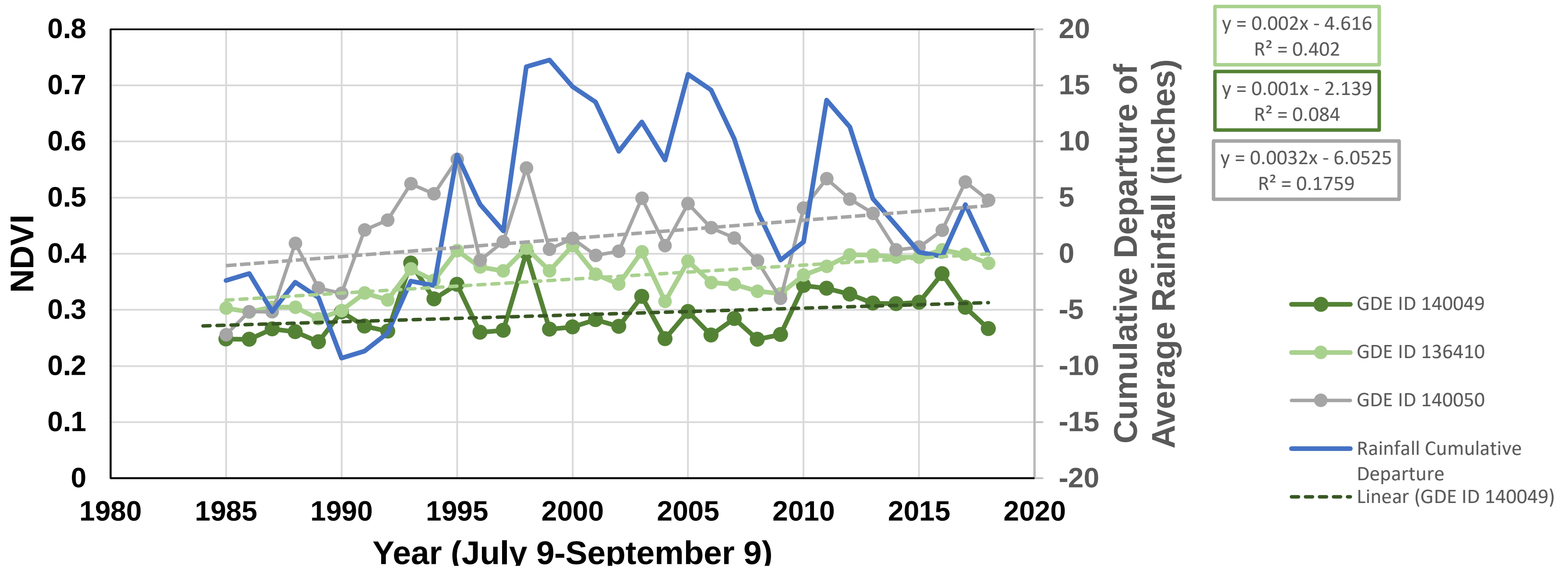


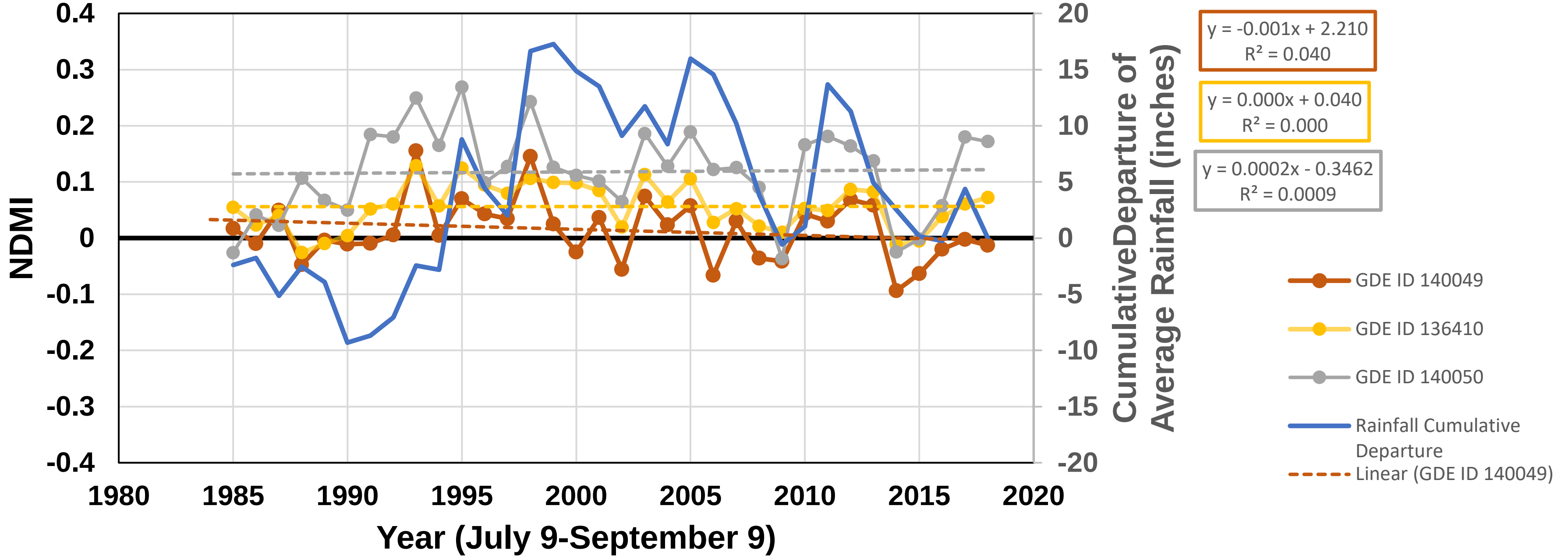
GDE AOI-4

White Wolf GSA
Kern County, California
May 2021
B50001.06

eki environment & water

Figure 5





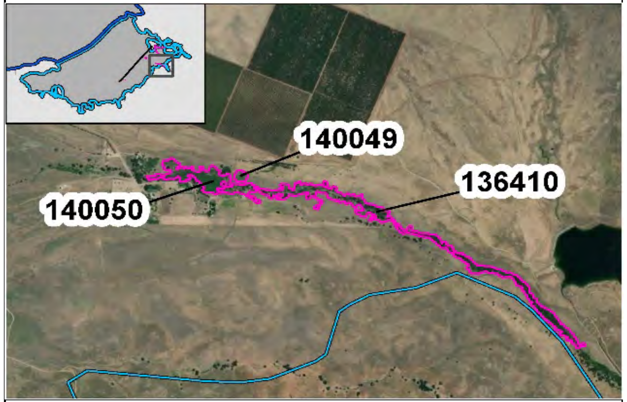
Abbreviations:
AOI= Area of Interest
GDE = Groundwater Dependent Ecosystem
ID = Identification number
NDMI = Normalized Difference Moisture Index
NDVI = Normalized Difference Vegetation Index

Notes:

1. Cumulative departure of average rainfall calculated over the available period of record (i.e., 1985-2018).
2. The field study undertaken in May 2020 classified GDE ID 136410 as Valley Oak and GDE ID 140049, as well as GDE ID 140050, as California Grape.

Sources:

1. GDE Pulse polygons of interest from TNC (https://gde.codefornature.org)

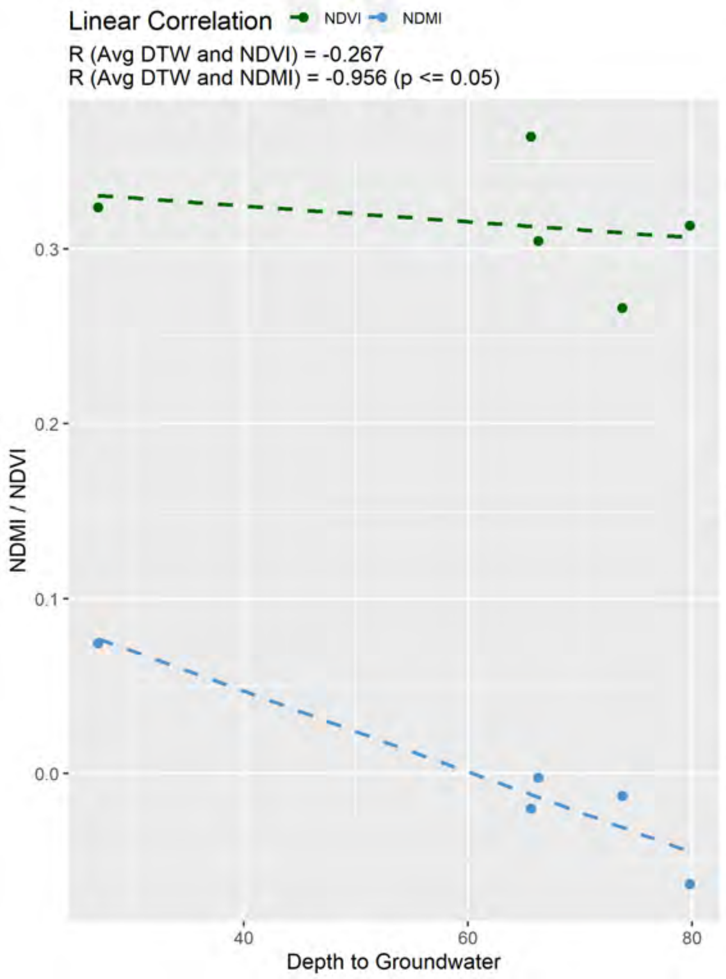


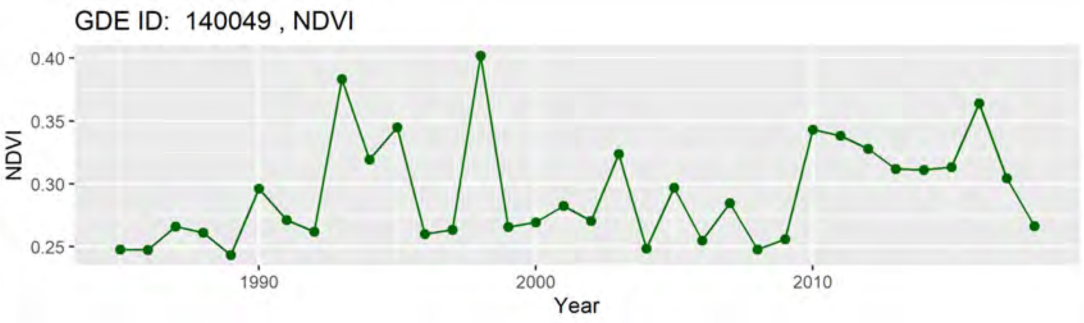
GDE AOI-5

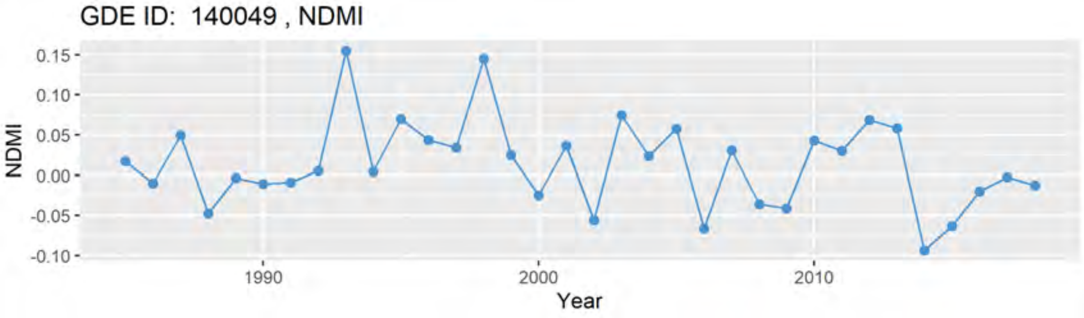
White Wolf GSA
Kern County, California
May 2021
B50001.06

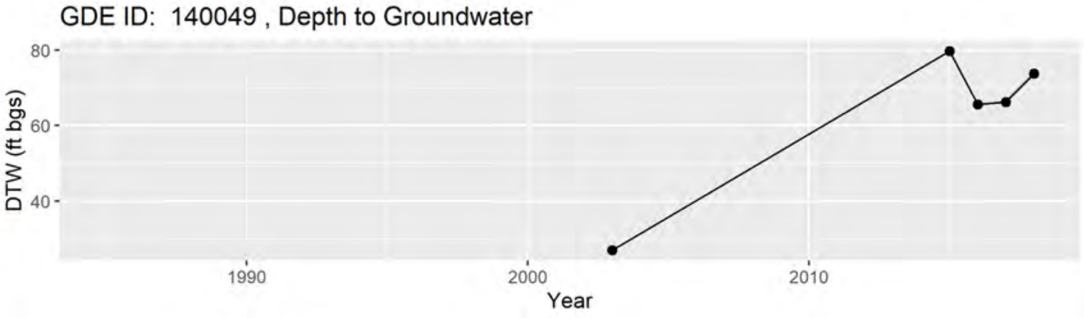
eki environment & water

Figure 6





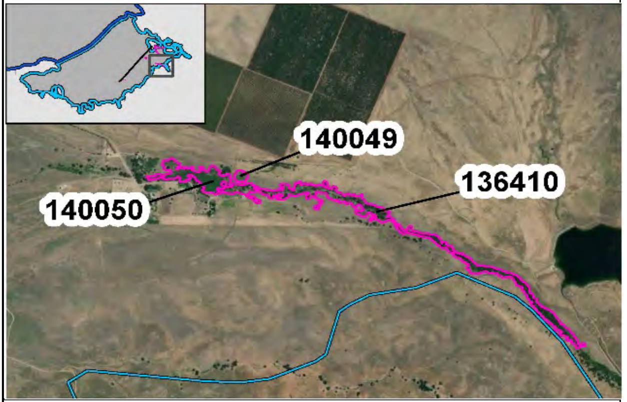




Abbreviations:
α = alpha
DTW= depth to groundwater
GDE = Groundwater Dependent Ecosystem
ID = Identification number
NDMI = Normalized Difference Moisture Index
NDVI = Normalized Difference Vegetation Index
R = Pearson's correlation coefficient
TNC= The Nature Conservancy

Notes:
1. P-value list by statistically significant correlation coefficient (α = 0.05)

Sources:
1. Depth to groundwater from well 11N18W24H001S.
2. GDE Pulse polygons of interest from TNC (https://gde.codefornature.org)

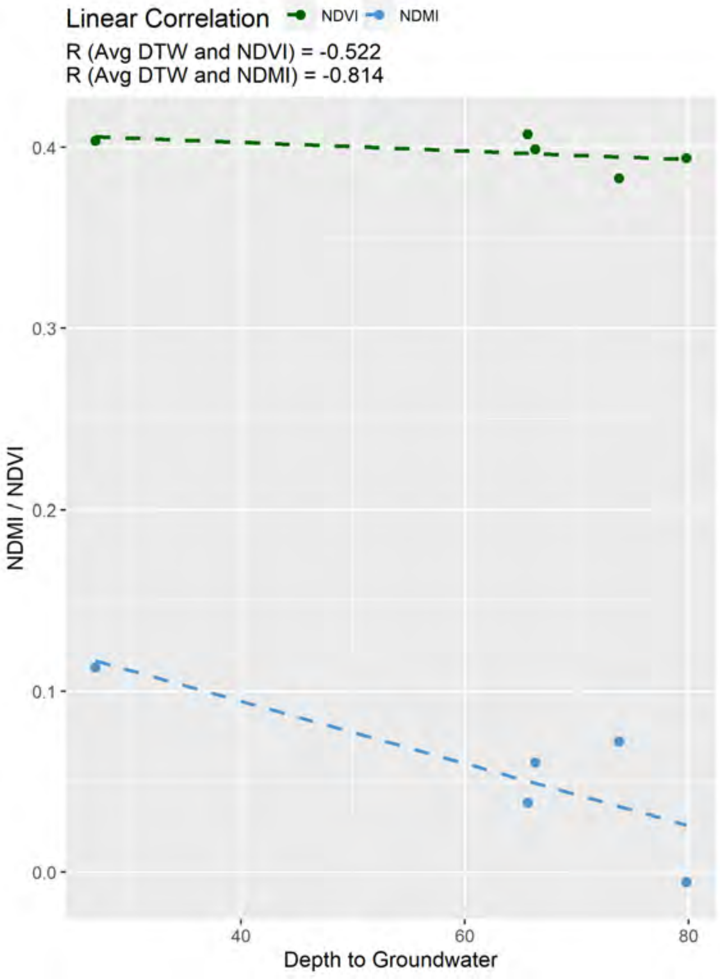


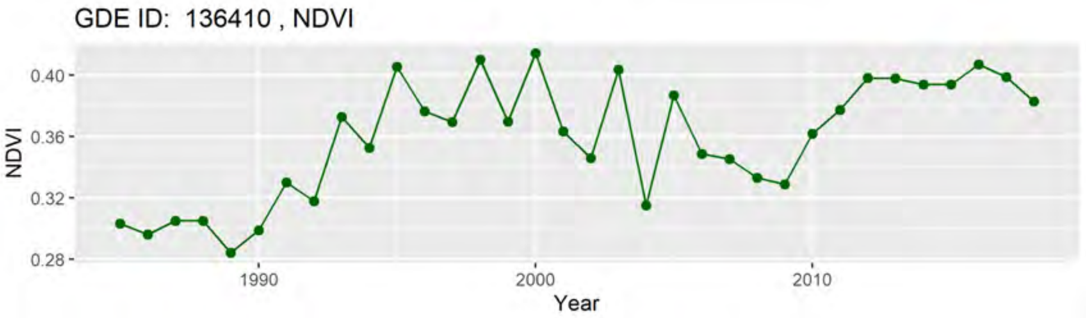
Correlation between Vegetation Indices and Depth to Groundwater GDE ID 140049

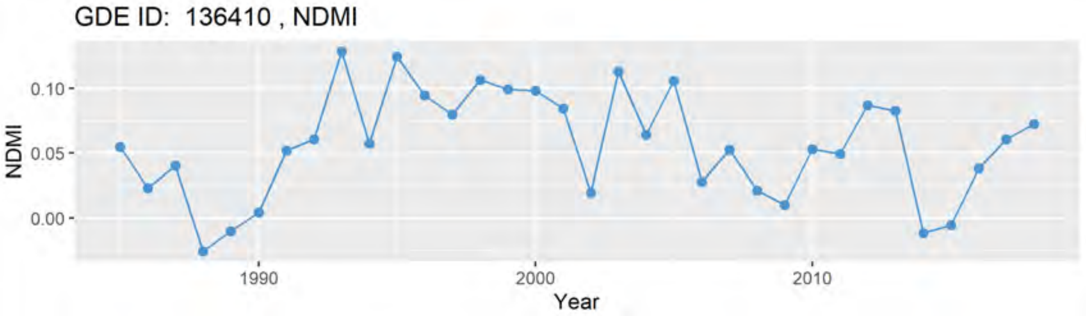
White Wolf GSA
Kern County, California
May 2021
B50001.06

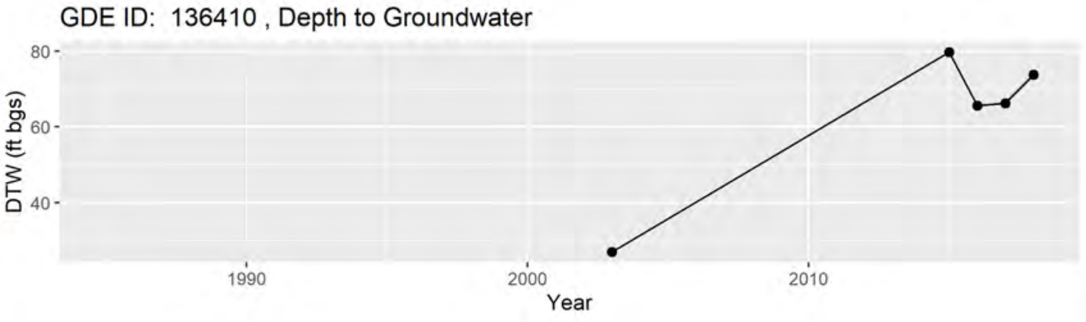
eki environment & water

Figure 7









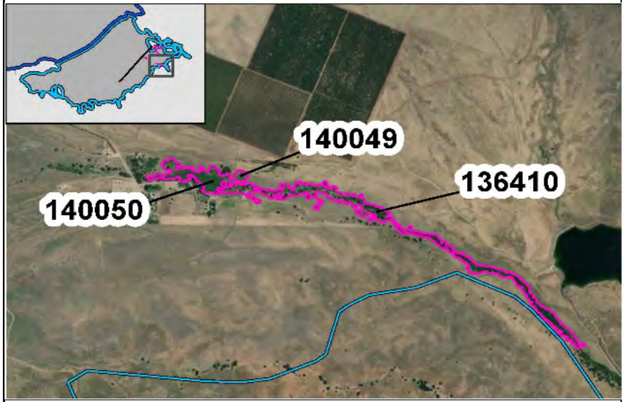
Abbreviations:
α = alpha
DTW= depth to groundwater
GDE = Groundwater Dependent Ecosystem
ID = Identification number
NDMI = Normalized Difference Moisture Index
NDVI = Normalized Difference Vegetation Index
R = Pearson's correlation coefficient
TNC= The Nature Conservancy

Notes:

1. P-value list by statistically significant correlation coefficient (α = 0.05)

Sources:

1. Depth to groundwater from well 11N18W24H001S.
2. GDE Pulse polygons of interest from TNC (https://gde.codefornature.org)

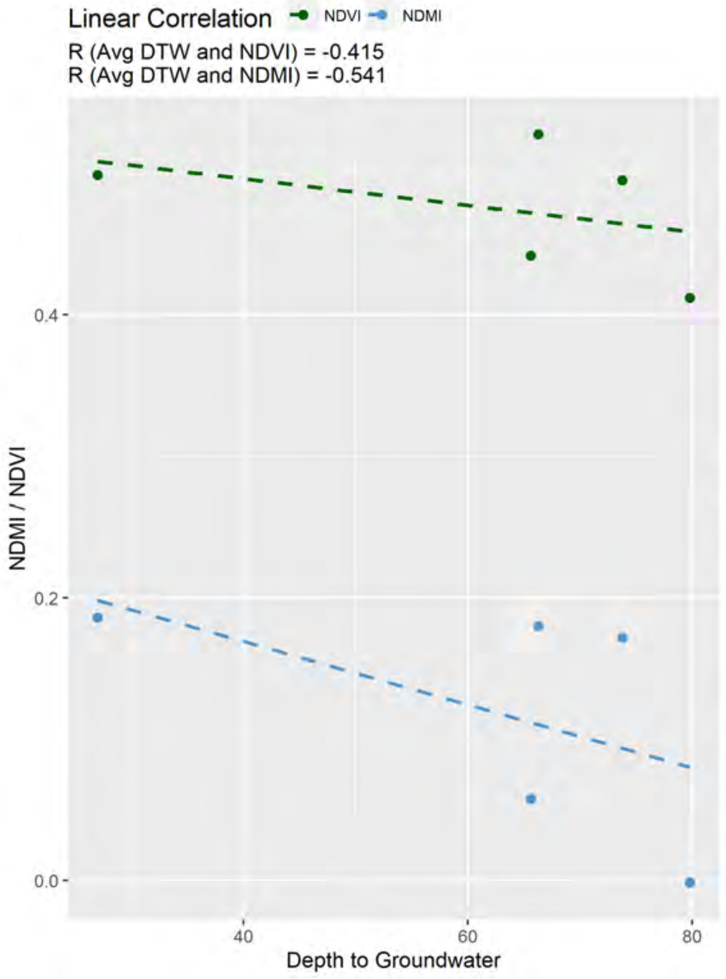


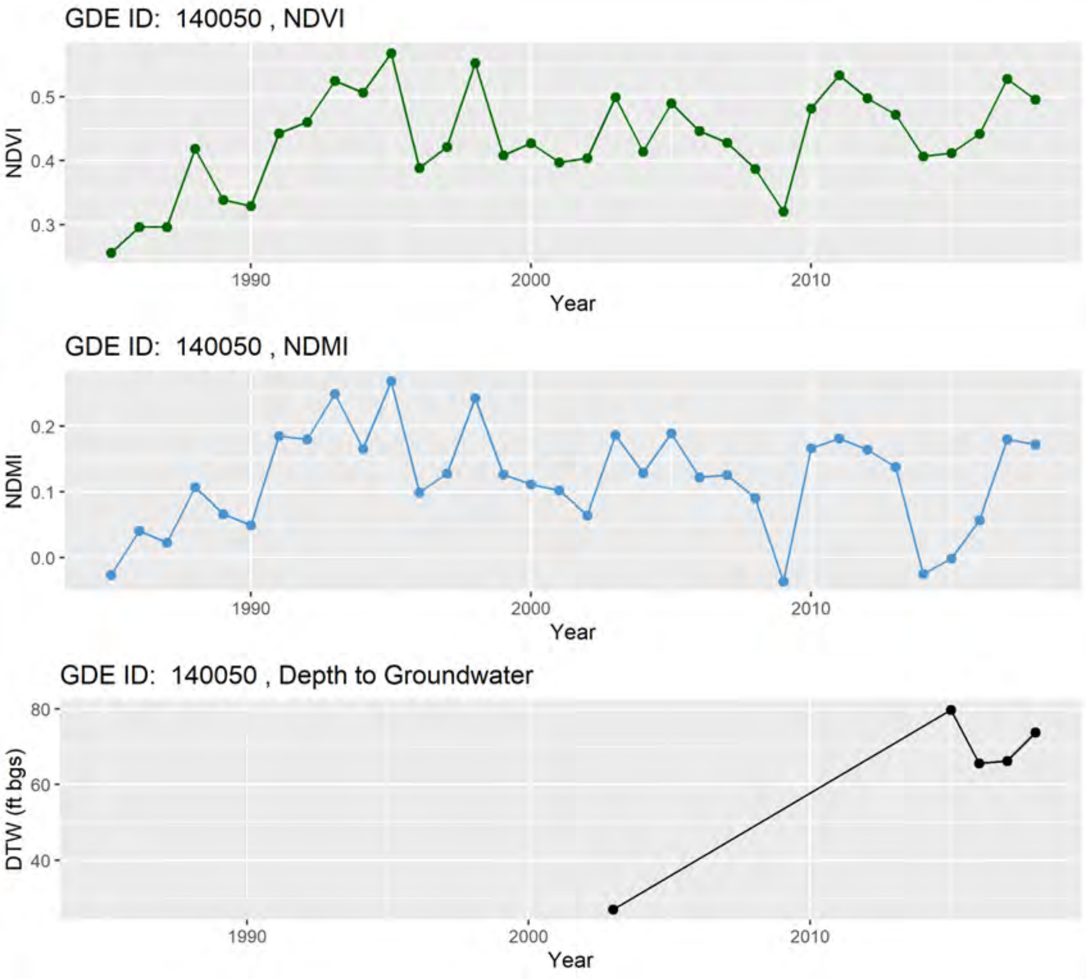
Correlation between Vegetation Indices and Depth to Groundwater GDE ID 136410

White Wolf GSA
Kern County, California
May 2021
B50001.06

eki environment & water

Figure 8

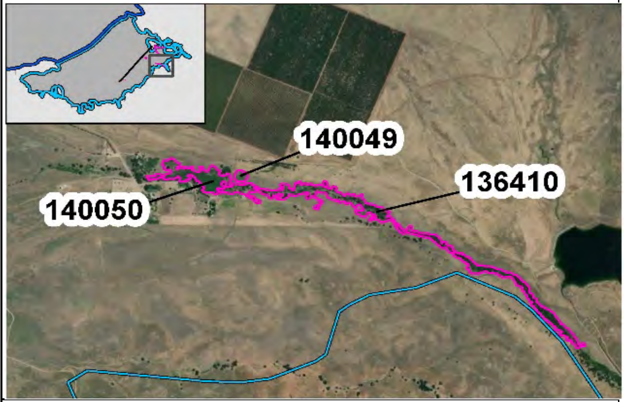




Abbreviations:
α = alpha
DTW= depth to groundwater
GDE = Groundwater Dependent Ecosystem
ID = Identification number
NDMI = Normalized Difference Moisture Index
NDVI = Normalized Difference Vegetation Index
R = Pearson's correlation coefficient
TNC= The Nature Conservancy

Notes:
1. P-value list by statistically significant correlation coefficient (α = 0.05)

Sources:
1. Depth to groundwater from well 11N18W24H001S.
2. GDE Pulse polygons of interest from TNC (https://gde.codefornature.org)



Correlation between Vegetation Indices and Depth to Groundwater GDE ID 140050

White Wolf GSA
Kern County, California
May 2021
B50001.06

eki environment & water

Figure 9

Appendix J

The Nature Conservancy Freshwater Species List for the White Wolf Subbasin

The Nature Conservancy Freshwater Species List for the San Joaquin Valley Groundwater Basin – White Wolf Subbasin

Freshwater Species List for the White Wolf Subbasin was made available by The Nature Conservancy (TNC) at https://groundwaterresourcehub.org/sgma-tools/environmental-surface-water-beneficiaries/

Header rows correspond to the following:

Attribute	**Explanation**
OBJECTID	Processing field - ignore
Elements_GROUP_	Taxonomic grouping (Mammal, Bird, Fishes, Herps, Mollusks, Crustaceans, Insects & other inverts, Plants)
Elements_ELM_SCINAM	Scientific name
Elements_ELM_COMNAM	Common name
Elements_Fed_list	Status on Federal Endangered Species List as of April 13, 2015
Elements_State_list	Status on California Endangered Species or Sensitive Species lists as of April 13, 2015
Elements_Other_list	Status on other sensitive species lists as of April 13, 2015
Elements_MgtAg_list	Status on land management agency (USFS, BLM) sensitive species lists as of April 13, 2015
ObservationType_ObsTyp_Name	Observation Type Name (e.g., observations, modeled habitat, range, critical habitat)
Format_Fmt_Name	Format Name (Point, Line, Polygon)
HabitatUsage_HabU_Name	Habitat Usage Name (e.g., spawning, migration, breeding, wintering)
Source_Source_Name	Short name for source of species occurrence information

OBJECTID	Elements GROUP	Elements ELM SCINAM	Elements ELM COMNAM	Elements Fed list	Elements State list	Elements Other list	Elements MgtAg list	ObservationType ObsTyp Name	Format Fmt Name	HabitatUsage HabU Name	Source Source Name
1	Birds	Haliaeetus leucocephalus	Bald Eagle	Bird of Conservation Concern	Endangered		USFS, BLM	Current observations (post 1980)	Polygon	Undefined	California Natural Diversity Database (4/2016)
2	Herps	Actinemys marmorata marmorata	Western Pond Turtle		Special Concern	ARSSC	BLM, USFS	Modeled habitat/ generalized observation	Polygon	Undefined	California Wildlife Habitat Relationships
3	Herps	Anaxyrus boreas boreas	Boreal Toad					Modeled habitat/ generalized observation	Polygon	Undefined	California Wildlife Habitat Relationships
4	Herps	Rana draytonii	California Red-legged Frog	Threatened	Special Concern	ARSSC		Modeled habitat/ generalized observation	Polygon	Undefined	California Wildlife Habitat Relationships
5	Herps	Spea hammondii	Western Spadefoot	Under Review in the Candidate or Petition Process	Special Concern	ARSSC	BLM	Modeled habitat/ generalized observation	Polygon	Undefined	California Wildlife Habitat Relationships
6	Herps	Thamnophis couchii	Sierra Gartersnake					Modeled habitat/ generalized observation	Polygon	Undefined	California Wildlife Habitat Relationships
7	Herps	Thamnophis sirtalis sirtalis	Common Gartersnake					Modeled habitat/ generalized observation	Polygon	Undefined	California Wildlife Habitat Relationships
8	Birds	Actitis macularius	Spotted Sandpiper					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
9	Birds	Aechmophorus occidentalis	Western Grebe					Current observations (post 1980)	Point	Undefined	CLO EBIRD
10	Birds	Agelaius tricolor	Tricolored Blackbird	Bird of Conservation Concern	Special Concern	BSSC - First priority	BLM	Current observations (post 1980)	Point	Undefined	CLO EBIRD
11	Birds	Agelaius tricolor	Tricolored Blackbird	Bird of Conservation Concern	Special Concern	BSSC - First priority	BLM	Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
12	Birds	Agelaius tricolor	Tricolored Blackbird	Bird of Conservation Concern	Special Concern	BSSC - First priority	BLM	Unknown	Point	Undefined	California Natural Diversity Database (4/2016)
13	Birds	Anas acuta	Northern Pintail					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
14	Birds	Anas americana	American Wigeon					Current observations (post 1980)	Point	Undefined	CLO EBIRD
15	Birds	Anas americana	American Wigeon					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
16	Birds	Anas crecca	Green-winged Teal					Current observations (post 1980)	Point	Undefined	CLO EBIRD
17	Birds	Anas crecca	Green-winged Teal					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
18	Birds	Anas platyrhynchos	Mallard					Current observations (post 1980)	Point	Undefined	CLO EBIRD
19	Birds	Anas platyrhynchos	Mallard					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
20	Birds	Anas strepera	Gadwall					Current observations (post 1980)	Point	Undefined	CLO EBIRD
21	Birds	Anas strepera	Gadwall					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
22	Birds	Ardea alba	Great Egret					Current observations (post 1980)	Point	Undefined	CLO EBIRD
23	Birds	Ardea alba	Great Egret					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
24	Birds	Ardea herodias	Great Blue Heron					Current observations (post 1980)	Point	Undefined	CLO EBIRD
25	Birds	Aythya affinis	Lesser Scaup					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
26	Birds	Aythya americana	Redhead		Special Concern	BSSC - Third priority		Current observations (post 1980)	Point	Undefined	CLO EBIRD
27	Birds	Aythya americana	Redhead		Special Concern	BSSC - Third priority		Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
28	Birds	Aythya collaris	Ring-necked Duck					Current observations (post 1980)	Point	Undefined	CLO EBIRD
29	Birds	Aythya collaris	Ring-necked Duck					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
30	Birds	Aythya valisineria	Canvasback		Special			Current observations (post 1980)	Point	Undefined	CLO EBIRD
31	Birds	Aythya valisineria	Canvasback		Special			Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
32	Birds	Bucephala albeola	Bufflehead					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
33	Birds	Cistothorus palustris palustris	Marsh Wren					Current observations (post 1980)	Point	Undefined	CLO EBIRD
34	Birds	Egretta thula	Snowy Egret					Current observations (post 1980)	Point	Undefined	CLO EBIRD
35	Birds	Fulica americana	American Coot					Current observations (post 1980)	Point	Undefined	CLO EBIRD
36	Birds	Fulica americana	American Coot					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
37	Birds	Haliaeetus leucocephalus	Bald Eagle	Bird of Conservation Concern	Endangered		USFS, BLM	Current observations (post 1980)	Point	Undefined	California Natural Diversity Database (4/2016)
38	Birds	Haliaeetus leucocephalus	Bald Eagle	Bird of Conservation Concern	Endangered		USFS, BLM	Current observations (post 1980)	Point	Undefined	CLO EBIRD
39	Birds	Himantopus mexicanus	Black-necked Stilt					Current observations (post 1980)	Point	Undefined	CLO EBIRD
40	Birds	Lophodytes cucullatus	Hooded Merganser					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
41	Birds	Megaceryle alcyon	Belted Kingfisher					Current observations (post 1980)	Point	Undefined	CLO EBIRD
42	Birds	Mergus merganser	Common Merganser					Current observations (post 1980)	Point	Undefined	CLO EBIRD
43	Birds	Numenius americanus	Long-billed Curlew					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
44	Birds	Oxyura jamaicensis	Ruddy Duck					Current observations (post 1980)	Point	Undefined	CLO EBIRD
45	Birds	Oxyura jamaicensis	Ruddy Duck					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
46	Birds	Phalacrocorax auritus	Double-crested Cormorant					Current observations (post 1980)	Point	Undefined	CLO EBIRD
47	Birds	Phalacrocorax auritus	Double-crested Cormorant					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
48	Birds	Plegadis chihi	White-faced Ibis		Watch list			Current observations (post 1980)	Point	Undefined	CLO EBIRD
49	Birds	Podiceps nigricollis	Eared Grebe					Current observations (post 1980)	Point	Undefined	CLO EBIRD
50	Birds	Podiceps nigricollis	Eared Grebe					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
51	Birds	Podilymbus podiceps	Pied-billed Grebe					Current observations (post 1980)	Point	Undefined	CLO EBIRD
52	Birds	Podilymbus podiceps	Pied-billed Grebe					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
53	Birds	Tachycineta bicolor	Tree Swallow					Current observations (post 1980)	Point	Undefined	CLO EBIRD
54	Birds	Tachycineta bicolor	Tree Swallow					Current observations (post 1980)	Point	Undefined	CLO EBIRD CA
55	Herps	Spea hammondii	Western Spadefoot	Under Review in the Candidate or Petition Process	Special Concern	ARSSC	BLM	Current observations (post 1980)	Point	Undefined	California Natural Diversity Database (4/2016)
56	Plants	Alnus rhombifolia	White Alder					Unknown	Point	Undefined	Consortium of California Herbaria RSA
57	Plants	Alnus rhombifolia	White Alder					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
58	Plants	Alnus rhombifolia	White Alder					Unknown	Point	Undefined	Consortium of California Herbaria SD
59	Plants	Alnus rhombifolia	White Alder					Unknown	Point	Undefined	Consortium of California Herbaria UC
60	Plants	Alnus rhombifolia	White Alder					Unknown	Point	Undefined	Consortium of California Herbaria UCR
61	Plants	Ammannia coccinea	Scarlet Ammannia					Unknown	Point	Undefined	Consortium of California Herbaria UC
62	Plants	Anemopsis californica	Yerba Mansa					Unknown	Point	Undefined	Consortium of California Herbaria RSA
63	Plants	Anemopsis californica	Yerba Mansa					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
64	Plants	Anemopsis californica	Yerba Mansa					Unknown	Point	Undefined	Consortium of California Herbaria UC
65	Plants	Arundo donax	NA					Current observations (post 1980)	Point	Undefined	Calflora
66	Plants	Arundo donax	NA					Unknown	Point	Undefined	Consortium of California Herbaria RSA
67	Plants	Arundo donax	NA					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
68	Plants	Arundo donax	NA					Unknown	Point	Undefined	Consortium of California Herbaria UCSB
69	Plants	Azolla filiculoides	NA					Unknown	Point	Undefined	Consortium of California Herbaria RSA
70	Plants	Azolla microphylla	Mexican mosquito fern		Special	CRPR - 4.3		Unknown	Point	Undefined	Consortium of California Herbaria SD
71	Plants	Baccharis salicina				Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria JEPS
72	Plants	Baccharis salicina				Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria POM
73	Plants	Baccharis salicina				Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria RSA
74	Plants	Baccharis salicina				Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria SBBG
75	Plants	Baccharis salicina				Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria UC
76	Plants	Baccharis salicina				Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria UCR
77	Plants	Berula erecta	Wild Parsnip					Unknown	Point	Undefined	Consortium of California Herbaria RSA
78	Plants	Berula erecta	Wild Parsnip					Unknown	Point	Undefined	Consortium of California Herbaria UC
79	Plants	Berula erecta	Wild Parsnip					Unknown	Point	Undefined	Consortium of California Herbaria UCR
80	Plants	Bidens laevis	Smooth Bur-marigold					Unknown	Point	Undefined	Consortium of California Herbaria JEPS
81	Plants	Bidens laevis	Smooth Bur-marigold					Unknown	Point	Undefined	Consortium of California Herbaria UC
82	Plants	Bolboschoenus maritimus paludosus	NA			Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria SBBG
83	Plants	Bolboschoenus robustus				Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria RSA
84	Plants	Callitriche marginata	Winged Water-starwort					Unknown	Point	Undefined	Consortium of California Herbaria RSA
85	Plants	Carex alma	Sturdy Sedge					Unknown	Point	Undefined	Consortium of California Herbaria RSA
86	Plants	Carex alma	Sturdy Sedge					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
87	Plants	Carex densa	Dense Sedge					Unknown	Point	Undefined	Consortium of California Herbaria UCR
88	Plants	Carex lasiocarpa	Slender Sedge		Special	CRPR - 2B.3		Unknown	Point	Undefined	Consortium of California Herbaria RSA
89	Plants	Carex lasiocarpa	Slender Sedge		Special	CRPR - 2B.3		Unknown	Point	Undefined	Consortium of California Herbaria UC

OBJECTID	Elements_GROUP	Elements_ELM_SCINAM	Elements_ELM_COMNAM	Elements_Fed_list	Elements_State_list	Elements_Other_list	Elements_MgtAg_list	ObservationType_ObsTyp_Name	Format_Fmt_Name	HabitatUsage_HabU_Name	Source_Source_Name
90	Plants	Carex pellita	Woolly Sedge					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
91	Plants	Carex pellita	Woolly Sedge					Unknown	Point	Undefined	Consortium of California Herbaria UCR
92	Plants	Carex senta	Western Rough Sedge					Unknown	Point	Undefined	Consortium of California Herbaria RSA
93	Plants	Carex senta	Western Rough Sedge					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
94	Plants	Carex senta	Western Rough Sedge					Unknown	Point	Undefined	Consortium of California Herbaria UCSB
95	Plants	Castilleja miniata miniata	Greater Red Indian-paintbrush					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
96	Plants	Castilleja minor minor	Alkali Indian-paintbrush					Unknown	Point	Undefined	Consortium of California Herbaria JEPS
97	Plants	Castilleja minor minor	Alkali Indian-paintbrush					Unknown	Point	Undefined	Consortium of California Herbaria RSA
98	Plants	Castilleja minor minor	Alkali Indian-paintbrush					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
99	Plants	Cephalanthus occidentalis	Common Buttonbush					Unknown	Point	Undefined	Consortium of California Herbaria UC
100	Plants	Cicuta douglasii	Western Water-hemlock					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
101	Plants	Cirsium crassicaule	Slough Thistle		Special	CRPR - 1B.1	BLM	Unknown	Point	Undefined	Consortium of California Herbaria CDA
102	Plants	Cirsium crassicaule	Slough Thistle		Special	CRPR - 1B.1	BLM	Unknown	Point	Undefined	Consortium of California Herbaria RSA
103	Plants	Cirsium scariosum scariosum	Drummond's Thistle			Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria IRVC
104	Plants	Cirsium scariosum scariosum	Drummond's Thistle			Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria JEPS
105	Plants	Cotula coronopifolia	NA					Unknown	Point	Undefined	Consortium of California Herbaria UCR
106	Plants	Crassula aquatica	Water Pygmyweed					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
107	Plants	Cyperus erythrorhizos	Red-root Flatsedge					Unknown	Point	Undefined	Consortium of California Herbaria POM
108	Plants	Cyperus erythrorhizos	Red-root Flatsedge					Unknown	Point	Undefined	Consortium of California Herbaria RSA
109	Plants	Cyperus erythrorhizos	Red-root Flatsedge					Unknown	Point	Undefined	Consortium of California Herbaria UC
110	Plants	Datisca glomerata	Durango Root					Current observations (post 1980)	Point	Undefined	UCSB
111	Plants	Datisca glomerata	Durango Root					Current observations (post 1980)	Point	Undefined	UCSB UCSB
112	Plants	Datisca glomerata	Durango Root					Unknown	Point	Undefined	Consortium of California Herbaria RSA
113	Plants	Datisca glomerata	Durango Root					Unknown	Point	Undefined	Consortium of California Herbaria UC
114	Plants	Datisca glomerata	Durango Root					Unknown	Point	Undefined	Consortium of California Herbaria UCR
115	Plants	Downingia bella	Hoover's Downingia					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
116	Plants	Downingia pulchella	Flat-face Downingia					Unknown	Point	Undefined	Consortium of California Herbaria JEPS
117	Plants	Echinodorus berteroi	Upright Burhead					Unknown	Point	Undefined	Consortium of California Herbaria RSA
118	Plants	Eleocharis bella	Delicate Spikerush					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
119	Plants	Eleocharis macrostachya	Creeping Spikerush					Unknown	Point	Undefined	Consortium of California Herbaria RSA
120	Plants	Eleocharis macrostachya	Creeping Spikerush					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
121	Plants	Eleocharis macrostachya	Creeping Spikerush					Unknown	Point	Undefined	Consortium of California Herbaria UCR
122	Plants	Eleocharis montevidensis	Sand Spikerush					Unknown	Point	Undefined	Consortium of California Herbaria RSA
123	Plants	Eleocharis parishii	Parish's Spikerush					Unknown	Point	Undefined	Consortium of California Herbaria RSA
124	Plants	Eleocharis parishii	Parish's Spikerush					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
125	Plants	Epilobium oregonense	Oregon Willow-herb					Unknown	Point	Undefined	Consortium of California Herbaria UCR
126	Plants	Epipactis gigantea	Giant Helleborine					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
127	Plants	Euthamia occidentalis	Western Fragrant Goldenrod					Unknown	Point	Undefined	Consortium of California Herbaria RSA
128	Plants	Euthamia occidentalis	Western Fragrant Goldenrod					Unknown	Point	Undefined	Consortium of California Herbaria UCR
129	Plants	Helenium bigelovii	Bigelow's Sneezeweed					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
130	Plants	Helenium puberulum	Rosilla					Unknown	Point	Undefined	Consortium of California Herbaria JEPS
131	Plants	Helenium puberulum	Rosilla					Unknown	Point	Undefined	Consortium of California Herbaria RSA
132	Plants	Helenium puberulum	Rosilla					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
133	Plants	Iris missouriensis	Western Blue Iris					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
134	Plants	Iris missouriensis	Western Blue Iris					Unknown	Point	Undefined	Consortium of California Herbaria UCR
135	Plants	Isolepis cernua	Low Bulrush					Unknown	Point	Undefined	Consortium of California Herbaria RSA
136	Plants	Isolepis cernua	Low Bulrush					Unknown	Point	Undefined	Consortium of California Herbaria UCR
137	Plants	Juncus acutus leopoldii	Spiny Rush		Special	CRPR - 4.2		Unknown	Point	Undefined	Consortium of California Herbaria RSA
138	Plants	Juncus acutus leopoldii	Spiny Rush		Special	CRPR - 4.2		Unknown	Point	Undefined	Consortium of California Herbaria UCR
139	Plants	Juncus dubius	Mariposa Rush					Unknown	Point	Undefined	Consortium of California Herbaria RSA
140	Plants	Juncus macrandrus	Long-anther Rush					Unknown	Point	Undefined	Consortium of California Herbaria UCR
141	Plants	Juncus macrophyllus	Longleaf Rush					Unknown	Point	Undefined	Consortium of California Herbaria RSA
142	Plants	Juncus macrophyllus	Longleaf Rush					Unknown	Point	Undefined	Consortium of California Herbaria UCR
143	Plants	Juncus textilis	Basket Rush					Unknown	Point	Undefined	Consortium of California Herbaria UCR
144	Plants	Juncus xiphioides	Iris-leaf Rush					Unknown	Point	Undefined	Consortium of California Herbaria RSA
145	Plants	Juncus xiphioides	Iris-leaf Rush					Unknown	Point	Undefined	Consortium of California Herbaria UCR
146	Plants	Lasthenia ferrisiae	Ferris' Goldfields		Special	CRPR - 4.2		Unknown	Point	Undefined	Consortium of California Herbaria UC
147	Plants	Lemna gibba	Inflated Duckweed					Unknown	Point	Undefined	Consortium of California Herbaria JEPS
148	Plants	Lemna gibba	Inflated Duckweed					Unknown	Point	Undefined	Consortium of California Herbaria UC
149	Plants	Lemna minuta	Least Duckweed					Unknown	Point	Undefined	Consortium of California Herbaria RSA
150	Plants	Lemna minuta	Least Duckweed					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
151	Plants	Limosella aquatica	Northern Mudwort					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
152	Plants	Lythrum californicum	California Loosestrife					Unknown	Point	Undefined	Consortium of California Herbaria RSA
153	Plants	Lythrum californicum	California Loosestrife					Unknown	Point	Undefined	Consortium of California Herbaria UCR
154	Plants	Marsilea vestita vestita	NA			Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria RSA
155	Plants	Myosurus minimus	NA					Unknown	Point	Undefined	Consortium of California Herbaria UCR
156	Plants	Myriophyllum aquaticum	NA					Unknown	Point	Undefined	Consortium of California Herbaria POM
157	Plants	Navarretia intertexta	Needleleaf Navarretia					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
158	Plants	Paspalum distichum	Joint Paspalum					Unknown	Point	Undefined	Consortium of California Herbaria RSA
159	Plants	Paspalum distichum	Joint Paspalum					Unknown	Point	Undefined	Consortium of California Herbaria UCR
160	Plants	Perideridia parishii latifolia	Parish's Yampah					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
161	Plants	Perideridia parishii parishii	Parish's Yampah		Special	CRPR - 2B.2		Unknown	Point	Undefined	Consortium of California Herbaria SBBG
162	Plants	Perideridia pringlei	Pringle's Yampah		Special	CRPR - 4.3		Unknown	Point	Undefined	Consortium of California Herbaria RSA
163	Plants	Perideridia pringlei	Pringle's Yampah		Special	CRPR - 4.3		Unknown	Point	Undefined	Consortium of California Herbaria SBBG
164	Plants	Perideridia pringlei	Pringle's Yampah		Special	CRPR - 4.3		Unknown	Point	Undefined	Consortium of California Herbaria UC
165	Plants	Perideridia pringlei	Pringle's Yampah		Special	CRPR - 4.3		Unknown	Point	Undefined	Consortium of California Herbaria UCR
166	Plants	Persicaria lapathifolia				Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria RSA
167	Plants	Persicaria lapathifolia				Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria UC
168	Plants	Persicaria lapathifolia				Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria UCR
169	Plants	Persicaria maculosa	NA			Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria POM
170	Plants	Persicaria pensylvanica	NA			Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria UC
171	Plants	Phacelia distans	NA					Current observations (post 1980)	Point	Undefined	Calflora
172	Plants	Phacelia distans	NA					Unknown	Point	Undefined	Consortium of California Herbaria JEPS
173	Plants	Phacelia distans	NA					Unknown	Point	Undefined	Consortium of California Herbaria POM
174	Plants	Phacelia distans	NA					Unknown	Point	Undefined	Consortium of California Herbaria RSA
175	Plants	Phacelia distans	NA					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
176	Plants	Phacelia distans	NA					Unknown	Point	Undefined	Consortium of California Herbaria UC
177	Plants	Phacelia distans	NA					Unknown	Point	Undefined	Consortium of California Herbaria UCR
178	Plants	Phalaris arundinacea	Reed Canarygrass					Unknown	Point	Undefined	Consortium of California Herbaria UC
179	Plants	Phragmites australis australis	Common Reed					Unknown	Point	Undefined	Consortium of California Herbaria RSA
180	Plants	Phragmites australis australis	Common Reed					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
181	Plants	Phyla nodiflora	Common Frog-fruit					Unknown	Point	Undefined	Consortium of California Herbaria RSA
182	Plants	Phyla nodiflora	Common Frog-fruit					Unknown	Point	Undefined	Consortium of California Herbaria UCR
183	Plants	Pilularia americana	NA					Unknown	Point	Undefined	Consortium of California Herbaria SBBG

OBJECTID	Elements GROUP	Elements ELM SCINAM	Elements ELM COMNAM	Elements Fed list	Elements State list	Elements Other list	Elements MgtAg list	ObservationType ObsTyp Name	Format Fmt Name	HabitatUsage HabU Name	Source Source Name
184	Plants	Plagiobothrys acanthocarpus	Adobe Popcorn-flower					Unknown	Point	Undefined	Consortium of California Herbaria RSA
185	Plants	Plagiobothrys acanthocarpus	Adobe Popcorn-flower					Unknown	Point	Undefined	Consortium of California Herbaria UC
186	Plants	Plagiobothrys leptocladus	Alkali Popcorn-flower					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
187	Plants	Plagiobothrys leptocladus	Alkali Popcorn-flower					Unknown	Point	Undefined	Consortium of California Herbaria SD
188	Plants	Plagiobothrys leptocladus	Alkali Popcorn-flower					Unknown	Point	Undefined	Consortium of California Herbaria UCR
189	Plants	Plantago elongata elongata	Slender Plantain					Unknown	Point	Undefined	Consortium of California Herbaria UCR
190	Plants	Platanthera sparsiflora sparsiflora	Canyon Bog Orchid					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
191	Plants	Platanthera sparsiflora sparsiflora	Canyon Bog Orchid					Unknown	Point	Undefined	Consortium of California Herbaria UCR
192	Plants	Platanus racemosa	California Sycamore					Unknown	Point	Undefined	Consortium of California Herbaria RSA
193	Plants	Platanus racemosa	California Sycamore					Unknown	Point	Undefined	Consortium of California Herbaria UC
194	Plants	Pluchea odorata odorata	Scented Conyza					Unknown	Point	Undefined	Consortium of California Herbaria JEPS
195	Plants	Pluchea odorata odorata	Scented Conyza					Unknown	Point	Undefined	Consortium of California Herbaria UC
196	Plants	Pluchea sericea	Arrow-weed					Unknown	Point	Undefined	Consortium of California Herbaria JEPS
197	Plants	Psilocarphus brevissimus brevissimus	Dwarf Woolly-heads					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
198	Plants	Psilocarphus brevissimus brevissimus	Dwarf Woolly-heads					Unknown	Point	Undefined	Consortium of California Herbaria UC
199	Plants	Psilocarphus tenellus	NA					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
200	Plants	Puccinellia simplex	Little Alkali Grass					Unknown	Point	Undefined	Consortium of California Herbaria UC
201	Plants	Rhododendron occidentale occidentale	Western Azalea					Unknown	Point	Undefined	Consortium of California Herbaria UC
202	Plants	Rorippa curvisiliqua curvisiliqua	Curve-pod Yellowcress					Unknown	Point	Undefined	Consortium of California Herbaria RSA
203	Plants	Rorippa palustris palustris	Bog Yellowcress					Unknown	Point	Undefined	Consortium of California Herbaria UC
204	Plants	Rumex conglomeratus	NA					Unknown	Point	Undefined	Consortium of California Herbaria POM
205	Plants	Rumex conglomeratus	NA					Unknown	Point	Undefined	Consortium of California Herbaria RSA
206	Plants	Rumex conglomeratus	NA					Unknown	Point	Undefined	Consortium of California Herbaria UCR
207	Plants	Rumex salicifolius salicifolius	Willow Dock					Unknown	Point	Undefined	Consortium of California Herbaria RSA
208	Plants	Rumex salicifolius salicifolius	Willow Dock					Unknown	Point	Undefined	Consortium of California Herbaria UCR
209	Plants	Salix exigua exigua	Narrowleaf Willow					Unknown	Point	Undefined	Consortium of California Herbaria RSA
210	Plants	Salix exigua exigua	Narrowleaf Willow					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
211	Plants	Salix exigua exigua	Narrowleaf Willow					Unknown	Point	Undefined	Consortium of California Herbaria SJSU
212	Plants	Salix exigua exigua	Narrowleaf Willow					Unknown	Point	Undefined	Consortium of California Herbaria UC
213	Plants	Salix exigua exigua	Narrowleaf Willow					Unknown	Point	Undefined	Consortium of California Herbaria UCR
214	Plants	Salix exigua hindsiana				Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria SBBG
215	Plants	Salix gooddingii	Goodding's Willow					Unknown	Point	Undefined	Consortium of California Herbaria RSA
216	Plants	Salix gooddingii	Goodding's Willow					Unknown	Point	Undefined	Consortium of California Herbaria UC
217	Plants	Salix gooddingii	Goodding's Willow					Unknown	Point	Undefined	Consortium of California Herbaria UCR
218	Plants	Salix laevigata	Polished Willow					Unknown	Point	Undefined	Consortium of California Herbaria JEPS
219	Plants	Salix laevigata	Polished Willow					Unknown	Point	Undefined	Consortium of California Herbaria RSA
220	Plants	Salix laevigata	Polished Willow					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
221	Plants	Salix laevigata	Polished Willow					Unknown	Point	Undefined	Consortium of California Herbaria UC
222	Plants	Salix laevigata	Polished Willow					Unknown	Point	Undefined	Consortium of California Herbaria UCR
223	Plants	Salix lasiandra lasiandra				Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria SBBG
224	Plants	Salix lasiolepis lasiolepis	Arroyo Willow					Unknown	Point	Undefined	Consortium of California Herbaria RSA
225	Plants	Salix lasiolepis lasiolepis	Arroyo Willow					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
226	Plants	Salix lasiolepis lasiolepis	Arroyo Willow					Unknown	Point	Undefined	Consortium of California Herbaria UC
227	Plants	Salix lasiolepis lasiolepis	Arroyo Willow					Unknown	Point	Undefined	Consortium of California Herbaria UCR
228	Plants	Schoenoplectus acutus occidentalis	Hardstem Bulrush					Unknown	Point	Undefined	Consortium of California Herbaria POM
229	Plants	Schoenoplectus acutus occidentalis	Hardstem Bulrush					Unknown	Point	Undefined	Consortium of California Herbaria RSA
230	Plants	Schoenoplectus acutus occidentalis	Hardstem Bulrush					Unknown	Point	Undefined	Consortium of California Herbaria UC
231	Plants	Schoenoplectus americanus	Three-square Bulrush					Unknown	Point	Undefined	Consortium of California Herbaria RSA
232	Plants	Schoenoplectus americanus	Three-square Bulrush					Unknown	Point	Undefined	Consortium of California Herbaria SD
233	Plants	Schoenoplectus americanus	Three-square Bulrush					Unknown	Point	Undefined	Consortium of California Herbaria UC
234	Plants	Schoenoplectus americanus	Three-square Bulrush					Unknown	Point	Undefined	Consortium of California Herbaria UCR
235	Plants	Schoenoplectus pungens pungens	NA					Unknown	Point	Undefined	Consortium of California Herbaria RSA
236	Plants	Scirpus microcarpus	Small-fruit Bulrush					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
237	Plants	Sesbania herbacea				Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria CDA
238	Plants	Sidalcea neomexicana	Rocky Mountain Checker-mallow		Special	CRPR - 2B.2	USFS	Unknown	Point	Undefined	Consortium of California Herbaria SBBG
239	Plants	Sphenosciadium capitellatum	Swamp Whiteheads					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
240	Plants	Stachys albens	White-stem Hedge-nettle					Unknown	Point	Undefined	Consortium of California Herbaria RSA
241	Plants	Stachys albens	White-stem Hedge-nettle					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
242	Plants	Stachys albens	White-stem Hedge-nettle					Unknown	Point	Undefined	Consortium of California Herbaria SD
243	Plants	Stachys albens	White-stem Hedge-nettle					Unknown	Point	Undefined	Consortium of California Herbaria UC
244	Plants	Stachys albens	White-stem Hedge-nettle					Unknown	Point	Undefined	Consortium of California Herbaria UCR
245	Plants	Typha domingensis	Southern Cattail					Unknown	Point	Undefined	Consortium of California Herbaria RSA
246	Plants	Typha domingensis	Southern Cattail					Unknown	Point	Undefined	Consortium of California Herbaria UCSB
247	Plants	Veronica americana	American Speedwell					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
248	Plants	Veronica americana	American Speedwell					Unknown	Point	Undefined	Consortium of California Herbaria UC
249	Plants	Veronica anagallis-aquatica	NA					Unknown	Point	Undefined	Consortium of California Herbaria CHSC
250	Plants	Veronica anagallis-aquatica	NA					Unknown	Point	Undefined	Consortium of California Herbaria JEPS
251	Plants	Veronica anagallis-aquatica	NA					Unknown	Point	Undefined	Consortium of California Herbaria RSA
252	Plants	Veronica anagallis-aquatica	NA					Unknown	Point	Undefined	Consortium of California Herbaria SBBG
253	Plants	Veronica anagallis-aquatica	NA					Unknown	Point	Undefined	Consortium of California Herbaria UCR
254	Plants	Veronica catenata	NA			Not on any status lists		Unknown	Point	Undefined	Consortium of California Herbaria SBBG
255	Plants	Zannichellia palustris	Horned Pondweed					Unknown	Point	Undefined	Consortium of California Herbaria RSA
256	Plants	Zannichellia palustris	Horned Pondweed					Unknown	Point	Undefined	Consortium of California Herbaria UCR

Appendix K

Spreadsheet Water Budget Model Details

Appendix K-1

Water Budget Model Overview

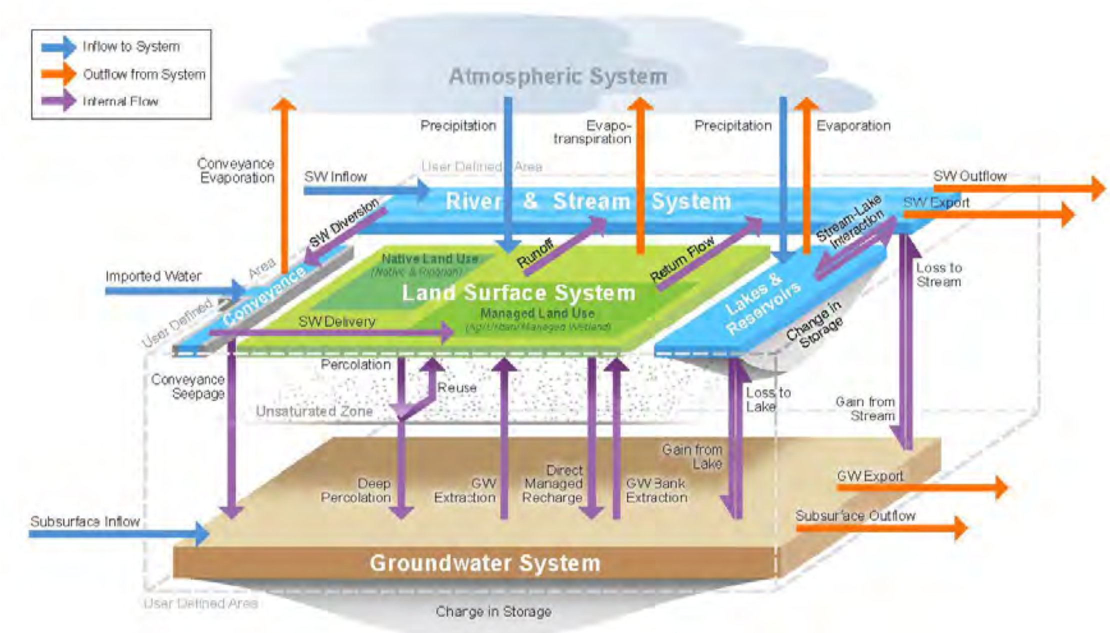
APPENDIX K-1
WATER BUDGET MODEL OVERVIEW

A water budget is an accounting of all water inflows to and outflows from a given spatial domain and enforces the principle of mass balance through use of a change in water storage term. A water budget is expressed by the following simple equation:

Inflows - Outflows = Change in Storage

The above fundamental equation holds true for any defined domain (e.g., parcel, watershed, basin, etc.) and length of time (e.g., day, month, year, etc.) and, when properly constructed using process- and/or physics-based components, serves as a powerful tool for understanding water flow through a system. A schematic of a water budget is shown in **Figure K-1-2**.

Figure K-1-1: DWR Water Budget Schematic (Fig. 7 from DWR's SGMA BMP #4, pg. 30)



Description of Water Budget Framework

A water budget "framework" has been developed to inform the development of a water budget model for the White Wolf Subbasin (WW Subbasin) that is consistent with the requirements of the Sustainable Groundwater Management Act (SGMA) and aligns with the historical water budget period as specified by the White Wolf Groundwater Sustainability Agency (GSA). The conceptual water budget model is depicted on **Figure K-1-2** and **Figure K-1-3** and is further described below.

<u>Water Budget Subdomains</u>

The water budget is divided into five internal subdomains, each influenced by a number of flow components and within which mass-balance is enforced (i.e., the sum of inflow components is balanced by the sum of outflow components and/or a change in storage component). **Figure K-1-2** shows the water budget domain, and the following internal subdomains:

a. Artificial channels
b. Agricultural Lands
c. Urban Lands
d. Natural Channels, and
e. Groundwater subbasin

In addition to the five internal subdomains, several external subdomains are incorporated into the spreadsheet model. These include the atmosphere which is a source of precipitation and sink for evapotranspiration, watersheds that contribute streamflow to streams entering the WW Subbasin, imported water such as State Water Project and Central Valley Project water, and the adjacent groundwater basin. The spreadsheet model does not explicitly account for the vadose (unsaturated) zone between the land surface and the (saturated) groundwater system, but instead incorporates temporal lag factors to account for the movement of water through this zone. An implicit assumption in this approach, therefore, is that the vadose zone does not experience any change in storage over time.

Water Budget Flow Components

Within and between each subdomain are 29 water budget flow components that route water through the WW Subbasin. **Figure K-1-3** shows a conceptual diagram of the individual water budget flow components between subdomains as well as flow components that are external to the overall water budget domain (i.e., serve only as an inflow or outflow to the entire system, rather than a flow between subdomains). The 29 conceptual water budget flow components are listed in **Table K-1-1**, along with an overview of their estimation methods**.**

Certain components are based on "raw" data which are directly measured and based on historical records. These "raw" components are considered to have a relatively high degree of certainty. Other components are estimated using a variety of analytical methods (e.g., Darcy's Law to calculate subsurface flows across the domain's external boundaries) and are thus subject to greater uncertainty based on the parameters used in their estimation. Some components (i.e., groundwater pumping for agricultural use) constitute major proportions of the overall water budget and have thus been given significant attention. Others are relatively minor in magnitude (e.g., seepage from artificial channels) and are, to some degree, less significant to the overall water budget and less well defined.

While the various subdomains and linkages shown on **Figures K-1-2 and K-1-3** and in **Table K-1-1** indicate a highly complex system, the use of such a component-based bottom-up approach allows each component to be considered separately which can benefit model development and application. For example, if new data or methods become available for a certain component they can be easily plugged into the appropriate component without disturbing the rest of the model.

Water Budget Spreadsheet Model Functionality

The water budget spreadsheet model was developed using Microsoft Excel. The calculations for most water budget components occur in the "master" green-shaded tab *"WWB_monthly_budget"* of the spreadsheet. In this tab, each row (excluding the top header rows) represents one month, and each column represents an input or calculated value. All values are in acre-feet (AF). User input values are shown in blue shaded cells. These include various "User Input Parameters" below the header rows (rows 1-3), including:

- Irrigation Efficiency Coefficients (for micro-drip, micro-sprinkler, sprinkler, center-pivot, and furrow irrigation types; see **Appendix K-4**)

- Deep Percolation Lag Period (i.e., approximate time delay for deep percolation to reach groundwater table; see **Appendix K-4**)

- White Wolf Fault Hydraulic Conductivity and Thickness (to estimate transmissivity along the fault; see **Appendix K-3**)

- Leachate Water Electrical Conductivity (to estimate leaching demands; see **Appendix K-4**)

- Additional Operational Demands (to estimate additional applied water demands [in terms of AFY/irrigated acre] from cultural practices and other operation requirements, e.g. dust abatement, frost control, etc.; see **Appendix K-4**)

- Ineffective Precipitation Deep Percolation Coefficient (to estimate deep percolation from ineffective precipitation; see **Appendix K-4**)

- Watershed Consumptive Use Fraction (to estimate residual streamflows into the WW Subbasin; see **Appendix K-2**)

- Watershed Precipitation Threshold for Runoff (to estimate residual streamflows into the District, see **Appendix K-2**)

- Artificial Canals Seepage Rate

- Natural Channels Seepage Fraction (see **Appendix K-2**)

These "User Input Parameters" have been adjusted within the model to reflect best available information and/or calibrated to optimize model response, but can be adjusted manually to reflect updated information or to test model response. Adjustments to the User Input Parameters are made within the "*Calibration_03-01*" tab, and the values within the other tabs will update automatically. Additionally, the "raw" temporal data included within the monthly budget are denoted in blue shaded cells; however, in all cases this data has already been populated with input data (as available) and should not be edited unless intending to override the existing data with updated inputs. Raw inputs that remain questionable, due to either a lack of data or uncertain data quality, are shaded in tan within these raw input columns. Unshaded cells contain formulas and should not be edited.

Rows 7-9 of the main water budget tab shows a number (from 1 to 29) which corresponds to the water budget component as described in this memo and its tables and figures. Live tables and figures that are not included in-line within the memo and other information used in generation of tables and figures can be found in the blue shaded tabs within the water budget spreadsheet.

All other tabs within the spreadsheet contain various input data and calculations used to support water budget calculations on the main water balance tabs and should not be edited. Uncolored tabs correspond to various raw input data that are directly linked to the main water balance tab, including:

- *"Monthly_operations_AE"*
- *"Deliveries to WW_AE"*
- *"Deliveries to WW_WR"*
- *"Deliveries_AE_Overlap_WR"*

- *"M_I_Deliveries_WR"*
- *"M_I_deliveries TCWD"*
- *"Monthly_precip"*
- *"C2VSim_FG_Boundary_Params"*
- *"SW_Imports_AE_WR"*

Pink-shaded tabs represent spreadsheets involving a calculation or series of calculations for incorporation into the main water budget models. These include:

- *"climate_parser_master_WWB"* – used to estimate precipitation on Basin lands and within surrounding watersheds (see **Appendix K-2**)
- "*GW_Fluxes"* –used to estimate subsurface fluxes across District boundaries (see **Appendix K-3**)
- Various tabs used to calculate components within the Agricultural Lands subdomain (see **Appendix K-4**), including:
    - *"Monthly _ET_by_zone_AE+overlap"*
    - *"Monthly_ET_by_zone_WR_no_overla"*
    - *"Monthly_ET_County"*
    - *"Monthly_ET_Channels"*
    - *"Monthly_acreages_AE"*
    - *"Monthly_acreages_WR_no_overlap"*
    - *"Monthly_acreages_WWB"*
    - *"Monthly_GW_Pumping_WR"*
    - *"Crops_pre2k_estimators_AE"*
    - *"pre_2k_operations_WR"*
    - *"Monthly_irr_eff_&_DP_factor_WR" and "Monthly_irr_eff_&DP_factors_AE"*
    - *"leaching_master_AE" and "leaching_master_WR"*
    - *"2012_AgDomain_AE" and "2012_agDomain_WR"*
    - *"operational_demands_AE" and "operational_demands_WR"*
    - *"Constants"*

Light yellow-shaded tabs represent spreadsheets imported directly from the R processing software, which was used predominantly to process land use and ITRC-METRIC data for integration into the Agricultural Lands subdomain (see **Appendix K-4**).

Purple-shaded tabs contain information for reference only.

And finally, the orange-shaded tab, "*Calibration_03_01*", contains the active module used to calibrate the water budget, along with corresponding fitting statistics and figures (see **Appendix K-5**).

TABLE K-1-1.
CONCEPTUAL WATER BUDGET COMPONENTS

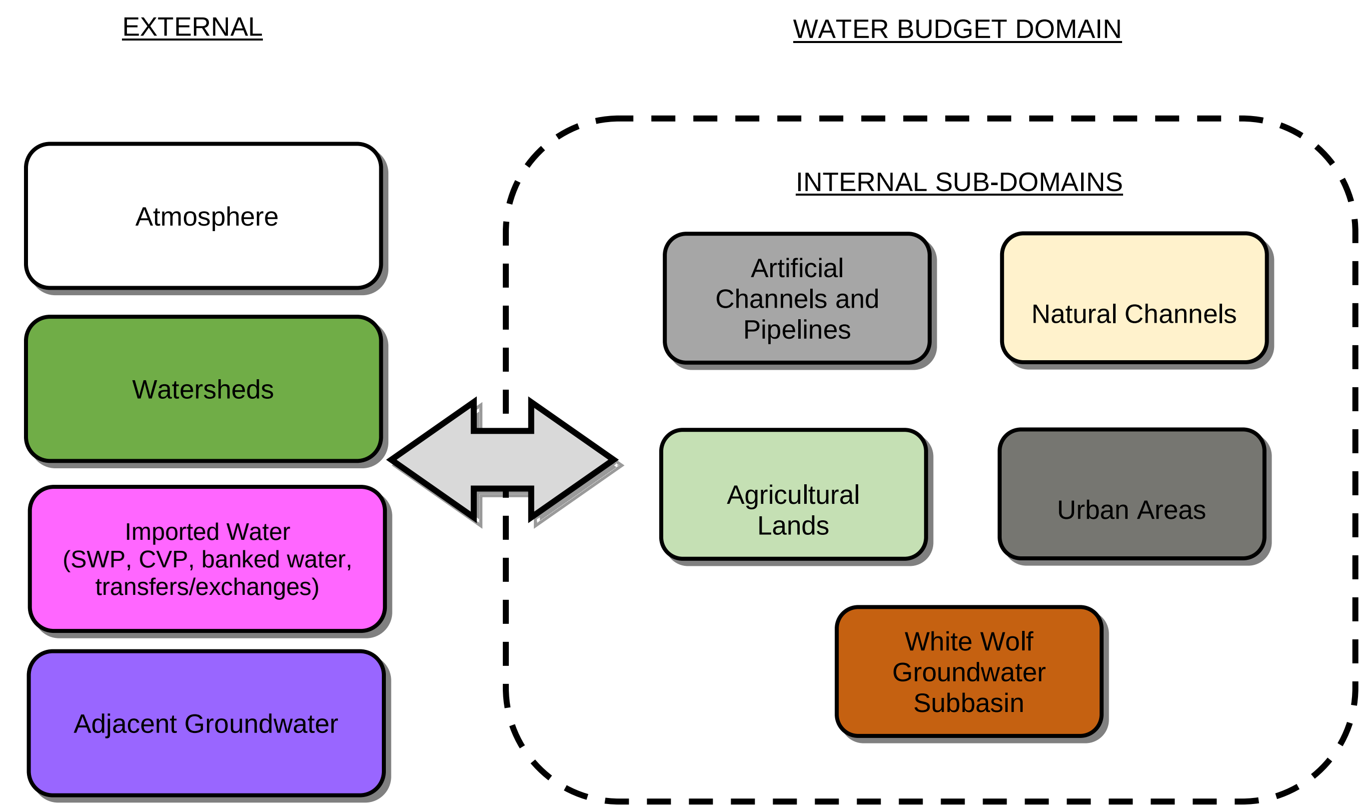
#	Water Balance Component	Component's Role in Overall Water Budget Domain	"Raw" Component	Likely Neglig-ible	Water Budget Subdomain							Component Estimation Method in Water Budget Model
					Imported Water (External)	Watersheds (External)	Artificial Channels & Pipelines	Natural Channels	Agricultural Lands	Urban Areas	Groundwater Basin	
1	State Water Project Allocation	External			In							Not currently estimated in water budget
2	Out-of-District Water Banks	External			In/Out							Not currently estimated in water budget
3	Out-of-District Transfers/Exchanges	External			In/Out							Not currently estimated in water budget
4	Total Surface Water Imports	Inflow					In					Calculated as Residual of Total Deliveries [10 + 11] - GW Inputs [6 + 7] - Atmospheric Exchange [5 - 8]
5	Rainfall onto Artificial Channels	Inflow		Yes			In					Precip Rate * CA Aqueduct & 850 Canal area
6	District Groundwater Pumping Inputs to Artificial Channels	Internal Linkage	Yes				In				Out	From "WRM_Wells_Production_2001-2016_ver_2017-07-18e.xls"
7	Private Groundwater Pumping Inputs to Artificial Channels	Internal Linkage	Yes				In				Out	From "AFUSRINPUT" column of WLEDGER records, or from FAA (Table IV) Sheets; monthly distribution estimated from District GW Pump-in records
8	Evaporation from Artificial Channels	Outflow		Yes			Out					Average ITRC-METRIC ET along CA Aqueduct, 850 Canal * CA Aqueduct, 850 Canal area
9	Seepage from Artificial Channels	Internal Linkage		Yes			Out				In	Seepage Rate * CA Aqueduct, 850 Canal area
10	District Deliveries to Agricultural Lands	Internal Linkage	Yes (see Note 4)				Out		In			Total Deliveries from "WLEDGER" monthly records - M&I Deliveries [11]
11	District Deliveries to Municipal & Industrial Customers	Internal Linkage	Yes (see Note 4)				Out			In		M&I delivery data not provided; currently using placeholder value based off AWMP tables (2015); TCWD deliveries estimated from TRCC Hydraulic Evaluation Report (2013)
12	Surface Water Exports / Unused Water	Outflow					Out					No export data; unused water calculated as residual in Artificial Channels subdomain
13	Rainfall on Agricultural Lands	Inflow							In			Precip Rate * Ag. Lands area
14	Agricultural Groundwater Pumping	Internal Linkage							In		Out	Calculated as the residual of the Ag. Lands subdomain (see Appendix K-4)
15	Total Evapotranspiration from Agricultural Lands	Outflow	Yes						Out			Directly observed from ITRC-METRIC ET data (see Appendix K-4)
16	Infiltration from Agricultural Lands	Internal Linkage							Out		In	Total ET on Ag. Lands [15] - Total Applied Water (see Appendix K-4)
17	Rainfall onto Surrounding Watersheds	External				In						Precip. Rate * Surrounding Watershed area (see Appendix K-2)
18	Consumptive Use from Surrounding Watersheds	External				Out						Rainfall onto Surrounding Watersheds [17] * CU Fraction
19	Streamflow into District	Inflow						In				Rainfall onto Surrounding Watersheds [17] - CU from Surrounding Watersheds [18]
20	Rainfall onto Natural Channels	Inflow		Yes				In				Assumed negligible due to small stream area, and included in estimate of Rainfall on Ag. Lands [13]
21	Evaporation from Natural Channels	Outflow		Yes				Out				Assumed negligible due to small stream area, and included in estimate of Evap. from Ag. Lands [15]
22	Seepage from Natural Channels	Internal Linkage						Out			In	Streamflow Into District [19] * Natural Channels Seepage Fraction
23	Streamflow Out of District	Outflow		Yes				Out				Streamflow Into District [19] - Seepage [22] + Atmospheric Exchange [20 - 21]
24	Rainfall onto Urban Areas	Inflow								In		Precip Rate * Urban Lands area

TABLE K-1-1.
CONCEPTUAL WATER BUDGET COMPONENTS

#	Water Balance Component	Component's Role in Overall Water Budget Domain	"Raw" Component	Likely Neglig-ible	Water Budget Subdomain							Component Estimation Method in Water Budget Model
					Imported Water (External)	Watersheds (External)	Artificial Channels & Pipelines	Natural Channels	Agricultural Lands	Urban Areas	Groundwater Basin	
25	Infiltration from Urban Areas	Internal Linkage								Out	In	M&I Deliveries [11] + Rainfall onto Urban Areas [24] - ET & CU from Urban Areas [26]
26	Evapotranspiration & Consumptive Use from Urban Areas	Outflow	Yes							Out		ET directly observed from ITRC-METRIC data (see Appendix K-4); CU = M&I Deliveries * M&I CU Fraction
27	Subsurface Groundwater Inflows	Inflow									In	Estimated by applying Darcy's Law to groundwater head gradients derived from interpolated groundwater elevation maps. Assumed to be zero except along WWF (see Appendix K-3).
28	Subsurface Groundwater Outflows	Outflow									Out	Estimated by applying Darcy's Law to groundwater head gradients derived from interpolated groundwater elevation maps (see Appendix K-3).
29	White Wolf Basin Change in Groundwater Storage	Inflow/Outflow									In	Calculated as Residual of Groundwater Basin subdomain within the White Wolf monthly budget.

Notes:
1. Water budget subdomains outlined in dashed line are considered part of the overall water budget domain.
2. "Raw" components are those that generally are best quantified based on actual data.
3. The Artificial Channels Subdomain includes the CA Aqueduct, 850 Canal and the delivery pipeline network.
4. Total Deliveries reported in WRMWSD "WLEDGER" files were parsed to Agricultural and Urban Lands based on historical land use data (2001 - present) provided from WRMWSD "CROPS" shapefile. See Appendix K-4 for further details.

Abbreviations:
Ag. = agricultural
AFY = acre-feet per year
CU = consumptive use
ET = evapotranspiration
Evap. = evaporation
GW = groundwater
M&I = municipal and industrial
Precip. = precipitation
WB = water budget
WRMWSD = Wheeler Ridge-Maricopa Water Storage District

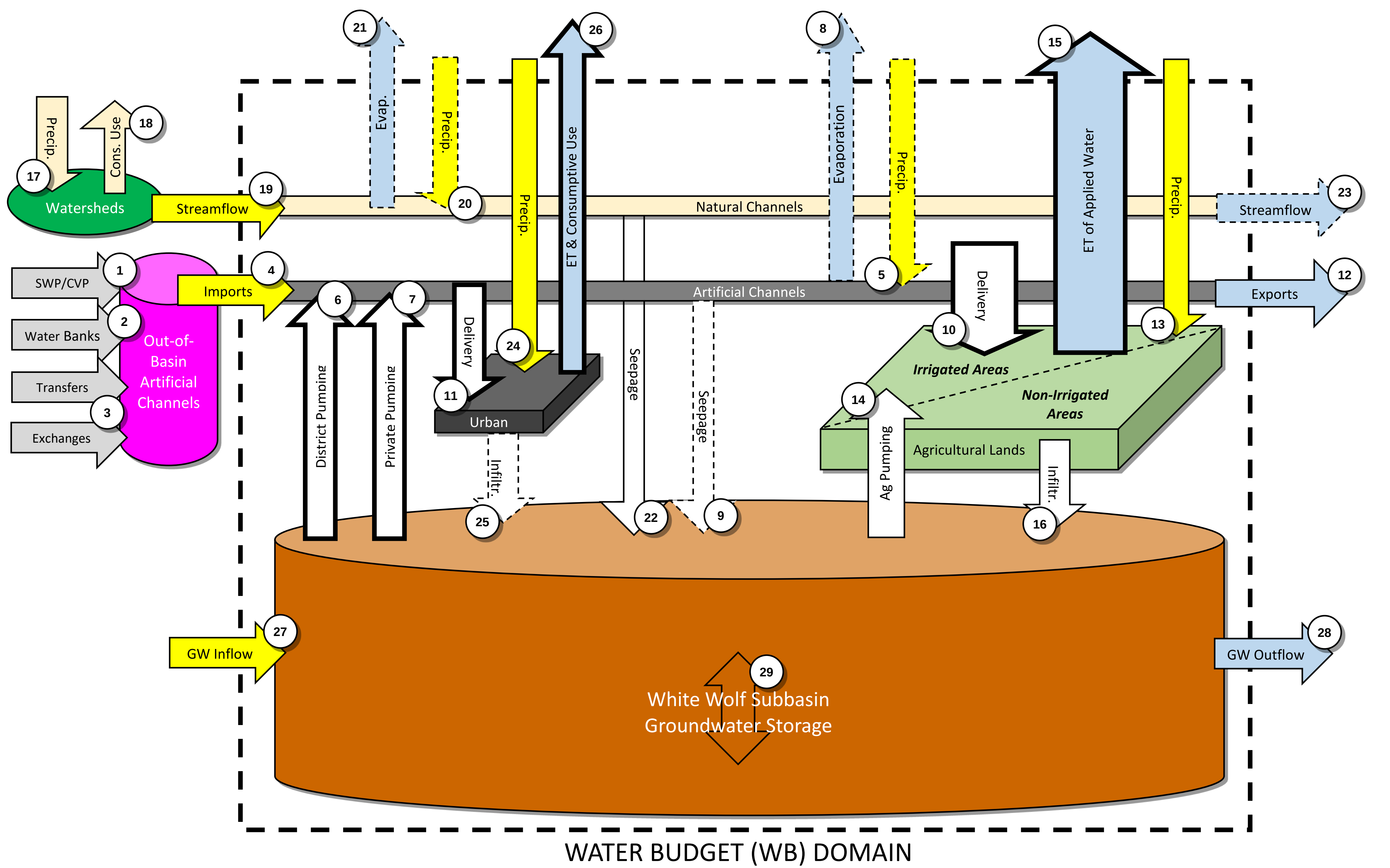


Abbreviations:
CVP = Central Valley Project
SWP = State Water Project

Water Budget Domains and Subdomains

Tejon-Castac Water District
Kern County, California
December 2018
EKI B50001.05

Figure K-1-2



Legend:

- "Raw"
- Likely Negligible
- External
- Inflow to WB Domain
- Internal
- Outflow from WB Domain
- Currently Not Estimated in WB

Abbreviations:

Ag = agricultural
CVP = Central Valley Project
Evap. = evaporation
ET = evapotranspiration
GW = groundwater
Infiltr. = infiltration
M&I = municipal & industrial
Perc. = percolation
Precip. = precipitation
SWP = State Water Project
WB = water budget

Notes:

1. "Raw" components are those that are based on actual data.

Water Budget Flow Components

Tejon-Castac Water District
Kern County, California
December 2018
B50001.05

eki environment & water

Figure K-1-3

Appendix K-2

Description of Precipitation and Contributing Streamflow Estimates

APPENDIX K-2

DESCRIPTION OF PRECIPITATION AND CONTRIBUTING STREAMFLOW ESTIMATES

This appendix documents the process used to derive estimates of precipitation on District lands and the surrounding watersheds contributing to streamflow within the District.

Selection of Climate Stations

Precipitation on White Wolf Subbasin (Basin) lands and on surrounding watersheds is estimated using two of the six local climate stations maintained by and located within the Wheeler Ridge-Maricopa Water Storage District (WRMWSD), and two additional climate stations located outside of the WRMWSD maintained by the National Oceanic and Atmospheric Administration (NOAA). Each of these stations report measurements of monthly precipitation (inches per month [in/mo]) during the water budget period of interest (1995 – 2015), although data availability varies by station.

The two local climate stations maintained by the WRMWSD and used for this analysis include:

- **PA-2 Pumping Plant** (*January 1978 – December 2017)*
- **Spillway Basin** (*January 1978 – December 2017)*

The additional climate stations maintained by NOAA employed for this analysis include:

- **Tejon Rancho, CA [NOAA Coop. ID #48839]** (*January 1895 – December 2017)*[1]
- **Lebec, CA [NOAA Coop. ID #44863]** (*July 1948 – December 2017)*[2]

The NOAA stations were incorporated into this analysis because there is significant topographic difference (i.e., nearly 8,000 foot elevation difference) between Basin lands and the peaks of the surrounding watersheds in the San Emigdio and Tehachapi mountains to the southwest and southeast, respectively, that contribute to streamflow to the Basin. This elevation difference results in an orographic effect whereby precipitation in the surrounding watersheds is significantly greater than precipitation measured at the six WRMWSD climate stations. In order to account for this precipitation difference, data from the two additional NOAA climate stations were used. NOAA climate stations were selected based on the following criteria:

1) Data availability & continuity within the time-period of interest (1995 – 2015);
2) Location within the Basin's surrounding watersheds; and
3) Ground surface elevation (relative to the elevation range within surrounding watersheds).

Interpolation of Missing Data for NOAA Climate Stations

NOAA stations employed in this analysis contained several missing monthly values within the period of interest. For these months, precipitation was estimated based on a linear regression model developed with a WRMWSD climate station. The WRMWSD climate station that exhibited the best correlation with both the Tejon Rancho and Lebec stations was the Spillway Basin (elevation ~840 feet above mean sea

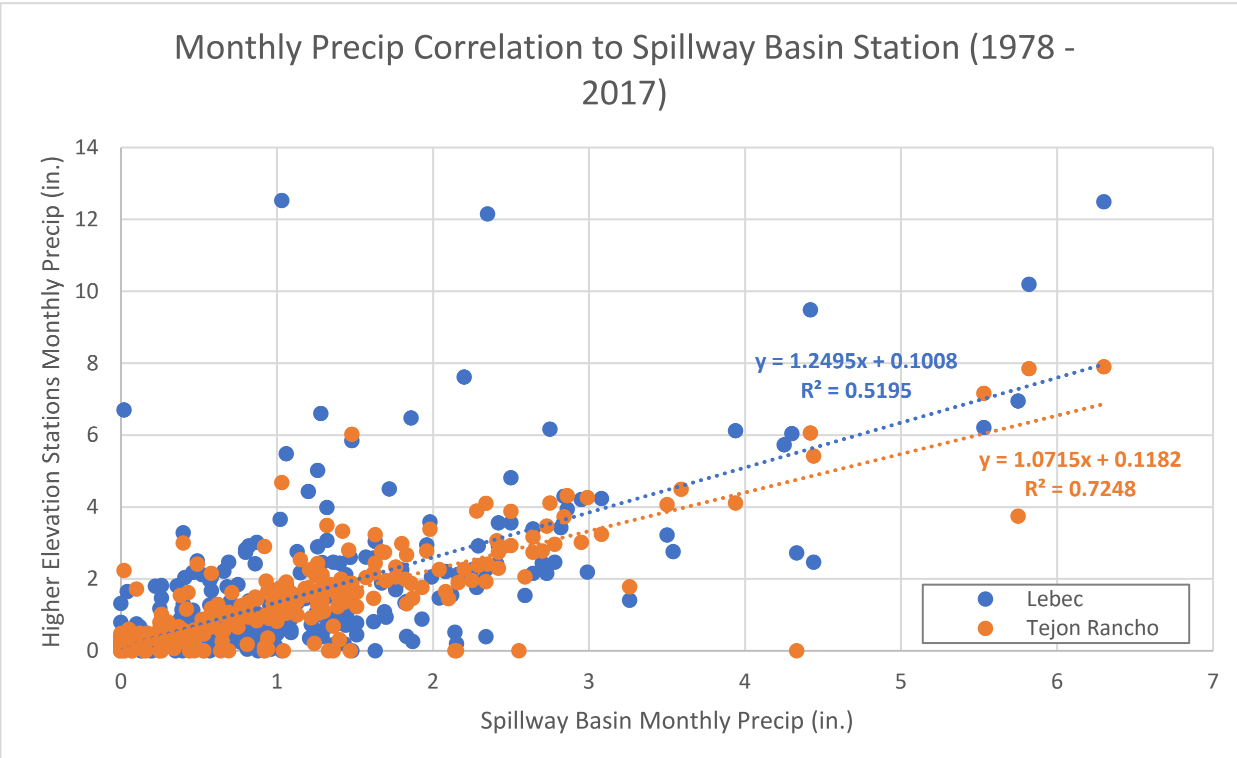
---

[1] Data retrieved from NOAA's National Climatic Data Center (NCDC) online portal (https://www.ncdc.noaa.gov/cdo-web/datasets/GSOM/stations/GHCND:USC00048839/detail)

[2] Data retrieved from NOAA's National Climatic Data Center (NCDC) online portal (https://www.ncdc.noaa.gov/cdo-web/datasets/GSOM/stations/GHCND:USC00044863/detail)

level [ft msl]). As shown on **Figure K-2-1** below, over the entire period of record (1978-2017), monthly precipitation records collected from the Spillway Basin station showed an **85% correlation** (R^2 = 0.72) with data collected from the Tejon Rancho station (elevation ~1,370 ft. msl), and a **72% correlation** (R^2 = 0.52) with data collected from the Lebec station (elevation ~3,600 ft. msl).

Figure K-2-1. Long-term Correlation between Spillway Basin Station and NOAA Stations



As such, monthly precipitation values for months with missing precipitation data within the Tejon Rancho and Lebec records were estimated using the linear regression models derived for each station with respect to the Spillway Basin station.

Spatial Representation of Precipitation Data

Precipitation is a spatially variable phenomenon and can usually only be directly observed at discrete points within a domain (i.e., at climate station locations). Additionally, precipitation is affected by surrounding topography, and the orographic effect must be considered when deriving rainfall estimates over watershed areas with significant elevation range. As mentioned previously, the nearly 8,000 ft difference in elevation between District lands and the peaks of the surrounding watersheds in the San Emigdio and Tehachapi mountains results in an orographic effect. As such, it is practical to employ precipitation data from higher-elevation climate stations to estimate precipitation within these surrounding watersheds contributing to streamflow into the District.

Table K-2-1 reports the approximate elevation of each climate station used in this analysis, as derived from the U.S. Geological Survey National Elevation Dataset (NED):

Table K-2-1. Climate Stations and Corresponding Ground Surface Elevations

Climate Station	Operator	Ground Surface Elevation (ft. msl)
Spillway Basin	WRMWSD	840
PA-2 Pumping Plant	WRMWSD	940
Tejon Rancho	NOAA	1,370
Lebec	NOAA	3,590

Based on the distribution of locations and elevations from the four climate stations employed for this analysis, a two-fold approach was employed to represent precipitation on District lands and from surrounding watersheds:

1) **Within the Basin** the average precipitation at the Spillway Basin and PA-2 Pumping Plant stations was used to represent precipitation in areas where the elevation is less than 1,155 ft. msl, the Tejon Ranch station was used to represent precipitation in areas where the elevation is between 1,155 and 2,480 ft. msl, and Lebec station was used to represent precipitation in areas where the elevation is greater than 2,480 ft. msl.
2) **In the surrounding Watersheds** these elevation cutoffs were used to delineate the representative area for the higher-elevation NOAA climate stations.

This analysis is based on the following assumptions:

- The two WRMWSD climate stations are located within the Basin at relatively similar elevations; thus, precipitation within the lower elevations within the subbasin is best represented using the average precipitation from these stations.
- The two NOAA climate stations are located at higher elevations than the WRMWSD climate stations (see **Table K-2-1** above); thus, precipitation on the surrounding watersheds is best represented by the NOAA climate station at the <u>nearest elevation</u> to each point within the surrounding watershed area.

Figure K-2-2 shows the location of each climate station within the Basin and its surrounding watersheds. The following elevation cutoffs were used to determine which NOAA station would be employed to estimate precipitation in these areas:

- Areas within the Basin are represented by the District climate stations;
- Watershed elevations between less than 2,480 ft. msl are represented by the Tejon Rancho climate station; and
- Watershed elevations greater than or equal to 2,480 ft. msl are represented by the Lebec climate station.

Calculation of Rainfall and Contributing Streamflow

Following the spatial delineation process described above, total areas represented by each climate station were calculated for Basin lands, as well as for the surrounding watershed area. Watershed areas to the north of the Basin (**Figure K-2-2**) were assumed not to contribute significant streamflow to the Basin due to the watershed topography and land use and the limited length of streams passing through the Basin from those watershed areas.

The volume of monthly rainfall (acre-feet per month; [AF/mo]) on the Basin and on surrounding watersheds is then estimated as follows:

$$Rainfall = \sum \frac{p_{station}}{12} * A_{station} \quad (1)$$

where $p_{station}$ = monthly precipitation [in/mo] and $A_{station}$ = total area represented by the station(s) [acres].

Contributing streamflow into the Basin is then calculated from the Rainfall on Watersheds using a linear equation with two parameters: a Precipitation Threshold for Runoff Initiation and a Watershed Consumptive Use Fraction. These parameters are defined in the "User Input Parameters" of the water budget spreadsheet model. Contributing streamflow into to the Basin is calculated as:

$$Streamflow\ into\ District = max\left(0, Rainfall\ on\ Watersheds - \frac{p_{threshold}}{12} * A_{watershed}\right) * (1 - CU_{watershed}) \quad (2)$$

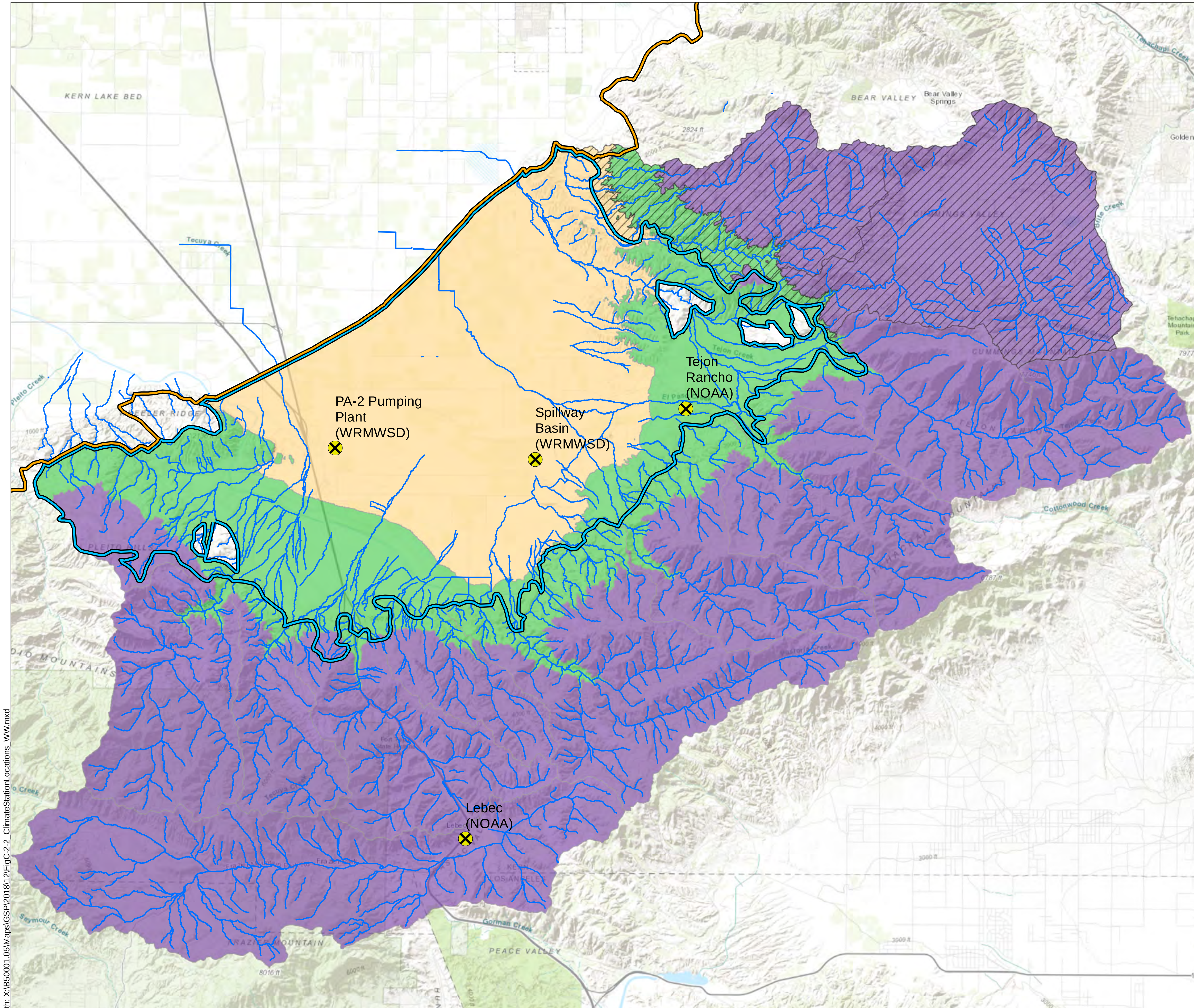
where $p_{threshold}$ = Precipitation Threshold for Runoff Initiation [in], $CU_{watershed}$ = Watershed Consumptive Use Fraction [dimensionless], and $A_{watershed}$ = total area of surrounding watersheds [acres].

Ultimately, a Watershed Consumptive Use Fraction of 95% and Precipitation Threshold of 0.50 inches were employed to estimate resultant contributing streamflow into the District. See **Appendix K-5** for further details regarding the water budget calibration process. The above methodology resulted in and of 8,400 acre-feet per year (AFY) of streamflow into the Basin from the surrounding watersheds for Water Years 1995-2015.

The water budget-estimated streamflow info the Basin was compared to flow into the Basin estimated using the U.S. Geological Survey Basin Characterization Model (BCM)[3]. The BCM calculates a monthly water balance at a 270-meter spatial resolution using climate, soils, geologic, and topographic data. Outputs from the BCM include rasters of runoff and recharge that can be used to estimate discharge from a watershed. For this comparison it was assumed that all runoff and recharge estimated by the BCM for watersheds above the Basin will discharge into the Basin as streamflow. Using rasters of average runoff and recharge for Water Years 1981-2010, the estimated streamflow into the Basin for that period was 9,700 AFY, which compares well with the water budget-estimated streamflow into the Basin.

---

[3] Flint, Lorraine E., A.L. Flint, J.H. Thorne, and R. Boynton, 2013, Fine-scale hydrologic modeling for regional landscape applications: the California Basin Characterization Model development and performance, Ecological Process 2013 2:25. https://ca.water.usgs.gov/projects/reg_hydro/basin-characterization-model.html



Legend

Climate Station

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

Representative Climate Station

Spillway Basin/PA-2 Pumping Plant

Tejon Rancho

Lebec

Assumed no Significant Streamflow into Basin

Abbreviations

CIMIS	=	California Irrigation Management Information System
DWR	=	California Department of Water Resources
NHD	=	National Hydrography Dataset
NOAA	=	National Centers for Environmental Information
WRMWSD	=	Wheeler Ridge-Maricopa Water Storage District

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 December 2018.
2. Surface water features and watersheds from NHD website: (https://viewer.nationalmap.gov/basic/).
3. WRMWSD Climate Station information provided by WRMWSD.
4. NOAA climate stations information from NOAA website: (https://www.ncdc.noaa.gov/cdo-web/)

N

0 3 6

(Scale in Miles)

Climate Station Locations and Representative Areas White Wolf Subbasin

Tejon-Castac Water District
Kern County, California
December 2018
B50001.05

eki environment & water

Figure K-2-2

Path: X:\B50001.05\Maps\GSP\2018\12\FigC-2-2_ClimateStationLocations_WW.mxd

Appendix K-3

Description of Subsurface Cross Boundary Flow Estimates

eki environment & water

APPENDIX K-3

DESCRIPTION OF SUBSURFACE CROSS-BOUNDARY FLOW ESTIMATES

This appendix documents the process used to estimate subsurface cross-boundary flows as a means of quantifying groundwater inflows and outflows to the aquifer system underlying White Wolf Subbasin (Basin) lands. Groundwater flow across the White Wolf Fault (WWF) to the adjacent Kern County Subbasin was assumed to be the only groundwater flow into or out of the Basin. Groundwater inflow from surrounding watersheds is likely negligible and inflow from the surrounding watersheds was accounted as for as inflow from streams. Monthly groundwater flux across the WWF was calculated using Darcy's Law, which states that:

$$Q = T * i * L \tag{1}$$

where Q = volumetric groundwater flow rate [feet cubed per day; ft^3/d], T = aquifer transmissivity [feet squared per day; ft^2/d], i = hydraulic gradient [dimensionless], and L = length of boundary perimeter used to calculate groundwater flux [feet; ft]. As shown in **Figure K-3-1**, cross-boundary groundwater flux across the fault was calculated for the section of subbasin boundary coincident with the WWF. Methods used to derive values for *T, I,* and *L* along the fault are further documented below.

Estimation of Aquifer Transmissivity

Aquifer transmissivity (*T)* is calculated as the product of aquifer hydraulic conductivity (K) [feet per day; ft/d] and aquifer thickness (b) [ft]:

$$T = K * b \tag{2}$$

There is significant uncertainty associated with each of these parameters for the fault. As such, we chose initial estimates for each parameter based on associated values reported in historical hydrogeological studies, numerical models, and water budgets conducted within the region, including:

- Dibblee and Oakeshott, 1953. Dibblee, T.W. Jr. and G.B. Oakeshott, *White Wolf fault in relation to geology of the southeastern margin of San Joaquin Valley, California*, GSA Bulletin, vol. 64, p. 1502-1503, 1953.
- Wood and Dale, 1964. Wood P.R. and R. H. Dale, *Geology and Ground-Water Features of the Edison-Maricopa Area, Kern County, California*, USGS Water Supply Paper 1656, 1964.
- Croft, M.G., 1972, *Subsurface geology of the late Tertiary and Quaternary water-bearing deposits of the southern part of the San Joaquin Valley, California*, USGS Water Supply Paper 1999-H, 29 pp.
- Bookman-Edmonston Engineering, 1995. *Ground Water Studies, Wheeler Ridge-Maricopa Water Storage District*, 66 pp.
- Hagan, Karin, 2001, *The effects of the White Wolf fault on groundwater hydrology in the southern San Joaquin Valley, California*: CSU Bakersfield, M.S. theses, 96 pp.
- Bookman-Edmonston Engineering, 2007. *Groundwater Storage and Recovery Pilot Project in the White Wolf Basin. Wheeler Ridge-Maricopa Water Storage District*, 47 pp.

- Brush et al., 2013. Brush, C.F., Dogrul, E.C., and T.N. Kadir, *Development and Calibration of the California Central Valley Groundwater-Surface Water Simulation Model (C2VSim), Version 3.02-CG*, 2013.

- EKI, 2016. *White Wolf Basin Technical Report*, 77 pp.

Final aquifer hydraulic conductivity and thickness values were subsequently determined through water budget calibration. See **Table K-3-1** below for initial and final (calibrated) estimates of *K* and *b* along the WWF.

Table K-3-1. Aquifer Hydraulic Conductivity and Depth Estimates

Boundary Segment	Initial *K* [ft/d]	Final *K* [ft/d]	Initial *b* [ft]	Final *b* [ft]
White Wolf Fault	1	3	1,000	1,000

Estimation of Aquifer Gradients and Boundary Length

To calculate hydraulic gradients (*i)* across the WWF, we employed a Geographic Information System (GIS)-based methodology using interpolated groundwater elevation rasters, lines on both sides and generally parallel to the WWF, and the "Zonal Statistics" toolbox to estimate average hydraulic heads across the fault.

EKI developed regional spring and fall groundwater elevation contour maps in the WWF area for multiple years between 1994 and 2015. Groundwater elevation rasters were generated through kriging interpolation of water level data compiled from AEWSD and Wheeler Ridge-Maricopa Water Storage District (WRMWS). Two simplified lines were then drawn in GIS approximately 10,000 feet apart that generally traced both sides of the fault segment (see **Figure K-3-1**).

Subsequently, for analysis period, an average groundwater elevation (in feet above mean sea level [ft msl]) was estimated along each line using the Zonal Statistics raster processing toolbox. Finally, the dimensionless hydraulic gradient (*i)* across the boundary segment for each analysis period was calculated as follows:

$$i = \frac{GWE_2 - GWE_1}{10{,}000\ ft} \quad (3)$$

where GWE_1 and GWE_2 are the average groundwater elevations along the two lines for each boundary segment.

Estimation of Monthly Groundwater Flux in the Water Budget Model

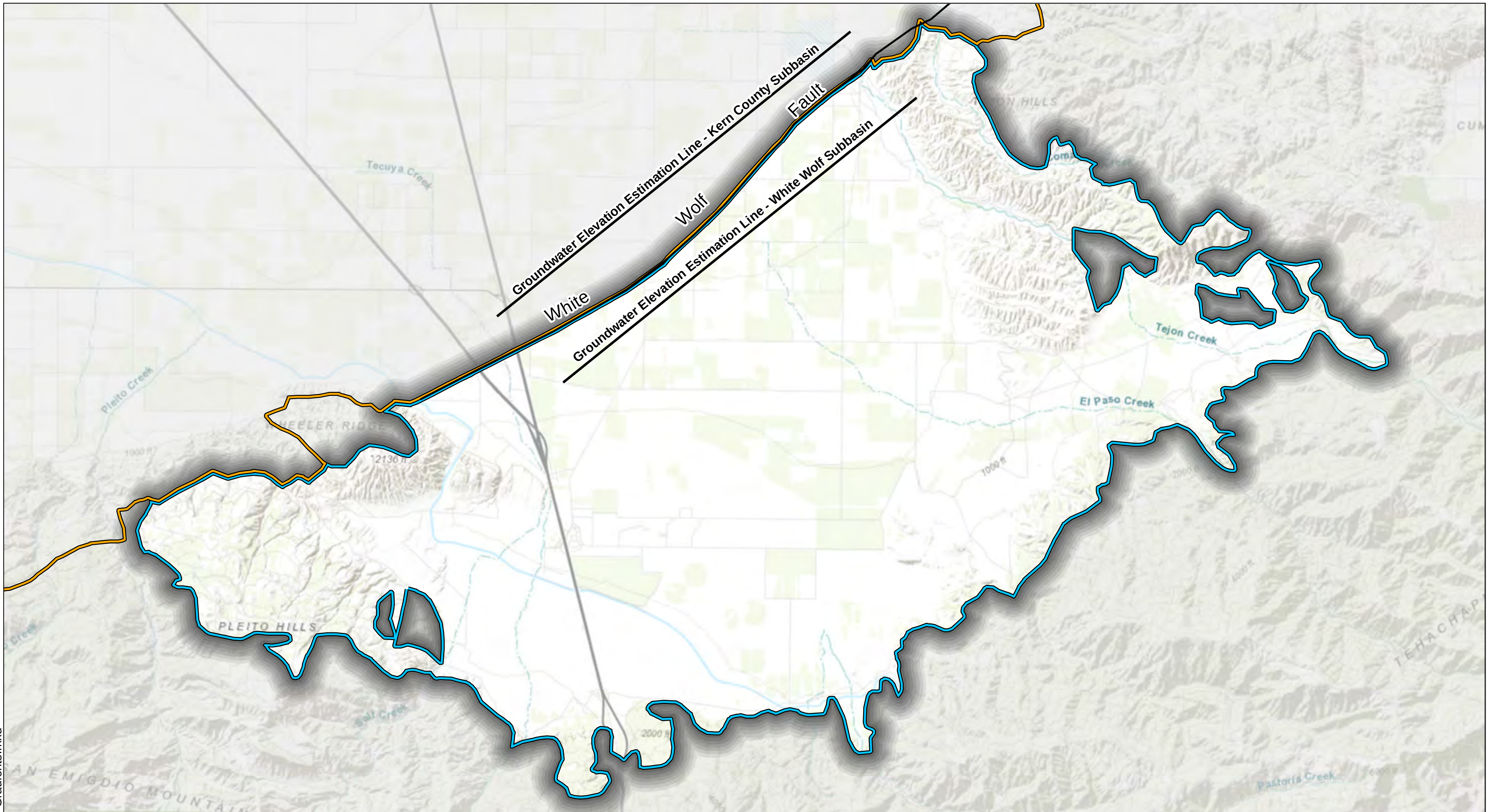
After deducing aquifer transmissivity (*T*), boundary length (*L*) and hydraulic gradient (*i*) parameters for each analysis period, groundwater flux was calculated using Darcy's Law (see Equation 1). Fluxes for each analysis period were converted from ft^3/d to acre-feet per month (AF/mo) and were used to provide a representative "monthly" flux estimate associated for the period 1994-2015.

The WWF is known to act as hydrogeologic barrier to groundwater flow, and a relatively continuous historical groundwater gradient has been demonstrated across the fault[1]. Therefore, it is assumed that groundwater flux across this boundary is not significantly affected by seasonal or annual variability in groundwater conditions in the vicinity of the fault line because flow is largely constrained by the low-conductivity fault zone.

As is such, a simplifying assumption was used that the average monthly groundwater flux derived from the groundwater elevation maps developed for select years is reasonably representative of the monthly flux across the White Wolf Fault for the entire water budget period.

The Basin is surrounded by mostly granitic and metamorphic bedrock formations of the Tehachapi Mountains to the south and east and San Emigdio Mountains to the west, and the WWF to the north. Given the low bulk permeability and porosity of these bedrock materials, the Basin likely does not receive significant subsurface inflows and is thus predominantly recharged via deep percolation of (1) contributing streamflow from surrounding watersheds, (2) direct precipitation, and (3) imported surface water. Furthermore, it is understood that most natural surface water features within the subbasin are ephemeral creeks, whereby nearly all surface water entering the subbasin will evaporate or percolate into the subsurface before crossing over the WWF into the Kern County Subbasin.

[1] See EKI's *White Wolf Basin Technical Report* (2016) for further details.



Path: X:\B50001.05\Maps\GSP\2018\12\FigC-3-1_WWFGradients.mxd

Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

Abbreviations

DWR = California Department of Water Resources
ft = feet
ft bgs = feet below ground surface

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 19 December 2018.

N 0 3 6 (Scale in Miles)

Horizontal Groundwater Gradient Calculation Locations - White Wolf Fault

Tejon-Castac Water District
Kern County, California
December 2018
B50001.05

eki environment & water

Figure K-3-1

Appendix K-4

Description of the Agricultural Lands Water Budget Subdomain

APPENDIX K-4

DESCRIPTION OF THE AGRICULUTRAL LANDS WATER BUDGET SUBDOMAIN

This appendix describes the process for calculating water budget components within the Agricultural Lands subdomain of the White Wolf Subbasin (Basin) Long-term Water Budget (currently populated for Water Years 1994–2015). This analysis was based on the following data sources:

- **Satellite Evapotranspiration (ET) Data** from the Cal Poly Irrigation Training & Research Center (ITRC)[1] "Mapping Evapotranspiration at High Resolution with Internalized Calibration" (ITRC-METRIC) Study, funded by the Kern Groundwater Authority (KGA)[2]
  - *monthly, January 1993 – December 2015* [3]

- **Land Use Data**
  - Wheeler Ridge-Maricopa Water Storage District (WRMWSD) Land Use Surveys from the District's internal land use records
    - *Seasonal resolution*, *Spring 2001 – Spring 2017(data availability varies by season)*
  - Arvin-Edison Water Storage District (AEWSD) Land Use Surveys from the District's internal land use records, including:
    - "10YRCROP_1968-2017.xls" – *District-wide summary, yearly, 1994 – 1996*
    - "1997-1998 Landuse.xls" – *by Township/Range/Section (TRS), seasonal (spring & fall), 1997 – 1998*
    - *"*1999 Overlap Landuse.xls" – *by TRS, seasonal (spring & fall), 1999*
    - "AECropSurvey_00to03.shp" – *by Parcel, seasonal (spring & fall), 2000 – 2003*[4]
    - "AECropSurvey_04.shp" – *by Parcel, seasonal (spring & fall), 2004*
    - "AE_LandUse_05to08" – *by Parcel, seasonal (spring & fall), 2005 – 2008*
    - *"*AEWSD 2015 Crops.shp" – *by Parcel, seasonal (spring & fall), 2009 – 2016*

- **Surface Water Delivery and Operations Data**
  - WRMWSD surface water delivery records from the District's "WRM_DataMDB" Access databases (i.e., "WLEDGER" tables)
    - *monthly resolution, January 1999 – December 2016*
  - WRMWSD Delivery Records to AEWSD Overlap Lands, provided by WRMWSD:
    - *"WRMWSD-AE_Overlap_Deliveries_2018-05-10" – by WRMWSD Turnout, monthly, 2006 – 2017*
    - *"WLEDGER" (from "WRM_DataMDB.mdb") – by WRMWSD Turnout, monthly, 1999 - 2005*

---

[1] The Irrigation Training & Research Center is part of the California Polytechnic State University, San Luis Obispo.
[2] Howes, D., 2017, *1993-2015 ITRC-METRIC ETc for Kern County*, prepared for the Kern Groundwater Authority on behalf of the Cal Poly Irrigation Training & Research Center. (see **Attachment K-4-1**)
[3] There is no ITRC satellite ET data for calendar year 2012, as the Landsat satellite system employed in the METRIC analysis was out of order during this period. See **Attachment K-4-1** for further details.
[4] Does not include Fall land use information for 2000, 2001, 2003

- AEWSD District Operations Records (surface water imports, spreading, deliveries, and groundwater extractions) compiled from various spreadsheets provided by the District, including:
    - "supplyest1998.xls" – "supplyest2016.xls" – *monthly, 1998 - 2016*
    - "SUMYEST1993 – final.pdf", "SUMRYEST1996 – final.pdf", "SUMRYEST1995 – final.pdf" – *monthly, 1993; 1995 – 1996*
    - "1994 WY Deliveries.pdf", "1994 WY Gross Spreading", "BIGSUMRY1994.pdf" – *monthly, 1994*
    - "1992 – 2017 (Monthly) White Wolf Subbasin AEWSD Deliveries.xlsx" – *monthly, 1992 - 2017*

- **Precipitation Records** from the two local climate stations maintained by WRMWSD and located within the Basin, and two additional climate stations (one located inside and one located outside of the Basin) maintained by the National Oceanic and Atmospheric Administration (NOAA)[5]
    - *monthly resolution, January 1971 – December 2017 (data availability varies by station)*

<u>Description of ITRC-METRIC ET Dataset</u>

The ITRC-METRIC ET dataset uses satellite-based remote sensing of radiant energy and the METRIC energy balance theory to quantify actual water flux to the atmosphere from the land surface (including ET and evaporation from bare soil and open water). This approach differs from other commonly-used methods that estimate ET based on land use (i.e., cropping) patterns and reference ET data and/or crop water use coefficients. There are several advantages of the ITRC-METRIC approach over conventional crop coefficient methods:

- ITRC-METRIC provides the ability to measure <u>actual ET</u> over large areas without any previous knowledge of land use or climate variables, whereas crop coefficients will estimate ET based on known cropping acreages and assumed crop water use properties.

- ITRC-METRIC provides semi-continuous (i.e., rasterized) ET data at a high spatial resolution (satellite image pixel size of 30 x 30 meters) for an area of study, whereas crop coefficient-based ET estimates are limited to the resolution of the land use dataset being employed.

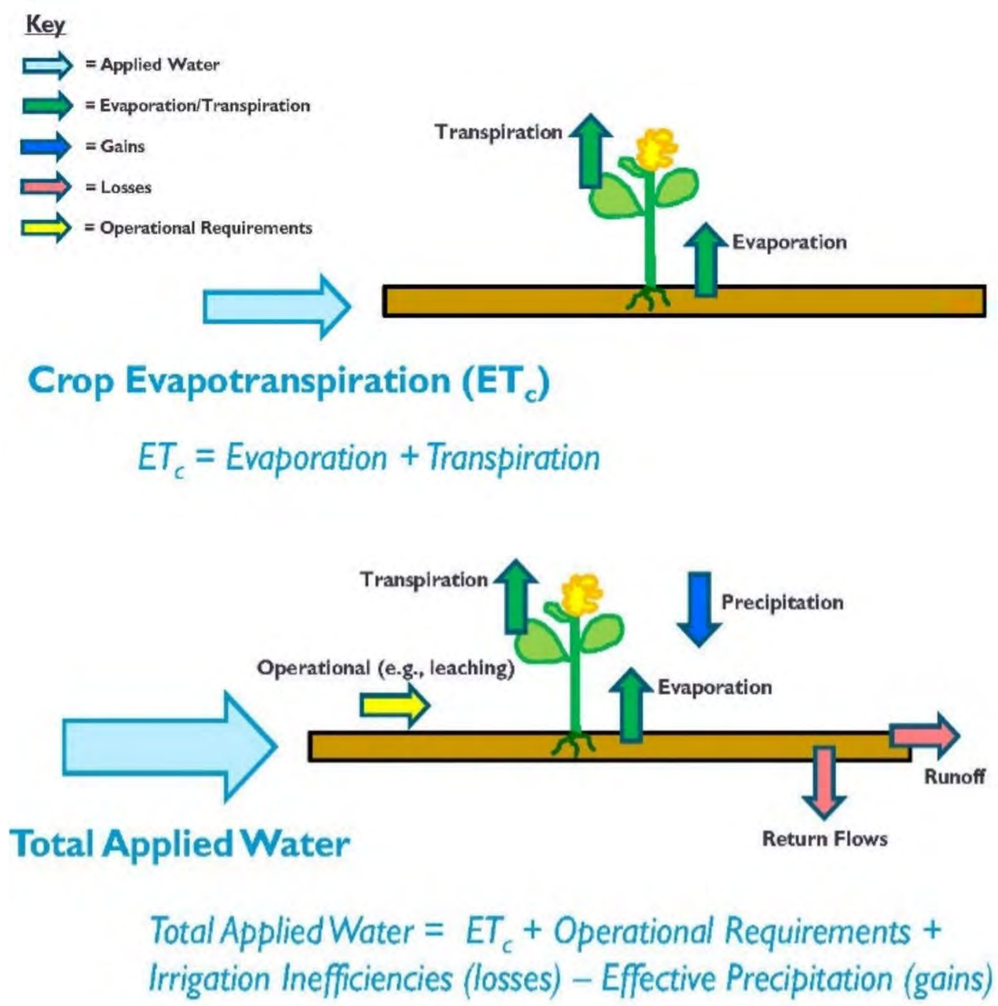
- ITRC-METRIC allows for ET measurement at a relatively frequent temporal resolution (e.g., approximately every 16 days), whereas crop coefficient methods are typically only available on a seasonal, or at best monthly, basis.

Due to these advantages, ET data developed using the ITRC-METRIC method will intrinsically reflect spatial and temporal variabilities in ET due to factors that cannot be fully accounted for using conventional crop coefficient methods. For example, the ITRC-METRIC ET rasters (image files) will reflect impacts on ET due to crop stresses from drought conditions, ET for crops at various stages of growth, ET for land parcels with multiple growing seasons (i.e., double cropping) and/or interbedded crops, and evaporation from surface water features (such as canals, reservoirs, spreading basins, etc.).

[5] See Appendix K-2 for a detailed description of how climate stations are used to estimate precipitation on Basin lands and surrounding watersheds.

However, the ITRC-METRIC dataset has a significant limitation for water-budgeting purposes in that it does not provide an estimate of ***total applied water***, only ***actual (observed) ET***. *Total applied water* is a term used by water resource engineers to estimate how much water is actually being applied to the land. This differs from ET in that it includes not only water applied to satisfy crop water demand, but also unintentional over-irrigation due to irrigation inefficiency and water intentionally applied for other operation requirements or cultural practices (e.g., leaching, dust abatement, field preparation, frost control). During the main growing season from spring through fall, when precipitation is minimal and ET is greatest, total applied water is nearly always greater than evapotranspiration for any irrigated land, as no irrigation method is 100 percent efficient[6]. Calculation of total applied water must also consider water added to the land surface via precipitation, as this will reduce the irrigation demand for a given area. **Figure K-4-1** illustrates the difference between actual (crop) ET (ET_c) and total applied water.

Figure K-4-1. Crop Evapotranspiration (ET or ETc) vs. Total Applied Water



Land Surface Processes within the Water Budget

[6] Irrigation efficiency is defined as the fraction of total applied water that is used by the crop to satisfy its vegetative water demand.

From a holistic water budgeting perspective, total applied water that does not go towards satisfying crop ET will be subject to four main processes once it is applied to the land surface:

1) Evaporation to the atmosphere
2) Land surface runoff
3) Infiltration and accumulation in the root zone
4) Deep percolation below the root zone to the groundwater table (i.e., return flows)

Although this water budget model allows for temporary carry-over storage of excess effective precipitation in the root zone for subsequent uptake by crops (see below), it is assumed that there is <u>no net long-term accumulation of water within the root zone</u>. Accurate simulation of soil moisture changes would require detailed spatial information on soil properties and root zone depth, as well as data for precipitation, irrigation, and ET on the timescale of hours to days. As the current water budget is designed to reflect monthly changes at the Basin scale, this level of detail is beyond the current scope of the effort. Furthermore, assuming quasi-steady state conditions within the root zone mimics the approach of the MODFLOW Farm Process package, which has proven that "simulated inflows into the root zone converged to outflows after time intervals of several days"[7]. Therefore, the assumption of steady-state soil moisture within the root zone is justified.

Similarly, as this water budget was developed at the Basin scale, and given the generally low topographic slope and lack of significant permanent streams along Basin boundaries, we have assumed that <u>land surface runoff of applied water is negligible</u> for the purposes of this water budget. Though runoff may occur between parcels within the Basin, there is no continuous receiving water body (i.e., "Natural Channels" such as streams) that could transport surface water runoff outside of the Basin in any significant volume. Therefore, we have assumed that all land surface runoff occurring between parcels within the Basin will either (1) evaporate or (2) infiltrate into the subsurface before leaving Basin boundaries.

Under the above assumptions, excess water applied to the ground surface on Basin lands will predominantly either (1) evaporate from the wetted bare soil or (2) percolate below the root zone into the deeper subsurface (eventually recharging groundwater) before leaving Basin boundaries. Considering that landowners within AEWSD and WRMWSD generally employ highly efficient irrigation techniques (such as micro-drip irrigation) and follow irrigation schedules designed to minimize evaporation of excess irrigation water, it is further assumed that evaporation of excess irrigation water is considered to be a negligible flux component of the ITRC-METRIC ET signal, and thus <u>all "inefficient irrigation" of these lands will infiltrate through the root zone</u> and eventually make its way down into the underlying principal aquifer.

<u>Building the Agricultural Lands Subdomain Water Budget</u>

Land Use Data Availability by Year

[7] Dogrul, E. C., Schmid, W., Hanson, R., Kadir, T., & Chung, F. 2011. Integrated Water Flow Model and Modflow-Farm Process: A Comparison of Theory, Approaches, and Features of Two Integrated Hydrologic Models. prepared by California Department of Water Resources, Bay-Delta Office in conjunction with the U.S. Geological Survey.

As described earlier, historical land use information was available for this water budget analysis for AEWSD (Water Years[8] 1994-2015) and WRMWSD (DWR Water Years 1995, 1997, 2001-2015) in multiple data formats and at varying spatial and temporal resolutions. Land use files therefore required individual processing for integration into the water budget depending on the level of detail provided within each file. **Tables K-4-1 and K-4-2** below summarizes data format and availability by year as provided in the AEWSD and WRMWSD historical land use records.

Table K-4-1 – AEWSD Land Use Data Availability by Water Year

AEWSD Water Year	Data Format	Spatial Resolution	Temporal Resolution	Includes Irrigation Type?
1994	Excel	District-wide	Annual	No
1995	Excel	District-wide	Annual	No
1996	Excel	District-wide	Annual	No
1997	Excel	TRS	Seasonal (Spring/Fall)	Yes
1998	Excel	TRS	Seasonal (Spring/Fall)	Yes
1999	Excel	TRS	Seasonal (Spring/Fall)	Yes
2000	Shapefile	Parcel	Annual	Yes
2001	Shapefile	Parcel	Annual	Yes
2002	Shapefile	Parcel	Seasonal (Spring/Fall)	Yes
2003	Shapefile	Parcel	Annual	Yes
2004	Shapefile	Parcel	Seasonal (Spring/Fall)	Yes
2005	Shapefile	Parcel	Seasonal (Spring/Fall)	Yes
2006	Shapefile	Parcel	Seasonal (Spring/Fall)	Yes
2007	Shapefile	Parcel	Seasonal (Spring/Fall)	Yes
2008	Shapefile	Parcel	Seasonal (Spring/Fall)	Yes
2009	Shapefile	Parcel	Seasonal (Spring/Fall)	Yes
2010	Shapefile	Parcel	Seasonal (Spring/Fall)	Yes
2011	Shapefile	Parcel	Seasonal (Spring/Fall)	Yes
2012	Shapefile	Parcel	Seasonal (Spring/Fall)	Yes
2013	Shapefile	Parcel	Seasonal (Spring/Fall)	Yes
2014	Shapefile	Parcel	Seasonal (Spring/Fall)	Yes
2015	Shapefile	Parcel	Seasonal (Spring/Fall)	Yes

Abbreviations: TRS = township-range-section

[8] AEWSD defines a water year (referred to herein as the "District Water Year") as extending from March through February of the following year.

Table K-4-2 – WRMWSD Land Use Data Availability by Water Year

DWR Water Year	Data Format	Spatial Resolution	Temporal Resolution	Includes Irrigation Type?
1995	Shapefile	Parcel	Seasonal (Spring/Fall)	No
1997	Shapefile	Parcel	Seasonal (Spring/Fall)	No
2001	Shapefile	Parcel	Seasonal (Spring/Fall)	No
2002	Shapefile	Parcel	Seasonal (Spring/Fall)	No
2003	Shapefile	Parcel	Seasonal (Spring/Fall)	No
2004	Shapefile	Parcel	Seasonal (Spring/Fall)	No
2005	Shapefile	Parcel	Seasonal (Spring/Fall)	No
2006	Shapefile	Parcel	Seasonal (Spring/Fall)	No
2007	Shapefile	Parcel	Seasonal (Spring/Fall)	No
2008	Shapefile	Parcel	Seasonal (Spring/Fall)	No
2009	Shapefile	Parcel	Seasonal (Spring/Fall)	No
2010	Shapefile	Parcel	Seasonal (Spring/Fall)	No
2011	Shapefile	Parcel	Seasonal (Spring/Fall)	Yes
2012	Shapefile	Parcel	Seasonal (Spring/Fall)	Yes
2013	Shapefile	Parcel	Seasonal (Spring/Fall)	Yes
2014	Shapefile	Parcel	Seasonal (Spring/Fall)	No
2015	Shapefile	Parcel	Seasonal (Spring/Fall)	No

The following subsections of this appendix are organized by Water District and year (or groups of years) based on the associated level of detail required within each land use processing step, given the annual land use data availability constraints outlined above.

Determining Irrigated vs. Non-Irrigated and Urban Lands

As mentioned above, deep percolation is the only major component of total applied water not measured by the ITRC-METRIC dataset within the agricultural lands subdomain. Deep percolation can result from any or all of three main applications of excess water to the ground surface:

1) Intentional operational and/or cultural processes, such as soil leaching
2) Irrigation inefficiencies
3) Excess precipitation

Excess water from operational processes and irrigation inefficiencies are only relevant to the irrigated portion of the Basin, whereas precipitation in excess of vegetative water demands must be considered across the entire Basin area. Therefore, for purposes of this water budget, we have separated the irrigated portion of the Basin from the non-irrigated portion of the Basin (i.e., including agricultural and native vegetation lands as well as urban lands) before estimating deep percolation and total applied water.

AEWSD

District Water Years 1994 – 1996

For District Water Years 1994 – 1996, land use data was in the format of a summary table outlining the major crop / land use types and their associated acreages by year. Major land use types were categorized within the spreadsheet as "Irrigated" or "Non-Irrigated", and within the "Non-Irrigated" category was a subset devoted to "Urban" lands. These categories were subsequently employed within the water budget model.

District Water Years 1997 – 2015

For District Water Years 1997 – 2015, all annual/seasonal land use data included specific columns devoted to both Crop Type as well as Irrigation Type[9]. Irrigation types listed in these records included:

- "S" – Sprinkler
- "C" – Center Pivot Sprinkler
- "L" – Linear Move Sprinkler
- "R" – Side Roll Sprinkler
- "H" – Hand Move Sprinkler
- "P" – Permanent Sprinkler
- "M" – Micro-sprinkler
- "F" – Furrow Irrigation
- "G" – Gravity (Furrow)
- "B" – Border Strip Irrigation
- "D" – Surface Drip Irrigation
- "A" – Buried Drip Irrigation
- "N" – Not Irrigated

The "Irrigation Type" codes were used to decipher irrigated lands (i.e., TRS areas for 1997 – 1999 and parcels for 2000 – 2015) within the 1997 – 2015 land use datasets, by assuming that all entries marked as "N" were **Non-Irrigated**, and all other irrigation codes were considered to be **Irrigated**. From here, the "Crop Type" codes were used to further categorize certain lands as **Urban Lands:**

- "U" – Urban
- "UC" – Commercial
- "UC6" – Commercial (Schools)
- "UF" – Urban (unknown?)
- "UI" – Urban (Industrial)
- "UL" – Urban (Landscape)

[9] Crop & irrigation codes were derived from DWR's "Standard Land Use Legend", accessible online at <http://www.cd.water.ca.gov/land_wateruse/ludata.cfm>

- "UN" – Urban (Unknown?)
- "UR" – Urban (Residential)
- "UV" – Urban (Vacant)
- "UV-K" – Urban (Vacant – Freeways)

In addition, all parcels (or TRS areas) clearly marked as Highways were considered to be **Urban Lands** within this water budget. Associated codes included:

- "HWY 16"
- "HWY 166"
- "HWY 5"
- "HWY 58"
- "HWY 99"
- "HWY ED"
- "HWY 5"

Finally, **Open Water Features** were categorized separately from Urban Lands and Non-Irrigated Lands, though evaporation was ultimately estimated independently for the Artificial Channels subdomain within the water budget spreadsheet model. This allowed for a more accurate estimation of ET on non-irrigated lands that does not include evaporation from open water features. Open water features that were not associated with the Artificial Channels subdomain were ultimately included in the Urban Lands subdomain of the budget, as these features generally corresponded to local storage ponds and/or recreational water bodies.

All of the data processing steps mentioned above were performed in R[10] software to facilitate data processing and reproducibility of results.

WRMWSD

Land use data for the WRMWSD service area for Spring and Fall, 1995, 1997, and 2001 – 2017 was provided in a shapefile entitled "CROPS.shp"[11]. Land use for each parcel was classified on a biannual "seasonal" (i.e., Spring/Fall) basis using crop categories defined in the District's "BAL_XREF" and "CROP_XREF" spreadsheets within the "WRMData_MDB" access database. For the Fall seasons, parcels without crop category information were assumed to have the same crop as was indicated in the Spring season of that same water year (per direction from the District's GIS technician). Parcels were then classified into Irrigated, Non-Irrigated, and Urban categories for each season as follows:

- **"Non-Irrigated"** – land parcels marked as:
  - "NV" – Native Vegetation
  - "DEF" – Idle Lands
  - "FAL" – Fallowed Lands

[10] R is a free software environment for statistical computing and graphics. www.r-project.org

[11] Before the year 2001, the "CROPS.shp" shapefile only contained cropping information for Spring/Fall 1995 and 1997. These were used to infer general land use categories (e.g. "irrigated", "non-irrigated", "urban") for all years before 2001, where Spring/Fall 1995 crops were used to infer land use for Spring/Fall 1994 – 1996, and Spring/Fall 1997 were used to infer land use for Spring/Fall 1997 – 2000.

  - "EUC" – Eucalyptus (not irrigated)
  - "WHD" – Wheat (dry farmed)
  - N/A (i.e., Spring parcels with blank entries)
- **"Urban"** – land parcels marked as "OTH" – Other Lands[12]
- "**Irrigated"** – all other land parcels included in the CROPS.shp

This analysis was performed in R software to facilitate data processing and reproducibility of results.

In areas where the AEWSD and WRMWSD land use data overlap, the AEWSD land use designations where used in the water budget calculations. Areas of the Basin outside the WRMWSD and AEWSD service areas were assumed to be non-irrigated lands and were treated as non-irrigated land in the Agricultural Land subdomain.

Determining Irrigation Methods and Irrigation Efficiency Coefficients

As mentioned above, the contribution of "unintentional overwatering" resulting from irrigation inefficiency must be accounted for in estimating total applied water and deep percolation within the agricultural lands subdomain. As such, a representative irrigation efficiency coefficient must be associated with each irrigation type listed in the land use records.

AEWSD

District Water Years 1994 – 1996

As mentioned previously, for District Water Years 1994 – 1996 the land use records only provided detail on the total acreages of "irrigated" vs. "non-irrigated" lands within the District. Therefore, for the irrigated portion of the District, a uniform irrigation efficiency coefficient was applied for District Water Years 1994 – 1996 that reflected the average, area-weighted irrigation efficiency coefficient across the District (by groundwater subbasin), based off the 1997 – 1999 "Irrigation Type" records, as this was the closest period to 1994 – 1996 with available "Irrigation Type" information.

Based on this methodology, the irrigation efficiency coefficient employed for 1994 – 1996 was 78.7% for the portion of the District within the Basin. See below for more information on how irrigation efficiency coefficients were defined for each "Irrigation Type" listed within this dataset.

District Water Years 1997 – 2015

For District Water Years 1997 – 2015, the "Irrigation Type" data included in the land use records was used to inform irrigation efficiency across the District. Irrigation types were first re-classified as follows:

- **Sprinkler**
  - "S" – Sprinkler
  - "C" – Center Pivot Sprinkler
  - "L" – Linear Move Sprinkler
  - "R" – Side Roll Sprinkler
  - "H" – Hand Move Sprinkler

[12] "OTH" parcels were classified as "urban lands" based on observations from Google Earth, in which most cases "OTH" parcels were recognized as built structures or paved surfaces.

- "P" – Permanent Sprinkler
- **Micro-Sprinkler**
    - "M" – Micro-sprinkler
- **Micro-Drip**
    - "D" – Surface Drip Irrigation
    - "A" – Buried Drip Irrigation
- **Gravity**
    - "F" – Furrow Irrigation
    - "G" – Gravity (Furrow)
    - "B" – Border Strip Irrigation

WRMWSD

In addition to providing seasonal crop categories, the WRMWSD "CROPS.shp" shapefile also included information on parcel-specific irrigation methods for the years 2011, 2012, and 2013. Irrigation methods listed in this shapefile included:

- "MD" – Micro-Drip
- "MS" – Micro-Sprinkler
- "SP" – Sprinkler
- "CP" – Center-Pivot Sprinkler
- "Fur" – Furrow (Surface)
- "NON" – Not Irrigated

For parcels marked as "irrigated" based on the reclassification procedure described above, irrigation methods were assigned as follows:

- For years 2001— 2011, Irrigation Method = "IRR_METH_11" (2011 irrigation data)
- For year 2012, Irrigation Method = "IRR_METH_12" (2012 irrigation data)
- For years 2013—2017, Irrigation Method = "IR_METH_13" (2013 irrigation data)

This analysis was performed in R software to facilitate data processing and reproducibility of results.

From here, an area-weighted average irrigation efficiency coefficient was calculated for each season in the record within each basin, which was then later incorporated into the calculation of deep percolation on irrigated lands. Irrigation efficiencies were initially estimated for each irrigation method based on representative values reported by the Food and Agricultural Organization of the United Nations (FAO)[13] and other commonly used resources, as follows:

- Micro-Drip – **85%**
- Micro-Sprinkler – **80%**
- Sprinkler – **75%**
- Center-Pivot Sprinkler – **70%**

[13] Brouwer, C., Prins, K., & Heibloem, M., 1989, Annex I – Irrigation efficiencies. *Irrigation Water Management Training Manual No. 4 – Irrigation Scheduling*, prepared by the Food & Agricultural Organization of the United Nations.

- Furrow (Surface) – **65%**

These values were included as “User Input Parameters” in the budget to facilitate easy adjustment, but were ultimately left unchanged during the calibration process. WRMWSD parcels marked “NON” (Not Irrigated) in 2011 – 2013 almost always fell into the “Not Irrigated” category based on the crop category classification as described above. However, for years where irrigation methods were not explicitly reported in the data, various parcels may have been irrigated for that year and attributed a “NON” irrigation type if they were not irrigated during 2011 – 2013. For these parcels, the irrigation efficiency coefficient of “NON” was determined as the long-term (2011-2016), acreage-weighted average irrigation efficiency coefficient across the District for all known irrigation types. This weighted average was calculated as **83%** based on the available data, reflecting a dominance of micro-drip irrigation systems within the District.

The resulting irrigation efficiency coefficient (e_{irr}^{i}) for agricultural lands in any month *i* in the water budget period is then calculated as:

$$e_{irr}^{i} = \frac{\sum(0.85*Acreage_{MD}^{i}+0.80*Acreage_{MS}^{i}+0.75*Acreage_{S}^{i}+0.70*Acreage_{CS}^{i}0.65*Acreage_{F}^{i}+0.83*Acreage_{NON}^{i})}{Acreage_{Irrigated\ Lands}^{i}} \quad (1)$$

where $Acreage_{x}^{i}$ = acreage of irrigated lands supplied by *x* irrigation type for month *i*, and where *x* = micro-drip (MD), micro-sprinkler (MS), sprinkler (S), center-pivot sprinkler (CS), furrow (F), and NON (unknown type) irrigation types.

Linking Reclassified Land Use Information to ITRC-METRIC ET Data

On a parallel workflow, monthly ITRC-METRIC data was processed using a GIS model (i.e., automated procedure) that sums observed ET values (in raster format) by a specified set of overlying polygon features (e.g., by GSA boundaries, land use parcels, etc.).

The GIS model employs a Spatial Analyst tool known as “Zonal Statistics” to sum the ET values from each 30 x 30 meter raster pixel within an overlying boundary to determine the total ET value (in inches per month; [in/mo]) within each boundary feature. This is then multiplied by the area of each feature and converted into acre-feet per month (AF/mo) to provide a volumetric estimate of ET (in AF/mo) for each boundary feature for a given month. For this analysis, the selection of overlying boundary features for which to summarize ET within was determined by the data format and spatial resolution of the land use records provided by AEWSD and WRMWSD, and thus varied by year. This process was iterated for the entire set of monthly ITRC-METRIC ET rasters (265 in total) resulting in monthly ET values for each for the entire period of record of the ITRC-METRIC dataset (1993 – 2011, 2013 – 2015).

AEWSD

District Water Years 1994 – 1996

For District Water Years 1994-1996, land use data was provided on a District-wide level in the form of an Excel spreadsheet. As such, EKI chose to summarize monthly ET values from the ITRC-METRIC dataset for January 1994 – February 1997 (i.e., the end of District Water Year 1996) using the overlying GSA boundaries within the District. These included the boundary of the Kern Groundwater Authority GSA (KGA

GSA) within the Kern County Subbasin portion of the District, and the White Wolf GSA (WWGSA) boundary within the Basin portion of the District.

After summarizing monthly ET by GSA, the total irrigated, non-irrigated, and urban acreages as defined by the 1994 – 1996 land use files were subsequently parsed by subbasin under the assumption that the 1997-1999 land use records were generally representative of the subbasin-based distribution of land use within the District during District Water Years 1994 – 1996. Total monthly ET values by subbasin (as derived from the GIS model) were subsequently parsed into the "Irrigated Lands", "Non-Irrigated Lands", and "Urban Lands" subdomains based on the estimated proportion of acreages within each subdomain, by subbasin, derived from the 1997 – 1999 land use records. An example of this process is as follows:

$$ET^{March,1994}_{Irrigated\ Lands,WWB} = Total\ ET^{March\ 1994}_{KGA\ GSA} * \frac{Acreage^{1994}_{Irrigated\ Lands}}{Acreage^{1994}_{Total}} * \%\ Irrigated\ Lands^{1997-1999}_{WWB} \quad (2)$$

whereby

$$\%\ Irrigated\ Lands^{1997-1999}_{WWB} = \frac{mean(Acreage^{1997-1999}_{Irrigated\ Lands,WWB})}{mean(Acreage^{1997-1999}_{Irrigated\ Lands,Total})} \quad (3)$$

This process was iterated for the set of monthly ITRC-METRIC ET rasters spanning January 1994 – February 1997 (i.e., the representative period of the 1994 – 1996 land use records) to produce an aggregated monthly estimate of ET on each subdomain, by basin, within this timeframe.

District Water Years 1997 – 1999

For District Water Years 1997 – 1999, land use data was provided by TRS unit in the form of an Excel spreadsheet. As such, the same approach was employed as for the 1994 – 1996 datasets, whereby monthly ET was summarized by overlying GSA boundaries and subsequently parsed into the Irrigated Lands, Non-Irrigated Lands, and Urban Lands subdomains by subbasin. The only difference here is that, for District Water Years 1997 – 1999, the TRS unit information allows for estimation of the percentage of Irrigated Lands, Non-Irrigated Lands, and Urban lands for the Basin directly, so it was no longer necessary to use an estimation factor as was done for 1994 – 1996. For example, ET on Irrigated Lands can be calculated as follows:

$$ET^{March,1997}_{Irrigated\ Lands,WWB} = Total\ ET^{March\ 1997}_{KGA\ GSA} * \frac{Acreage^{Spring\ 1997}_{Irrigated\ Lands,WWB}}{Acreage^{Spring\ 1997}_{Total,WWB}} \quad (4)$$

This process was iterated for the set of monthly ITRC-METRIC ET rasters spanning March 1997 – February 2000 (i.e., the representative period of the District Water Years 1997 – 1999 land use records) to produce an aggregated monthly estimate of ET on each subdomain for the Basin within this timeframe. Because the 1997 – 1999 land use data is reported biannually, whereas the ITRC-METRIC data is collected monthly, the following time periods were employed to link reclassified land use data to the ITRC-METRIC dataset:

- **"Spring"** – March through August of the calendar year
- **"Fall"** – September through February of the following calendar year

As an example, under this scenario an ITRC raster developed for July 1997 would be linked to the "Spring 1997" land use dataset, whereas an ITRC raster developed for February 1998 would be linked to the "Fall 1997" dataset.

District Water Years 2000 – 2015

For District Water Years 2000 – 2015, land use information was available in a shapefile format by parcel, thus making it possible to summarize monthly ET information by overlying parcel boundaries using the GIS model. Land use shapefiles for the Basin were input into the GIS model to produce a monthly ET breakdown by parcel within the Basin.

This process was iterated for the set of monthly ITRC-METRIC ET rasters spanning March 2000 – December 2015 (apart from 2012, where ITRC-METRIC data was not provided) to produce an aggregated monthly estimate of ET on each parcel within this timeframe. These values were then joined to the reclassified Crop Type & Irrigation Type information using a unique parcel-based key incorporated into both datasets, allowing for the calculation of total ET on each subdomain for the Basin for each month. Because the land use data is reported biannually[14], whereas the ITRC-METRIC data is collected monthly, the following time periods were employed to link reclassified land use data to the ITRC-METRIC dataset:

- **"Spring"** – March through August of the calendar year
- **"Fall"** – September through February of the following calendar year

As an example, under this scenario an ITRC raster developed for July 2003 would be linked to the "Spring 2003" land use dataset, whereas an ITRC raster developed for February 2003 would be linked to the "Fall 2002" dataset.

WRMWSD

Monthly ET values from the ITRC-METRIC dataset were joined to the reclassified crop information for WRMWSD using a unique parcel-based key incorporated into both datasets. Because the crop classification data is reported biannually, whereas the ITRC data is collected monthly, the same time periods used for the AEWSD data were employed to link reclassified WRMWSD land use data to the ITRC-METRIC dataset:

- **"Spring"** – March through August of the calendar year
- **"Fall"** – September through February of the following calendar year

The result of this process is an aggregated monthly dataset containing parcel-based information on:

- Acreage
- Crop type
- Irrigation type (irrigated, not irrigated, urban)
- Irrigation method (if irrigated)
- Monthly ET

[14] For 2000, 2001, and 2003, Spring data was available only and thus was used as the representative land use dataset for the entire water year.

A complicating factor in this process is that the ITRC rasters do not cover the entire WRMWSD area within the Basin, leaving approximately 467 acres of land (~1%) without associated ET data. To account for this gap in coverage, a value for "unused acreage" by parcel was developed based on the difference in acreages of the original and joined datasets. ET was then estimated for the area of each parcel outside of ITRC coverage (if any) by applying the average per-acre ITRC ET rate for each of the three irrigation types (irrigated, not irrigated, and urban) from the covered area. This ensured that the entirety of WRMWSD contained an ET estimate for each month.

The eastern part of the Basin is not covered by the ITRC rasters (5,400 acres). This area was assumed to be non-irrigated lands similar to the other parts of the Basin outside the AEWSD and WRMWSD areas. The monthly ET for these non-irrigated lands was scaled up by a factor proportional to the ratio of the total area of non-irrigated lands to the area of non-irrigated lands covered by the ITRC rasters (factor = 1.15).

Determining Additional Irrigation Demands

As mentioned above, ITRC-METRIC data provides a reasonable estimate of actual ET occurring within the Basin but should not be considered to represent total applied water on Basin lands. In addition to accounting for irrigation inefficiencies, estimates of total applied water must also consider the additional irrigation demands associated with crop leaching and other operational water requirements, as well as account for any contributions of effective precipitation in meeting the ET demand measured by ITRC-METRIC. The following subsections detail how additional irrigation demands are estimated within the analytical water budget model.

Crop Leaching Requirements

As mentioned above, soil leaching is a common practice that can significantly increase the volume of applied water required for long-term operations beyond the ET demands estimated by ITRC-METRIC data. As no specific information on leaching practices (i.e., amounts, locations, timing) was available from AEWSD or WRMWSD, a conventional approach outlined by the FAO and employed by AEWSD's agricultural consultant *JMLord, Inc.* was used to determine leaching requirements based on crop-specific salinity thresholds and estimates of leaching water salinity[15]. For a given crop, the "leaching fraction" (i.e., the incremental portion of irrigation water in excess of crop ET demands required to maintain the soil salinity at levels conducive to optimal crop yield) is defined as follows:

$$LF = \frac{EC_w}{5(EC_e) - EC_w} \quad (5)$$

where LF = leaching fraction [dimensionless], EC_w = electrical conductivity of the irrigation water [deciSiemens per meter; dS/m], and EC_e = crop salinity threshold [dS/m].

From here, the volumetric "leaching requirement" can be calculated as the incremental volume of water needed to satisfy the leaching demand:

$$LR = \frac{ET_c * LF}{1 - LF} \quad (6)$$

[15] Tanji, K.K., & Kielen, N.C., 2002, Annex I – Crop salt tolerance data. *Agricultural drainage water management in arid and semi-arid areas*, prepared by the Food & Agricultural Organization of the United Nations.

where LR = leaching requirement [AF] and ET_c = crop evapotranspiration [AF].

For the purposes of this analysis, leaching demands are calculated for the entire irrigated lands portion of the agricultural lands subdomain for each month. To achieve this, an area-weighted crop-salinity threshold is calculated for the irrigated lands area for each basin based on the relative acreages of each crop category included in AEWSD and WRMWSD's land use datasets (see **Attachment K-4-2** for the list of indicative crop salinity thresholds used in this methodology). A leaching fraction (LF) is then calculated per equation (5) above within the water budget based on the area-weighted crop salinity threshold and an assumed electrical conductivity of irrigation water (EC_w). The EC_w is implemented as a user-adjustable input parameter within the water budget spreadsheet, and was ultimately set at 500 microsiemens per centimeter (µS/cm) in line with the general water quality profile of AEWSD's and WRMWSD's imported surface water supplies. Crop evapotranspiration (ET_c) is estimated from the monthly ITRC-METRIC ET data for irrigated lands, and a monthly leaching requirement (LR) is calculated using equation (6) above.

<u>*Other Operational Demands*</u>

As mentioned above, in addition to soil leaching, other operational practices that require additional applied water are commonly employed for purposes such as pre-irrigation requirements, harvesting, pest control, frost control, crop uniformity, germination, and dust control. As no specific information on specific operational water uses (i.e., amounts, locations, timing) was available from AEWSD or WRMWSD, these additional "operational demands" are estimated from the *JMLord, Inc.* historical agricultural demand reports[16] provided for AEWSD.

Based on the *JMLord, Inc.* reports, it was determined that across AEWSD, agricultural water users were historically applying an additional **0.16 AFY/acre** to their lands on average (over Water Years 1994 – 2015) to meet additional operational demands beyond leaching. This value was employed for the "Additional Operational Demands" User Input Parameter within the analytical water budget model to estimate <u>operational water demands</u> on irrigated lands for any given month:

$$OD^i = \frac{0.16}{12} * Acreage^i_{Irrigated\ Lands} \qquad (7)$$

where OD^i = operational demands for month *i* [AF] and $Acreage^i_{Irrigated\ Lands}$ = irrigated acreage for month *i*.

Processing Precipitation Data

As mentioned above, estimates of total applied water should also take into account any contribution of effective precipitation in meeting ET demands on District lands. The residual "ineffective precipitation" (i.e., the portion of precipitation which is not considered available to meet ET demands) may also contribute to groundwater recharge to a certain degree and should thus be quantified and routed to appropriate subdomains within the analytical water budget to ensure mass balance is fully conserved within the model.

[16] JMLord, Inc., 1998 – 2015. *Arvin-Edison Storage District – Assessment of Reasonable Water Requirements.* Internal Reports.

Calculating Effective Precipitation

Effective precipitation as defined as "the part of rainfall that can be used to meet the evapotranspiration of growing crops. It does not include surface runoff or percolation below the crop root zone." (USDA-SCS, 1970)[17]. Since limited data exists to quantify historical rates of effective precipitation within the Basin, we have chosen to employ an empirical equation developed by the United States Department of Agricultural Soil Conservation Service (USDA-SCS)[18] which factors in measurements of monthly rainfall, evapotranspiration (i.e. crop consumptive use), and estimated depth of application (or "usable soil water storage" depths) to approximate effective rainfall (in inches) for any given month[19]. The resulting equation for estimating monthly effective precipitation [in] is:

$$p_e = f * (0.70917 * p_t^{0.82416} - 0.1156) * 10^{0.02426 * ET_c} \quad (8)$$

where p_e = effective precipitation [in], p_t = total precipitation [in], ET_c = crop evapotranspiration [in], and f = correction factor for irrigation application depths different from 3 inches, where:

$$f = (0.531747 + 0.295164 * D - 0.057697 * D^2 + 0.003804 * D^3) \quad (9)$$

where D = net depth of application during irrigation [in].

Effective precipitation (p_e) was calculated for each month for both irrigated and non-irrigated lands, where D was set to the default value of 3 inches for irrigated lands and set to zero inches for non-irrigated lands. These normalized values were subsequently converted into volumetric effective precipitation rates (in AF per month) using the acreages of irrigated and non-irrigated lands for the given month. For example:

$$P_{e\,Irrigated\ Lands}^{\,i} = \frac{p_{e\,Irrigated\ Lands}^{\,i}}{12} * Acreage_{Irrigated\ Lands}^{i} \quad (10)$$

where $P_{e\,Irrigated\ Lands}^{\,i}$ = effective precipitation on irrigated lands for month i [AF]. A similar calculation was used for the non-irrigated lands.

Effective Precipitation Carryover Term

While a soil moisture balance is not explicitly modeled in this analytical water budget, it is recognized that excess effective precipitation in the rainy winter months of the year may be retained temporarily in the root zone and can help contribute to meeting ET demands in the early growing season, thus reducing the irrigation demand during these months. To account for this phenomenon, we have included an effective precipitation "carryover" term to allow for any residual effective precipitation in excess of ITRC-METRIC ET signal to remain available for meeting ET demands in the following month(s) throughout the model period. This effective precipitation carryover term is defined as:

---

[17] United States Department of Agriculture – Soil Conservation Service (USDA-SCS), 1970. *Irrigation Water Requirements*. USDA-SCSC Technical Release No. 21. 88 pp

[18] *Ibid [17].*

[19] "SCS scientists analyzed 50 years of rainfall records at 22 locations throughout the United States to develop a technique to predict [monthly] effective precipitation (USDA 1970). A daily soil moisture balance incorporating crop [ET], rainfall, and irrigation was used to determine the ET effectiveness." (USDA-SCS, 1993).

$$P_{e\,Carryover}^{\;i} = \max\left(0,\; P_e^i - \; ET^i\right) \tag{11}$$

where $P_{e\,Carryover}^{\;i}$ = carryover of excess effective precipitation from month *i* [AF], P_e^i = effective precipitation for month *i* [AF], and ET^i = ITRC-METRIC measured ET for month *i* [AF].

This effective precipitation carryover term is subsequently added to the effective precipitation value calculated for the following month:

$$P_e^{i+1} = +P_{e\,initial}^{\;i+1} + \; P_{e\,Carryover}^{\;i} \tag{12}$$

where P_e^{i+1} = adjusted effective precipitation for month *i + 1* [AF], $P_{e\,initial}^{\;i+1}$ = initial effective precipitation for month *i +1* (calculated from equations 8 – 10) [AF], and $P_{e\,Carryover}^{\;i}$ = effective precipitation carryover term from month *i* [AF] (calculated from equation 11).

<u>Parsing Ineffective Precipitation</u>

As mentioned above, "ineffective precipitation" is defined as the portion of total (direct) precipitation that is not considered available to meet ET demands:

$$P_{ineff}^i = P_t^i - \; P_{e\,initial}^{\;i} \tag{13}$$

where P_{ineff}^i = ineffective precipitation for month *i* [AF], P_t^i = total precipitation for month *i* [AF], and P_e^i = initial effective precipitation for month *i* [AF] (calculated from equations 8 – 10).

Ineffective precipitation can either (1) runoff as a surface outflow from the water budget domain; (2) evaporate from the land surface before infiltrating into the root zone; or (3) percolate from the root zone into the vadose zone, where it eventually becomes groundwater recharge. As mentioned above, (1) surface runoff outside of the Basin is considered negligible in this water budget, leaving (2) evaporation and (3) deep percolation as the only pathways for parsing ineffective precipitation. Very little historical data or reference information exists for quantifying the proportions of evaporation versus deep percolation for ineffective precipitation, so we have chosen to define an **"ineffective precipitation deep percolation coefficient"** (f_{DP}) user input parameter to apportion these flux components within the model. Here, the <u>portion of ineffective precipitation contributing to deep percolation</u> for a given month (P_{DP}^i) is defined as:

$$P_{DP}^i = P_{ineff}^i * f_{DP} \tag{14}$$

where P_{ineff}^i = ineffective precipitation for month *i* [AF], and f_{DP} = ineffective precipitation deep percolation coefficient [-].

Consequently, the <u>portion of ineffective precipitation that will evaporate from the land surface</u> for a given month (P_{evap}^i) is defined as:

$$P_{evap}^i = P_{ineff}^i * (1 - f_{DP}) \tag{15}$$

Notably, P^i_{evap} is included as a unique evaporative flux component from the water budget domain in addition to ITRC-METERIC derived ET, as opposed to assuming that evaporation of ineffective precipitation was included in the ITRC-METRIC signal. Though the ITRC-METRIC method is considered a generally reliable estimator of actual ET over large spatial domains, it faces certain limitations, particularly in the winter months where usable LANDSAT satellite imagery may not be available due to the presence of clouds, etc., and/or satellite imagery may not adequately capture the evaporation occurring from wetted soils immediately following a precipitation event[20]. With this constraint in mind, and under the observation that ITRC-METRIC measured ET in the winter months (i.e., November – February) was usually significantly lower than reference ET (ETo) measured at the nearby Arvin CIMIS Station 125 for the same months, it was determined that an additional "evaporation of ineffective precipitation" term (P^i_{evap}) was warranted for estimating evaporation of ineffective rainfall during the winter months when it is likely to be underestimated by the ITRC-METRIC method. Inclusion of P^i_{evap} also results in a more reasonably conservative estimate of groundwater recharge from ineffective precipitation (P^i_{DP}) during the wet season.

The ineffective precipitation deep percolation coefficient (f_{DP}) user input parameter was ultimately determined via calibration of the water budget model, as described further in **Appendix K-5**. A constant value of f_{DP} = 0.55 (i.e., 55% deep percolation of ineffective precipitation) was used for the White Wolf Subbasin analytical water budget model.

Calculating the Total Irrigation Demand and Agricultural Groundwater Pumping

Following the above methodologies to calculate the monthly ET demand, irrigation efficiency, leaching and other operational demands, and contributions of effective precipitation, the total irrigation demand within the Basin can be determined. After accounting for the volume of surface water deliveries to irrigated lands from AEWSD and WRMWSD monthly operations records, the volume of groundwater pumping for irrigation (otherwise termed "agricultural groundwater pumping") can also be estimated for any given month during the water budget period.

For any given month (*i*), the unadjusted irrigation demand is defined as the ET demand on irrigated lands minus any contributions of effective precipitation:

$$I^i_{demand} = \max\left(0, ET^i_{Irrigated\ Lands} - P_{e}{}^{i}_{Irrigated\ Lands}\right) \tag{16}$$

where I^i_{demand} = unadjusted irrigation demand [AF], $ET^i_{Irrigated\ Lands}$= ITRC-METRIC ET on irrigated lands [AF], and $P_{e}{}^{i}_{Irrigated\ Lands}$ = effective precipitation on irrigated lands [AF] (equation 12) for month *i*.

The adjusted irrigation demand is then computed as follows:

$$I^i_{demand,adj} = I^i_{demand} * \left(1 + \left(1 - e^i_{irr}\right)\right) + LR^i + OD^i \tag{17}$$

where e^i_{irr} = irrigation efficiency coefficient (equation 1), LR^i = leaching requirement (equation 6), and OD^i = operational demands (equation 7) for month *i.*

[20] *Ibid [2].* See full ITRC-METRIC report for further details.

As seen in equations (16) and (17), if the unadjusted irrigation demand (I_{demand}) is less than zero (i.e., if there is effective precipitation in excess of the measured ET on irrigated lands) than I_{demand} is set to zero and the adjusted irrigation demand only includes the leaching requirements & operational demands for that given month.

From here, we can calculate agricultural groundwater pumping ($GW^i_{pumping}$) for month *i* as the residual of the surface water deliveries to irrigated lands and the adjusted irrigation demand:

$$GW^i_{pumping} = \max\left(0, I^i_{demand,adj} - SW^i_{deliveries}\right) \tag{18}$$

where $SW^i_{deliveries}$= surface water deliveries[21] [AF] for month *i*.

If surface water deliveries to irrigated lands are greater than the adjusted irrigation demand, then there is no additional need for irrigation water and agricultural groundwater pumping term is thus set to zero.

Calculating Instantaneous and Time-Averaged Deep Percolation

Using the above methodology, total applied water (*TAW)* [AF] is intrinsically calculated within the water budget as follows:

$$TAW^i = SW^i_{deliveries} + GW^i_{pumping} \tag{19}$$

For the irrigated lands, *TAW* includes groundwater pumping and surface water deliveries after accounting for effective precipitation on the irrigated portion of the Basin (see equation 16). The *TAW* term therefore inherently reflects all assumptions about irrigation efficiency, leaching, operational requirements, and effective precipitation, as these values are included in the calculation of groundwater pumping within the irrigated portion of the Basin. TAW reduces to zero for non-irrigated lands, while for urban lands TAW will only include surface water deliveries to municipal & industrial (M&I) customers, and/or any M&I groundwater pumpage.

From here, the total instantaneous deep percolation on irrigated lands ($DP^i_{inst_{Irrigated\ Lands}}$) [AF] for month *i* is calculated as:

$$DP^i_{inst_{Irrigated\ Lands}} = TAW^i - ET^i_{Irrigated\ Lands} + P^i_{DP_{Irrigated\ Lands}} \tag{20}$$

where $ET^i_{Irrigated\ Lands}$ = ITRC-METRIC ET on irrigated lands [AF] and $P^i_{DP_{Irrigated\ Lands}}$= portion of ineffective precipitation contributing to deep percolation on irrigated lands (equation 14) [AF].

For the irrigated lands, this term will reflect all deep percolation resulting from inefficient precipitation, irrigation inefficiency, leaching demands and any other operational water uses.

For the non-irrigated lands, TAW is, by definition, zero and the total instantaneous deep percolation on non-irrigated lands ($DP^i_{inst_{Non-Irrigated\ Lands}}$) can be re-written as:

[21] The term "surface water deliveries" is used here to refer to deliveries by the District to its customers within the Surface Water Service Area through the District's conveyance system. These deliveries may in fact include some groundwater recovered from storage by the District's recovery wells.

$$DP^{i}_{inst_{Non-Irrigated\ Lands}} = P^{i}_{e_{Non-Irrigated\ Lands}} - ET^{i}_{Non-Irrigated\ Lands} + P^{i}_{DP_{Non-Irrigated\ Lands}} \quad (21)$$

Note that in equation 21 deep percolation includes a contribution from effective precipitation on non-irrigated lands ($P^{i}_{e_{Non-Irrigated\ Lands}}$). This term is included in equation 21 as a mass-balance closure term, since it is not intrinsically considered in the calculation of TAW as it is for the irrigated lands subdomain. By definition of P^{i}_{e} in equation 12, this term should include all carryover effective precipitation from previous months where $P^{i}_{e_{Non-Irrigated\ Lands}} > ET^{i}_{Non-Irrigated\ Lands}$ so as to prevent any effective precipitation from percolating below the root zone, thus reducing equation (21) to only include $P^{i}_{DP_{Non-Irrigated\ Lands}}$. However, it has been noted that the ITRC-METRIC measured $ET_{Non-Irrigated\ Lands}$ routinely exceeds $P_{e_{Non-Irrigated\ Lands}}$ estimates during the dry season, thus resulting in a negative $DP^{i}_{inst_{Non-Irrigated\ Lands}}$ during the summer months. Whether or not this high ET signal in the non-irrigated portions of the District is an artifact of the ITRC-METRIC method or is in fact a real signal, for the purposes of this water budget a negative $DP^{i}_{inst_{Non-Irrigated\ Lands}}$ value results in a net reduction of groundwater storage from the non-irrigated subdomain for the given month.[22]

Though the instantaneous deep percolation value serves as a closure term within the irrigated and non-irrigated lands water budget subdomains, in reality, because the groundwater table can occur several hundred feet below the ground surface, it may take a considerable time for deep percolation to travel through the thick vadose zone before it actually reaches the groundwater table and adds to groundwater storage. For the purposes of this water budget, this "lag effect" is represented by including a "Deep Percolation Lag Period" as a user input parameter within the water budget. This allows the user to specify an estimated time (in months) that it would take for any deep percolation water to travel through the vadose zone and reach the groundwater table. The resulting "time-averaged" deep percolation, DP_{avg} [AF], is thus calculated as a moving average as follows:

$$DP_{avg} = \frac{\sum_{i-N}^{i} DP^{i}_{inst}}{N+1} \quad (22)$$

where *N* = the deep percolation lag period [months].

This value represents the estimated volume of "deep percolation" that actually reaches the groundwater table on a given month. For the AEWSD water budget, a final deep percolation lag period of **11 months** was selected, so the amount of deep percolation recharging the groundwater basin for a given month would equal the time-averaged deep percolation (DP_{avg}) percolation for the past 11 months up to the present. Use of this time-averaged deep percolation (i.e., use of a moving average) results in a smoothed-out time series of recharge. This method was also applied to the recharge from stream flows into the

[22] It should be noted that the excess non-irrigated demand likely does not come from groundwater storage depletion, but is rather made up by a combination of local runoff from adjacent irrigated lands, contributions from streamflows, and/or seepage from natural and artificial water systems. Functionally, it is justified to attribute this demand to groundwater storage depletion, because if it were to come from surface water it would then reduce the amount of surface water available for delivery to agricultural lands which would increase the demand for pumping, and so the same result is achieved.

Basin, seepage from man-made channels (negligible), return flows from urban water use, and recharge from spreading basin operations (spreading basin lag period = 3 months).

Conclusions

The result of the above processing steps is a water budget for the agricultural lands subdomain that:

- Incorporates direct measurements of ET from the land surface using ITRC-METRIC data as well as estimates of direct precipitation from local climate stations;

- Links monthly ITRC-ET data to seasonal, parcel-based land use details;

- Parses ET into buckets of (1) irrigated lands, (2) non-irrigated lands, and (3) urban lands;

- Calculates estimates of agricultural pumping and deep percolation on irrigated lands due to ineffective precipitation, irrigation inefficiencies, leaching, and operational demands;

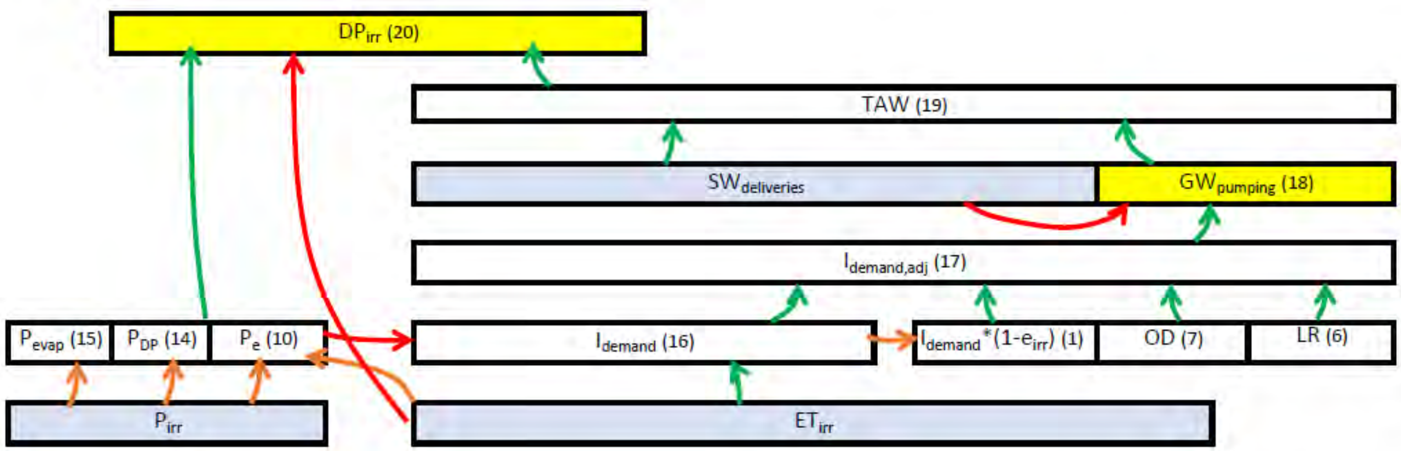
- Calculates estimates of deep percolation on non-irrigated lands due to ineffective precipitation;

- Factors in a user-defined lag period to represent the time lag effect of vadose-zone flow on groundwater recharge due to deep percolation; and

- Accounts for evaporation of ineffective precipitation in the winter months where ITRC-METRIC ET data may not fully capture evaporation after rain events due to gaps in imaging frequency and/or less-reliable interpolations between imaging dates.

The attached **Figure K-4-2** provides a schematic of the irrigated agricultural lands subdomain equations and their interrelationships as described above.

For Irrigated Lands:



Legend

= Raw Data

= Quantity of Interest

= Calculated by Sum

= Calculated by Difference

= Calculated using Multiplication by a Calibration Factor or other constant

(#) = Corresponding equation in Appendix J-4-2

Abbreviations

ft = feet

ft msl = feet above mean sea level

eki environment & water

Irrigated Agricultural Lands
Equations & Interrelationships

Tejon-Castac Water District
Kern County, California
December 2019
EKI B50001.05

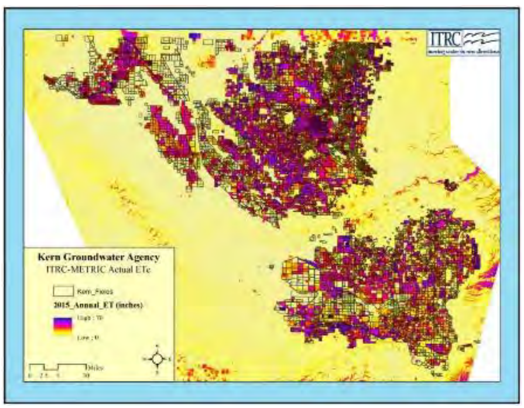
Figure K-4-2

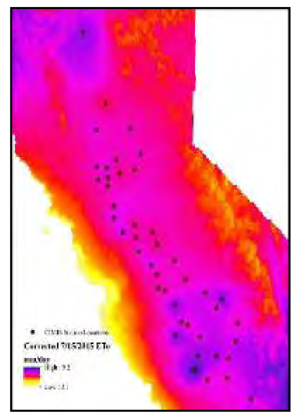
Attachment K-4-1

2015 ITRC-METRIC ET Study Report (GEI)

Kern Groundwater Authority

1993-2016 ITRC-METRIC ETc for Kern County





Prepared by
Daniel J. Howes, Ph.D., P.E.
Project Manager
Irrigation Training and Research Center
California Polytechnic State Univ.
Office: 805-756-2347, Mobile: 858-354-0504
djhowes@calpoly.edu

Prepared for
Kern Groundwater Authority
c/o Eric Averett, General Manager
Rosedale-Rio Bravo WSD
P.O. Box 20820, Bakersfield, CA 93390-0820
Phone: 661-589-6045
eaverett@rrbwsd.com

June 2018

ITRC moving water in new directions

IRRIGATION TRAINING & RESEARCH CENTER
California Polytechnic State University
San Luis Obispo, CA 93407-0730
Office Phone: (805) 756-2434 FAX: (805) 756-2433
www.itrc.org

Table of Contents

List of Figures

List of Tables

Kern Groundwater Authority
1993-2016 ITRC-METRIC

Introduction

The Irrigation Training & Research Center (ITRC) at California Polytechnic State University, San Luis Obispo was contracted by the Kern Groundwater Authority (KGA) to compute actual evapotranspiration (ETc) from the Southern San Joaquin Valley within and near the Kern Groundwater Basin. The area of interest is shown in Figure 1 with a "natural color" image in the background.

ITRC uses a modified Mapping of EvapoTranspiration with Internal Calibration (METRIC^{TM}) procedure to compute actual evapotranspiration using LandSAT Thematic Mapper (LandSAT) data. The original METRIC procedure was developed by Dr. Richard Allen (University of Idaho). ITRC has made a number of modifications to the original procedures including using a grass reference evapotranspiration instead of alfalfa, a semi-automated calibration procedure, spatially interpolated ETo, modifications to the aerodynamic resistance and albedo computations for certain crops, improved open water evaporation algorithm, etc.

Figure 1. Aerial image of the area of interest within which actual evapotranspiration was provided to KGA

This report will describe the general process and some results of the modeling over the timeframe. The monthly and annual results of ITRC-METRIC for this project have been transmitted to KGA (care of Eric Averett, General Manager, Rosedale-Rio Bravo WSD).

ITRC- METRIC Procedures

This *Procedures* section will discuss the information that was gathered and used to compute the actual crop evapotranspiration (ET) in the Delta. The ITRC-METRIC process is based on a surface energy balance and includes corrections for aerodynamic resistance. It depends upon both accurate and frequent LandSAT satellite thermal images and understanding of the cropping systems within a region. The METRIC programs have gradually evolved from research in the US and other countries with the objective of being able to directly estimate actual ET over large areas with limited data availability (such as crop type, irrigation method, irrigation practices, etc.). The image processing is relatively fast; however, the collection of significant background data (besides the satellite images) that are necessary to start the processing in a new area can be somewhat time-consuming. Proper use of METRIC also requires expert input/interpretation by those who run the program.

LandSAT 5, 7, and 8 image pixel resolution is 30 meters by 30 meters for all but the thermal band. The thermal band pixel resolution is 120 meters by 120 meters for LandSAT 5, 60 meters by 60 meters for LandSAT 7, and 100 meters by 100 meters for LandSAT 8. For this project, the thermal band was sharpened to 30 meter by 30 meter resolution using the nominal cubic spline that is provided in the raw images by USGS. ITRC has a more advanced thermal sharpening process, but that was not used because of time and budget constraints for this project. Inputs into the ITRC-METRIC model included:

- LandSAT imagery
- Digital elevation maps
- NASS CropScape data
- Corrected weather station data (hourly and daily)
- Corrected spatial grass reference evapotranspiration (ETo) maps (daily)
- Spreadsheet calculated values
- Tabulated constants

A critical benefit of using ITRC-METRIC to determine actual evapotranspiration is that land use/crop type information is not needed. Therefore, inaccuracies of determining land use are not part of the uncertainty in ETc output. General land use information (row crop, orchard, etc.) is used to correct for aerodynamic influences on ETc. The information provided through the NASS CropScape is of sufficient accuracy for this piece of the process.

Satellite Images

LandSAT 5, LandSAT 7, and LandSAT 8 images available from the United States Geological Survey (USGS) on sixteen-day intervals were used for the METRIC process. Table 1 shows the time frame of available images from each satellite.

Table 1. Time frame of available images for LandSAT 5, 7, and 8

LandSAT 5	LandSAT 7**	LandSAT 8
November 1982 – October 2011	June 1999 – Present	April 2013 – Present

***After May 2003, LandSAT 7 began producing images with missing data, or "bandgaps" because of a defective sensor/mirror. LandSAT 7 is only used as a backup if other LandSAT data is missing. Bandgaps are filled using interpolation techniques in GIS as described in the METRIC Application Manual Version 2.0.7 (Allen et al. 2010)*

The area of interest is covered by the LandSAT image path 42, rows 35 and 36**.** Each path identifies a path, or single trip the LandSAT takes, and the rows are different portions of that path. The rows along the same path are taken on the same day and the center of the row image is taken at approximately the same time of the day (approximately 11 a.m. Pacific Standard Time).

The METRIC modeling process relies on surface temperature data from the LandSAT thermal band. Actual ETc cannot be computed for the regions covered by clouds or fog. Figure 2 compares a non-clouded image with a cloud-covered LandSAT image. The best quality (minimal clouds and fog) LandSAT images were selected for processing. Every LandSAT image available throughout the study period was evaluated manually.

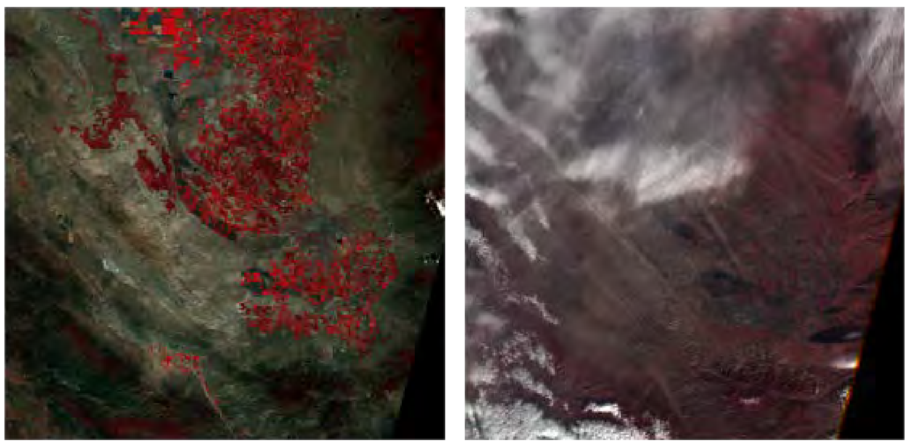


Figure 2. Cloud free LandSAT image (left) and LandSAT image with clouds (right)

All relatively cloud-free available images were used for the modeling process. Table 2 lists the images processed from late 1992 through early 2016. A total of 234 images were used to cover the study period.

If a cloud-free image was not available during a month, the image with the fewest clouds was selected or LandSAT 7 imagery was used. If an image with clouds had to be used, the clouds were masked out of the results and replaced with interpolated results from images processed before and after the image date. For the cloud masking interpolation, the two previous and three subsequent processed images were used to estimate the actual crop coefficient for the cloudy region.

Some months (generally during winter) had no usable images because of significant cloud cover. Available images, before and after the month with no data, were selected to be used to interpolate the missing image.

For those cases when three or more consecutive months did not have usable images, the closest available image was used in combination with a correction factor, to get an average estimated Kc map for the missing month. Those correction factors were established based on data from years with usable winter images. Because this process was used only for winter months, which have low ET, the overall accuracy should not be influenced significantly. However, users should understand that the uncertainty of the data for these months is greater than if LandSAT images were available. The months when this process was used can be seen in Table 3.

Table 2. Chosen image dates for 1993-2016 Kern County METRIC process

1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
10/1/1992	2/25/1994	4/1/1995	4/3/1996	3/5/1997	3/8/1998	1/22/1999	2/2/2000*	1/3/2001*	2/7/2002*	3/6/2003
12/20/1992	3/13/1994	5/3/1995	5/21/1996	4/6/1997	4/9/1998	2/23/1999	3/21/2000*	2/4/2001*	3/3/2002	4/7/2003
3/10/1993	6/1/1994	6/3/1995	6/22/1996	5/8/1997	5/27/1998	3/27/1999	4/30/2000	3/24/200*	4/12/2002*	6/10/2003
4/27/1993	6/17/1994	7/6/1995	7/8/1996	6/9/1997	6/28/1998	5/14/1999	5/24/2000	4/17/2001	5/14/2002*	7/12/2003
5/29/1993	7/3/1994	7/22/1995	7/24/1996	7/11/1997	7/14/1998	6/15/1999	6/17/2000	5/11/2001*	6/15/2002	8/13/2003
6/30/1993	8/4/1994	8/7/1995	8/9/1996	7/27/1997	7/30/1998	7/17/1999	7/3/2000	6/20/2001	7/9/2002	8/29/2003
7/16/1993	9/5/1994	9/8/1995	9/10/1996	8/28/1997	8/31/1998	7/25/1999*	7/19/2000	7/14/2001*	7/25/2002	9/14/2003
8/1/1993	9/21/1993	10/10/1995	9/26/1996	9/29/1997	9/16/1998	8/2/1999	8/12/2000*	7/30/2001*	8/18/2002*	10/16/2003
8/17/1993	10/23/1993	11/11/1995	11/29/1996	10/15/1997	10/18/1998	9/3/1999	9/29/2000*	8/23/2001	9/19/2002*	11/25/2003*
9/2/1993					11/19/1998	10/5/1999	10/7/2000	9/16/2001*	10/21/2002*	
10/20/1993					12/5/1998	11/22/1999	11/16/2000*	10/18/2016*	12/8/2002*	
11/5/1993						12/24/1999	12/26/2000	11/3/2001*		
								12/13/2001		

2004	2005	2006	2007	2008	2009	2010	2011	2014	2015
3/16/2004*	1/30/2005*	1/25/2006	1/12/2007	2/16/2008	1/17/2009	2/13/2010*	2/8/2011	12/14/2013**	1/2/2015**
4/9/2004	4/12/2005	2/10/2006	2/21/2007*	3/19/2008	2/2/2009	4/26/2010	3/4/2011*	12/30/2013**	2/27/2015*
5/11/2004	5/14/2005	4/7/2006*	3/17/2007	4/20/2008	3/30/2009*	5/12/2010	4/29/2011	1/15/2014**	3/7/2015**
6/12/2004	6/15/2005	5/7/2006*	4/10/2007*	5/30/2008*	4/23/2009	6/29/2010	5/7/2011*	2/24/2014*	4/16/2015*
7/14/2004	7/1/2005	5/17/2006	5/20/2007	6/23/2008	5/25/2009	7/15/2010	6/16/2011	4/13/2014*	5/10/2015**
7/30/2004	7/17/2005	6/18/2006	6/21/2007	7/25/2008	6/26/2009	7/31/2010	7/2/2011	4/29/2014*	6/11/2015**
8/31/2004	8/18/2005	7/20/2006	7/7/2007	8/10/2008	7/12/2019	8/16/2010	8/3/2011	5/23/2014**	7/13/2015**
9/16/2004	9/19/2005	8/5/2006	8/8/2007	8/26/2008	7/28/2009	9/17/2010	9/4/2011	6/24/2014**	7/29/2015**
10/2/2004	10/5/2005	8/21/2006	8/24/2007	9/27/2008	8/29/2009	10/3/2010	10/22/2011	7/10/2014**	8/14/2015**
	11/14/2005*	9/22/2006	9/25/2007	10/13/2008	9/30/2009	11/12/2010*	11/15/2011*	8/27/2014**	9/23/2015 *
		10/8/2006	10/19/2007*	11/14/2008	10/24/2009*	12/6/2010	12/1/2011*	9/12/2014**	10/09/2015*
		11/9/2006	11/4/2007*		11/17/2009		1/18/2012*	10/14/2014**	11/18/2015**
		12/19/2006*			12/3/2009		2/3/2012*	11/7/2014*	2/6/2016**

Note: * indicates LandSAT 7, ** indicates LandSAT 8, and no asterisk indicates LandSAT 5 images

Table 3. Months with data estimated by the factor process

1994	1995	1996	1997	1998	2003	2004
November December	January February March December	January February March December	January February November December	January February	December	January February

Weather Data

ITRC-METRIC utilizes daily spatially varied grass reference ETo for interpolation between image dates. SpatialCIMIS is a product provided by the California Irrigation Management Information System (CIMIS) maintained by the California Department of Water Resources (DWR). Spatially varied ETo is developed by interpolating ETo between CIMIS weather stations, which measure and compute the ETo on an hourly basis. However, the collected data could have errors. Therefore, ITRC quality controls the hourly weather data at each weather station in the Central Valley (Redding to south of Bakersfield) and corrects the daily Spatial CIMIS data.

ITRC-METRIC also relies on hourly weather data from a station within the area of interest for processing the instantaneous images (prior to interpolation). The Shafter and Famoso CIMIS stations were utilized as the "primary" weather stations. These stations were selected because of their centralized locations within the primary area of interest. Shafter was used from 1992-1997 and Famoso was used from 1998-2015. The same quality control procedure was used at all weather stations, as will be described.

Hourly weather data for the project time frame was collected from CIMIS weather stations located throughout the project area. Forty-nine weather stations were used for the METRIC modeling process. Figure 3 shows the majority of weather stations used in this project. Not all stations were available during the entire analysis period. Each station is listed in Table 4 showing the approximate range of time that the station was utilized. A station may have become active or inactive within this timeframe.

The weather component data collected from the weather stations included:

1. Solar radiation (W/m^2)
2. Vapor pressure (kPa)
3. Air temperature (ºC)
4. Wind speed (m/s)
5. Precipitation (mm)
6. Relative humidity (%)
7. Dew point temperature (ºC)
8. PM ETo (mm)

Figure 3. Locations of the CIMIS weather stations used in this evaluation

Table 4. Weather stations used for the METRIC modeling process

1993-2004 CIMIS Station	2005-2015 CIMIS Station
Arvin-Edison	Alpaugh
Auburn	Arvin-Edison
Belridge	Auburn
Blackwells Corner	Belridge
Brentwood	Blackwells Corner
Browns Valley	Brentwood
Bryte	Browns Valley
Colusa	Bryte
Davis	Colusa
Dixon	Davis
Durham	Delano
Esparto	Denair II
Fair Oaks	Dixon
Famoso	Durham
Firebaugh-Telles	Esparto
FivePoints	Fair Oaks
FresnoState	Famoso*
Gerber	Firebaugh
Gerber South	Five Points
Hastings Tract East	Five Points SW
Kesterson	Fresno State
Kettleman	Gerber
Lindcove	Gerber South
Los Banos	Hastings Tract East
Madera	Kesterson
Manteca	Kettleman
Merced	Lindcove
Modesto	Lodi West
Orange Cove	Los Banos
Panoche	Madera
Parlier	Madera II
Shafter*	Manteca
Shasta College	Merced
Stratford	Modesto
Twitchell Island	Oakdale
Verona	Orange Cove
Westlands	Panoche
Winters	Parlier
Woodland	Patterson
	Porterville
	Shafter
	Shasta College
	Stratford
	Tracy
	Twitchell Island
	Verona
	Westlands
	Winters
	Woodland

* "Primary" stations

All collected **hourly** weather data from the stations went through a quality control check and correction procedure. A detailed procedure on the quality control conducted can be found in FAO Irrigation and Drainage Paper No. 56[1] along with correction procedures. The main variable needing correction to accurately compute the hourly ETo is solar radiation. However, relative humidity was also examined using the procedures described in Allen et al. (1998). Figure 4 contains a graph of the corrected solar radiation for the Famoso CIMIS station for 2010-2014. This weather parameter is often in error if a pyranometer becomes covered with dust or debris, or if it loses calibration. This can be identified by comparing the daily incoming solar radiation with the maximum potential solar radiation (computed based on elevation, latitude, and time of year). If the measured value does not approach or become equal to the maximum potential over a time frame of several weeks, this could indicate an error in the measurement. Day-to-day variability is expected, but during a clear day, the measured should approach the potential. High values of solar radiation can be caused by incorrect sensor calibration.

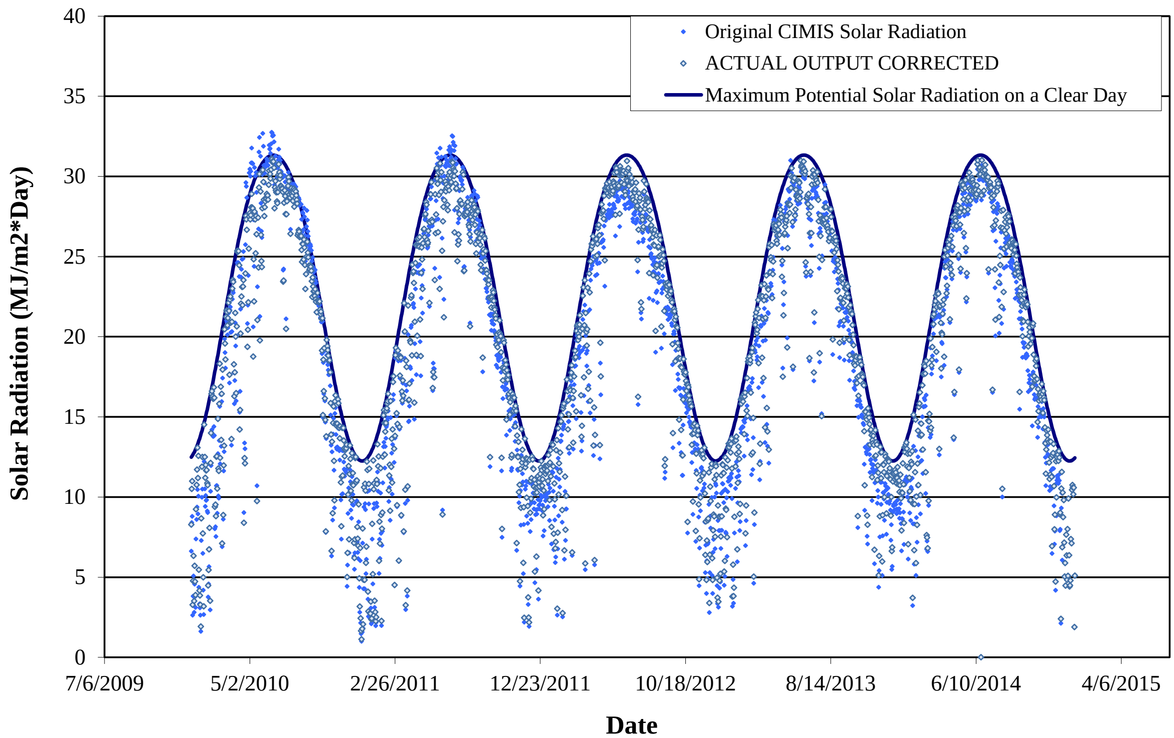


Figure 4. Example of solar adjustments made on Famoso CIMIS Station for 2010-2014. The same analysis was conducted for all weather stations in the Central Valley.

For missing data, or if an error was flagged on the CIMIS station signifying missing, incomplete, or odd data results, data were examined for general consistency. Missing data and data believed to be in error were corrected. The correction procedure used in this analysis replaced the missing or flawed data with the averages from nearby weather stations. Once all hourly data was corrected, the data was input into REF-ET™ (Dr. Richard Allen, University of Idaho) to compute the corrected hourly ASCE Standardized ETo that was used in this study.

[1] Allen, R.G.; Pereira, L.S.; Raes, D. & Smith, M. (1998). Crop evapotranspiration – Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper, No. 56, FAO, Rome

ETo and individual weather data are used within the ITRC-METRIC process to compute inputs into the software. METRIC computes the instantaneous ETc for every pixel within the LandSAT image at the instant the image is taken. Knowing the ETo at that instant from the local weather station, a **crop coefficient (Kc)** can be computed (Kc = ETc/ETo). It has been shown that this instantaneous actual Kc at the time of image acquisition (approximately 11 a.m.) is a very good representation of the Kc for that entire day. These instantaneous Kc results are interpolated using a cubic spline procedure between image dates. The interpolated pixel Kc for each day is then multiplied by the daily corrected spatial ETo discussed in the next section.

Corrected Spatial ETo

Spatial CIMIS ETo is a relatively new resource available through the DWR. A specialized algorithm uses weather station data, elevations and other inputs to interpolate ETo between stations. However, Spatial CIMIS ETo rasters rely on CIMIS weather data that could have errors. In order to improve accuracy, ITRC incorporated the corrected CIMIS weather data into the Spatial CIMIS ETo raster images using a model we developed for ArcGIS 10.1.

The basic correction procedure first included adding the locations of all 49 stations into GIS. The uncorrected Spatial ETo at the weather station location was extracted for each day over the time frame investigated. The difference between the corrected daily ETo for each station and the uncorrected Spatial ETo was computed. These differences were used to generate a difference raster using Inverse Distance Weighting (IDW) interpolation. The difference raster was combined with the uncorrected Spatial ETo to generate the corrected Spatial ETo image.

Figure 5 shows a comparison of the uncorrected Spatial CIMIS ETo and the corrected Spatial ETo for July 15, 2015. The corrected Spatial ETo represents the combination of our corrected ETo data blended with the original Spatial CIMIS ETo.

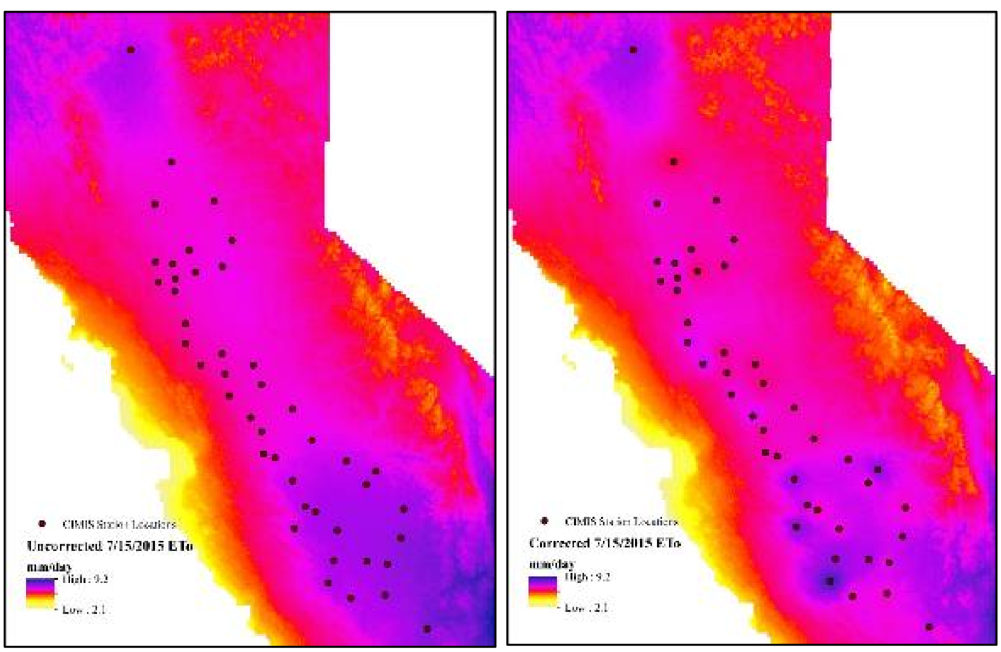


Figure 5. Example of uncorrected Spatial CIMIS ETo compared to corrected Spatial ETo for July 15, 2015

Calibration near Primary Weather Station

The METRIC process requires calibration of the hot and cold pixel for each image processed. The calibration should be conducted near a primary weather station within the image. Therefore, a primary weather station was selected for each image path. The stations selected (Shafter (1993-1997) and Famoso (1998-2015)) were chosen on the basis of the stations' history of reliable, relatively error-free data. Other reasons for choosing primary stations included:

- The location within intensive agricultural areas.
- Relatively representative of weather throughout the agricultural regions in the path.

Shafter was used as a primary station for the years 1993 through 1997. Famoso was used as a primary station for the remainder of the study period.

For the semi-automated calibration process, an area of interest (AOI) is created around the primary weather station. This AOI is generally within a 5 to 10 mile radius of the primary station and urban areas, or large non-agricultural areas are avoided. Figure 6 shows the calibration AOI for the Famoso CIMIS station.

Figure 6. Famoso CIMIS station calibration area of interest (AOI)

Elevation Data

A Digital Elevation Model (DEM) obtained from the USGS was used to adjust the model outputs based on the surface elevation throughout the area of interest. The DEM used had a resolution of 10m (1/3 arc second) which was then re-projected into a 30m × 30m pixel size to match the resolution of the LandSAT images.

Land Use Map

As previously mentioned, accurate land use/crop types are not necessary for ITRC-METRIC. General information on whether land is natural vegetation, row/field crops, orchards, or vineyards is used to adjust for aerodynamic resistance of the canopy, and is also a function of leaf area index. NASS CropScape provides sufficient accuracy for this information.

Land Use Data 2007 to Present

For years 2007 to present, only the land use data from the NASS annual rasters were used. While this information is sufficient for METRIC, there are issues with consistency within fields. Land use surveys were conducted by the California DWR on a field-by-field basis for all of the counties located in the Central Valley. DWR land use survey shapefiles were downloaded for each county, some of which may have last been surveyed in the 1990s. The shapefiles contain field boundaries or in some cases boundaries of the same crop that cover multiple fields. All non-agricultural areas in the DWR land use surveys were removed from the shapefile. Using the zonal statistics tool in ArcGIS, the NASS land use was summarized for each DWR agricultural field boundary in the Central Valley. The crop that made up the majority of the field area was assumed to cover the entire field area.

The final corrected land use maps went through a quality control check to ensure that a single land use value was uniform across an entire field. Figure 7 shows an example of the original uncorrected NASS land use compared to the land use used in this analysis, which is much more consistent. The inconsistent "pixelated" areas in the corrected land use were identified as non-cropped areas in the DWR land use survey. Therefore, these non-ag areas use the original NASS data.

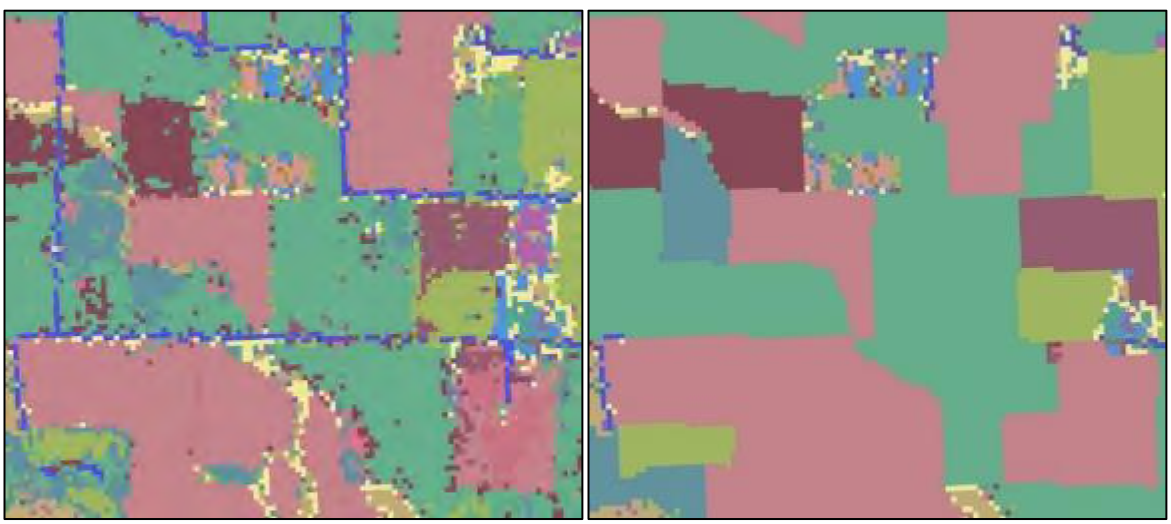


Figure 7. Example original NASS land use (left) compared to corrected land use based on the majority crop type within each agricultural field (right). Each color identifies a different land use type (i.e., almonds, alfalfa, developed, etc.)

Land Use Data 1997 to 2006

The earliest NASS land use raster available for California is from 2007. The County of Kern Agriculture and Measurement Standards provides land use shapefiles only for agricultural fields in the county from 1997 to present. The shapefiles did not provide land use data outside of the agricultural fields. Therefore, information from the last available NASS land use raster (2007) was used to fill in the missing background. The following process was used to combine the two sources to create land use maps for 1997 through 2006:

1. The crop data for each individual field from the Kern County data was converted to a specific value to match the crop identification value used by NASS. For example, a field containing alfalfa in the Kern County data was converted to the NASS crop value of 16.
2. The Kern County shapefile, with the added NASS crop value, was then converted to a raster image to represent the crop value.
3. The DWR survey shapefile was used to quality control the 2007 NASS land use raster so that the raster values within the field boundaries were all uniform.
4. The new Kern County raster was then mosaicked with the corrected 2007 NASS raster. The land use values from the Kern County raster had top priority over the 2007 NASS values and therefore were utilized in the final land use raster. Then 2007 NASS values were used in the non-agricultural areas as well as the background portion of the image.

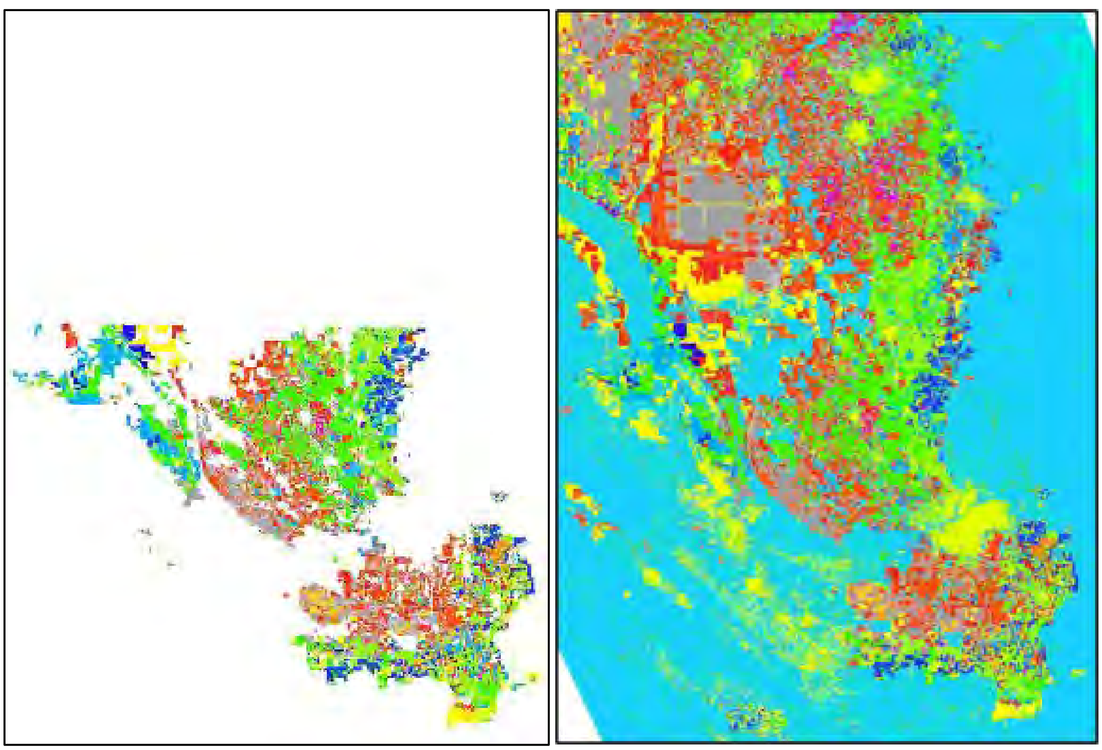


Figure 8. County of Kern agricultural land use fields (left). Combined County of Kern and NASS land use image (right)

Land Use Data 1993-1996

No land use data was available prior to 1997. Therefore, the final quality controlled 1997 land map was used for 1993 through 1996.

Interpolation between Image Dates

The selected images were processed, resulting in instantaneous actual crop coefficients (Actual Kc) on those dates for each pixel. The crop coefficient has been shown to remain constant during the majority of the daylight hours. Therefore, the instantaneous actual Kc was used as a surrogate for the daily actual Kc. In order to estimate the actual ETc between dates that images are available, actual Kc's are interpolated between image dates. A modified cubic spline approach is used to examine images within the month to be computed, prior to that month, and after that month. For example, to interpolate the ETc in the month of July, the July image(s) would be used along with May and June, and August and September. Cubic spline interpolation provides a smooth, non-linear interpolation between image dates. The interpolation takes place for every pixel in the image and the results are temporary Kc images for every day in the month. The daily pixel actual Kc values are then multiplied by the daily corrected Spatial ETo previously discussed to compute the daily actual ETc for each pixel. These daily ETc images are summed together for each month. Finally, the corrected Spatial ETo is summed for each month and the monthly ETc is divided by the ETo to generate the final monthly Kc image.

Monthly actual Kc and actual ETc results for Kern County for the period 1993-2016 have been provided to the Kern Groundwater Authority in GIS raster (image) format.

Accuracy of ITRC-METRIC ETc Estimates

Uncertainty is the quantification of accuracy in measurements and estimates. The most accurate method to estimate ETc is using a weighing lysimeter (correctly) but this is not feasible except in research situations. There are various methods that can be used to estimate ETc, each with different levels of uncertainty:

1. Traditional crop coefficient models (not used here but common in groundwater modeling) have uncertainty due to the assumptions that ETc is constant within a field and between fields in a region. Additionally, errors in land use determination (acreage of each crop), planting and harvest dates (or budbreak and dormancy for permanent crops), and crop management (irrigation, pruning, etc.) all impact the ETc uncertainty. Errors in weather data collection to determine grass reference ETo also impact the uncertainty. As a reference, uncertainties with crop coefficient methods are in the range of 20-25%.
2. Sensor-based measurements such as eddy covariance and surface renewal only measure a small footprint in a field and have potential for sensor errors due to improper calibration, loss of calibration over time, or sensor fouling. Additionally, the sensors must be adjusted, installed correctly, and some (e.g., surface renewal) depend on assumptions that may not hold. Data management and technical support make these infeasible when examining ETc over many fields.
3. NDVI-based ETc estimates have some advantages over (1) and (2) in that they provide spatial variation over a field and field to field. But these still rely on accurate crop surveys. Additionally, this method does not account for crop stress, unless that stress is so severe that it impacts the vegetative index. As with (1) above, the ETo errors translate to ETc uncertainty.
4. ITRC-METRIC ETc overcomes many of the issues with other methods, which is why it was developed. This method does not rely on accurate crop surveys. It also accounts for crop stress before it impacts the vegetation. Spatial variation in ETc throughout a field and between fields is accounted for. ETo continues to be an important part of ITRC-METRIC, which is why quality control of the data is important. In order to limit errors in ETo, ITRC conducts an extensive quality control of the weather station data and utilize spatially varied ETo to account for different climates within a region. As with other methods, it is imperative that the person doing the processing understands agronomic aspects

within the region being evaluated. Errors in processing will generate errors in ETc estimation. All ITRC-METRIC images are reviewed by project managers with many years of experience in farming, irrigation, and crop water use estimation to ensure that the outputs are correct. This overcomes potential errors in LandSAT sensor data since each image is calibrated independently.

ITRC-METRIC uncertainty is estimated to be +/-7 to 10% in this study. On a large scale (GSA or county-wide ETc volumes) the error is on the lower end of this range. On a field scale, it may be on the upper end currently. We have continued to make improvements to our methodology and feel that in the future field-scale ETc will be on the lower end of the range provided. Additionally, the launch of LandSAT 9 (planned for December 2020) will improve the temporal resolution, providing images every 16 days, offset by 8 days from LandSAT 8 (potential for images on an 8 day interval). There are no other ETc computational methods available with uncertainties on both a large scale and field scale within these ranges.

Summary of Results

The annual results have been summarized for the Kern County Valley floor and the field boundaries (majority) within the Valley floor of Kern County. Figure 9 shows the boundaries used for the data extraction for the summaries discussed in this section. Average annual ITRC-METRIC ETc was extracted using the Zonal Statistics tool in ArcGIS. The average ETc from the extracted area was multiplied by the area within the boundaries (overall boundary or each field boundary for the fields) to compute volumes. Over the 23-year period, the field boundaries and overall boundary were the same.

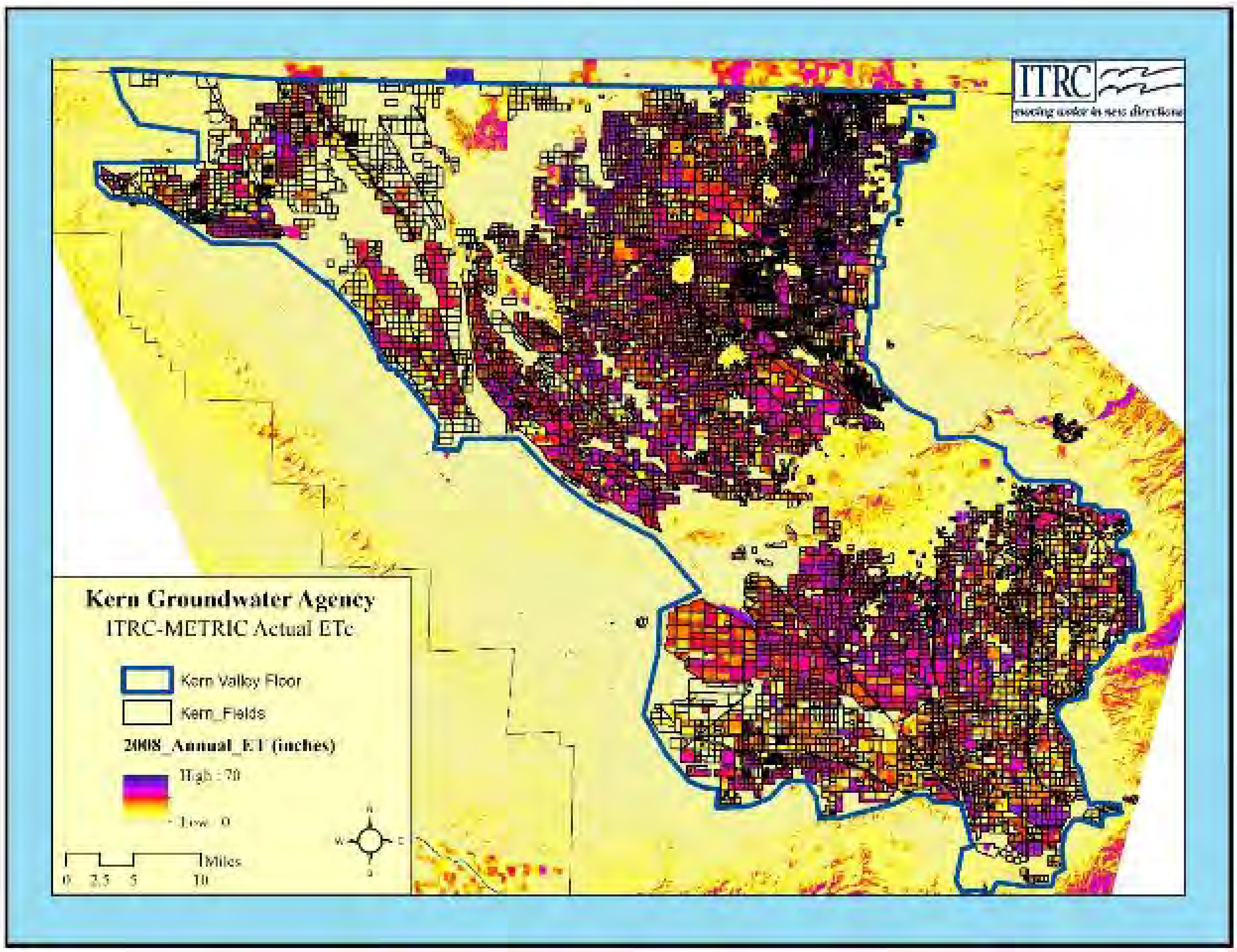


Figure 9. 2008 ETc image with Valley floor and field boundaries used for the summary analysis

The volume of actual ETc for the overall area and only within fields is shown in Figure 10. For reference, the grass reference evapotranspiration (ETo) and precipitation from the Shafter CIMIS station (1992-1997) and Famoso CIMIS (1998-2015) are also shown. ETo provides an idea of the weather conditions that drive evapotranspiration. Hotter, drier years have a higher ETo.

Figure 11 shows the volume of ETc for all water districts in Kern County and Kern Groundwater Authority members. The acreage of all districts is greater than the "Valley Floor Area" because of district boundaries covering areas outside of the valley floor (e.g., West Kern W.D.). Some districts with substantial overlap of other districts were removed from the evaluation to limit double counting. However, some minor overlap may cause the estimates to be slightly higher than the actual volume of ETc.

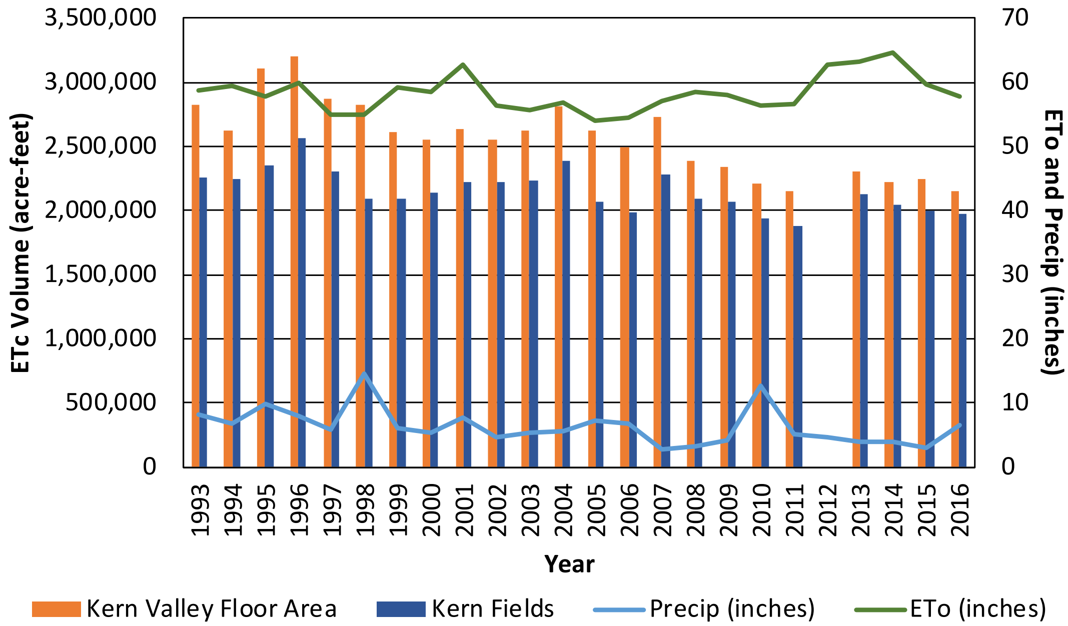


Figure 10. Annual volume of ETc for the Kern County Valley floor and within fields in Kern County. Grass reference ETo and precipitation depths are shown for each year as a reference.

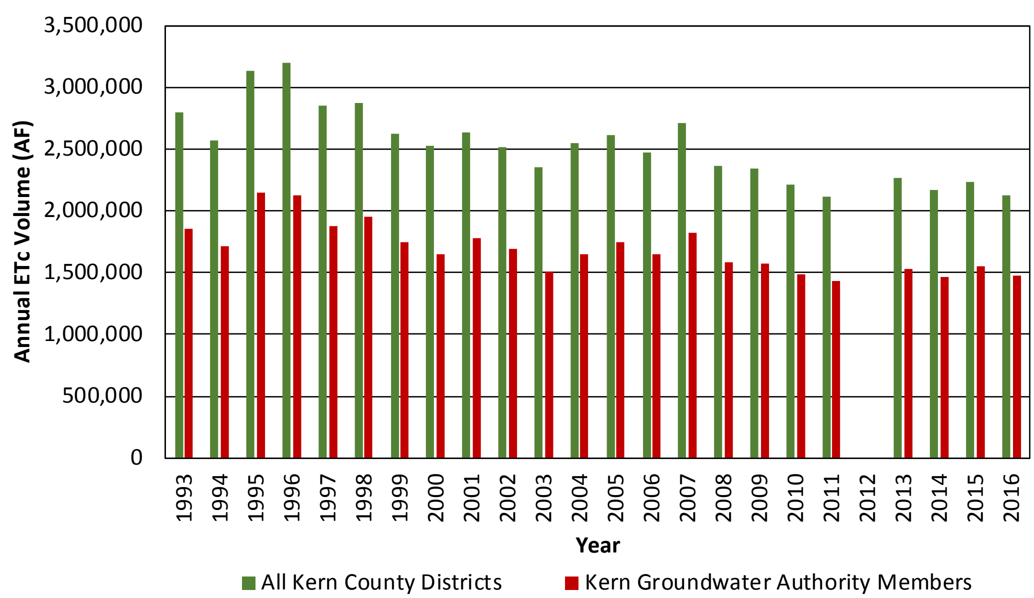


Figure 11. Annual volume of ETc for irrigation/water districts in Kern County and just Kern Groundwater Authority member districts

Evaluation of ETc Variation

In general, there is an overall decline in ETc volume from the Valley floor starting over the 23 years that the ET analysis covers. The field ETc decline is not as significant but does trend downward. The difference between the Valley floor and field ETc is due to ET and evaporation occurring outside of field boundaries. Year to year variability in ETc volume might be explained by weather differences between years. To examine this, the data was normalized to exclude weather variation by examining the annual crop coefficient (Kc), computed as the actual ETc divided by ETo (ETo is computed based on weather data, not including precipitation). Annual Kc values are shown in Figure 12 for the study period (bar graphs) for the entire Kern valley floor area (includes urban, streets, undeveloped areas, etc.) and within fields only (only agricultural fields in the same area).

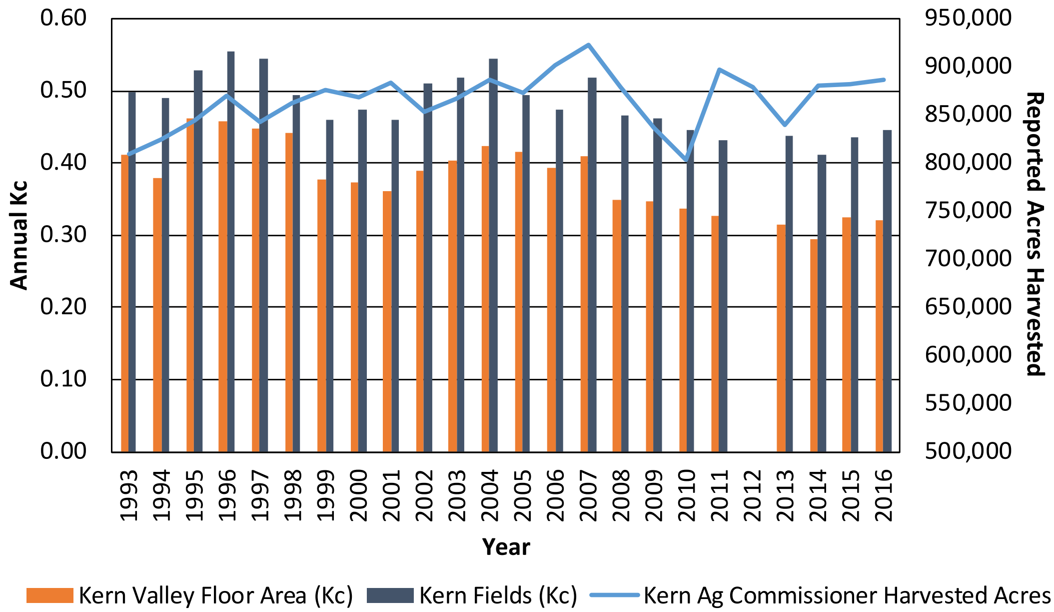


Figure 12. Annual crop coefficient (Kc) for the Kern County Valley floor and within fields in Kern County. Reported Ag Commissioner total harvested acres per year on the right axis of the graph.

As expected, the Kc is higher when only looking within field boundaries compared to the entire Valley floor of Kern County. Areas outside of the fields are in large part reliant on precipitation or are a mix of landscape and residential areas. Urban areas and open water are also included. As with the volume, there seems to be a general decline in overall Kc over the 23 years.

In the mid-2000s the Kc increases. Figure 12 also includes the Kern County Ag Commissioners total harvested acres over the 23 year period for reference and to possibly explain some of the variation. Interestingly, the Ag Commissioners' total harvested acreage increases from 1993 to 2016. While there are some general trends indicating that the annual Kc increases as the acreage increases, the trends do not follow as closely as one might expect. This could be due to the types of crops harvested over the period or the age of permanent crops being grown. <u>It is important to restate that crop types are not used to determine ETc using ITRC-METRIC. They are only shown here as a reference to potentially explain the variation in ETc.</u>

To delve further into the theory that crop type shifts may explain ETc variation, crop acreages of the major crops in Kern County (Kern County Agricultural Commissioner Reports) are shown in Figure 13. The higher ETc and Kc values in the mid-2000s are likely due to the increase in alfalfa acreage during this period in combination with the higher almond acreage. However, the higher ETc and Kc values in the mid-1990s are more challenging to explain. Obviously there is more cotton acreage and likely more double cropping of different row crops (although cotton is not commonly double cropped). Other crops in the cotton rotations likely include double cropping, such as corn and grain hay, which are not shown.

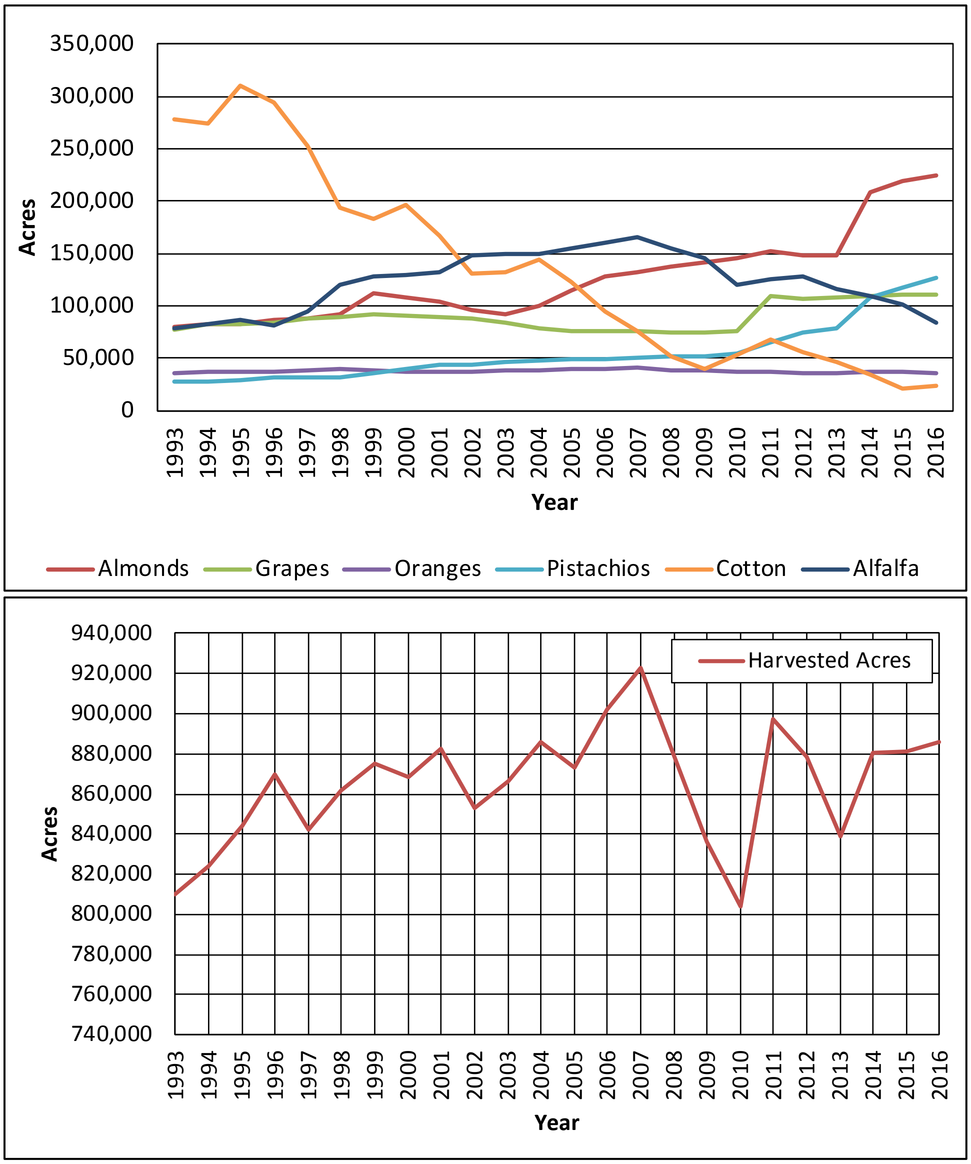


Figure 13. Crop acreage for major crops in Kern County from 1993-2016 (top) and total harvested acres (bottom) from Ag Commissioner Reports

As previously discussed, the Kern County Ag Commissioner reports showed an overall increase in harvested acreage from 1993 to 2015. The Ag Commissioner reports showed the 1993 total harvested acres at approximately 809,700 compared to the 2015 harvested acreage of 881,000. Year-to-year variations are shown in Figure 12.

There are also some unexplainable anomalies in the Ag Commissioner data, such as the increase in almond acreage from 2013 to 2014. Figure 13 shows that total acres (bearing and non-bearing) for almonds increased by over 50,000 acres from 2013-2014. The bearing acreage showed the most significant increase from 2013 to 2014 even though only 1,600 acres of non-bearing trees were reported for 2013. The bottom line is that over 50,000 acres of bearing almonds showed up in 2014 without explanation. This could be due to an error in the Ag Commissioner's reporting or a shifting methodology of accounting for certain crops.

The annual Kc by field in Kern County from ITRC-METRIC was plotted from lowest to highest Kc for four selected years (Figure 14). The fields with the lowest Kc would be fallow or young orchards/vineyards. Notice that there are more fields with Kc values below 0.2 in 2008 and 2015 than in 1993 or 1996. Of these, 1996 has the fewest low Kc fields while 2015 has the most. Different fields have different Kc values each of these years. The key point is that the lower Kc values in 2014 and 2015 (Figure 12) are likely driven down by increased fallowing or young orchards. Additionally, Figure 14 indicates that the overall field acreage was probably lower in 2015 than in 1993. While field acreage is not the same as harvested acreage because it does not account for double-cropping, it is unlikely that double cropping accounts for the full difference in reported acreage.

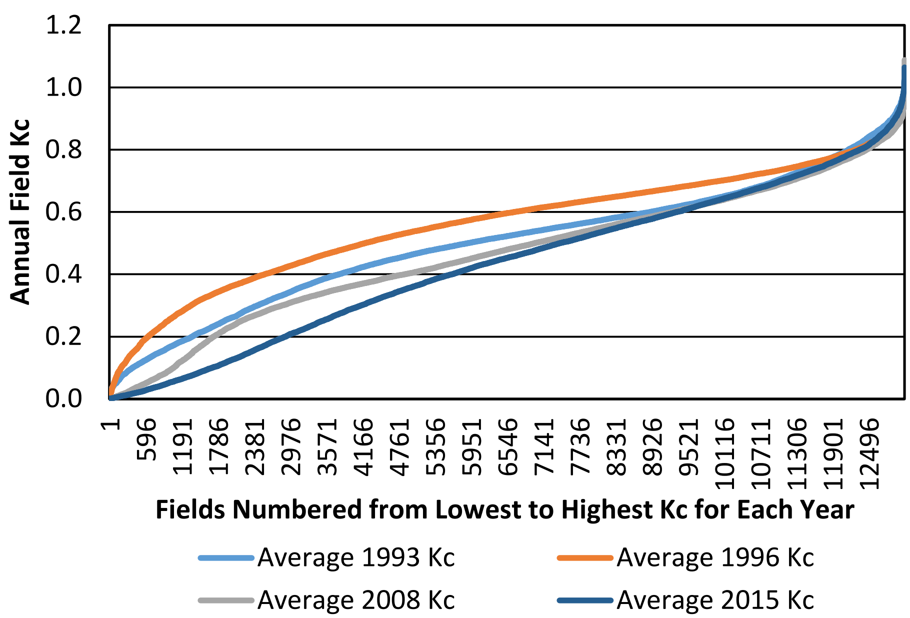


Figure 14. Annual Kc by field sorted from lowest to highest for four different years

Visually, significantly more non-cropped fields can be seen in 2015 than in 1993 (Figure 15). Portions of Kern County (red circles which include portions of Lost Hills Water District, Buena Vista WSD, and Henry Miller WD) show much lower ET in 2015 than 1993. These areas were fallowed or not cropped during the drought. In other areas, new permanent crop plantings may be the cause of lower ET. Additionally, the Kern Lake and areas south of Bakersfield have much lower ET values indicating new permanent crops or fallowing.

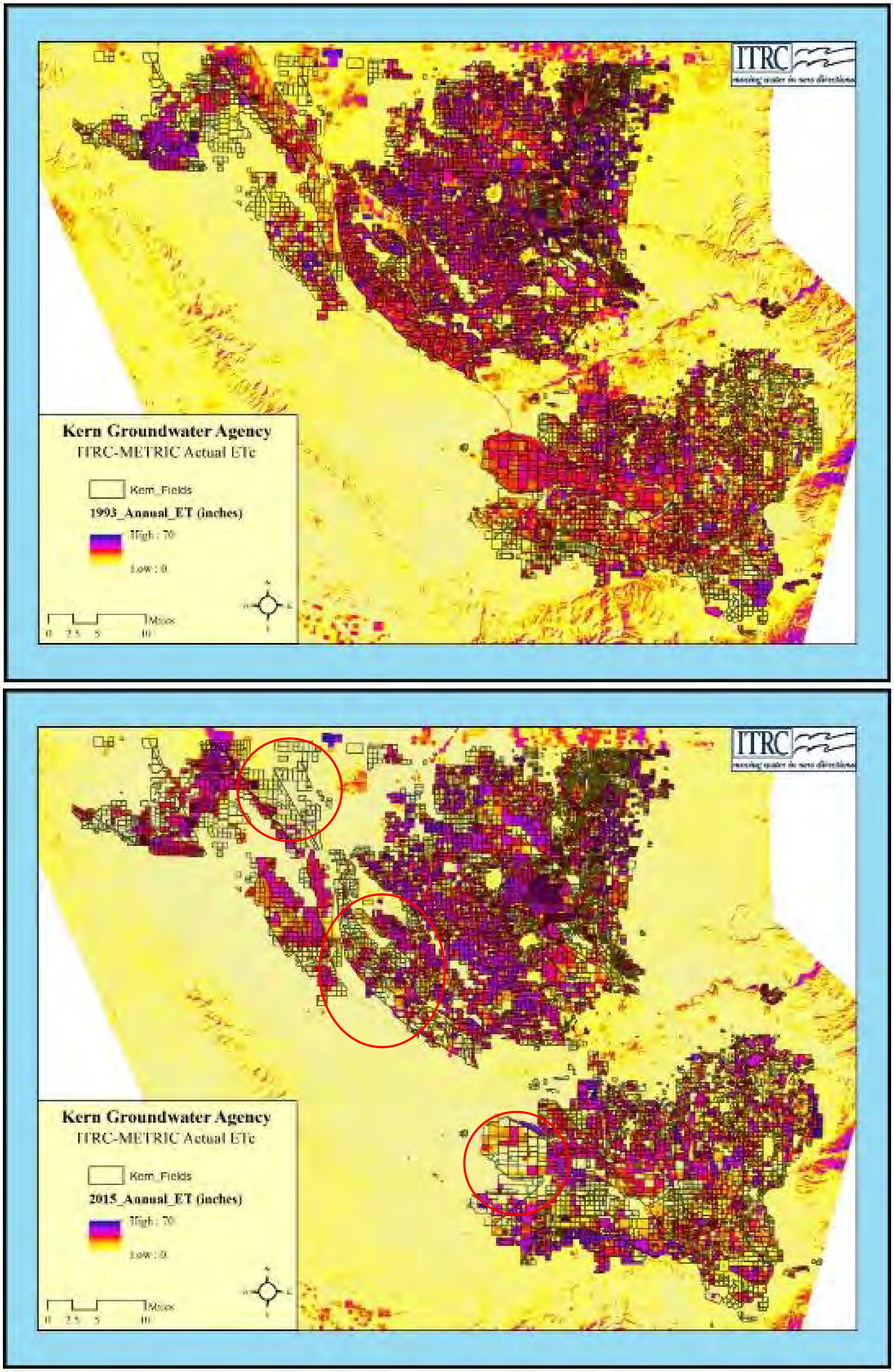


Figure 15. Annual ITRC METRIC ET in 1993 (top) and 2015 (bottom) with field boundaries

Conclusion

Over the 1993-2016 period, the volume of evapotranspiration from fields within the valley floor of Kern County ranged from approximately 2-2.5 million acre-feet. Evapotranspiration varies year to year in the valley floor portion of Kern County. This is caused by several factors including weather, crop mix, water availability, precipitation, and land fallowing. It was beyond the scope of this study to investigate exactly why evapotranspiration varied. However, the previous figures indicate that there seems to be increased fallowing or young orchards and vineyards planted in more recent years, resulting in lower evapotranspiration in this period. This acreage reduction does not coincide with Kern County Ag Commissioner's reported harvest acreage changes over the period.

The monthly and annual evapotranspiration and Kc imagery in GIS format has been transmitted to Kern Groundwater Authority.

Future Work

Net To/From Groundwater (NTFGW)

ITRC has developed a process to examine net groundwater use without the need to monitor groundwater pumping. This process is called the Net To and From Groundwater (NTFGW) and can be conducted at various scales from the farm/field, GSA, and Basin. This method incorporates surface water diversions, turnout deliveries (for farm/field scale), surface outflows, and precipitation with the monthly ETc to determine net groundwater use. Basically, if precipitation and surface water deliveries exceed ETc, the excess water would be stored in the root zone or moves to the groundwater (net to groundwater). If ETc exceed surface supplies, there is a net extraction from the groundwater to make up the difference. Results are provided spatially at the 30 meter pixel resolution. NTFGW is being used for two purposes:

1. Using historical data, to assist in calibration/verification of groundwater models. Equally important, the results provide a directly computed future ETc with net zero extraction.
2. For future management and regulation of groundwater use within the GSA. Monthly results will be provided to each GSA participant in near real-time (approximately 15 days after surface delivery information is provided to ITRC). Some GSAs are planning on providing this to farmers via a web mapping portal.

The benefits of NTFGW include:

- No groundwater metering program with meters at each well is needed. DWR has approved the method as a best-available science alternative.
- No estimates on irrigation efficiency are needed. Irrigation efficiency estimates have a high level of uncertainty, vary from field to field, and will change over time. NTFGW simplifies the evaluation of sustainable yield because inherently sustainable yield is a net value of how much groundwater can be consumed in a GSA. There is no need to estimate leaching requirements or other non-consumptive uses of groundwater. Comparing net values eliminates many uncertainties.
- It offers the ability to track net canal seepage and net recharge basin recharge by basin.
- It offers the ability to continuously track banked or over-drafted groundwater on a farm, district, and GSA level.
- It is cost-effective: the anticipated cost will be $30,000-$50,000 per year per district/GSA. Actual cost will depend on the district/GSA size and the level of evaluation.

ITRC-METRIC ETc

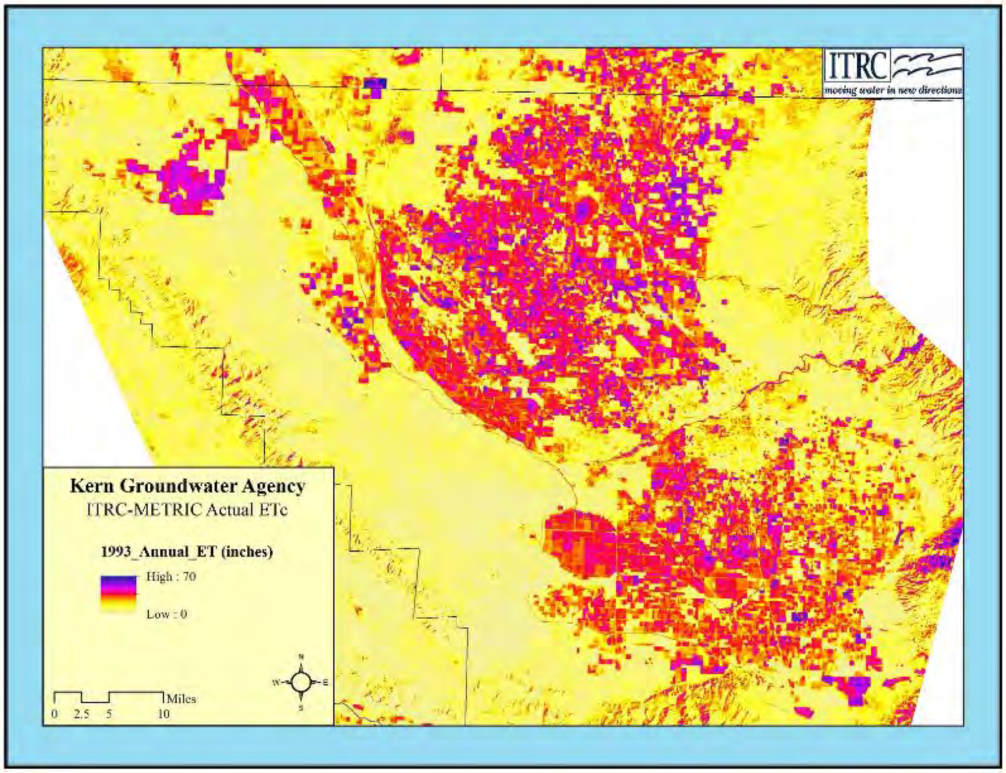
There are several options moving forward. ITRC-METRIC ETc will be an important tool. Over the past several years there have been lessons learned which will impact the process in the future:

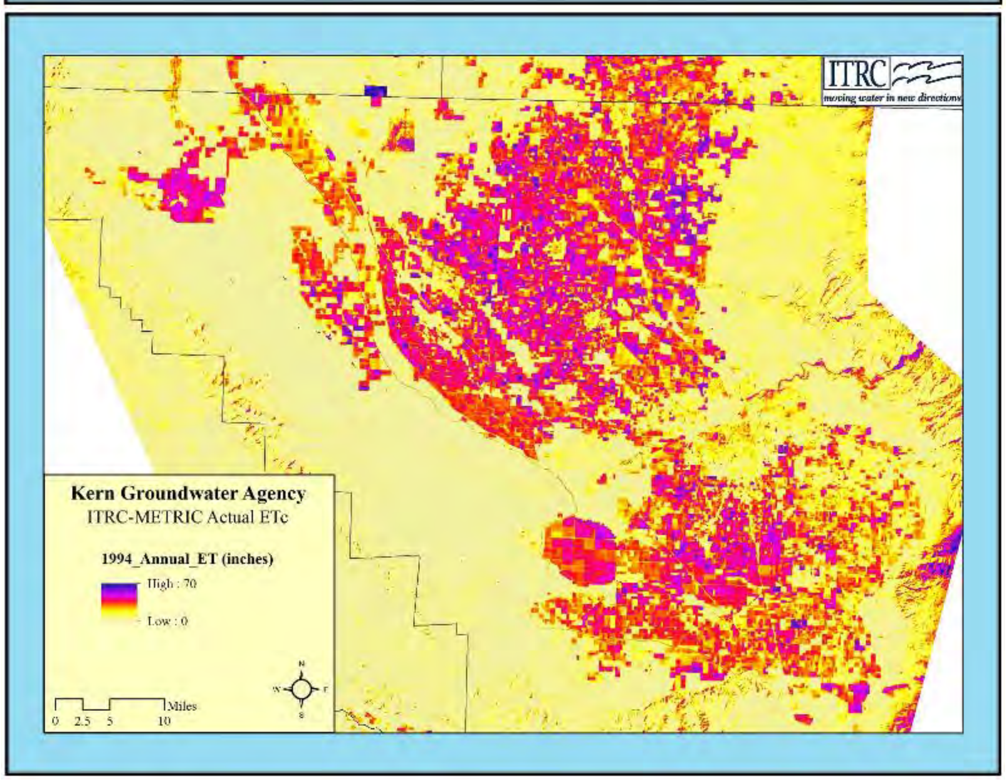
1. Thermal sharpening has not been extensively used because it is time-consuming. However, ITRC is working on expediting this process. Currently, the thermal sharpening process increases the overall processing cost by a factor of 50%. It is expected that this cost will be reduced in the future. On a larger scale it is not important because the overall ETc is not increased or decreased. On a field level, it may be more important.
2. In the past we used at least 1 image per month to compute ETc. ITRC now uses all available good-quality images (mostly cloud/fog free, some cloud coverage is okay). Again, on a large scale (over a district for example) it is not as critical, but for individual fields, especially for row and field crops, it is critical to have images at least on a 16-day interval to capture harvests appropriately.

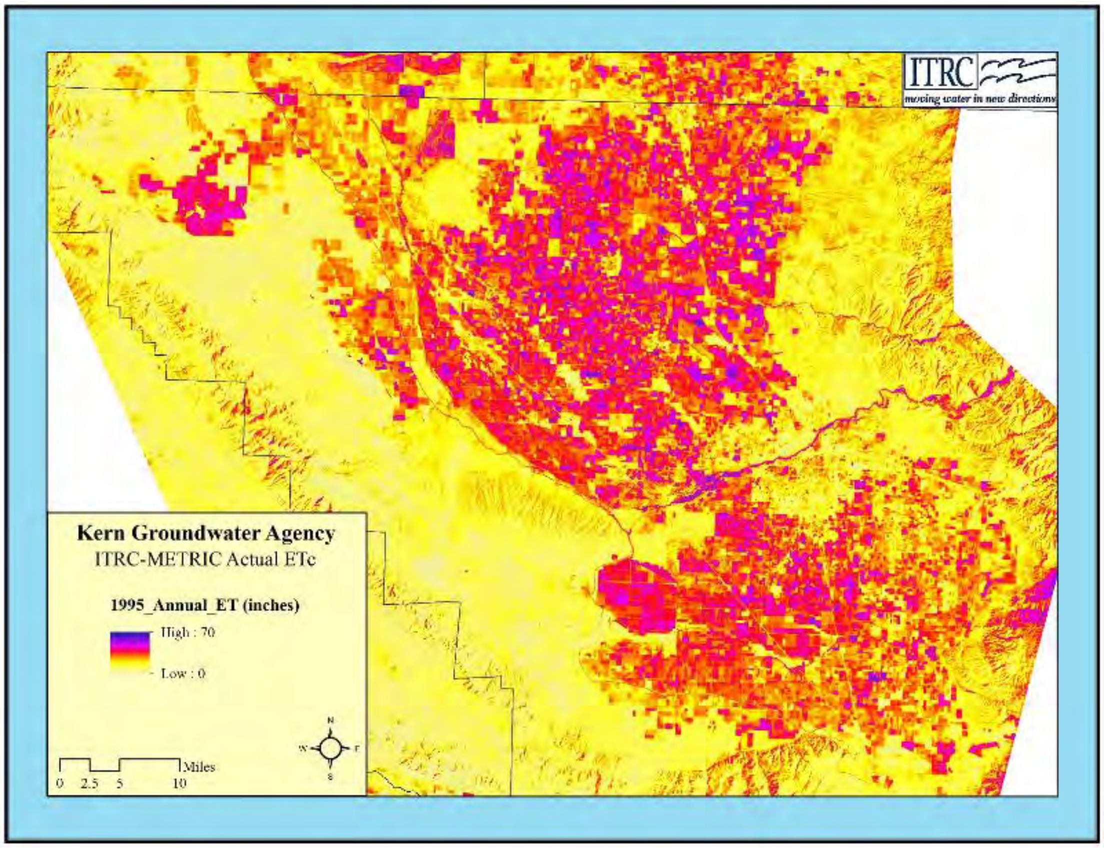
Future implementation of continuous ETc will be important for groundwater management in the Kern subbasin. The historical data generated as part of this project is being implemented in the groundwater modeling efforts in the subbasin. The next steps are towards monitoring sustainable use of the groundwater into the future. ITRC believes that NTFGW is the best methodology to monitor groundwater use since net groundwater use is more important than gross groundwater pumping. Pilot projects using NTFGW compared to groundwater pumping have been successfully implemented in a subbasin just north of Kern. ITRC would be pleased to share these results with interested parties.

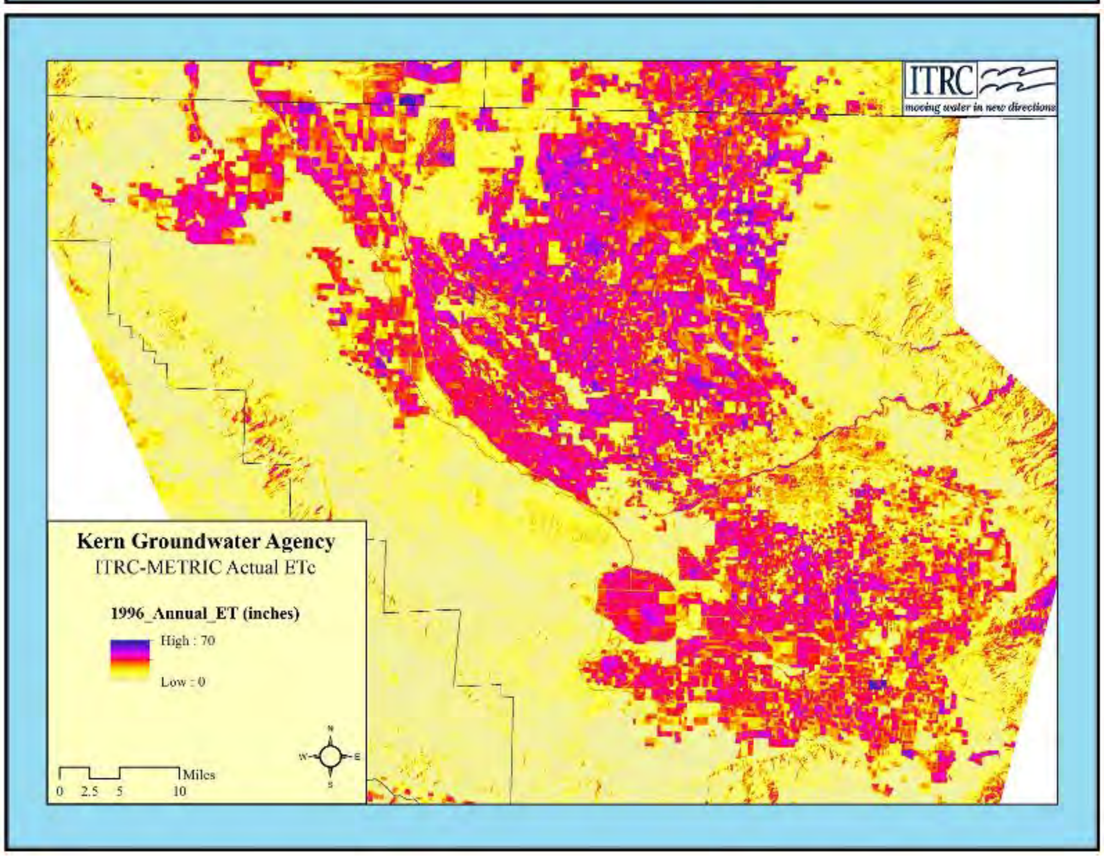
Attachment A

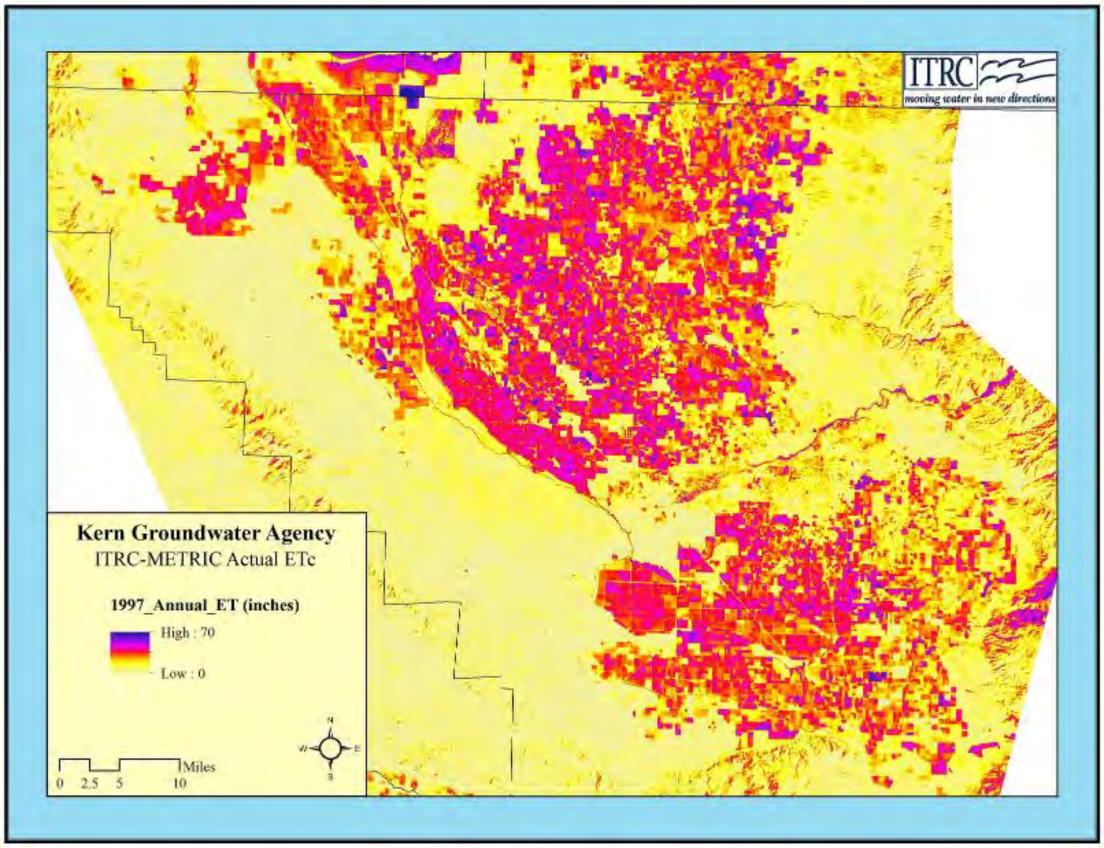
Annual ITRC-METRIC ETc

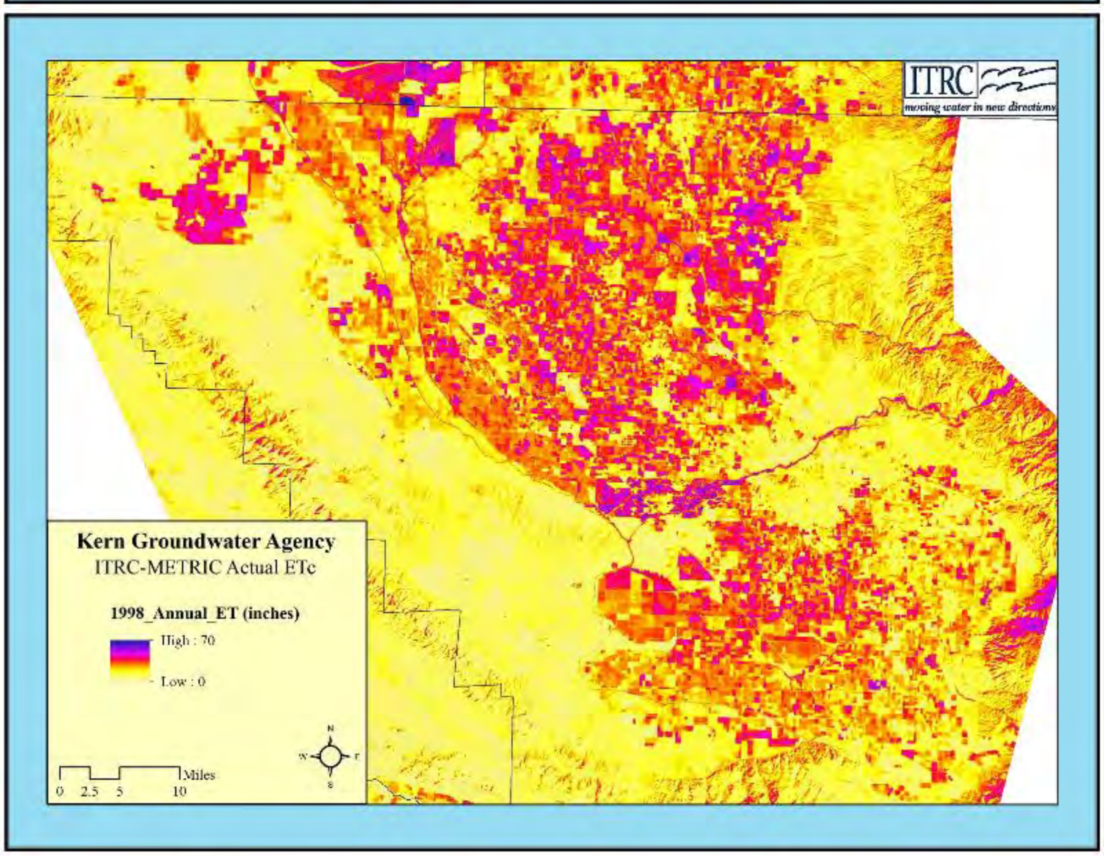


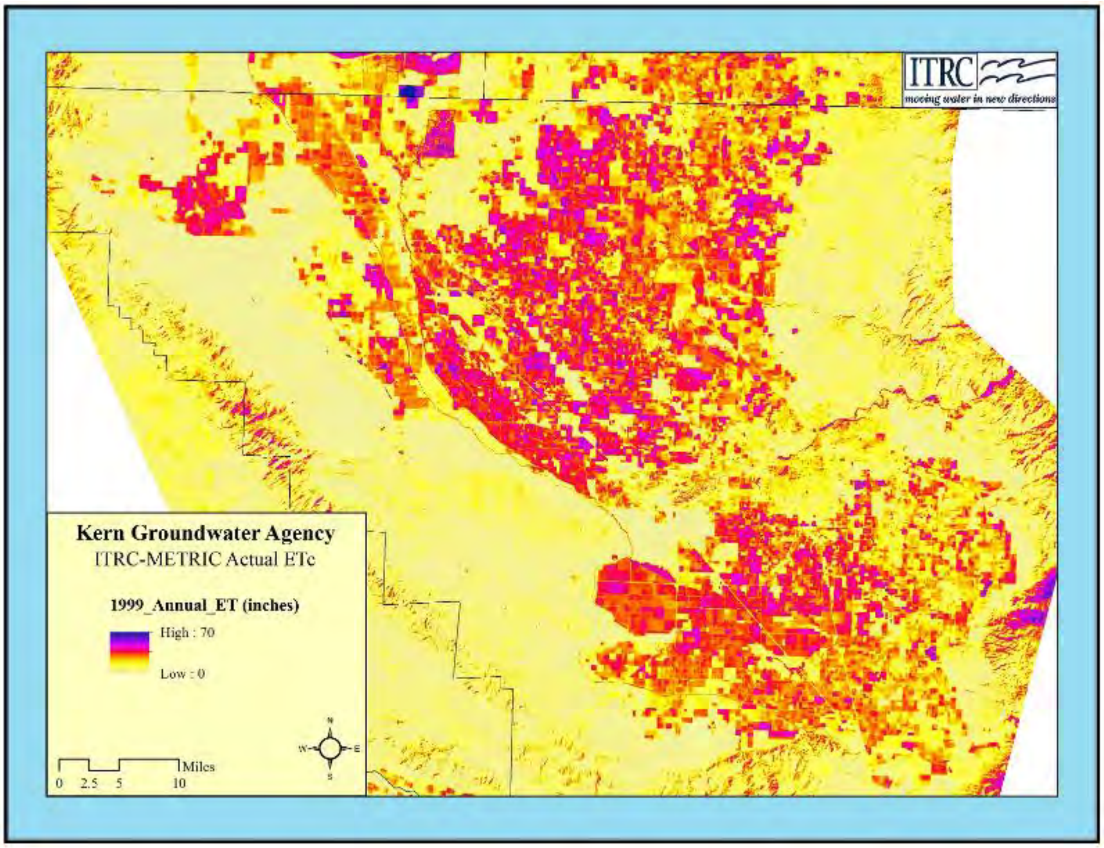


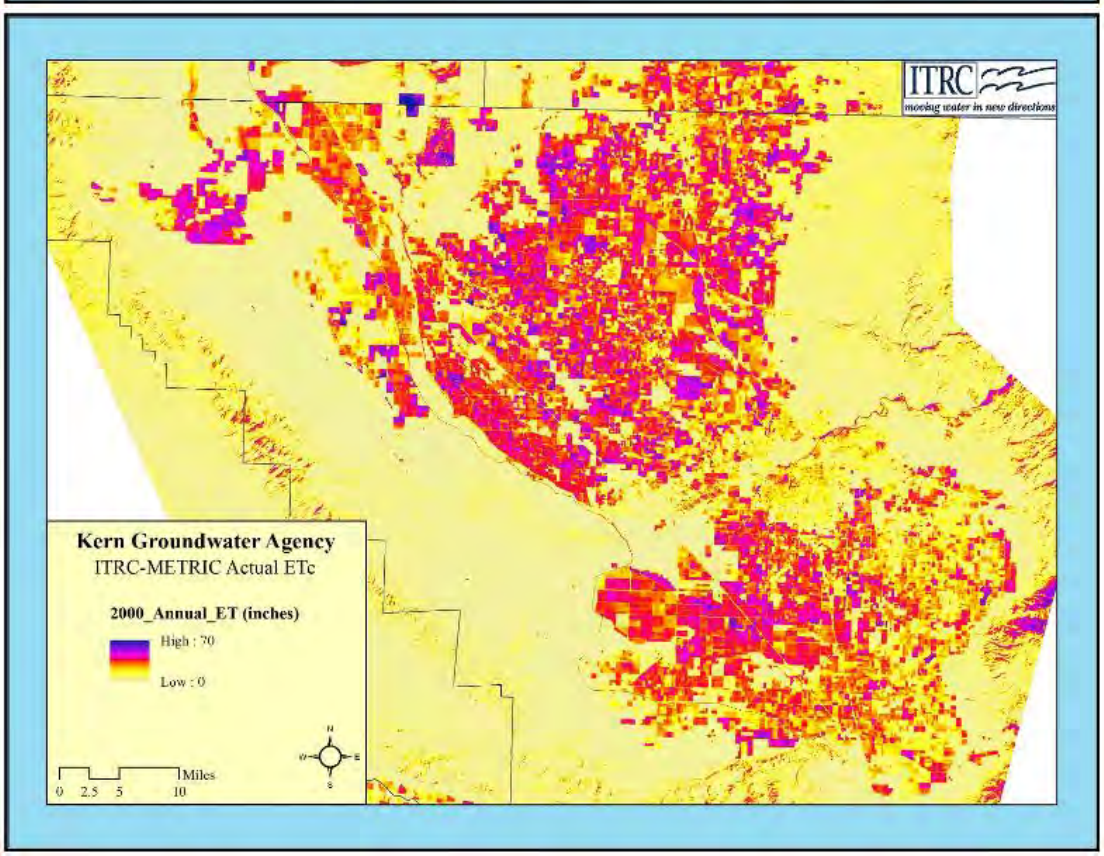

ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
1995_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10

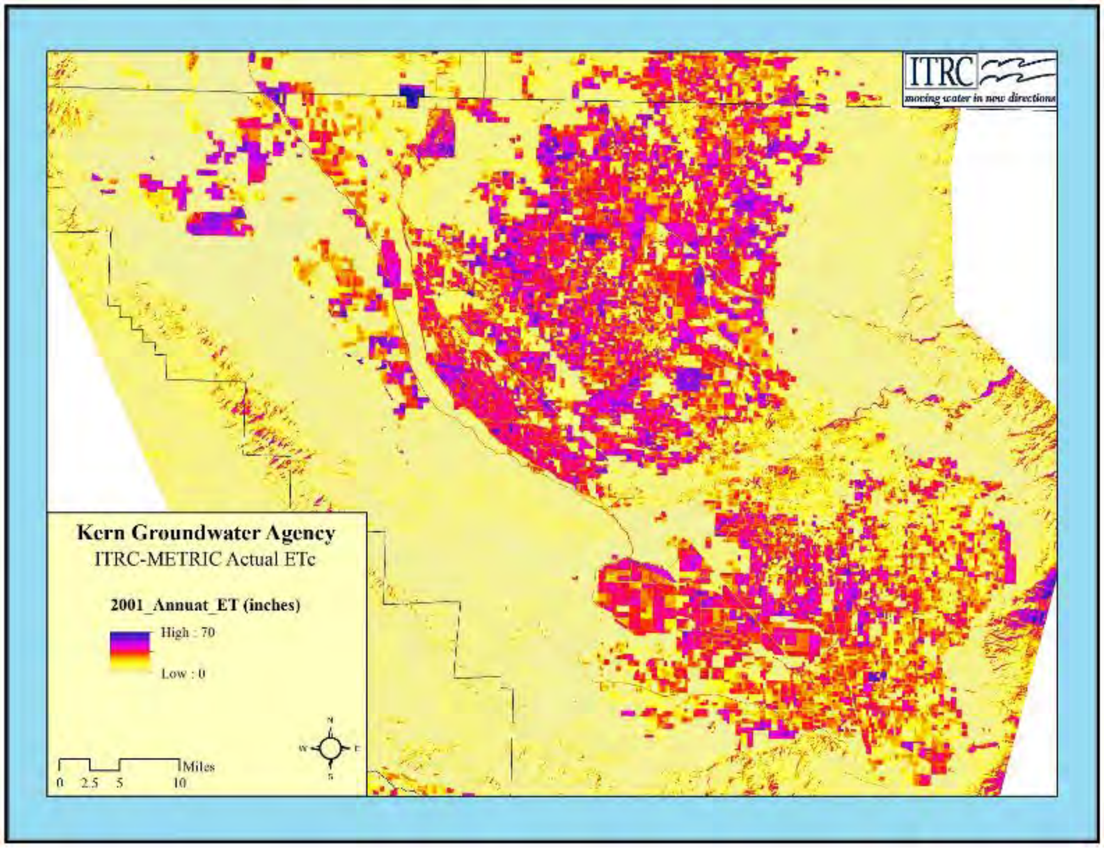

ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
1996_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10


ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
1997_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10

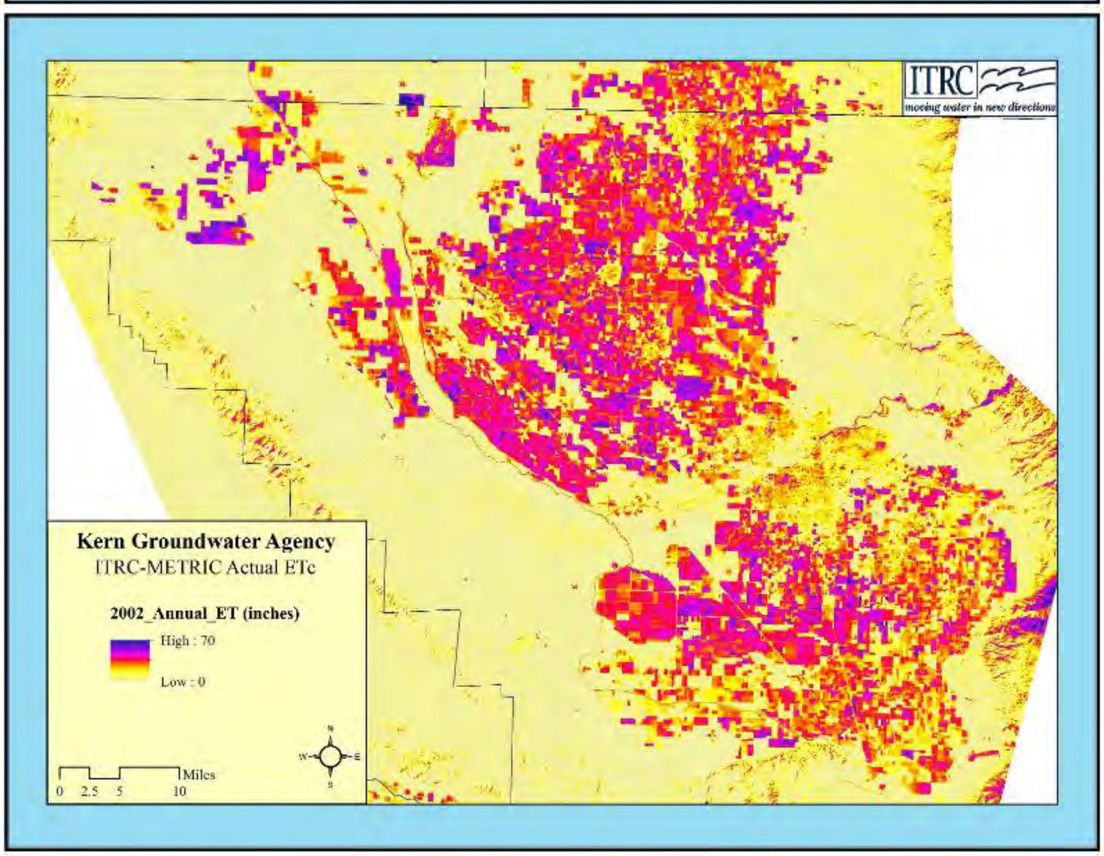

ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
1998_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10


ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
1999_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10

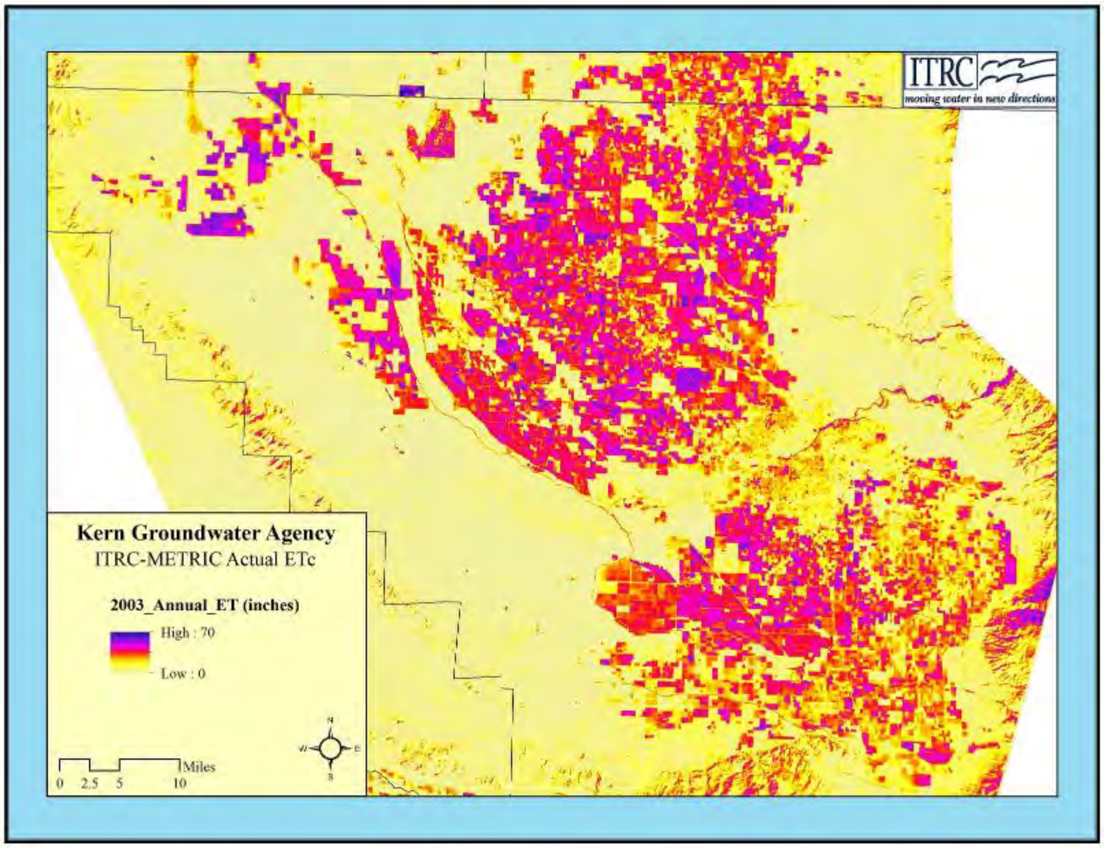

ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
2000_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10

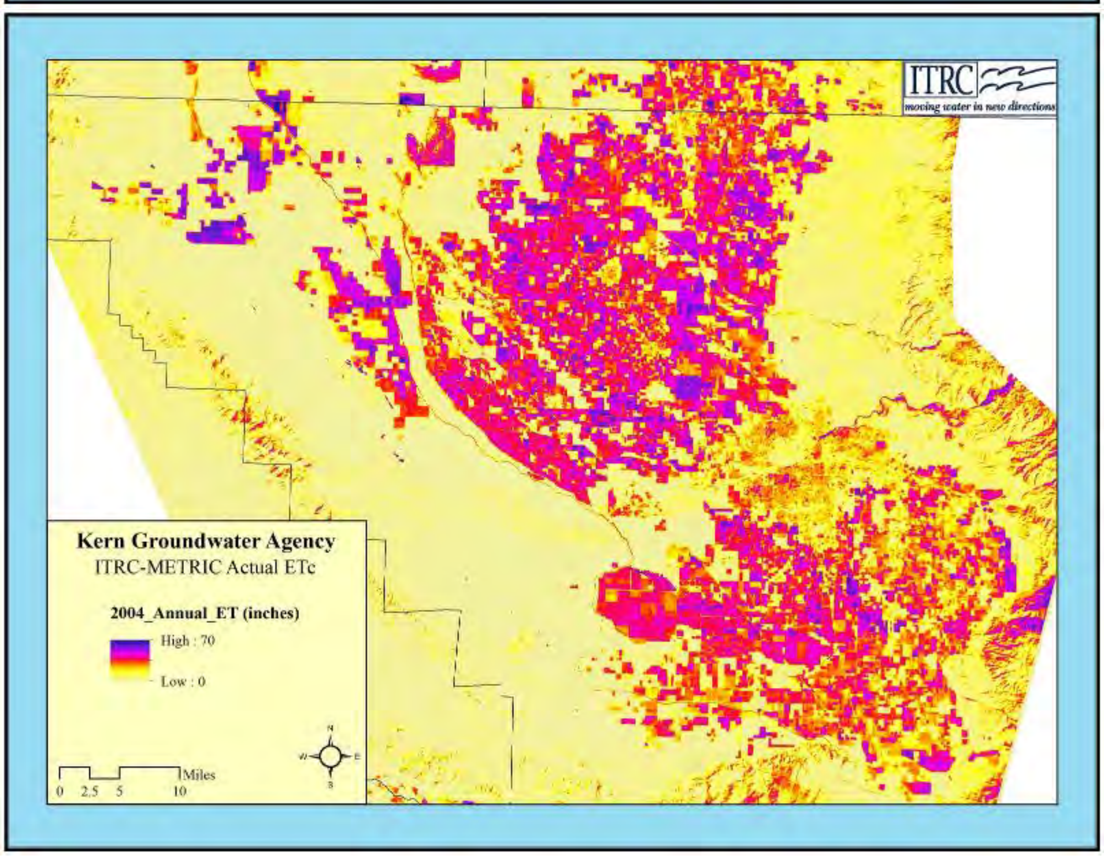


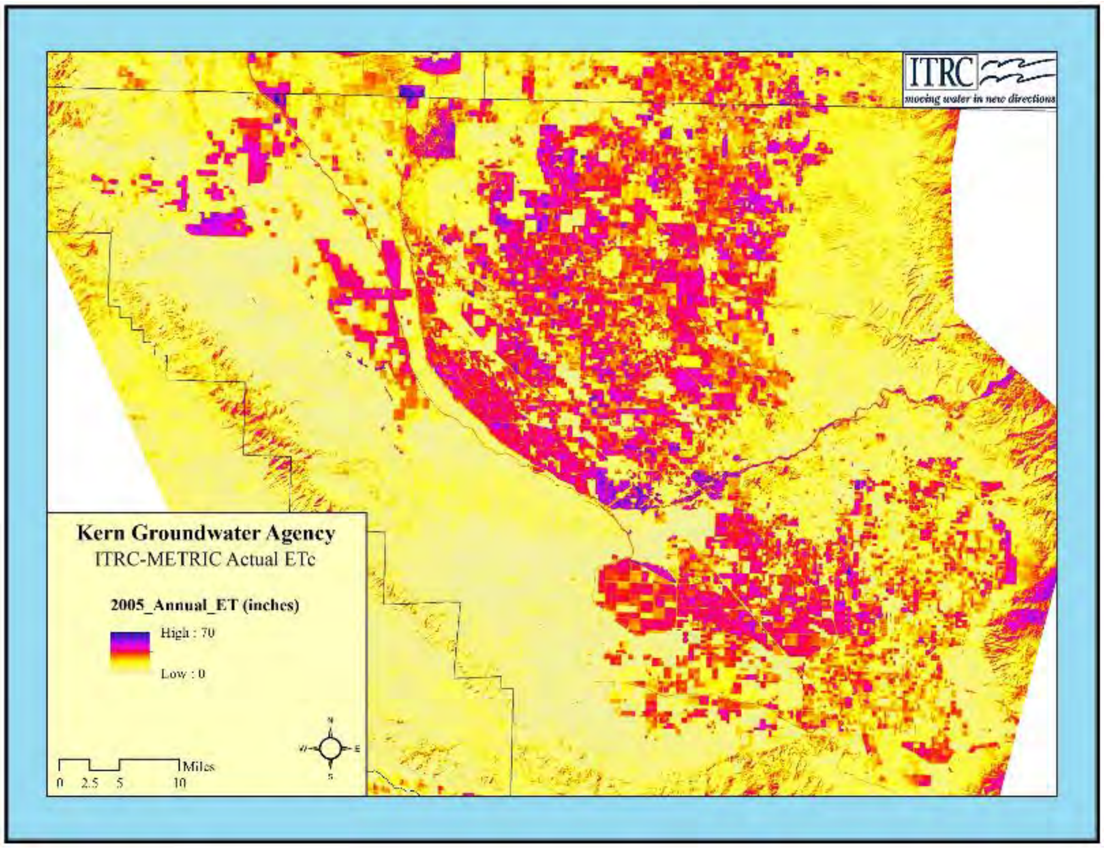
ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
2001_Annuat_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10

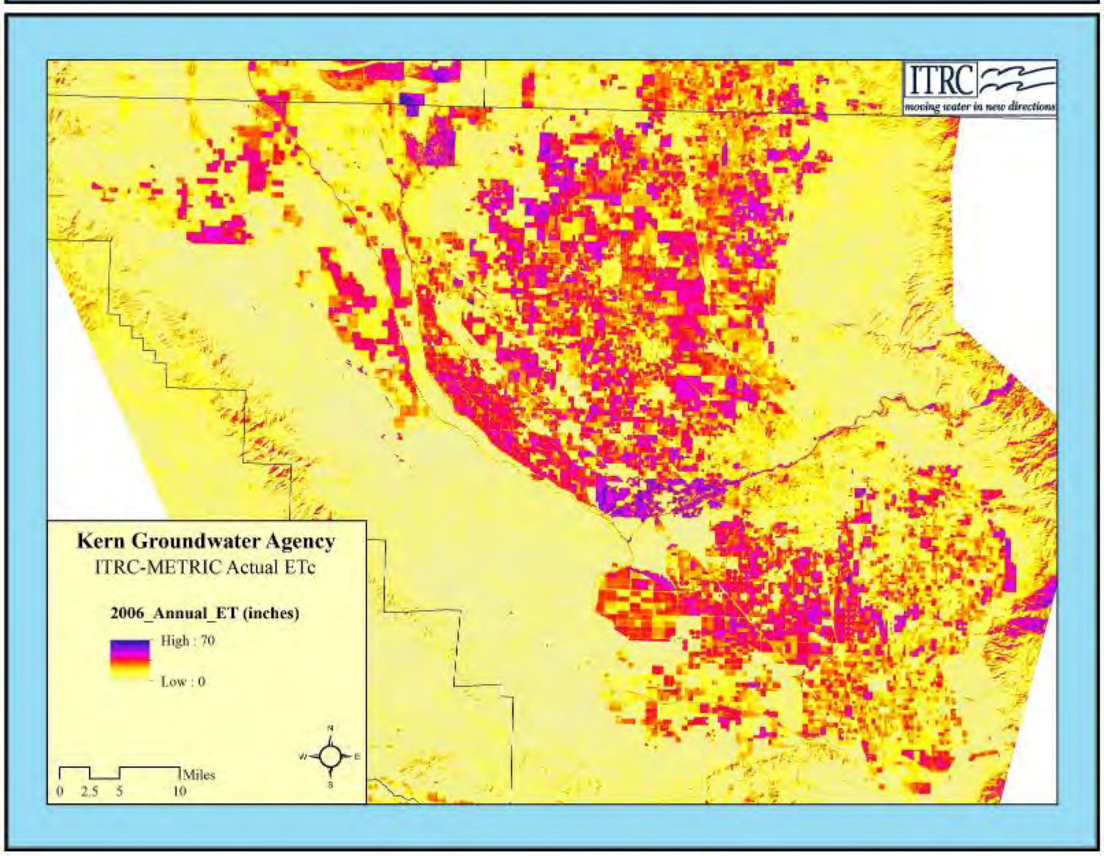


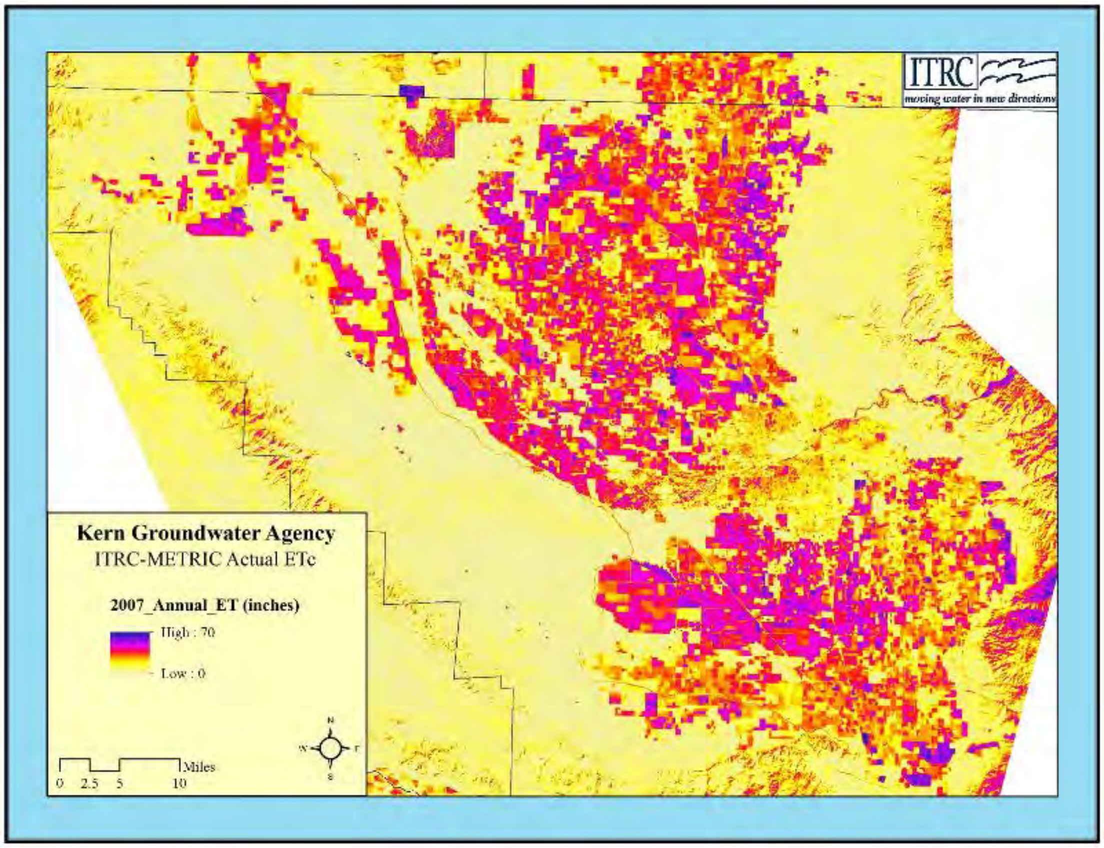
ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
2002_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10

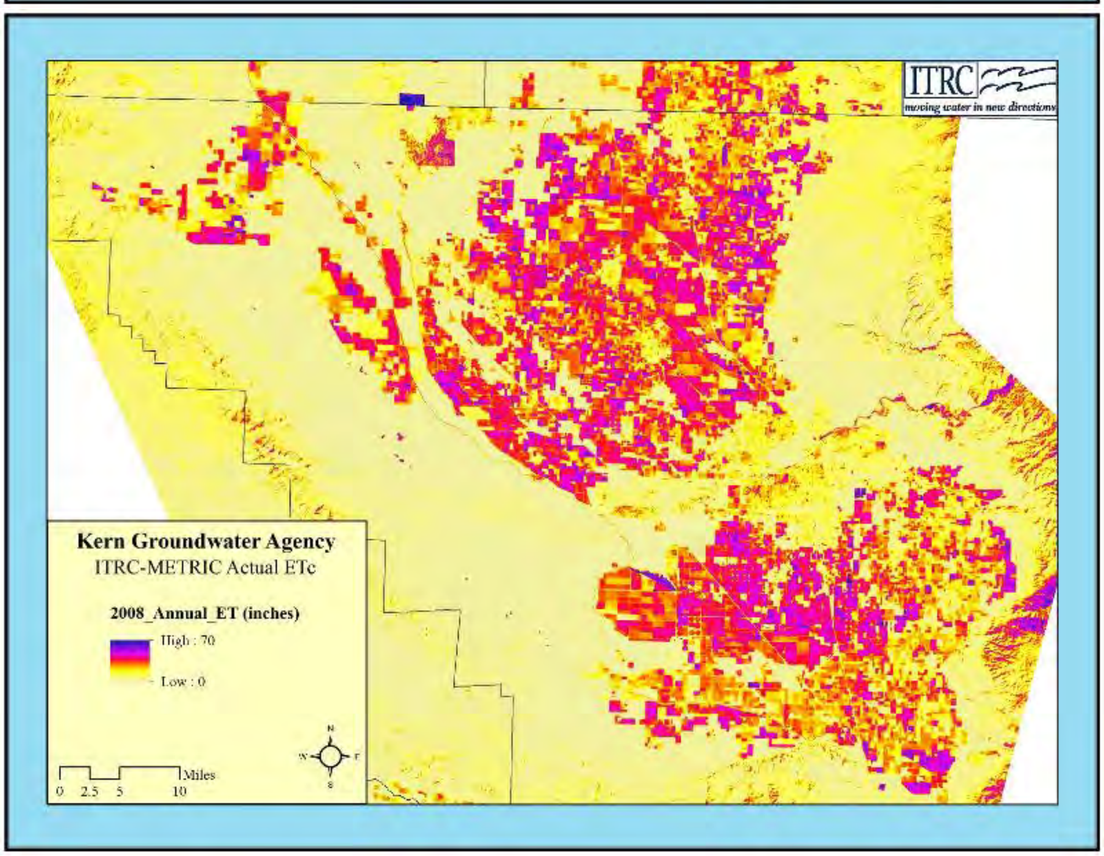

ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
2003_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10

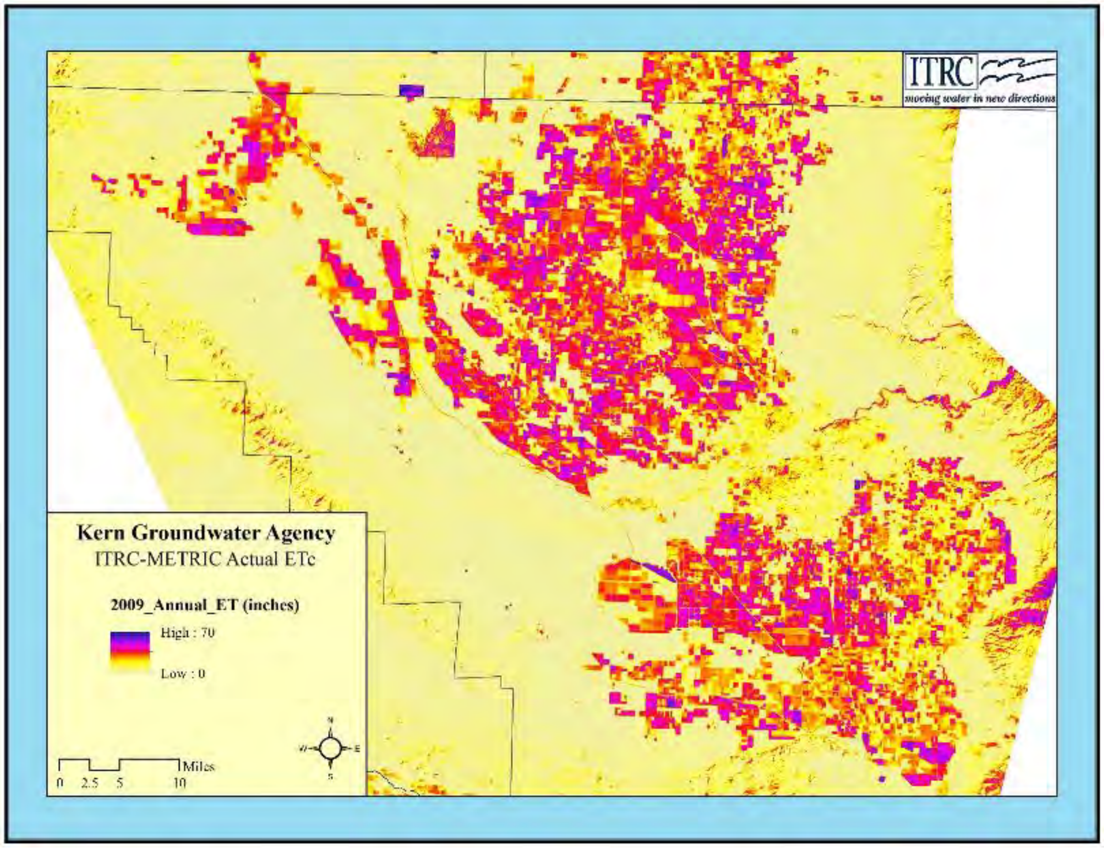

ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
2004_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10

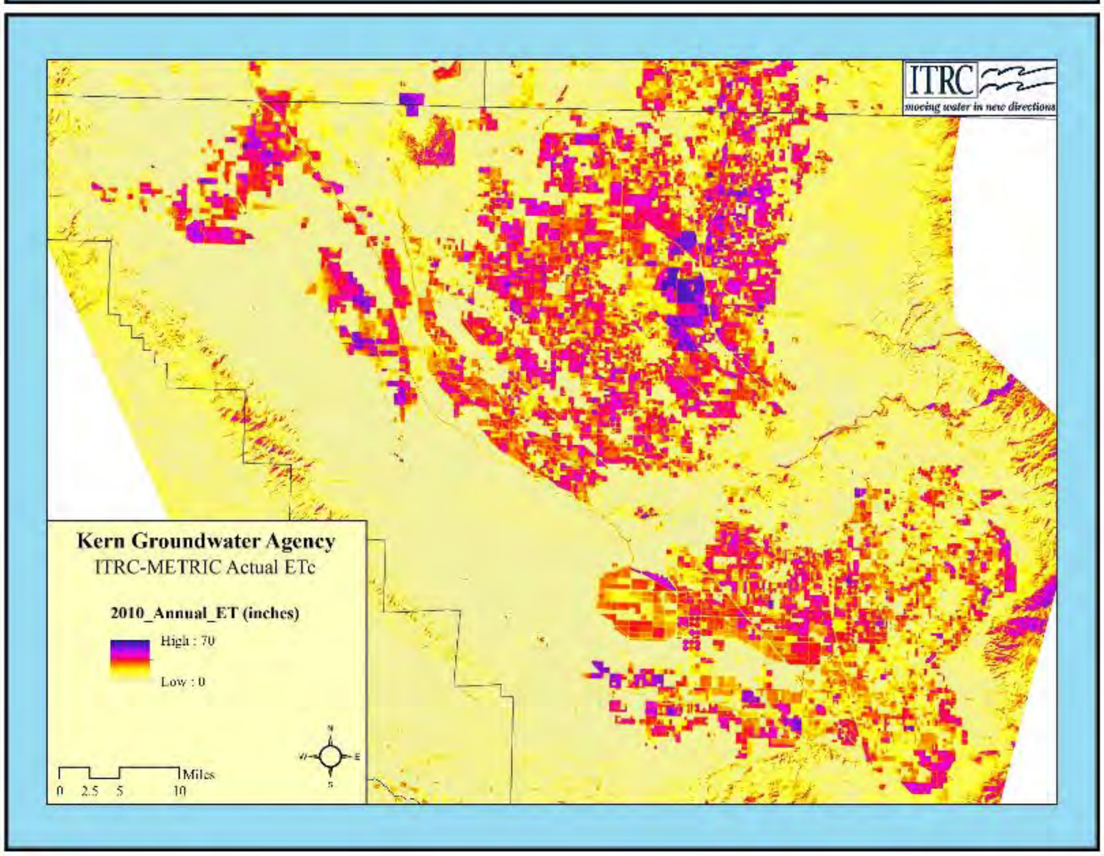

ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
2005_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10

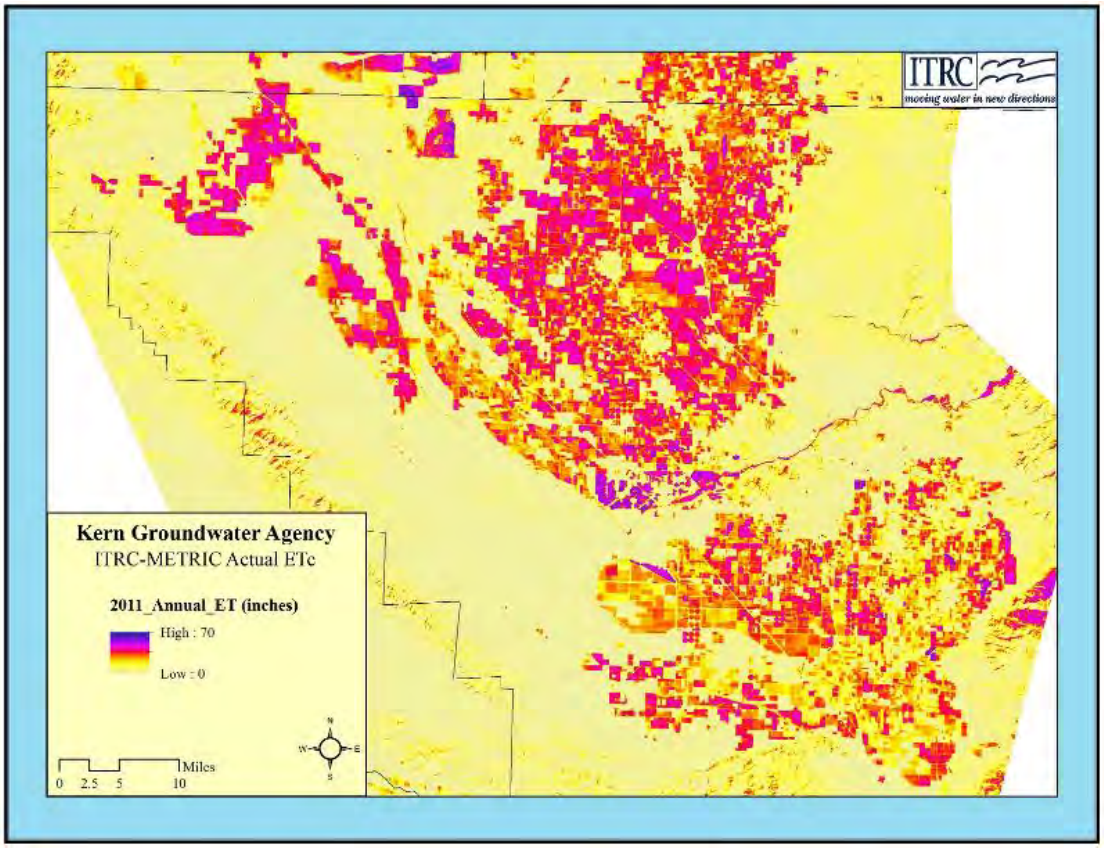

ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
2006_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10

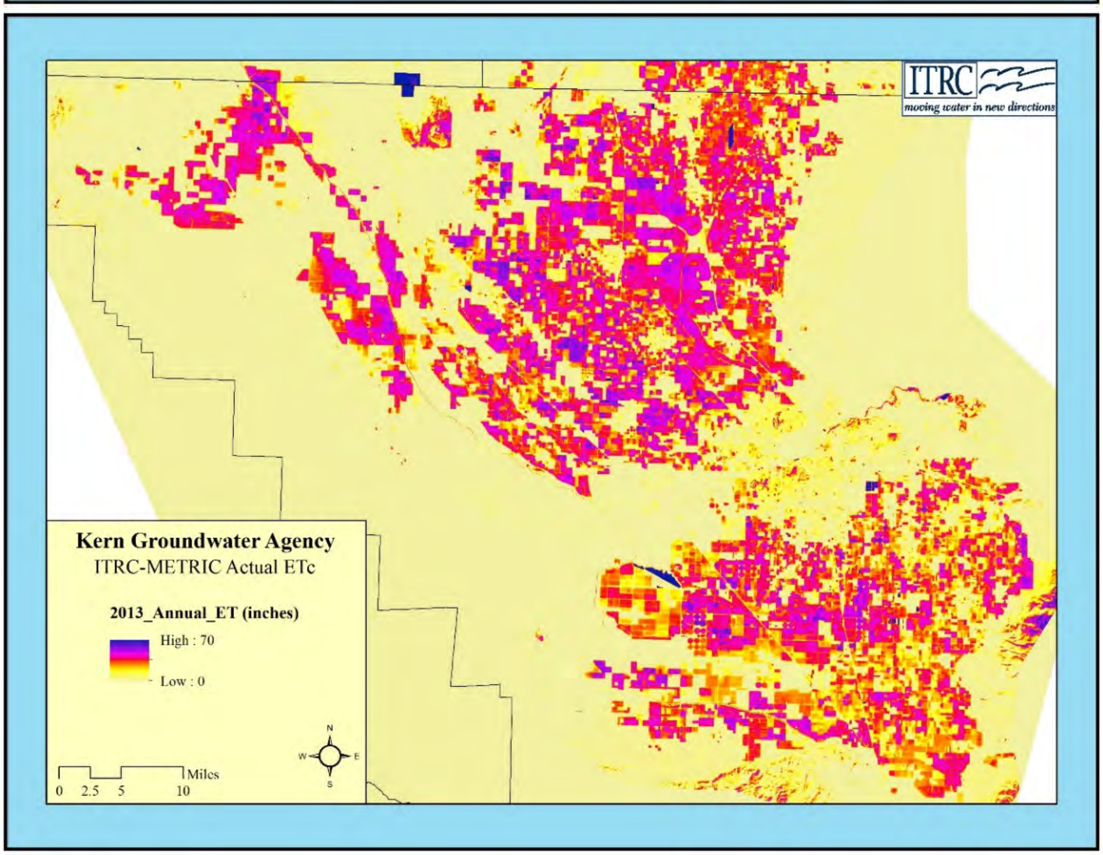

ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
2007_Annual_ET (inches)
High : 70
Low : 0
N
W
E
S
Miles
0 2.5 5 10

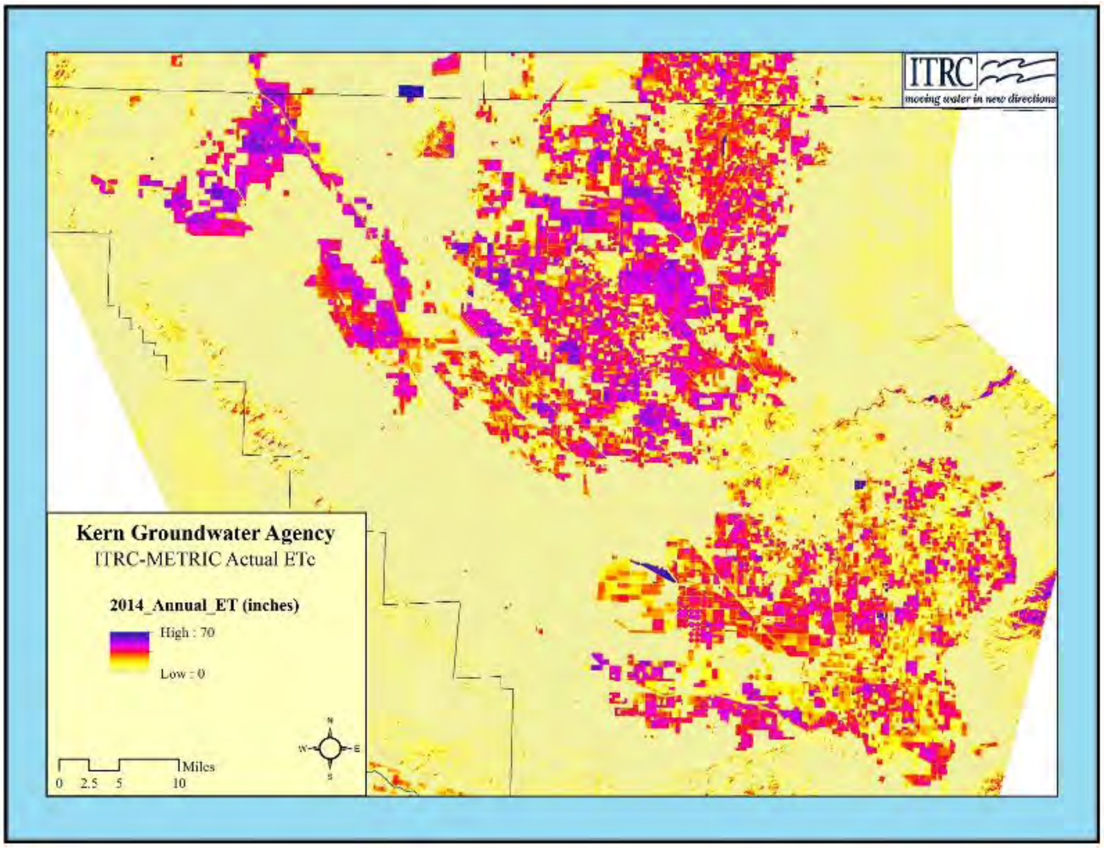

ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
2008_Annual_ET (inches)
High : 70
Low : 0
N
W
E
S
Miles
0 2.5 5 10

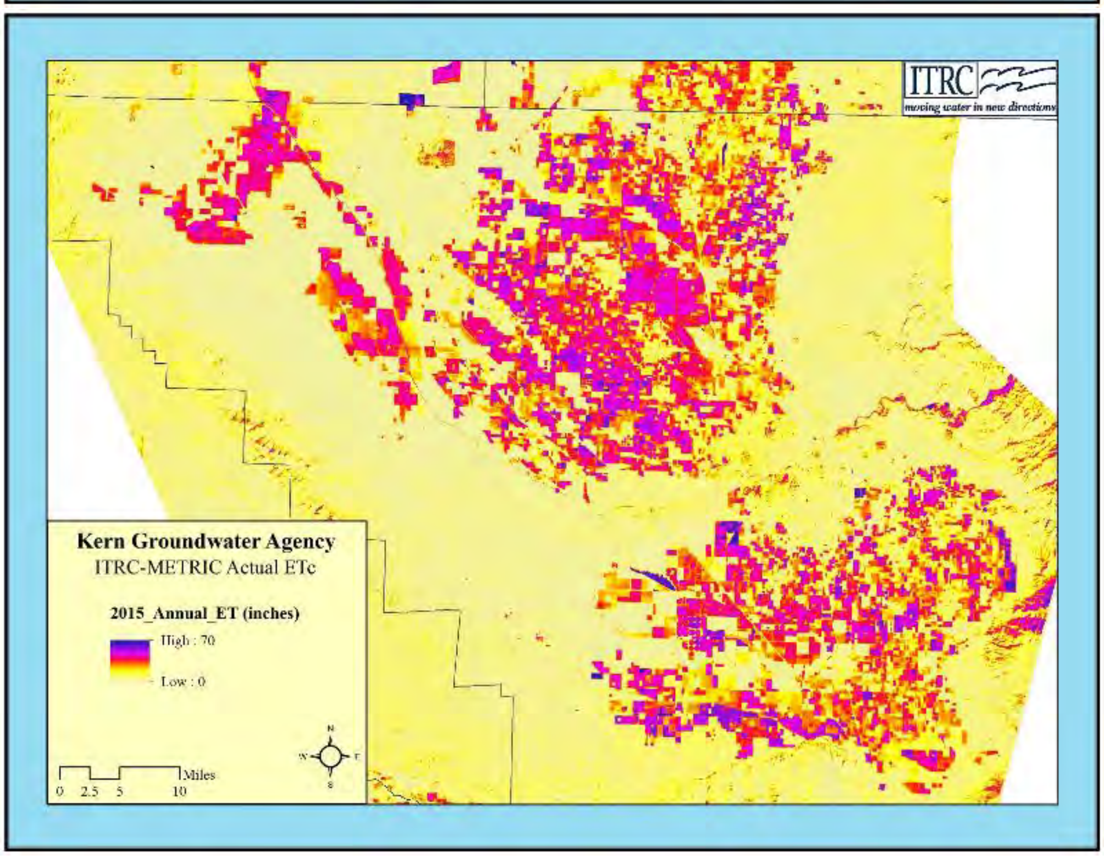

ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
2009_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10

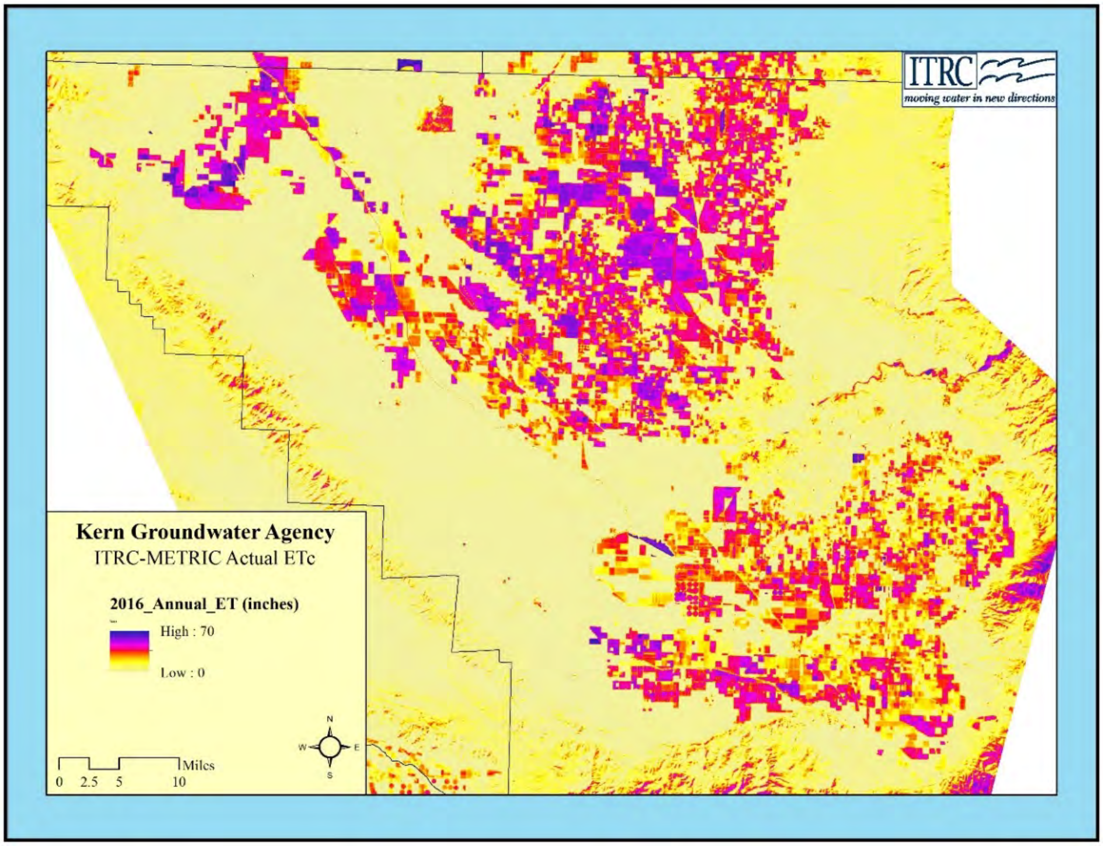

ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
2010_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10


ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
2011_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10
N
W
E
S


ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
2013_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10
N
W
E
S


ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
2014_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10


ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
2015_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10


ITRC
moving water in new directions
Kern Groundwater Agency
ITRC-METRIC Actual ETc
2016_Annual_ET (inches)
High : 70
Low : 0
Miles
0 2.5 5 10
N
W
E
S

Attachment K-4-2

List of Crop Salinity Thresholds Used for Leaching Estimate (JMLord)

Crop Salinity Thresholds for Various Crops

Crop	Salinity Threshold (dS/m)	Crop	Salinity Threshold (dS/m)	Crop	Salinity Threshold (dS/m)
Alfalfa	2	Garlic	1.2	Pecans	1.5
Almonds	1.5	Garlic (Early)	1.2	Peppers	1.5
Almonds, Young	1.5	Grain Hay	6	Peppers (Late)	1.5
Apples	1.5	Grapefruit	1.7	Persimmons	1.5
Apricots	1.6	Grapefruit, Young	1.7	Pistachios	2.5
Apricots, Young	1.6	Grapes	1.5	Pistachios, Young	2.5
Artichokes	1	Irrigated Pasture	4	Pistachios Standard	2.5
Barley	8	Jojoba	1.7	Plums	1.5
Beans (Blackeye)	1.3	Kiwi	1.5	Plums, Young	1.5
Beans (Dry)	1	Lettuce (Fall)	1.3	Potatoes	1.7
Beans (Green)	1	Lettuce (Spring)	1.3	Pumpkins	2.2
Berries	1.5	Melons	2.2	Radishes	1.2
Broccoli (Fall)	2.8	Melons(Early)	2.2	Rice	3
Broccoli (Spring)	1.8	Melons, cucumbers, squash	2.2	Safflower	5.3
Bushberries	1.5	Milo (Sorghum)	6.8	Safflower (Early)	5.3
Bushberries, Young	1.5	Misc. Deciduous	1.7	Safflower (Late)	5.3
Cabbage (Fall)	1.8	Misc. Field	6	Silage (Early)	6.8
Cabbage (Spring)	1.8	Misc. Hay & Grain	6	Silage (Late)	6.8
Cactus	4	Misc. Subtropical Fruits	1.7	Small Grains	6
Cantaloupes	2.2	Misc. Subtropical Fruits,Young	1.7	Sod	4
Carrots (Fall)	1	Misc. Trees	1.7	Spinach	1.2
Carrots (Spring)	1	Misc. Truck/Berry	1.5	Squash	2.5
Cauliflower (Fall)	1.8	Misc. Veg.	1.2	Strawberries	1
Cauliflower (Spring)	1.8	Mixed Hay & Grain	6	Sudan Grass	2.8
Celery	2.2	Native Pasture	6	Sugar Beets	7
Cherries	1.5	Nectarines	1.7	Sunflowers	5.3
Cherries, Young	1.5	Nursery Roses	0	Sweet Corn (Early)	1.7
Christmas	1.5	Oats	6	Sweet Corn (Late)	1.7
Citrus (All)	1.7	Onions & Garlic	1.2	Sweet Potatoes	1.5
Cole Crops (Fall)	2.3	Onions (Early)	1.2	Tomatoes	2.5
Cole Crops (Spring)	2.3	Onions (Late)	1.2	Tomatoes (Late)	2.5
Corn – Fall	1.7	Oranges	1.7	Turf Farm	4
Corn - Spring	1.7	Oranges, Young	1.7	Turnip	1
Cotton	7.7	Parsnips	1	Vineyards	1.5
Eucalyptus	8	Peaches	1.7	Vineyards, Young	1.5
Eggplant	1.1	Peaches & Nectarines	1.7	Walnuts	1.7
Figs	2.7	Peaches &Nectarines, Young	1.7	Watermelon	2.2
Flowers & Nursery	2.5	Pears	1.5	Wheat	6

Appendix K-5

Water Budget Model Calibration

APPENDIX K-5
WATER BUDGET MODEL CALIBRATION

This appendix documents the processes used to calibrate the White Wolf Subbasin (Basin) long-term (WY 1995 – 2015) water budget spreadsheet model and reports the final water budget calibration results.

Calibration Process

As described in **Appendix K-1**, the water budget model is a spreadsheet-based tool that quantifies 29 individual hydrologic flow “components” and then uses mass balance principles to link components and calculate a residual change in storage from the groundwater system at a monthly timestep.

Included in the water budget spreadsheet model are various “User Input Parameters” that can be adjusted to improve model performance. Values for these adjustable parameters were initially set to reasonable values based on review of previous relevant studies and local information, where possible (see **Appendices K-1** through **K-4**), and were subsequently adjusted to minimize the difference between model-calculated change in storage and the change in storage derived from rasterized groundwater elevation monitoring data.

Development of Groundwater Storage Change Rasters

Due to the lack of available water level data outside of the main irrigated agricultural area of the Basin, the storage change analysis included only the area where reasonable estimates of groundwater elevations could be interpolated, totaling approximately 35,000 acres. Storage change in areas of the Basin outside of the irrigated areas is assumed to be negligible over the long term. The change in groundwater storage was estimated between various time periods using local groundwater elevation data included in the Data Management System (DMS). Local groundwater level data within and proximate storage change analysis area were interpolated using kriging[1] to create continuous groundwater elevation surfaces (rasters) for several “bookend” years of interest within the water budget period[2]. Interpolated water level surfaces were subsequently compared between bookend years to calculate the change in storage, as follows:

$$GW\ Storage\ Change_{t1 \rightarrow t2} = (GWEL_{t2} - GWEL_{t1}) * Specific\ Yield * Area$$

where *GWEL* is the groundwater elevation and the subscripts *t1* and *t2* refer to the beginning and ending bookend years, respectively. For the purposes of this analysis, a uniform specific yield value of **0.15** was used to calculate groundwater storage change from the rasterized water level data, in line with the representative average specific yield value of the unconfined aquifer (i.e., Layer 1) within the Basin used

[1] Data were interpolated using kriging, a geostatistical method commonly used to interpolate groundwater elevation data, in the software package Surfer. The output of this interpolation process is a raster file with 100-ft by 100-ft pixels, which can be subtracted from or multiplied by other raster files covering the same area, and for which total volume can be calculated.

[2] The interpolated surfaces vary significantly depending on which well data sets are used. Based on significant analysis, we have more confidence in the change in storage estimates generated from surfaces constructed using groundwater elevation data from paired and/or “nearby” wells within a 1-mile buffer radius between each other between datasets (i.e., when groundwater elevation data from each season and year were only selected if the same well or a “nearby” well also had a measurement for the other season and year used for the storage change analysis). Use of the full dataset would allow for greater data density in each bookend year, but, because of historically variable groundwater monitoring patterns, the groundwater storage change estimates are then impacted by changes in monitoring well locations.

in DWR's "California Central Valley Groundwater-Surface Water Simulation model, "fine-grid" version (C2VSim-FG)[3], as discussed in **Section 7.1.4.2**. of the Groundwater Sustainability Plan (GSP).

Using this approach, groundwater storage change was calculated within the District's SGMA jurisdictional area for the following five periods:

- Spring 1994 – Spring 2015
- Spring 1994 – Spring 2003
- Spring 2003 – Spring 2015
- Spring 2009 – Spring 2011
- Spring 2014 – Spring 2015

Water Budget Calibration to Change in Storage Rasters

User input parameters specified within the water budget spreadsheet model (see **Appendix K-1**) were subsequently adjusted within reasonable limits to improve the fit between the water budget-calculated change in storage and the water level-based change in storage estimates for each of the five time periods mentioned above[4].

First, a sensitivity analysis was conducted to determine the most "critical" user input parameters (i.e., those that have the greatest effect on the water budget) for adjustment during model calibration. The most "critical" input parameters identified were those related to subsurface outflows, streamflow, and contributing precipitation to the Basin, including:

- **Hydraulic conductivity of the aquifer near the White Wolf Fault,** which controls the rate of groundwater flux across the fault (see **Appendix K-3**);
- **Watershed Consumptive Use Fraction and Watershed Precipitation Threshold for Runoff**. These parameters determine the amount of precipitation on contributing watersheds that runs off and becomes streamflow recharge within the District service area (see **Appendix K-2**);
- **Ineffective Precipitation Deep Percolation Coefficient**. This parameter controls how much ineffective precipitation is expected to infiltrate from the wetted land surface and become deep percolation (see **Appendix K-4**).

The above parameters were used as the primary calibration parameters to achieve an acceptable fit with the storage change estimated using the water level change method. Calibration was conducted by systematically adjusting the values of these key parameters to try to minimize the difference (in terms of root-mean-squared error [RMSE]) between the "observed" (i.e., based on water level records) change in storage for a given time period and the water budget model-calculated change in storage. Other user input parameters are less sensitive and were therefore left at their initial values in the final calibration.

[3] C2VSim-FG is the latest release of C2VSim from DWR and is currently being used for SGMA planning and GSP development within the Kern Subbasin. Note this model is currently uncalibrated. C2VSim input files downloaded 13 June 2018 from: : https://data.cnra.ca.gov/dataset/c2vsimfg-beta-model

[4] March 1st was chosen as the representative date for which to compare "Spring" water level data to within the water budget model spreadsheet.

Calibration Results

Table K-5-1 below reports the final calibrated values of each "User Input Parameter" included in the water budget model spreadsheet. Parameters listed in **bold** are those whose values were adjusted during the calibration process; all other parameters were held at their initial values during calibration.

Table K-5-1. Results of Water Budget Sensitivity Analysis

Parameter	Calibrated Value
White Wolf Fault Hydraulic Conductivity (ft/day) [1]	**3**
Watershed Consumptive Use Fraction (-)	**0.95**
Watershed Precipitation Threshold for Runoff (in)	**0.50**
Ineffective Precipitation Deep Percolation Coefficient (-)	**0.55**
Irrigation Efficiency Coefficients (-)	Variable, ranging from 0.65 for furrow to 0.85 for micro-drip
Deep Percolation Lag Period (months)	11
Leachate Water EC (uS/cm)	500
Additional Operational Demands (AFY/ irrigated acre)	0.16
Artificial Channel Seepage Rate (ft/day)	0.01
Natural Channels Seepage Fraction (-)	1

Abbreviations:

ft/day = feet per day; EC = electrical conductivity; in = inches; uS/cm = microSiemens per centimeter; M&I = municipal and industrial

Notes:

1. The hydraulic conductivity value the White Wolf Fault function as calibration parameters for the groundwater inflow/outflow components. Other factors affecting this component (i.e., vertical saturated thickness of the inflow/outflow boundary) are assumed to be fixed for the purposes of calibration.

Table K-5-2 and **Figure K-5-1** (attached) present the results of the water budget model calibration in terms of the water budget spreadsheet model-calculated change in storage compared to the change in storage estimated using the water level change method for all five calibration periods mentioned above.

Table K-5-2. Water Budget Calibration Results to Raster-Based Storage Change Estimates

Time Period[1]	Rationale for Selection of Time Period Employed for Model Calibration	Average Annual Groundwater Storage Change Calculated from Water Level Rasters (AFY)[2,3]	Average Annual Groundwater Storage Change Calculated from Water Budget Model (AFY)[2,3]	Difference (Relative to Water Level Raster Method) (%)
Spring 1994 – Spring 2015	Entire KGA Water Budget Period	5,700	5,000	-13%
Spring 1994 – Spring 2003	A representative long-term "wet" period	25,100	24,500	-2%
Spring 2003 – **Spring 2015**	A representative long-term "dry" period	-12,500	-9,700	-22%
Spring 2009 – Spring 2011	A representative short-term "wet" period	-5,700	-29,200	412%
Spring 2014 – Spring 2015	A representative short-term "dry" period	-49,100	-30,100	-39%

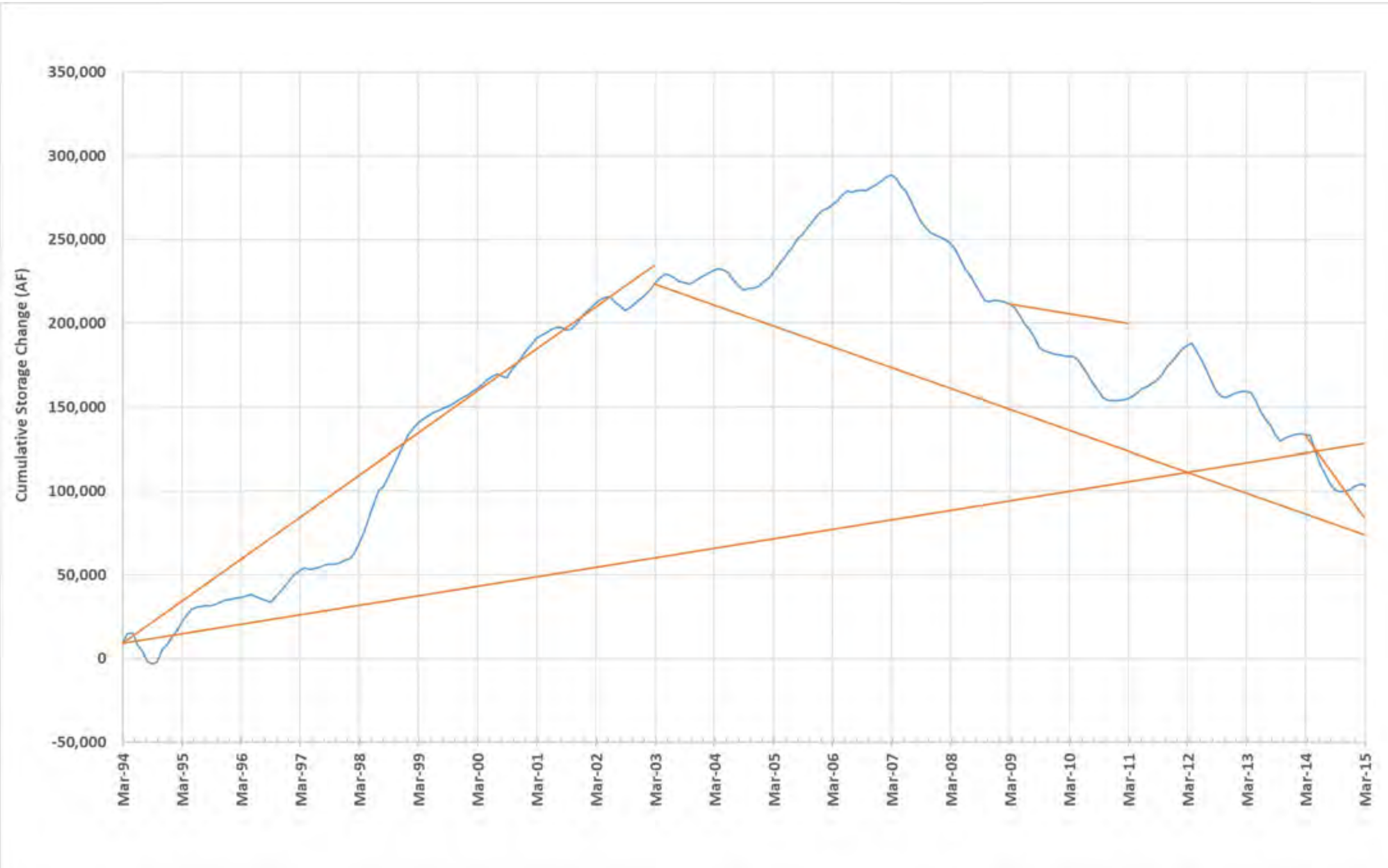
Notes:

1. March 1st was chosen as the representative date for which to compare "Spring" water level data to within the water budget model spreadsheet.
2. Results shown are rounded to the nearest 100 AFY.
3. Storage change estimates are calculated assuming of a uniform storage coefficient of 0.15.

Table K-5-2 and **Figure K-5-1** demonstrate the successful calibration of the water budget spreadsheet model to change in storage estimates deduced from the water level-change method over longer time periods. Calibration of the water budget to match the water level-change method for shorter time periods is more difficult due to transient effects on storage change from the previous years. Adjustment of the "critical" user input parameters resulted in a model calibration with a RMSE between "observed" and model-calculated annual change in storage **13,600 AFY** when considering all five calibration targets periods, and **1,700 AFY** when only considering the three long-term calibration target periods (i.e., Spring 1994 – 2015, 1994 – 2003, and 2003 – 2015). For context, the residuals in calculated vs. "observed" change in storage estimates for the three long-term periods (approximately -600 to 2,800 AFY) represent **2% to 8%** of the total annual average inflows into the Basin, thus demonstrating the spreadsheet model's accuracy in simulating long-term changes in groundwater storage relative to the total magnitude of the water budget domain.

Figure K-5-2 (attached) demonstrates the water budget-calculated change in water levels[5] relative to a set of long-term hydrographs compiled from AEWSD and WRMWSD's local groundwater elevation records. This figure further demonstrates the general agreement between observed and model-calculated changes in water levels, both in terms of magnitude and directionality, throughout the 21-year water budget timeframe.

[5] The model-calculated change in water levels is based on the model-calculated change in storage and an assumed storage coefficient value of 0.15.



Legend

= Water Level-Based Estimated Change In Storage (AF)

= Water Budget Spreadsheet Model-Calculated Change In Storage (AF)

Abbreviations

AF = acre-feet

Notes

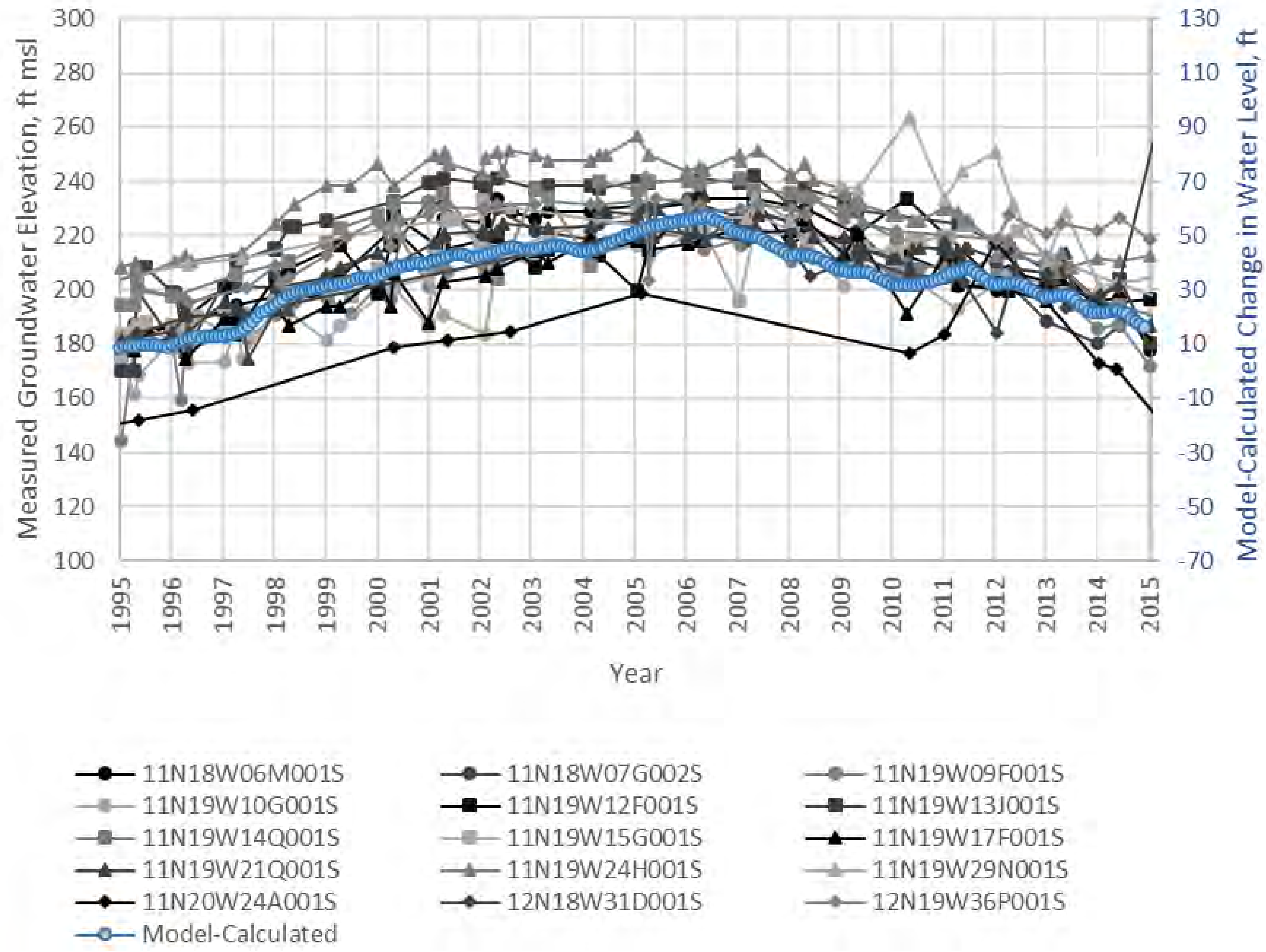
1. Calibration of the water budget spreadsheet model was performed for the entire White Wolf Subbasin.
2. Water Level-Based estimated change in storage calculations correspond to periods in Table GWC-3.

Comparison of Modeled & Water Level-Based Estimated Change in Storage

Tejon-Castac Water District
Kern County, California
September 2019
EKI B50001.05

environment & water

Figure K-5-1



Legend

= Measured Water Level

= Water Budget Spreadsheet Model-Calculated Change In Water Level (ft)

Abbreviations

ft = feet
ft msl = feet above mean sea level
WY = water year

Notes:

1. Model-calculated water levels calculated assuming storage change occurs in the develop part of the White Wolf Subbasin.

Observed vs. Modeled Change in Water Levels, WY 1995 - 2015

Tejon-Castac Water District
Kern County, California
September 2019
EKI B50001.05

eki environment & water

Figure K-5-2

Appendix L

White Wolf Groundwater Flow Model Documentation

WHITE WOLF GROUNDWATER FLOW MODEL DOCUMENTATION

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

ABBREVIATIONS AND ACRONYMS

AEWSD	Arvin-Edison Water Storage District
AFY/ft	acre-feet per year per foot
C2VSimFG	California Central Valley Surface Water-Groundwater Simulation Model-Fine Grid
CCR	California Code of Regulations
CVHM	Central Valley Hydrologic Model
DEM	Digital Elevation Model
DMS	Data Management System
DOGGR	Division of Oil, Gas and Geothermal Resources
DWR	California Department of Water Resources
EKI	EKI Environment & Water, Inc.
ET	Evapotranspiration
EVT	MODFLOW Evapotranspiration Package
ft	feet
ft bgs	feet below ground surface
ft/d	feet per day
GHB	MODFLOW General-Head Boundary Package
GPM	gallon per minute
GSP	Groundwater Sustainability Plan
HCM	Hydrogeological Conceptual Model
HFB	MODFLOW Hydrologic Flow Barrier package
ITRC-METRIC	Irrigation Training and Research Center-Mapping EvapoTranspiration at high Resolution with Internalized Calibration
MNW2	MODFLOW Mulit-Node Well package
PEST	Model-Independent Parameter Estimation and Uncertainty Analysis
POD	Point of Diversion
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RCH	MODFLOW Recharge package
RMSE	root mean square error
S_{bot}	Streambed bottom elevation
SMB	Soil moisture budget accounting model
Ss	Specific storage
S_{top}	Streambed top elevation
STR	MODFLOW Stream Package
Sy	Specific yield
TCWD	Tejon-Castac Water District
USGS	United States Geological Survey
WEL	MODFLOW Well Package
WRMWSD	Wheeler Ridge-Maricopa Water Storage District

WWF	White Wolf Fault
WWGFM	White Wolf Groundwater Flow Model
WY	Water Year

1. MODEL DEVELOPMENT OVERVIEW

The White Wolf Groundwater Flow Model (WWGFM or "model") is an approximation of the spatial extent and variability of the White Wolf Subbasin (Basin) and can be used to quantitatively evaluate local hydrogeologic conditions associated with water inflows, outflows, and associated connectivity between the adjacent Kern County Subbasin. The purpose of the WWGFM is to quantify the historical, current, and projected water budgets for the Basin and their uncertainties, and to evaluate the impacts of future land use, hydrologic, and water supply/demand projections as well as any proposed management decisions on groundwater conditions within the Basin. The model can also help identify gaps in available data and deficiencies in the conceptual understanding of groundwater conditions in the Basin. These results help prioritize plans for future data collection and other Groundwater Sustainability Plan (GSP) implementation activities.

2. METHODOLOGY AND APPROACH

2.1 Model Source Code

The WWGFM utilizes the United States Geological Survey (USGS) computer code MODFLOW-NWT (Niswonger et al., 2011); MODFLOW is a widely used model code and is publicly available and supported by the USGS. MODFLOW-NWT is a Newton formulation of MODFLOW-2005 which excels at solving models whose cells have active drying and rewetting in the unconfined groundwater flow equation (Niswonger et al., 2011). As the Basin has a thick unconfined zone, MODFLOW-NWT is an appropriate and effective computer code to solve the groundwater flow equation.

MODFLOW-NWT's utility is enhanced by additional software processes for model development, processing, and analysis of results. Specifically, ZONEBUDGET version 3 (Harbaugh, 1990) is a post-processor used to extract water budget results for user-defined model subareas.

As discussed in more detail below in *Section 3.1 Recharge* and *Attachment 2*, a code was developed and used to represent the root zone processes and ultimately create the recharge and pumping datasets within the WWGFM. Attachment 3 provides a list of the MODFLOW files used in the WWGFM.

2.2 Discretization

When employing numerical models, the spatial domain is discretized into "model cells" and time is discretized into "stress periods". The discretization of the spatial domain is the spatial approach and the discretization of time is referred to as the temporal approach. Both approaches are further discussed below.

2.2.1 <u>Spatial Approach</u>

MODFLOW represents the groundwater system as a set of discrete, rectangular blocks (cells) forming a grid in space. MODFLOW then computes an approximate solution to the groundwater flow mathematical equations at each model cell. The model grid consists of 105 rows and 182 columns of cells that cover the entire extent of the California Department of Water Resources (DWR) Basin boundary (DWR No. 5-022.14)

(**Figure 1**). The square cells have a dimension of 660 feet (ft) on a side, representing an area of 10 acres. The coordinates of the lower left corner of the grid are 6,272,396, 2,129,233 (State Plane Zone 5, NAD 83, Feet). The grid is rotated 37 degrees counterclockwise so that the rows align approximately with the White Wolf Fault (WWF). The grid consists of 10,704 active cells in the upper-most layer and the number of active cells reduce with depth to follow the underlying basin boundary.

2.2.2 Temporal Approach

The historical simulation is discretized temporally into 408 monthly stress periods, representing a simulation period from Water Year (WY) 1986 (October 1985) through WY 2019 (September 2019). The period WY 1985-2015 was utilized to calibrate the model (the "calibration period"), and the period WY 2016-2019 was utilized to test model performance as part of model verification (the "verification period").

GSPs are required to "*provide a quantitative assessment of the historical water budget, starting with the most recently available data and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon*" (23-California Code of Regulations [CCR] §354.18(b)(2)). The historical water budget accounting period is WY 1995-2014, which allows for a nine-year pre-conditioning period to minimize the influence of uncertainty in the specified initial conditions.

Projected water budgets are required "*to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation*" (23-CCR §354.18(b)(3)). The projected water budget must use 50 years of historical precipitation, evapotranspiration (ET), and streamflow information as the basis for evaluating future conditions under baseline and climate-modified scenarios. Several projected scenarios were developed from the historical model to evaluate aquifer response to future climate, land use, and water supply and demand conditions (See GSP Section 9.4 Projected Water Budget for further details). The projected simulations are discretized temporally into 636 monthly stress periods, representing a simulated analog period from WY 2020 (October 2019) through WY 2072 (September 2072). The 53-year period was selected to cover the 50-year period following GSP submittal (WY 2023 through WW 2072).

2.2.3 Vertical Geometry

The model is discretized vertically into four layers:

- **Layer 1** represents the alluvium and surficial uplands deposits,
- **Layer 2** and **Layer 3** represent the undifferentiated Kern River and Chanac Formations, and
- **Layer 4** represents the Santa Margarita Formation.

Layers 1 through 3 represent the Principal Aquifer and Layer 4 represents the unpumped aquifer. **Figure 2a** and **Figure 2b** show two representative cross-sections from the hydrogeological conceptual model (HCM) and the model layers. The water table can occur in layers 1 or 2, and where present the layer is represented as unconfined; the deeper model layers beneath the water table are represented as confined. The minimum thickness for any layer was specified as 25 feet (ft); **Figure 3** shows the thicknesses of each model layer.

The top of Layer 1 is represented by land surface elevations as determined from a Digital Elevation Model (DEM). Layer 1 is active over the entire extent of the Basin. The bottom of Layer 1 was estimated to be approximately 500 ft below ground surface (ft bgs) in the central part of the Basin based on cross sections in WZI (2013). The thickness of Layer 1 decreases near the margins of the Basin. In the eastern tip of the Basin, the Layer 1 bottom was controlled by the depth to basement based on Division of Oil, Gas and Geothermal Resources (DOGGR) logs. The Layer 1 bottom in this area is approximately 50 ft bgs. In the west part of the Basin, west of the Pleito Thrust Fault, the topography rises rapidly and is variable. In order to prevent extreme variations in the Layer 1 bottom in this area, the bottom of the layer was specified as a relatively smooth surface. Similar procedures were used in other areas of the basin margins where the topography rises sharply.

In the east and southern parts of the Basin, surficial geology maps show that Chanac and deeper older marine continental formations outcrop at the surface (see GSP Figure HCM-13). In these areas, Layer 1 represents these older formations and is delineated into a separate physiographic zone as discussed in *Section 2.5 Aquifer Properties* below.

The bottom of layer 3 was estimated as the top of the Santa Margarita Formation in the central part of the Basin. Various datasets estimating the depth of the Santa Margarita stratigraphy were compiled into one set of datapoints representing the top of the formation. The dataset included point-specific information from DOGGR logs and Scheirer (2007), and selected locations along cross sections from Lofgren (1975), DOGGR (1998), and Bartow (1984). A raster spanning the entire active model extent was then created using the Kriging interpolation method.

The interval between the bottom of Layer 1 and the bottom of Layer 3 was split into two layers by using the base of fresh water based on DOGGR logs[1] for the main portion of the Basin. Where DOGGR logs were unavailable, the bottom of Layer 2 was estimated to occur at approximately 50% above the bottom of Layer 3. In the southern portion of the model, manual adjustments were made to the bottom of layer 2 to preserve the northward dip of the formations and account for irregularities in the reported base of fresh water.

The bottom of layer 4 was estimated as the base of Santa Margarita Formation. Various datasets estimating the depth of the Santa Margarita stratigraphy were compiled into one set of datapoints representing the bottom of the formation. The dataset included point-specific information from DOGGR logs and Scheirer (2007), selected locations along cross sections from Lofgren (1975), DOGGR (1998), Bartow (1984), and WZI (2013). A raster spanning the entire active model extent was then created using the Kriging interpolation method.

2.3 Initial Conditions

Fall 1985[2] water levels are used as initial conditions for the model. For wells that did not have Fall 1985 measurements, estimated water levels were calculated from their correlation with seasonal water levels in wells with long-term records having Fall 1985 water levels (coefficient of determination (R^2) of 0.7 or greater). The resulting dataset was comprised of 29 wells with measured Fall 1985 water levels and 16 wells with estimated Fall 1985 water levels. Three additional artesian wells were added to the dataset because they are known have had artesian water levels during the modeled period.

[1] The base of fresh water and the base of freshwater sands were both assumed to represent the base of fresh water.
[2] Seasonal average water levels were calculated for each well, where Fall includes measurements from August 15th to November 15th and Spring includes measurements from January 15th to April 15th.

Surfer was used to generate a grid of Fall 1985 water levels. In addition to the well dataset described above, 11 surrogate points were added at the edge of the Basin constrain initial water levels at the margins where data do not exist. A Gaussian model variogram was applied to the kriging gridding method to generate a grid representing Fall 1985 water levels, which was applied to all four layers of the model grid. Upon model calibration, Layers 1 and 2 in the area immediately south of the Springs Fault were assumed to be dewatered.

Data used to develop initial heads were limited to the shallow layers in the central part of the Basin. Some zonal adjustments were made to the initial heads in some areas with limited or no data to improve the model calibration. Adjustments were also made to ensure that all initial heads were below land surface.

2.4 Boundary Conditions

Boundary conditions represent flow constraints in the model domain. Four types of boundary conditions are specified in the WWGFM: 1) no-flow boundary, 2) general-head boundary, 3) stream boundary, and 4) internal faults (**Figure 4**).

2.4.1 No-Flow Boundary

The margin of the Basin, except for the northern boundary with the Kern Subbasin, is represented as a No-Flow boundary. The model bottom, which coincides with the bottom of the Santa Margarita Formation or basement, is also represented as a No-Flow boundary.

2.4.2 General-Head Boundary

The Basin is separated from the Kern County Subbasin by the WWF. The WWF is a partial barrier to groundwater flow and is represented by a general-head boundary (GHB) in the WWGFM. The GHB is a head-dependent flow boundary, and the flow across this boundary is proportional to the difference between the model-calculated head at the boundary and the head in the Kern County Subbasin specified at a distance from the boundary. The proportionality constant used to calculate the flow is the conductance, which was calculated from the hydraulic conductivity of the boundary cell, area of the face of the boundary cell, and the distance from the boundary cell to the point in the Kern County Subbasin represented by the specified head.

The active extents of layers 2-4 were adjusted because the WWF dips to the southeast, which causes its location and the corresponding extent of each model layer to change with depth. Previous investigators have reported the dip to be in the range of 45° to 66° from horizontal (Goodman and Malin, 1992; Oakshott, 1955; Wood and Dale, 1964). This dip was implemented in the model by assuming a dip angle of 60°, and corresponds to 58 ft of horizontal displacement in the extent of the model layers for every 100 ft increase in depth. The active extent of layers 2 through 4 was therefore displaced to the southeast relative to the layer 1 active extent to approximate the horizontal displacement of the fault at depth.

The head specified for the GHB cells was obtained from eight wells located on the north side of the fault in the Kern County Subbasin. The wells were selected based on their proximity to the WWF and the completeness of their water level record. A monthly water level time series was developed for each of these wells by removing obvious outliers, interpolating monthly values between measurements, and extending the period of record where needed by applying the slope in model-calculated water levels from the Kern Subbasin's modified California Central Valley Surface Water-Groundwater Simulation Model-Fine Grid (C2VSimFG-Kern) at each well location. The monthly water level time series for each well was applied to the GHB cell nearest each of the wells and extrapolated between wells using linear interpolation.

The initial conductance of the GHB cells was calculated using an assumed hydraulic conductivity of 1 ft/day, and the mapped distance from the GHB cell to the eight wells representing the specified heads. The distance used for the GHB cells between the eight wells was determined by linear interpolation. The GHB conductance was adjusted during calibration as described below in *Section 4.3 GHB Conductance*.

2.4.3 Stream Boundary

Ten major streams with channels running through the Basin were represented using the stream package (STR) (**Figure 4**). Active model cells that intersected 100 ft or more of the stream trace were specified as STR package cells. Model cells intersecting stream lengths less than 100 ft were not specified as STR package cells, and the stream lengths in these cells was added to the stream length in adjacent STR package cells to preserve the total stream length in the stream package calculations.

Streambed top elevation (S_{top}) was set to 5 ft bgs and streambed bottom elevation (S_{bot}) was set to 1 ft below S_{top}. Stream width was assigned a value of either 25 ft or 250 ft based on inspection of aerial imagery along the stream length. Stream conductance was adjusted during calibration as described below in *Section 4.5 Streambed Conductance*.

2.4.3.1 Stream Inflow

Initial monthly stream inflow was estimated based on the estimated amount of rainfall runoff from each surrounding watershed (**Figure 4**).[3] Precipitation is affected by surrounding topography and must be considered when estimating rainfall over watershed areas with significant elevation range (the "orographic effect"). The nearly 8,000 ft difference in elevation between Basin lands and the peaks of the surrounding watersheds in the San Emigdio and Tehachapi mountains results in this orographic effect. As such, we utilized Parameter-elevation Regressions on Independent Slopes Model (PRISM) estimated precipitation for each watershed area. PRISM uses an interpolation method called climatologically-aided interpolation which estimates the best guess of spatial rainfall patterns based on the long-term average calculated using a DEM predictor grid (PRISM, 2019). Therefore, PRISM accounts for elevation in its daily rainfall estimates. The area-weighted average rainfall from all PRISM cells within each individual watershed was used to estimate monthly rainfall on each watershed surrounding the Basin.

Initial monthly streamflow into the Basin was calculated from the estimated rainfall on watersheds surrounding the Basin using a linear equation with two parameters: a Precipitation Threshold for Runoff Initiation and a Watershed Consumptive Use Fraction, using the following equation:

Equation [1] Contributing Streamflow from Surrounding Watersheds

$$Streamflow = max\left(0, Rainfall\ on\ Watersheds - \frac{p_{threshold}}{12} * A_{watershed}\right) * (1 - CU_{watershed})$$

where:

$p_{threshold}$ = Precipitation Threshold for Runoff Initiation [in],
$CU_{watershed}$ = Watershed Consumptive Use Fraction [dimensionless], and
$A_{watershed}$ = total area of surrounding watersheds [acres].

[3] The watershed associated with Telegraph Creek in the western part of the Basin was assumed not to contribute significant streamflow to the Basin due to its small contributing area.

Ultimately, a Watershed Consumptive Use Fraction of 95% and Precipitation Threshold of 0.50 inches were employed to estimate resultant contributing streamflow, which is consistent with the spreadsheet water budget model discussed in *Section 9.2* and *Appendix K* of the GSP. The Chanac Creek watershed above the Basin includes a small reservoir that likely captures much of the flow in Chanac Creek before it enters the Basin. Therefore, runoff entering the Basin in Chanac Creek was estimated using only the area of the watershed below the reservoir.

Upon inspection of streamflow estimates, estimated streamflow from Grapevine Creek into the Basin was abnormally high compared to other streams. Comparisons with the maximum recorded flow at a gauging station operated by Kern County located north of the Basin suggest that streamflow estimates were exceeding recorded maximums by approximately 45%. It is likely that some of the runoff from the watershed is captured by Castac Lake and never flows into the Basin. Therefore, estimated Grapevine Creek flows were reduced by 45% to better align with measured values. Further adjustments to specified streamflow occurred during calibration of diversion flows.

During calibration it was determined that initial monthly stream inflow was not always sufficient to meet the demands of downstream diversions, as discussed below in *Section 2.4.3.2 Diversions*, including some months having specified diversions but no stream inflow upstream of the diversions. This may be caused by uncertainty in the estimated stream inflow and assumptions related to the timing of the precipitation and the timing of the resulting runoff into the Basin. Whenever the monthly stream inflow was less than the downstream diversions for the four streams having downstream diversions, the initial monthly stream inflow was adjusted by multiplying the monthly downstream diversion value by a factor of 1.5, which was determined during calibration. This ensured that there was inflow to the streams above the specified diversions and resulted in improved simulation of the diversions.

2.4.3.2 Diversions

Records of monthly diversions from streams were available for six points of diversion (POD). The six PODs (4, 6, 7, 9, 10, and 14)[4] have monthly diversion records available for October 2007 through December 2019. Because the monthly diversions are not correlated to precipitation or water year indices[5], the data set was completed using the median monthly diversion from the available records for each POD.

Diversions from PODs 10 (Grapevine Creek), 7 (Tunis Creek), 14 (Pastoria Creek), and 6 (El Paso Creek) were simulated directly within the STR package (**Figure 4**). Diversions from PODs 4 (El Paso Creek) and 9 (Grapevine Creek) were not represented in the model and the volume of this diverted water was removed from the estimated stream inflows, as they were located proximal to the Basin boundary. Specified diversions only occur if the stream supplying the diversion has sufficient water to meet the entire specified diversion. The adjustments to stream inflows described in the previous *Section 2.4.3.1 Stream Inflow* resulted in simulated diversions that were 81% of the reported diversions, on average. This suggests that there is uncertainty in both the specified stream inflows and the specified diversion amounts.

[4] POD 4 and 6 are located on El Paso Creek, POD 7 and 14 are located on Tunis Creek, and POD 9 and 10 are located on Grapevine Creek. POD 3 has a long record, however it is located out of the model and was therefore not modeled. Diversion data obtained from Tejon-Castac Water District (TCWD), personal communication, 5 October 2020.

[5] Chronological Reconstructed Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indices http://cdec.water.ca.gov/reportapp/javareports?name=WSIHIST, accessed on 4 December 2020.

2.4.4 Internal Faults

Two internal faults are represented using the Hydrologic Flow Barrier (HFB) package in MODFLOW, which represents faults as thin, vertical low conductivity material that impedes horizontal flow between two adjacent model cells. The Springs Fault is located in the southeast center of the Basin (see **Figure 1**). The occurrence of springs in this area and high groundwater levels south of the fault suggest this fault is a partial barrier to groundwater flow. The location of the fault was determined primarily from the fault trace as mapped in Bartow (1984) and extended along the fault trace as mapped in Goodman and Malin (1992). As discussed in more detail below in *Section 4.4 Fault Hydraulic Characteristic*, the fault hydraulic characteristic values were calibrated to the limited available water levels measured in wells located south and north of the fault.

The Wheeler Ridge Fault is located in the western corner of the Basin (see **Figure 1**). The location of the fault was determined from a fault trace as mapped in California Division of Mines and Geology (1985). The Wheeler Ridge Fault is designated as an Alquist-Priolo Earthquake Fault Zone, which means it has been active within the last 11,000 years with a surface rupture and/or land displacement (California Division of Mines and Geology, 1985). As discussed in more detail below in *Section 4.4 Fault Hydraulic Characteristic*, the fault hydraulic characteristics were calibrated to the limited available water levels measured in wells located east of the fault.

2.5 Aquifer Properties

Model grid cells were grouped into five physiographic zones, representing the (1) main basin, (2) shallow alluvium upgradient of Springs Fault, (3) uplands outcrops, (4) south-western uplands area, and (5) faulted transitional area (**Figure 5**).

2.5.1 Hydraulic Conductivity

In alluvial aquifers, the spatial distribution of hydraulic conductivity is influenced by the distribution of sediment texture (i.e., the fraction of coarse-grained sand and gravel relative to the fraction of silt and clay), the size and shape of the pores between the sediment grains, and the effectiveness of the interconnections between those pores. Texture maps constructed for each model layer based on lithologic descriptions from 101 boreholes were therefore employed to represent the spatial distribution of hydraulic conductivity in the model (**Figure 6**).

The texture maps are based on the lithologic descriptions from borehole logs. Most of the borehole data is in the central part of the Basin, and the number of boreholes decreases with depth. Layer 1 utilized 101 borehole logs, layer 2 utilized 74 borehole logs, layer 3 utilized 37 borehole logs, and layer 4 utilized 22 borehole logs. The logs were coded on a 1-ft interval as either coarse-grained or fine-grained material, using a rubric consistent with the USGS' Central Valley Hydrologic Model (CVHM; Faunt et al., 2009). For each borehole, the average fraction of coarse-grained sediment was calculated over the total thickness of each model layer, and resultant values extrapolated to create a fraction of coarse-grained sediment for each model cell (**Figure 6**). In general, the borehole data indicate that layer 1 has the greatest fraction of coarse-grained sediment, and the sediments generally become finer with depth.

Areas and depth intervals characterized with relatively coarse-grained sediments transmit water at a higher rate than areas and depth intervals characterized by fine-grained sediments. The resulting distributions in the fraction of coarse-grained sediment was therefore utilized to specify the spatial distribution in horizontal and vertical hydraulic conductivity. The modeled horizontal hydraulic conductivity is calculated as the product of the fraction of coarse-grained sediment and specified coarse-grained horizontal hydraulic conductivity. Vertical hydraulic conductivity is typically less than horizontal hydraulic conductivity because fine-grained beds can impede the downward movement of water. The modeled vertical hydraulic conductivity is therefore calculated as the product of the fraction of coarse-grained sediment and specified coarse-grained vertical hydraulic conductivity.

Aquifer test results and well specific capacity data were utilized to provide initial estimates for the horizontal hydraulic conductivity of coarse-grained sediments.[6] The locations of aquifer tests and wells with specific capacity data are shown on **Figure 7**. The initial specified coarse-grained hydraulic conductivity (21.4 feet per day, or ft/d) was calculated as an average horizontal hydraulic conductivity for wells coincident with the texture dataset, and with an average fraction of coarse-grained sediment greater than 50% over the length of well screen. The final specified coarse-grained horizontal and vertical hydraulic conductivity vary by physiographic zone and layer and were determined by calibration, as discussed below in *Section 4.2 Aquifer Properties*.

2.5.2 Storage

As mentioned above, layers 1 and 2 are unconfined and therefore require specification of both specific yield (Sy) and specific storage (Ss). Storage in confined layers 3 and 4 is controlled solely by Ss. The reported average Sy values weighted by depth vary in the Basin from 8.8% to 17.6%, with Sy decreasing with depth (see **Table 1**; Bookman-Edmonston, 1975). An initial Sy value of 15% was specified for all zones and layers, based on the median range for the upper 1,000 ft of sediments. The final specified Sy values were then adjusted and finalized by calibration, as discussed below in *Section 4.2 Aquifer Properties*.

Table 1. Estimated Average Specific Yield for Depth Zones in White Wolf Subbasin

Depth Zone Below Ground Surface (feet)	Weighted Average Specific Yield (percent)
200-300	11.8
300-400	16.1
400-500	15.4
500-600	17.6
600-700	15.4
700-800	10.3
800-900	15.2
900-1,000	13.2
1,000-1,250	9.9
Below 1,250	8.8

<u>**Source:**</u> Reproduced from Table 1 in Bookman-Edmonston (1975)

[6] Specific capacity was calculated as the reported drawdown in a well (ft) divided by the pumped rate (gallons per minute, or GPM). Transmissivity was estimated from the specific capacity using a scaling factor of 1,500, representative of coarse-, unconfined aquifers (Driscoll, 1986). Finally, the effective hydraulic conductivity was estimated by dividing the transmissivity value by the entire length of well screen.

An initial Ss value of $1x10^{-5}$ was specified for all layers and zones. The final specified Ss values were adjusted and finalized by calibration, as discussed below in *Section 4.2 Aquifer Properties*. The specified Ss values vary by physiographic zone and layer.

3. STRESSES

3.1 Recharge

Recharge is simulated using the Recharge (RCH) Package. To quantify the spatial and temporal distribution of recharge across the WWGFM domain, a Soil Moisture Budget accounting model (SMB) was developed (see *Attachment 2*). The SMB simulates land surface processes (e.g., precipitation, applied water, and plant ET) and root zone processes which ultimately determine the amount of deep percolation on a grid cell basis that is specified as groundwater recharge.

The SMB uses a mass-balance approach to quantify the movement of water that arrives at the land surface from either precipitation or irrigation into the subsurface or atmosphere. The processes included in the SMB code are precipitation, interception, canopy evaporation, rainfall excess runoff, applied water from District deliveries, applied water from private pumping (deficit pumping), ET by vegetation, recharge, saturation excess runoff, and dynamic soil moisture storage.

The SMB calculates the above processes on a grid cell basis using the uppermost layer and grid of the WWGFM. Spatially variable properties include soil type (and associated soil hydrologic group, vertical hydraulic conductivity, soil depth, field capacity, wilting point, and total porosity), land use type (and associated canopy/depression storage capacity), parcel identifier (and associated surface water service area flag and temporally variable ET values). The combination of soil type and land use type determines the Curve Number (runoff coefficient) that controls rainfall excess runoff. Land use is also temporally variable, with crop types updated twice a year. Calculation of ET is based on one of two data sources/methods depending on the land use type: (1) for irrigated land uses, ET is based on Irrigation Training and Research Center-Mapping EvapoTranspiration at high Resolution with Internalized Calibration (ITRC-METRIC) data, which calculates actual ET using remote-sensing data and an energy balance equation); or (2) for non-irrigated (native) land uses, ET is calculated using the crop coefficient method with daily CIMIS reference crop evapotranspiration for native/non-irrigated land uses. Evapotranspiration is limited when soil moisture declines to the wilting point. Irrigation with private groundwater occurs for irrigated lands when the combination of precipitation, applied delivered water, and soil moisture storage is insufficient to meet vegetative water demand (ET).

The SMB calculates a running soil moisture balance for each grid cell on a daily timestep and is driven by daily spatially-variable precipitation from the PRISM dataset. Recharge is simulated to occur when the water content in the soil column, after infiltration of precipitation, applied water, and evapotranspiration, is greater than the field capacity of the soil. When this occurs, recharge is released from the soil column to the point where soil water content equals field capacity. Calculation of daily evapotranspiration for each grid cell is based on monthly input data. Daily calculated values are summed into monthly totals for use as input to the WWGFM.

In addition to the recharge calculated by the SMB, the WWGFM also includes water distribution and conveyance system leakage in the RCH Package. Leakage was estimated as 4% of delivered water and was individually distributed across cells that cross each of the three Districts (Arvin-Edison Water Storage

District [AEWSD], Tejon-Castac Water District [TCWD], and Wheeler Ridge-Maricopa Water Storage District [WRMWSD]) water distribution systems (**Figure 8**).

3.2 Pumping

Pumping is simulated using the Well (WEL) Package. Monthly pumping rates were estimated based on available data or by the SMB. As detailed below, well-specific pumping rates were available for wells owned by WRMWSD, private irrigation wells which pump into WRMWSD's water distribution system, and public water system wells; all other private pumping rates for agricultural irrigation are unavailable and were therefore estimated using the SMB. Locations of the pumping wells specified in the model are shown on **Figure 9**.

All pumping was vertically distributed based on available well construction information (i.e., screened interval depths or total well depths). When well construction information was unavailable, pumping was distributed based on average well and screen depths calculated from wells with known construction information. This resulted in all wells with unknown construction information being assigned to Layer 2 except for one well that was assigned to Layer 4. The MODLFOW-NWT solver has an option that smoothly reduces the specified pumping rate in an unconfined cell when the model-calculated water level approaches the cell bottom. The pumping rate is reduced when the water level drops below a specified percentage of the cell thickness (5 percent) and the pumping rate reaches zero when the head is at or below the cell bottom. In some instances, the vertical distribution of pumping was adjusted during calibration to reduce the loss of specified pumping in cells where the simulated head approaches or drops below the cell bottom.

3.2.1 District Pumping

The WRMWSD owns several wells that are used to pump groundwater into the WRMWSD distribution system for delivery to agricultural fields for irrigation. The WRMWSD maintains monthly records of this District pumping beginning in January 2001. From January 1994 through December 2000, total annual District pumping for the portion of the WRMWSD service area within the Basin was reported by the WRMWSD. From January 1992 through December 1993, total annual District pumping for the entire WRMWSD service area, including the Kern County Subbasin, was reported by WRMWSD. The portion of District pumping that occurred within the Basin in 1992 and 1993 was estimated based on the portion of District pumping that occurred within the Basin for the period 1994-2000. Total annual District pumping in the Basin was distributed monthly based on the average monthly distribution for the period 2001-2015 when monthly records are available. Total estimated monthly pumping was distributed to individual wells based on the distribution between wells in 2001. It was assumed that no District pumping occurred prior to January 1992 based on District records of total imports, deliveries, and exchanges.

3.2.2 Private Pumping

Pumping from private wells consists of (1) pumping into the WRMWSD water distribution system for credit, (2) pumping directly to irrigate agricultural fields, and (3) de minimis pumping for domestic and public water system use.

The WRMWSD maintains annual records of private pumping into the turnouts of the water distribution system and a list of wells used for pumping into the water distribution system. However, the monthly distribution of this pumping is unknown. The location of the private pumping that is delivered into the water distribution was determined using records provided by WRMWSD and well locations in the DMS.

The locations of private wells that deliver groundwater into the water distribution but whose location is not precisely known were estimated using the well name and PLSS grid. The WRMWSD maintains records of annual pumping from private wells into the water distribution system beginning in January 1999. Total annual pumping was distributed monthly based on the monthly fractions of District pumping during the years 2001-2015. Prior to 1999, monthly private pumping into the water distribution system for years in which some amount of private pumping was recorded in the WRMWSD records by turnout was estimated as the average monthly reported private pumping during the period 2001-2015 by water year type.

Data on the quantity of private pumping directly to agricultural fields is not available. An estimate of the monthly private pumping directly to agricultural fields was developed based irrigation demand using the SMB. Pumping estimated by SMB was distributed to 220 potential irrigation wells, as identified in the Basin's (DMS).

Private de minimis pumping for domestic uses is small and was not considered, except for limited available data for three public water systems (Tut Brothers #96, TCWD, and Cuyama Orchards). Monthly pumping volumes for these public water system wells were electronically reported to the Division of Drinking Water between 2013 and 2019, with records varying by public water system.[7]

3.3 Evaporation

Evaporation of groundwater can occur in areas where the water table is near land surface. In the WWGFM, this is mostly likely to occur in the areas south of the Springs Fault and near streams where there is a shallow water table. Evaporation of groundwater was simulated in the WWGFM using the Evapotranspiration (EVT) Package. The EVT Package requires the specification of the evaporation surface, the maximum evaporation rate, and the evaporation extinction depth. The evaporation surface was specified as land surface. The maximum evaporation rate occurs at the evaporation surface (land surface) and decreases linearly to zero at the extinction depth. The maximum evaporation rate was based on the average monthly pan evaporation rate from several sites near and within the Basin. The twelve maximum monthly rates range from 1.5 to 11.0 inches per month and were repeated for each year in the simulation. The extinction depth was set to 7 ft bgs.

4. CALIBRATION

4.1 Calibration Data

Historical groundwater elevation data collected from wells located throughout the Basin were used to calibrate the model. Groundwater elevation observations collected from 36 wells between October 1985 and September 2014 were used for model calibration (see **Figure 10** for well locations).

Limited historical stream gauge data collected at three points along El Paso Creek and one point on Tunis Creek were used to calibrate the stream conductance (see **Figure 10** for gauge locations).

[7] https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/eardata.html

4.2 Aquifer Properties

A primary goal of model calibration was to minimize the residual (i.e., difference) between model-calculated and observed water levels throughout the Basin. As described in *Section 2.5.1 Hydraulic Conductivity*, preliminary estimates of aquifer properties were used as initial conditions. Through a trial-and-error approach, the modeled water-transmitting and storage properties were calibrated by manually adjusting the parameter values to reduce the residuals. The calibrated distribution of aquifer properties are mapped in **Figure 11** (horizontal hydraulic conductivity), **Figure 12** (vertical hydraulic conductivity), and **Figure 13** (specific storage). The calibrated specific yield was specified as a uniform value (0.12) over the entire model and therefore, not mapped in a figure.

4.2.1 Evaluation of Calibrated Aquifer Properties

The horizontal hydraulic conductivity values in Layers 1 and 2 range from 0.001 to 49.8 ft/d, and in Layers 3 and 4 the values range from 0.01 to 2.0 ft/d. Spatially, the highest values are in layers 1 and 2, and in the Main Basin followed by the Shallow Alluvium upgradient of the Springs Fault.

Boxplots showing a comparison of horizontal hydraulic conductivity values estimated from specific capacity data, from aquifer tests and other reported values from oil fields, and from Layers 1 and 2 are shown in **Figure 14**. The boxplots of model values are for the Main Basin only because that is where most of the specific capacity data (81%) and all the limited aquifer test data are located. The boxplots show that the horizontal hydraulic values estimated from specific capacity data are generally lower than the values obtained from aquifer tests. The values specified in the model are generally within the ranges of the specific capacity and aquifer test values.

The vertical hydraulic conductivity ranges from $3x10^{-5}$ to 2.4 ft/d and is highest in Layers 1 and 2. There is a notable exception of low vertical hydraulic conductivity in the Faulted Transitional Area. No field estimates of vertical hydraulic conductivity values are available in this area.

Specific storage values were specified uniformly within each physiographic zone and range from $2.0x10^{-6}$ to $3.0x10^{-3}$. The lowest values tend to be in the Main Basin and Faulted Transitional Area.

The uniform specific yield value (0.12) falls within the range of reported specific yield values (see **Table 1**).

4.3 GHB Conductance

The GHB conductance representing the WWF was manually calibrated to (1) match observed water levels measured in wells near the WWF and (2) reasonably match other estimates of subsurface flows. The WWF is considered to be a partial barrier to flow in deep layers with some outflow occurring in the shallower layers. Therefore, the GHB conductance of layers 3 and 4 were set to half of that specified in layers 1 and 2 to limit the groundwater interaction across the WWF in the deeper layers. The final calibrated GHB conductance of layers 1 and 2 was 0.15 ft/d and of layers 3 and 4 was 0.075 ft/d.

As shown in the **Figure 15**, the WWGFM reasonably simulates flow across the WWF compared to other estimates. Due to differences between estimates of the assumed saturated thickness across the WWF, a saturated thickness-weighted average simulated flow was calculated for the period between WY 1995-2014 to normalize the comparisons. The saturated thickness of the shallow layers in the WWGFM (layers 1 and 2) is approximately 2,500 ft. Flow across the WWF over this thickness averages approximately 8,000

AFY, yielding 3.2 acre-feet per year per foot (AFY/ft). For a comparison, C2VSimFG-Kern simulates 3.0 AFY/ft over layers 1-3 and the spreadsheet model simulates 7.0 AFY/ft.[8]

4.4 Fault Hydraulic Characteristic

The internal fault hydraulic characteristic was manually calibrated to (1) match observed water levels in wells and (2) simulate artesian conditions south of the Springs Fault. As shown on **Figure 10** and **Table 2**, the Springs Fault was discretized into four segments with varying hydraulic characteristics by reach and layer. The Wheeler Ridge Fault was assumed to have one segment with the same hydraulic characteristic specified for all layers.

Table 2. Calibrated Internal Fault Hydraulic Characteristic

Layer	Hydraulic Characteristic (day^{-1})				
	Springs Fault				Wheeler Ridge
	Segment 1	Segment 2	Segment 3	Segment 4	
Layer 1	0.00012	0.0004	0.0004	0.005	0.00005
Layer 2	0.0005	0.0005	0.0005	0.005	0.00005
Layer 3	0.0005	0.0005	0.0005	0.005	0.00005
Layer 4	0.000025	0.000075	0.000075	0.005	0.00005

The WWGFM simulates artesian conditions south of the Springs Fault. However, very limited data were available during both the calibration and verification periods to validate the calibration of aquifer properties and Springs Fault conductance. Ongoing data collection from the three shallow monitoring wells installed during Spring 2021 will be critical for future WWGFM updates and potential recalibration.

4.5 Streambed Conductance

Streambed conductance was manually adjusted to (1) generally match limited stage measurements at several stream gauges on Tunis, El Paso, and Tejon Creeks, and (2) match streamflow events whereby there was observed streamflow leaving the Basin and flowing into the Kern County Subbasin. There are not enough streamflow data to calibrate the model to match measured streamflow. Due to a lack of measured streambed property data, all streams were assigned a single stream conductance value. The final calibrated stream conductance was 0.125 ft/d.

Streamflow occasionally flows out of the Basin during major storms. Years in which streamflow was observed leaving the Basin include 1998, 2003, 2005, and 2017.[9] Simulated stream outflow from the Basin occurs in Tecuya, El Paso, Tejon, and Comanche creeks. During the calibration and verification periods (WY 1995-2019), the model simulates streamflow leaving the Basin in 1995, 1998, 2003, 2005, 2008, 2011, and 2017. These years generally align with the periods of observed stream outflow from the Basin.

[8] Flow leaving the Basin across the WWF was calculated as part of the spreadsheet model using the estimated water level difference across the fault, an assumed hydraulic conductivity, and an assume saturated aquifer thickness.

[9] Personal communication, Tom Suggs, WRMWSD

4.6 Calibration Results

The calibration was assessed using statistics calculated from the differences between observed and model-calculated water levels (residuals), a map of residuals, plots of calibration results, and hydrographs of observed and calculated water levels. Calibration statistics for the Principal Aquifer are summarized in **Table 3**. The root-mean square error (RMSE)[10] for the Principal Aquifer is 23.1 ft and the mean error is 7.9, indicating that average model-calculated water levels are within 7.9 ft of observed water levels. The RMSE normalized by the range of the observed data was also calculated because it represents the RMSE in terms of the range of water levels in the model domain. The normalized RMSE, expressed as a percent of the observed range, is 2%. This low normalized RMSE is an often and indicator that the RMSE is reasonable given the range of observed data. However, if there is a large range in observed water levels, as is the case in the WWGFM, this calibration metric can be less reliable (Anderson and Woessner, 1991).

Table 3. Calibration Statistics for the Principal Aquifer

	Water Level Count	RMSE (ft)	Minimum Error (ft)	Mean Error (ft)	Maximum Error (ft)	Range In Observations (ft)	Normalized RMSE (%)
Principal Aquifer	1469	23.1	-91.4	7.9	104.4	1,326	2

A scatter plot of calculated vs. observed water levels and a histogram of residuals are shown in **Figure 16**. In a perfect calibration, the points would plot exactly along the solid 1:1 match line. Points above the line represent calculated water levels that are too high relative to observed data and points below the line represent calculated water levels that are too low relative to observed data. The scatter plot shows a fairly equal distribution of points above and below the line. The coefficient of determination (R2) of 0.98 indicates that there is a good match between calculated and observed water levels. Residuals are the difference between calculated and observed water levels. The histogram of residuals shown on **Figure 16** shows that the residuals exhibit a normal distribution, and most residuals are between the values of -10 and 30 ft. The slight bias of residuals to the positive side of zero indicates that the model-calculated water levels tend to be greater than observed water levels.

Average residuals are shown on **Figure 17**. Residuals are representative of site-specific errors between the modeled and observed water levels, and are calculated as modeled minus observed groundwater elevation. Therefore, a positive value indicates model-calculated water levels are greater than observed water levels and a negative value indicates model-calculated water levels are less than observed water levels. Average residuals are spatially variable with no discernable spatial pattern between positive and negative residuals. In general, the greatest residuals occur near the peripheral uplands areas of the Basin.

Hydrographs of model-calculated and observed water levels are included in *Attachment 1*. The locations of wells with hydrographs are shown on **Figure 10**. In the central part of the Basin, the hydrographs of measured and simulated water levels match well, especially during the calibration period. The simulated water levels capture the rising water levels through WY 2005 and the declining water levels beginning in WY 2006. Most wells represent data from the Principal Aquifer in this area. Outside of the central part of the Basin, the wells often represent water levels from deeper layers and there are less data from these

[10] RMSE is a quantitative measure of the closeness of fit, and is calculated as the square root of the average squared residuals.

wells. The measured and simulated water levels do not match as well in these peripheral areas because there is more uncertainty in the aquifer conditions and initial water level conditions.

5. SENSITIVITY AND UNCERTAINTY ANALYSIS

A sensitivity analysis was conducted to evaluate the effects of changing model parameters on model calibration. The analysis was conducted by changing model parameters in a systematic way and assessing the impact on the model-calculated water levels. The sensitivity analysis was conducted using a software package for Model-Independent Parameter Estimation and Uncertainty Analysis (PEST)[11]. PEST manages the systematic changes to the model parameters, runs the model multiple times, evaluates the effect on model-calculated water levels, and calculates the composite sensitivities for each parameter of interest.

The composite sensitivity was calculated for 71 parameters representing horizontal hydraulic conductivity, vertical hydraulic conductivity, specific storage, specific yield, general-head boundary conductance, internal fault conductance, and streambed conductance. The composite sensitivities for hydraulic conductivity, vertical hydraulic conductivity, and specific storage were calculated for each physiographic zone/layer represented by these parameters. Composite sensitivities for the 10-most sensitive parameters are shown in **Figure 18.** The composite sensitivities for the 61 parameters not shown in the figure are each 0.15 percent or less.

The most sensitive parameters are the specific storage values for all layers of the Main Basin. Other highly sensitive parameters include the specific storage in the Shallow Alluvium upgradient of the Springs Fault, the conductance of the Wheeler Ridge fault and a segment of the Springs Fault, and the vertical hydraulic conductivity of Layer 4 in the main basin. There are little to no data on specific storage values in the Basin. Given this uncertainty in measured values of specific storage and the high sensitivity of these parameters, additional data collection (aquifer tests) could help constrain the range of values specified in the model. Fault conductance cannot be directly measured resulting in high uncertainty in these values. Additional water level data near the faults would help to constrain the range of values specified in the model.

Sensitivity analysis was performed on inputs to the SMB to determine which inputs have the largest impacts on pumping and recharge output from the SMB. Pumping and recharge calculated by the SMB were most sensitive to precipitation and ET inputs. Precipitation input to the SMB was estimated using PRISM data and ET input was estimated from ITRC-METRIC data. Both precipitation and ET inputs to the SMB were adjusted in some months and years to improve the reliability of the inputs. The need for these adjustments indicates that there is some uncertainty in the precipitation and ET data used. A 10% change in precipitation input to the SMB model resulted in a 7% change in recharge. The change in precipitation had a minimal effect on the calculated pumping. A 10% change in ET input to the SMB resulted in a 7% change in recharge and a 10% in pumping. Pumping and recharge are less sensitive to other parameters and assumptions in the SMB such as soil depth, depression storage, and the ET stress function multiplier.

[11] https://pesthomepage.org/

6. POST-AUDIT VERIFICATION

A post-audit compares simulated groundwater conditions under hydrologic conditions that are different from the calibration period. In a post-audit, the stresses specified in the model (e.g., pumping and recharge) have already occurred and therefore can be estimated with some degree of accuracy. Hence, the resulting model-calculated water levels can "verify" the calibration or reveal errors and uncertainty in the model parameter values specified for the water transmitting and storage properties of the aquifer (the calibrated values of hydraulic conductivity and storage coefficients). We conducted a post-audit to verify model calibration results over the time period WY 2015-2019. In this post-audit verification process, we examined the model performance statistics and by comparing differences between measured and model-calculated water levels by examining calibration statistics, residual distributions, and trends over WY 2015-2019.

Historical groundwater elevation data collected from wells located throughout the Basin were used for the verification. Groundwater elevation observations collected from 37 wells between October 2015 and September 2019 were used for model verification (see **Figure 10** for well locations). Verification statistics for the Principal Aquifer are shown in **Table 4**. The RMSE for the Principal Aquifer over the verification period (34.7 ft) is higher than the RMSE for the calibration period (23.1 ft). The normalized RMSE (3%) is slightly greater than the calibration period, but as previously discussed, this can be less reliable given the large range in observed data.

Table 4. Verification Statistics for the Principal Aquifer

	Water Level Count	RMSE (ft)	Minimum Error (ft)	Mean Error (ft)	Maximum Error (ft)	Range In Observations (ft)	Normalized RMSE (%)
Principal Aquifer	304	34.7	-182.2	-5.3	117	1,387	3

A scatter plot of calculated vs. observed water levels and a histogram of residuals are shown in **Figure 19.** The scatter plot shows a fairly equal distribution of points above and below the line. The coefficient of determination (R2) of 0.99 indicates that there is a good match between calculated and observed water levels. The histogram of residuals shown on **Figure 19** shows that the residuals exhibit a normal distribution. The distribution is skewed slightly to the positive side indicating that the model-calculated water levels tend to be greater than observed water levels. Average residuals are shown on **Figure 20**. Average residuals are spatially variable with no discernable spatial pattern between positive and negative residuals or the magnitude of the residuals.

Review of water level trends during the verification period indicates that the model tends to under-represent the slope of the water level trends, both in wells having a downward slope and in wells having an upward slope. However, these trend deviations are distributed randomly throughout the Basin which suggests there is no spatial bias.

These results suggest that the model does not perform as well under the hydrologic conditions represented by the verification period (WY 2015-2019) as it does under the hydrologic conditions represented by the calibration period (WY 1995-2014). Additional data collection and model updates described in the following section will be important in updating and improving the model calibration under all hydrologic conditions.

7. MODEL LIMITATIONS AND SUGGESTED FUTURE REFINEMENTS

7.1 Pumping

Most pumping in the Basin is not measured or reported. Most of the pumping specified in the model relies on estimates from the SMB which is based on assumptions and data having inherent uncertainty. Pumping estimates from the SMB could be checked and improved by comparing against metered data from select wells. It is recommended that select wells be identified that serve parcels that receive only groundwater for irrigation. Meters can be installed on these wells to monitor the volume of water delivered to these parcels and these data can be used to improve the SMB pumping estimates.

The WWGFM currently employs the WEL package to specify pumping rates and distribution. As discussed above in *Section 3.2 Pumping*, specified pumping is reduced and/or set to zero for cells in which the simulated head approaches or drops below the cell bottom. Additionally, because the active model domain trends southeastward with depth along the WWF, wells located within the Basin near the WWF may be screened in inactive model cells/layers that are on the northwest side of the fault resulting in a loss of pumping in the model. Pumping from these well located within the Basin may actually be occurring the adjacent Kern County Subbasin. Although adjustments have been made to the vertical distribution of pumping in some wells to minimize loss of pumping, 1,400 AFY (3% of pumping) of pumping losses persist. To further minimize pumping losses, the Multi-Node Well (MNW2) Package could be utilized in future model updates.

7.2 Streams

Streamflow into the Basin is not well known. There are very few records of streamflow within the Basin to identify rate and timing of streamflows. There is uncertainty in estimates of inflow based on precipitation, estimated consumptive use, etc. For example, in some cases, the reported diversions are higher than the estimated stream inflow. Although streamflow was manually adjusted for streams with diversion data to account for this, streams without PODs were not adjusted. Streamflow data loggers could be deployed on one or more streams to better quantify stream inflow. Furthermore, regression analysis between streams with PODs and without could be used to improve the timing of specified stream inflows. The magnitude and variability in streambed conductance in the Basin are poorly understood. Streambed conductance was specified as a uniform value in all streams represented in the model. Additional data and model testing could be used to improve the representation of streambed conductance in the model.

7.3 Aquifer Properties

There have been limited aquifer tests in the Basin and there are very little data on aquifer properties to constrain the values specified in the model. The model is most sensitive to specific storage in the main part of the Basin. Therefore, results from well-planned aquifer tests performed in the Basin could provide additional data on aquifer properties to help constrain model parameters.

7.4 Faults

The WWGFM is sensitive to fault properties. Very limited data exist to aid in calibration of aquifer and fault properties along the Springs Fault. Additional water level data near faults may help improve calibration of fault hydraulic characteristic values. For instance, ongoing high-frequency data collected from the three shallow monitoring wells installed in 2021 will be crucial in future calibration of the Springs Fault hydraulic characteristics. Similarly, other high-frequency data could be obtained from wells located to the north, down-gradient side, of the Springs Fault. However, the closest well on the down-gradient side of the fault is screened within the Santa Margarita Formation (WWGFM layer 4). Installation of a shallower monitoring well screened within the Kern River and/or Chanac Formation would provide more appropriate data for calibrating the Springs Fault hydraulic characteristics.

7.5 Evaporation

Evaporation extinction depth is set to 7 ft bgs, consistent with values utilized in other regional models in the San Joaquin Valley. However, sensitivity tests on model response to extinction depth may help better quantify this assumed value has on model performance in uplands areas where groundwater is typically shallow.

7.6 Unsaturated Zone

The unsaturated zone is not represented in the WWGFM. Recharge applied to each model cell is assumed to reach the water table instantaneously. Given the large depth to water in some parts of the Basin, this assumption may not be valid. Additional investigation and testing may be warranted to evaluate the effect of this assumption and determine if a specified delay in recharge reaching the water table or representation of the unsaturated zone will improve model performance.

8. REFERENCES

Anderson, M, and Woessner, W, 1991, Applied Groundwater Modeling, Academic Press, 381 pp.

Bartow, 1984. *Geologic Map and Cross Sections of the Southeastern Margin of the San Joaquin Valley, California*: U.S. Geological Survey Map I-1496.

California Division of Mines and Geology, 1985. *State of California Special Studies Zones Delineated in compliance with Chapter 7.5, Division 2 of the California Public Resources Code (Alquist-Priolo Special Studies Zone Act) Metter Quadrangle.*

DOGGR, 1998. *California Oil & Gas Fields Volume 1 – Central California*.

Faunt CC, Hanson RT, Belitz K, 2009. *Groundwater Availability of the Central Valley Aquifer, California. Chapter A Introduction, Overview of Hydrogeology, and Textural Model of California's Central Valley*: U.S. Geological Survey Professional Paper 1766.

Goodman ED, and Malin PE, 1992. Evolution of the southern San Joaquin Basin and mid-Tertiary "transitional" tectonics, central California, Tectonics, V. 11, no. 3, pp. 478-498.

Lofgren, BE, 1975. *Land Subsidence Due to Ground-Water Withdrawal, Arvin-Maricopa Area, California*: U.S. Geological Survey Professional Paper 437-D.

Niswonger RG, Panday S, and Ibaraki M, 2011. MODFLOW-NWT, A Newton formulation for MODFLOW-2005: U.S. Geological Survey Techniques and Methods 6–A37, 44 p.

Oakshott GB, 1955. The Kern County earthquakes in California's geologic history, in Earthquakes in Kern County, California, 1952: California Dept. Nat. Resources, Div. Mines Bull. 171. 9915-22.

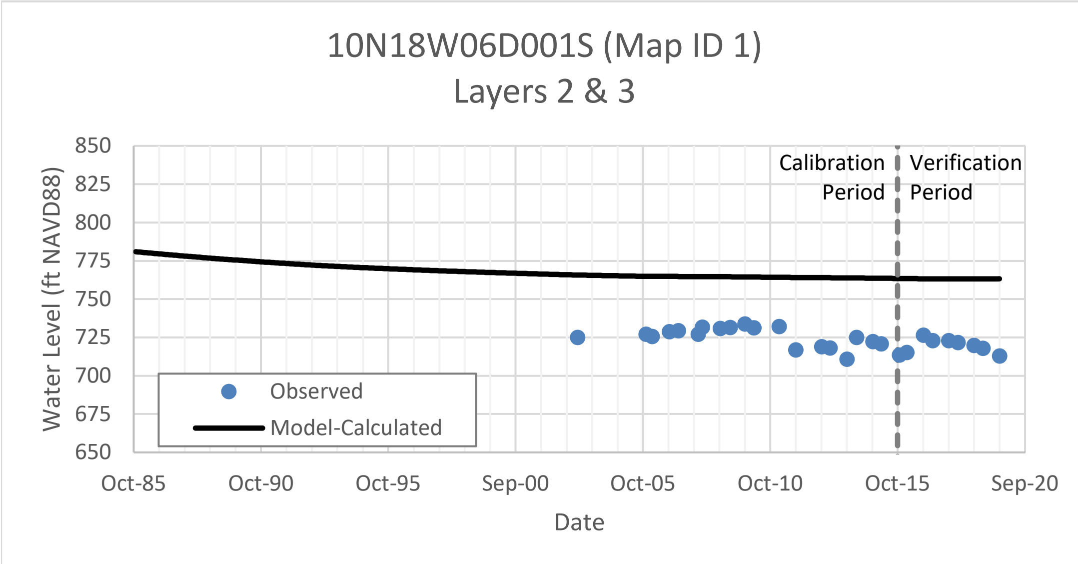
PRISM, 2019. Descriptions of PRISM Spatial Climate Datasets for the Conterminous United States. Last revised October 2019. Available online at: https://prism.oregonstate.edu/documents/PRISM_datasets.pdf

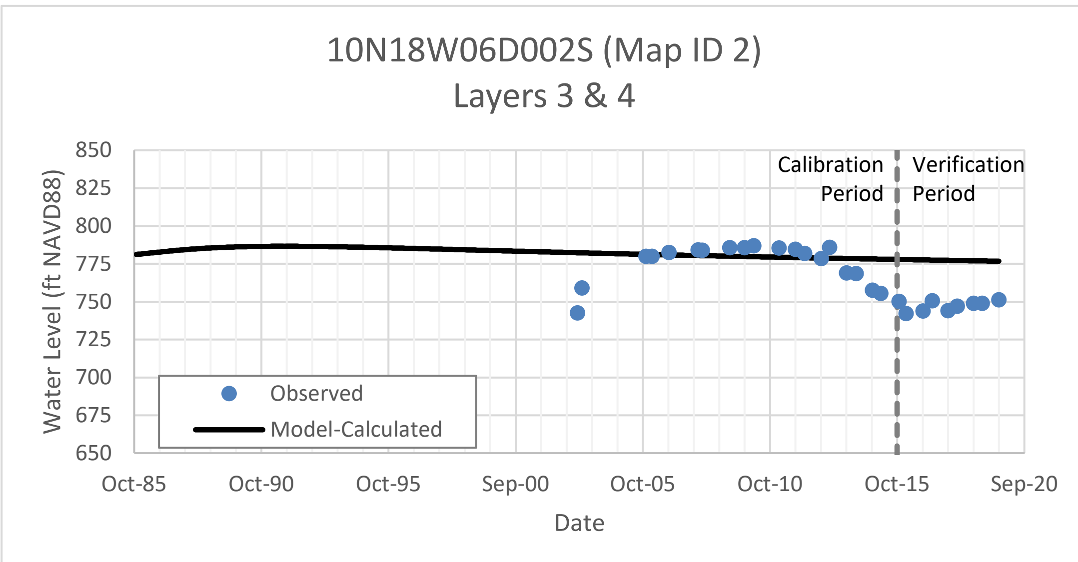
Scheirer AH, 2007, *The Three-Dimensional Geologic Model Used for the 2003 National Oil and Gas Assessment of the San Joaquin Basin Province, California*: U. S. Geological Survey Professional paper 1713, Chapter 7, Appendix 7.2.

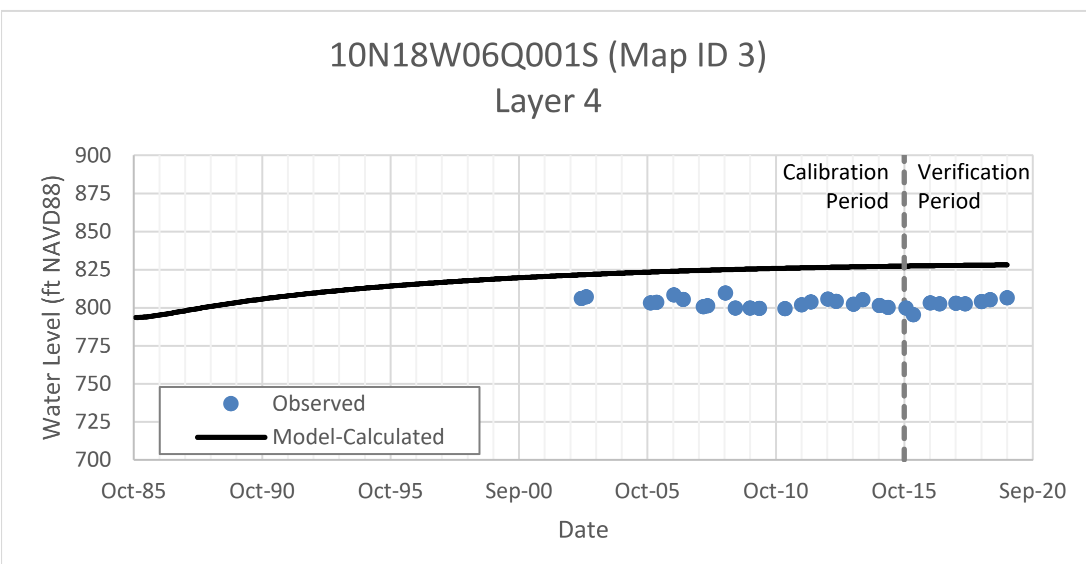
Wood PR and Dale RH, 1964. *Geology and Ground-Water Features of the Edison-Maricopa Area, Kern County, California*: U.S. Geological Survey Water-Supply Paper 1656, 108 p.

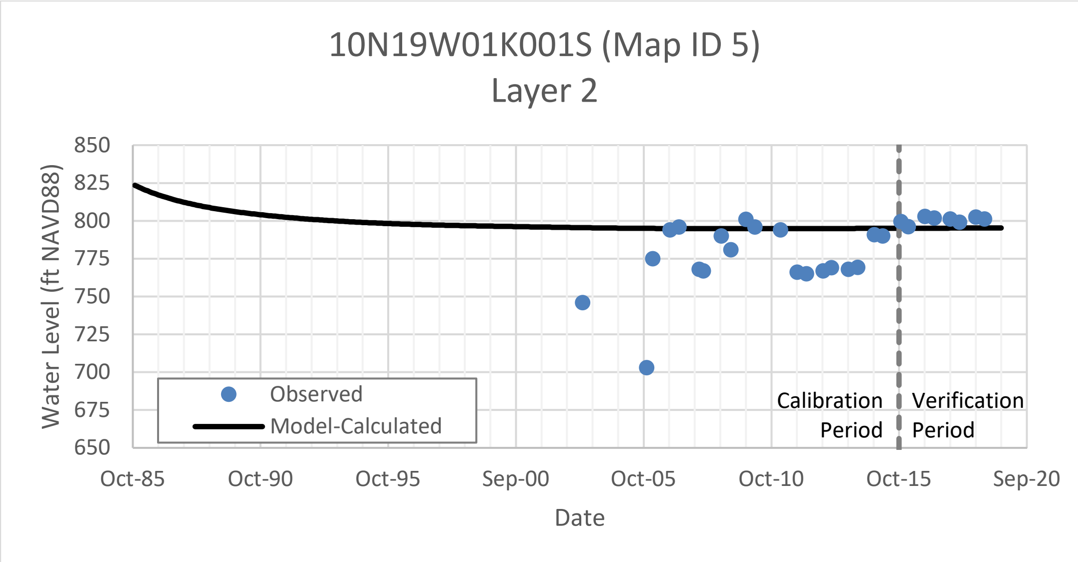
WZI, 2013. "Tejon Ranch Grapevine Area Grapevine Regional Groundwater Assessment Kern County, California"

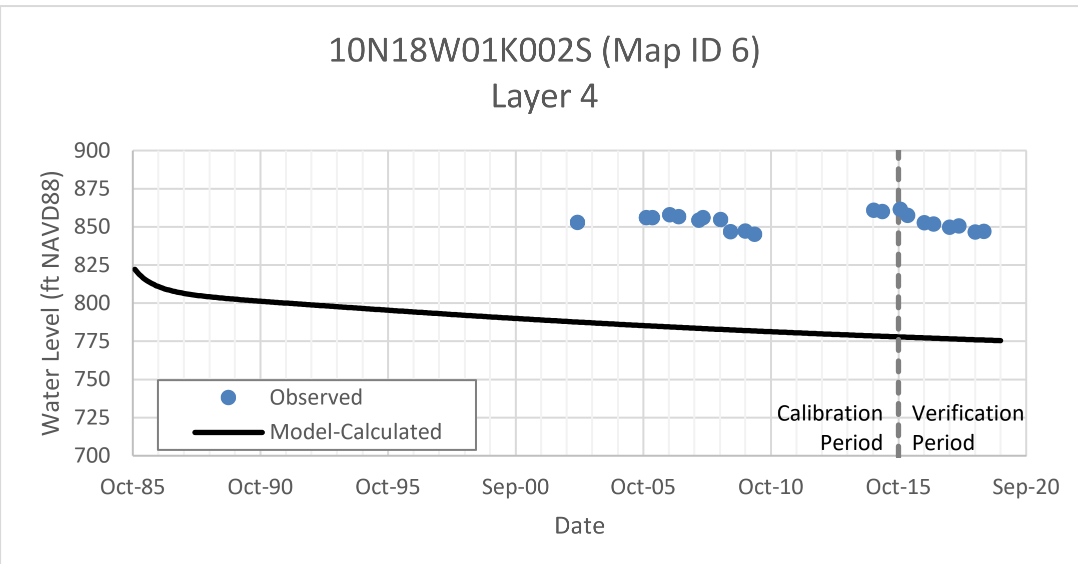
Attachment 1. Hydrographs

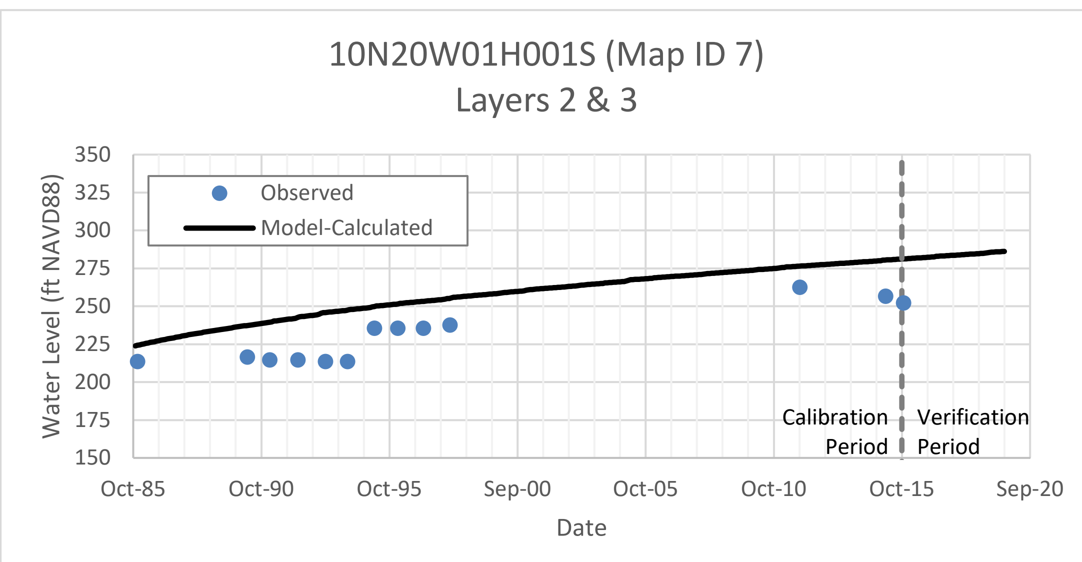

10N18W06D001S (Map ID 1)
Layers 2 & 3
Water Level (ft NAVD88)
850
825
800
775
750
725
700
675
650
Calibration Period
Verification Period
Observed
Model-Calculated
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

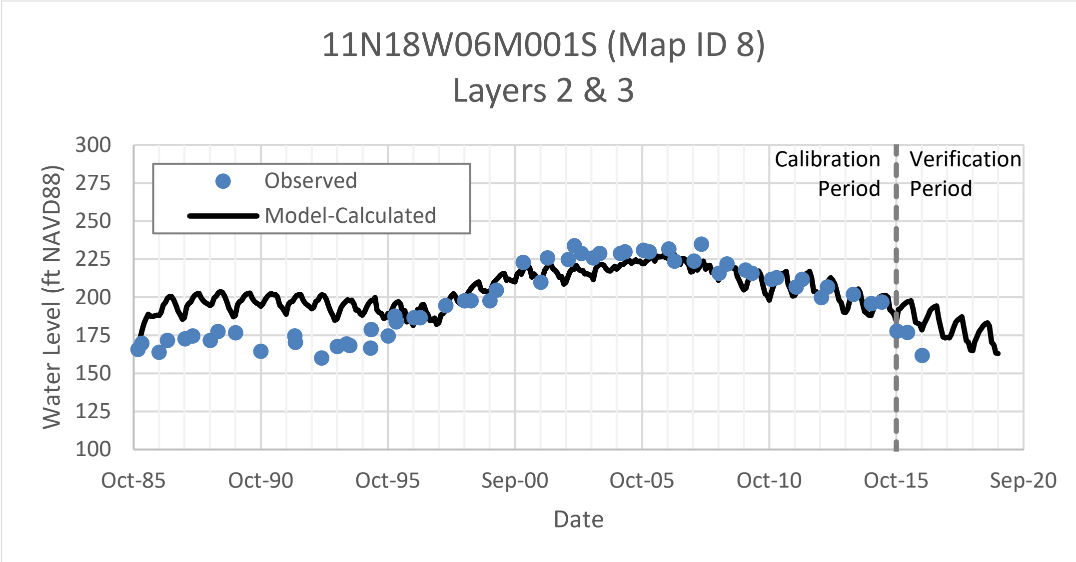

10N18W06D002S (Map ID 2)
Layers 3 & 4
Water Level (ft NAVD88)
850
825
800
775
750
725
700
675
650
Calibration Period
Verification Period
Observed
Model-Calculated
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

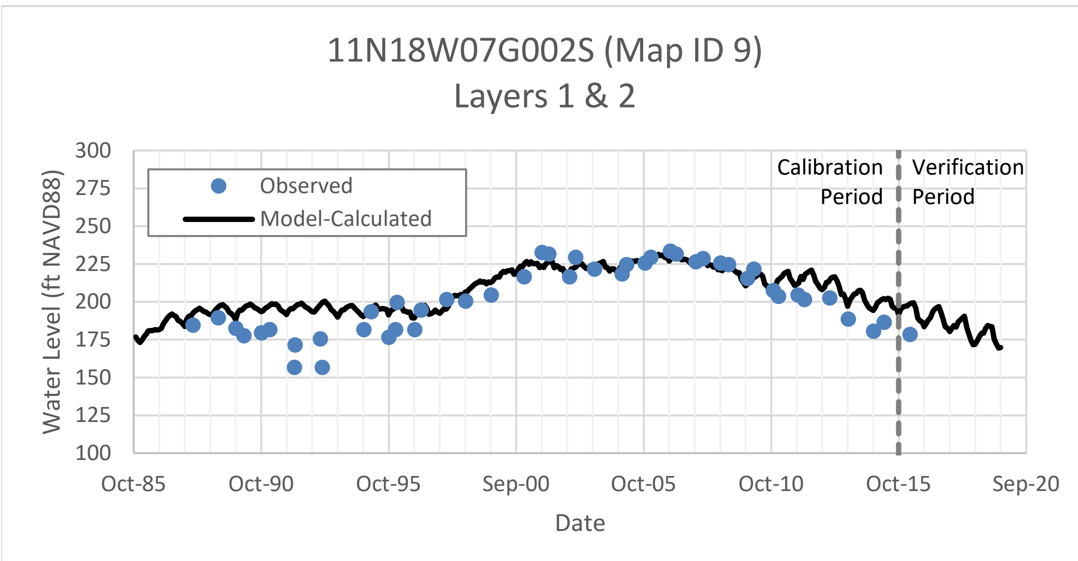

10N18W06Q001S (Map ID 3)
Layer 4
Water Level (ft NAVD88)
900
875
850
825
800
775
750
725
700
Calibration Period
Verification Period
Observed
Model-Calculated
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

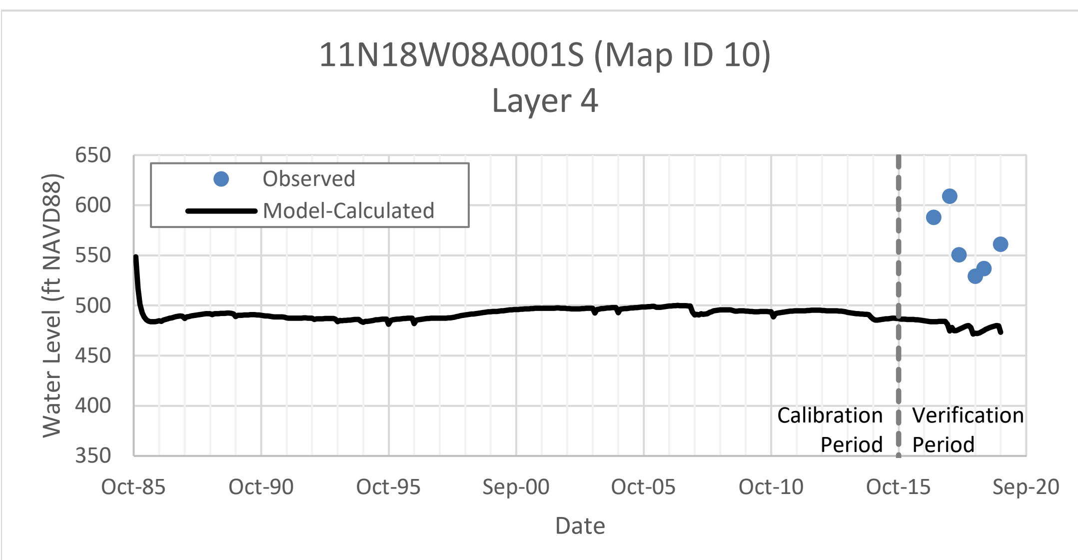

10N19W01K001S (Map ID 5)
Layer 2
Water Level (ft NAVD88)
850
825
800
775
750
725
700
675
650
Observed
Model-Calculated
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

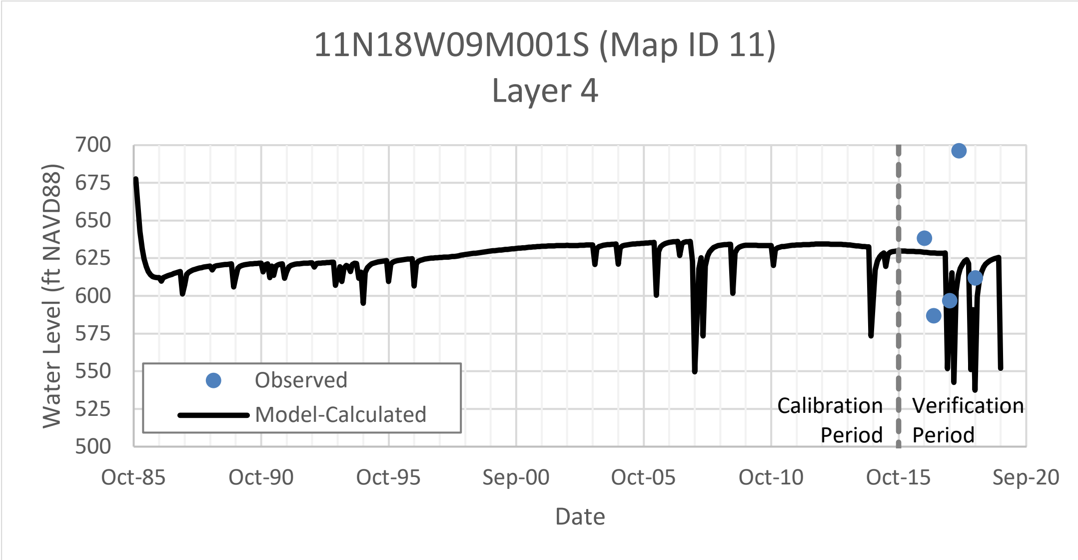

10N18W01K002S (Map ID 6)
Layer 4
Water Level (ft NAVD88)
900
875
850
825
800
775
750
725
700
Observed
Model-Calculated
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

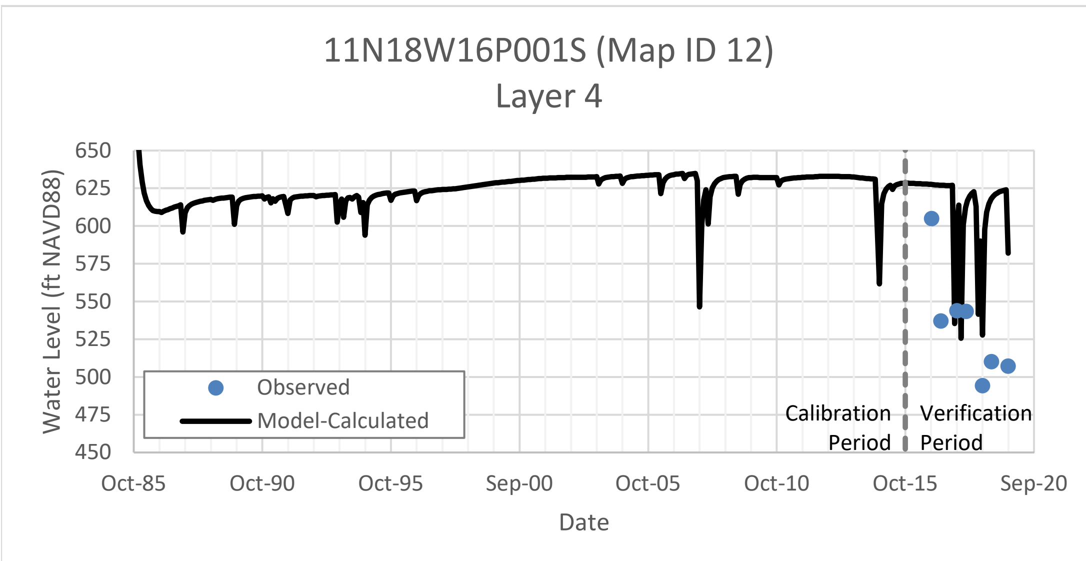

10N20W01H001S (Map ID 7)
Layers 2 & 3
Water Level (ft NAVD88)
350
325
300
275
250
225
200
175
150
Observed
Model-Calculated
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

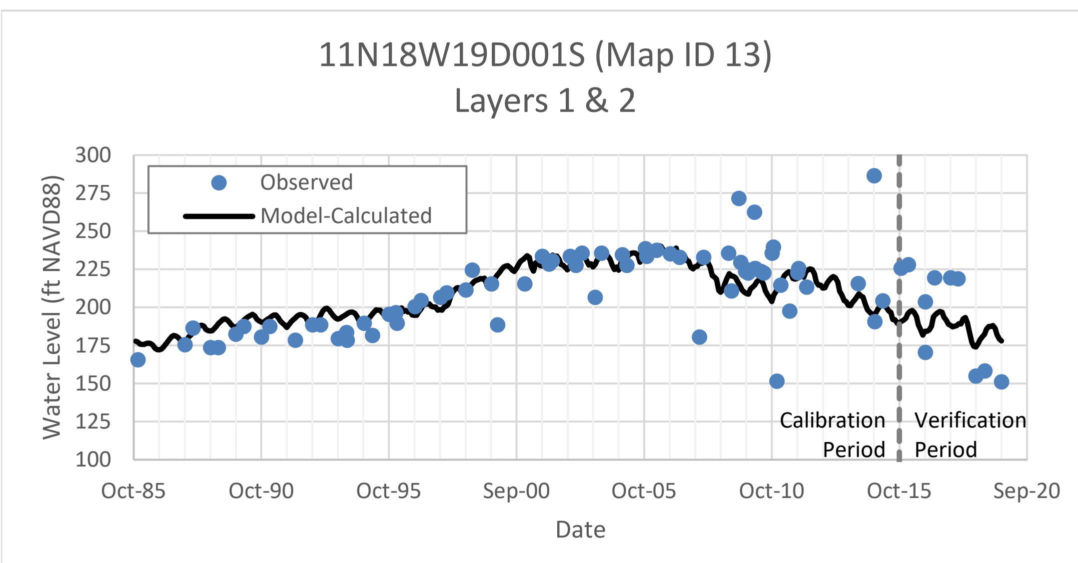

11N18W06M001S (Map ID 8)
Layers 2 & 3
Observed
Model-Calculated
Calibration Period
Verification Period
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

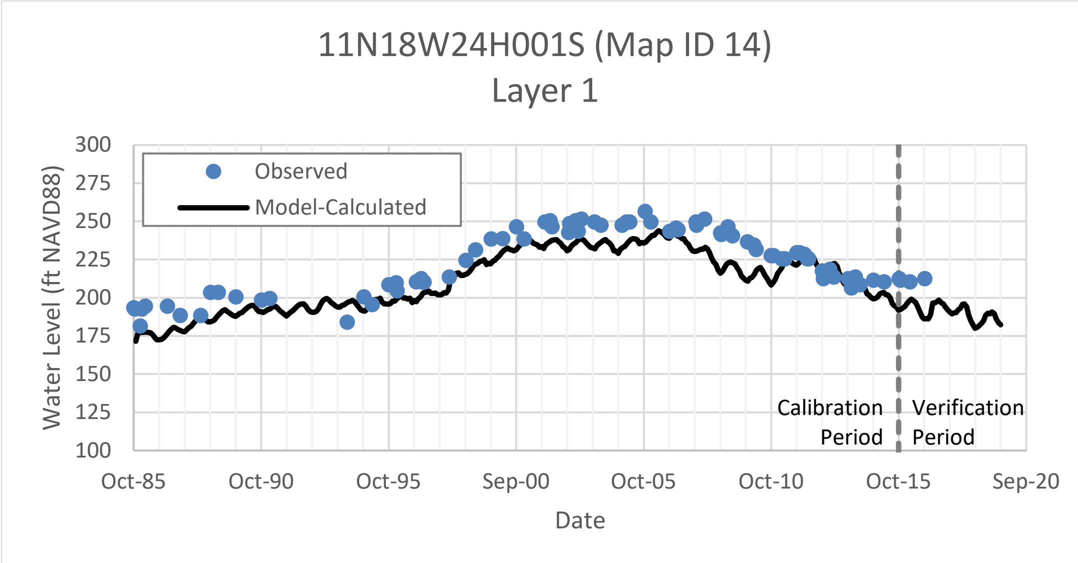

11N18W07G002S (Map ID 9)
Layers 1 & 2
Observed
Model-Calculated
Calibration Period
Verification Period
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

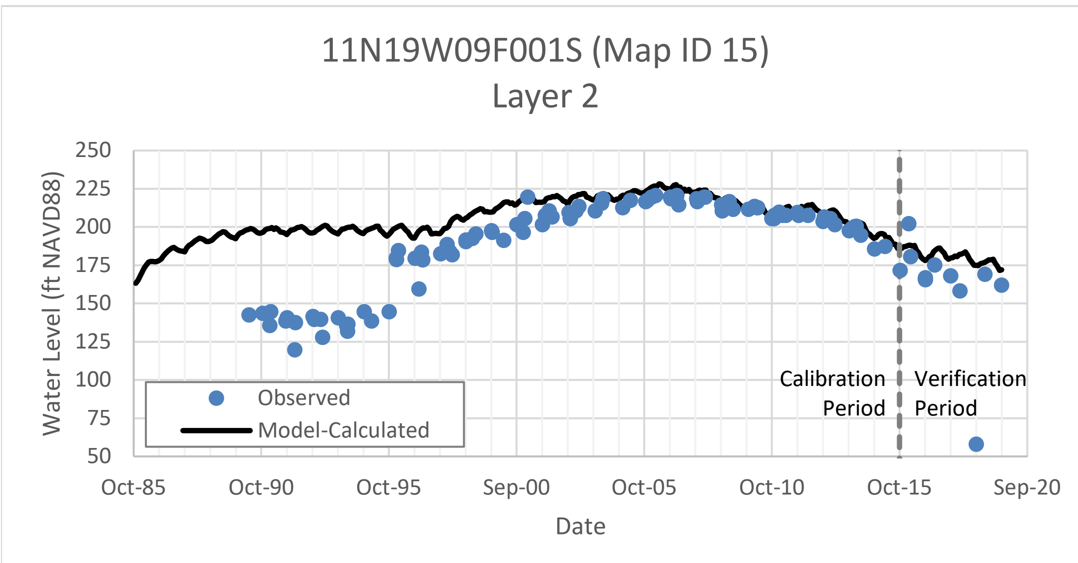

11N18W08A001S (Map ID 10)
Layer 4
Observed
Model-Calculated
Calibration Period
Verification Period
Water Level (ft NAVD88)
650
600
550
500
450
400
350
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

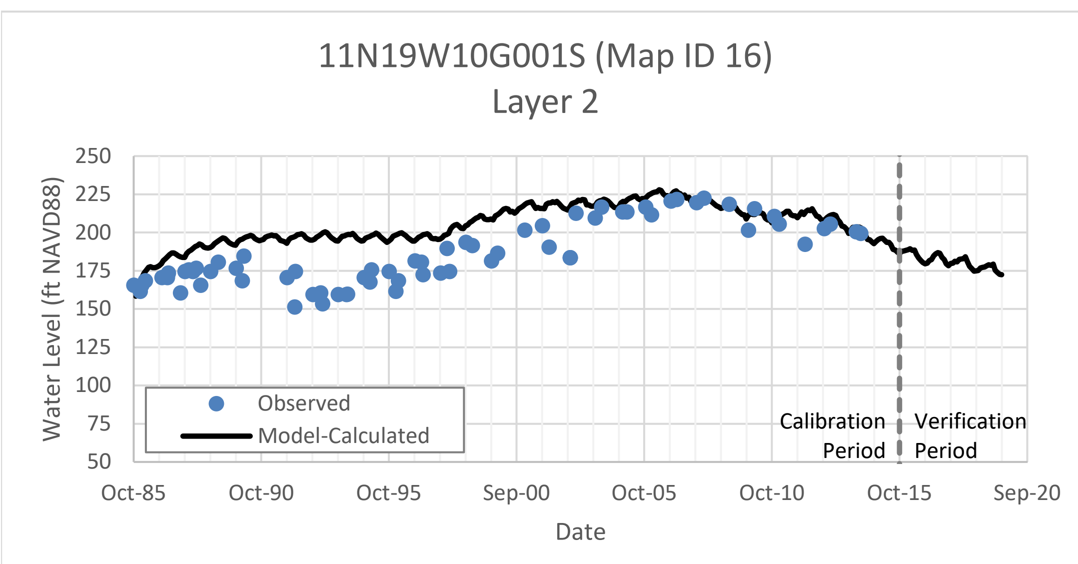

11N18W09M001S (Map ID 11)
Layer 4
Water Level (ft NAVD88)
700
675
650
625
600
575
550
525
500
Observed
Model-Calculated
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

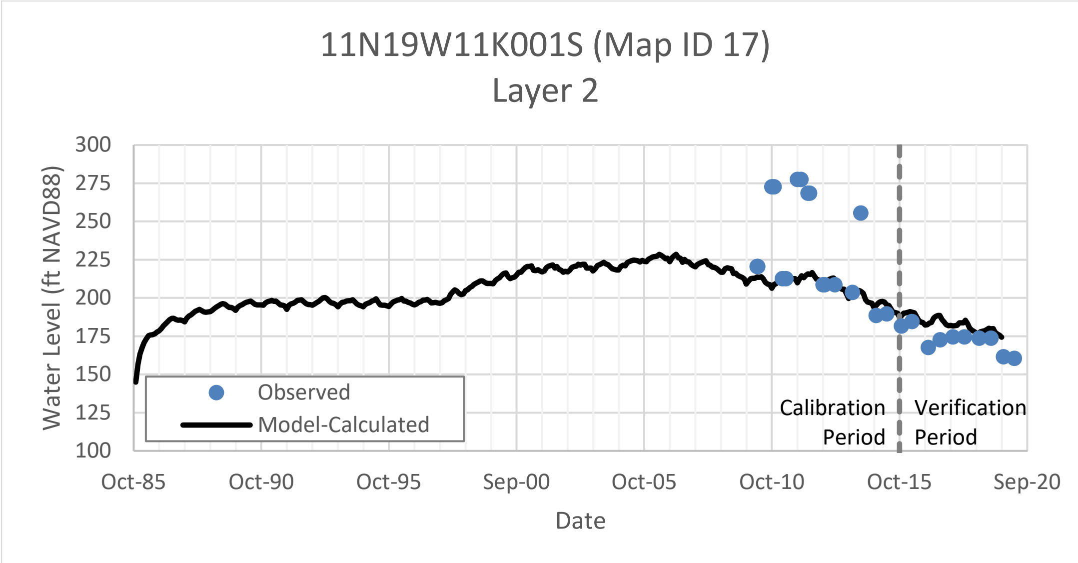

11N18W16P001S (Map ID 12)
Layer 4
Water Level (ft NAVD88)
650
625
600
575
550
525
500
475
450
Observed
Model-Calculated
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

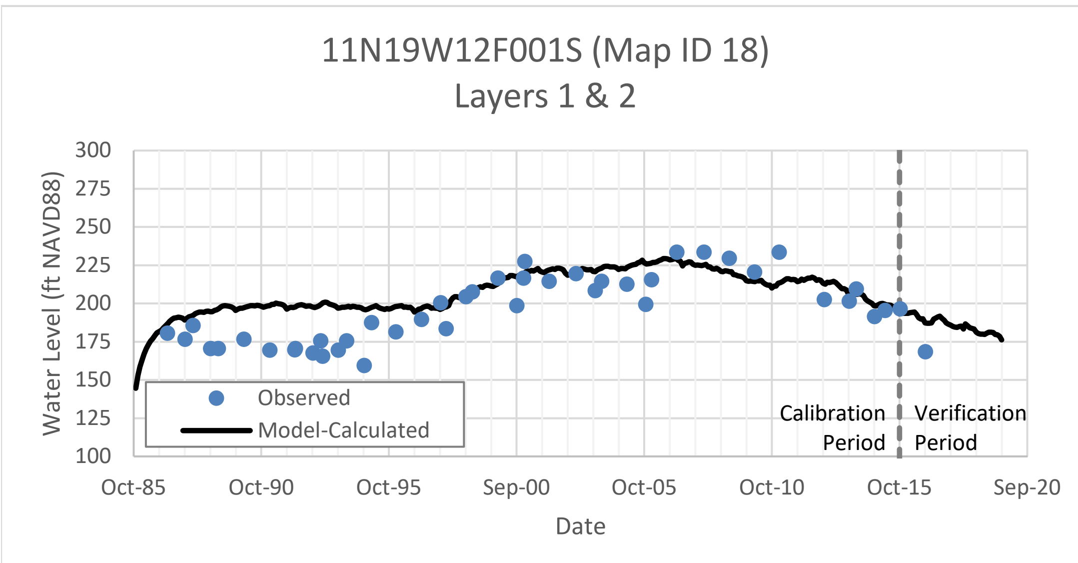

11N18W19D001S (Map ID 13)
Layers 1 & 2
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Observed
Model-Calculated
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

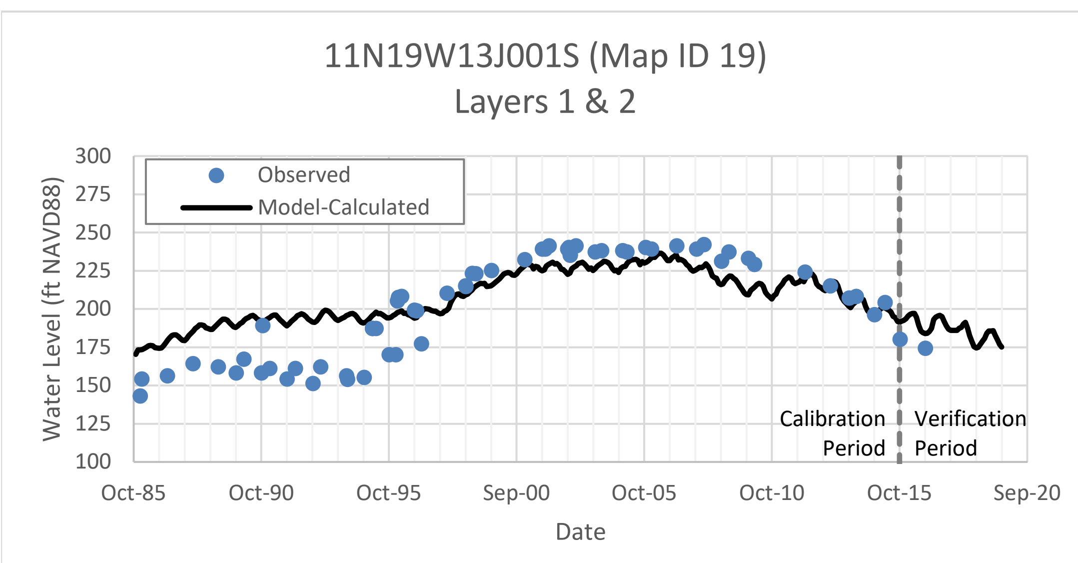

11N18W24H001S (Map ID 14)
Layer 1
Observed
Model-Calculated
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

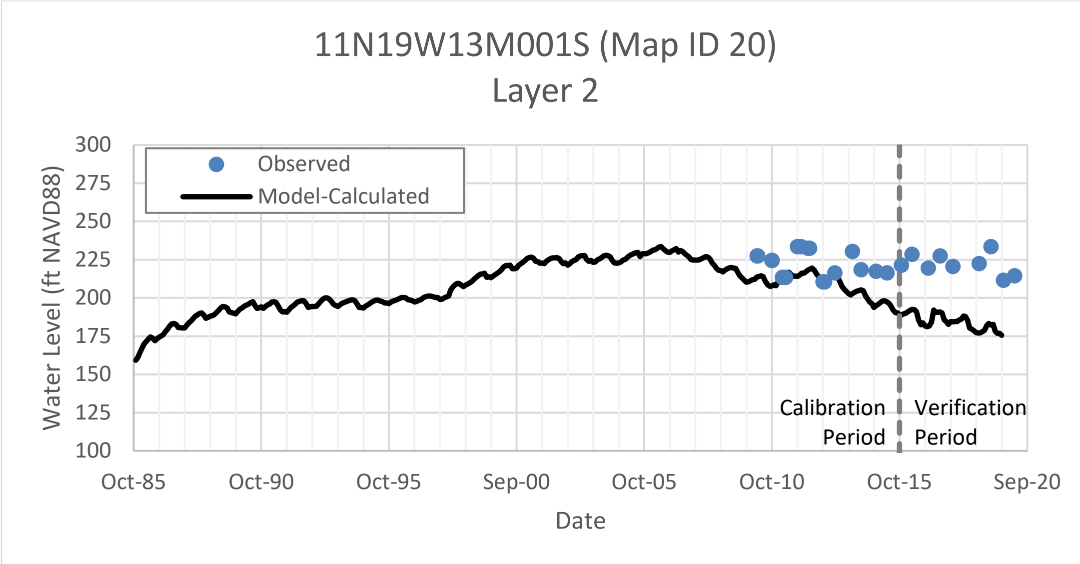

11N19W09F001S (Map ID 15)
Layer 2
Observed
Model-Calculated
Water Level (ft NAVD88)
250
225
200
175
150
125
100
75
50
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

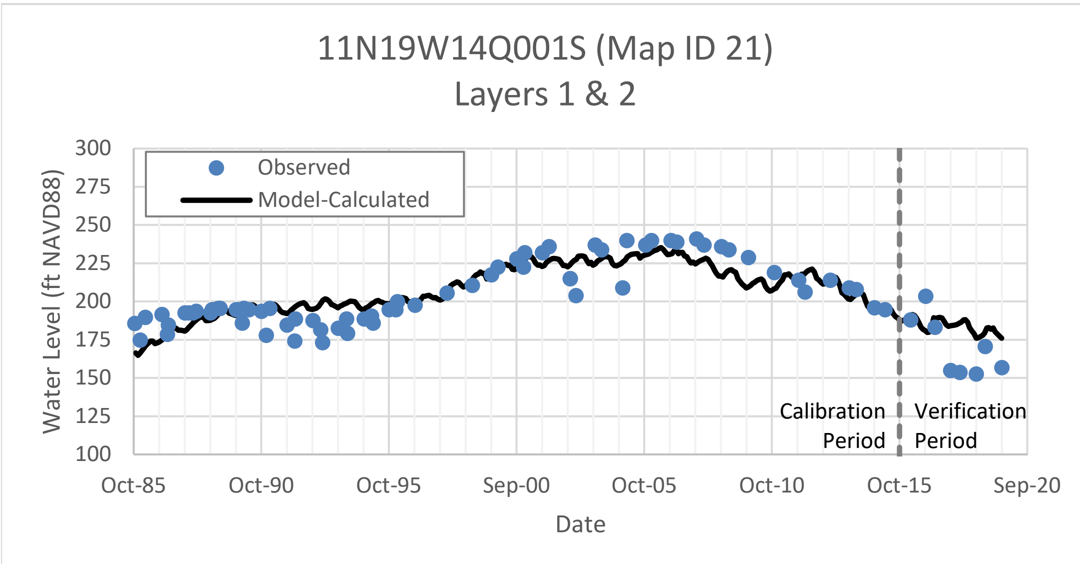

11N19W10G001S (Map ID 16)
Layer 2
Observed
Model-Calculated
Water Level (ft NAVD88)
250
225
200
175
150
125
100
75
50
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

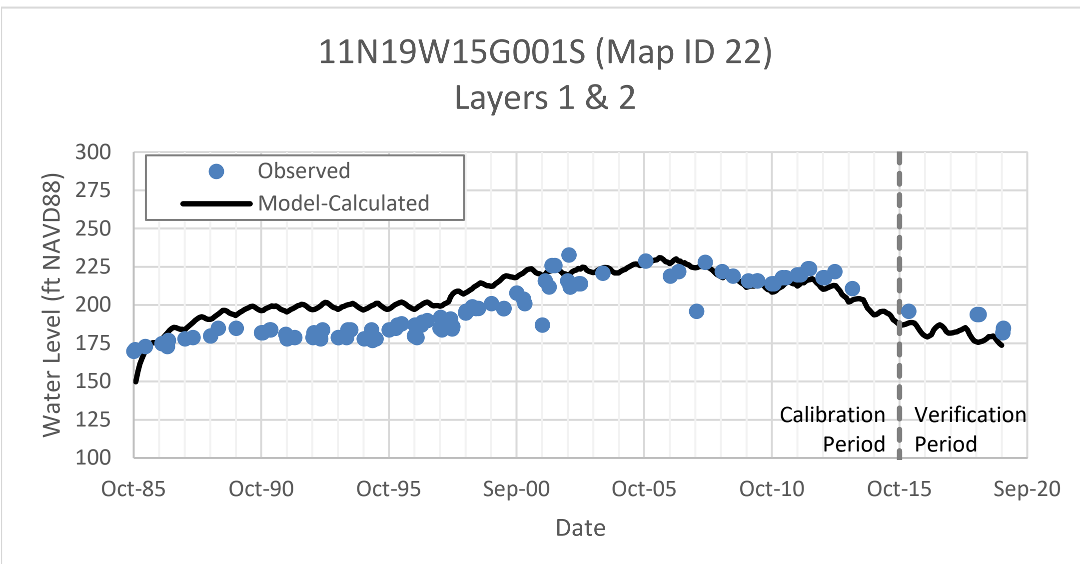

11N19W11K001S (Map ID 17)
Layer 2
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Observed
Model-Calculated
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

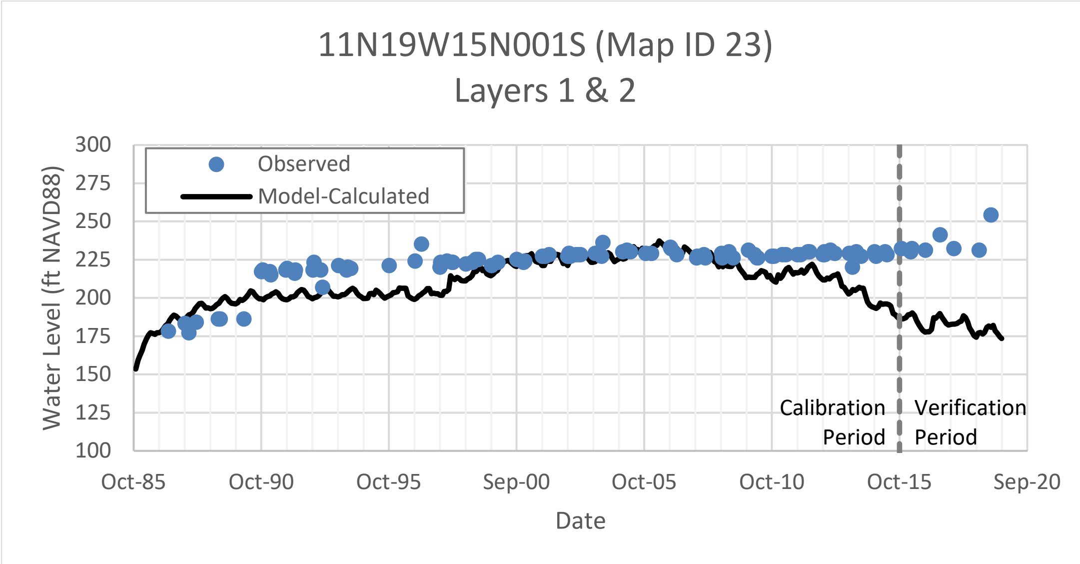

11N19W12F001S (Map ID 18)
Layers 1 & 2
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Observed
Model-Calculated
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

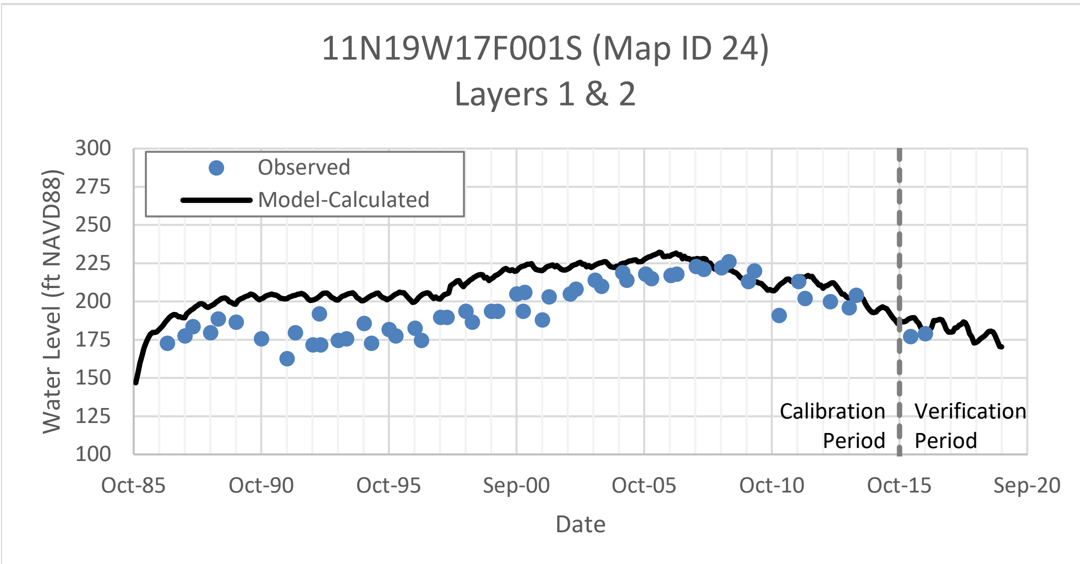

11N19W13J001S (Map ID 19)
Layers 1 & 2
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Observed
Model-Calculated
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

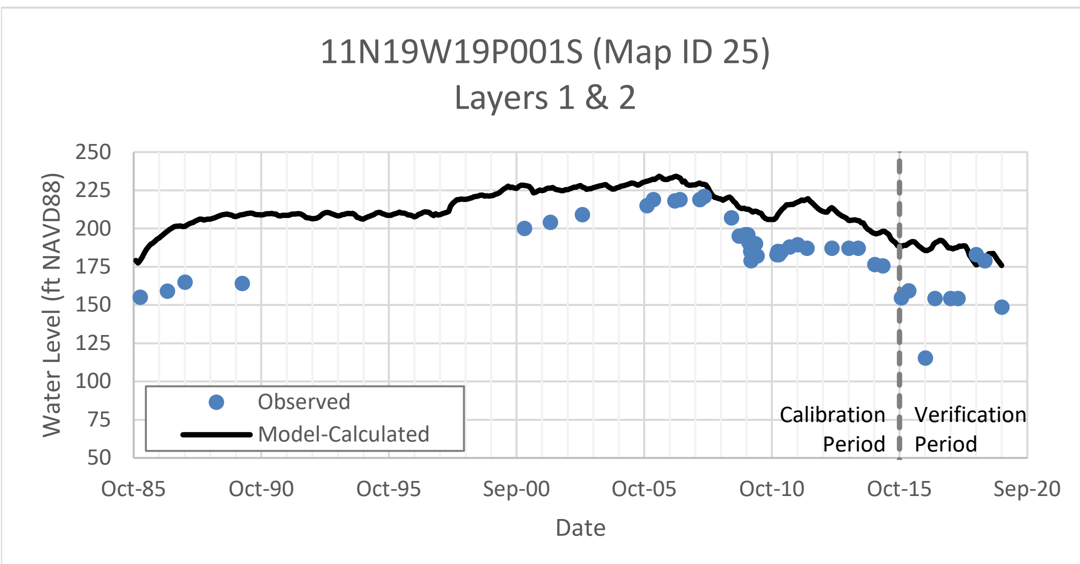

11N19W13M001S (Map ID 20)
Layer 2
Observed
Model-Calculated
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

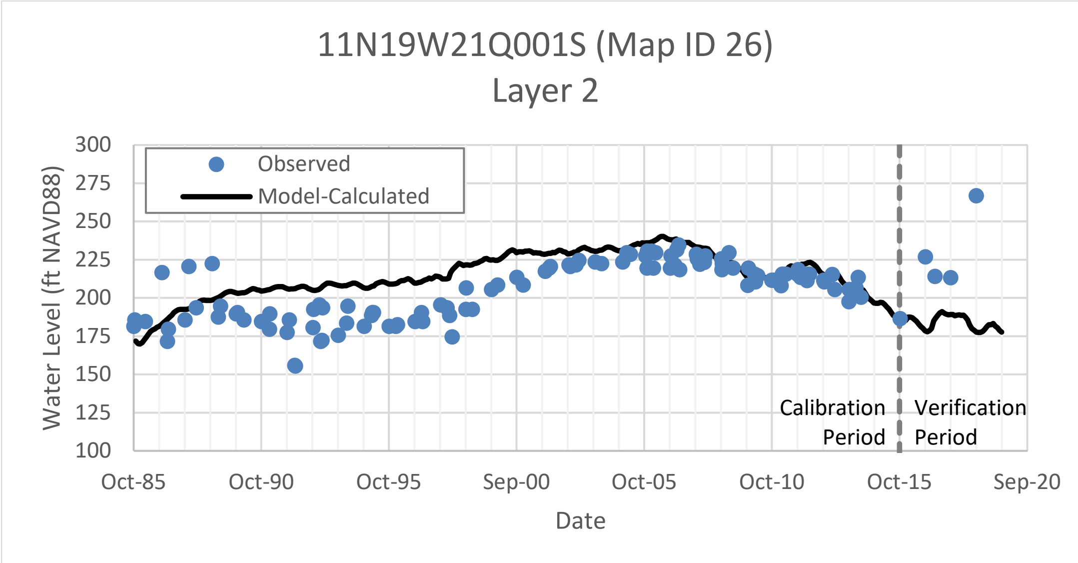

11N19W14Q001S (Map ID 21)
Layers 1 & 2
Observed
Model-Calculated
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

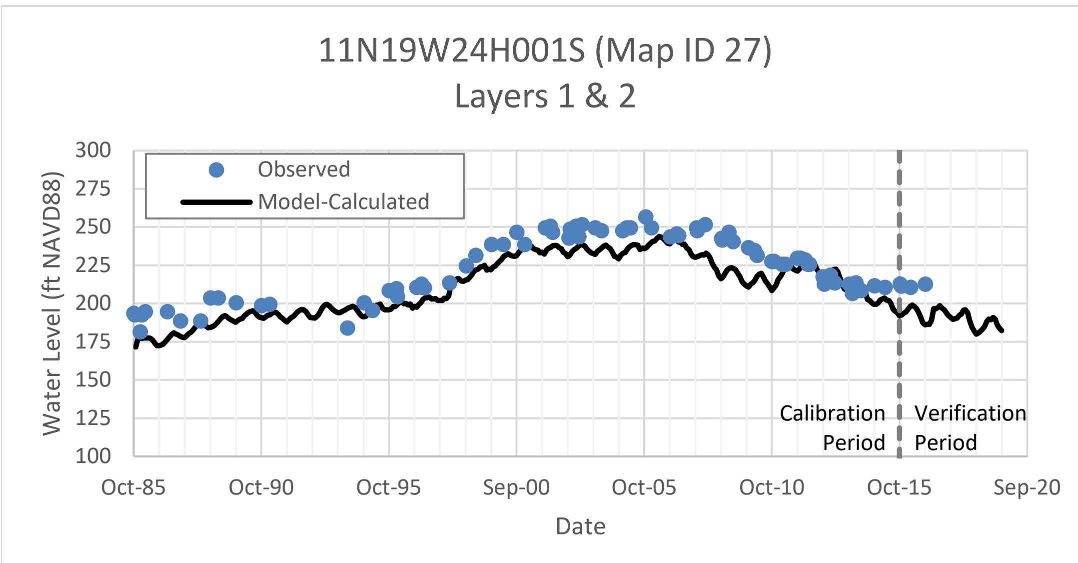

11N19W15G001S (Map ID 22)
Layers 1 & 2
Observed
Model-Calculated
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

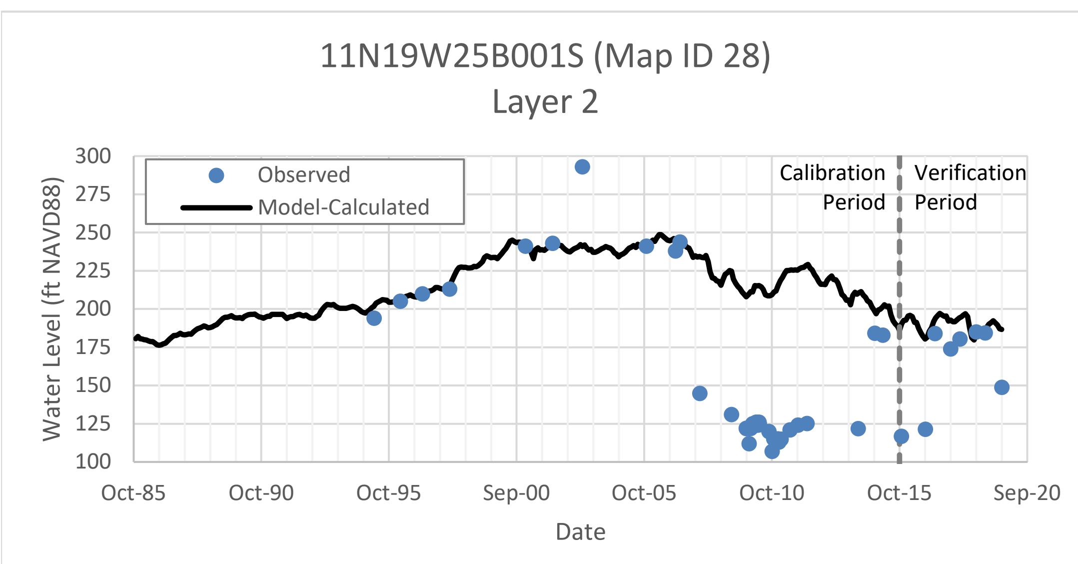

11N19W15N001S (Map ID 23)
Layers 1 & 2
Observed
Model-Calculated
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date
Calibration Period
Verification Period

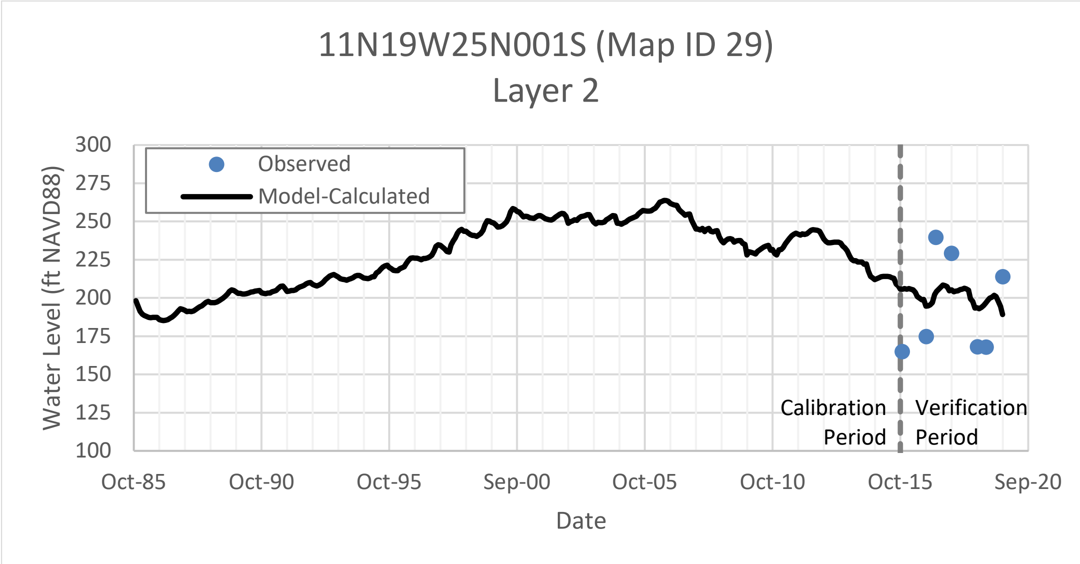

11N19W17F001S (Map ID 24)
Layers 1 & 2
Observed
Model-Calculated
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date
Calibration Period
Verification Period

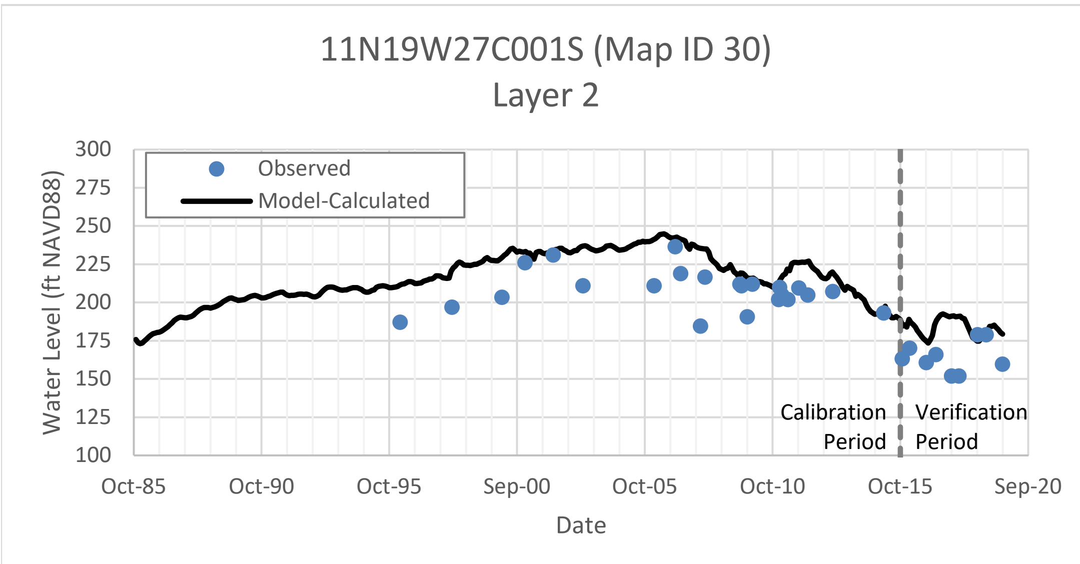

11N19W19P001S (Map ID 25)
Layers 1 & 2
Observed
Model-Calculated
Water Level (ft NAVD88)
250
225
200
175
150
125
100
75
50
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date
Calibration Period
Verification Period

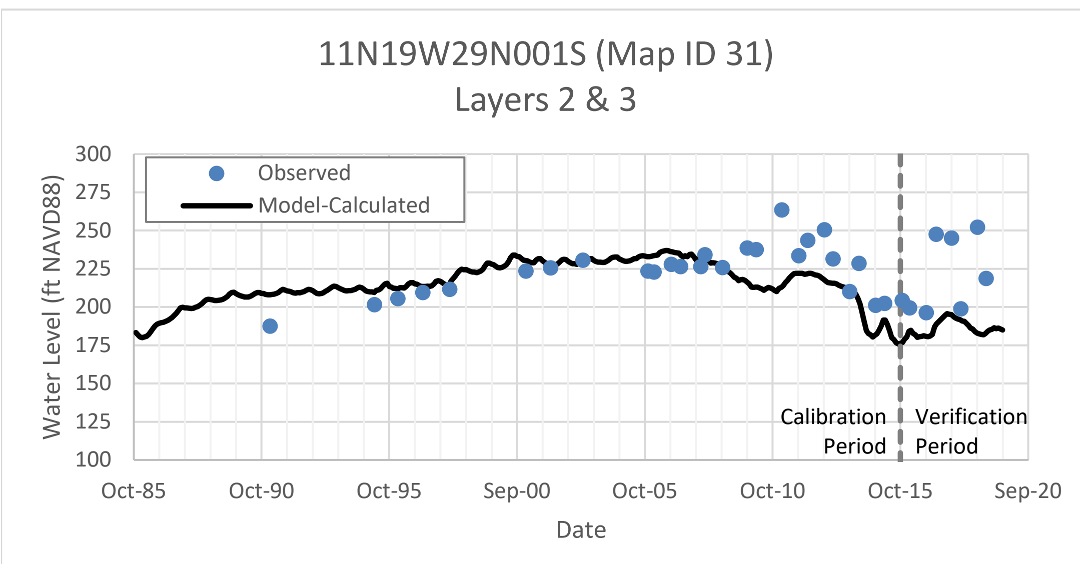

11N19W21Q001S (Map ID 26)
Layer 2
Observed
Model-Calculated
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

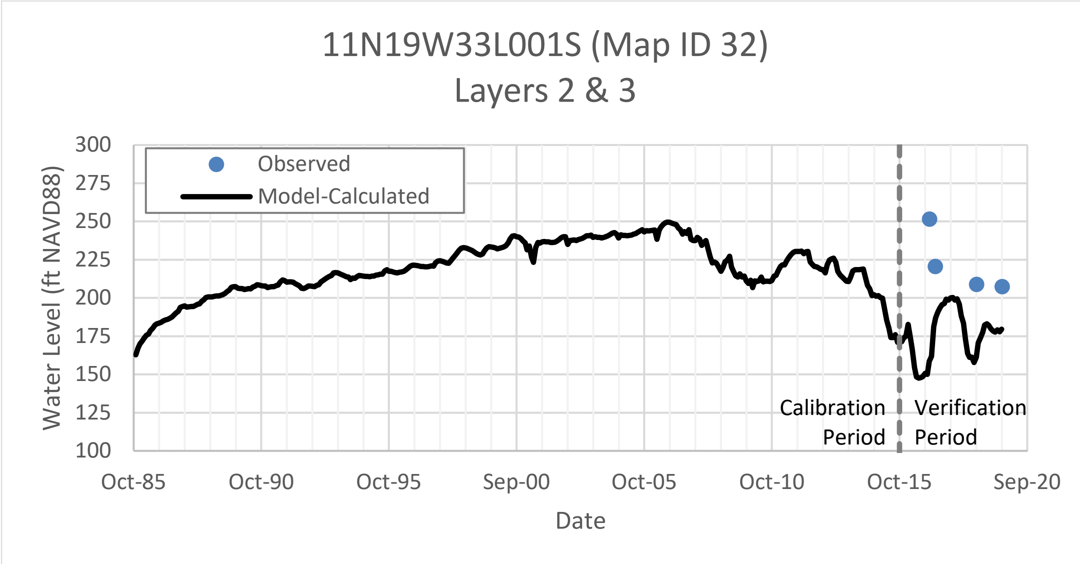

11N19W24H001S (Map ID 27)
Layers 1 & 2
Observed
Model-Calculated
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

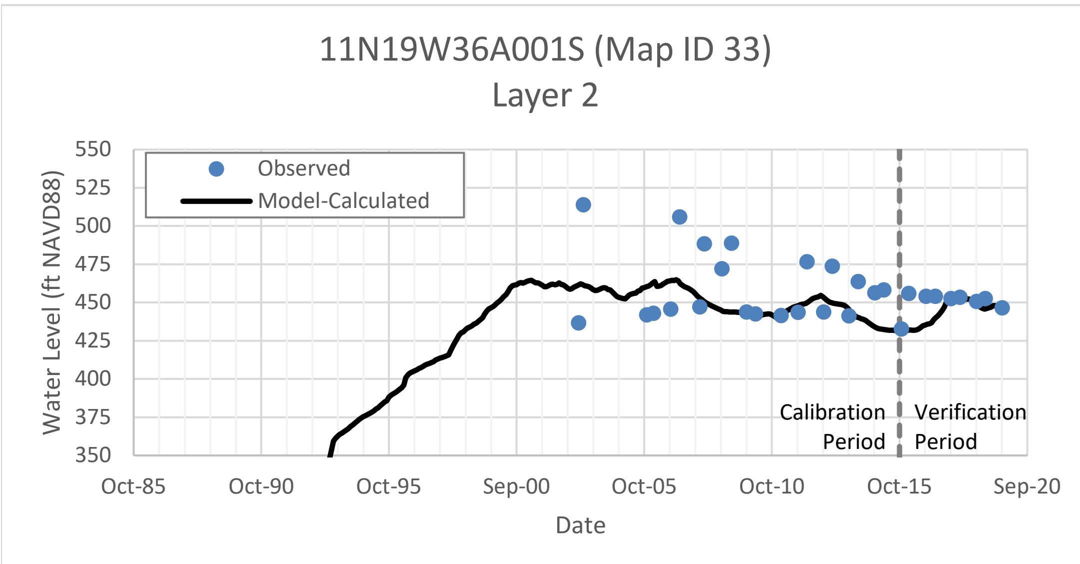

11N19W25B001S (Map ID 28)
Layer 2
Observed
Model-Calculated
Calibration Period
Verification Period
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

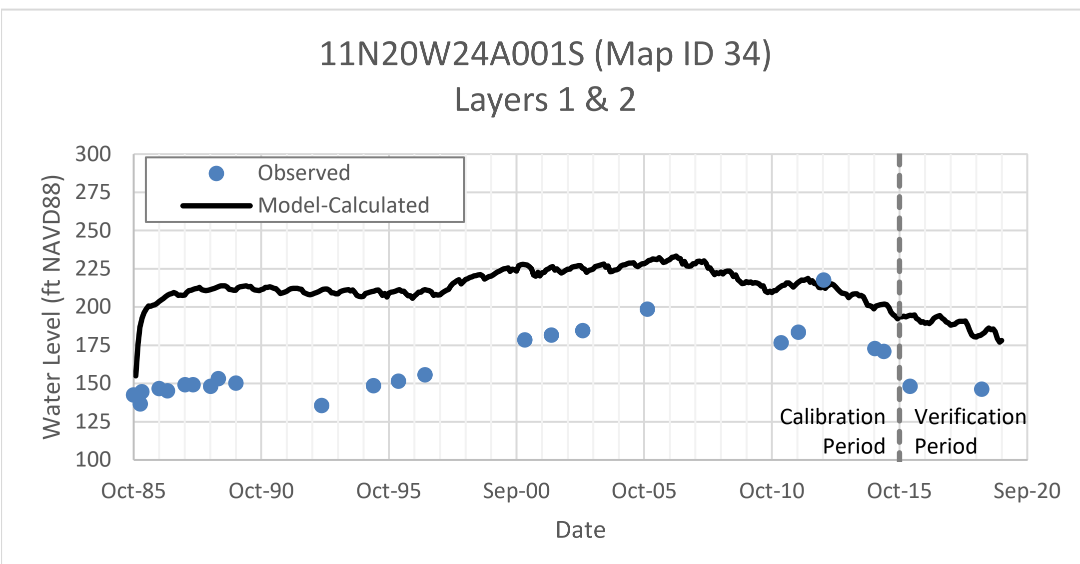

11N19W25N001S (Map ID 29)
Layer 2
Observed
Model-Calculated
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

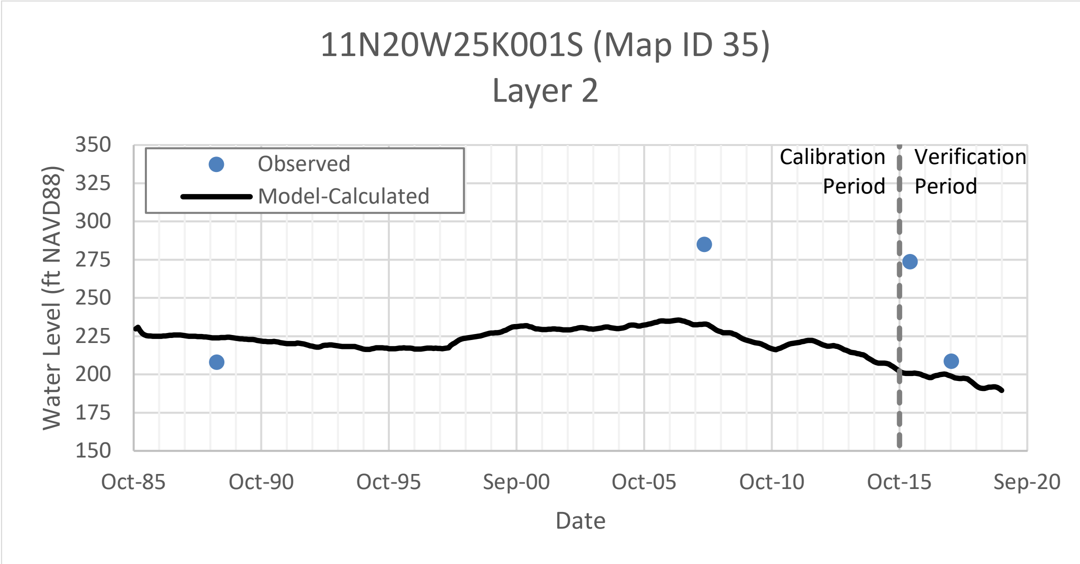

11N19W27C001S (Map ID 30)
Layer 2
Observed
Model-Calculated
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

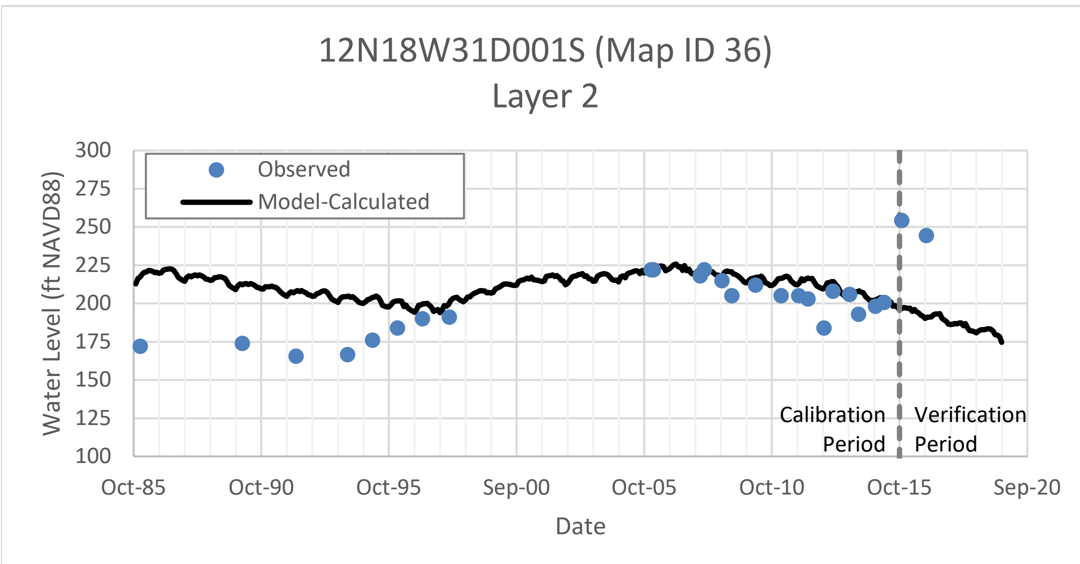

11N19W29N001S (Map ID 31)
Layers 2 & 3
Observed
Model-Calculated
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

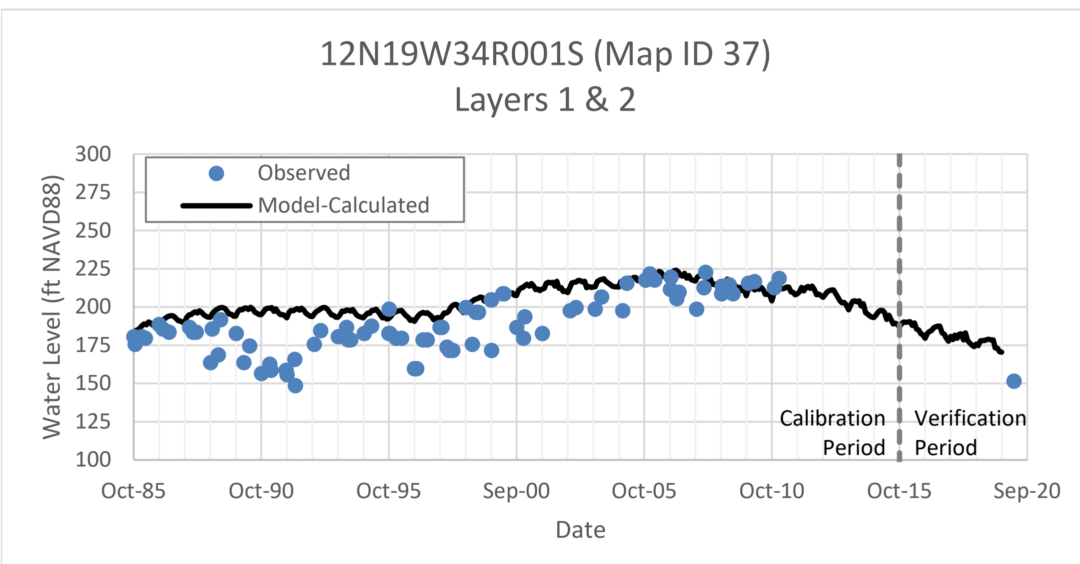

11N19W33L001S (Map ID 32)
Layers 2 & 3
Observed
Model-Calculated
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

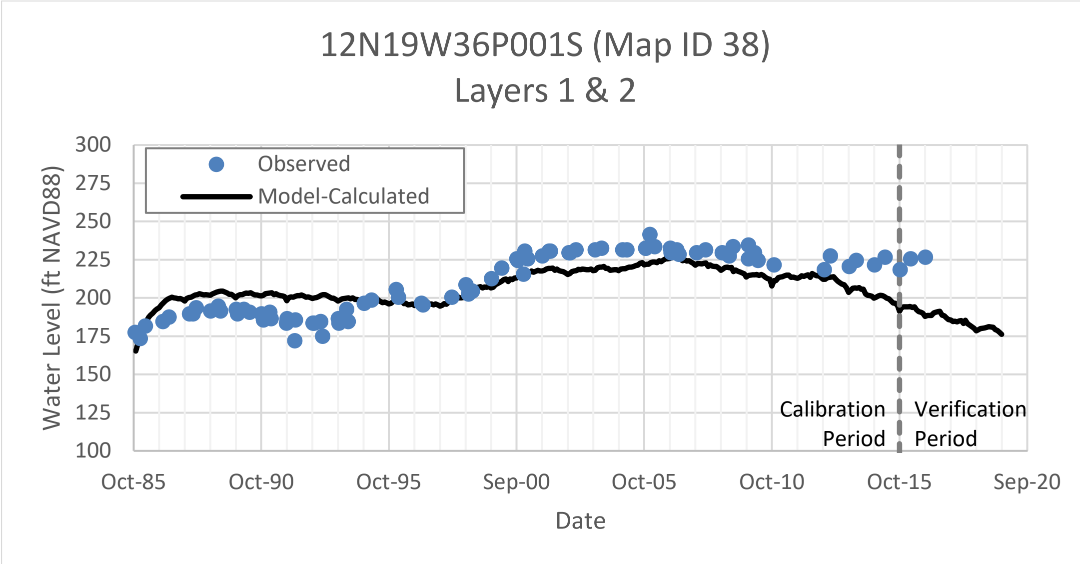

11N19W36A001S (Map ID 33)
Layer 2
Observed
Model-Calculated
Water Level (ft NAVD88)
550
525
500
475
450
425
400
375
350
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

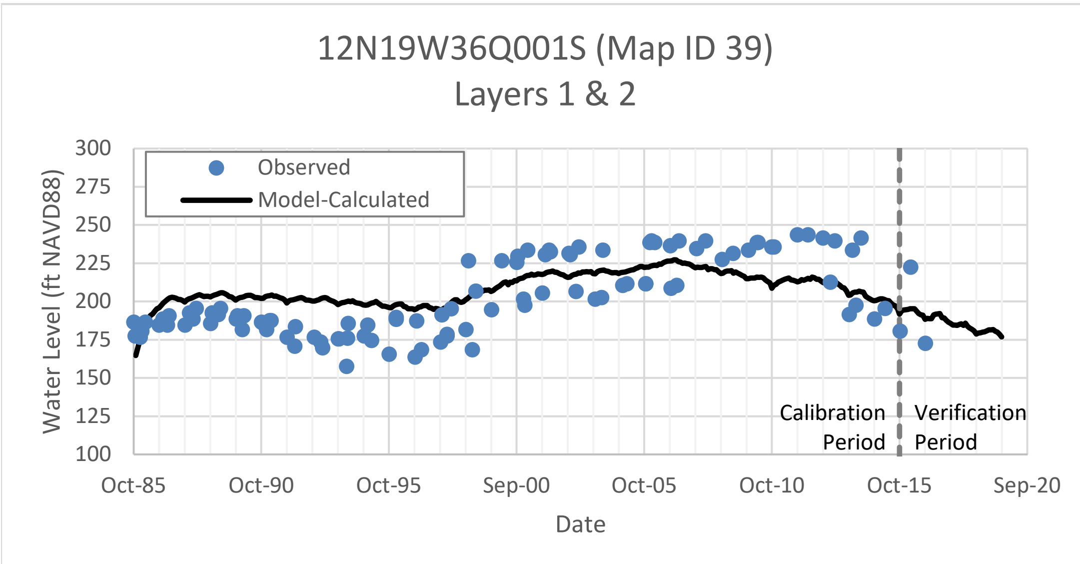

11N20W24A001S (Map ID 34)
Layers 1 & 2
Observed
Model-Calculated
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

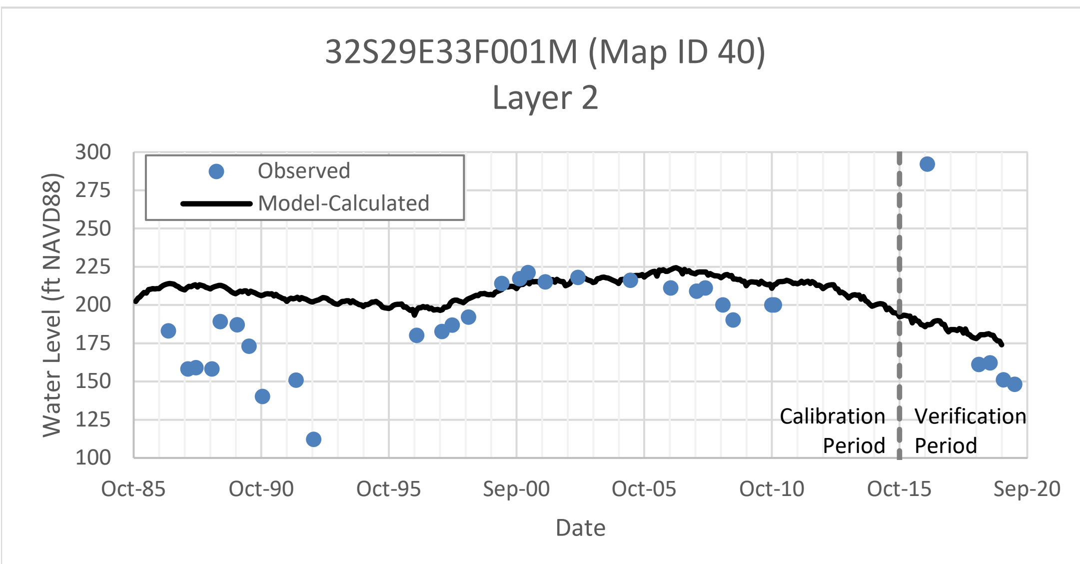

11N20W25K001S (Map ID 35)
Layer 2
Observed
Model-Calculated
Calibration Period
Verification Period
Water Level (ft NAVD88)
350
325
300
275
250
225
200
175
150
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date

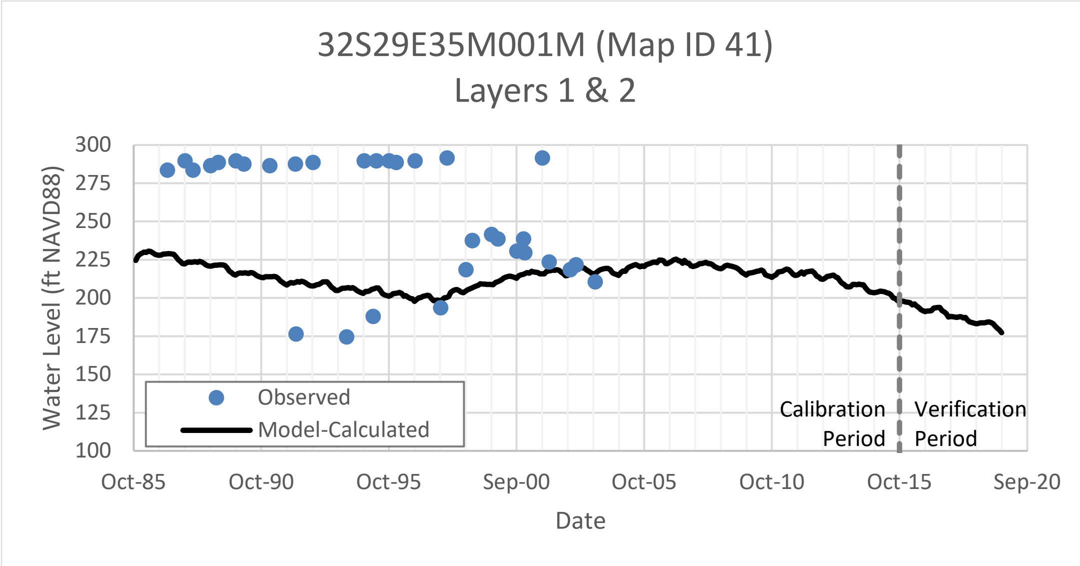

12N18W31D001S (Map ID 36)
Layer 2
Observed
Model-Calculated
Calibration Period
Verification Period
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date


12N19W34R001S (Map ID 37)
Layers 1 & 2
Observed
Model-Calculated
Calibration Period
Verification Period
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date


12N19W36P001S (Map ID 38)
Layers 1 & 2
Observed
Model-Calculated
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date


12N19W36Q001S (Map ID 39)
Layers 1 & 2
Observed
Model-Calculated
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date


32S29E33F001M (Map ID 40)
Layer 2
Observed
Model-Calculated
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Calibration Period
Verification Period
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date


32S29E35M001M (Map ID 41)
Layers 1 & 2
Water Level (ft NAVD88)
300
275
250
225
200
175
150
125
100
Oct-85
Oct-90
Oct-95
Sep-00
Oct-05
Oct-10
Oct-15
Sep-20
Date
Observed
Model-Calculated
Calibration Period
Verification Period

Attachment 2. Soil Moisture Budget Accounting Manual

SOIL MOISTURE BUDGET ACCOUNTING MODEL DOCUMENTATION

TABLE OF CONTENTS

ABBREVIATIONS

AEWSD	Arvin-Edison Water Storage District
CIMIS	California Irrigation Management Information System
ET	Evapotranspiration
ETo	Reference Evapotranspiration
ITRC	Irrigation Training and Research Center
LU	Land Use
METRIC	Mapping EvapoTranspiration at high Resolution with Internalized Calibration
NRCS	Natural Resources Conservation Service
PRISM	Parameter-elevation Regressions on Independent Slopes Model
SMB	Soil moisture budget accounting model
TCWD	Tejon-Castac Water District
USDA	United States Department of Agriculture
WRMWSD	Wheeler Ridge-Maricopa Water Storage District
WWGFM	White Wolf Groundwater Flow Model

1. INTRODUCTION

A Soil Moisture Budget (SMB) accounting model (SMB model) was developed to provide groundwater recharge and pumping estimates for use as input to the White Wolf Groundwater Flow Model (WWGFM). This documentation presents a description of the hydrologic processes included in the SMB model along with the associated calculations, the input data requirements, and the model execution process.

1.1 Purpose and Objectives of the Soil Moisture Budget Accounting Model

As described in detail in Appendix L, the WWGFM is a numerical model that calculates the movement of groundwater and surface water into, within, and out of the White Wolf Subbasin (Subbasin) by discretizing the three-dimensional model domain horizontally into a grid of cells and vertically into four layers. Like all groundwater models, the WWGFM relies on various user-specified inputs related to aquifer hydraulic properties, initial conditions, and boundary conditions to represent the Subbasin and its transient hydrologic functioning. Two of the main boundary condition inputs required for the WWGFM are recharge and groundwater pumping rates as a function of space (location) and time. The purpose of the SMB model described herein is to estimate these spatiotemporal variables and generate recharge and well pumping datasets for use in the WWGFM.

1.2 SMB Model Background

1.2.1 <u>Conceptual Approach</u>

The SMB model uses mass-balance principles to quantify and track the movement of water that arrives at the land surface from either precipitation or irrigation into the subsurface or back into the atmosphere, based on the processes and spatially- and temporally variable factors that control recharge and groundwater pumping. The order of calculations is generally consistent with the sequence of hydrologic processes that govern this movement of water, as discussed further in Section 2 below. At each stage in the calculation for a given time step, the volume of water in the system (consisting of soil moisture in the soil/root zone and canopy/depression storage) is balanced in accordance with the various inflows or outflows associated with the hydrologic process at that stage.

1.2.2 <u>Spatial Approach</u>

The SMB model performs calculations on a grid cell basis using the same spatial grid as the WWGFM. Within each time step, calculations are performed for all active model grid cells simultaneously using vector operations. As discussed in greater detail in Section 3 below, spatial properties assigned to grid cells vary depending on location (e.g., within a water service area), land use, and soil type characteristics. The model therefore provides spatially variable recharge estimates that reflect variable land use, soil conditions, and imported water availability throughout the Subbasin. The SMB model also calculates spatially variable groundwater pumping demands based on evapotranspiration (ET), District water deliveries to agricultural lands, and irrigation efficiency, and then assigns that pumping demand to the nearest groundwater well for use as input to the WWGFM.

1.2.3 Temporal Approach

The SMB model runs using a daily time step. As discussed in greater detail in Section 3 below, the various transient input datasets vary in their temporal resolution (e.g., precipitation data is daily, whereas potential evapotranspiration and District water deliveries data is monthly, and land use is biannual). The outputs from the model are monthly to be consistent with the stress periods of the WWGFM. The decision to use a daily time step in the SMB model is driven largely by the need to incorporate the rainfall-runoff process which functions at a relatively high temporal frequency; use of a longer time step would obscure the high frequency behavior of the system.

1.2.4 Code Setup and Execution

The SMB model is written and run in the Octave programming language. During model execution, the model first reads in a set of user-prepared input datasets (discussed further in Section 3 below) and sets up various variables and parameters. The model then runs through soil moisture budget accounting calculations for each time step in the specified simulation period. The calculations associated with each relevant hydrologic (or water movement) process are presented in Section 2 below. In addition to the hydrologic processes described below, a set of “bookkeeping” calculations are performed at the start of each time step related to updating the various grid cell properties as needed, primarily the land use type which then affects other properties such as Curve Number, canopy storage, native vs. non-native type (which affects the ET calculation), and surface water service area (SWSA) flag. After the last time step is completed, the model performs final calculations to sum daily values into monthly values and writes the output data to files.

2. PROCESSES INCLUDED IN THE SMB MODEL

The water movement processes included in the SMB model are (1) precipitation, (2) interception, (3) evaporation from canopy and depression storage, (4) rainfall-excess runoff, (5) applied water from District deliveries, (6) applied water from private pumping (deficit pumping), (7) ET by vegetation, (8) recharge, (9) saturation excess runoff, and (10) dynamic soil moisture storage. Each of these processes is described below along with the associated calculations/equations.

2.1 Precipitation

Precipitation is an input to the SMB model rather than a calculated variable. The precipitation data used in the SMB model is gridded daily precipitation from the Parameter-elevation Regressions on Independent Slopes Model (PRISM) dataset developed by the Northwest Alliance for Computational Science and Engineering (NACSE) based at Oregon State University (PRISM, 2019). The spatial resolution of the gridded precipitation data is 4 kilometers (km).

2.2 Interception

Interception occurs when rainfall is caught by the vegetation canopy (leaves, stems, etc.) before reaching the ground. Intercepted rainfall accumulates within the canopy storage and is then subject to evaporation. The similar process of depression storage, where water accumulates in depressions on the soil surface, is treated the same way as interception in the SMB model. The model uses a running canopy storage budget for each grid cell to track the accumulation and evaporation of intercepted rainfall and depression storage, collectively referred to as interception.

$$interception = \max\left(0\middle|\min\left(rainfall\middle|stor\ cap_{canopy} + stor\ cap_{depr} - CS_0\right)\right) \quad (1)$$

where *stor cap*$_{canopy}$ and *stor cap*$_{depr}$ are the canopy storage capacity and depression storage capacity, respectively.

$$CS_1 = CS_0 + interception \quad (2)$$

where CS is the volume (depth) of canopy and depression storage, and the subscripts indicate an order of calculation.

2.3 Evaporation from Canopy and Depression Storage

Evaporation from canopy and depression storage is the removal of water from the vegetation canopy and soil surface through the meteorological process of evaporation. The evaporated water is lost to the atmosphere. This evaporation does not go towards satisfying the vegetation's transpiration demand but does use a portion of the potential evapotranspiration available from meteorological conditions (i.e., temperature, humidity, windspeed, etc.).

$$AET_c = \min(PET|CS_1) \quad (3)$$

where AET_c is the actual evaporation from canopy and depression storage and PET is the potential evapotranspiration. In the WWGFM application of the SMB model, fallow and native (natural) land use classes rely on California Irrigation Management Information System (CIMIS) reference evapotranspiration (ETo) data and the crop coefficient method to calculate PET, as further described in Section 2.8 below. Non-native land use classes (irrigated crops and urban lands) rely on Mapping Evapotranspiration using high Resolution and Internalized Calibration (METRIC) data as the basis for PET.

$$CS_2 = CS_1 - AET_c \quad (4)$$

$$PET_{leftover} = PET - AET_c \quad (5)$$

$$rainfall_{leftover} = rainfall - interception \quad (6)$$

The subscript "leftover" indicates that portion of either rainfall or PET that is not yet used at this point in the SMB model calculation.

2.4 Rainfall-Excess Runoff

Precipitation in excess of interception reaches the land surface and under certain conditions can become runoff (i.e., overland surface flow). Rainfall-excess runoff occurs when the rate of precipitation exceeds the rate at which water can move downwards through the soil. In the SMB model, rainfall-excess runoff is estimated using the U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) Curve Number approach. Under this approach, runoff is a function of rainfall amount and surface properties including the land cover type and soil hydrologic group.

$$S = \frac{1000}{CN} \tag{7}$$

$$S_{adj} = S * \left(1 - \max\left(0 \middle| \frac{SM_1 - \left(\frac{FC+WP}{2}\right)}{SM_{sat} - \left(\frac{FC+WP}{2}\right)}\right)\right) \tag{8}$$

where S is the maximum retention, CN is the curve number (a function of land cover type and soil hydrologic group), FC is the field capacity and WP is the wilting point (both functions of soil type), SM is the soil moisture (inches) at that grid cell (a transient variable calculated by the model), and SM_{sat} is the soil moisture at saturation. Equation (8) essentially adjusts the S parameter for varying antecedent moisture conditions (Schroeder et al., 1994), and thus the "adj" subscript is applied.

$$Ia_{adj} = 0.2 * CN_{adj} \tag{9}$$

where Ia is the initial abstraction (initial loss).

For cells where $rainfall_{leftover} - Ia_{adj} > 0$ and $rainfall_{leftover} - Ia_{adj} - CN_{adj} > 0$

$$Runoff_{CN} = \frac{\left(rainfall_{leftover} - Ia_{adj}\right)^2}{rainfall_{leftover} - Ia_{adj} - CN_{adj}} \tag{10}$$

$$rainfall_{leftover} = rainfall_{leftover} - Runoff_{CN} \tag{11}$$

where $Runoff_{CN}$ is the volume (depth) of rainfall-excess runoff via the Curve Number approach.

2.5 Interim Calculations of Soil Moisture, Soil Water Content, Available Water, ET Stress Function, and Vegetative Water Demand

While not strictly a water movement or hydrologic process, the SMB model performs a set of interim calculations prior to the calculation of applied water from District deliveries. These interim calculations include updating soil moisture (SM), soil water content (SWC, expressed as a percentage of total soil volume), available water (AW), as follows:

$$SM_2 = SM_1 + rainfall_{leftover} \tag{12}$$

$$SWC_2 = \frac{SM_2}{rootdepth} \tag{13}$$

$$AW_2 = SWC_2 - WP \tag{14}$$

Calculation of an ET Stress Function ($ETSF$) allows for a reduction in vegetative water demand under dry soil conditions (Shuttleworth, 1993) for the grid cells that use the crop coefficient method (i.e., the fallow and native land grid cells).

$$ETSF = \max\left(0 \middle| \min\left(1 \middle| \frac{AW_2}{(FC - WP) * ETSF_{mult}}\right)\right) \tag{15}$$

where $ETSF_{mult}$ is the user-specified ETSF multiplier.

As mentioned previously, the Vegetative Water Demand (VWD) is calculated in two different ways depending on the source of the PET data. For non-native land grid cells that use METRIC data as the basis for PET (described further in Section 2.8 below), the VWD is calculated as follows:

$$VWD = PET_{leftover} \tag{16}$$

For fallow and native land grid cells that use CIMIS reference evapotranspiration (ETo) as the basis for PET, the VWD is calculated using the crop coefficient method along with the ET Stress Function, as follows:

$$VWD = PET_{leftover} * crop\ coeff * ETSF \tag{17}$$

2.6 Applied Water from District Deliveries

Records of District deliveries to lands within their respective surface water service areas (SWSA) are used in the calculation of applied surface water[1] from District deliveries. Deliveries data are on a monthly basis and are therefore first normalized to a daily basis by dividing by the number of days in the month when rainfall was less than a specified Maximum Daily Rainfall for Irrigation. This prevents District deliveries from occurring on days with appreciable rainfall.

Distribution of District water to grid cells within a District's SWSA can occur one of two ways – normalized or scaled to VWD. If using normalized deliveries:

$$SW_{applied} = \min(max\ daily\ applied\ SW | deliveries_{normalized}) \tag{18}$$

If using deliveries scaled to Vegetative Water Demand, applied surface water for a given grid cell is proportional to that cell's share of the total VWD (if the total VWD is greater than zero) as follows:

$$SW_{applied} = \min\left(max\ daily\ applied\ SW \middle| \left(\frac{VWD}{VWD_{total}}\right) \frac{deliveries_{total,SWSA}}{irrigation\ days_{SP} * area}\right) \tag{19}$$

If the total VWD in the applicable SWSA equals zero, then applied surface water is calculated as follows (same as equation [18]):

$$SW_{applied} = \min(max\ daily\ applied\ SW | deliveries_{normalized}) \tag{20}$$

2.7 Applied Water from Private Groundwater Pumping

Private groundwater pumping is estimated in the SMB model as the amount of water required to fill the soil profile up to its field capacity, adjusted for irrigation efficiency. Pumping is triggered when the soil moisture, after adding applied surface water (if any) from the previous step, drops below a soil moisture trigger value. The soil moisture trigger from pumping is based on user-defined percentage between field capacity and wilting point ($dry\ scaler$) as follows:

$$SM_{trigger} = root\ depth * \left(WP + dry\ scaler(FC - WP)\right) \tag{21}$$

---

[1] Not all District-delivered water is surface water; however, for purposes of this documentation, the term $SW_{applied}$ refers to all District-delivered water regardless of the actual source of the water.

The initial pumping estimate is calculated as follows:

If $SM_2 + SW_{applied} < SM_{trigger}$

$$pumping_{initial} = root\ depth * \left(FC - \frac{SM_2 + SW_{applied}}{root\ depth}\right) / irrig\ eff \quad (22)$$

Pumping can be limited by a user-defined pumping limit applied on a cell basis (allowing for pumping to be turned off, if needed for certain cases), as follows:

$$pumping = \min(pumping_{initial} | pumping\ limit) \quad (23)$$

The difference between the initial pumping estimate and the potentially limited pumping is tracked as a pumping deficit for later use in the actual soil/root zone ET calculation:

$$pumping_{deficit} = pumping_{init} - pumping \quad (24)$$

2.8 Evapotranspiration by Vegetation

As described above, the SMB model uses METRIC ET data as the basis for PET in non-native areas and CIMIS ET and crop coefficients as the basis for PET for fallow and native lands. The METRIC data used in the SMB model was provided by the Irrigation Training and Research Center (ITRC) at California Polytechnic State University, San Luis Obispo, and is based on an energy balance model using Landsat satellite images. CIMIS is a program unit in the Water Use and Efficiency Branch, California Department of Water Resources that manages a network of over 145 automated weather stations in California, which provides reference evapotranspiration (ETo) values based on surface weather stations.

Actual ET from the root/soil zone is calculated differently for fallow or native land cells versus non-native land cells. For non-native lands, the actual ET is equal to the full VWD and is satisfied by a combination of applied surface water or private pumping, minus pumping deficit due to pumping limits:

$$AET_s = \max\left(0 \middle| VWD - pumping_{deficit}\right) \quad (25)$$

For fallow and native lands, the actual ET is the lesser of the VWD and the available moisture above the wilting point:

$$AET_s = \min\left(VWD \middle| SM_2 - (WP * root\ depth)\right) \quad (26)$$

For all grid cells (native and non-native), the soil moisture is updated at this point as follows:

$$SM_3 = SM_2 + SW_{applied} + pumping - AET_s \quad (28)$$

2.9 Aerial Recharge

Aerial recharge is the process of water movement below the bottom of the root zone where it then travels by gravity through the unsaturated zone to the saturated zone, adding to groundwater storage. Additional types of recharge such as stream recharge also occur and are accounted for in the WWGFM, separately from the aerial recharge calculated with the SMB model. Aerial recharge occurs when the soil moisture exceeds the field capacity of the soil, and continues until the soil moisture reaches field capacity. It is also subject to a maximum daily recharge limit.

$$recharge = \max\left(0\middle|\min\left(max\ daily\ recharge\middle|SM_3 - (FC * root\ depth)\right)\right) \tag{29}$$

Soil moisture is once again updated after recharge:

$$SM_4 = SM_3 - recharge \tag{30}$$

2.10 Saturation Excess Runoff

Saturation excess runoff occurs when the soil becomes completely saturated due to high rates of rainfall or applied water exceeding the rate at which recharge can drain water from the soil. This process is relatively common in areas with shallow water tables but is relatively rare in the Subbasin due to the thick unsaturated zones and relatively permeable soils.

$$Runoff_{SE} = max\left(0\middle|SM_4 - (porosity * root\ depth)\right) \tag{31}$$

Soil moisture and soil water content are updated one final time:

If $Runoff_{SE} > 0$

$$SM_5 = porosity * root\ depth \tag{32}$$

If $Runoff_{SE} = 0$

$$SM_5 = SM_4 \tag{33}$$

$$SWC_5 = \frac{SM_5}{root\ depth} \tag{34}$$

2.11 Soil Moisture Storage

Soil moisture storage provides a short-term reservoir allowing for the relatively continuous outputs to evapotranspiration and transpiration from the discontinuous rainfall and applied water inputs. Soil moisture storage typically varies between field capacity, which is the maximum quantity of water that can be held in the soil against gravity, and wilting point that is the threshold under which vegetation cannot extract water further. During wet periods soil moisture may rise temporarily above field capacity. Soil moisture storage is a key component of the SMB model and is updated at several points during the calculation of each time step, per equations (12), (28), (30), and (33).

3. INPUT DATASETS

This section describes the input datasets used to develop and apply the SMB model for the WWGFM. These datasets provide the spatial and temporal information on factors that control the movement of water through the SMB model.

3.1 Grid Data

The following attributes are assigned by the SMB model to grid cells, based on input datasets that were developed using a combination of Geographic Information System (GIS) and spreadsheet analysis.

- Active cell: flag (1 or 0) specifying whether the grid cell is active in the WWGFM or inactive; SMB model calculations are only performed on active cells
- Grid area: area of the grid cell (in square feet); all grid cells are 435,600 square feet in the WWGFM application of the SMB model
- Soil code: code corresponding to the soil map unit key; soils data were obtained from the United States Department of Agriculture (USDA) Soil Survey Geographic Database (SSURGO)
- Closest well: ID number for the closest well, derived using GIS analysis
- District: location within a District area (if any), based on the boundaries for the three District areas within the Basin, including Arvin-Edison Water Storage District (AEWSD), Wheeler Ridge-Maricopa Water Storage District (WRMWSD), Tejon-Castac Water District (TCWD), with a separate code for TCWD urban areas; used to determine which set of parcels apply to the grid cell and which District deliveries, if the parcel is in the District's SWSA

District ID	District
1	AEWSD
2	WRMWSD
3	TCWD
4	TCWD urban areas
0	No district

- Parcel: parcel ID associated with the overlying District (if any); used to assign PET, land use, and surface water deliveries to cells (see parcel data below)
- Land use for areas outside of Districts: land use (LU) codes for grid cells that are outside of Districts, based on land use information obtained from the USDA Forest Service Region 5 Classification and Assessment with Landsat of Visible Ecological Groupings (CalVeg) dataset for Zone 5 (Central Valley)

Land Use Code	CalVeg Land Use
4	Urban (URB)
5	Herbaceous (HEB)
6	Barren (BAR)
7	Shrubby herbaceous (SHB)
8	Woody vegetation (CON, MIX, and HDW)
9	Water (WAT)

- PRISM cell identifier: PRISM cell identifier used to link SMB grid cells to PRISM gridded precipitation data

3.2 Climate Data

The following datasets are used to define the climate characteristics for the SMB model period.

- CIMIS ETo: Daily ETo data (in inches) from the CIMIS Arvin #125 Station

- METRIC ET by parcel: ET values (in inches) by District parcels from the METRIC model. Monthly METRIC ET provided by ITRC in georeferenced raster format was processed using GIS analysis (zone statistics) to obtain monthly ET values for each District parcel
- METRIC monthly scaler: scaling factors used to adjust METRIC ET data to better match crop ET values determined using independent estimation methods, including Cal-SIMETAW, and to better match the independent estimate of pumping from the White Wolf Subbasin analytical water budget

Month	**METRIC ET scalar**
January	3.5
February	2.7
March	1.4
April	1.2
May	1.2
June	1.2
July	1.2
August	1.3
September	1.3
October	1.2
November	1.2
December	2.9

- PRISM precipitation: gridded daily precipitation data from the PRISM dataset

3.3 Parcel Data

The SMB uses parcel information to inform parameters related to land use and management.

- Parcel numbers: list of active parcels for the three Districts
- SWSA flag: flag (1 or 0) indicating whether a parcel is in District's surface water service area or not
- Land use: land use code for District parcels

Land Use Code	**Land Use**
1	Row crop (ROW)
2	Orchard crop (ORCH)
3	Fallow/idle (3)
4	Urban (URB)
5	Herbaceous (HEB)
6	Barren (BAR)
7	Shrubby herbaceous (SHB)
8	Woody vegetation (CON, MIX, and HDW)
9	Water (WAT)

- Pumping limit: flag specifying whether there is a pumping limit or not for district parcels.

3.4 Deliveries Data

Data on surface water deliveries, provided by each District, are used in the calculation of applied surface water to each parcel in the Districts' SWSA. Data are on a monthly basis.

3.5 Other Data

Several other datasets are used as input including the following:

- Soil characteristics: soil properties and parameters for all soils, including soil hydrologic group, field capacity, wilting point, root depth, porosity and saturated hydraulic conductivity
- Curve Number: curve number for all soil hydrological groups for each land use type, after USDA (1986)

Soil Hydrologic Group	Land Use Code								
	1	2	3	4	5	6	7	8	9
A	64	43	74	89	58	77	55	40	99.9
B	75	65	83	92	71	86	72	58	99.9
C	82	76	88	94	81	91	81	73	99.9
D	85	82	90	95	89	94	86	80	99.9

- Canopy Storage: canopy storage depth (in inches) for all land use types, based on values from Shuttleworth (1993) and Barr (2010)

Land Use Code	Canopy Storage (inches)
1	0.03
2	0.09
3	0.03
4	0
5	0.08
6	0.02
7	0.08
8	0.12
9	0

- Crop coefficients: crop coefficients for all land use types, after Howes et al. (2015)

Month	Land Use Code								
	1	2	3	4	5	6	7	8	9
January	1.16	1.11	1.13	0.3	0.66	1.13	0.3	0.8	0.7
February	0.59	0.67	0.92	0.3	0.64	0.92	0.3	0.8	0.72
March	0.43	0.34	0.12	0.3	0.70	0.12	0.3	0.8	0.86

April	0.55	0.57	0.61	0.35	0.64	0.61	0.35	0.8	0.79
May	0.51	0.62	0.01	0.45	0.33	0.01	0.45	0.9	0.97
June	0.65	0.76	0.39	0.5	0.10	0.39	0.5	1	1.01
July	0.62	0.80	0.01	0.6	0.03	0.01	0.6	1.1	1.12
August	0.36	0.80	0.0	0.55	0.02	0.0	0.55	1.2	1.09
September	0.20	0.75	0.02	0.45	0.01	0.02	0.45	1.2	1.11
October	0.16	0.60	0.33	0.35	0.01	0.33	0.35	1.15	1.20
November	0.65	0.66	0.87	0.4	0.43	0.87	0.4	1	0.95
December	1.07	1.05	1.16	0.35	0.86	1.16	0.35	0.85	0.80

- Stress periods: provides information on stress period, month (of year), and end of month (day)

3.6 User-Specified Parameters

In addition to the spatial and temporal datasets described above, the SMB model uses several parameters to modify certain inputs or calculations for purposes of model calibration.

- Depression storage capacity: the storage capacity of surface depressions, expressed as a depth of water (in inches); set to 0 in the WWGFM application of the SMB model[2]
- ETSF multiplier: number specifying the multiplier for the evapotranspiration stress function; set to 0.0001 in the WWGFM application of the SMB model[3]
- Irrigation efficiency: efficiency of irrigation; set to 85% in the WWGFM application of the SMB model[4]
- Dry scaler: dryness trigger for groundwater pumping irrigation, expressed as a percentage of the soil moisture between field capacity and wilting point; set to 10% in the WWGFM application of the SMB model

[2] Depression storage was set to zero during SMB model calibration after it was determined that non-zero values resulted in too much PET being used for evaporation from canopy and depression storage.
[3] The ETSF multiplier was set close to zero, resulting in a functional form where vegetative water demand remains close to the full PET rate (after canopy ET) until soil moisture reaches the wilting point at which point VWD is zero.
[4] Irrigation efficiency was set based on typical values for drip irrigation which is common in the Subbasin. Larger or smaller values for irrigation efficiency result in less or greater groundwater pumping, respectively, with over-irrigation becoming recharge. Thus, the net recharge after accounting for pumping, is insensitive to irrigation efficiency.

- Maximum daily applied surface water: maximum daily applied surface water for irrigation; set to 1.0 inches in the WWGFM application of the SMB model[5]
- Maximum rainfall for irrigation: threshold value of rainfall above which surface water deliveries are assumed not to occur; set to 0.1 inches in the WWGFM application of the SMB model

[5] Because surface water deliveries are normalized from monthly to daily values and would never exceed 1 inch per day on an average daily basis, setting the maximum daily applied surface water to 1 inch per day is used as a way to prevent erroneously high applied water values that could occur due to small areas of SWSA. This safeguard applies only very rarely and does not have a significant effect on total applied water or the SMB model outputs.

4. REFERENCES

Barr Engineering Company, 2010. *Abstractions (Interception and Depression Storage) (Item 5, Work Order 1)*, Memorandum to MIDS Work Group, dated 14 December 2010.

Howes, D.J., Fox, P., and Hutton, P.H., 2015. *Evapotranspiration from Natural Vegetation in the Central Valley of California: Monthly Grass Reference-Based Vegetation Coefficients and the Dual Crop Coefficient Approach*. SCE Journal of Hydrologic Engineering, January 20, 2015, 17 pp.

PRISM, 2019. Descriptions of PRISM Spatial Climate Datasets for the Conterminous United States. Last revised October 2019. https://prism.oregonstate.edu/documents/PRISM_datasets.pdf

Schroeder, P. R., Dozier, T.S., Zappi, P. A., McEnroe, B. M., Sjostrom, J. W., and Peyton, R. L., 1994. *The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3*, EPA/600/R-94/168b, September 1994, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.

Shuttleworth, W. J., 1993. Chapter 4: Evaporation, in: Maidment, D. R., ed., 1993, *Handbook of Hydrology*, McGraw-Hill, Inc., New York.

USDA, 1986. *Urban Hydrology for Small Watersheds*, TR-55, dated June 1986.

Attachment 3. White Wolf Groundwater Flow Model File Descriptions

Folder: Model_Files

Package: NAM
Filename: wwgfm_hist.nam
Description: The Name file controls MODFLOW execution. Packages listed in the NAM file are turned on unless preceded with a pound symbol (#). Package names preceded with a pound symbol are turned off.

Package: BAS
Filename: wwgfm_hist.bas
Description: The Basic package file includes the IBOUND array, which identifies active cells and inactive cells, and initial heads.

Package: DIS
Filename: wwgfm_hist.dis
Description: The Discretization file specifies the model grid dimensions, model layer elevations, and model simulation time as stress periods. The WWGFM has 4 model layers. There are 408 monthly transient stress periods representing WY 1986-2019 [October 1985 through September 2019].

Package: UPW
Filemane: wwgfm_hist.upw
Description: The Upstream Weighting package file specifies parameters and aquifer properties for each model cell. Model cells have been combined into physiographic zones, each of which has unique hydraulic properties. The WWGFM has 5 physiographic zones, each designated using a unique parameter for Kh, Kv, Ss, and Sy by layer. Parameters are specified for some individual physiographic zones and in some cases physiographic zones have been combined and use a single parameter.

Package: HOB
Filename: wwgfm_cal_95-14.hob
Description: This Head-Observation package input file specifies the locations and times for which model-calculated heads should be written to an output file for the calibration period. The file also contains observed heads for comparison with model-calculated heads.
Filename: wwgfm_cal_15-19.hob
Description: This Head-Observation package input file specifies the locations and times for which model-calculated heads should be written to an output file for the verification period. The file also contains observed heads for comparison with model-calculated heads.
Filename: wwgfm_hyds.hob
Description: This Head-Observation package input file specifies the locations and times for which model-calculated heads should be written to an output file for plotting of hydrographs over the entire simulation period. The observed data in this file only act as placeholders and do not represent actual measurements.

Only one HOB package file can be turned at for a given model run. The files are turned on or off in the NAM file using the pound symbol (#). To output the calibration well data, verification data, and hydrograph plotting data, the MODFLOW model must be run three times using a different HOB file for each run. Output is written to file HOBData.txt. After each run, move and rename the "HOBData.txt" file to the "Output_Files" folder to prevent the previous results from being overwritten.

Package: WEL

Filename: wwgfm_hist.wel
Description: The Well package file specifies the location of pumping wells and the monthly pumping rates (ft^3/d). Entries are identified as either calculated by the SMB "SMB Pumping[Well Identifier]" or as specified directly "Well Pumping" from reported data. Output from the SMB and the other pumping data are then formatted into a MODFLOW WEL file using an external application.

Package: GHB
Filename: wwgfm_hist.ghb
Description: The General-Head Boundary package file simulates head-dependent flow into or out of each GHB cell from an external source. The flow is proportional to the the difference between the model-calculated head and a specified head and boundary conductance and a proportionality constant. In the WWGFM, the head specified for each GHB cell represents the head on the north side of the White Wolf Fault and the conductance is the proportionality constant. Each layer has its own parameter specified, where:
Parameter WWFL1 represents cells in layer 1;
Parameter WWFL2 represents cells in layer 2;
Parameter WWFL3 represents cells in layer 3; and
Parameter WWFL4 represents cells in layer 4.

Package: RCH
Filename: wwgfm_hist.rch
Description: The Recharge package file specifies aerially distributed recharge for each cell (ft/d). Recharge is calculated externally using a Soil Moisture Budget (SMB) model and the SMB output is formatted into a MODFLOW RCH file using an external application.

Package: EVT
Filename: wwgfm_hist.evt
Description: The Evapotranspiration package file specifies information required for MODFLOW to calculate evaporation from shallow groundwater. In the WWGFM, the ET surface is specified as land surface, monthly ET rates are based on nearby pan evaporation rates, and evaporation from the shallow groundwater is specified to decrease linearly to a depth of 7 ft. below ground surface (extinction depth).

Package: STR
Filename: wwgfm_hist.str
Description: The Stream package file simulates the interaction of flow between surface water and groundwater systems. Within the WWGFM, stream cells represent 10 creeks: Salt, Tecuya, Grapevine, Liveoak, Pastoria, Tunis, El Paso, Tejon, Chanac, and Comanche. Additionally, there are four points of diversion simulated on Grapevine, Pastoria, Tunis, and El Paso Creeks. There is one global parameter for Specifying streambed conductance.
Filename: wwgfm_hist_print.str
Description: This file is identical to the STR file described above except that a setting has been changed to print stream stage and flow to the LST file. If this file is turned on, stream volumetric budget results will not be saved to the budget file. Only one STR package file can be turned on for a given model run. This file is turned off and on in the NAM file via the pound (#) symbol. To print stream stage and flow information, the MODFLOW model must be run two times using a different STR file each time. After each run, move and rename either the "wwgfm_hist.cbb" or the “wwgfm_hist.lst" files to the "Output_Files" folder to prevent the results from being overwritten.

Package: HFB

Filename: wwgfm_hist.hfb
Description: The Horizontal-Flow Barrier package file simulates partial barriers to horizontal flow, such as faults. Within the WWGFM, the Springs Fault and the Wheeler Ridge Fault are represented using the HFB package. The hydraulic characteristics of the faults are controlled by parameters, where the Springs Fault is represented by one parameter for each layer and the Wheeler Ridge Fault is represented by one global parameter. The Springs Fault is also split into four segments representing various fault segment lengths.

Package: OC
Filename: wwgfm_hist.oc
Description: Output control option file controls type and timing of data that is printed or saved. Within the WWGFM, the output control is set to save model-calculated heads and volumetric budget results for each stress period.

Package: NWT
Filename: wwgfm_hist.nwt
Description: Newton solver file which solves the finite difference groundwater flow equations.

Package: PVAL
Filename: wwgfm_hist.pval
Description: Parameter values file. The parameter values specified here overwrite parameter values specified within individual files above.

Package: MULT
Filename: wwgfm_hist.MLT
Description: The Multiplier file is used to specify multiplier arrays based on texture for calculating hydraulic conductivity. The values specified in the MULT file are the fraction of coarse-grained material for each cell and layer.

Package: ZONE
Filename: wwgfm_hist.zon
Description: The Zone file is used to define the physiographic zones.

Other files

Filename: MODFLOW-NWT_64.exe
Description MODFLOW 2005-NWT executable.

Filename: Run_MF.bat
Description: DOS batch file used to run the model. Double-Click on this to run MODFLOW.

Folder: Output_Files

Folder name: STR
Description: This subfolder contains stream package output and a processing spreadsheet.

Folder: WL
Description: This subfolder contains water level output and processing spreadsheets.

Folder: ZB

Description: This subfolder folder contains water budget output, processing applications, and summary spreadsheets. Copy the *.cbb file from the Model_Files folder to the ZB folder and run zonebudget (zonbud.exe) to extract budget information from binary model output file. Zonebudget LISTING FILE should be specified as "zbout csv2".
Zonebudget zone files:
Filename: zones_3zones.txt
Description: This file contains the main model area zones. Zones 1, 2, and 3 represent the agricultural, developed, and native areas, respectively.
Filename: zones_layers.txt
Description: This file contains specifies zones by model layer.

Output from Zonebudget is in ft^3/d.

Appendix M

Change in GDE Area Analysis

Change in GDE Area Analysis

Normalized Derived Vegetation Index (NDVI) is the most widely used vegetation metric in the literature and is a reliable measure of the photosynthetic chlorophyll content in leaves and vegetation cover.[1] The Nature Conservancy (TNC) Groundwater Dependent Ecosystem (GDE) Pulse calculated annual NDVI from surface reflectance corrected multispectral Landsat imagery, and applied a linear fit to the NDVI time series data to estimate the NDVI trends over specific timespan of interest. The NDVI trends can be viewed on the TNC GDE Pulse website (https://gde.codefornature.org/#/map).

Since NDVI is used to estimate vegetation greenness and provides a proxy for vegetation growth, change in GDE area can be estimated using TNC GDE Pulse raster data that show NDVI trends between 2009 and 2018.[2] Moderate to large increases in NDVI trends represent an increase in the GDE area and moderate to large decreases in NDVI trends represent a decrease in the GDE area. Therefore, the change in GDE area can be estimated by subtracting GDE area with decreasing NDVI trends from GDE area with increasing NDVI trends.

This analysis was performed in ArcGIS.[3] The statewide raster data that show NDVI trends between 2009 and 2018 were clipped using the White Wolf Subbasin (Basin) GDEs of interest polygons (i.e., those supported by a shallow water-bearing zone upgradient of the Springs Fault). Raster values of zero mean no change in NDVI trends. Positive and negative raster values mean increasing and decreasing NDVI trends respectively. For the purpose of this analysis, raster values that range from -628 to 628 were assumed to represent little or no change in NDVI trends.[4] For GDE zones grouped by general spatial location, the total number of raster pixels that fall within the GDE polygon boundary, number of pixels that show increasing NDVI trends, and number of pixels that show decreasing NDVI trends were summarized, as shown in **Table 1**. Change in area for each GDE zone was then calculated by dividing the difference between the increasing and decreasing NDVI trends' pixel counts by the total pixel count.

Percentages of GDE area reduction in 2009 compared to 2018 by GDE zones are shown in **Table 1**. **Figure 1** shows the raster data of NDVI trends by GDE zones. Compared to the 2018 GDE area, reductions in GDE area range from -18% to 91%, with an average of 33% (i.e., on average the GDE area in 2009 was 33% less than the GDE area in 2018).

[1] https://gde.codefornature.org/#/methodology
[2] Statewide raster data that show NDVI trends were provided by TNC on 30 August 2021.
[3] https://www.esri.com/en-us/arcgis/about-arcgis/overview
[4] The range of -628 to 628 is approximately two percent of the raster values' total range. It was selected by visually comparing raster pixels that fall within this range with the "little or no change" NDVI trend category from the TNC GDE Pulse website. Therefore, raster values larger than 628 represent moderate or large increase in NDVI trends, and raster values smaller than -628 represent moderate or large decreasing in NDVI trends.

Table 1. Change in GDE Area (2009-2018)

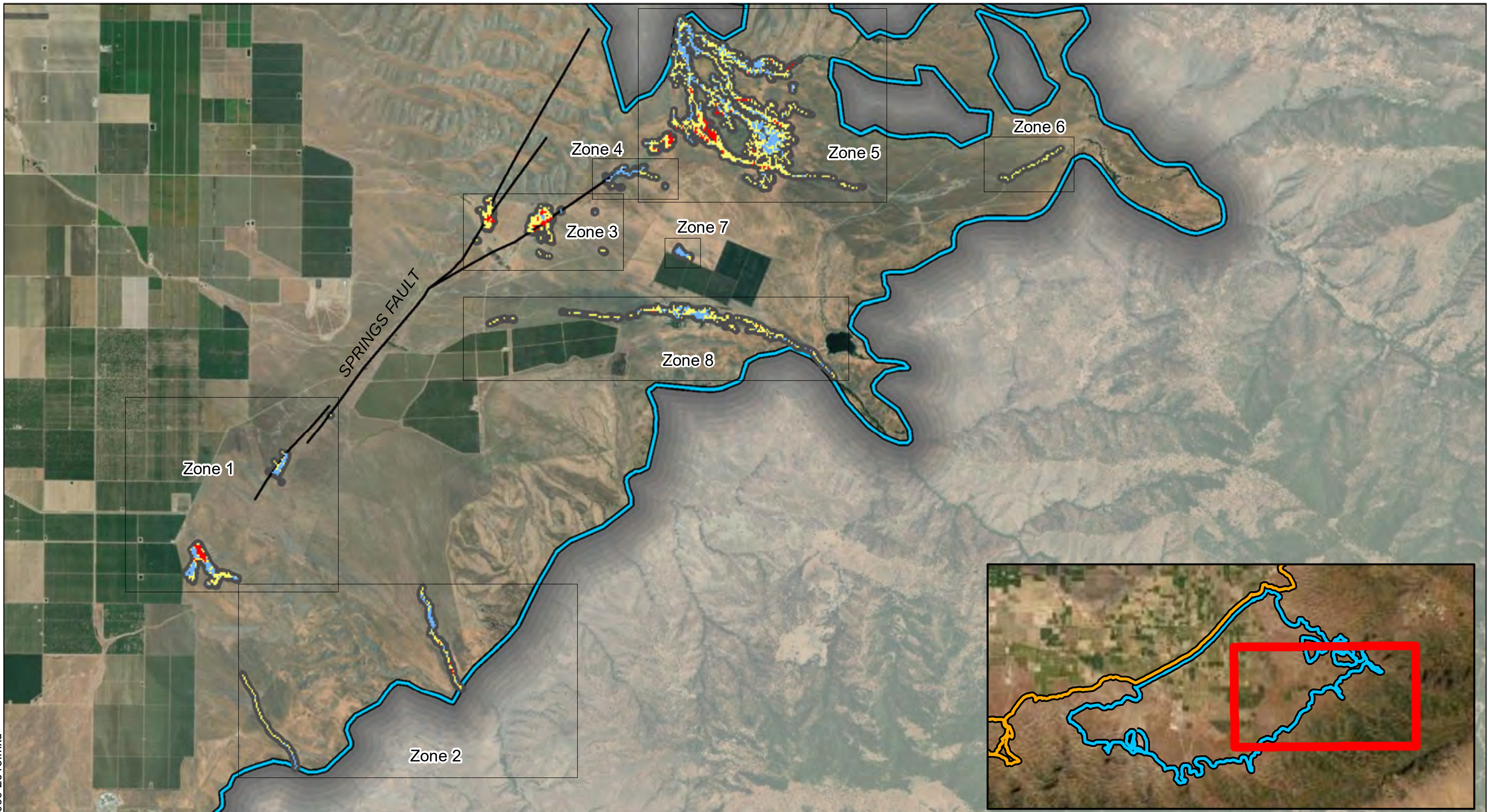
GDE ZONE	Total Pixel Count	Pixel Count of Decreasing NDVI Trends	Pixel Count of Increasing NDVI Trends	GDE Area Reduction in 2009[(a)]
1	226	35	103	30%
2	112	5	43	34%
3	190	44	9	-18%
4	41	0	32	78%
5	1493	110	430	21%
6	27	0	0	0%
7	22	0	20	91%
8	247	3	70	27%
			Average	**33%**

Abbreviation:

GDE = Groundwater Dependent Ecosystem
NDVI = Normalized Derived Vegetation Index
TNC = The Nature Conservancy

Notes:

(a) Positive percentages represent net reduction in GDE area and negative percentages represent net increase in GDE area in 2009 relative to 2018.



Legend

Groundwater Subbasin

White Wolf (DWR 5-022.18)

Kern County (DWR 5-022.14)

Springs Fault

NDVI Trend (2009-2018)

Large or Moderate Decrease

Little or No Change

Large or Moderate Increase

Notes

1. All locations are approximate.
2. GDEs of interest for the purpose of the White Wolf Groundwater Sustainability Plan are those categorized as sites appearing to be supported by the shallow water-bearing zone upgradient of the Springs Fault (“B”) or the Regional Aquifer (“R”).

Sources

1. Basemap is ESRI's ArcGIS Online world aerial map, obtained 3 September 2021.
2. Statewide raster data showing NDVI trends were provided by The Nature Conservancy on 30 August 2021.

Abbreviations

DWR= California Department of Water Resources

GDE= Groundwater Dependant Ecosystem

NDVI=Normalized Derived Vegetation Index

DRAFT

N

0 1 2

(Scale in Miles)

GDE Pulse NDVI Trends

eki environment & water

White Wolf GSA
Kern County, California
September 2021
B50001.05

Figure 1

Path: X:\B50001.05\Maps\2021\09\GDE Pulse NDVI_2009-2018.mxd

Appendix N

Project and Management Action Information Forms

WHITE WOLF GROUNDWATER SUSTAINABILITY AGENCY
PROJECT / MANAGEMENT ACTION
INFORMATION FORM

P/MA ID: 01 **BASIN/MANAGEMENT AREA** (if any): White Wolf Subbasin

TITLE: Recharge from Grapevine Development

DESCRIPTION[1]:

At full build-out, the Grapevine Development will consist of approximately 4,778 acres and will include 12,000 residential units, 10.7 million square feet of commercial and industrial space, and approximately 3,232 acres designated as agriculture, grazing and open spaces. The Grapevine Development is anticipated to be constructed in six phases over 19 years with an anticipated break-ground date of 2026 to 2027. Potable water will be supplied via the California Aqueduct. Potable water demand is estimated at 5,620 acre-feet per year (AFY) and includes both indoor and outdoor water uses and system losses. Additionally, highly-treated reclaimed water produced from the development will be used to meet some non-potable industrial and landscape irrigation demands. Non-potable water demand is estimated at 2,241 AFY which includes 1,983 AFY of recycled water and 258 AFY of supplemental outdoor use (including system losses).

EXPECTED ANNUAL BENEFIT (demand reduction or supply augmentation, in acre-feet per year):

System losses which will directly recharge the groundwater system are estimated to be 629 AFY at full build-out.

AGENCY(s):

Primary/Lead: Tejon-Castac Water District

Supporting:

LOCATION: ☐ Check here if Basin-wide

Township / Range: 10N/19W and 11N/19W

Coordinates (Latitude / Longitude): 34.956, -118.927

Description: Southern area of the White Wolf Subbasin, adjacent to I-5 and California Aqueduct

AFFECTED SUSTAINABILITY INDICATOR (check all that apply):

- ■ Chronic Lowering of Groundwater Levels
- ■ Reduction of Groundwater Storage
- ☐ Seawater Intrusion
- ☐ Degraded Water Quality
- ☐ Land Subsidence
- ☐ Depletions of Interconnected Surface Water

TYPE (check all that apply):

- ■ Water Supply Augmentation
  - ■ Surface Water ■ Groundwater (Recharge) ■ Recycled Water
  - ☐ Transfer ☐ Stormwater ☐ Other
  - Source of Outside Water (if applicable): Imported Kern River water through TCWD
- ☐ Water Demand Reduction
  - ☐ Conservation ☐ Land / Water Use Changes
- ☐ Infrastructure / Capital Project ☐ Policy Project
- ☐ Data Gap Filling / Monitoring ☐ Water Quality Improvement
- ☐ Other:

[1] *Please continue to next page or attach additional pages to this form as necessary*

COSTS & FUNDING SOURCE(s):

Capital / Up-front ($): Not applicable - costs integrated into development

Source(s): Developer

O&M / On-going ($ per year): Not applicable

Source(s): TCWD

REGULATORY / LEGAL AUTHORITY REQUIREMENTS (describe all that apply):

Permits (name of authority, type of permit): RWQCB, SWRCB; a WDR

CEQA: Completed

Other: Coordination with Kern County and the State

SCHEDULE / TIMING:

Implementation Trigger(s): Upon initiation of Grapevine construction, estimated to begin in 2026 with 19 years to complete construction.

Termination Trigger(s): N/A

Timeframe to Accrue Expected Benefits: Upon project initiation

ADDITIONAL DETAILS (as necessary):

Wastewater treatment facilities and their capacities are expected to be built and expanded as Grapevine is developed. The amount of available imported Kern River water and reclaimed water will therefore increase throughout buildout.

WHITE WOLF GROUNDWATER SUSTAINABILITY AGENCY
PROJECT / MANAGEMENT ACTION
INFORMATION FORM

P/MA ID: 02 | **BASIN/MANAGEMENT AREA** (if any): White Wolf Subbasin

TITLE: Recharge from Produced Water

DESCRIPTION[1]:

The oil field located on Tejon Ranch has a yield of approximately 20,000 barrels per day of produced water or approximately 940 acre-feet per year or 1.3 cubic feet per second (cfs) or 583 gallons per minute (gpm). A pilot study to clean the water took place in 2015. 100 gpm or 0.22 cfs of produced water was treated utilizing a pre-manufactured treatment system.The treatment system initially included the following components: filtration, activated carbon and reverse osmosis.
Mid-way through the pilot test, a walnut shell filter was added as a pretreatment step.Water quality data from pilot testing was reviewed and evaluated and compared with the existing “Pump In Guidelines for the SWP (State Water Project)”. Recharging this water would potentially improve water quality in the area.

EXPECTED ANNUAL BENEFIT (demand reduction or supply augmentation, in acre-feet per year):

An expected recharge of 1,000 AFY .

AGENCY(s):
Primary/Lead: Tejon-Castac Water District
Supporting: AEWSD, WRMWSD

LOCATION: ☐ Check here if Basin-wide
Township / Range: ____
Coordinates (Latitude / Longitude): ____
Description: Southern area of the White Wolf Subbasin, adjacent to I-5 and California Aqueduct

AFFECTED SUSTAINABILITY INDICATOR (check all that apply):
■ Chronic Lowering of Groundwater Levels
■ Reduction of Groundwater Storage
☐ Seawater Intrusion
☐ Degraded Water Quality
☐ Land Subsidence
☐ Depletions of Interconnected Surface Water

TYPE (check all that apply):
■ Water Supply Augmentation
- ■ Surface Water
- ■ Groundwater (Recharge)
- ■ Recycled Water
- ☐ Transfer
- ☐ Stormwater
- ☐ Other

Source of Outside Water (if applicable): New produced and treated water

☐ Water Demand Reduction
- ☐ Conservation
- ☐ Land / Water Use Changes

☐ Infrastructure / Capital Project
☐ Policy Project
☐ Data Gap Filling / Monitoring
■ Water Quality Improvement
☐ Other: ____

[1] *Please continue to next page or attach additional pages to this form as necessary*

COSTS & FUNDING SOURCE(s):

Capital / Up-front ($): Not applicable - costs integrated into development

Source(s): Districts, Grants

O&M / On-going ($ per year): Not applicable

Source(s): TRC

REGULATORY / LEGAL AUTHORITY REQUIREMENTS (describe all that apply):

Permits (name of authority, type of permit):

CEQA: ??

Other:

SCHEDULE / TIMING:

Implementation Trigger(s): Upon completion of Pilot test.
By 2024

Termination Trigger(s): N/A

Timeframe to Accrue Expected Benefits: Upon project initiation

ADDITIONAL DETAILS (as necessary)**:**

The source of new water is constant and may increase in volume.

TEJON RANCH COMPANY

Building the Legacy

HALLMARK GROUP Capital Program Management

Persistence | Proficiency | Performance

CONFIDENTIAL
PREPARED FOR TEJON RANCH
MAY 2017

PURPOSE

REVIEW OF OUTLINE FOR PHASE II: PILOT PLANT DEVELOPMENT AND TESTING FOR TEJON RECLAMATION PROJECT

Describe the approach for Pilot Plant Development and Testing (Phase II Pilot Treatment Plant) and provide an outline of the project components.

The Outline document will be reviewed by Tejon and the Project Advisory Group (PAG) to provide additional direction necessary to develop a RFP or RFQ in sufficient detail to solicit proposals.

HALLMARK GROUP Capital Program Management

AGENDA

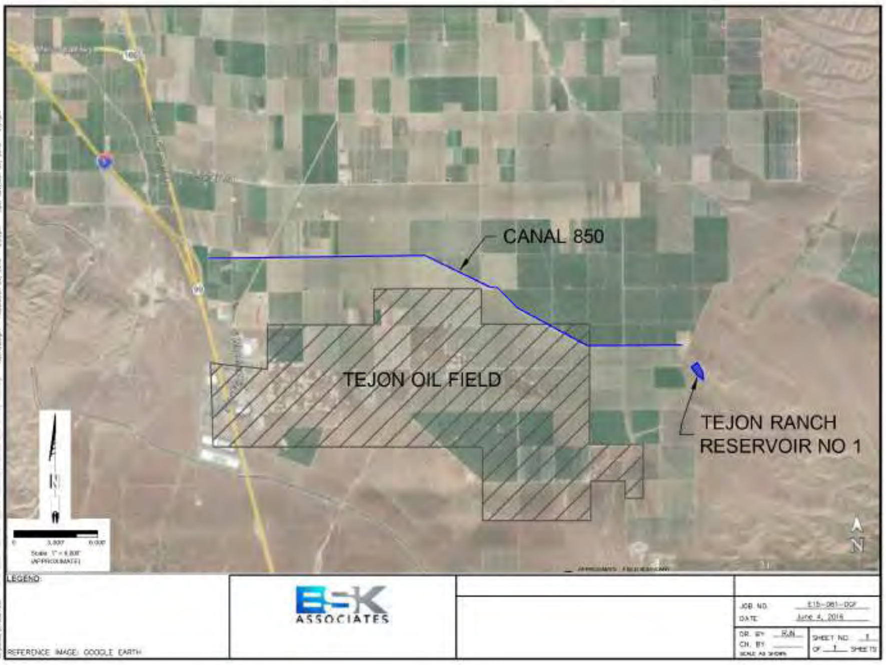
- Overview
- Background
- Phase II Implementation Strategy
- Project Management
- Next Steps

HALLMARK GROUP Capital Program Management

BACKGROUND

Map

HALLMARK GROUP Capital Program Management



HALLMARK GROUP Capital Program Management

SITE PLAN

FIGURE 1

[illegible]

[illegible]

HALLMARK GROUP Capital Program Management

BACKGROUND

Tejon Field has a yield of approximately 20,000 barrels per day of produced water or approximately 940 acre-feet per year or 1.3 cubic feet per second (cfs) or 583 gallons per minute (gpm).

CRC commissioned BSK Associates (BSK) to conduct a pilot study.

100 gpm or 0.22 cfs of produced water was treated utilizing a pre-manufactured treatment system.
The treatment system initially included the following components: filtration, activated carbon and reverse osmosis.
Mid-way through the pilot test, a walnut shell filter was added as a pretreatment step.

The study began on September 1, 2015 and continued through December 10, 2015.

After completion of the study, in June 2016, CRC shared the results with Tejon in order to explore potential partnership opportunities.

Tejon commissioned an independent study to review the project and the data collected.

HALLMARK GROUP Capital Program Management

BACKGROUND

A review of the proposed treatment facilities was conducted.

Water quality data from pilot testing was reviewed and evaluated for compliance with the existing "Pump In Guidelines for the SWP (State Water Project)".

Recommended next steps were presented.

HALLMARK GROUP Capital Program Management

Comparison with Historical Water Quality Conditions in the SWP

Table 6- Comparison of Historical Water Quality Conditions at O'Neill Forebay Outlet- 1988to 2011 to Expected Quality of Treated Water from Pilot Test

Parameter	Mean	Min.	Max.	Std. Dev.	Treated Water	Notes on Comparison
	0.03	0.01	0.527	0.05	NA	No evaluation
Antimony	0.002	0.001*	0.005	0.002	<0.002	Below mean
	0.002	0.001	0.004	0.001	<0.002	Below mean
	0.05	0.05	0.068	0.002	0.015	Below mean
Beryllium	0.001*	0.001*	0.001*	0.000	<0.001	Below mean
	0.22	0.04	0.54	0.16	0.54	Above mean
	0.003	0.001	0.005	0.002	<0.001	Below mean
Chromium	0.004	0.001	0.011	0.002	<0.010	Below mean
	0.004	0.001	0.028	0.003	<0.005	Below mean
	0.1	0.1	0.5	0.1	<0.10	Below mean
	0.037	0.005	0.416	0.050	<0.03	Below mean
Manganese	0.009	0.005	0.06	0.007	<0.010	Below detection limit - detection limit is above mean
	0.001	0.0002	0.001	0.0004	<0.00020	Below mean
	0.001	0.001	0.004	0.0005	<0.010	Below detection limit - detection limit is above mean
	2.9	0.2	8.1	1.6	<0.053	Below mean
	0.001	0.001	0.002	0.0001	<0.002	Below detection limit - detection limit is above mean
	0.003	0.001	0.005	0.002	<0.010	Below detection limit - detection limit is above mean
	42	14	99	15	<1.0	Below mean
Total Organic Carbon	4.0	0.8	12.6	1.6	NA	No evaluation
	0.007	0.005	0.21	0.01	<0.050	Below mean

*These values represent reporting limits. Actual values would be lower

The key finding was that the treatment regimen tested was able to produce high quality water on a consistent basis that met strict drinking water standards for the analyzed constituents.

In some instances, the treated water quality exceeded the background quality of the Aqueduct, but only very slightly.

In those cases, additional refinements in the treatment process and more analytical information could reduce those constituents to below background level.

Reduction of the levels of those constituents, coupled with the identification of benefits from non-measured constituents, like TOC, would provide a good foundation for complying with the technical provisions of the SWP Pump-In Guidelines.

Overcoming the non-scientific concerns that are policy and perception based will require an approach that utilizes sound scientific information with policy makers and then with the public to the degree that it is required.

For the next pilot plant study, refinement of the treatment processes would be appropriate, the pilot plant demonstrated that the treatment regimen could be utilized to treat produced water to meet current drinking water standards for the regulated constituents that were measured.

In the future, it would be necessary to test for all of the regulated constituents on a more robust sampling schedule.

Analytical detection limits should be at least as low as the data used by DWR in the "Pump In Guidelines".

Additional research should be done to identify constituent analyses that should be performed to address concerns with food safety and treated water.

HALLMARK GROUP Capital Program Management

BACKGROUND – Key Findings

- Groundwater in the area is useable, but higher in Total Dissolved Solids (TDS) than is desirable for long term use.

- Appropriate QA/QC measures were developed and implemented for the pilot testing and analyses.

- More frequent testing and more robust testing of more constituents would be required for DWR and KCWA approval.

- The treatment regimen was very effective at removing hydrocarbon related constituents, with only 1 exception, methane.

- Minor refinement and optimization of the pilot plant treatment regimen would be necessary for increased removal of methane.

- Treated water quality was much better than the water be conveyed in the 850 Canal, during the test.

HALLMARK GROUP Capital Program Management

BACKGROUND – Key Findings

• Treated water from the pilot plant was generally very suitable for agricultural use, however a close watch should be maintained, if it were used on boron sensitive crops.

• The treated water meets all drinking water standards for the regulated constituents that were tested.

• Arsenic could be treated and removed to below the detection level.

• Bromide was higher in the treated water than in the Aqueduct at O'Neill Forebay.

• TDS was much lower in the treated water than in the Aqueduct at O'Neill Forebay.

HALLMARK GROUP Capital Program Management

BACKGROUND – Next Steps

- Future testing should be more frequent and more robust.
- Analyses of all regulated constituents should be performed.
- Analytical detection limits should be at least as low as the data used by DWR in the "Pump In Guidelines".
- Additional research should be done to identify constituent analyses that should be performed to address concerns with food safety and treated water.
- Treatment regimens should be further optimized to reduce bromide and methane levels.
- Targeted, additional testing should be performed to address unexpected increases in constituents.
- After completion of the next set of analyses, the KCWA pump-in model should be run utilizing the anticipated concentrations and flow rates to determine more specifically how delivery of the treated water would affect the quality of water in the Aqueduct in a "real life" situation.

HALLMARK GROUP Capital Program Management

BACKGROUND – Next Steps

- Tejon Ranch is now preparing to begin the Phase II Pilot Treatment Plant where the plant will be operated for a period that demonstrates the ability to reach and maintain treatment goals for long term operation.

- Throughout the development, implementation, and operation of the Phase II Pilot Treatment Plant, Tejon Ranch will work closely with the PAG to ensure that their concerns are addressed through the strategic development of an appropriately structured project.

HALLMARK GROUP Capital Program Management

PHASE II IMPLEMENTATION STRATEGY

- The Phase II Pilot Treatment Plant contains two project components and an assessment;
- The *Treatment Component* encompasses all the activity todesign, build and operate an optimized pilot water treatment plant.
- The *Sampling Component* includes all the monitoring activity necessary to document, evaluate, and optimize the operation of the facility.
- Data collected will be used to assess the feasibility of proceeding to a full-scale plant.
- Both project components will be managed using a detailed plan that includes regular reporting and decision making.

HALLMARK GROUP Capital Program Management

PHASE II IMPLEMENTATION STRATEGY

- An RFP or RFQ will be developed in sufficient detail to solicit proposals.
- The draft RFP or draft RFQ will be approved by Tejon, and then submitted to the PAG for their review and comments.
- After finalizing the project documents, they will be distributed to prequalified firms that demonstrate the ability to meet the specific criteria for each of the project components.
- Qualified firms will be required to provide a cost proposal and a detailed description of their approach for the Treatment and Sampling Components based on criteria developed by Tejon and the PAG.

HALLMARK GROUP Capital Program Management

TREATMENT COMPONENT CRITERIA

- Each proposal shall include a detailed description of the treatment components, such as make and manufacturer of key equipment, operational expenses, and performance specifications.

- The RFQ will also provide information to the proposing firm regarding permits and site conditions, operational criteria, and other information as agreed upon.

  - Project location
  - Site conditions
  - Power services
  - Other operational needs

HALLMARK GROUP Capital Program Management

TREATMENT COMPONENT CRITERIA

- The pilot plant will be designed to treat a minimum of 100 gallons per minute (gpm) of produced water with the water quality characteristics generally described in Table 1 (this table will be prepared with input from the PAG).

- The treatment package may include optimized components used in the Phase I Project, that included; pre-filtration with walnut shells, filtration, activated carbon and reverse osmosis or the proposing firm may choose another treatment strategy.

- In any case, the proposing firm must demonstrate that the selected treatment strategy is capable of producing water that meets the criteria generally described in the Department of Water Resources Water Quality Policy and Implementation Process for Acceptance of Non-ProjectWater into the State Water Project (see Appendix B).

- The Phase II Pilot Treatment Plant will operate for a minimum of 6 months.

HALLMARK GROUP Capital Program Management

SAMPLING AND MONITORING PACKAGE

- A water quality monitoring and sampling program shall be developed that meets all standards of the American Water Works Association (AWWA) and the State of California State Water Resources Control Board Department of Drinking Water.

- A key component of the sampling program will be a detailed description of the specific water quality parameters and constituents to be measured during the Phase II Pilot Treatment Plant.

- Parameters will be selected to assist in optimizing plant performance and to assess the effectiveness of the treatment facility in meeting the SWP Pump In Guideline criteria.

- Additional parameters will be selected to addressany potential concerns with using the treated water as a source of drinking water when blendedwith the water in the California Aqueduct.

- Parameters will also be selected to address concernswhen the treated water is used directly or when blended with other water supplies to irrigate food crops.

HALLMARK GROUP Capital Program Management

SAMPLING AND MONITORING PACKAGE

- A water quality monitoring and sampling program shall be developed that meets all standards of the American Water Works Association (AWWA) and the State of California State Water Resources Control Board Department of Drinking Water.

- A key component of the sampling program will be a detailed description of the specific water quality parameters and constituents to be measured during the Phase II Pilot Treatment Plant.

- Parameters will be selected to assist in optimizing plant performance and to assess the effectiveness of the treatment facility in meeting the SWP Pump In Guideline criteria.

- Additional parameters will be selected to address any potential concerns with using the treated water as a source of drinking water when blended with the water in the California Aqueduct.

- Parameters will also be selected to address concernswhen the treated water is used directly or when blended with other water supplies to irrigate food crops.

HALLMARK GROUP Capital Program Management

SAMPLING AND MONITORING PACKAGE

- The sampling program report will also include a description of the water quality sampling locations for the Phase II Pilot Treatment Plant. Sampling shall occur prior to treatment and post treatment and at all other key steps in the treatment process.
- The nature of the sampling (grab, continuous, composite, etc.) and the frequency of sampling will be described in detail.
- The proposing firm will develop a water quality sampling protocol handbook that will describe all the steps necessary to perform appropriate collection and handling of the samples.
- This protocol will be followed in the collection of all water quality samples for the project.
- The proposing firm will prepare and submit a Quality Assurance / Quality Control Plan (QA/QC Plan) that will cover both the sample collection and laboratory analyses.

SAMPLING AND MONITORING PACKAGE

- The proposing firm will develop an operational monitoring plan.
- That plan will describe how key operational parameters will be monitored.
- The type of data will include inflow, outflow, power usage, and other key process control and monitoring indices.
- The project proposing firm may recommend other types of monitoring in addition to water quality monitoring, that will be helpful in evaluating the performance of the pilot plant or in optimizing treatment operations.
- If the proposing firm recommends additional monitoring, an appropriate monitoring plan and QA/QC Plan will be developed.

PROJECT ASSESSMENT

- At the end of the project, a Preliminary Phase II Assessment will be prepared by the proposing firm.
- Drafts of the Preliminary Phase II Assessment will be circulated to members of their PAG for their review and input.
- The PAG comments will be incorporated into the Phase II Findings Report that will include a summary of all the data collected for the project and an overall assessment on the ability for the treatment strategy to meet the water quality objectives.
- The report will present an evaluation of the cost effectiveness of constructing a full-scale plant based on the outcome of the Phase II Pilot Treatment Plant project.
- The cost effectiveness analysis will consider all aspects of constructing and operating a treatment plant, including planning and permitting costs, construction, operation and maintenance costs.
- The report will present recommended next steps.

HALLMARK GROUP Capital Program Management

PROJECT MANAGEMENT

- Project management and oversight will be provided by Tejon to ensure the selected proposer is meeting budget and schedule milestones as well as the proposal criteria and that project changes are subject to rigorous change management process.

- Reporting
  - Biweekly updates will include a summary of all key operational parameters and an overall assessment of plant operation.
  - A summary of monitored water quality parameters will be presented

  - Monthly reports will be prepared in advance of monthly meetings.
  - The report will include a detailed summary and review of all data collected during the month.
  - It will include any recommended changes to plant operation.
  - An update on the project budget and schedule will be prepared.
  - All reports will be shared with the PAG.

- Monthly meetings will be held that include Tejon, the PAG and the contractor.

HALLMARK GROUP Capital Program Management

SCHEDULE

Complete Outline for Phase II Pilot Plant Project

- Develop Initial Draft Outline -1 week
- PAG Review - 4 weeks (includes 2 meetings with PAG)
- Finalize - 1 week

RFQ Development for Phase II Pilot Plant Project

- Develop Initial Draft - 4 weeks
- PAG Review - 2 weeks (includes 1 meeting with the PAG)
- Finalize RFQ - 1 week

RFQ Distribution and Award

- Distribute – 1 week
- Receive Submittals - 4 weeks (allow 30 days for responses)
- Review - 2 weeks (includes 1 meeting with the potential contractor)
- Contract Development and Award – 2 weeks

HALLMARK GROUP Capital Program Management

SCHEDULE

Plant Construction – 3 months (1 month to mobilize, 2 months to construct)

Plant Operation – 6 months

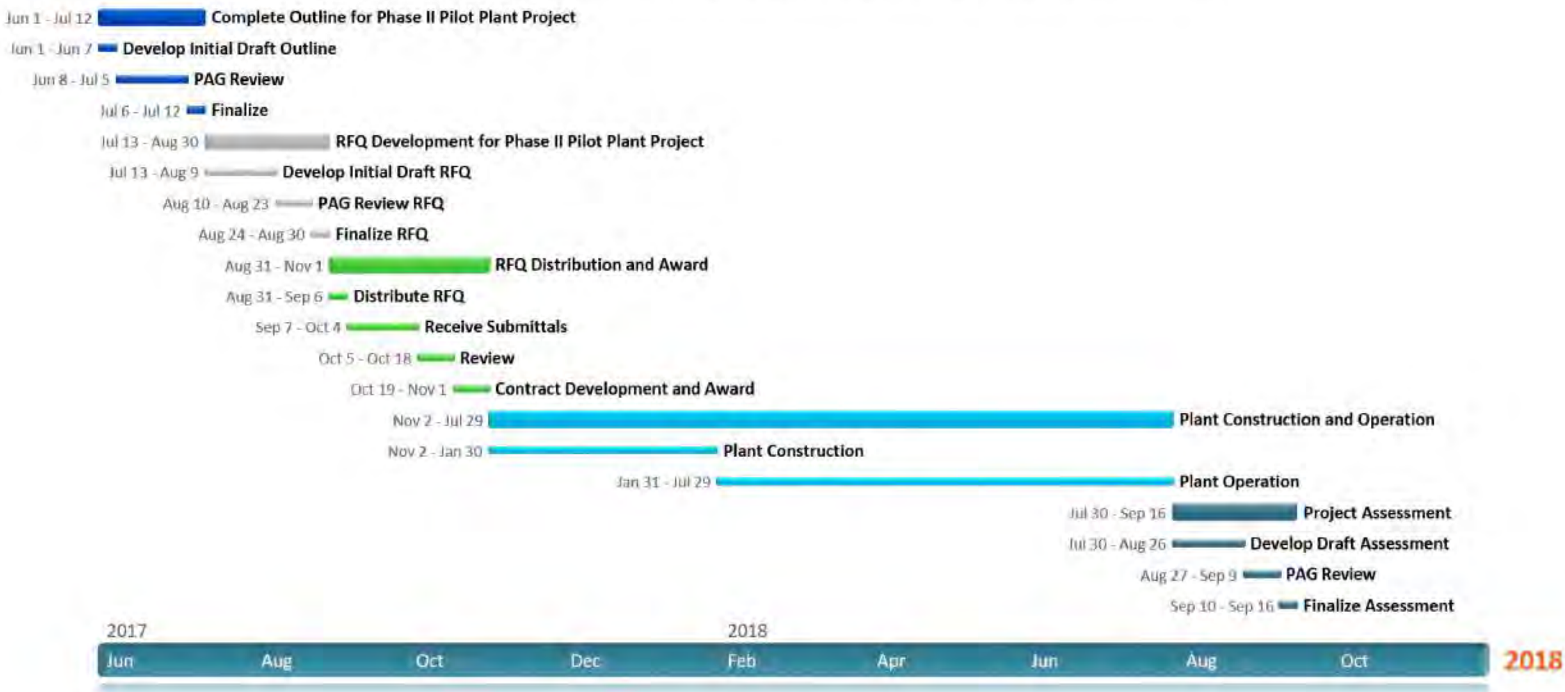
Project Assessment

- Draft Complete – 4 weeks
- Review – 2 weeks (includes 1 meeting with the PAG)
- Final – 1 week

Using this estimated schedule, it will be approximately 16 months from the start of the project to completion of the Project Assessment.

HALLMARK GROUP Capital Program Management

PROPOSED SCHEDULE FOR THE TEJON PHASE II PILOT TREATMENT PLANT



SCALE UP IMPLEMENTATION STRATEGY

Once the Phase II Findings Report is finalized, Tejon may decide to:

- Discontinue future efforts
- Continue working with the selected Phase II Pilot Treatment Plant firm
- Make changes in the criteria and solicit new proposals for the full-scale Treatment Plant.

HALLMARK GROUP Capital Program Management

NEXT STEPS

- Edit document and presentation based on Tejon comments
- Present revisions to Tejon for approval
- Provide document to KCWA and MWD staff for their review
- Meet with KCWA and MWD staff to review document and receive comments (May require 2 meetings)
- Revise document based on comments received
- Prepare to meet with CRC to discuss project
- Provide documents to CRC for their review
- Meet with CRC to review documents and receive comments
- Distribute revised document to CRC, KCWA and MWD
- Prepare RFP/RFQ
- Distribute RFQ and begin Phase II Project Construction and Operation

HALLMARK GROUP Capital Program Management

Next Steps ?

HALLMARK GROUP Capital Program Management

Persistence | Proficiency | Performance

HALLMAR GROU

Capital Program Management

1901 ROYAL OAKS DRIVE, SUITE 200 SACRAMENTO, CA 95815
(916) 923-1500 WWW.HGCPM.COM

WHITE WOLF GROUNDWATER SUSTAINABILITY AGENCY
PROJECT / MANAGEMENT ACTION
INFORMATION FORM

P/MA ID: 03 **BASIN/MANAGEMENT AREA** (if any): AEWSD

TITLE: Oilfield Reclaimed Water in AEWSD

DESCRIPTION[1]:

Reclaiming water from oil production facilities for irrigation purposes is currently an untapped water source in AEWSD. After treatment and cooling, water could be pumped into AEWSD facilities to serve irrigation demands in-lieu of groundwater pumping.

EXPECTED ANNUAL BENEFIT (demand reduction or supply augmentation, in acre-feet per year):

1,000 AF/yr

AGENCY(s):

Primary/Lead: TBD, Private oilfield

Supporting: ______

LOCATION: ☐ Check here if Basin-wide

Township / Range: N/A

Coordinates (Latitude / Longitude): various

Description: various

AFFECTED SUSTAINABILITY INDICATOR (check all that apply):

■ Chronic Lowering of Groundwater Levels
■ Reduction of Groundwater Storage
☐ Seawater Intrusion
■ Degraded Water Quality
☐ Land Subsidence
☐ Depletions of Interconnected Surface Water

TYPE (check all that apply):

☐ Water Supply Augmentation
- ☐ Surface Water
- ☐ Groundwater (Recharge)
- ■ Recycled Water
- ☐ Transfer
- ☐ Stormwater
- ☐ Other

Source of Outside Water (if applicable): ______

☐ Water Demand Reduction
- ☐ Conservation
- ☐ Land / Water Use Changes

☐ Infrastructure / Capital Project
☐ Policy Project
☐ Data Gap Filling / Monitoring
☐ Water Quality Improvement
☐ Other: ______

[1] *Please continue to next page or attach additional pages to this form as necessary*

COSTS & FUNDING SOURCE(s):

Capital / Up-front ($): TBD

Source(s): AEWSD and partnering oilfield

O&M / On-going ($ per year): Not applicable

Source(s): Not applicable

REGULATORY / LEGAL AUTHORITY REQUIREMENTS (describe all that apply):

Permits (name of authority, type of permit): ____

CEQA: Uknown

Other: ____

SCHEDULE / TIMING:

Implementation Trigger(s): TBD

Termination Trigger(s): TBD

Timeframe to Accrue Expected Benefits: 1 Year Post Construction

ADDITIONAL DETAILS (as necessary)**:**

WHITE WOLF GROUNDWATER SUSTAINABILITY AGENCY
PROJECT / MANAGEMENT ACTION
INFORMATION FORM

P/MA ID: 09 | **BASIN/MANAGEMENT AREA** (if any): White Wolf Subbasin

TITLE: El Paso Creek Recharge Project

DESCRIPTION[1]:

The project is an artificial recharge project that uses El Paso Creek, existing and planned pipeline, and planned recharging ponds. The project consists of two phases. Phase 1 will utilize the existing 850D Lateral pipeline to direct water into the El Paso Creek for in-stream recharge with check structures. Total recharge area along the El Paso Creek is 221 gross acres, which is equivalent to 145 net pond acres. Phase 2 will involve construction of new recharge pipeline parallel to 850D Lateral and off-stream ponds for recharge. Additional 335 gross acres (250 net pond acres) will be added to the recharge area. Recharged water can be recovered using existing wells near the recovery pipeline. Assuming the project will be operating 120 days per year, and the infiltration rate is 145 AF/day for Phase 1 and 125 AF/day for Phase 2, total recharge capacity is estimated to be 32,400 AFY (Phase 1: 17,400 AFY and Phase 2: 15,000 AFY).

EXPECTED ANNUAL BENEFIT (demand reduction or supply augmentation, in acre-feet per year):

Depends on operating days, approximately 32,400 AFY (17,400 AFY from Phase 1 and 15,000 AFY from Phase 2)

AGENCY(s):
Primary/Lead: WRMWSD
Supporting: ____

LOCATION: ☐ Check here if Basin-wide
Township / Range: 11N18W, 11N19W, and 12N19W
Coordinates (Latitude / Longitude): 35°03'10.5"N 118°51'03.8"W
Description: Along and in the vicinity of El Paso Creek

AFFECTED SUSTAINABILITY INDICATOR (check all that apply):
- ■ Chronic Lowering of Groundwater Levels
- ■ Reduction of Groundwater Storage
- ☐ Seawater Intrusion
- ☐ Degraded Water Quality
- ☐ Land Subsidence
- ☐ Depletions of Interconnected Surface Water

TYPE (check all that apply):
- ■ Water Supply Augmentation
  - ☐ Surface Water
  - ■ Groundwater (Recharge)
  - ☐ Recycled Water
  - ☐ Transfer
  - ☐ Stormwater
  - ☐ Other
  - Source of Outside Water (if applicable): ____
- ☐ Water Demand Reduction
  - ☐ Conservation
  - ☐ Land / Water Use Changes
- ☐ Infrastructure / Capital Project
- ☐ Policy Project
- ☐ Data Gap Filling / Monitoring
- ☐ Water Quality Improvement
- ☐ Other: ____

[1] *Please continue to next page or attach additional pages to this form as necessary*

COSTS & FUNDING SOURCE(s):

Capital / Up-front ($): ______

Source(s): ______

O&M / On-going ($ per year): ______

Source(s): ______

REGULATORY / LEGAL AUTHORITY REQUIREMENTS (describe all that apply):

Permits (name of authority, type of permit): RWQCB, SWRCB, WDR

CEQA: ______

Other: ______

SCHEDULE / TIMING:

Implementation Trigger(s): ______

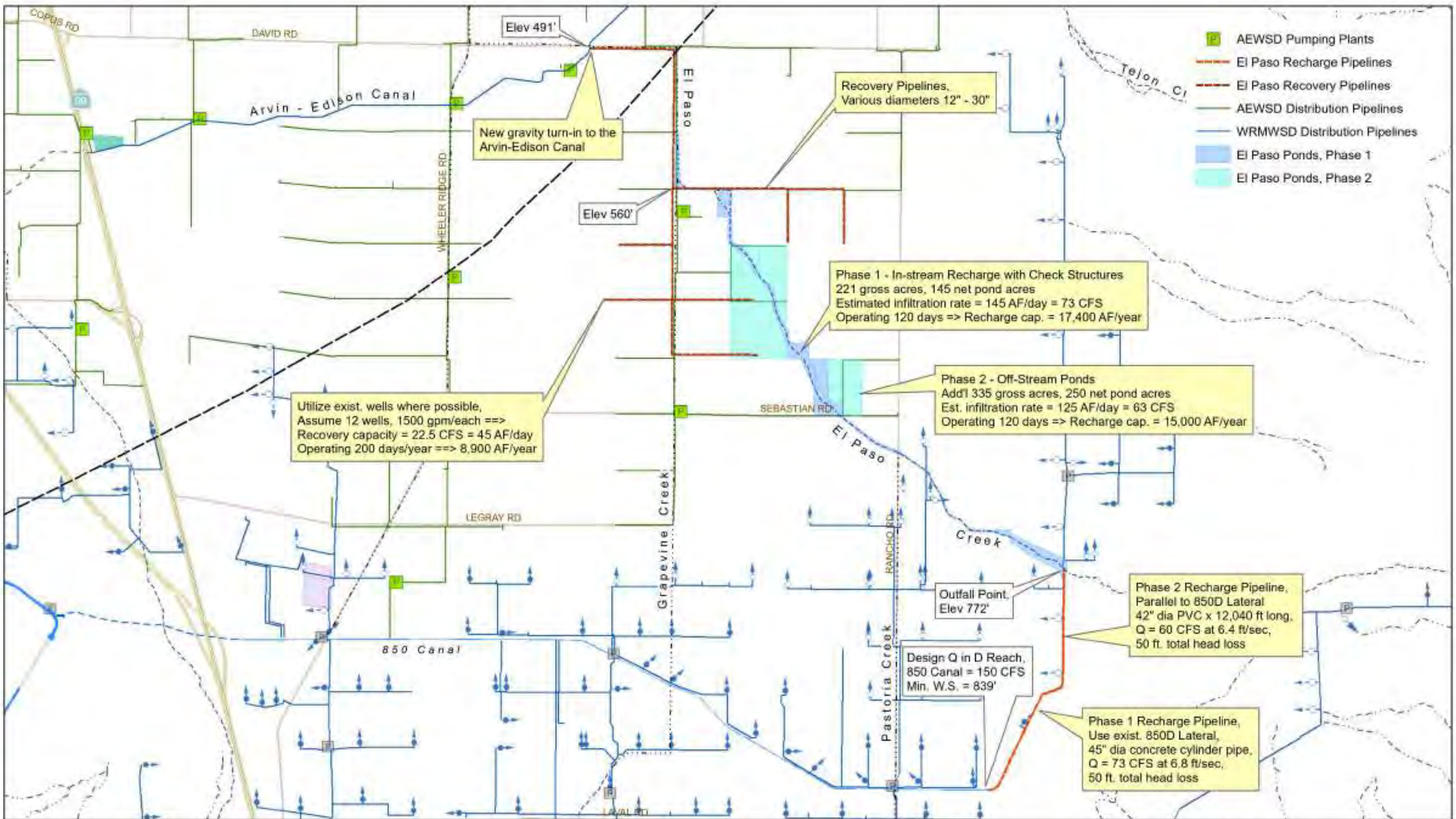
Termination Trigger(s): N/A

Timeframe to Accrue Expected Benefits: Upon project initiation

ADDITIONAL DETAILS (as necessary)**:**

Please see attached map for more details about the project.

Additional benefits of the project include: a) subsurface flows across the White Wolf fault are captured, b) new facilities are minimized, c) to the extent in-stream recharge is used, land is not taken out of production, and d) except for lifting water into the 850 Canal and pumping groundwater to the surface, it all works by gravity.



Date: June 2021
Author: Thomas Suggs
Name: WRM_B_Size_2021-06-15_El_Paso_Ponds

N

0 0.25 0.5 1 Miles

WHEELER RIDGE-MARICOPA WATER STORAGE DISTRICT
BAKERSFIELD, CA

EL PASO CREEK PONDS AND CONVEYANCE PIPELINES LOCATION MAP

WHITE WOLF GROUNDWATER SUSTAINABILITY AGENCY
PROJECT / MANAGEMENT ACTION
INFORMATION FORM

P/MA ID: 10 | **BASIN/MANAGEMENT AREA** (if any): AEWSD

TITLE: AEWSD In-Lieu Banking Program

DESCRIPTION[1]:

The Ground Water Service Area (GWSA) within the District consists of landowners that rely only on Groundwater (GW) sources to meet their crop irrigation requirements. With the In-lieu Banking Program the District will supply Surface Water (SW) when available through new facilities to the GWSA to meet its water requirements with the intent of reducing District-wide GW use. However when SW is in short supply and under agreement, the landowners could recover and return GW from their own wells to the District canal system through new pipelines once they have satisfied their own water needs. With the District's new 9(d) contract, certain provisions of Reclamation law are no longer applicable and all lands within the service area can now be served with federal water supplies. In addition, water users have inquired about District supplied power to provide an alternative to current power suppliers. The project would include new irrigation conveyance facilities consisting of pipelines, turnouts, booster pumps, etc. in the GWSA.

The project may integrate with the Lateral Capacity Improvement Project, South Balancing project, and other agency needs for the White Wolf Basin. The District has begun increasing the in-lieu service area with temporary water contracts, utilizing existing infrastructure (turnouts, pipelines that are both District and landowner owned). Interconnections from the South Canal to the groundwater service areas are possible projects/pipelines. Connections to WRMWSD may also allow for use of other local recharge facilities. In addition, another component of in-lieu banking, considering the District is a participant in the Power and Water Resources Pooling Authority (PWRPA), is the potential of District landowner to be eligible to receive PWRPA power (instead of current PG&E service). As a part of the program, District landowner could provide their wells for overall District operations and in return the District would provide the landowner surface water during times of available supplies.

EXPECTED ANNUAL BENEFIT (demand reduction or supply augmentation, in acre-feet per year):

Dependent on service area. ~5,000 acres would be ~15,000 AF; resulting in a yield of 6,000AF/yr.

AGENCY(s):

Primary/Lead: AEWSD

Supporting: Multiple possibilities given project description and benefits including energy grants

LOCATION: ☐ Check here if Basin-wide

Township / Range: TBD

Coordinates (Latitude / Longitude): TBD

Description: Groundwater Service Areas

AFFECTED SUSTAINABILITY INDICATOR (check all that apply):

- ■ Chronic Lowering of Groundwater Levels
- ■ Reduction of Groundwater Storage
- ☐ Seawater Intrusion
- ■ Degraded Water Quality
- ☐ Land Subsidence
- ☐ Depletions of Interconnected Surface Water

TYPE (check all that apply):

- ■ Water Supply Augmentation
  - ■ Surface Water
  - ■ Groundwater (Recharge)
  - ☐ Recycled Water
  - ☐ Transfer
  - ☐ Stormwater
  - ☐ Other
  - Source of Outside Water (if applicable): ______
- ☐ Water Demand Reduction
  - ☐ Conservation
  - ☐ Land / Water Use Changes
- ■ Infrastructure / Capital Project
- ☐ Policy Project
- ☐ Data Gap Filling / Monitoring
- ■ Water Quality Improvement
- ☐ Other: ______

[1] *Please continue to next page or attach additional pages to this form as necessary*

COSTS & FUNDING SOURCE(s):

Capital / Up-front ($): $1-10 Million

Source(s): AEWSD

O&M / On-going ($ per year): ~$5,000

Source(s): AEWSD

REGULATORY / LEGAL AUTHORITY REQUIREMENTS (describe all that apply):

Permits (name of authority, type of permit): SJVAPCD Dust Control

CEQA: MND

Other: NEPA if federal grant funds used

SCHEDULE / TIMING:

Implementation Trigger(s): Grant Funding

Termination Trigger(s): Project completion

Timeframe to Accrue Expected Benefits: 1-3 years post construction

ADDITIONAL DETAILS (as necessary):

The District, water exchangers, water banking partners, and neighboring areas will benefit from increased conjunctive water management programs in the area. Possible water quality benefits may result for banking partners from high quality recovered water. Note that the District and drinking water users have a variety of water quality issues. These include salts, boron, nitrates, Bromides, and disinfection byproducts.

WHITE WOLF GROUNDWATER SUSTAINABILITY AGENCY
PROJECT / MANAGEMENT ACTION INFORMATION FORM

P/MA ID: 11 | **BASIN/MANAGEMENT AREA** (if any): AEWSD

TITLE: AEWSD Private & Caltrans Basin Connections

DESCRIPTION[1]:

There are multiple on-farm private basins and some Caltrans sumps near AEWSD facilities that could be connected by gravity pipeline and utilized for groundwater recharge and floodwater capture. The existing Murray Basin Connection Project is a prime example of how private basins can be better utilized District wide.

EXPECTED ANNUAL BENEFIT (demand reduction or supply augmentation, in acre-feet per year):

Depending on number of basin connections, ~50 - 500 AF

AGENCY(s):

Primary/Lead: AEWSD

Supporting: Private party and Caltrans

LOCATION: ☐ Check here if Basin-wide

Township / Range: N/A

Coordinates (Latitude / Longitude): various

Description: various

AFFECTED SUSTAINABILITY INDICATOR (check all that apply):

- ■ Chronic Lowering of Groundwater Levels
- ■ Reduction of Groundwater Storage
- ☐ Seawater Intrusion
- ☐ Degraded Water Quality
- ☐ Land Subsidence
- ☐ Depletions of Interconnected Surface Water

TYPE (check all that apply):

- ☐ Water Supply Augmentation
  - ■ Surface Water
  - ■ Groundwater (Recharge)
  - ☐ Recycled Water
  - ☐ Transfer
  - ■ Stormwater
  - ☐ Other
  - Source of Outside Water (if applicable): ______
- ☐ Water Demand Reduction
  - ☐ Conservation
  - ☐ Land / Water Use Changes
- ■ Infrastructure / Capital Project
- ☐ Policy Project
- ☐ Data Gap Filling / Monitoring
- ☐ Water Quality Improvement
- ☐ Other: ______

[1] *Please continue to next page or attach additional pages to this form as necessary*

COSTS & FUNDING SOURCE(s):

Capital / Up-front ($): 100,000 - 500,000 depending upon pipe size and length

Source(s): AEWSD, Grants

O&M / On-going ($ per year): Not applicable

Source(s): Not applicable

REGULATORY / LEGAL AUTHORITY REQUIREMENTS (describe all that apply):

Permits (name of authority, type of permit): Caltrans encroachment

CEQA: required for longer pipeline connections

Other: NEPA if federal grant funds used

SCHEDULE / TIMING:

Implementation Trigger(s): Participant interest, Caltrans permitting, Grant funding

Termination Trigger(s): project completion

Timeframe to Accrue Expected Benefits: 1-3 years post construction

ADDITIONAL DETAILS (as necessary):

WHITE WOLF GROUNDWATER SUSTAINABILITY AGENCY
PROJECT / MANAGEMENT ACTION
INFORMATION FORM

P/MA ID: 12 | **BASIN/MANAGEMENT AREA** (if any): AEWSD

TITLE: AEWSD South Canal WRMWSD 850 Canal Intertie

DESCRIPTION[1]:

There is a need to improve existing interties and/or construct new interties between AEWSD's South Canal and WRMWSD's 850 canal to facilitate water exchanges between the two districts. Many existing and potential future water exchange and banking programs benefiting the two districts, their banking and exchange partners in Kern County and Southern California depend upon successful construction and operation of the Project. Primary benefits of the Project are improved water supplies and operational efficiency. Ancillary benefits include water quality improvements for SWP customers and floodplain management in Kern County and other areas in the San Joaquin Valley. Project location could benefit other conveyance facilities in the near vicinity (CA Aqueduct) and assist in exchanges. The 850 is owned and operated by Wheeler Ridge-Maricopa WSD. .

EXPECTED ANNUAL BENEFIT (demand reduction or supply augmentation, in acre-feet per year):

Increased delivery flexibility and transfer/exchange potential, ~24,000 AF

AGENCY(s):

Primary/Lead: AEWSD

Supporting: WRMWSD

LOCATION: ☐ Check here if Basin-wide

Township / Range: N/A

Coordinates (Latitude / Longitude): 35° 5'14.87"N 118°54'39.73"W

Description: On South Canal approximately at Station 72+00

AFFECTED SUSTAINABILITY INDICATOR (check all that apply):

- ■ Chronic Lowering of Groundwater Levels
- ■ Reduction of Groundwater Storage
- ☐ Seawater Intrusion
- ■ Degraded Water Quality
- ☐ Land Subsidence
- ☐ Depletions of Interconnected Surface Water

TYPE (check all that apply):

- ■ Water Supply Augmentation
  - ■ Surface Water
  - ■ Groundwater (Recharge)
  - ■ Recycled Water
  - ■ Transfer
  - ☐ Stormwater
  - ☐ Other
  - Source of Outside Water (if applicable): ______
- ■ Water Demand Reduction
  - ☐ Conservation
  - ☐ Land / Water Use Changes
- ■ Infrastructure / Capital Project
- ☐ Policy Project
- ☐ Data Gap Filling / Monitoring
- ☐ Water Quality Improvement
- ☐ Other: ______

[1] *Please continue to next page or attach additional pages to this form as necessary*

COSTS & FUNDING SOURCE(s):

Capital / Up-front ($): ~$15M

Source(s): AEWSD, WRMWSD

O&M / On-going ($ per year): $40,000

Source(s): AEWSD, WRMWSD

REGULATORY / LEGAL AUTHORITY REQUIREMENTS (describe all that apply):

Permits (name of authority, type of permit):

CEQA:

Other:

SCHEDULE / TIMING:

Implementation Trigger(s): Completion of feasibility study and design drawings

Termination Trigger(s): Project completion

Timeframe to Accrue Expected Benefits: 1 year post construction

ADDITIONAL DETAILS (as necessary):

WHITE WOLF GROUNDWATER SUSTAINABILITY AGENCY
PROJECT / MANAGEMENT ACTION
INFORMATION FORM

P/MA ID: 13 **BASIN/MANAGEMENT AREA** (if any): AEWSD

TITLE: AEWSD South Canal Balancing Reservoir Project

DESCRIPTION[1]:

District is in need of additional infrastructure to allow water storage and regulation of flow mismatches in the Canal System during operation or emergencies (e.g, a local/global power outage in one or more pumping plants). This infrastructure is most needed in the lower third of the canal system. Additional storage may also allow the District to better match available surface water supply (to its peak irrigation season demands) and groundwater supply (i.e., well capacity) (to demands any time of year), both of which increase water supply for the year. Additional storage will also provide delivery flexibility to on-farm users. Additional in-District storage may allow increased water ordering and delivery flexibility (more variable rate and duration allowed with shorter notice vs. now). This will benefit customers District-wide and result in improved water use efficiency and increased crop yields and quality. Ancillary floodplain management benefits would result from additional ability to capture and store floodwaters.

EXPECTED ANNUAL BENEFIT (demand reduction or supply augmentation, in acre-feet per year):

Depends on selected location, ~500AF

AGENCY(s):

Primary/Lead: AEWSD

Supporting: __________

LOCATION: ☐ Check here if Basin-wide

Township / Range: TBD

Coordinates (Latitude / Longitude): TBD

Description: AEWSD South Canal and parts of Kern County outside AEWSD

AFFECTED SUSTAINABILITY INDICATOR (check all that apply):

- ■ Chronic Lowering of Groundwater Levels
- ■ Reduction of Groundwater Storage
- ☐ Seawater Intrusion
- ☐ Degraded Water Quality
- ☐ Land Subsidence
- ☐ Depletions of Interconnected Surface Water

TYPE (check all that apply):

- ■ Water Supply Augmentation
  - ■ Surface Water
  - ■ Groundwater (Recharge)
  - ☐ Recycled Water
  - ☐ Transfer
  - ■ Stormwater
  - ☐ Other
  - Source of Outside Water (if applicable): __________
- ■ Water Demand Reduction
  - ■ Conservation
  - ☐ Land / Water Use Changes
- ■ Infrastructure / Capital Project
- ☐ Policy Project
- ☐ Data Gap Filling / Monitoring
- ■ Water Quality Improvement
- ☐ Other: __________

[1] *Please continue to next page or attach additional pages to this form as necessary*

COSTS & FUNDING SOURCE(s):

Capital / Up-front ($): $1-10 Million

Source(s): AEWSD and partnering agencies

O&M / On-going ($ per year): ~$5,000

Source(s): AEWSD

REGULATORY / LEGAL AUTHORITY REQUIREMENTS (describe all that apply):

Permits (name of authority, type of permit): SJVAPCD Dust Control

CEQA: MND

Other: NEPA if federal grant funds used, SMARA exemption

SCHEDULE / TIMING:

Implementation Trigger(s): Grant funding, South County flooding response

Termination Trigger(s): Project completion

Timeframe to Accrue Expected Benefits: 1-3 years post construction

ADDITIONAL DETAILS (as necessary):

WHITE WOLF GROUNDWATER SUSTAINABILITY AGENCY
PROJECT / MANAGEMENT ACTION INFORMATION FORM

P/MA ID: 14 **BASIN/MANAGEMENT AREA** (if any): AEWSD

TITLE: AEWSD Groundwater Subsidies for Land Conversion

DESCRIPTION[1]:

The District may adopt a management action to provide subsidies to incentivize groundwater users to convert land to alternative land uses and reduce groundwater extractions. The District may consider a subsidy structure study to determine which subsidies would result in the greatest expected annual benefit in acre-feet per year. Subsidies could be provided to growers willing to implement one or more of the following:

1. Change crop type to one with lower water demand
2. Rotate crops and temporarily fallow portions of their irrigated acreage to reduce water demand
3. Retire, or permanently fallow, land for alternative uses such as solar arrays or upland habitat creation
4. Recharge/regulation basin infrastructure for increased surface water use and recharge

Since the subsidy programs would be voluntary with an unknown number of participants, it is assumed the District would define a maximum budget account with each corresponding type of subsidy. In addition, there would costs associated with field verification prior to the subsidy payment.

EXPECTED ANNUAL BENEFIT (demand reduction or supply augmentation, in acre-feet per year):

~2.75 AF/ac fallowed (temporary or permanent), ~2.75 AF/ac converted to basin, ~0.5-1.0 AF/ac permanent to annual crop

AGENCY(s):

Primary/Lead: AEWSD

Supporting: ________

LOCATION: ☐ Check here if Basin-wide

Township / Range: N/A

Coordinates (Latitude / Longitude): various

Description: various

AFFECTED SUSTAINABILITY INDICATOR (check all that apply):

- ■ Chronic Lowering of Groundwater Levels
- ■ Reduction of Groundwater Storage
- ☐ Seawater Intrusion
- ☐ Degraded Water Quality
- ■ Land Subsidence
- ☐ Depletions of Interconnected Surface Water

TYPE (check all that apply):

- ☐ Water Supply Augmentation
  - ☐ Surface Water ☐ Groundwater (Recharge) ■ Recycled Water
  - ☐ Transfer ☐ Stormwater ☐ Other
  - Source of Outside Water (if applicable): ________
- ■ Water Demand Reduction
  - ■ Conservation ■ Land / Water Use Changes
- ■ Infrastructure / Capital Project ■ Policy Project
- ☐ Data Gap Filling / Monitoring ☐ Water Quality Improvement
- ■ Other: potential renewable energy and habitat creation

[1] *Please continue to next page or attach additional pages to this form as necessary*

COSTS & FUNDING SOURCE(s):

Capital / Up-front ($): 15,000 - 30,000, but the levied fees will recoup costs and generate on-going revenue

Source(s): AEWSD

O&M / On-going ($ per year): ~10,000 - 1M as District budgets allow

Source(s): AEWSD

REGULATORY / LEGAL AUTHORITY REQUIREMENTS (describe all that apply):

Permits (name of authority, type of permit): GSA coordination

CEQA: none

Other:

SCHEDULE / TIMING:

Implementation Trigger(s): The policy may be implemented 3-5 years after the adoption of the GSP.

Termination Trigger(s): Remain indefinitely or until subsidy funds diminish

Timeframe to Accrue Expected Benefits: 1 year post implementation

ADDITIONAL DETAILS (as necessary):

The expected benefits will reduce irrigated acreage and overall groundwater pumping.

WHITE WOLF GROUNDWATER SUSTAINABILITY AGENCY
PROJECT / MANAGEMENT ACTION
INFORMATION FORM

P/MA ID: 16 **BASIN/MANAGEMENT AREA** (if any): AEWSD

TITLE: AEWSD Groundwater Allocation per Acre

DESCRIPTION[1]:

The District may adopt a program which provides a finite groundwater allocation on a per acre basis. The policy would identify and forecast the demands associated with prior rights, domestic and environmental uses. The sustainable yield and ultimate groundwater allocation would take into consideration the existing water rights holders, disadvantaged communities (DACs), community service districts (CSDs), groundwater-dependent ecosystems (GDEs), and California Native American tribes. The District through collaboration with its users and beneficial users may consider whether an equal-, reduced-, or zero-allocation is given to lands with unexercised groundwater rights. The goal of the groundwater allocation are to ensure a fair groundwater allocation and extract groundwater in a sustainable manner. This management action alone may not generate a quantifiable demand reduction. However, it would serve other management actions and encourage growers to implement water conservation BMPs.

Once an individual groundwater allocation is determined, the District may adopt a policy which provides a gradual "ramp-down" allocation decrease over time to arrive at the actual groundwater allocation to allow growers time to adjust to the concept of an allocation and, for some growers, a reduction in groundwater use. The policy would detail the number of years and amount of reduction each year.

The District may adopt a policy which describes an "adaptive management" approach, whereby the groundwater allocation may be reviewed, changed, and reestablished every 5 years or during extreme drought as necessary to achieve long term sustainability. It is prudent for the District to acknowledge the current level of uncertainty in the available data and existing data gaps by providing flexibility in initial groundwater allocations as more data is gathered and analyzed in the upcoming years.

EXPECTED ANNUAL BENEFIT (demand reduction or supply augmentation, in acre-feet per year):

amount depends on overdraft

AGENCY(s):

Primary/Lead: AEWSD

Supporting: __________

LOCATION: □ Check here if Basin-wide

Township / Range: N/A

Coordinates (Latitude / Longitude): various

Description: various

AFFECTED SUSTAINABILITY INDICATOR (check all that apply):

■ Chronic Lowering of Groundwater Levels
■ Reduction of Groundwater Storage
□ Seawater Intrusion
□ Degraded Water Quality
■ Land Subsidence
□ Depletions of Interconnected Surface Water

TYPE (check all that apply):

□ Water Supply Augmentation
- □ Surface Water
- □ Groundwater (Recharge)
- ■ Recycled Water
- □ Transfer
- □ Stormwater
- □ Other

Source of Outside Water (if applicable): __________

■ Water Demand Reduction
- ■ Conservation
- □ Land / Water Use Changes

□ Infrastructure / Capital Project
■ Policy Project
□ Data Gap Filling / Monitoring
□ Water Quality Improvement
□ Other: __________

[1] *Please continue to next page or attach additional pages to this form as necessary*

COSTS & FUNDING SOURCE(s):

Capital / Up-front ($): 25,000 - 100,000

Source(s): AEWSD

O&M / On-going ($ per year): Not applicable

Source(s): AEWSD

REGULATORY / LEGAL AUTHORITY REQUIREMENTS (describe all that apply):

Permits (name of authority, type of permit): GSA coordination

CEQA: none

Other:

SCHEDULE / TIMING:

Implementation Trigger(s): The policy may be implemented 3-5 years after the adoption of the GSP.

Termination Trigger(s): Remain indefinitely or until other programs are enacted.

Timeframe to Accrue Expected Benefits: 1-3 years post implementation

ADDITIONAL DETAILS (as necessary):

The expected benefits would be tied to the Education of Groundwater Use per Acre management action. The goals of the groundwater allocation per acre management action are to ensure a fair groundwater allocation, allow groundwater users time to adjust, and provide future flexibility in allocation determinations. The groundwater allocation management action alone may not generate a quantifiable demand reduction, but it would benefit public education and outreach, and serve as a prerequisite to other management actions including groundwater marketing and trading, fees and subsidies, and pumping restrictions.

WHITE WOLF GROUNDWATER SUSTAINABILITY AGENCY
PROJECT / MANAGEMENT ACTION
INFORMATION FORM

P/MA ID: 17 | **BASIN/MANAGEMENT AREA** (if any): AEWSD

TITLE: AEWSD Groundwater Fee Increase

DESCRIPTION[1]:

The District may adopt a management action to increase GWSA costs to incentivize groundwater users to reduce groundwater extractions and take surface water when available. The District may consider modifying its fee structure study to determine the best strategy for curbing groundwater overdraft without causing inequitable economic impact. The following potential fee structures would affect groundwater users differently, so a composite fee structure may also be considered.

1. Once a groundwater allocation policy including individual allocations and chosen quantification method has been adopted, the District may adopt a policy to levy fees for pumping beyond the current groundwater allocation.
2. The District may adopt a policy to levy tiered fees based upon usage in acre-feet of pumped groundwater.
3. The District may adopt a policy to levy flat rate well head fees. As a prerequisite, the GSA must first ascertain a database of all groundwater extraction facilities, or only charge new permits, such that the District can efficiently and accurately collect the well head fee.

EXPECTED ANNUAL BENEFIT (demand reduction or supply augmentation, in acre-feet per year):

~2.75 AF/ac fallowed (temporary or permanent), ~2.75 AF/ac converted to basin, ~0.5-1.0 AF/ac permanent to annual crop

AGENCY(s):

Primary/Lead: AEWSD

Supporting:

LOCATION: ☐ Check here if Basin-wide

Township / Range: N/A

Coordinates (Latitude / Longitude): various

Description: various

AFFECTED SUSTAINABILITY INDICATOR (check all that apply):

- ■ Chronic Lowering of Groundwater Levels
- ■ Reduction of Groundwater Storage
- ☐ Seawater Intrusion
- ☐ Degraded Water Quality
- ■ Land Subsidence
- ☐ Depletions of Interconnected Surface Water

TYPE (check all that apply):

- ☐ Water Supply Augmentation
  - ☐ Surface Water
  - ☐ Groundwater (Recharge)
  - ■ Recycled Water
  - ☐ Transfer
  - ☐ Stormwater
  - ☐ Other
  - Source of Outside Water (if applicable):
- ■ Water Demand Reduction
  - ■ Conservation
  - ☐ Land / Water Use Changes
- ☐ Infrastructure / Capital Project
- ■ Policy Project
- ☐ Data Gap Filling / Monitoring
- ☐ Water Quality Improvement
- ☐ Other: potential renewable energy and habitat creation

[1] *Please continue to next page or attach additional pages to this form as necessary*

COSTS & FUNDING SOURCE(s):

Capital / Up-front ($): 15,000 - 30,000, but the levied fees will recoup costs and generate on-going revenue

Source(s): AEWSD

O&M / On-going ($ per year): ~25,000 for accounting, billing, and processing paym

Source(s): AEWSD

REGULATORY / LEGAL AUTHORITY REQUIREMENTS (describe all that apply):

Permits (name of authority, type of permit): GSA coordination

CEQA: none

Other:

SCHEDULE / TIMING:

Implementation Trigger(s): The policy may be implemented 3-5 years after the adoption of the GSP.

Termination Trigger(s): Remain indefinitely or until other programs are enacted.

Timeframe to Accrue Expected Benefits: 1-3 years post implementation

ADDITIONAL DETAILS (as necessary):

The expected benefits would be tied to the Groundwater Extraction Quantification Method and Groundwater Allocation per Acre management actions. The expected benefits may mitigate local overdraft by incentivizing groundwater extractors to reduce pumping or pump groundwater supplies in a sustainable fashion. The ancillary benefits include additional funds for the GSA to invest in other projects and management actions.

WHITE WOLF GROUNDWATER SUSTAINABILITY AGENCY
PROJECT / MANAGEMENT ACTION
INFORMATION FORM

P/MA ID: 18 | **BASIN/MANAGEMENT AREA** (if any): AEWSD

TITLE: AEWSD Groundwater Marketing & Trading

DESCRIPTION[1]:

Once a groundwater allocation policy including individual allocations and chosen quantification method was adopted, the District would pursue a groundwater market and trading program to provide users and beneficial users more flexibility in utilizing their allocation.
The District may adopt a policy to define groundwater allocation carryover provisions year-to-year and/or allow multi-year pumping averages. The inter-annual flexibility may be useful to growers who could change cropping patterns or fallow acreage. Though there is a risk that extreme drought may induce exceptionally high pumping in a single year, groundwater extractors may be able to strategize and better manage their assets.
The District may adopt a policy to define a groundwater banking program. The banking program would consider using surface water supplies when available in lieu of groundwater pumping. Though not feasible for all users, growers capable of surface water recharge on-farm may be able to percolate floodwater, or other transferred water, for recharge credits. There are many complexities and considerations required to initiate and successfully manage a banking program. The District should acknowledge and discuss any other water bank/credit systems in existence. The District may approve past replenishment projects and determine the timeframe for any banking efforts that took place prior to banking program adoption. The District may consider adjusting banked credits if future changes in sustainable yield and/or groundwater allocation require adjustment. The District may define a "leave-behind" amount for groundwater migration and operational and evaporative losses, as well as to buffer against impacts to neighboring wells. The District may consider finite timelines or expiration dates on banked water or ongoing "leave-behind" amounts.
The District may adopt a groundwater trading structure and consider a variety of structures including:
1. Bilateral contracts or "coffee shop" markets
2. Brokerage
3. Bulletin boards
4. Auctions and reverse auctions
5. Electronic clearing-houses or "smart markets"
6. Other trade structures

There are various advantages, disadvantages, and costs to all of the stated trading structures. The GSA may consider exploring some of these options with neighboring GSAs and basin wide for an aggregated approach and mutual cost savings. Trading may be executed through short-and long-term leases, permanent transfers, inter-annual water exchanges, or dry-year option contracts. The GSA may determine physical trade limitations such as distance, aquifer, soil conditions, or management areas.

EXPECTED ANNUAL BENEFIT (demand reduction or supply augmentation, in acre-feet per year):

N/A

AGENCY(s):
Primary/Lead: AEWSD
Supporting: ____

LOCATION: ☐ Check here if Basin-wide
Township / Range: N/A
Coordinates (Latitude / Longitude): various
Description: various

AFFECTED SUSTAINABILITY INDICATOR (check all that apply):

■ Chronic Lowering of Groundwater Levels
■ Reduction of Groundwater Storage
☐ Seawater Intrusion
☐ Degraded Water Quality
■ Land Subsidence
☐ Depletions of Interconnected Surface Water

TYPE (check all that apply):

☐ Water Supply Augmentation
- ☐ Surface Water
- ☐ Groundwater (Recharge)
- ■ Recycled Water
- ☐ Transfer
- ☐ Stormwater
- ☐ Other

Source of Outside Water (if applicable): ____

■ Water Demand Reduction
- ■ Conservation
- ☐ Land / Water Use Changes

☐ Infrastructure / Capital Project
■ Policy Project
☐ Data Gap Filling / Monitoring
☐ Water Quality Improvement
☐ Other: ____

[1] *Please continue to next page or attach additional pages to this form as necessary*

COSTS & FUNDING SOURCE(s):

Capital / Up-front ($): 25,000 - 100,000 depending upon complexity of banking and trading structures

Source(s): AEWSD

O&M / On-going ($ per year): ~25,000 for accounting, billing, and processing paym

Source(s): AEWSD

REGULATORY / LEGAL AUTHORITY REQUIREMENTS (describe all that apply):

Permits (name of authority, type of permit): GSA coordination

CEQA: none

Other:

SCHEDULE / TIMING:

Implementation Trigger(s): The policy may be implemented 3-5 years after the adoption of the GSP.

Termination Trigger(s): Remain indefinitely or until other programs are enacted.

Timeframe to Accrue Expected Benefits: 1-3 years post implementation

ADDITIONAL DETAILS (as necessary):

The expected benefits would be tied to the Groundwater Extraction Quantification Method and Groundwater Allocation per Acre management actions. The groundwater marketing and trading management action alone may not generate a quantifiable demand reduction, but it would provide flexibility to groundwater extractors when other management actions are adopted such as groundwater fees and pumping restrictions.

WHITE WOLF GROUNDWATER SUSTAINABILITY AGENCY
PROJECT / MANAGEMENT ACTION INFORMATION FORM

P/MA ID: 22 | **BASIN/MANAGEMENT AREA** (if any): AEWSD

TITLE: Improved Stormwater Management and Flood Control in AEWSD

DESCRIPTION[1]:

The District's canal system needs modifications/improvements to comply with storm runoff pollution prevention. Additionally, there is a need to modify old and build new facilities for flood protection from intermittent creeks (Tejon Creek, El Paso Creek, their tributaries and others). The project integrates with projects identified in Kern County RMA's studies for improved stormwater management and flood control for the Southern Stream Group. This project integrates with flood protection for Lamont, Arvin, and Mettler. Construction of new sedimentation/detention basins, flood ditch erosion protection, Spillway Basin expansion, lengthening the South Canal's siphon under David Road or the flood study and extension of the South Canal liner through designated floodplain reaches, are example projects. District infrastructure (including conveyance interconnections including California Aqueduct), landowners, communities and cities will benefit from the improved stormwater management (i.e., erosion, scouring, flooding).

EXPECTED ANNUAL BENEFIT (demand reduction or supply augmentation, in acre-feet per year):

TBD

AGENCY(s):

Primary/Lead: AEWSD

Supporting: Kern County RMA, Mettler CWD, Tejon Ranch (possible)

LOCATION: □ Check here if Basin-wide

Township / Range: 11N 19W

Coordinates (Latitude / Longitude): 35° 1'33.08"N 118°55'58.14"W

Description: AEWSD South Canal and parts of Kern County outside AEWSD

AFFECTED SUSTAINABILITY INDICATOR (check all that apply):

■ Chronic Lowering of Groundwater Levels
■ Reduction of Groundwater Storage
□ Seawater Intrusion
■ Degraded Water Quality
□ Land Subsidence
□ Depletions of Interconnected Surface Water

TYPE (check all that apply):

■ Water Supply Augmentation
- ■ Surface Water
- ■ Groundwater (Recharge)
- □ Recycled Water
- □ Transfer
- ■ Stormwater
- □ Other
- Source of Outside Water (if applicable): ______

□ Water Demand Reduction
- □ Conservation
- □ Land / Water Use Changes

■ Infrastructure / Capital Project
□ Policy Project
□ Data Gap Filling / Monitoring
■ Water Quality Improvement
□ Other: ______

[1] *Please continue to next page or attach additional pages to this form as necessary*

COSTS & FUNDING SOURCE(s):

Capital / Up-front ($): $1-10 Million

Source(s): AEWSD and partnering agencies

O&M / On-going ($ per year): TBD

Source(s): AEWSD and partnering agencies

REGULATORY / LEGAL AUTHORITY REQUIREMENTS (describe all that apply):

Permits (name of authority, type of permit): TBD

CEQA: portions exempt under 15301 Existing Facilities and 15303 New Construction of Small Structure

Other: NEPA if federal grant funds used, SMARA exemption for basins

SCHEDULE / TIMING:

Implementation Trigger(s): Grant funding

Termination Trigger(s):

Timeframe to Accrue Expected Benefits: 1-3 years post construction

ADDITIONAL DETAILS (as necessary)**:**

WHITE WOLF GROUNDWATER SUSTAINABILITY AGENCY
PROJECT / MANAGEMENT ACTION
INFORMATION FORM

P/MA ID: 23	**BASIN/MANAGEMENT AREA** (if any): AEWSD

TITLE: AEWSD Groundwater Extraction Quantification Method

DESCRIPTION[1]:

The District may adopt a policy to specify the approved method or methods to quantify the individual and aggregate groundwater extractions for the required SGMA annual reporting. The District may consider a variety or combination of quantification methods including, but not limited to the following:

1. Irrigated Acreage determined by aerial flyovers or remote sensing
2. Irrigated area hybrid determined by annual crop survey alongside aerial flyovers or remote sensing of irrigation areas including crop coefficients
3. Calibrated energy records determined by energy records and meter calibrations
4. Volumetric flow measurement
5. Remote sensing of evapotranspiration
6. Other methods

There are various advantages, disadvantages, and costs to all of these quantification methods. The District may consider exploring some of these methods with neighboring GSAs and basin wide for an aggregated approach and mutual cost savings.

EXPECTED ANNUAL BENEFIT (demand reduction or supply augmentation, in acre-feet per year):

N/A

AGENCY(s):

Primary/Lead: AEWSD

Supporting: ______

LOCATION: ☐ Check here if Basin-wide

Township / Range: N/A

Coordinates (Latitude / Longitude): various

Description: various

AFFECTED SUSTAINABILITY INDICATOR (check all that apply):

- ■ Chronic Lowering of Groundwater Levels
- ■ Reduction of Groundwater Storage
- ☐ Seawater Intrusion
- ☐ Degraded Water Quality
- ■ Land Subsidence
- ☐ Depletions of Interconnected Surface Water

TYPE (check all that apply):

- ☐ Water Supply Augmentation
  - ☐ Surface Water
  - ☐ Groundwater (Recharge)
  - ■ Recycled Water
  - ☐ Transfer
  - ☐ Stormwater
  - ☐ Other
  - Source of Outside Water (if applicable): ______
- ■ Water Demand Reduction
  - ■ Conservation
  - ☐ Land / Water Use Changes
- ☐ Infrastructure / Capital Project
- ■ Policy Project
- ■ Data Gap Filling / Monitoring
- ☐ Water Quality Improvement
- ☐ Other: ______

[1] *Please continue to next page or attach additional pages to this form as necessary*

COSTS & FUNDING SOURCE(s):

Capital / Up-front ($): 25,000 - 1M depending upon chosen method

Source(s): AEWSD

O&M / On-going ($ per year): ~$25,000 depending upon chosen method

Source(s): AEWSD

REGULATORY / LEGAL AUTHORITY REQUIREMENTS (describe all that apply):

Permits (name of authority, type of permit): GSA coordination

CEQA: none

Other:

SCHEDULE / TIMING:

Implementation Trigger(s): The policy may be implemented shortly after the adoption of the GSP.

Termination Trigger(s): Remain indefinitely or until other programs are enacted.

Timeframe to Accrue Expected Benefits: 1 year post implementation

ADDITIONAL DETAILS (as necessary):

The expected benefits would be tied to the Education of Groundwater Use per Acre and Groundwater Allocation per Acre management actions. The expected benefits may mitigate overdraft by improving the District's knowledge of aggregate and individual groundwater extractions. The goal of this policy is to accurately and efficiently quantify groundwater extractions. This management action alone may not generate a quantifiable demand reduction, but it would benefit public education and outreach, and serve as a prerequisite to other management actions including groundwater marketing and trading, fees and subsidies, and pumping restrictions.

Appendix O

Checklist for GSP Submittal

				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
§ 354.			**Introduction to Plan Contents**					
			This Article describes the required contents of Plans submitted to the Department for evaluation, including administrative information, a description of the basin setting, sustainable management criteria, description of the monitoring network, and projects and management actions.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
SubArticle 1.			**Administrative Information**					
§ 354.2.			**Introduction to Administrative Information**					
			This Subarticle describes information in the Plan relating to administrative and other general information about the Agency that has adopted the Plan and the area covered by the Plan.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.4.			**General Information**					
			Each Plan shall include the following general information:					
(a)			An executive summary written in plain language that provides an overview of the Plan and description of groundwater conditions in the basin.	18:31	ES.1:ES.13			
(b)			A list of references and technical studies relied upon by the Agency in developing the Plan. Each Agency shall provide to the Department electronic copies of reports and other documents and materials cited as references that are not generally available to the public.	357:364	References and Technical Studies			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10733.2 and 10733.4, Water Code.					
§ 354.6.			**Agency Information**					
			When submitting an adopted Plan to the Department, the Agency shall include a copy of the information provided pursuant to Water Code Section 10723.8, with any updates, if necessary, along with the following information:					
(a)			The name and mailing address of the Agency.	34	3.1			
(b)			The organization and management structure of the Agency, identifying persons with management authority for implementation of the Plan.	34:35	3.2			
(c)			The name and contact information, including the phone number, mailing address and electronic mail address, of the plan manager.	35	3.3			
(d)			The legal authority of the Agency, with specific reference to citations setting forth the duties, powers, and responsibilities of the Agency, demonstrating that the Agency has the legal authority to implement the Plan.	35	3.4			
(e)			An estimate of the cost of implementing the Plan and a general description of how the Agency plans to meet those costs.	35	3.5			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.8, 10727.2, and 10733.2, Water Code.					
§ 354.8.			**Description of Plan Area**					
			Each Plan shall include a description of the geographic areas covered, including the following information:					
(a)			One or more maps of the basin that depict the following, as applicable:					
	(1)		The area covered by the Plan, delineating areas managed by the Agency as an exclusive Agency and any areas for which the Agency is not an exclusive Agency, and the name and location of any adjacent basins.	37	5.1.1	PA-1		

Article 5.			Plan Contents for the White Wolf Basin Groundwater Sustainability Plan	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(2)		Adjudicated areas, other Agencies within the basin, and areas covered by an Alternative.	37:38	5.1.2			
	(3)		Jurisdictional boundaries of federal or state land (including the identity of the agency with jurisdiction over that land), tribal land, cities, counties, agencies with water management responsibilities, and areas covered by relevant general plans.	38:39	5.1.3	PA-1:PA-2		
	(4)		Existing land use designations and the identification of water use sector and water source type.	39:42	5.1.4	PA-3	PA-1	
	(5)		The density of wells per square mile, by dasymetric or similar mapping techniques, showing the general distribution of agricultural, industrial, and domestic water supply wells in the basin, including de minimis extractors, and the location and extent of communities dependent upon groundwater, utilizing data provided by the Department, as specified in Section 353.2, or the best available information.	42	5.1.5	PA-4:PA-5		
(b)			A written description of the Plan area, including a summary of the jurisdictional areas and other features depicted on the map.	37:42	5.1			
(c)			Identification of existing water resource monitoring and management programs, and description of any such programs the Agency plans to incorporate in its monitoring network or in development of its Plan. The Agency may coordinate with existing water resource monitoring and management programs to incorporate and adopt that program as part of the Plan.	43:44	5.2.1			
(d)			A description of how existing water resource monitoring or management programs may limit operational flexibility in the basin, and how the Plan has been developed to adapt to those limits.	45:48	5.2.2:5.2.3			
(e)			A description of conjunctive use programs in the basin.	48	5.2.4			
(f)			A plain language description of the land use elements or topic categories of applicable general plans that includes the following:					
	(1)		A summary of general plans and other land use plans governing the basin.	49:52	5.3.1	PA-3, PA-6, PA-7		
	(2)		A general description of how implementation of existing land use plans may change water demands within the basin or affect the ability of the Agency to achieve sustainable groundwater management over the planning and implementation horizon, and how the Plan addresses those potential effects	52:53	5.3.2	PA-8		
	(3)		A general description of how implementation of the Plan may affect the water supply assumptions of relevant land use plans over the planning and implementation horizon.	53:54	5.3.3			
	(4)		A summary of the process for permitting new or replacement wells in the basin, including adopted standards in local well ordinances, zoning codes, and policies contained in adopted land use plans.	54	5.3.4			
	(5)		To the extent known, the Agency may include information regarding the implementation of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management.	54	5.3.5			
(g)			A description of any of the additional Plan elements included in Water Code Section 10727.4 that the Agency determines to be appropriate.	54:56	5.4.1			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10720.3, 10727.2, 10727.4, 10733, and 10733.2, Water Code.					
§ 354.10.			**Notice and Communication**					
			Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:					

Article 5.			Plan Contents for the White Wolf Basin Groundwater Sustainability Plan	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(a)			A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.	57	5.5.1			
(b)			A list of public meetings at which the Plan was discussed or considered by the Agency.	57:58	5.5.2			
(c)			Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.	59	5.5.3		PA-2	
(d)			A communication section of the Plan that includes the following:					
	(1)		An explanation of the Agency's decision-making process.	60	5.5.4.1			
	(2)		Identification of opportunities for public engagement and a discussion of how public input and response will be used.	60	5.5.4.2			
	(3)		A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.	60:61	5.5.4.3			
	(4)		The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.	61	5.5.4.4			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.8, 10728.4, and 10733.2, Water Code					
SubArticle 2.			**Basin Setting**					
§ 354.12.			**Introduction to Basin Setting**					
			This Subarticle describes the information about the physical setting and characteristics of the basin and current conditions of the basin that shall be part of each Plan, including the identification of data gaps and levels of uncertainty, which comprise the basin setting that serves as the basis for defining and assessing reasonable sustainable management criteria and projects and management actions. Information provided pursuant to this Subarticle shall be prepared by or under the direction of a professional geologist or professional engineer.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.14.			**Hydrogeologic Conceptual Model**					
(a)			Each Plan shall include a descriptive hydrogeologic conceptual model of the basin based on technical studies and qualified maps that characterizes the physical components and interaction of the surface water and groundwater systems in the basin.	71:84	7.1			
(b)			The hydrogeologic conceptual model shall be summarized in a written description that includes the following:					
	(1)		The regional geologic and structural setting of the basin including the immediate surrounding area, as necessary for geologic consistency.	71:72	7.1.1	HCM-1, HCM-13		
	(2)		Lateral basin boundaries, including major geologic features that significantly affect groundwater flow.	72:73	7.1.2			
	(3)		The definable bottom of the basin.	73:76	7.1.3	HCM-2:HCM-3	HCM-1	
	(4)		Principal aquifers and aquitards, including the following information:					
		(A)	Formation names, if defined.	78:79	7.1.4.1	HCM-1, HCM-4	HCM-2	
		(B)	Physical properties of aquifers and aquitards, including the vertical and lateral extent, hydraulic conductivity, and storativity, which may be based on existing technical studies or other best available information.	79:82	7.1.4.2	HCM-5:HCM-6	HCM-3	

				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
		(C)	Structural properties of the basin that restrict groundwater flow within the principal aquifers, including information regarding stratigraphic changes, truncation of units, or other features.	83	7.1.4.3	HCM-13		
		(D)	General water quality of the principal aquifers, which may be based on information derived from existing technical studies or regulatory programs.	83:84	7.1.4.4	HCM-7:HCM-9		
		(E)	Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply.	84:85	7.1.4.5	HCM-10		
	(5)		Identification of data gaps and uncertainty within the hydrogeologic conceptual model	85	7.1.5			
(c)			The hydrogeologic conceptual model shall be represented graphically by at least two scaled cross-sections that display the information required by this section and are sufficient to depict major stratigraphic and structural features in the basin.	85:88	7.2	HCM-11:HCM:13		
(d)			Physical characteristics of the basin shall be represented on one or more maps that depict the following:					
	(1)		Topographic information derived from the U.S. Geological Survey or another reliable source.	88:89	7.3.1	HCM-14		
	(2)		Surficial geology derived from a qualified map including the locations of cross-sections required by this Section.	89	7.3.2	HCM-13		
	(3)		Soil characteristics as described by the appropriate Natural Resources Conservation Service soil survey or other applicable studies.	89	7.3.3	HCM-15		
	(4)		Delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas, including significant active springs, seeps, and wetlands within or adjacent to the basin.	89:91	7.3.4	HCM-16:HCM-17		
	(5)		Surface water bodies that are significant to the management of the basin.	91:92	7.3.5	HCM-18		
	(6)		The source and point of delivery for imported water supplies.	92:93	7.3.6	HCM-19		
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2, 10733, and 10733.2, Water Code.					
§ 354.16.			**Groundwater Conditions**					
			Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:					
(a)			Groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:					
	(1)		Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin.	115:117	8.2.1	GWC-1:GWC-4, HMC-19	GWC-1	
	(2)		Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.	117:119	8.2.2	GWC-5:GWC-6	GWC-2	
(b)			A graph depicting estimates of the change in groundwater in storage, based on data, demonstrating the annual and cumulative change in the volume of groundwater in storage between seasonal high groundwater conditions, including the annual groundwater use and water year type.	119:121	8.3	GWC-7:GWC-8	GWC-3	
(c)			Seawater intrusion conditions in the basin, including maps and cross-sections of the seawater intrusion front for each principal aquifer.	121:122	8.4			
(d)			Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes.	122:129	8.5	GWC-9:GWC-14	GWC-4:GWC-5	

				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(e)			The extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the Department, as specified in Section 353.2, or the best available information.	129:130	8.6.1:8.6.2	GWC-15		
(f)			Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from the Department, as specified in Section 353.2, or the best available information.	131:132	8.7	GWC-4, GWC-16,		
(g)			Identification of groundwater dependent ecosystems within the basin, utilizing data available from the Department, as specified in Section 353.2, or the best available information.	132:136	8.8	GWC-17:GWC-18,	GWC-6	
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10727.4, and 10733.2, Water Code.					
§ 354.18.			**Water Budget**					
(a)			Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.	155:199	9		WB-1	
(b)			The water budget shall quantify the following, either through direct measurements or estimates based on data:					
	(1)		Total surface water entering and leaving a basin by water source type.	161:163	9.2.1			
	(2)		Inflow to the groundwater system by water source type, including subsurface groundwater inflow and infiltration of precipitation, applied water, and surface water systems, such as lakes, streams, rivers, canals, springs and conveyance systems.	163:165	9.2.2	HCM-17:HCM-18	WB-1	
	(3)		Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow.	163:165	9.2.2			
	(4)		The change in the annual volume of groundwater in storage between seasonal high conditions.	165:166	9.2.3	WB-2	WB-2	
	(5)		If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.	181:182	9.3.6			
	(6)		The water year type associated with the annual supply, demand, and change in groundwater stored.	176:178	9.3.4	WB-12:WB-15	WB-6:WB-7	
	(7)		An estimate of sustainable yield for the basin.	182:184	9.3.7	GWC-5:GWC-6, WB-6	WB-9	
(c)			Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:					

				GSP Document References				
				Page Numbers of Plan	**Or Section Numbers**	**Or Figure Numbers**	**Or Table Numbers**	**Notes**
	(1)		Current water budget information shall quantify current inflows and outflows for the basin using the most recent hydrology, water supply, water demand, and land use information.	171:175, 179:180	9.3.2, 9.3.3, 9.3.5	WB-7:WB-11, WB-13:WB-14, WB-16:WB-18, GWC-5:GWC-6	WB-4:WB-5, WB-7:WB-8	
	(2)		Historical water budget information shall be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. The historical water budget shall include the following:					
		(A)	A quantitative evaluation of the availability or reliability of historical surface water supply deliveries as a function of the historical planned versus actual annual surface water deliveries, by surface water source and water year type, and based on the most recent ten years of surface water supply information.	167:171	9.3.1	WB-5:WB-6	WB-3	
		(B)	A quantitative assessment of the historical water budget, starting with the most recently available information and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and project future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon.	167:180	9.3.1:9.3.5	WB-2, WB-6, WB-10:WB-11, WB-14:WB-15,	WB-2,WB-4	
		(C)	A description of how historical conditions concerning hydrology, water demand, and surface water supply availability or reliability have impacted the ability of the Agency to operate the basin within sustainable yield. Basin hydrology may be characterized and evaluated using water year type.	182:184	9.3.7	GWC-5:GWC-6, WB-16,	WB-9	
	(3)		Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:					
		(A)	Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology. The projected hydrology information shall also be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise.	185:195	9.4	PA-3, WB-19, WB-20	WB-10, WB-11	
		(B)	Projected water demand shall utilize the most recent land use, evapotranspiration, and crop coefficient information as the baseline condition for estimating future water demand. The projected water demand information shall also be applied as the baseline condition used to evaluate future scenarios of water demand uncertainty associated with projected changes in local land use planning, population growth, and climate.	185:195	9.4	PA-3, WB-19, WB-20	WB-10, WB-11	

				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
		(C)	Projected surface water supply shall utilize the most recent water supply information as the baseline condition for estimating future surface water supply. The projected surface water supply shall also be applied as the baseline condition used to evaluate future scenarios of surface water supply availability and reliability as a function of the historical surface water supply identified in Section 354.18(c)(2)(A), and the projected changes in local land use planning, population growth, and climate.	185:195	9.4	PA-3, WB-19, WB-20	WB-10, WB-11	
(d)			The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:					
	(1)		Historical water budget information for mean annual temperature, mean annual precipitation, water year type, and land use.	167:184	9.3		WB-2, WB 4, WB-7, WB-8	
	(2)		Current water budget information for temperature, water year type, evapotranspiration, and land use.	167:184	9.3		WB-4, WB 7, WB-8	
	(3)		Projected water budget information for population, population growth, climate change, and sea level rise.	185:195	9.4		WB-10:WB-11	
(e)			Each Plan shall rely on the best available information and best available science to quantify the water budget for the basin in order to provide an understanding of historical and projected hydrology, water demand, water supply, land use, population, climate change, sea level rise, groundwater and surface water interaction, and subsurface groundwater flow. If a numerical groundwater and surface water model is not used to quantify and evaluate the projected water budget conditions and the potential impacts to beneficial uses and users of groundwater, the Plan shall identify and describe an equally effective method, tool, or analytical model to evaluate projected water budget conditions.	160:166	9.2			
(f)			The Department shall provide the California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) and the Integrated Water Flow Model (IWFM) for use by Agencies in developing the water budget. Each Agency may choose to use a different groundwater and surface water model, pursuant to Section 352.4.	160:166	9.2			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10721, 10723.2, 10727.2, 10727.6, 10729, and 10733.2, Water Code.					
§ 354.20.			**Management Areas**					
(a)			Each Agency may define one or more management areas within a basin if the Agency has determined that creation of management areas will facilitate implementation of the Plan. Management areas may define different minimum thresholds and be operated to different measurable objectives than the basin at large, provided that undesirable results are defined consistently throughout the basin.	220	10			Management areas are not being utilized in this basin.
(b)			A basin that includes one or more management areas shall describe the following in the Plan:					
	(1)		The reason for the creation of each management area.	N/A	N/A			Management areas are not being utilized in this basin.

Article 5.			Plan Contents for the White Wolf Basin Groundwater Sustainability Plan	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(2)		The minimum thresholds and measurable objectives established for each management area, and an explanation of the rationale for selecting those values, if different from the basin at large.	N/A	N/A			Management areas are not being utilized in this basin.
	(3)		The level of monitoring and analysis appropriate for each management area.	N/A	N/A			Management areas are not being utilized in this basin.
	(4)		An explanation of how the management area can operate under different minimum thresholds and measurable objectives without causing undesirable results outside the management area, if applicable.	N/A	N/A			Management areas are not being utilized in this basin.
(c)			If a Plan includes one or more management areas, the Plan shall include descriptions, maps, and other information required by this Subarticle sufficient to describe conditions in those areas.	N/A	N/A			Management areas are not being utilized in this basin.
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10733.2 and 10733.4, Water Code.					
SubArticle 3.			**Sustainable Management Criteria**					
§ 354.22.			**Introduction to Sustainable Management Criteria**					
			This Subarticle describes criteria by which an Agency defines conditions in its Plan that constitute sustainable groundwater management for the basin, including the process by which the Agency shall characterize undesirable results, and establish minimum thresholds and measurable objectives for each applicable sustainability indicator.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.24.			**Sustainability Goal**					
			Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.	223	12			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10721, 10727, 10727.2, 10733.2, and 10733.8, Water Code.					
§ 354.26.			**Undesirable Results**					
(a)			Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.	224:242	13			
(b)			The description of undesirable results shall include the following:					
	(1)		The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.	230:231, 233, 234, 235, 237, 240	13.1.1, 13.2.1, 13.3, 13.4.1, 13.5.1, 13.6.1		SMC-1:SMC-2	Since these criteria are covered across the different sections for Undesirable results of sustainability indicator of concern, all of them have been referenced.

				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(2)		The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.	231:232, 233:234, 236, 237:238, 240:241	13.1.2, 13.2.2, 13.3, 13.4.2, 13.5.2, 13.6.2		SMC-1:SMC-2	
	(3)		Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.	232, 234, 236:237, 238, 241	13.1.3, 13.2.3, 13.3, 13.4.3, 13.5.3, 13.6.3	PA-3	SMC-1:SMC-2	
(c)			The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.	249:250	14.1.2, 14.1.3		SMC-3:SMC-4	
(d)			An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.	234	13.3			Seawater intrusion
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10721, 10723.2, 10727.2, 10733.2, and 10733.8, Water Code.					
§ 354.28.			**Minimum Thresholds**					
(a)			Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.	243:258	14		SMC-2, SMC-4	
(b)			The description of minimum thresholds shall include the following:					
	(1)		The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.	243:258	14.1, 14.2, 14.3, 14.4, 14.5, 14.6		SMC-3	Since these criteria are covered across the different sections for MTs of sustainability indicator of concern, all of them have been referenced.
	(2)		The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.	243:258	14.1, 14.2, 14.3, 14.4, 14.5, 14.6		SMC-3	
	(3)		How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.	248	14.1.1.3	SMC-5		

				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(4)		How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.	243:258	14.1, 14.2, 14.3, 14.4, 14.5, 14.6	SMC-2, SMC-4, SMC-6, SMC-7	SMC-3, SMC-4, SMC-5, SMC-6, GWC-6	
	(5)		How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.	254	14.4.1.2			
	(6)		How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.	243:258	14.1, 14.2, 14.3, 14.4, 14.5, 14.6	SMC-2, SMC-4, SMC-6, SMC-7	SMC-3, SMC-4, SMC-5, SMC-6, GWC-6	
(c)			Minimum thresholds for each sustainability indicator shall be defined as follows:					
	(1)		Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following:					
		(A)	The rate of groundwater elevation decline based on historical trends, water year type, and projected water use in the basin.	245:250	14.1	SMC-2	SMC-4	
		(B)	Potential effects on other sustainability indicators.	245:250	14.1	SMC-1, SMC-2, SMC-3, SMC-4		
	(2)		Reduction of Groundwater Storage. The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be supported by the sustainable yield of the basin, calculated based on historical trends, water year type, and projected water use in the basin.	251:252	14.2	SMC-6		
	(3)		Seawater Intrusion. The minimum threshold for seawater intrusion shall be defined by a chloride concentration isocontour for each principal aquifer where seawater intrusion may lead to undesirable results. Minimum thresholds for seawater intrusion shall be supported by the following:					
		(A)	Maps and cross-sections of the chloride concentration isocontour that defines the minimum threshold and measurable objective for each principal aquifer.	N/A	N/A			Not applicable - there is no seawater intrusion as the Basin is located inland.
		(B)	A description of how the seawater intrusion minimum threshold considers the effects of current and projected sea levels.	N/A	N/A			Not applicable - there is no seawater intrusion as the Basin is located inland.

Article 5.			Plan Contents for the White Wolf Basin Groundwater Sustainability Plan	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(4)		Degraded Water Quality. The minimum threshold for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results. The minimum threshold shall be based on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin. In setting minimum thresholds for degraded water quality, the Agency shall consider local, state, and federal water quality standards applicable to the basin.	252:255	14.4			
	(5)		Land Subsidence. The minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results. Minimum thresholds for land subsidence shall be supported by the following:					
		(A)	Identification of land uses and property interests that have been affected or are likely to be affected by land subsidence in the basin, including an explanation of how the Agency has determined and considered those uses and interests, and the Agency's rationale for establishing minimum thresholds in light of those effects.	255:256	14.5			
		(B)	Maps and graphs showing the extent and rate of land subsidence in the basin that defines the minimum threshold and measurable objectives.	255:256	14.5			
	(6)		Depletions of Interconnected Surface Water. The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results. The minimum threshold established for depletions of interconnected surface water shall be supported by the following:					
		(A)	The location, quantity, and timing of depletions of interconnected surface water.	257:258	14.6		SMC-6, GWC-6	
		(B)	A description of the groundwater and surface water model used to quantify surface water depletion. If a numerical groundwater and surface water model is not used to quantify surface water depletion, the Plan shall identify and describe an equally effective method, tool, or analytical model to accomplish the requirements of this Paragraph.	257:258	14.6		SMC-6, GWC-6	
(d)			An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.	257:258	14.6		SMC-6, GWC-6	
(e)			An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish minimum thresholds related to those sustainability indicators.	252	14.3			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10733, 10733.2, and 10733.8, Water Code.					
§ 354.30.			**Measurable Objectives**					

Article 5.			Plan Contents for the White Wolf Basin Groundwater Sustainability Plan	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(a)			Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.	259:262	15.1, 15.2, 15.3, 15.4, 15.5, 15.6	SMC-8, SMC-9, SMC-10	SMC-4, SMC-5, SMC-7	
(b)			Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.	259:262	15.1, 15.2, 15.3, 15.4, 15.5, 15.6	SMC-8, SMC-9, SMC-10	SMC-4, SMC-5, SMC-7	
(c)			Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.	259:262	15.1, 15.2, 15.3, 15.4, 15.5, 15.6	SMC-8, SMC-9, SMC-10	SMC-4, SMC-5, SMC-7	
(d)			An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.	259:262	15.1, 15.2, 15.3, 15.4, 15.5, 15.6	SMC-8, SMC-9, SMC-10	SMC-4, SMC-5, SMC-7	
(e)			Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.	259:262	15.1, 15.2, 15.3, 15.4, 15.5, 15.6	SMC-8, SMC-9, SMC-10	SMC-4, SMC-5, SMC-7	
(f)			Each Plan may include measurable objectives and interim milestones for additional Plan elements described in Water Code Section 10727.4 where the Agency determines such measures are appropriate for sustainable groundwater management in the basin.	N/A	N/A			Not applicable, no additional plan elements were incorporated
(g)			An Agency may establish measurable objectives that exceed the reasonable margin of operational flexibility for the purpose of improving overall conditions in the basin, but failure to achieve those objectives shall not be grounds for a finding of inadequacy of the Plan.	N/A	N/A			Not applicable, all Measurable Objectives have a reasonable margin of operational flexibility.
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2, 10727.4, and 10733.2, Water Code.					
SubArticle 4.			**Monitoring Networks**					
§ 354.32.			**Introduction to Monitoring Networks**					
			This Subarticle describes the monitoring network that shall be developed for each basin, including monitoring objectives, monitoring protocols, and data reporting requirements. The monitoring network shall promote the collection of data of sufficient quality, frequency, and distribution to characterize groundwater and related surface water conditions in the basin and evaluate changing conditions that occur through implementation of the Plan.					
			Note: Authority cited: Section 10733.2, Water Code.					

				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
			Reference: Section 10733.2, Water Code.					
§ 354.34.			**Monitoring Network**					
(a)			Each Agency shall develop a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions, and yield representative information about groundwater conditions as necessary to evaluate Plan implementation.	276:311	17		MN-1	
(b)			Each Plan shall include a description of the monitoring network objectives for the basin, including an explanation of how the network will be developed and implemented to monitor groundwater and related surface conditions, and the interconnection of surface water and groundwater, with sufficient temporal frequency and spatial density to evaluate the affects and effectiveness of Plan implementation. The monitoring network objectives shall be implemented to accomplish the following:					
	(1)		Demonstrate progress toward achieving measurable objectives described in the Plan.	277:301	17.1		MN-1	
	(2)		Monitor impacts to the beneficial uses or users of groundwater.	277:301	17.1		MN-1	
	(3)		Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds.	277:301	17.1		MN-1	
	(4)		Quantify annual changes in water budget components.	277:301	17.1		MN-1	
(c)			Each monitoring network shall be designed to accomplish the following for each sustainability indicator:					
	(1)		Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:					
		(A)	A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.	282:284	17.1.1	MN-1	MN-2	
		(B)	Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.	282:284	17.1.1			
	(2)		Reduction of Groundwater Storage. Provide an estimate of the change in annual groundwater in storage.	284:286	17.1.2	WB-8:WB-10		
	(3)		Seawater Intrusion. Monitor seawater intrusion using chloride concentrations, or other measurements convertible to chloride concentrations, so that the current and projected rate and extent of seawater intrusion for each applicable principal aquifer may be calculated.	287	17.1.3			
	(4)		Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.	287:292	17.1.4	MN-2	MN-3	
	(5)		Land Subsidence. Identify the rate and extent of land subsidence, which may be measured by extensometers, surveying, remote sensing technology, or other appropriate method.	293:296	17.1.5	MN-3	MN-4	

				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(6)		Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:			MN-4	MN-5	
		(A)	Flow conditions including surface water discharge, surface water head, and baseflow contribution.	297:301	17.1.6			
		(B)	Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.	297:301	17.1.6			
		(C)	Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.	297:301	17.1.6			
		(D)	Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.	297:301	17.1.6			
(d)			The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.	282:301	17.1.1, 17.1.2, 17.1.3, 17.1.4, 17.1.5, 17.1.6			
(e)			A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.	276:311	17			
(f)			The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:					
	(1)		Amount of current and projected groundwater use.	297:301	17.1.6			
	(2)		Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.	297:301	17.1.6			
	(3)		Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.	297:301	17.1.6			
	(4)		Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.	297:301	17.1.6			
(g)			Each Plan shall describe the following information about the monitoring network:					
	(1)		Scientific rationale for the monitoring site selection process.	282:301	17.1.1, 17.1.2, 17.1.3, 17.1.4, 17.1.5, 17.1.6			
	(2)		Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.	277:301	17.1			
	(3)		For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36.	277:301	17.1			

				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(h)			The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.	282:301	17.1.1, 17.1.2, 17.1.3, 17.1.4, 17.1.5, 17.1.6		MN-1:MN-5	
(i)			The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.	302:308	17.2			
(j)			An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish a monitoring network related to those sustainability indicators.	287	17.1.3			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10727.4, 10728, 10733, 10733.2, and 10733.8, Water Code					
§ 354.36.			**Representative Monitoring**					
			Each Agency may designate a subset of monitoring sites as representative of conditions in the basin or an area of the basin, as follows:					
(a)			Representative monitoring sites may be designated by the Agency as the point at which sustainability indicators are monitored, and for which quantitative values for minimum thresholds, measurable objectives, and interim milestones are defined.	308:309	17.3			
(b)			(b) Groundwater elevations may be used as a proxy for monitoring other sustainability indicators if the Agency demonstrates the following:					
	(1)		Significant correlation exists between groundwater elevations and the sustainability indicators for which groundwater elevation measurements serve as a proxy.	308:309	17.3			
	(2)		Measurable objectives established for groundwater elevation shall include a reasonable margin of operational flexibility taking into consideration the basin setting to avoid undesirable results for the sustainability indicators for which groundwater elevation measurements serve as a proxy.	308:309	17.3			
(c)			The designation of a representative monitoring site shall be supported by adequate evidence demonstrating that the site reflects general conditions in the area.	308:309	17.3			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2 and 10733.2, Water Code					
§ 354.38.			**Assessment and Improvement of Monitoring Network**					
(a)			Each Agency shall review the monitoring network and include an evaluation in the Plan and each five-year assessment, including a determination of uncertainty and whether there are data gaps that could affect the ability of the Plan to achieve the sustainability goal for the basin.	310:311	17.4			
(b)			Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.	310:311	17.4			
(c)			If the monitoring network contains data gaps, the Plan shall include a description of the following:					
	(1)		The location and reason for data gaps in the monitoring network.	310:311	17.4			

Article 5.			Plan Contents for the White Wolf Basin Groundwater Sustainability Plan	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(2)		Local issues and circumstances that limit or prevent monitoring.	310:311	17.4			
(d)			Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.	310:311	17.4			
(e)			Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:					
	(1)		Minimum threshold exceedances.	310:311	17.4			
	(2)		Highly variable spatial or temporal conditions.	310:311	17.4			
	(3)		Adverse impacts to beneficial uses and users of groundwater.	310:311	17.4			
	(4)		The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.	310:311	17.4			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10728.2, 10733, 10733.2, and 10733.8, Water Code					
§ 354.40.			**Reporting Monitoring Data to the Department**					
			Monitoring data shall be stored in the data management system developed pursuant to Section 352.6. A copy of the monitoring data shall be included in the Annual Report and submitted electronically on forms provided by the Department.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10728, 10728.2, 10733.2, and 10733.8, Water Code.					
SubArticle 5.			**Projects and Management Actions**					
§ 354.42.			**Introduction to Projects and Management Actions**					
			This Subarticle describes the criteria for projects and management actions to be included in a Plan to meet the sustainability goal for the basin in a manner that can be maintained over the planning and implementation horizon.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.44.			**Projects and Management Actions**					
(a)			Each Plan shall include a description of the projects and management actions the Agency has determined will achieve the sustainability goal for the basin, including projects and management actions to respond to changing conditions in the basin.	316:342	18			
(b)			Each Plan shall include a description of the projects and management actions that include the following:					
	(1)		A list of projects and management actions proposed in the Plan with a description of the measurable objective that is expected to benefit from the project or management action. The list shall include projects and management actions that may be utilized to meet interim milestones, the exceedance of minimum thresholds, or where undesirable results have occurred or are imminent. The Plan shall include the following:					
		(A)	A description of the circumstances under which projects or management actions shall be implemented, the criteria that would trigger implementation and termination of projects or management actions, and the process by which the Agency shall determine that conditions requiring the implementation of particular projects or management actions have occurred.	334	18.3			

Article 5.			Plan Contents for the White Wolf Basin Groundwater Sustainability Plan	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
		(B)	The process by which the Agency shall provide notice to the public and other agencies that the implementation of projects or management actions is being considered or has been implemented, including a description of the actions to be taken.	334	18.4		PMA-1	
	(2)		If overdraft conditions are identified through the analysis required by Section 354.18, the Plan shall describe projects or management actions, including a quantification of demand reduction or other methods, for the mitigation of overdraft.	335	18.5	WB-21	WB-11	
	(3)		A summary of the permitting and regulatory process required for each project and management action.	335:336	18.6		PMA-1	
	(4)		The status of each project and management action, including a time-table for expected initiation and completion, and the accrual of expected benefits.	336:337	18.7		PMA-1:PMA-2	
	(5)		An explanation of the benefits that are expected to be realized from the project or management action, and how those benefits will be evaluated.	337:338	18.8	PMA-2	PMA-1	
	(6)		An explanation of how the project or management action will be accomplished. If the projects or management actions rely on water from outside the jurisdiction of the Agency, an explanation of the source and reliability of that water shall be included.	339	18.9		PMA-1	
	(7)		A description of the legal authority required for each project and management action, and the basis for that authority within the Agency.	340	18.10			
	(8)		A description of the estimated cost for each project and management action and a description of how the Agency plans to meet those costs.	340:341	18.11		PMA-1	
	(9)		A description of the management of groundwater extractions and recharge to ensure that chronic lowering of groundwater levels or depletion of supply during periods of drought is offset by increases in groundwater levels or storage during other periods.	341:342	18.12			
(c)			Projects and management actions shall be supported by best available information and best available science.	349:350	19.1.6			
(d)			An Agency shall take into account the level of uncertainty associated with the basin setting when developing projects or management actions.	316:342	18			2030 climate change scenario was selected to incorporate uncertainty with future climate and surface water reliability.
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2, 10727.4, and 10733.2, Water Code.					

eki environment & water

2001 Junipero Serra Blvd., Suite 300 | Daly City, CA 94014
(650) 292-9100 | Fax (650) 552-9012 | Ekiconsult.com