JANUARY 2022

SISKIYOU COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT

Butte Valley Groundwater Sustainability Plan



SISKIYOU COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT GROUNDWATER SUSTAINABILITY AGENCY
BUTTE VALLEY GROUNDWATER SUSTAINABILITY PLAN

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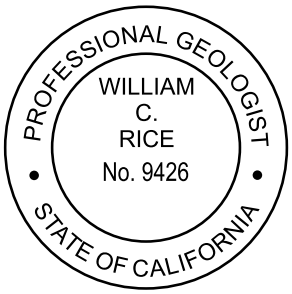
Suggested Citation: Siskiyou County Flood Control and Water District Groundwater Sustainability Agency, Butte Valley Groundwater Sustainability Plan, January 2022, https://www.co.siskiyou.ca.us/naturalresources/page/sustainable-groundwater-management-act-sgma

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Butte Valley Basin Groundwater Sustainability Plan
Siskiyou County Flood Control and Water Conservation District

This report was prepared by the staff and subconsultants of Larry Walker Associates and of the University of California Davis. The findings, recommendations, specifications, or professional opinions are presented within the limits described by the client, in accordance with generally accepted professional engineering and geologic practice. The Butte Valley basin setting was prepared under the direction of a professional geologist or engineer licensed in the state of California as required per California Code of Regulations, Title 23 Section 354.12 consistent with professional standards of practice. No warranty is expressed or implied.



William C. Rice
12/10/2021
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Acronyms

Abbreviation	Explanation
AF	Acre-feet
AFY	Acre-feet per year
AGR	Agricultural Supply (acronym used to describe beneficial use)
amsl	above mean sea level
AQUA	Aquaculture (acronym used to describe beneficial use)
ASAR	Adjusted sodium absorption ratio
bgs	Below ground surface
BLM	United States Department of the Interior Bureau of Land Management
BVID	Butte Valley Irrigation District
BVIHM	Butte Valley Integrated Hydrogeologic Model
BVWA	Butte Valley Wildlife Area
CASGEM	California Statewide Groundwater Elevation Monitoring Program
CCR	California Code of Regulations
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
CDPH	California Department of Public Health
cfs	Cubic feet per second
CIMIS	California Irrigation Management Information System
CIWQS	California Integrated Water Quality System Project
cm	Centimeter
CNRA	California Natural Resources Agency
CSEHD	County of Siskiyou Environmental Health Division
DAC	Disadvantaged community
DDW	Division of Drinking Water
DOI	U.S. Department of the Interior
DTSC	California Department of Toxic Substances Control

(continued)

Abbreviation	Explanation
DTW	Depth to Water
DWR	California Department of Water Resources
ET	Evapotranspiration
ft	Foot/feet
FZ	Fault zone, an interconnected network of closely space earthquake faults.
gal	Gallon(s)
GAMA	Groundwater Ambient Monitoring and Assessment Program
gpd	Gallons per day
gpm	Gallons per minute
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
HCM	Hydrogeologic conceptual model
Holocene	A geologic time scale term, marking the time period between 11,500 years ago to the Present.
in	Inch/inches
IND	Industrial Service Supply (acronym used to describe beneficial use)
InSAR	Interferometric Synthetic Aperture Radar
km	Kilometer/kilometers
l/min	Liters per minute
LLNL	Lawrence Livermore National Laboratory
LUST	Leaking underground storage tank
m	Meter/meters
m3	Cubic meters
m3/yr	Cubic meters per year
Ma	Million years ago
MCL	Maximum contaminant level
mg/L	Milligrams per liter
MHI	Median household income
mi	Mile/miles
ML	Local magnitude (Richter magnitude)
mm	Millimeter
MO	Measurable Objective
MOU	Memorandum of understanding

(continued)

Abbreviation	Explanation
MT	Minimum Threshold
MTBE	Methyl tert-butyl ether
MUN	Municipal and Domestic Supply (acronym used to describe beneficial use)
MW	Monitoring well
NCRWQCB	California North Coast Regional Water Quality Control Board
NOAA	United States National Oceanic and Atmospheric Administration
OSWCR	Online Systems for Well Completion Reports
Pleistocene	A geologic time scale term, marking the time period between 1.8 Ma and 11,500 years ago.
Pliocene	A geologic time scale term, marking the time period between 5.3 Ma and 1.8 Ma years ago.
PLSS	Public Land Survey System
PMA	Projects and Management Actions
ppb	Parts per billion
ppm	Parts per million
PRO	Industrial Process Supply (acronym used to describe beneficial use)
Quaternary	A geologic time scale term, marking the time period between 1.8 Ma to the Present.
RMP	Representative Monitoring Point
ROWD	Report of Waste Discharge
SAGBI	Soil Agricultural Banking Index
SDAC	Severely disadvantaged community
SGMA	Sustainable Groundwater Management Act
SI	Sustainability Indicator
sq	Square
SSURGO	Soil Survey Geographic Database
SWRCB	California State Water Resources Control Board
TAC	Technical Advisory Committee
TAF	Thousand acre-feet
TDS	Total dissolved solids
Tertiary	A geologic time scale term, marking the time period between 65.5 Ma to 1.8 Ma.
TMDL	Total Maximum Daily Load
U.S.	United States

(continued)

Abbreviation	Explanation
UCCE	University of California Cooperative Extension
UCD	University of California, Davis
ug/L	Micrograms per liter
UL	Upper level
umhos/cm	Micromhos per centimeter
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UST	Underground storage tank
WQO	Water quality objective

Glossary

Term	Explanation
Adjudicated Areas	Where disputes over legal rights to groundwater have resulted in a court-issued ruling (known as an adjudication). Adjudications can cover an entire basin, a portion of a basin, or a group of basins.
Alluvial Fan	A gently sloping mass of sediment deposited by a stream that looks like an open fan when viewed from above. They often occur in arid or semiarid regions where a stream issues from a narrow canyon onto a plain or valley floor.
Alluvium	Clay, silt, sand, gravel, or other particulate material that have been deposited by a body of running water in a streambed, flood plain, delta, or at the base of a mountain.
Andesite	A fine-grained dark-colored ignous rock that has been erupted on the Earth's surface, and is more viscous or "sticky" compared to basalt. Cooled andesite lava flows typically consist of large, smooth-sided blocks up to several meters (~10 feet) in size. The edges of lava flow edges are steep and can be more than 100 m (300 ft) thick, consisting of piles of large angular blocks balancing precariously on one another.
Basalt	A dark-colored, fine-grained igneous rock that has been erupted on the Earth's surface, that typically form thin, extensive lava sheets that can travel long distances. Basalt is the least viscous or most "fluid" of the main lava types. It is considered the most primitive type of lava, with minimal alteration from the source mantle material beneath the tectonic plates.
Basin Prioritization	Classification of California's 515 groundwater basins and subbasins into priorities based primarily on the importance of groundwater to the area. The priority of basins and subbasins determines the schedule for completing GSPs and whether SGMA provisions apply in a given basin. Critical, High, and medium, priority basins must comply with SGMA.
Basin Setting	The physical setting, characteristics, and conditions of the basin.
Best Management Practices (BMPs)	Practices designed to help achieve sustainable groundwater management. BMPs are intended to be effective, practical, and based on best available science.

(continued)

Term	Explanation
Block Faulting	A type of normal faulting where large normal faults break the Earth's crust into blocks as the region is pulled apart under extensional stress. Typically forms valleys, such as Death Valley in California.
Breccia	A coarse-grained rock of angular rock fragments that has been consolidated with mineral cement or fine-grained matrix.
Bulletin 118	A California Department of Water Resources (DWR) document outlining the locations and characteristics of groundwater basins in California.
CASGEM	The California Statewide Groundwater Elevation Monitoring Program
Confined Aquifer	A water bearing formation that is completely filled with groundwater and under pressure from overlying material that restricts movement of water.
Consolidated / Unconsolidated	Consolidation is any process where loose material becomes firm and coherent, such as cementation of sand into sandstone. Unconsolidated material is loose earth material such as volcanic ash or sand.
Critically Overdrafted	Basins and subbasins identified by DWR to be subject to conditions of critical overdraft. GSPs are due in 2020.
Dacite	A fine-grained light-colored ignous rock that has been erupted on the Earth's surface, with a mineral composition that makes dacite lava flows sluggish and thick. Typically, dacite lava flows are so viscous and thick that they form a dome over the eruption center at the end of an explosive eruption cycle. Eruptions of dacite magmas can be explosive.
Data Gap	A lack of information that could limit the ability to evaluate whether a basin is being sustainably managed, that significantly affects understanding of the basin setting or that limits assessment of the efficacy of implementation of the groundwater sustainability plan.
De Minimis Extractor	A person who extracts, for domestic purposes, less than or equal to 2 acre-feet of groundwater per year.
Dune Sand	Sand piled up by the wind into a sand dune.
Eocene	An epoch within the Tertiary period that began 55.8 million years ago (Ma) and ended 33.8 Ma.
Glaciation	The formation of glaciers, a large mass of ice formed on land that can cause extensive erosion of surrounding rock. When glaciers melt, they can leave behind moraines or mounds of rock debris (glacial till). The last major period of glaciation in the western US was 18,000 years ago.

(continued)

Term	Explanation
Graben	An elongate portion of the crust bound by faults on the long sides and displaced downward, such as rift valleys. They form in conditions where the Earth's crust is being pulled apart under extensional stress.
Groundwater Dependent Ecosystems	Ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface.
Groundwater Sustainability Agency (GSA)	One or a combination of local agencies with water supply, water management or land use responsibilities may establish a Groundwater Sustainability Agency (GSA). The GSA holds the responsibility to develop and implement a groundwater sustainability plan.
Groundwater Sustainability Plan (GSP)	A 20-year plan to ensure groundwater is managed sustainability within a groundwater basin. Proposed by a GSA and approved by the State.
Holocene	An epoch within the Quaternary that began 0.012 million years ago (Ma) and continues to the present.
Hydrogeological Conceptual Model	A description of the geologic and hydrologic setting that determines groundwater occurrence, movement, and general conditions in a basin or subbasin.
Igneous	A rock that solidified from molten material such as lava or magma. One of the three major rock classes (igneous, sedimentary, metamorphic).
Interconnected surface water	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.
Interim Milestones	Periodic goals (defined every five years, at minimum), that are used to measure progress toward measurable objectives and the sustainability goal.
Measurable Objectives	Specific and quantifiable goals that are defined to reflect the desired groundwater conditions in the Basin and achieve the sustainability goal within 20 years. Measurable objectives are defined in relation to the six undesirable results and use the same metrics as minimum thresholds.
Metamorphic	A metamorphic rock formed from mineralogical, chemical, or structural changes of a pre-existing rock in response to changes in temperature, pressure or stress. This generally occurs if the rock has been moved deep into the Earth's crust, such as through long-term deposition of materials on top of the rock or faulting. One of the three major rock classes (igneous, sedimentary, metamorphic).

(continued)

Term	Explanation
Minimum Threshold	A quantitative value representative of groundwater conditions at a site (or sites), that, if exceeded, may cause an undesirable result. The term ”maximum threshold” is the equivalent value for sustainable management criteria with a defined maximum limit (e.g., groundwater quality).
Miocene	An epoch within the Tertiary period that began 23 million years ago (Ma) and ended 5.3 Ma.
Normal Fault	A fracture in the Earth crust that forms when a region is under extensional stress (the region is being pulled apart). The fault dip is usually 45 to 90 degrees. Typically, one block or side of the fault is moving down relative to the other side.
Phytogenic Dune	Phytogenic dunes are common in modern day playas and form when wind-deposited silt and fine sand are trapped by scrub plants.
Playa	A playa is a dry, vegetation-free, flat area at the lowest part of an undrained desert basin.
Pleistocene	An epoch within the Quaternary that began 1.8 million years ago (Ma) and ended 0.012 Ma.
Pliocene	An epoch within the Tertiary period that began 5.3 million years ago (Ma) and ended 1.8 Ma.
Potentiometric Surface	The total head of groundwater, defined as the level at which groundwater would rise in a well. The water table is a type of potentiometric surface.
Projects and Management Actions	creation or modification of a physical structure / infrastructure (project) and creation of policies, procedures, or regulations (management actions) that are implemented to achieve Basin sustainability.
Pyroclastic Deposit/Rock	Pyroclastic rocks are composed of rock fragments from an explosive volcanic eruption or aerial expulsion from a volcanic vent, and may include ash, lapilli, bombs, blocks, and shattered country rock.
Quaternary	A period that starts after the end of the Tertiary that began 1.8 millions years ago (Ma) and continues in the present. Epochs or sub-periods within the Quaternary, from the oldest to most recent, includes the Pleistocene and Holocene.
Representative Monitoring Points	for each sustainability indicator, a subset of the entire monitoring network where minimum thresholds, measurable objectives, and milestones are measured and evaluated.
Rhyolite (Tuff)	A light-colored ignous rock that has been erupted on the Earth’s surface, with a mineral composition that typically erupts explosively and fragments into small pieces (pyroclasts). Consolidated rhyolite pyroclasts is called a rhyolite tuff. Rhyolite is typically pale colored and often light grey, tan, or pink.

(continued)

Term	Explanation
Sedimentary	A sedimentary rock formed from the consolidation of sediment, such as sand (sandstone) or organic material (coal). One of the three major rock classes (igneous, sedimentary, metamorphic).
SGMA	Sustainable Groundwater Management Act, a three-bill package signed into California state law in 2014.
Sustainability Goals	The overarching goal for the Basin with respect to managing groundwater conditions to ensure the absence of undesirable results.
Sustainability Indicators	Six indicators defined under SGMA: chronic lowering of groundwater levels, reduction of groundwater storage, seawater intrusion, degraded groundwater quality, land subsidence, and depletions of interconnected surface water. These indicators describe groundwater-related conditions in the Basin and are used to determine occurrence of undesirable results (23 CCR 354.28(b)(1)-(6).)
Sustainable Management Criteria	Minimum thresholds, measurable objectives, and undesirable results, consistent with the sustainability goal, that must be defined for each sustainability indicator.
Sustainable Yield	The amount of water that can be extracted from a basin without causing problems to the groundwater basin.
Talus	A heap or mass of rock fragments lying at the base of a cliff or very steep, rocky slope, and formed by gravitational falling, rolling, or sliding.
Tertiary	A period in the geologic time scale that began 65.5 million years ago (Ma) and ended 1.8 Ma. The Tertiary includes several sub-periods or epochs, from the oldest to most recent: Paleocene, Eocene, Oligocene, Miocene, and Pliocene. The next period after the end of the Tertiary is the Quaternary.
Tuff	A rock of consolidated pyroclastic (fragmented rock erupted explosively) material.
Unconfined Aquifer	A water bearing formation partially filled with groundwater where the upper groundwater surface is free to fluctuate under atmospheric pressure.
Unconformity	A break in the geologic record, typically by erosion. Commonly recognized by a sudden jump or large gap in rock ages between deep older rocks and shallow young rocks.
Undesirable Result	Conditions, defined under SGMA as: ”â€¦ one or more of the following effects caused by groundwater conditions occurring throughout a basin:

(continued)

Term	Explanation
	1. Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizonâ€¦. 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." (Wat. Code Â§ 10721(x)(1)-(6).)
Volcanic Ash	Fine pyroclastic material (material ejected from a volcanic eruption) smaller than 2 mm in diameter. The term usually refers to unconsolidated material. Consolidated volcanic ash is called a tuff.
Water Budget	An estimated accounting of all the water (surface and groundwater) that flows into and out of a basin.
Water Budget	An estimated accounting of all the water (surface and groundwater) that flows into and out of a basin.
Water Year	The period from October 1 through and including the following September 30.
Water Year Type	A classification, provided by the Department of Water Resources that reflects the amount of annual precipitation in a basin.

Glossary references include King (1994); USGS (2009b); USGS (2009a); USGS (n.d.d); USGS (n.d.a); USGS (n.d.c); USGS (n.d.b); Bates and Jackson (1984); Francis and Oppenheimer (2004); USGS (2007); USGS (n.d.e).

Executive Summary

ES-1: INTRODUCTION (CHAPTER 1)

Background (Section 1.1)

Section 1 describes the 2014 Sustainable Groundwater Management Act (SGMA) and the purpose of the Groundwater Sustainability Plan (GSP). Section 1 also introduces the management structure of the agencies developing and implementing the GSP.

SGMA was established to provide local and regional agencies the authority to sustainably manage groundwater resources through the development and implementation of GSPs for high and medium priority subbasins (e.g., Butte Valley). In accordance with SGMA, this GSP was developed and will be implemented by the groundwater sustainability agency (GSA) representing the Butte Valley groundwater basin (Basin): the Siskiyou County Flood Control and Water Conservation District.

The California Department of Water Resources (DWR) and the State Water Resources Control Board (SWRCB) provide primary oversight for implementation of SGMA. DWR adopted regulations that specify the components and evaluation criteria for groundwater sustainability plans, alternatives to GSPs, and coordination agreements to implement such plans. To satisfy the requirements of SGMA, local agencies must do the following:

Locally controlled and governed GSAs must be formed for all high- and medium-priority groundwater basins in California.

- GSAs must develop and implement GSPs or Alternatives to GSPs that define a roadmap for how groundwater basins will reach long-term sustainability.
- The GSPs must consider six sustainability indicators defined as: groundwater level decline, groundwater storage reduction, seawater intrusion, water quality degradation, land subsidence, and surface-water depletion.
- GSAs must submit annual reports to DWR each April 1 following adoption of a GSP.
- Groundwater basins should reach sustainability within 20 years of implementing their GSPs.

This GSP was prepared to meet the regulatory requirements established by DWR. The completed GSP Elements Guide is organized according to the GSP Emergency Regulations sections of the California Code of Regulations and is provided in Appendix 1-D.

Purpose of the Groundwater Sustainability Plan

The Butte Valley GSP outlines a 20-year plan to direct sustainable groundwater management activities that considers the needs of all users in the Basin and ensures a viable groundwater resource

for beneficial use by agricultural, residential, industrial, municipal and ecological users. The initial GSP is a starting point towards achievement of the sustainability goal for the Basin. Although available information and monitoring data have been evaluated throughout the GSP to set sustainable management criteria and define projects and management actions, there are gaps in knowledge and additional monitoring requirements. Information gained in the first five years of plan implementation, and through the planned monitoring network expansions, will be used to further refine the strategy outlined in this draft of the GSP. The GSA will work towards implementation of the GSP to meet all provisions of the SGMA using available local, state, and federal resources. It is anticipated that coordination with other agencies that conduct monitoring and/or management activities will occur throughout GSP implementation to fund and conduct this important work. Fees or other means may be required to support progress towards compliance with SGMA.

ES-2: PLAN AREA AND BASIN SETTING (CHAPTER 2)

Chapter 2 provides an overview of the Basin area. This includes descriptions of plan area, relevant agencies and programs, groundwater conditions, water quality, interconnected surface waters (ISWs), and groundwater dependent ecosystems (GDEs). These details inform the hydrogeologic conceptual model and water budget developed for the Basin which will be used to frame the discussion for sustainable management criteria (SMCs; Chapter 3) and projects and management actions (PMAs; Chapter 4).

Description of Plan Area (Section 2.1)

Summary of Jurisdictional Areas and Other Features (Section 2.1.1)

The Basin is a medium priority basin located in Northern California. The Basin is surrounded by several mountain ranges: the Cascade Mountains in the north, south and west, the Mahogany Mountain ridge in the east and Sheep Mountain and Red Rock Valley in the southeast. The major water features in the basin are Meiss Lake and several streams including Butte Creek. The primary communities in Butte Valley are the City of Dorris (population 962) and the smaller communities of Macdoel (population 155) and Mount Hebron (population 81) (DWR 2016b). All three of these populations are classified as severely disadvantaged communities (SDACs), based on annual median household income. The most significant land use in the Basin is for agriculture, accounting for 38.7% of the land in the Basin according to the 2010 County land use survey (DWR 2010) with primary crops of alfalfa, hay, and strawberry.

Water Resources Monitoring and Management Programs (Section 2.1.2)

Section 2.1.2 documents monitoring and management of surface water and groundwater resources in the Basin and their relation to GSP implementation. These include federal, state, and local agencies and their associated activities in Butte Valley.

Land Use Elements or Topic Categories of Applicable General Plans (Section 2.1.3)

Applicable land use and community plans in the Basin are outlined in Section 2.1.3, including the County of Siskiyou General Plan and City of Dorris General Plan.

Additional GSP Elements (Section 2.1.4)

Well policies, groundwater use regulations and the role of land use planning agencies and federal regulatory agencies in GSP implementation are outlined in Section 2.1.4.

Basin Setting (Section 2.2)

Section 2.2 includes descriptions of geologic formations and structures, aquifers, and properties of geology related to groundwater, among other related characteristics of the Basin.

Hydrogeologic Conceptual Model (Section 2.2.1)

The hydrogeologic conceptual model encompasses the Basin setting including its geographical location, climate, geology, soils, land use and water management history, and hydrology (Sections 2.2.1.1 through 2.2.1.9).

Current and Historical Groundwater Conditions (Section 2.2.2)

Groundwater Elevation (2.2.2.1)

Groundwater levels in the Basin fluctuate on a short-term scale with a seasonal high in the spring and seasonal low in the fall, and over the long term based on precipitation levels and changes in the amount of total groundwater extraction. Groundwater recharge in the Basin depends on precipitation, which has been in decline since the 1980s. Groundwater levels have decreased around 30 feet from the spring of 1979 to the spring of 2015; the decline in groundwater levels in five wells is shown in Figure 1.

Estimate of Groundwater Storage (2.2.2.2)

Groundwater storage and specific yield are difficult to estimate due to the interconnectivity of all confined and unconfined units, and critical data gaps in the main water bearing and recharge unit, the High Cascade Volcanics. For the unconfined units, Lake Deposits, pyroclastic rocks, and Butte Valley Basalt, the weighted average specific yield is calculated to be 9.5% and total groundwater storage capacity is 2,560,000 acre-feet. The High Cascade Volcanics has unknown depth and extent, and a total estimate of storage is based on the Butte Valley Integrated Hydrologic Model (BVIHM; see Section 2.2.3).

Groundwater Quality (Section 2.2.2.3)

Based on an evaluation of Basin groundwater quality using available monitoring data (see Appendix 2-B), a list of constituents of interest was generated for the Basin. This list includes

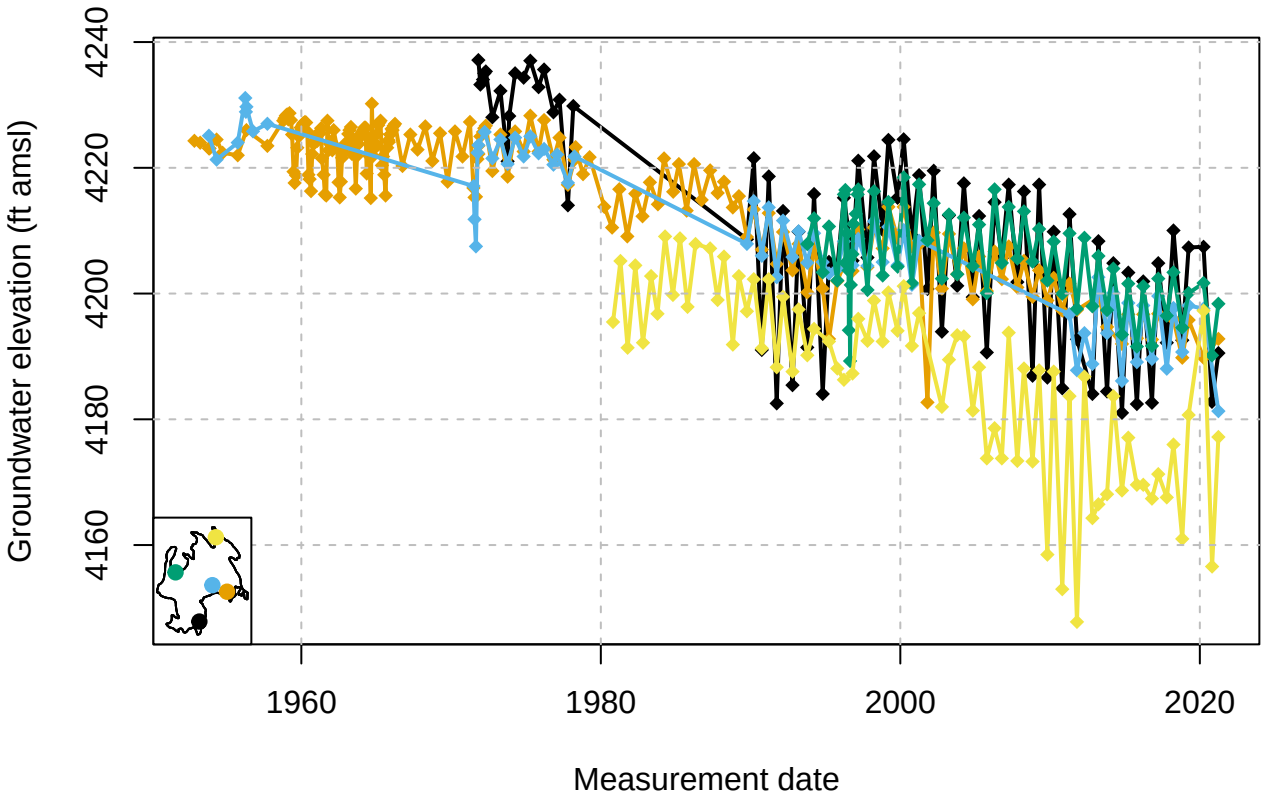


Figure 1: Groundwater elevation measurements over time in five wells, one located in each hydrogeologic zone.

1,2 Dibromoethane, arsenic, benzene, boron, nitrate, and specific conductivity. The known contaminated sites in the Basin include a PCE plume near Dorris, Calzona Tankways, and a former petroleum fueling facility.

Seawater Intrusion (Section 2.2.2.4))

The Basin is located well over 100 miles east of the Pacific Ocean with lowest observed water levels thousands of feet above mean sea level. Seawater intrusion is therefore not an issue of concern.

Land Subsidence Conditions (Section 2.2.2.5)

Land subsidence is lowering of the ground surface elevation and is not known to be currently or historically significant in the Basin. The maximum observed subsidence is approximately 0.15 ft (46 millimeters [mm]) between June 2015 to September 2019 in an area west of the City of Dorris. The change in land elevation was likely the result of localized land leveling. Land subsidence will continue to be periodically re-evaluated.

Identification of Interconnected Surface Water Systems (Section 2.2.2.6)

ISWs are defined as surface water which is connected to groundwater through a continuous saturated zone. SGMA mandates an assessment of the location, timing, and magnitude of ISW depletions, and to demonstrate that projected ISW depletions will not lead to significant and undesirable results for beneficial uses and users of groundwater.

The Basin is a hydrologically closed basin. No surface water leaves the Basin and the Basin has no major drainage. Surface waters in Butte Valley are limited to Meiss Lake (hydrologically a terminal lake) and five creeks: Butte, Prather, Ikes, Harris, and Musgrave. Many of these waterbodies go dry in the summer and fall. Groundwater elevations near the creeks have been identified as data gaps. Interpolated (i.e., estimated) groundwater levels near the creeks are generally more than 30 feet below these creeks, suggesting losing stream conditions. Lack of streamflow data are also known data gaps. Additional information is required to determine in more detail the interconnections between the surface water bodies in Butte Valley with groundwater and the magnitude and direction of flow exchange.

Identification of Groundwater Dependent Ecosystems (Section 2.2.2.7)

SGMA refers to GDEs as “ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface.”

The habitat ranges of freshwater species in the Basin with special designations (i.e., endangered, threatened, species of special concern, or on a watch list) were mapped. Riparian vegetation is prioritized for management in the Basin: managing for riparian vegetation addresses the needs of other special-status species in the Basin. These prioritized species are considered throughout the GSP, particularly in setting the sustainability indicators defined in Chapter 3 and identifying projects and management actions identified in Chapter 4. Vegetative GDE identification and classification was conducted through:

- The mapping of potential GDEs.
- Assigning rooting depths based on predominant assumed vegetation type.

- Sstablishing representations of depth to groundwater.
- Identifying potential areas where depth to groundwater, rooting depth, and presence of potential GDES confirm likely groundwater-dependence.

Potential mapped GDEs were grouped into two categories: potential GDE (where the grid-based analysis showed that the area is likely to be connected to groundwater) or potentially not a GDE (where the grid-based analysis showed that the area is disconnected from groundwater). Based on this analysis, around 10% of the mapped potential GDE area is likely connected to groundwater and assumed to be a GDE (shown in Figure 2, below). The current list of potential GDEs is considered tentative, a data gap, and dependent on collection of additional groundwater level data.

Water Budget (Section 2.2.3)

The historical water budget for the Basin was estimated for the period October 1989 through September 2018, using the Butte Valley Integrated Hydrologic Model (BVIHM). This 29-year model period includes water years ranging from very dry (e.g., 2014) to very wet (e.g., 1999). On an interannual scale, it includes a multi-year wet period in the late 1990s and a multi-year dry period in the late 2000s and mid-2010s.

The water budget is presented as flows into and out of two subsystems of the integrated watershed: the soil zone (land/soil model subsystem) and the groundwater subsystem. The water budget for the entire watershed is also included in this section.

In the historical water budget, inflows include precipitation on the valley floor (to land) and subsurface inflow or mountain front recharge from the surrounding quaternary volcanic underlying the upper watershed (to groundwater). Precipitation input is variable with a median of 86 TAF. With a median of 185 TAF, subsurface inflows are more than twice as large as precipitation. Basin outflows consist of evapotranspiration (from land) and subsurface outflow (from groundwater) with median values of 108 TAF and 169, respectively. Fluxes between the two subsystems include recharge (from land to groundwater) and groundwater pumping for applied water (from groundwater to land). Median recharge to groundwater is 54 TAF, 22 TAF lower than the median groundwater pumping value. This difference between pumping and recharge is made up for though lateral inflows into the Basin.

While soil zone storage shows minimal interannual change, aquifer storage varies, with a long-term trend indicating some groundwater depletion.

Fifty-year future projected water budgets were developed using historical hydroclimate data (for water years 1991 to 2011) and four climate change scenarios were applied to explore potential effects of global warming on the Butte Valley watershed.

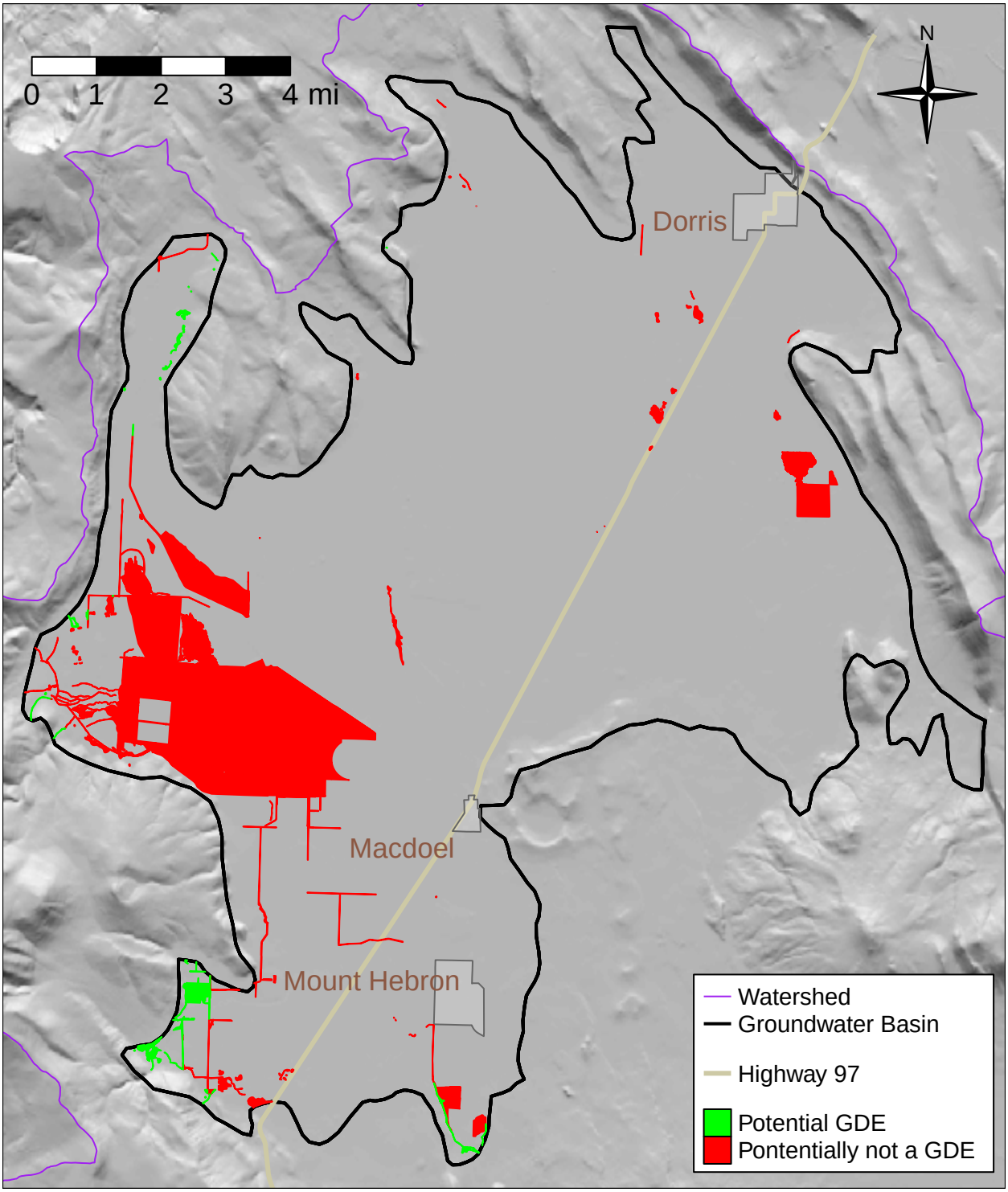


Figure 2: Categorized GDEs for the Basin.

ES-3: SUSTAINABLE MANAGEMENT CRITERIA (CHAPTER 3)

Chapter 3 builds on the information presented in the previous chapters and details the key sustainability criteria developed for the GSP and associated monitoring networks.

Sustainability Goal and Sustainability Indicators (Section 3.1)

The Sustainability Goal of the Basin is to maintain groundwater resources in ways that best support the continued and long-term health of the people, the environment, and the economy in Shasta Valley for generations to come.

The GSP details six sustainability indicators with a goal of preventing undesirable results to any one of the following sustainability indicators:

1. Chronic Lowering of Groundwater Levels
2. Reduction of Groundwater Storage
3. Degraded Water Quality
4. Depletions of Interconnected Surface Water
5. Seawater Intrusion
6. Land Subsidence

Table 3 defines undesirable results for each sustainability indicator. Quantifiable minimum thresholds (MT), measurable objectives (MO), and interim milestones were also developed as checkpoints that evaluate success in maintaining the sustainability goal and are quantified in Chapter 3 of the GSP. Monitoring wells throughout the basin will be used to assess conditions relevant to each sustainability indicator. Monitoring wells were selected based on well location, monitoring history, well information, and well access.

Table 3: Shasta Valley GSP Sustainability Indicator undesirable results defined

Sustainability Indicator	Undesirable Result Defined
Chronic Lowering of Groundwater Levels	The fall low water level observation in any of the representative monitoring sites in the Basin falls below the respective minimum threshold for 2 consecutive years.
Reduction of Groundwater Storage	Same as ”Chronic Lowering of Groundwater Levels.”
Degraded Water Quality	More than 25% of groundwater quality wells exceed the respective maximum threshold for concentration and/or concentrations in over 25% of groundwater quality wells increase by more than 15% per year, on average over ten years.
Depletions of Interconnected Surface Water	SMCs not developed for this sustainability indicator due to lack of information on interconnectedness of surface water and groundwater in the Basin. Depending on funding and the filling of data gaps, SMCs may be set in a future GSP update.

Table 3: Shasta Valley GSP Sustainability Indicator undesirable results defined *(continued)*

Sustainability Indicator	Undesirable Result Defined
Seawater Intrusion	Not applicable for the Basin.
Land Subsidence	Groundwater pumping induced subsidence is greater than the minimum threshold of 0.1 ft (0.03 m) in any single year.

ES-4: PROJECTS AND MANAGEMENT ACTIONS TO ACHIEVE SUSTAINABILITY (CHAPTER 4)

Chapter 4 describes past, current, and future projects management actions (PMAs) used to achieve the Butte Valley sustainability goal.

To achieve the sustainability goals for Butte Valley by 2042, and to avoid undesirable results over the remainder of a 50-year planning horizon, as required by SGMA regulations, multiple PMAs have been identified and considered in this GSP.

PMAs are categorized into three different tiers, as follows:

Tier I: Existing PMAs that are currently being implemented and are anticipated to continue to be implemented.

Projects or management actions in the Tier I category include:

- Abandonment of Sam's Neck Flood Control Facility
- City of Dorris Water Conservation
- Well Drilling Permits and County of Siskiyou Groundwater Use Restrictions
- Kegg Meadow Enhancement and Butte Creek Channel Restoration
- Permit required for groundwater extraction for use outside the basin from which it was extracted (Siskiyou County Code of Ordinances)
- Upland Management
- Watermaster Butte Creek Flow Management

Tier II: PMAs planned for near-term initiation and implementation (2022 to 2027) by individual member agencies.

Tier II PMAs include:

- High Priority PMAs - Data Gaps and Data Collection
  - Butte Valley Integrated Hydrologic Model (BVIHM) Update (High Priority)
  - Drought Year Analysis (High Priority)
  - Expand Monitoring Networks (High Priority)
  - General Data Gaps (High Priority)
  - Groundwater Dependent Ecosystem Data Gaps (High Priority)
  - Interconnected Surface Water Data Gaps (High Priority)
- Avoiding Significant Increase of Total Net Groundwater Use from the Basin

- Management of Groundwater Use and Recharge
- Conservation Easements
- Dorris Water Meter Installation Project
- Irrigation Efficiency Improvements
- Public Outreach
- Voluntary Managed Land Repurposing (not including Conservation Easements)
- Well Inventory Program
- Well Replacement

Tier III: Additional PMAs that may be implemented in the future, as necessary (initiation and/or implementation 2027 to 2042).

Tier III PMAs, identified as potential future options, include:

- Alternative, Lower ET Crops
- Butte Creek Diversion Relocation
- Butte Valley National Grassland Groundwater Recharge Project
- Strategic Groundwater Pumping Restriction

Additionally, other management actions are outlined that may be explored during GSP implementation are outlined.

ES-5: PLAN IMPLEMENTATION, BUDGET AND SCHEDULE (CHAPTER 5)

Section 5 details key GSP implementation steps and timelines. Cost estimates and elements of a plan for funding GSP implementation are also presented in this section.

Implementation of the GSP will focus on the following several key elements:

1. GSA management, administration, legal and day-to-day operations.
2. Implementation of the GSP monitoring program activities.
3. Technical support, including BVIHM model updates, SMC tracking, and other technical analysis.
4. Reporting, including preparation of annual reports and five-year evaluations and updates.
5. Implementation of PMAs.
6. Ongoing outreach activities to stakeholders.

Annual implementation of the GSP over the 20-year planning horizon is projected to cost between $135,000 and $230,000. The GSA may pursue funding from state and federal sources for GSP implementation. As the GSP implementation proceeds, the GSA will further evaluate funding mechanisms and fee criteria and may perform a cost-benefit analysis of fee collection to support consideration of potential refinements.

Chapter 1

Introduction

1.1 Background and Purpose

In September 2014, Governor Jerry Brown signed into law the Sustainable Groundwater Management Act (SGMA), a three-bill legislative package composed of Assembly Bill (AB) 1739 (Dickinson), Senate Bill (SB) 1168 (Pavley) and SB 1319 (Pavley), which is codified in Section 10720 et seq. of the California Water Code. The legislation provides a framework for long-term sustainable groundwater management across California. The intent of SGMA is to provide local and regional agencies the authority to sustainably manage groundwater resources to help preserve water supplies for existing and potential beneficial uses and to protect communities, farms, and the environment against prolonged dry periods and climate change.

The California Department of Water Resources (DWR) and the State Water Resources Control Board (SWRCB) provide primary oversight for implementation of SGMA. DWR adopted regulations that specify the components and evaluation criteria for groundwater sustainability plans, alternatives to Groundwater Sustainability Plans (GSPs), and coordination agreements to implement such plans. To satisfy the requirements of SGMA, local agencies must do the following:

- Locally controlled and governed Groundwater Sustainability Agencies (GSAs) must be formed for all high- and medium-priority groundwater basins in California.
- GSAs must develop and implement GSPs or Alternatives to GSPs that define a roadmap for how groundwater basins will reach long-term sustainability.
- The GSPs must consider six sustainability indicators defined as: groundwater level decline, groundwater storage reduction, seawater intrusion, water quality degradation, land subsidence, and surface-water depletion.
- GSAs must submit annual reports to DWR each April 1 following adoption of a GSP with the first report due April 2022.
- Groundwater basins should reach sustainability within 20 years of implementing their GSPs.

The Butte Valley groundwater basin (Basin) is a medium priority basin in Siskiyou County in Northern California. A description of the Basin, including a summary of the jurisdictional areas, water resources monitoring and management, land use, and groundwater conditions are presented in Chapter 2.

In accordance with SGMA, this GSP was developed and will be implemented by the GSA representing the Basin, the Siskiyou County Flood Control and Water Conservation District.

Per SGMA requirements, the GSA is responsible for developing and submitting a GSP, by January 31st, 2022. The GSA feels the GSP will provide long-term sustainability for all beneficial uses and users of water. The GSA also anticipates these plans will be a tool used for the overarching watershed goal of improving water management in the watershed bringing multiple interests to the table to resolve water conflicts in the Basin.

1.2. Sustainability Goal

The overall sustainability goal of groundwater management in the Basin is to maintain groundwater resources in ways that best support the continued and long-term health of the people, the environment, and the economy in the Basin, for generations to come. Further description of the sustainability goal, as it relates to the sustainability indicators, is included in Chapter 3.

1.3. Agency Information and Management Structure

1.3.1. Agency Information

Siskiyou County Flood Control and Water Conservation District
190 Greenhorn Road
Yreka, CA 96097

1.3.2. Organization and Management Structure

The Siskiyou County Flood Control and Water Conservation District is the sole GSA for the Basin. The Siskiyou County Flood Control and Water Conservation District Act (Cal Uncod. Water Deer, Act 1240 §§ 1-38) was adopted by the State Legislature in 1959. This Act established a special district of the same name, and of limited powers that could provide flood protection, water conservation, recreation and aesthetic enhancement within its boundaries. At the time of its creation, the jurisdictional boundaries of the Flood District were smaller than those of the County. In 1983, following County of Siskiyou Local Agency Formation Commission (LAFCO) action, the balance of the County was annexed into the District, making its jurisdictional boundaries coincide with the County. The District is governed by a Board of Directors that is composed of the Board of Supervisors; however, the District is a separate legal entity from the County, with independent rights and limited powers set forth in its originating act. The District's purpose is the conservation and control of storm, flood, and other waters and ensuring beneficial use thereof.

1.3.3. Legal Authority of the GSA

Approved by the District Board on April 4th, 2017, the Siskiyou County Resolution FLD17-01 authorized the District to act as the GSA for the Butte, Scott and Shasta Valley groundwater basins.

1.3.4. Contact Information for Plan Manager

The Siskiyou County Natural Resources Department is designated as the plan manager, and can be reached at:

1312 Fairlane Rd
Yreka, CA 96097
Phone: 530-842-8005
SGMA@co.siskiyou.ca.us

1.3.5. Estimated Cost of Implementing GSP and GSA's Approach to Meet Costs

The GSA will pursue all available grant funding opportunities to assist in covering the yearly costs. The GSA utilized a consultant to conduct a fee study, in case the GSA feels funds need to be

raised publicly to pay for yearly management of the plans. It is expected that the GSA will manage implementation and reporting of the GSP, with support from other entities as needed.

1.4. Notice and Communication

1.4.1. Notice

GSP information, GSA Board and Advisory Committee meeting schedules, and useful links can be found at the County of Siskiyou Website.[1]

The GSA holds publicly noticed public Board and Advisory Committee meetings to allow stakeholders to engage and provide input throughout the process, as well as meetings with specific working groups in the Basin to address specific technical topics or questions. As the GSP is developed and implemented, the website will be updated accordingly with new information for public comment. Notices of public hearings are communicated through multiple methods including local newspapers and postings on the County of Siskiyou website. A SGMA email outreach list exists to inform the public on meeting information, subjects, and how to provide comments.

1.4.2. Decision Making Process

The Siskiyou County Flood Control and Water Conservation District is governed by the Siskiyou County Board of Supervisors and covers the entire boundaries of each of the three medium priority basins. The District was enacted in 1957 to provide for the control and conservation of flood and storm waters and the protection of watercourses, watersheds, public highways, life and property from damage or destruction from such waters; to provide for the acquisition, retention, and reclaiming of drainage, storm, flood, and other waters and to save, conserve, and distribute such waters for beneficial use within the District boundaries, and to replenish and augment the supply of water in natural underground reservoirs. The District's Board of Directors is composed of the Siskiyou County Board of Supervisors, which are elected by the citizens of Siskiyou County. The District operates under the authority of the Board of Directors and Siskiyou County Natural Resources staff manages the GSP development and implementation.

Decisions of the District are completed pursuant to a majority vote. Actions of the Board are informed with input of the Butte Valley Advisory Committee, a community based organization who's members are appointed by Board members. Meetings of the Advisory Committee are publicly noticed consistent with the Brown Act. The public, stakeholder working groups, non-profit organizations and other users and uses of groundwater are encouraged to participate in GSP implementation at publicly noticed Board and Advisory Committee meetings.

[1] {https://www.co.siskiyou.ca.us/naturalresources/page/sustainable-groundwater-management-act-sgma}

1.4.3. Public Outreach

1.4.3.1. Communication and Engagement Plan

The Siskiyou County Groundwater Sustainability Agency developed a Butte Valley Basin Stakeholder Communication and Engagement Plan (C&E Plan) to educate interested parties about local SGMA implementation, describe the phases of GSP development, encourage public participation in the process, and address noticing and communication requirements in the law (Appendix 1-A).

The C&E Plan describes how the local GSA was formed in Siskiyou County, the support role played by technical and facilitation consultants, and the process by which the GSA board of directors (GSA Board) — with support from a stakeholder advisory committee — gathers, considers, and responds to needs and interests of constituents throughout the community. Consensus building is a foundational principle of all committee discussions, and membership is intended to reflect the diversity of beneficial groundwater uses and users in the Basin.

The GSA maintains a government-to-government relationship with any Native American Tribe in Siskiyou County or the larger Klamath River watershed which expresses interest in SGMA. Tribal representatives have been appointed to the advisory committees in the Scott Valley, Shasta Valley and Butte Valley groundwater basins. Moreover, Siskiyou County and the Karuk Tribe formalized good faith communication protocols around SGMA through an established memorandum of understanding.

The Butte Valley C&E Plan includes the following overarching public outreach goals:

- Provide the GSA, Advisory Committee, community leaders and other beneficial users a roadmap to ensure broad understanding and consistent messaging of SGMA requirements.
- Foster information sharing, communication and collaboration, and opportunities for stakeholders to have meaningful input on the GSA decision-making process.
- Provide reasonable opportunities for interested stakeholders to receive and understand the technical groundwater information developed as part of the GSP process.
- Ensure a collaborative GSP development and implementation process that is widely seen in the community as fair and respectful to the range of interested or affected stakeholders.
- Assist the GSA in meeting all SGMA communication and engagement requirements.

Specific objectives which help the GSA achieve these overarching goals include the following:

- Educate stakeholders on:
  - Important SGMA requirements, events and milestones.
  - The role, authorities and responsibilities of the local GSA in Siskiyou County.
  - The advisory committee's role and how the public can stay informed or involved.
  - The benefits of having a technically robust and broadly supported GSP.
  - Potential changes to groundwater monitoring and management under SGMA.
  - How the interests of beneficial uses and users will be considered under SGMA.
- Develop strategies and communication mechanisms for obtaining broad stakeholder input and feedback that informs GSP development.
- Coordinate outreach and engagement activities that foster information sharing, raise awareness, and encourage public engagement in SGMA.

- Ensure the needs, interests, and perspectives of all beneficial uses and users are identified, documented and considered by the GSA Board.
- Support local beneficial users to identify, preempt or otherwise proactively address and resolve different perspectives or conflicts over groundwater use and management.
- Track all input received by beneficial users during the GSP development process and document GSA Board responses as input is considered.
- Develop strategies and communication mechanisms for long-term GSP implementation.

A comprehensive list of identified stakeholder groups in the Basin is included in the C&E Plan. Initially developed by GSA staff, the list was reviewed and expanded by the local SGMA advisory committee. The list may be improved and updated at any time during the GSP development or implementation process. Stakeholder groups included in the list represent a priority target audience for SGMA-related communication and engagement.

The final section of the C&E Plan describes outreach strategies which the local GSA employs to effectively advance SGMA implementation. Specific tools and forums include the following:

- Advisory committee meetings
- Constituent briefings with local organizations
- Tribal engagement
- Public meetings and workshops
- GSA Board meetings
- Coordination with local resource conservation districts
- Coordination with state and federal agencies
- Integration of relevant studies and materials
- Interested parties list
- Informational materials
- County SGMA website
- Local media and public service announcements

The local GSA will evaluate the effectiveness and efficacy of its C&E Plans for each SGMA groundwater basin in Siskiyou County. Evaluations will likely occur at or near key milestones, such as the completion of a major phase of work or shortly before or after submission of the GSP for evaluation by DWR. As needed, the C&E Plan will be updated to best serve Siskiyou County, its constituents, and all its collaborative partners in the SGMA implementation process.

1.4.3.2. Butte Valley Basin Beneficial Uses and Users

Groundwater in the Basin serves the needs of communities, farms, and businesses and provides high quality drinking water to urban and rural residents, in addition to helping to sustain vital ecosystems. Beneficial uses of groundwater include water for irrigation, agriculture, domestic use, municipal use, and water for the protection and enhancement of fish and wildlife. Beneficial uses and users of the Basin have been identified as the following:

- Agricultural users (farmers, ranchers, dairy professionals).
- Rural, Agricultural, and Domestic well owners.
- Municipal well operators.

- Public water systems.
- Local land use planning agencies.
- Environmental uses and users of groundwater, including but not limited to habitat that supports fish, birds, animals and insects; endangered species protection; protection of beneficial habitat for recreation and other societal benefits.
- Surface water users.
- Tribal Governments.
- Disadvantaged communities (the entire Basin is a DAC or SDAC, see map in Chapter 2 - Section 2.1.1).

1.4.3.3. Public Engagement Opportunities

The GSA is committed to encouraging the active involvement of diverse social, cultural, and economic elements of the population within the Basin. The County of Siskiyou website provides information regarding GSA Board Meeting frequency, background information, documents, status updates, and contact information. GSP updates will be included as noticed per GSA respective meeting agendas that are published in advance. Meetings providing updates on GSP development are scheduled regularly, typically once a month, to inform the public and Interested Parties and provide opportunities to ask questions and make suggestions. These meetings are posted on the County of Siskiyou website and announced via email. A full list of public meetings where the GSP was discussed or considered are included in Appendix 1-B.

In addition, GSP Staff will be available throughout the GSP development process to communicate and engage with Interested Parties and the public. Interested Parties can be involved in GSP development by providing input throughout the process.

Other avenues for public engagement included or will include:

- **GSA Board meetings**: During Public comment period of any Siskiyou County Board of Supervisors or Siskiyou County Flood Control & Water Conservation District (GSA) Board meetings
- **Working Groups**: Working groups may be formed during GSP implementation to provide specific input from Interested Parties or on specific topics.
- **Comments**: Opportunity for the public or interested parties to comment on draft GSP sections or chapters is provided. Comments received through this process, and the responses provided are included in Appendix 1-C.

1.4.4. Coordination

GSA and Siskiyou County staff, and at times technical team, held coordination meetings or phone calls to provide additional input into the GSP with various state agencies, Tribes, non-governmental organizations (NGOs), or members of the public. GSA staff and at times the technical team also attended non-SGMA focused workshops to provide updates or information regarding SGMA and the GSP development. Some highlights of those efforts are below:

- **California Department of Fish and Wildlife (CDFW)**

  - GSA staff has monthly coordination meetings with CDFW staff to discuss numerous topics, which includes SGMA updates and key items and issues related to groundwater management.

- **Shasta Indian Nation**
- **Klamath Coalition of the Willing**

  - This is a large group of NGOs, Tribes, and irrigators brought together to develop solutions related to the Klamath Basin conflicts. County staff and the technical team has interacted with the group and developed project ideas that are either being implemented or in initial design phases, including managed aquifer recharge, storage development and improving upland lake management. These projects are further described in Chapter 4.

- **Butte/Tulelake**

  - GSA staff and the technical team has met with Lower Klamath Wildlife Refuge manager to discuss findings of possible existing connections between the groundwater basins. The Lower Klamath is a low priority basin and therefore is not required to develop a GSP.
  - GSA and the Butte Valley technical team met with the technical consultant team for Tule Lake to share results and expected GSP outcomes.

1.5. GSP Organization

The GSP is organized in accordance with the GSP Emergency Regulations and statutory provisions of SGMA. The format of the GSP is similar to the outline provided by DWR's Sustainable Groundwater Management program. A brief summary of each GSP section is provided below.

- **Executive Summary**. Provides a summary of what is included in the GSP.
- **Chapter 1 – Introduction**. The Introduction includes the purpose and administration of the GSP, sustainability goal, agency information, and GSP organization.
- **Chapter 2 – Plan Area and Basin Setting**. Plan Area describes the geographic setting, existing water resources planning and programs, and additional GSP components. The Basin Setting includes a detailed discussion of the hydrogeologic conceptual model used to prepare the GSP; current and historical groundwater conditions; future groundwater conditions after allowances for growth, land use changes, and climate change; and a discussion of the area's current and future groundwater budget.
- **Chapter 3 – Sustainable Management Criteria**. Includes the sustainability goal, addresses the mandated six sustainability indicators (SI) that monitor undesirable results; defines the minimum thresholds (MT) for each undesirable result; and sets measurable objectives (MO) for the GSP complete implementation, including interim milestones for intermediate plan years. This Chapter also describes the network of monitoring wells and other information to measure the GSP outcome; assesses the need for improvements to the network to provide fully representative data; and address monitoring protocols and data analysis techniques.
- **Chapter 4 – Projects and Management Actions to Achieve Sustainability**. Describes potential projects and management actions (PMAs) that may be implemented in pursuit of sustainability. Where available, project details include measurable objectives that are expected to benefit from the PMA, required permits, anticipated benefits, estimated costs, and how the PMA will be accomplished.

- **Chapter 5 – Plan Implementation**. Describes the GSP implementation process, including estimated costs, sources of funding, a preliminary schedule through full implementation, description of the required data management system, methodology for annual reporting, and how progress evaluations will be conducted over time.
- **Appendices – References and Technical Studies**. Contains the references and sources used to prepare this GSP.
  - **DWR GSP Elements Guide**– This GSP was prepared to meet the regulatory requirements established by DWR, as shown in the completed GSP Elements Guide, provided in Appendix 1-D, which is organized according to the California Code of Regulation Sections of the GSP Emergency Regulations.

Chapter 2

Plan Area and Basin Setting

2.1 Description of the Plan Area

2.1.1 Summary of Jurisdictional Areas and Other Features

The Butte Valley groundwater basin (Basin) is a 79,700 acre (125 square mile [sq mi]; 326 square kilometer [sq km]) subbasin within the upper Klamath Groundwater Basin that extends between California and Oregon (Wood 1960; Gannett, Wagner, and Lite Jr. 2012). The Butte Valley watershed (Watershed) is roughly three times larger than the Basin and contains two other Department of Water Resources (DWR) recognized groundwater basins. The Watershed is the drainage area that recharges surface water in the Basin, shown in Figure 2.1. The Watershed is located immediately northeast of Mount Shasta, whose flank can be seen in the bottom left corner of Figure 2.1.

The predominately agricultural Basin is in northern Siskiyou County, California, just south of the Oregon border (see Figure 2.1). Under the 2019 basin prioritization conducted by DWR, the Basin (DWR Basin 1-003) is designated as medium priority (DWR 2019d). The Basin sits on the western edge of the Modoc Plateau, a broad and rugged volcanic upland with land surface elevations generally between 4,500 to 5,000 feet (ft; 1371 to 1524 meters [m]) above mean sea level (amsl) (Gannett, Wagner, and Lite Jr. 2012). The Basin is located at an elevation of about 4,200 ft (1280 m) amsl and is topographically closed and bounded by topographic highs in all directions: the Cascade Mountains in the north, south and west, the Mahogany Mountain ridge in the east and Sheep Mountain and Red Rock Valley in the southeast (DOI 1980; DWR 2004). The Basin contains Meiss Lake, the remnant of a prehistoric lake that once filled Butte Valley, and several streams that all flow into the Basin from the surrounding Watershed, as shown in Figure 2.1 (King 1994). Butte Creek is the largest stream flowing into Butte Valley.

2.1.1.1 Jurisdictional Areas and Land Use

The Siskiyou County Flood and Water Conservation District serves as the Groundwater Sustainability Agency (GSA) for the Basin. The Basin has three notable population centers: the City of Dorris (Population: 962), Macdoel (Population: 155), and Mount Hebron (Population: 81) (DWR 2016b). Due to their small populations, Macdoel and Mount Hebron are described as census-designated places by the United States (U.S.) Census Bureau. U.S. Highway 97 crosses the Basin from the southwest to northeast, passing through Dorris and Macdoel. The Union Pacific Railroad passes through Butte Valley from north to south, passing through all three cities. The railroad generally follows U.S. Highway 97 between Macdoel and Dorris and leaves the Valley north of Dorris via a train tunnel through the Mahogany Mountain ridge. South of Mount Hebron, the railroad generally follows the path of Butte Creek (Figure 2.1). The Basin and Watershed do not contain any tribal lands or tribal interests.

Disadvantaged Communities

There are three severely disadvantaged communities (SDACs) in the Basin that suffer from a combination of economic, health, and environmental burdens (Figure 2.3). By definition, disadvantaged communities (DACs) have a median household income (MHI) less than 80% of the statewide MHI while SDACs are below 60%. All three of the communities in the Basin are categorized as SDACs: Dorris has a MHI of $28,963, Macdoel has a MHI of $35,294, and Mount Hebron has a MHI of $28,170 (DWR 2016b). All SDAC communities rely on groundwater as

their sole source of drinking water, using a combination of municipal water district, small water suppliers, and domestic wells.

Water Suppliers

The Basin has no adjudicated areas and contains one irrigation district, one water district, and four small water suppliers (Figure 2.2). The Butte Valley Irrigation District (BVID) is a private water supplier that manages irrigation water for roughly 5,000 acres (20 square kilometers [sq mi]) of land northwest of Mount Hebron. It manages the largest groundwater distribution and management network in the Basin and distributes water throughout the service area through a network of pipes. Farms serviced by the irrigation district are allocated two acre-feet per acre per year (AFY; 0.6 meters per year [m/yr]). BVID supplies water from approximately 20 wells out of its 25 well network. The City of Dorris has a small municipal water district serving approximately 938 residents (McKay 2019). It has two wells in its supply network. However, one well is only used as an emergency supply (McKay 2019). Groundwater supplies 100% of the district water supply (McKay 2019).

In the region surrounding Macdoel and Mount Hebron, four small water suppliers report to the California Department of Public Health (CDPH) (SWRCB 2019a). Macdoel Waterworks operates in the middle of Macdoel and serves a population of 20 with two monitoring wells (SWRCB 2019a). Juniper Village Farm Labor Housing is located southeast of Macdoel and has one groundwater well serving a population of 200 (SWRCB 2019a; SWRCB 2019c). The Mt. Hebron Work Center is operated by the U.S. Forest Service (USFS) and operates in the middle of Mount Hebron with one groundwater well serving a population of 30 (SWRCB 2019a; SWRCB 2019c). The USFS Goosenest District Office operates west of Mount Hebron alongside U.S. Highway 97. It has one groundwater well serving a population of 30 (SWRCB 2019a; SWRCB 2019c).

Federal Managed Lands

Over 40% of the Basin is covered by federal and state managed lands, as shown in Figure 2.2. Federally managed land consists of the Klamath National Forest, including the Butte Valley National Grassland and small sections of the National Forest along the Basin border. The Butte Valley National Grassland is primarily north of U.S. Highway 97, covering 18,400 acres (74 sq km) or 23% of the total Basin surface area. Butte Valley Grassland became the nation's 20th National Grassland in 1991 after strong support from the local Congressional delegation, California Cattlemen's Association, California Department of Fish and Wildlife (CDFW; formerly California Department of Fish and Game), and the local public.

After serving as a military practice bombing range in the 1940s, the federal government and Natural Resources Conservation Service (formerly Soil Conservation Service) re-stabilized the soil by planting over 4,000 acres (16 sq km) of crested wheatgrass. They worked with local ranchers to set up grazing associations and developed local conservation practices, which continue to the present day. Today, the National Grassland is shrub-steppe, with sagebrush, rabbitbrush, bitterbrush, basin wildrye, intermediate wheatgrass, and other arid grasses and flowers with scattered western juniper trees. Grazing cattle reside within the National Grassland alongside local wildlife including mule deer, Roosevelt elk, pronghorn, coyote, marmot, weasel, porcupine and bobcat. Resident bird species include Swainson's Hawk, golden eagle, bald eagle, merlin, sandhill crane, great horned owls, short-eared owls, and long-eared owls, with winter visitors including red-tailed hawk, Ferruginous Hawk, rough-legged hawk, northern harrier, American Kestrel, and prairie falcon (USFS 2020).

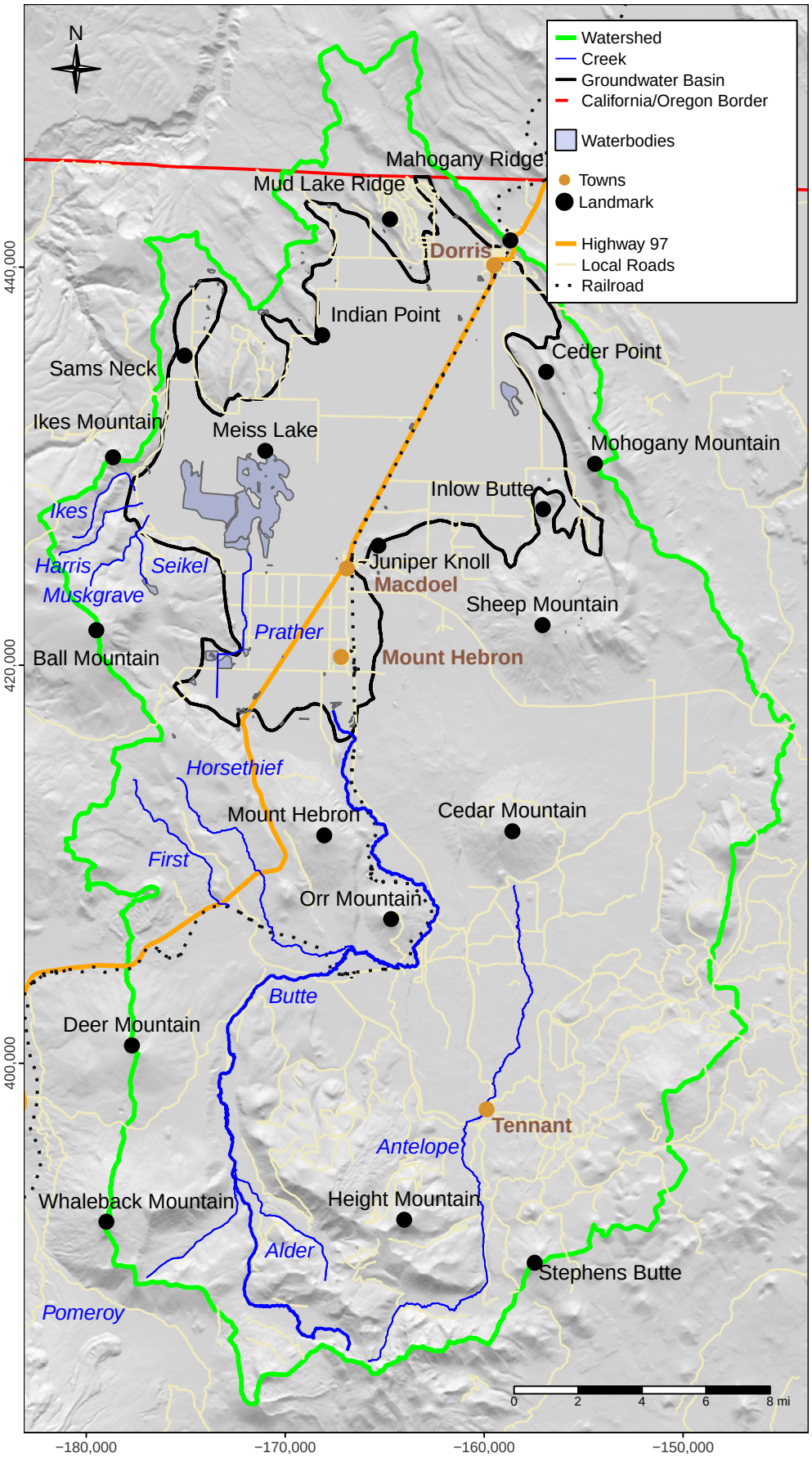


Figure 2.1: Butte Valley Watershed and Groundwater Basin Boundary

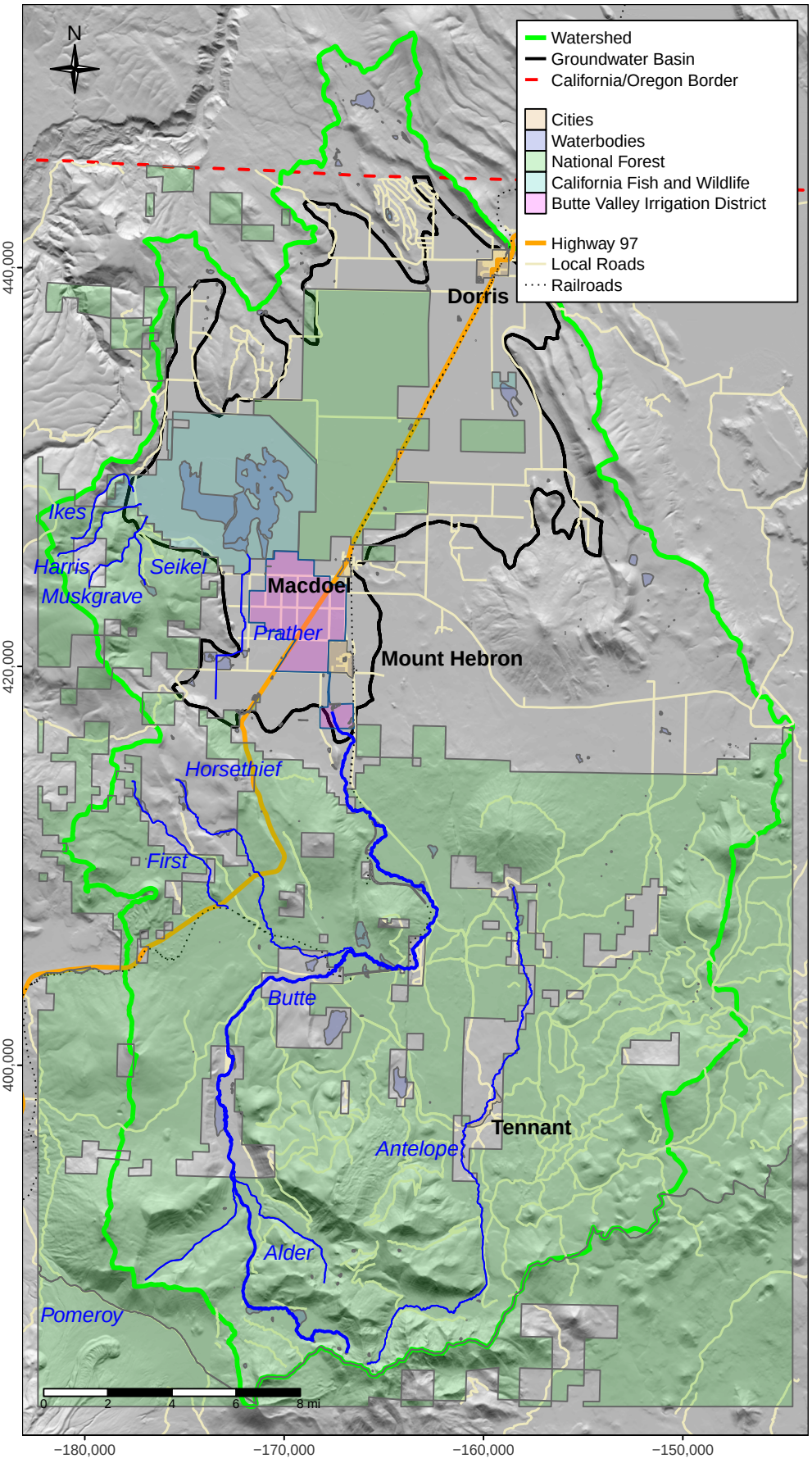


Figure 2.2: Butte Valley Watershed Jurisdictional Authorities.

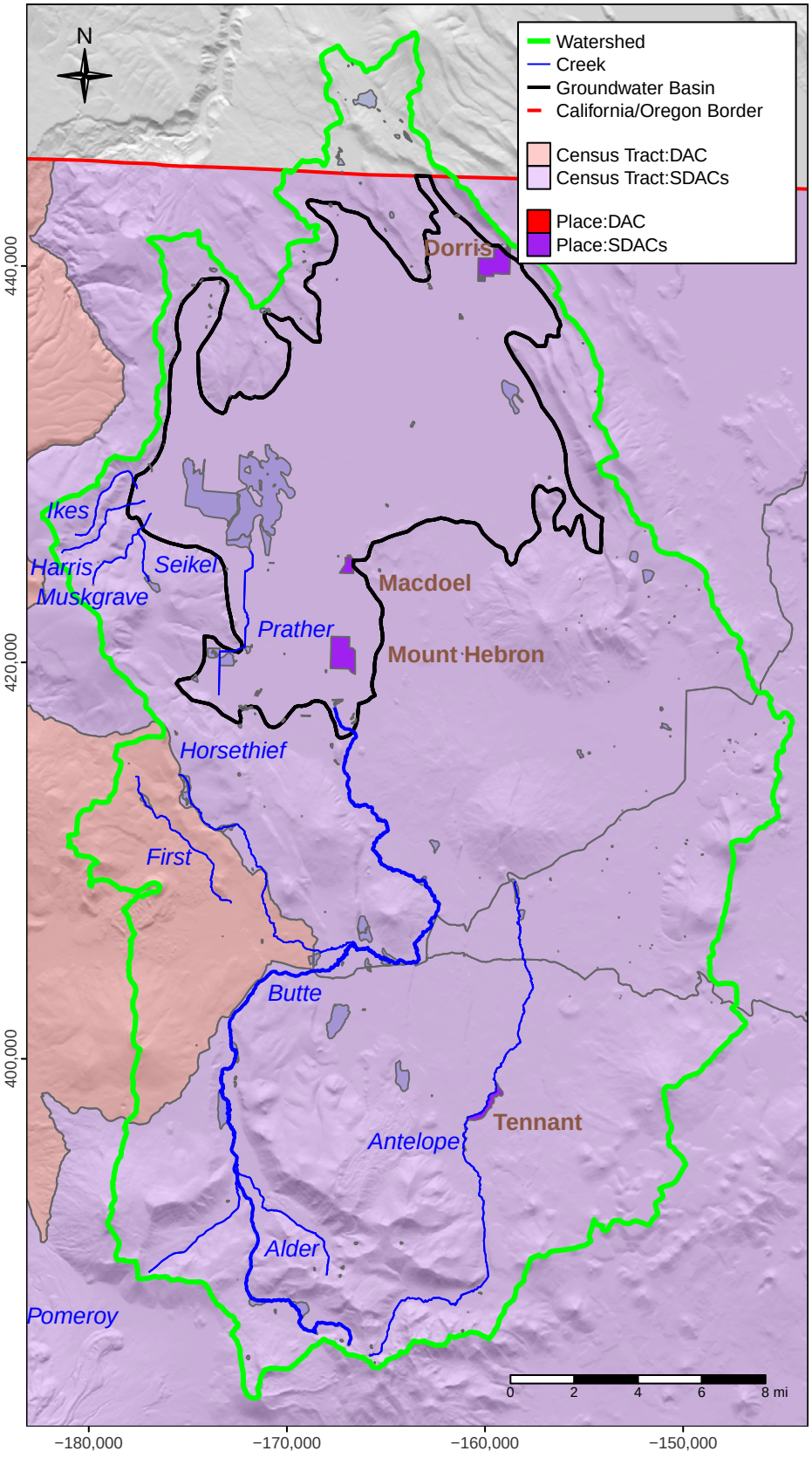


Figure 2.3: Based on the 2016 U.S. Census, place and tract boundaries of Disadvantaged Communities (DACs: $42,737 <= MHI < $56,982) and Severely Disadvantaged Communities (SDACs: MHI < $42,737) in the Butte Valley watershed, using data from the DWR DAC Mapping Tool (DWR 2016b).

During World War II the US Navy used 7,040 acres (28 sq km) of land to develop the Siskiyou Rocket and Bombing Range, an aerial gunnery range used in winter when other stations were inhibited by poor weather conditions. By May 1945, the U.S. Navy gained use of the area for air-to-ground firing, high and low level bombing and strafing. Sub-Caliber Aerial Rockets were used at the site. The area covered parts of the Butte Valley National Grassland and Butte Valley Wildlife Area. The U.S. Department of Defense (DOD) has conducted site inspection and monitored the site for discarded military munitions and explosives, including unexploded ordinance. In 1984, a wildlife survey discovered a rocket that was removed by the DOD, though only inert practice rockets were used at the site. Qualitative site reconnaissance and soil sampling found that metal pollution does not exceed human health screening values. The Department of Toxic Substances Control is the oversight and cleanup agency for the site, but no further action is planned as of September 2013. The cleanup site floods in the winter and is populated with grazing cattle the rest of the year (DTSC 2020).

State Managed Lands

The state owns 13,500 (55 sq km) acres within the Basin, or 17% of the total Basin surface area, which includes the Butte Valley Wildlife Area (BVWA) and a small property at Mud Lake, as shown in Figure 2.2. The BVWA is approximately 13,400 acres (54 sq km) and contains wetlands, sage flats, farmlands, and the 4,000 acre (16 sq km) Meiss Lake. BVWA is 13,200 acres (53.4 sq km) with 4,400 acres (17.8 sq km) of intensively managed wetlands, 4,000 acres (16.2 sq km) of Meiss Lake, and 4,800 acres (19.4 sq km) of habitat (NCRWQCB 2008). It is bordered by the federal Klamath National Forest on the east and southwest. The Fish and Game Commission designated the site as a wildlife area in 1981 and it is currently managed by CDFW. Over 200 species of birds can be spotted in the Wildlife Area. Recreational activities include camping, hiking, wildlife viewing, and hunting. Hunting options include waterfowl, coots, moorhens, snipe, and doves. Four grain fields lie on the west and south side of the Wildlife Area. The small property at Mud Lake is owned but not managed by the state.

Land Use

Historical land use maps for Butte Valley are not available before 1996. Even without detailed historical land use surveys, there are enough historical records to form an image of changing land use over time. Irrigated land in Butte Valley has increased from approximately 12,000 acres (4,850 hectares) in 1952 to over 37,000 acres (15,000 hectares) in 2010 as shown in Figure 2.5 (County of Siskiyou 1996; DWR 2010). Early records for Butte Valley do not track irrigated land by water supply or crop type, but between 2000 and 2010 the fraction of land irrigated by groundwater also increased as shown in Figure 2.5 (DWR 2000, 2010).

Butte Valley's economy is dominated by agriculture. The 2010 County land use survey assessed 60.8% of the Basin area and identified the following land use percent coverage: agriculture (38.7%), idle land (5.3%), and urban (10.6%). As of 2010 the major crops in Butte Valley were alfalfa, hay, and strawberry, which occupied approximately 18,400 acres, 8,000 acres, and 3,300 acres (7,450 hectares, 3,240 hectares, 1,300 hectares) respectively (DWR 2010). Butte Valley National Grassland is not included in the land use survey, but a number of local ranchers have permits to graze cattle (USFS 2020). Acreages associated with various land uses surveyed by DWR in 2010 are shown spatially in Figure 2.4, and numerically in Table 2.1 (DWR 2010).

Strawberry is a significant economic commodity in Butte Valley. Recent market prices are $50,000 per acre of strawberries compared to $1,040 per acre of alfalfa (in 2016) and $822 per acre of

Table 2.1: Acreage and percent of total Basin area covered by all identified land uses in the 2010 DWR land use survey.

Land Use Description	Acres	Percent of Basin Area
Alfalfa pasture	16,081	20.2
Grain and Hay	8,110	10.2
Urban Vacant	7,242	9.1
Riparian Vegetation	4,543	5.7
Idle	4,192	5.3
Truck and Nursery and Berry Crops	3,633	4.6
Pasture	2,341	2.9
Urban Residential	819	1.0
Semiagricultural and Incidental to Agriculture	655	0.8
Water Surface	398	0.5
Urban Industrial	292	0.4
Urban Commercial	51	0.1
Barren and Wasteland	1	0.0
Urban Landscape	17	0.0

hay (in 2016) (Smith 2016). Butte Valley produces approximately 500 million plants annually (Nelson 2021). Strawberries in California grow on approximately 39,000 acres (USDA 2020a) and approximately 3,000 of those acres are from nursery production in Butte Valley.

Butte Valley crops have several different growing cycles. Alfalfa is grown for four to six years before ripping soil and reseeding. In contrast, hay, idle/fallow, and strawberry rotate in three annual cycles with strawberries replanted in the same field every three years (Nelson et al. 2019). Each year that a field is part of the strawberry rotation it is either used for hay, idle, or strawberry. In 2010 approximately 9,900 acres (4,000 hectares) were part of that rotation. Strawberry is only grown from March to September and receives irrigation throughout (Nelson et al. 2019). A small amount of garlic, occupying less than 400 acres, is also grown from September to August with irrigation throughout the winter if precipitation is insufficient.

Strawberry is grown and harvested in Butte Valley for daughter plant production. Mother plants are started under protective coverings where they are grown for approximately twelve weeks under 22-inch tall micro-tunnels of flat fabric slightly above crops (Nelson et al. 2019). After twelve weeks the micro-tunnels are removed and the plants are allowed to produce stolons, commonly called runners, which produce daughter plants (Nelson et al. 2019). Eventually the daughter plants produce roots and form independent cloned plants from the mother plant. The harvested product grown in Butte Valley are live plants for transplant. Daughter plants are then transplanted to other regions where they produce fruit. In mid to late September, the field is harvested for strawberry plants, which are later transported to other parts of the United States for eventual berry production (Nelson et al. 2019).

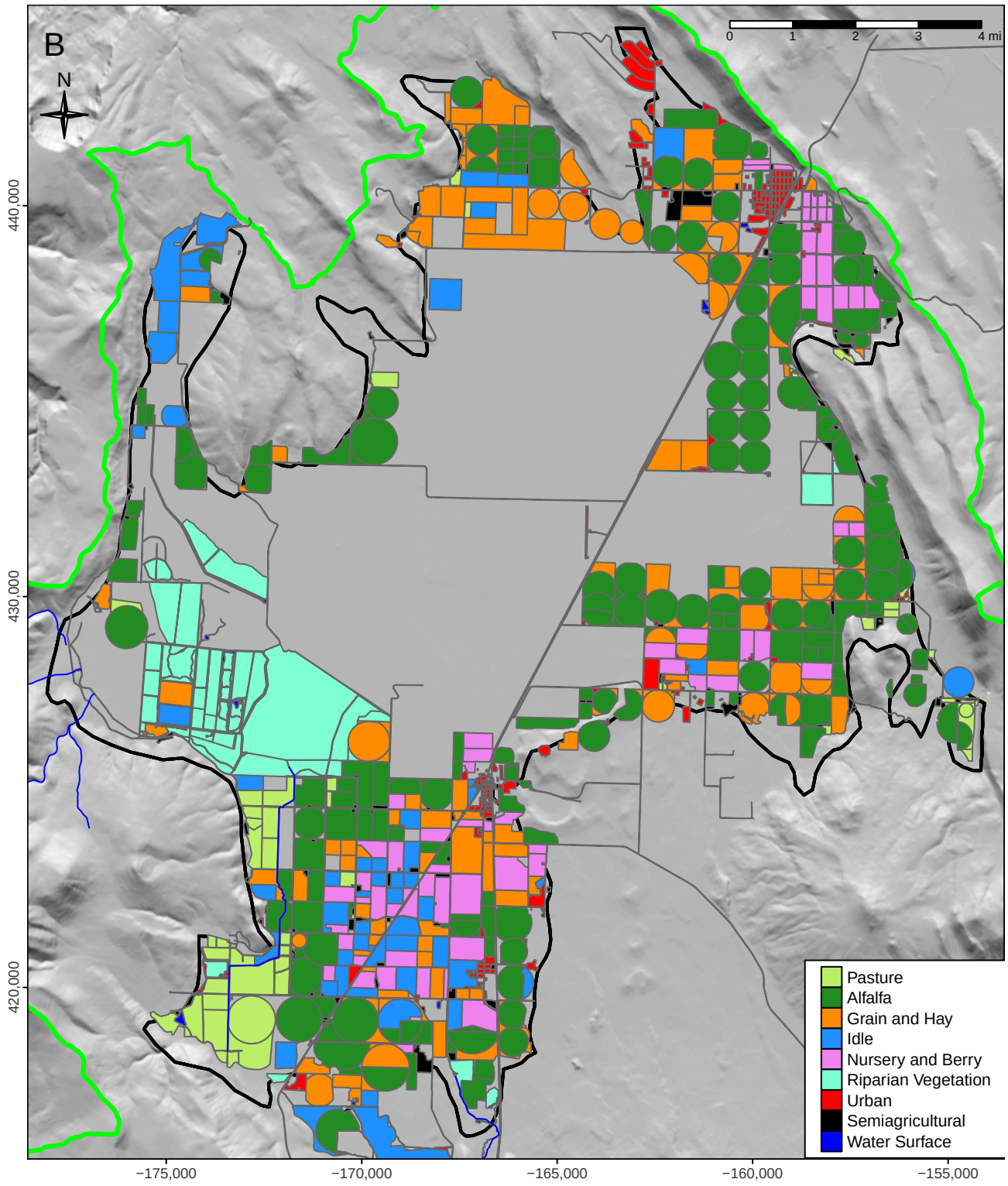


Figure 2.4: Land uses within the Butte Valley Groundwater Basin boundary taken from the DWR 2010 Land Use Survey.

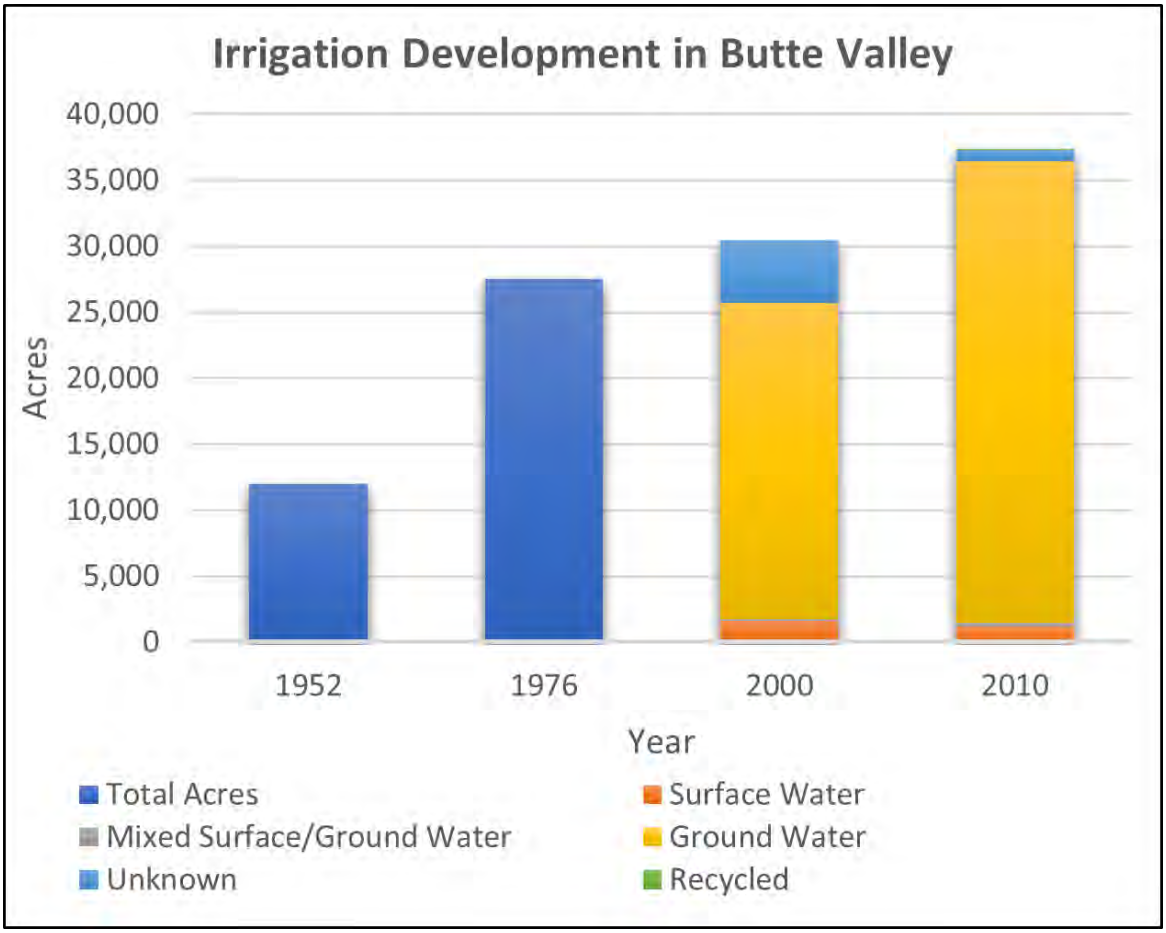


Figure 2.5: Change in Irrigated Acreage in Butte Valley, Siskiyou County, California (DWR 2000; DWR 2010; County of Siskiyou 1996). Sale price per ton and tons harvested per acre both vary per year.

2.1.1.2 Well Records

Public data regarding wells are limited in Butte Valley. Using data from the DWR Online System for Well Completion Reports (OSWCR; see DWR 2019a), it is possible to visualize the approximate distribution (i.e., well density) of domestic, agricultural production, and public drinking water wells in the Basin, aggregated to each Public Land Survey System (PLSS) section (Figure 2.6). Because OSWCR represents an index of Well Completion Report records dating back many decades, this dataset may include abandoned or destroyed wells, or quality control issues such as inaccurate, missing, or duplicate records, but is nevertheless a valuable resource for planning efforts. BVID is the source of additional well records.

The primary uses of the wells reviewed were:

- Domestic Wells: 368
- Agricultural Production Wells: 294
- Public/Municipal Wells: 11

Of these 673 wells, all were assessed to be in or near Butte Valley, and all wells were geolocated with the specificity necessary to include them in the Butte Valley geologic model. A database of these wells was created to facilitate model development.

The density of groundwater wells is highest in the south and east sections of the Basin, especially near the cities of Dorris, Macdoel, and Mount Hebron, following the extent of agricultural land use, as shown in Figure 2.6 and discussed further in Section 2.1.3.3. The density of wells per square mile is shown in Figure 2.6.

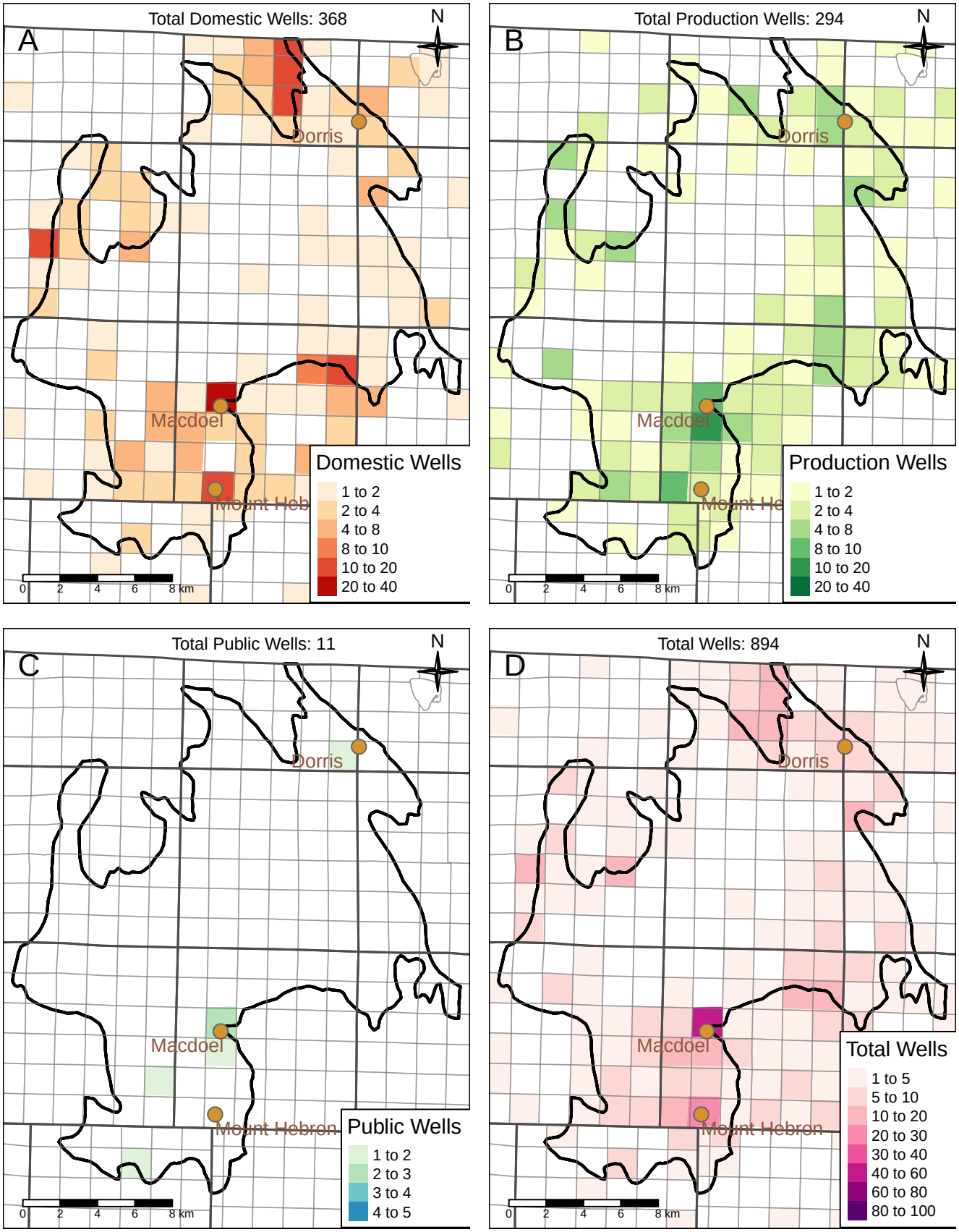


Figure 2.6: Choropleth maps indicating number of domestic (panel A), agricultural production (panel B), and public (panel C) Well Completion Reports present in each Public Land Survey System (PLSS) section, based on data from the DWR Online System for Well Completion Reports (OSWCR). Panel D shows the sum of panels A-C. PLSS sections delineated on maps are nominally one square mile.

2.1.2 Water Resources Monitoring and Management Programs

There is historical and ongoing work in the Basin related to monitoring and the management of surface water and groundwater resources. The following section describes each monitoring and/or management program and outlines the current understanding of (a) how these programs will be incorporated into the groundwater sustainability plan (GSP) implementation and (b) how they may limit operational flexibility in GSP implementation. At this time Butte Valley does not have established conjunctive use programs for surface and groundwater allocation.

The programs described include:

- Water Quality Control Plan for the North Coast Region (Basin Plan)
- California Statewide Groundwater Elevation Monitoring Program (CASGEM)
- Butte Valley Irrigation District (BVID)
- City of Dorris Municipal Water District
- United States National Forest Service (USFS)
- California Department to Fish and Wildlife (CDFW)
- United States Bureau of Reclamation (USBR)
- Butte Valley Sustainability Agency (GSA)
- Endangered Species Conservation Laws
  - Federal Endangered Species Act (ESA)
  - California Endangered Species Act (CESA)

2.1.2.1 Water Quality Control Plan for the North Coast Region

Groundwater within Butte Valley is regulated by the North Coast Regional Water Quality Control Board's (NCRWQCB) *Water Quality Control Plan for the North Coast Region* (Basin Plan; see NCRWQCB 2018). Groundwater is defined in the Basin Plan as:

> *Groundwater is defined as subsurface water in soils and geologic formations that are fully saturated all or part of the year. Groundwater is any subsurface body of water which is beneficially used or usable; and includes perched water if such water is used or usable or is hydraulically continuous with used or usable water.*

The Basin Plan includes water quality objectives for groundwater based on the assigned beneficial uses (NCRWQCB 2018). Table 2-1 in the Basin Plan designates all groundwaters with the following beneficial uses:

- Municipal and Domestic Supply (MUN)
- Agricultural Supply (AGR)
- Industrial Service Supply (IND)
- Native American Culture (CUL).

Potential beneficial uses designated for groundwater include: Industrial Process Supply (PRO) and Aquaculture (AQUA; see NCRWQCB 2018). The MUN beneficial use designation is used to

protect sources of human drinking water and has the most stringent water quality objectives. The MUN beneficial use applies to all groundwater in Butte Valley.

Section 3.4 and Table 3-1 of the Basin Plan outlines the water quality objectives for all groundwaters in the North Coast Region and those specific to the Butte Valley Hydrologic Area (NCRWQCB 2018). The Basin Plan refers to the California Code of Regulations for Domestic Water Quality and Monitoring Regulations (Title 22) for nearly all numeric limits (NCRWQCB 2018; State of California 2019). The Basin Plan water quality objectives and numerical limits are used in Section 2.2.2 of the GSP regarding water quality characterization and issues of concern. They also guide Chapter 3 of the GSP regarding groundwater sustainability criteria related to degraded water quality. The Basin Plan provides some limitations to operational flexibility in GSP implementation because the GSP must align with Basin Plan components such as water quality standards.

2.1.2.2 California Statewide Groundwater Elevation Monitoring Program

The California Statewide Groundwater Elevation Monitoring (CASGEM) Program collects and centralizes groundwater elevation data across the state, and makes them available to the public. The CASGEM Program was established in response to the passage of California State Senate Bill X7-6 in 2009. Currently, all CASGEM data are made available to the public through the interactive mapping tool on the CASGEM Public Portal website (DWR 2019b). Additionally, the full dataset can be retrieved from the California Natural Resources Agency (CNRA) Open Data website (CNRA 2019).

In Butte Valley, as of September 2019, there were 6 CASGEM wells and 40 wells designated as "voluntary" mapped within the Basin boundary, and an additional 18 voluntary wells immediately adjacent to the Basin (DWR 2019b). "Voluntary" status indicates that the well owner has contributed water level measurements to the CASGEM database, but the well is not enrolled in the CASGEM monitoring program.

Well monitoring under the CASGEM Program is ongoing. CASGEM water level data are used in the GSP to characterize historical Basin conditions and water resources (see Section 2.2.2) and will inform future management decisions. No limitations to operational flexibility in GSP implementation are expected in the Basin due to implementation of the CASGEM Program.

2.1.2.3 Butte Valley Irrigation District

Butte Valley Irrigation District (BVID) manages the largest groundwater distribution and management network in the Basin serving approximately 5,000 acres (20 sq km) of farmland. BVID distributes water throughout the service area through a network of pipes. BVID only services agriculture customers and no domestic customers. Farms serviced by the irrigation district are allocated two acre-feet per acre per year (0.6 m/yr). BVID supplies water from approximately 20 wells within its 25 well network. BVID and BVWA have an agreement where both entities can divert water from Meiss Lake to farmland, however BVID has not exercised the agreement due to pumping costs and the poor quality of the lake water (Kit Novick 1996).

BVID surface water and groundwater operations are important to all aspects of the GSP, from historical water quality data to land use to groundwater recharge. BVID will be a key partner for GSP implementation. BVID operations and management will likely affect operational flexibility in

GSP implementation in the Basin. The GSA will collaborate with BVID to balance flexibility of operations and management with GSP implementation in the Basin.

2.1.2.4 City of Dorris Municipal Water District

The City of Dorris has a small municipal water district serving approximately 938 residents (McKay 2019). Groundwater has supplied 100 percent of the district water supply since the town was founded in 1908. The municipal water supply is pumped from a single well, Well #6, which was drilled in 1971 to a depth of 1,236 ft (377 m). A back-up well, Well #4 ("Old Sandy"), is used for emergencies (Bray & Associates 2015; McKay 2019). "Old Sandy" was discontinued from use due to the production of an excessive amount of sand and elevated arsenic concentrations. Well #6 is metered and approximately 142 million gallons (gal) of water was pumped in 2014. Groundwater is treated with chlorine at the well site (Bray & Associates 2015).

The City of Dorris is designated as a severely disadvantaged community (SDAC) and has struggled to obtain funding to maintain its water distribution lines (Bray & Associates 2015; DWR 2016b). Many of the water distribution lines in Dorris are the original lines installed over 100 years ago, and some sections of pipe installed in 1912 are still in use (Bray & Associates 2015). The City is applying for grants and looking to increase assessment fees under Proposition 218 to fund extensive replacement of and upgrades to the City's water distribution system (Bray & Associates 2015; McKay 2019). In the early 1980s, a federal grant funded the construction of a 750,000-gal (2,840 m^3) welded steel water reservoir, which remains in use today. Bray & Associates proposed a Capital Improvement Plan of several million dollars and recommend installation of water meters to encourage water conservation, a move that was estimated to reduce water consumption by 30% if implemented (Bray & Associates 2015). The City successfully received grants from the Department of Public Health Safe Drinking Water State Revolving Fund and State Revolving Fund to begin the Dorris Water Meter Installation Project in 2021. The project will install water meters, replace old pipelines, and locate missing services.

The Municipal Code of the City of Dorris includes a water conservation program (Title 13, Chapter 5). The City may order the appropriate stage of water conservation based on projected supply and customer demand. The three water stages with mandatory compliance applies restrictions to a variety of water-dependent activities such as landscape watering and car washing. The most severe water conservation stage applies water usage cuts for agricultural or commercial nurseries purposes and commercial, manufacturing, and processing processes.

City reports and data are used in the GSP to characterize historical Basin conditions and the City is expected to be a key partner for GSP implementation. City operations and management will likely affect operational flexibility in GSP implementation in the Basin. The GSA will collaborate with the City to balance flexibility of operations and management with GSP implementation in the Basin.

2.1.2.5 United States Forest Service

USFS manages the Klamath National Forest, of which the Butte Valley National Grassland is included. USFS manages the Mt. Hebron Work Center in the city of Mount Hebron and the Goosenest District Office, both of which have groundwater wells that report data to CDPH and SWRCB (SWRCB 2019a; SWRCB 2019c). The USFS also owns and manages Juanita Lake, with water rights to divert water from Seikel Creek (a tributary of Muskgrave Creek) to the lake. From April

30 to November 1, 0.56 cfs can be diverted directly from Seikel Creek and 340 acre-feet (AF) of water can be stored from November 1 to April 30 (Kit Novick 1996).

USFS will be a key partner for GSP implementation. USFS land covers roughly 23% of the Basin surface area and coordination with the GSA will be important for GSP implementation. Butte Valley National Grassland operations and management will likely affect operational flexibility in the Basin. The GSA will collaborate with the USFS to align operations with GSP implementation in the Basin.

2.1.2.6 California Department to Fish and Wildlife

The Butte Valley Wildlife Area (BVWA) is managed by the California Department Fish and Wildlife (CDFW). In 1979 the California Legislature adopted Senate Concurrent Resolution No. 28 (SCR28) to maintain existing wetlands and increase wetland acreage by 50 percent by the year 2000. Purchase of BVWA preserved its existing wetlands. CDFW is working on expanding BVWA wetlands by restoring former wetlands to functioning wetlands for wildlife habitat (Kit Novick 1996). The BVWA management area is shown in Figure 2.7. CDFW manages 13,400 acres (54 sq km) of land that includes Meiss Lake and its surrounding land (DWR 1998). CDFW directly owns 13,200 acres and cooperatively manages lands owned by the United States Bureau of Land Management (BLM) and USFS. In the northwest corner of BVWA, BLM owns 80 acres managed for wildlife (field 11A). Adjacent to the southwest BVWA boundary, USFS owns 150 acres managed for wildlife (Kit Novick 1996). Water resources in BVWA are used for irrigation and wetland maintenance (Kit Novick 1996). Wetland expansion and management of Meiss Lake floodwaters have improved wildlife habitat, increased groundwater recharge for agricultural wells, improved forage for livestock in the National Grasslands, and reduced Siskiyou County pumping costs for flood protection (K. Novick 2009).

BVWA is managed as waterfowl habitat for the Pacific Flyway and provides foraging, resting and sanctuary areas for migratory birds. Resident waterfowl such as the Canada Goose and several duck species use BVWA for nesting, brood-rearing and molting. Three threatened or endangered species, including the bald eagle (state endangered status under review), sandhill crane, and Swainson's hawk use BVWA for hunting, nesting and foraging (Kit Novick 1996; CDFW 2021c). Bald eagles are year round residents of BVWA with dozens of eagles during the winter.

Within BVWA is 4,000 acre (16 sq km) Meiss Lake, managed wetlands and crop lands, meadows, creeks, native grasslands, brush fields and pine-oak forests (Kit Novick 1996). The 8,400 acres of wetlands are maintained by 40 miles of dikes and levees, 31 miles of canals and channels, 325 nesting islands and over 150 water control structures (NCRWQCB 2008). Macdoel Ditch is a 0.8 mi long drainage canal leading from the east shore of Meiss Lake to the adjacent USFS Butte Valley National Grasslands that can transport lake water to the grasslands (Kit Novick 1996; County of Siskiyou 1996). BVWA also includes riparian corridors along Ikes, Harris, Muskgrave and Prather Creeks, tributaries to Meiss Lake. Cereal grain crops are grown for waterfowl food and include wheat, barley, oats, and rye (Kit Novick 1996). Perennial crops are grown to provide nesting cover for ground nesting birds and include wheatgrass, alfalfa and native meadow hay. During the summer and fall, parts of the BVWA are flooded to provide brood habitat and habitat for migratory waterfowl, respectively (DWR 1998).

Water used to flood the BVWA ponds is generally provided by surface water supplies but is augmented or replaced with groundwater during surface water deficient periods (DWR 1998). Surface water supplies are typically sufficient for wetland flooding in the spring but insufficient in the summer and fall. BVWA surface water comes from four creeks and one canal that flow toward Meiss

Lake. From the west, spring-fed Ikes, Harris, and Muskgrave Creeks flow into the Perimeter Canal, which flows to Meiss Lake. From the south, spring-fed Prather Creek flows directly into Meiss Lake. Estimated creek inflows are 15,000 to 20,000 acre-feet annually but are low or nonexistent in the summer and fall. The Irrigated District Canal delivers excess irrigation water to Meiss Lake from wells and summer runoff, though flows are normally very low. Meiss Lake is a managed reservoir with a depth no greater than 6 feet. Lake depths greater than 6 feet cause flooding and subbage issues for adjacent private farmland. Lake water increases in alkalinity in the summer and fall and is not suitable to flood wetlands or irrigate crops when surface water supplies are low (Kit Novick 1996).

BVWA uses groundwater to meet its water demand when surface water supplies are insufficient, particularly in the summer and fall (Kit Novick 1996; DWR 1998). BVWA has five deep irrigation wells, though only four are currently used for production: Wells 1, 2, 3, and 5A. Wells 1, 2, and 3 tap into the High Cascade Volcanics water bearing formation. Groundwater from the three wells is used to irrigate food and nesting cover crops and maintain water levels in the BVWA wetlands for summer brood water for resident birds (500 to 600 acres of wetland) and fall migrating birds (increase to 1,000 to 1,200 acres of wetland). The four wells are operated intermittently from June to August and continuously from September to the end of October, though the pumps will run longer in drought years. In the southwest portion of BVWA, Wells 1, 2, and 3 are relatively shallow with depths of 90 to 284 feet. The wells once had artesian flows of 15 to 500 gpm. The artesian flows of Wells 1, 2, and 3, and several smaller domestic wells near BVWA headquarters stopped during the droughts of 1977, 1980 to 83, and from 1987 to Present. Wells 1, 2, and 3 have water yields of 2,588, 1,377, and 1,460 gpm, respectively. Well 7A is on the north side of BVWA with water yields of 2,500 gpm. Groundwater pumping from the four wells has no to minimal impact on offsite irrigation wells. Groundwater in the High Cascade water bearing formation near BVWA headquarters flows northerly then northeasterly (Kit Novick 1996).

Wells 5A is located southeast of Meiss Lake and taps into the Butte Valley Basalt water bearing formation. Groundwater from the well is only used to sprinkler-irrigate cereal grain crops in BVWA due to the seasonal depletion of the aquifer. It is 278 feet deep with water yields of 3,000. In the years 1981, 1991, 1992, and 1994, the well has gone dry near the end of the irrigation season when the Butte Valley Basalt water bearing formation was depleted (Kit Novick 1996).

In 1998 the BVWA total annual water demand was 13,200 AF. From the 1980s to 1998, the annual BVWA groundwater extraction amount has varied from 2,000 AF to 5,300 AF, with an average annual amount of approximately 3,000 AF. The average groundwater demand was expected to increase to 3,500 AF due to a proposed 500 AF increase in groundwater development. However the actual long-term average use (1987 to 2008) has actually decreased to 2,746 AF (K. Novick 2009). As of 1998, the BVWA applied groundwater demand was about 1.1 AF per acre (DWR 1998).

In 1998, DWR investigated DFG Well 7A (27C01M), located north of Meiss Lake, for an unacceptable level of interference with neighboring wells and springs. Well 7A taps into the highly transmissive High Cascade Volcanics water bearing formation and was confirmed to cause interference with adjacent wells but had minimal impact on nearby springs located on Holzhauser Ranch in Sam's Neck. Additionally, the 1998 DWR well interference study found that groundwater flow around Well 7A is noticeably influenced by nearby faults, which can act as both a flow barrier and a very transmissive conduit for flow (DWR 1998). CDFW altered use of Well 7A in a desire to be a good neighbor and minimize possible effects on the wells of private neighbors (K. Novick 2009). Actions included reduction of volume pumped from Well 7A from 2,800 gpm to 1,500 gpm

and overall operation is coordinated with adjacent private landowners to minimize any impacts on their irrigation wells (K. Novick 2009).

CDFW will be a key partner for GSP implementation. CDFW land covers roughly 17% of the Basin surface area and coordination with the GSA will be important for GSP implementation. CDFW reports and data are used to characterize the Basin in Section 2.2 of the GSP. CDFW operations and management will likely affect operational flexibility in GSP implementation in the Basin. CDFW groundwater extraction may potentially impact neighboring wells and the resulting cone of depression may be asymmetrical due to local faults (DWR 1998). The GSA will collaborate with the CDFW to align operations with GSP implementation in the Basin.

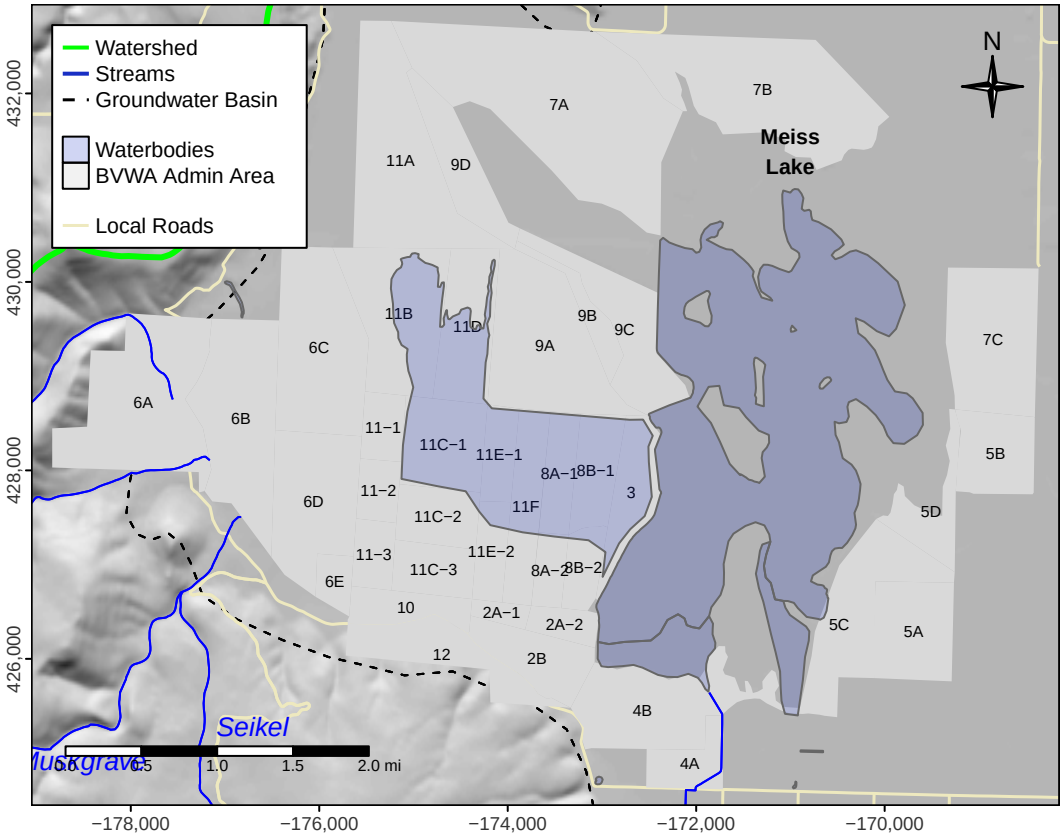


Figure 2.7: Map of the Butte Valley Wildlife Area adapted from the 1996 draft management plan for the wildlife area (Novick 1996).

2.1.2.7 United States Bureau of Reclamation

Through its WaterSMART program, the United States Bureau of Reclamation (USBR) is granting funds to the GSA to install 10 co-located, continuous groundwater level and soil moisture sensors that will be incorporated into the Basin's GSP development and implementation. The GSA will collaborate with the USBR to align operations with GSP implementation in the Basin.

2.1.2.8 Endangered Species Conservation Laws

Federal Endangered Species Act

The Federal Endangered Species Act (ESA) outlines a structure for protecting and recovering imperiled species and their habitats. Under the ESA, species are classified as "endangered," referring to species in danger of extinction throughout a significant portion of its range, or "threatened," referring to species likely to become endangered in the foreseeable future. The ESA is administered by two federal agencies, the Interior Department's U.S. Fish and Wildlife Service (FWS), primarily responsible for terrestrial and freshwater species, and the Commerce Department's National Marine Fisheries Service (NMFS) which primarily handles marine wildlife and anadromous fish.

California Endangered Species Act

The California Endangered Species Act (CESA) was first enacted in 1970 with the purpose of conserving plant and animal species at risk of extinction. Similar to the ESA, CESA includes the designations "endangered" and "threatened," used to classify species. Definitions for these designations are similar to those under the ESA and apply to native species or subspecies of bird, mammal, fish, amphibian, reptile, or plant. An additional category "candidate species" exists under CESA that includes species or subspecies that have been formally noticed as under review for listing by CDFW. Additional detail on other species in Butte Valley listed under CESA can be found in Section 2.2.1.7 as part of the discussion on groundwater dependent ecosystems (GDEs).

Both the ESA and CESA are used in the GSP to guide the identification of key species for consideration as part of GDEs. Listed species will continue to be considered throughout GSP implementation, as part of any project and management actions (PMAs), and to help inform future management decisions. These endangered species conservation laws may limit operational flexibility in GSP implementation. The GSA will incorporate this legislation into its decision-making and may seek to coordinate with the relevant state and federal lead agencies, as necessary.

2.1.3 Land Use Elements or Topic Categories of Applicable General Plans

2.1.3.1 General Plans

The overarching framework for land use and development in the County of Siskiyou (County) is the Siskiyou County General Plan (General Plan). A community-specific General Plan was also developed in Butte Valley for the City of Dorris. Elements of the general plans outline goals for land use and development, and mechanisms for achieving those goals that include policies and zoning regulations. The GSP will be developed to conform with the general plans as much as possible.

County of Siskiyou General Plan

The County's General Plan (County of Siskiyou 2019b) serves as a guide for land use decisions within the County, ensuring alignment with community objectives and policies. While the General Plan does not prescribe land uses to parcels of land, it does identify areas that are not suitable for specific uses. The components of the General Plan with the most relevance to the GSP include the Conservation Element and Open Space Element. Many of the objectives and policies within the General Plan align with the aims of the GSP and significant changes to water supply assumptions within these plans are not anticipated.

The Conservation Element of the General Plan recognizes the importance of water resources in the County and outlines objectives for the conservation and protection of these resources to ensure continued protection of beneficial uses for people and wildlife. Methods for achieving these objectives include local legislation such as flood plain zoning and mandatory setbacks, subdivision regulations, grading ordinances, and publicly managed lands to ensure preservation of open spaces for recreational use. The importance of water resources is clearly noted in this element: "Groundwater resources, water quality, and flood control remain the most important land use determinants within the county" (County of Siskiyou 1973). Specific topics addressed include preventing pollution from industrial and agricultural waste, maintaining water supply and planning for future expansion, reclaiming and recycling wastewater, and protecting watershed and recharge lands from

development. These objectives in the Conservation Element mirror the objectives of the GSP, namely ensuring a sustainable water supply, the protection and preservation of watershed and water recharge lands, and prevention of degradation of water quality.

The Open Space Element of the General Plan includes in its definition of open space any area of land that serves as open space, watershed and groundwater recharge land, among other uses. The importance of protecting these lands is recognized for maintaining water quality and quantity. Mechanisms to preserve these spaces include maintaining or creating scenic easement agreements, preserves, open space agreements, and the designation of lands for recreational or open space purposes. A policy for open space requirements is included with minimum thresholds of 15% of proposed developments as open space. Protection of open space for habitat, water quality, and water quantity align with the objectives of the GSP.

Siskiyou County Zoning Plan

The County of Siskiyou Zoning Plan (Zoning Plan) is codified in Title 10, Chapter 6 commencing with Article 37 (County of Siskiyou 2019a). The County of Siskiyou Zoning Ordinance outlines the permitted types of land use within each zoning district. Zoning categories include residential, commercial, industrial, agricultural, forestry, open space, and flood plains. Many of the purposes and policies of the Zoning Plan align with the objectives of the GSP. In particular, the “wise use, conservation, development and protection” of the County’s natural resources, protection of wildlife, and prevention of pollution support the objectives of the GSP. Mechanisms to achieve these goals include permitted and restricted uses for land parcels, and requirements and stipulations for land use and development.

2.1.3.2 Community Plans

Dorris General Plan

The City of Dorris General Plan (DGP) outlines objectives and programs to guide decision-making as it relates to land use and development to ensure the physical, economic, and social wellbeing of the community. The DGP is applicable through Year 2025 (updated in 2007) and incorporates all elements, as required by Section 65402 of the California Government Code: land use, circulation, housing, conservation, open space, noise, and safety (City of Dorris 2007).

2.1.3.3 Williamson Act Land

Contracts under the California Land Conservation Act of 1965, commonly known as the Williamson Act, are used to preserve open space and agricultural lands. Local governments and private landowners enter into voluntary agreements to restrict land for use in agriculture or as open space. Private landowners that enter into a Williamson Act contract benefit from lower property taxes. Lands that are eligible to be enrolled under these contracts must be a minimum of 100 acres and can be enrolled as either Prime or Non-Prime Williamson Act Farmland, based on the productivity specifications outlined in Government Code § 512021. In the County of Siskiyou, as of 2014, 96,993 acres (393 sq km) were enrolled as Prime Land and 324,300 acres (1,312 sq km) were enrolled as Non-Prime Land (DOC 2016).

2.1.3.4 Neighboring Groundwater Basins

The Butte Valley groundwater basin has several neighbors that could affect the ability of the GSA to achieve sustainable groundwater management: Tule Lake, Lower Klamath, Red Rock Valley, and Shasta Valley groundwater basins. DWR lists Tule Lake and Shasta Valley groundwater basins as medium priority basins, while the Lower Klamath and Red Rock Valley groundwater basins are low priority (DWR 2009).

2.1.4 Additional GSP Elements

2.1.4.1 Policies Governing Wellhead Protection and Well Construction, Destruction and Abandonment

In the Basin, wellhead protection and well construction, destruction and abandonment are conducted according to relevant state guidelines.

Well standards are codified in Title 5, Chapter 8 of the Siskiyou County Code. These well standards define minimum requirements, including those for monitoring wells, well construction, deconstruction, and repair, with the objective of preventing groundwater pollution or contamination (County of Siskiyou 2020). Processes and requirements for well permitting, inspections, and reporting are included under this chapter of the County Code of Ordinances.

The County of Siskiyou Environmental Health Division (CSEHD) is the local enforcing agency with the authority to issue well permits in the County. Well permit applications require information from the applicant and an authorized well contractor, along with a fee.

The County has worked on obtaining hydrological data/modeling to help inform individual well permitting decisions beginning with the Scott Valley; and public discussion and decision making related to the impacts of the public trust doctrine on groundwater management is on-going. The GSA will look for opportunities to coordinate with the County on providing collected hydrologic information that may assist the County.

2.1.4.2 Groundwater Extraction and Illegal Cannabis

On August 4, 2020, Ordinance 20-13 amended Chapter 13 of Title 3 of the County Siskiyou Code of Ordinances to add Article 7. Article 7 defines finds extracting and discharging use of groundwater for illegal cultivation of cannabis to be a public nuisance and a waste and/or unreasonable use of groundwater and prohibits extraction and discharge of groundwater underlying the County for this activity. Ordinance 20-13 was replaced by Ordinance 20-15 in the fall of 2020; however, the substantive provisions of the ordinance remain the same.

Groundwater extraction for the cultivation of illegal cannabis has expanded over the past five to seven years. This current land use practice is not accounted for in either the historical or future water budget analysis.

Siskiyou County has adopted multiple ordinances relating to the regulation of cannabis. Chapter 15 of Title 10 of the Siskiyou County Code prohibits all commercial cannabis activities, and Chapter 14 limits personal cannabis cultivation to the indoor growth of a maximum of 12 plants on premises with a legal water source and an occupied, legally established residence connected

to an approved sewer or septic system. Personal cultivators are also prohibited from engaging in unlawful or unpermitted surface drawing of water and/or permitting illegal discharges of water from the premises. Despite these ordinances, illegal cannabis cultivators continue to operate within and near the Basin.

Illegal cannabis growers rely on groundwater from production and residential well owners and utilize water trucks to haul groundwater off the parcel from which it is extracted for use at other locations. The proliferation and increase of illegal cannabis cultivation taking place in the Basin is a significant community concern; however, obtaining an accurate estimate of overall consumptive groundwater use for this illegal activity has been a challenge for the GSA due to it occurring on private and secluded parcels and the increasing use of covered greenhouses for illegal cannabis cultivation. Future model scenarios may use an estimated number of cannabis plants from the Siskiyou County Sheriff Department and a consumptive use of four to ten gallons of water per plant per day to consider the potential impacts to groundwater resources from this activity under current and future conditions.

In addition to community concern about estimated consumptive use of groundwater in the Basin for illegal cannabis cultivation, there is also concern about water quality impacts from the potential use of illegal and harmful chemicals at illegal grow sites, which may leach into the groundwater (see Chapter 2, Water Quality), and the non-permitted human waste discharge methods that have been found to occur at some of these sites. Data on baseline water quality conditions at illegal cannabis cultivation sites within the Basin or at nearby wells have not been collected; however, the GSA intends to include available wells within close proximity to these sites in its future monitoring network for the purpose of measuring water quality.

The GSA considers groundwater used for illegal cannabis cultivation to be a “waste and unreasonable use of water,” but acknowledges that there is not substantial enough data to include groundwater the use estimates from illegal cannabis production in the overall and future water budgets. The GSA will coordinate with local enforcement agencies regarding providing collected hydrologic information and will also use the emphasis on collecting data during the first five years of plan implementation to better understand the impacts of groundwater use for illegal cannabis on overall Basin-wide use estimates and the relation to nearby groundwater aquifers.

2.1.4.3 Groundwater Export

Groundwater export is regulated in the County under Title 3, Chapter 13 of the Siskiyou County Code. Since 1998, Chapter 13 has regulated the extraction of groundwater from Bulletin 118 basins underlying the County for use outside of the basin from which it was extracted. Exceptions include 1) groundwater extractions by a district purveyor of water for agricultural, domestic, or municipal use where the district is located partially within the County and partially in another county, so long as extracted quantities are comparable to historical values; and 2) extractions to boost heads for portions of these same water purveyor facilities, consistent with historical practices of the district. Groundwater extractions for use outside the County that do not fall within the exceptions are required to obtain a permit for groundwater extraction. Permit application processes, timelines, and specifications are described in this ordinance.

In May of 2021, Title 3, Chapter 13, was amended to add Article 3.5, which regulates, through ministerial permitting, the extraction of groundwater for use off the parcel from which it was extracted. This provision requires extracted groundwater be for uses and activities allowed by the underlying zoning designation of the parcel(s) receiving the water and does not apply to the extraction

of water for the purposes of supplying irrigation districts, emergency services, well replenishment for permitted wells, a “public water system,” a “community water system,” a “noncommunity water system,” or “small community water system” as defined by the Health and Safety Code, serving residents of the County of Siskiyou.

2.1.4.3 Policies for Dealing with Contaminated Groundwater

Migration of contaminated groundwater from point sources, such as leaking fuel tanks, is managed through coordination with NCRWQCB. Open and historic (“closed”) cleanup sites are discussed in Section 2.2.2.3, subsection “Contaminated Sites.” Non-point sources of contaminated groundwater, such as pesticides, are described in Section 2.2.2.3.

2.1.4.5 Replenishment of Groundwater Extractions and Conjunctive Use

There are no artificial groundwater replenishment or conjunctive use projects in Butte Valley. Proposed projects and management actions are described in Chapter 4.

2.1.4.6 Coordination with Land Use Planning Agencies

The GSA will manage land use plans and coordinate land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity.

2.1.4.7 Relationships with State and Federal Regulatory Agencies

The GSA has relationships with multiple state and federal agencies, as described in the Section 2.1.2. These state and federal agencies include CDFW, NCRWQB, USFS, DWR, and USBR. The GSA will continue to coordinate and collaborate with these agencies throughout GSP development and implementation.

2.2 Basin Setting

2.2.1 Hydrogeologic Conceptual Model

Executive Summary

Butte Valley is a topographically closed internally drained basin at the boundary between the western Modoc Plateau and eastern Cascade Range geomorphic provinces, near the western and northwestern border of the Medicine Lake Highlands. Butte Valley experiences east-west directed extensional tectonics and north-trending normal faults expressed as block faulting (Bryant 1990). This chapter reviews the background of the hydrogeologic conceptual model. A hydrogeologic conceptual model (HCM; see DWR 2016a) fulfills the following:

1. *Provides an understanding of the general physical characteristics related to regional hydrology, land use, geology and geologic structure, water quality, principal aquifers, and principal aquitards of the Butte Valley groundwater basin (Basin) setting;*
2. *Provides the context to develop water budgets, mathematical (analytical or numerical) models, and monitoring networks; and,*
3. *Provides a tool for stakeholder outreach and communication.*

The following is a graphical and narrative description of the physical components of the Basin. The following elements are required by DWR (DWR 2016c):

- Scaled cross-sections.
- Topographic information.
- Surficial geology.
- Soil characteristics.
- Delineation of existing recharge areas that substantially contribute to the replenishment of the Basin, potential recharge areas, and discharge areas.
- Surface water bodies.
- Source and point of delivery for local and imported water supplies.

2.2.1.1 Topography

Butte Valley is a structurally controlled closed drainage basin and the valley floor is a practically flat surface, with elevations ranging over an exceedingly narrow range from 4,226 to 4,236 ft (1,288 to 1,291 m) amsl, shown in Figure 2.8 (Bryant 1990; County of Siskiyou 1996). The Watershed is roughly three times larger than the Basin. As shown in Figure 2.13, the flat-floored structural depression is surrounded by youthful fault scarps and merges into fields of broken Quaternary basalts to the south (DOI 1980). The mountainous topography that bounds the Basin ranges from 5,000 to 8,000 ft (1,524 to 2,438 m) amsl (DWR 1968). The Basin is bounded in the north, south and west by the Cascade Mountains and on the southeast by Sheep Mountain and Red Rock Valley (Wood 1960; DWR 2004). Topography to the north is marked by block-faulted volcanic plateaus and several flat-floored grabens, including Sam's Neck and Pleasant Valley, that project beyond the Basin (DOI 1980; Bryant 1990). The eastern boundary has a prominent northwestward trending fault block (the Mahogany Mountain ridge or Mahogany Ridge), which isolates the Basin from the

Lower Klamath Lake marshland in the northeast (DWR 2004). The Mahogany Ridge is 20 mi (32 km) long, 1 to 3 mi (1.6 to 4.8 km) wide and bordered by steep, slightly dissected, talus-covered fault scarps. The north end of the ridge is broken by several en-echelon faults while the south end is characterized by a gently southward sloping plateau (DOI 1980).

The Watershed is immediately northeast of Mount Shasta, seen in the bottom left corner of Figure 2.8. The northern Watershed border crosses the state border into Oregon, with the northernmost extent bounded between Chicken Hills and Hamaker Mountain. In Oregon, Grenada Butte and Randolph Flats are within the Watershed. In addition to Butte Valley, the Watershed includes Red Rock Valley (northeast of Cedar Mountain), Round Valley (between Cedar Mountain and Orr Mountain), the Bray Town Area (south of Orr Mountain), plus other unnamed valleys.

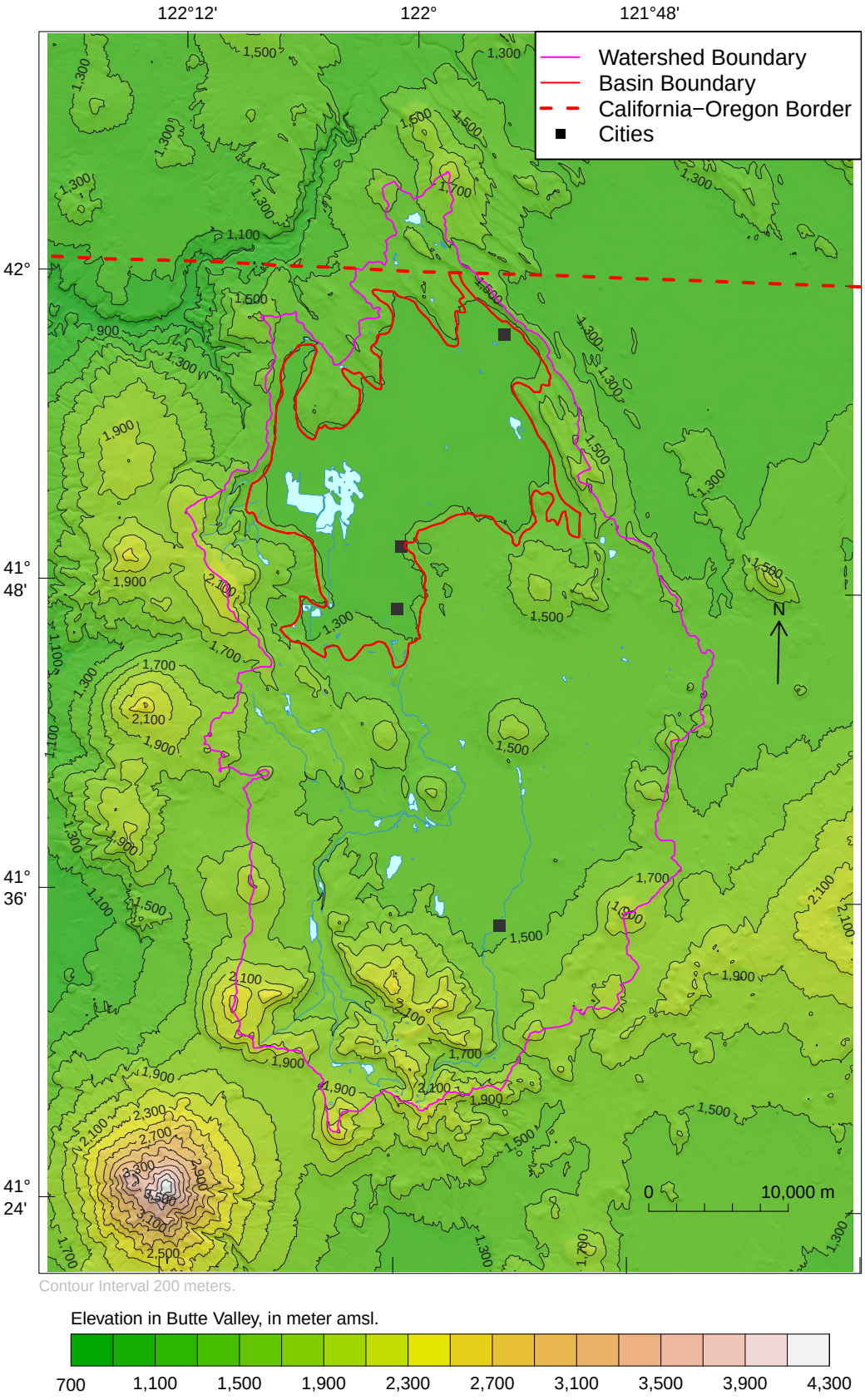


Figure 2.8: Topography of the Butte Valley Groundwater Basin and surrounding Watershed. City names from north to south are: Dorris, Macdoel, Mount Hebron and Tennant.

2.2.1.2 Climate

Butte Valley has a semiarid climate characterized by warm, dry summers and cool, wet winters. The Cascade Range on the west side of the Basin casts a rain shadow across the Basin, where precipitation is highest on the west side of the valley and decreases eastward (Kit Novick 1996). Annual precipitation also increases northward (DWR 2004). In 1996, the mountains and foothills on the west side of the Butte Valley Wildlife Area received an average of 20 to 28 inches of rainfall a year, the crop lands on the west side of Meiss Lake received 15 to 22 inches, BVWA headquarters received 18 inches, and the east side of Meiss Lake received 10 to 12 inches. Snow can occur during any month of the year but normally falls between November and March (Kit Novick 1996). July through September are historically the driest months [DOI (1980); see Figure 2.9]. Long-term climate records are available from National Oceanic and Atmospheric Administration (NOAA) weather stations in the Butte Valley watershed; relevant stations are listed in Table 2.2.

The Basin has experienced decreasing precipitation during much of the period between 1970 to 2020. From the 1940s to 2020, the NOAA station in Mount Hebron has an average annual precipitation of 9.3 inches (Figure 2.9). Between 1942 and 1979, the 10-year trailing rolling average precipitation ranged from 9.5 to 12.4 in (24.1 to 31.5 cm; water years 1953 and 1971, respectively); since 1980, it has ranged between 5.7 and 10.8 in (14.5 to 27.4 cm; water years 2018 and 1980, respectively; see Figure 2.9). Much of the expansion in agricultural land in Butte Valley occurred before 1976, with irrigated land expanding to 11,130 hectares (27,500 acres), during a period when average rainfall was relatively stable and significantly greater.

Mean daily low and high temperatures for January and July are -8 to 7°Celsius (C; 17 to 44°Farenheit [F]) and 5 to 29°C (41 to 84°F), respectively (Figure 2.10). Temperature extremes range from over 38°C (100°F) in the summer to below -18°C (0°F) in the winter (DOI 1980). Reference evapotranspiration (ET) ranges from 0.002 to 0.33 in/day (0.005 to 0.84 cm/day; Figure 2.10). Pan evaporation in Butte Valley is estimated to be 48 inches a year, with wind mainly responsible (Kit Novick 1996). Figure 2.11 illustrates the recent climate shift by comparing the average temperature in the past 15 years to historical records. In the past 15 years, the average maximum and minimum air temperature increased roughly 1 to 5 F (Figure 2.11).

Historically, killing frosts could occur at any time of the year and the growing season in Butte Valley was limited by the last and first killing frosts (<28°F). The growing season generally extended from May to October, but frequent killing frosts in May and June usually shortened the usable growing season. The average growing season was roughly 100 days but varied greatly. In 1952, only one day was frost-free. A short growing season and frost danger limited the type and amount of agricultural crops grown within Butte Valley (DOI 1980; Kit Novick 1996). Crops in BVWA were limited to hardy cereal grains and quickly maturing plants, which have marginal commercial value due to frost damage (Kit Novick 1996).

Over the past few decades, the frost danger in Butte Valley has decreased (Figure 2.12). The yearly average of days with temperatures less than 32 F has sharply declined since the 1980s. In recent years, strawberry crops have become increasingly important in Butte Valley.

Snow measurements in the Butte Valley watershed is a climate data gap. The nearest California Data Exchange Center (CDEC) weather stations are outside the watershed boundary. None of the NOAA weather stations in the Watershed are situated in the west or south mountains, which are important to surface and groundwater recharge.

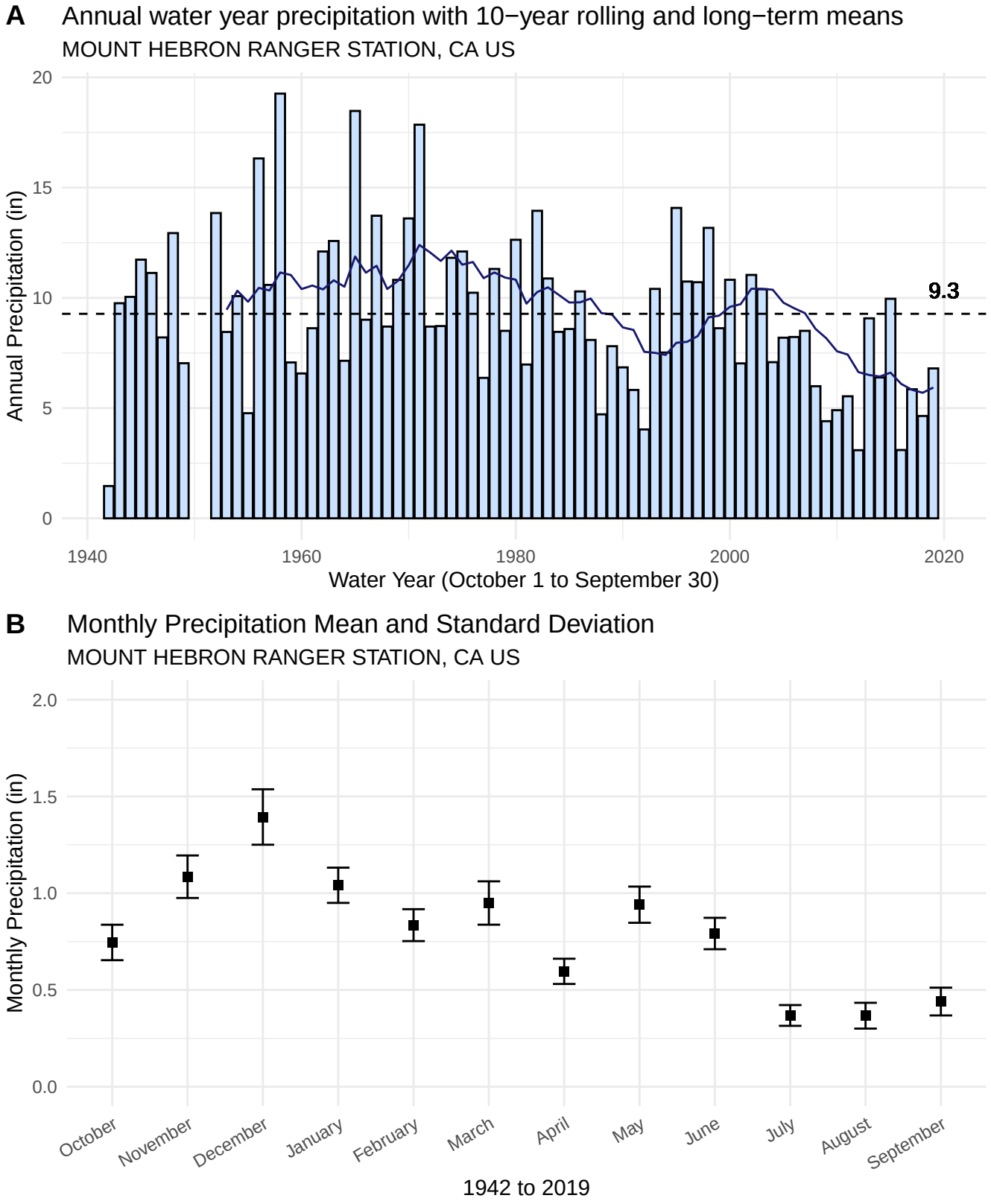


Figure 2.9: Annual (Panel A) and monthly precipitation (Panel B) over the 1942 to 2019 record as measured at the Mount Hebron Ranger weather station (USC00045941). In Panel A, the 10-year rolling average is shown as the average over the entire period of record. Each bar represents one water year, the total precipitation during the period between October 1 and September 30. Only the years 1950 and 1951 had significant data gaps and were removed.

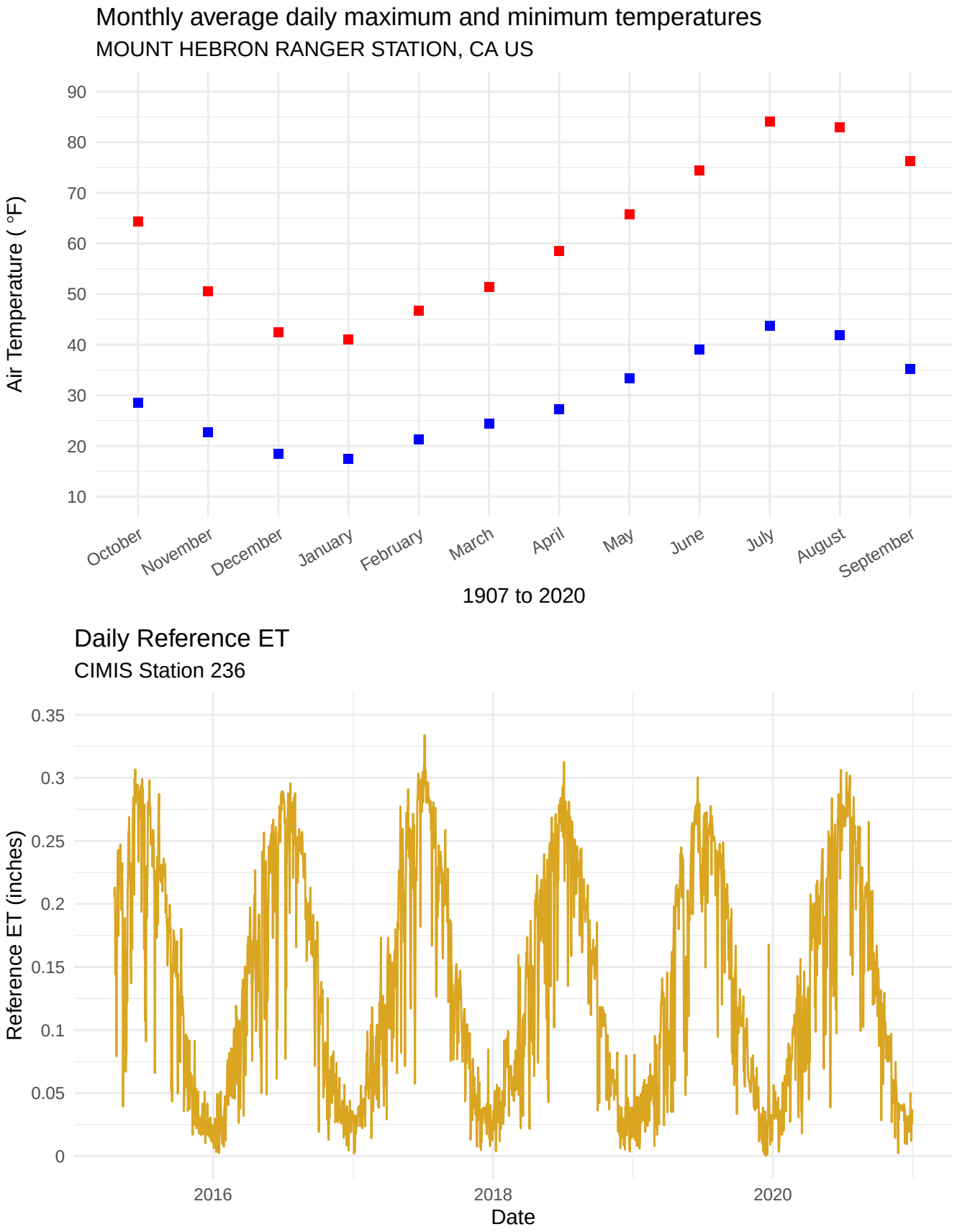


Figure 2.10: Monthly averages of daily maximum and minimum air temperature (top panel) over the 1942 to 2020 record at the Mount Hebron Ranger Station (USC00045941), and reference evapotranspiration (ET) from 2015 to 2020 calculated at CIMIS Station 236 between Macdoel and Mount Hebron.

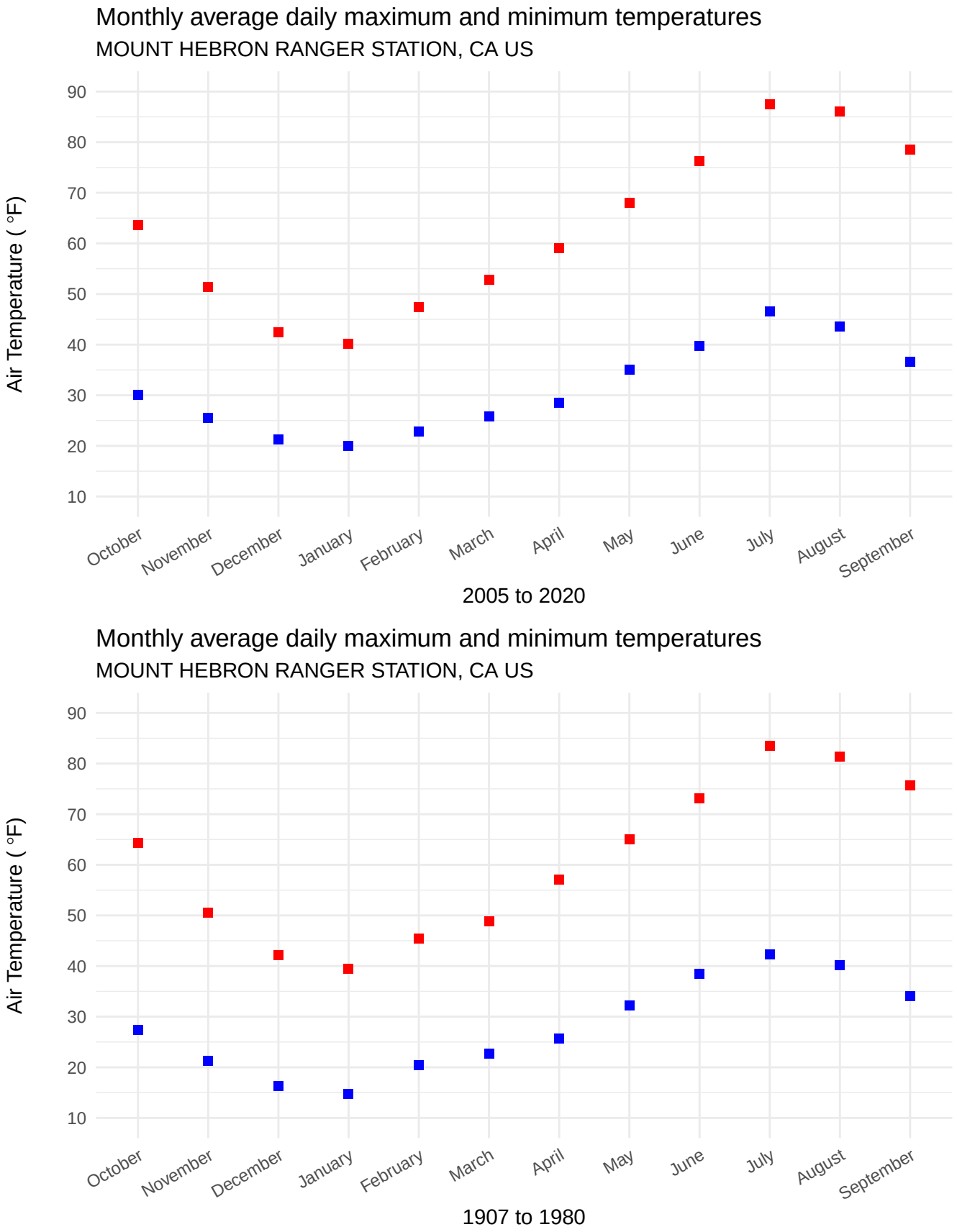


Figure 2.11: Monthly averages of daily maximum and minimum air temperature (top panel) over the 1942 to 1980 and 2005 to 2020 record at the Mount Hebron Ranger Station (USC00045941), which shows the recent warming of the Valley.

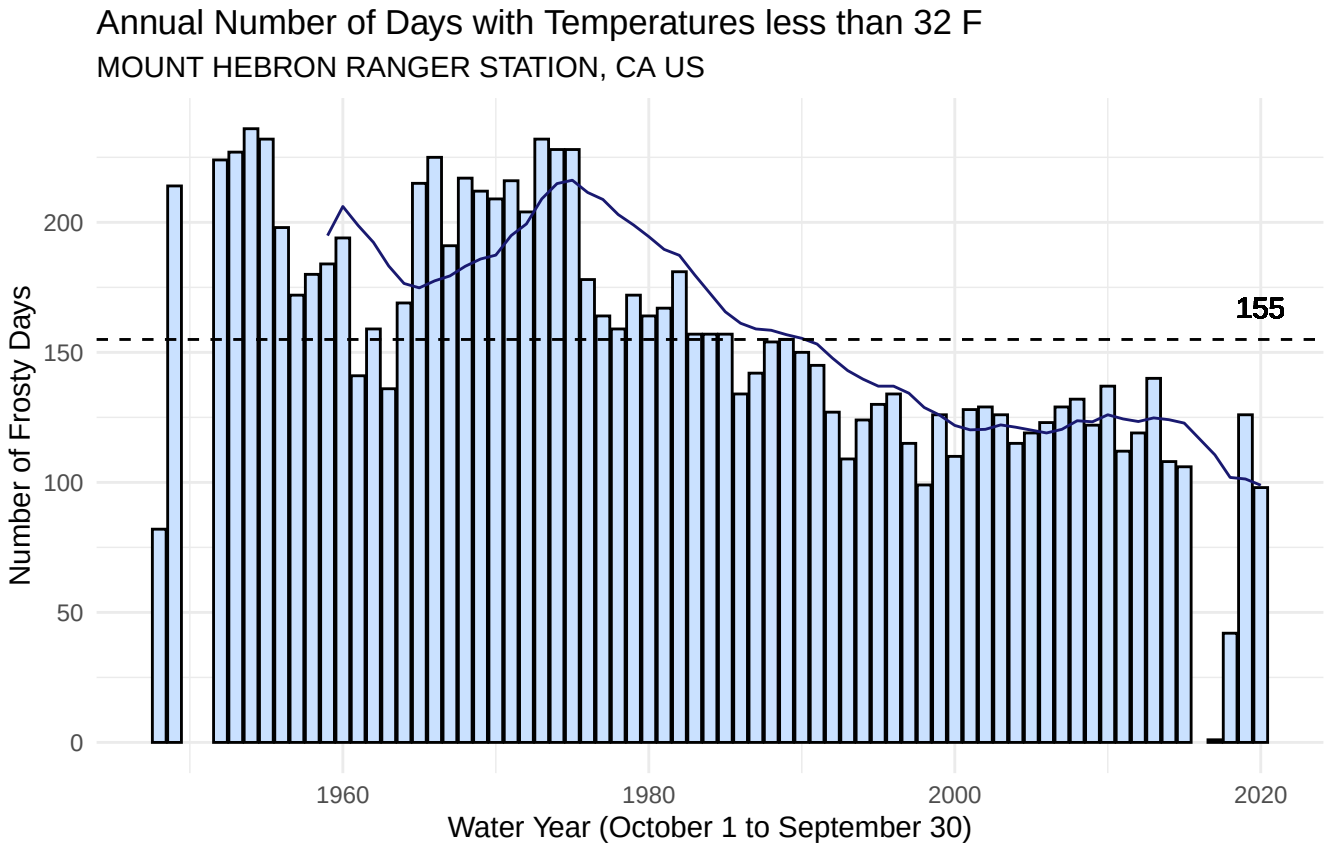


Figure 2.12: Total number of days with temperature minimums less than 32 F, representing frost potential. Totals are occasionally impacted by station equipment outtages.

Table 2.2: Station details and record length for NOAA weather stations in the Butte Valley watershed.

Station ID	Station Name	Elevation (ft amsl)	Start Date	End Date	Record Length (years)	No. Missing Days
US1CASK0010	DORRIS 0.2 SW, CA US	4249	1998-06-17	2021-06-27	23.0	1
USC00045940	MOUNT HEBRON 11 ESE, CA US	4383	1952-05-01	1960-12-31	8.7	7
USC00045941	MOUNT HEBRON RANGER STATION, CA US	4250	1907-01-01	2020-04-01	113.2	1956
USC00048860	TENNANT, CA US	4754	1952-05-01	1957-08-31	5.3	3
USR0000CJUA	JUANITA LAKE CALIFORNIA, CA US	5400	1988-12-30	2021-06-27	32.5	11102
USR0000CVAN	VAN BREMMER CALIFORNIA, CA US	4928	1993-06-01	2021-06-27	28.1	9921

2.2.1.3 Geologic History

The oldest rocks near Butte Valley were formed between the Eocene to Miocene (56 to 5.3 million years ago [Ma]) during the formation of the Western Cascades. The predominantly andesite volcanic rocks consist of interbedded basalts, dacites, rhyolite tuffs, and breccias. At the end of the Miocene (~5.3 Ma), the original Western Cascade landscape and parent cones were destroyed by uplift and erosion. During the same period, the regional uplift created the ancestral Cascade Range and a series of northwest-trending faults that cut through the Western Cascades. From the late Pliocene to the Pleistocene (3.6 to 0.012 Ma), volcanism reactivated in the region, forming a north-trending series of broad shield volcanoes along the crest of the ancestral Cascades. These volcanoes erupted the highly fluid basalts and andesites found in the High Cascade volcanic rocks in Butte Valley. The present Cascade Range was formed later in the Pleistocene (2.6 to 0.012 Ma) through the eruptions of andesites, dacites, and rhyolites. Sometime in the Pleistocene (2.6 to 0.012 Ma), faulting began to form the structural depression that would become Butte Valley (DOI 1980).

The Basin became a closed drainage basin as Butte Valley dropped and adjacent fault block mountains uplifted (County of Siskiyou 1996). At the same time Meiss Lake occupied Butte Valley, depositing the Lake Deposits on the valley floor (DOI 1980). During the Quaternary (2.6 Ma to Present), glaciation occurred in the high mountains that form the headwaters of Butte Creek, the largest creek in the Valley. Glaciation created glacial moraines and cirque valleys at the Butte Creek headwaters (King 1994). From the end of the Pleistocene to Present (0.012 Ma to Present), renewed volcanic activity erupted large amounts of fluid basalts from fissures in the High Cascades, including the Butte Valley Basalt (DOI 1980). This recent volcanic activity has shrunk the Butte Valley watershed by cutting off small drainages such as the Grass Lake area (King 1994). Today, the Cascade Range continues to be volcanically active. Butte Valley also remains seismically active (DOI 1980).

2.2.1.4 Geologic Units

The surface geology of Butte Valley and adjacent regions are primarily volcanic with lake deposits, alluvial fan deposits, and alluvium with some deposits of dune sand and talus (Wood 1960). A generalized geologic map of the Butte Valley watershed is shown in Figure 2.13 and described in Table 2.3 (Wood 1960; Jennings et al. 2013). Cross-sections A-A' through C-C' are shown in Figure 2.14, Figure 2.15, Figure 2.16. A 1,573 ft (479 m) deep test well drilled in 1978 by the U.S. Department of the Interior (DOI) in the south side of the Valley offers an example of Butte Valley stratigraphy (DOI 1980): from 0–47 ft (24–137 m) depth is alluvium deposits, from 47–78 ft (14–24 m) depth is Butte Valley Basalt, from 78–1,317 ft (24–401 m) is Lake Deposits (where 78–450 ft (24–137 m) is sands and gravels with thin clay interbeds, and 450–1,279 ft (137–390 m) is predominantly clay), and 1,279 to greater than 1,573 ft (390–479 m) is High Cascade Volcanics. Similar stratigraphy appears in Cross-section A-A' between 400 to 12,000 m distance (Figure 2.14). In other parts of the valley, the Butte Valley Basalt disappears and the stratigraphy is limited to lake sediments and High Cascade Volcanics, shown in Figure 2.14, Figure 2.15, and Figure 2.16. The following outlines the geologic units from oldest to youngest, separating the volcanic and sedimentary deposits.

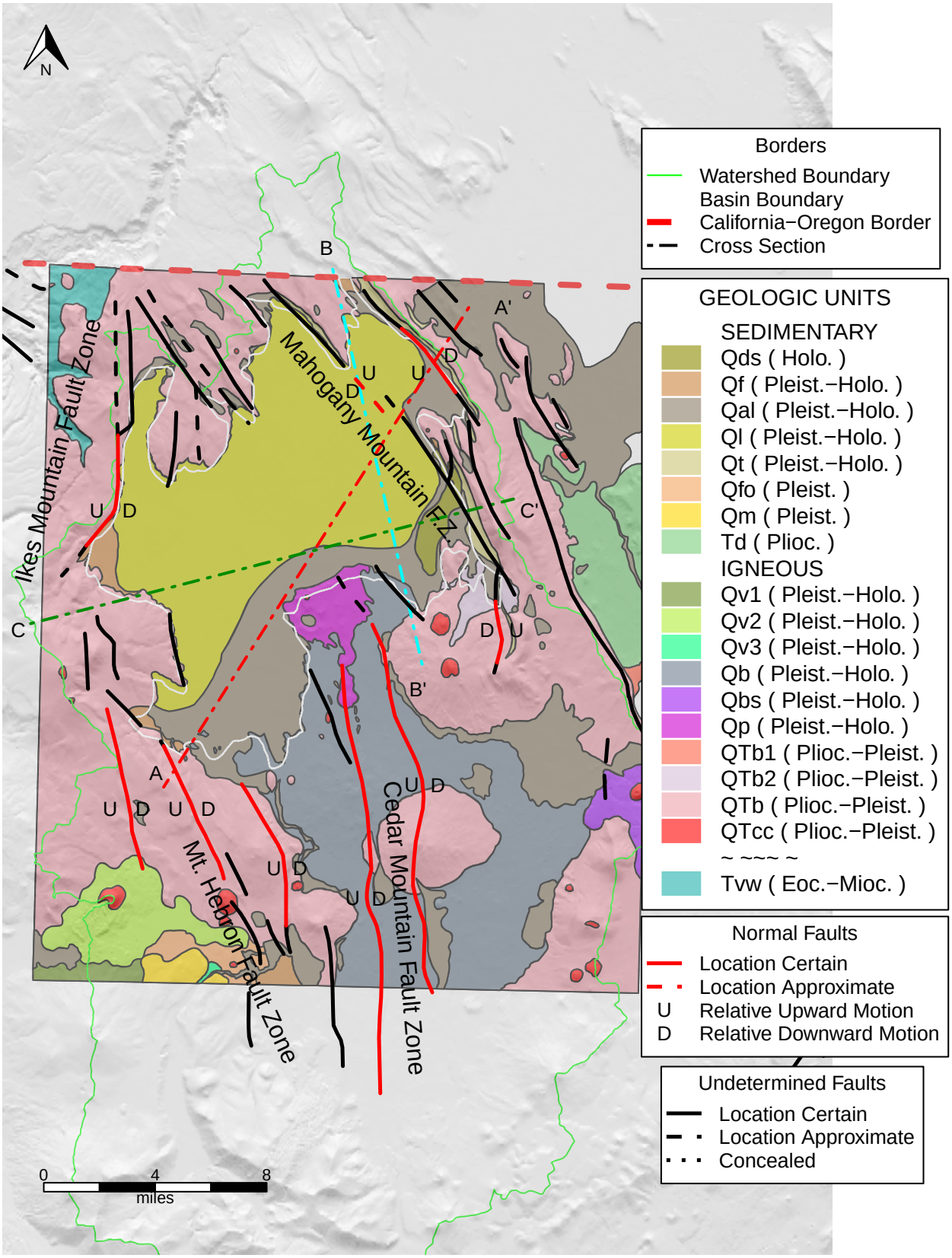


Figure 2.13: Geology of the Butte Valley Groundwater Basin and surrounding watershed. Fault zones are plotted with their major faults (minor faults not plotted). Legend abbreviations include the time periods Holocene (H.), Pleistocene (Pleist.), Pliocene (Plioc.), Miocene (Mioc.) and, Eocene (Eoc.). Geology layer from Wood, 1960.

Table 2.3: Geology Map Unit Descriptions (Wood 1960).

Unit Name	General Lithology	Age	Description
Qds	Dune Sand	Holocene	Unconsolidated sand, in part actively drifting.
Qf	Alluvial-fan deposits	Pleistocene-Holocene	Unconsolidated deposits consisting of poorly sorted boulders, gravel, sand, and silt beneath alluvial fans. Also includes remnants of older alluvial-fan deposits. Generally poorly permeable but transmits water to underlying formations.
Qal	Alluvium	Pleistocene-Holocene	Includes sand, gravel, and clay in the eastern and southern parts of Butte Valley; poorly sorted alluvial deposits collected in relatively shallow basins or depressions; local playa deposits; and gravel and sand in major stream channels. Moderately permeable.
Ql	Lake deposits	Pleistocene-Holocene	Semiconsolidated clay, volcanic ash, diatomite, and sand with local stringers of gravelly sand. Locally interfingers with and is overlain by talus, alluvium, and alluvial-fan deposits. In general poorly permeable but moderately permeable along the east side of Butte Valley.
Qt	Talus	Pleistocene-Holocene	Wedge-shaped deposits of blocky debris at the base of steep fault scarps. Highly permeable. May contribute to groundwater recharge. May act as groundwater storage reservoir or drain.
Qfo	Fluvioglacial deposits	Pleistocene	Poorly sorted rounded to angular rock fragments, boulders, sand, clay, and silt.
Qm	Glacial moraines	Pleistocene	Unstratified bouldery deposits in a clayey matrix.
Td	Diatomite	Pliocene	Massive-appearing gray to white diatomite. Locally contains interbedded sand, cindery tuff-breccia, and volcanic ash.
Qv1	Younger volcanic rocks of the ”High Cascades”	Pleistocene-Holocene	Highly permeable and important as recharge media. Hypershene-rich andesitic flos of Deer Mountain.
Qv2	Younger volcanic rocks of the ”High Cascades”	Pleistocene-Holocene	Highly permeable and important as recharge media. Black vesicular olivine-augite basalt flows from Little Deer Mountain.
Qv3	Younger volcanic rocks of the ”High Cascades”	Pleistocene-Holocene	Highly permeable and important as recharge media. Black vesicular olivine basalt in Butte Creek Canyon.
Qb	Butte Valley basalt	Pleistocene-Holocene	Grey vesicular olivine basalt that is highly permeable.

Table 2.3: Geology Map Unit Descriptions (Wood 1960). *(continued)*

Unit Name	General Lithology	Age	Description
Qbs	Basaltic flows near Sharp Mountain	Pleistocene-Holocene	Dark-colored olivine basalt that is highly permeable.
Qp	Pyroclastic rocks	Pleistocene-Holocene	Well-consolidated massive to thin-bedded lapilli tuff, and tuff-breccia. It is moderately permeable.
QTb1	Basaltic lava flows	Pliocene-Pleistocene	Generally very permeable and important for groundwater recharge. Grey vesicular olivine basalt flows on Big and Little Tablelands and extensive basalt flows south of Klamath Lake.
QTb2	Basaltic lava flows	Pliocene-Pleistocene	Generally very permeable and important for groundwater recharge. Coarsely vesicular black aphantic basalt near Sheep Mountain.
QTb	Older volcanic rocks of the ”High Cascades”	Pliocene-Pleistocene	Pale-grey olivine basalt and basaltic andesite and discontinous layers of yellowish tuff and tuff-breccia. Very permeable and an important groundwater storage reservoir.
QTcc	Cinder-cone deposits	Pliocene-Pleistocene	Red, brown, and black scoria mounds and cinder cones composed chiefly of andesitic and basaltic ejecta of Pliocene age and younger. Very permeable and largely unsaturated.
~~	Erosional or non-depositional surface	Miocene-Pliocene	Major Unconformity
Tvw	Volcanic rocks of the ”Western Cascades”	Eocene-Miocene	Chiefly andesitic lava flows and lesser amounts of andesitic tuff-breccia and lapilli tuff.

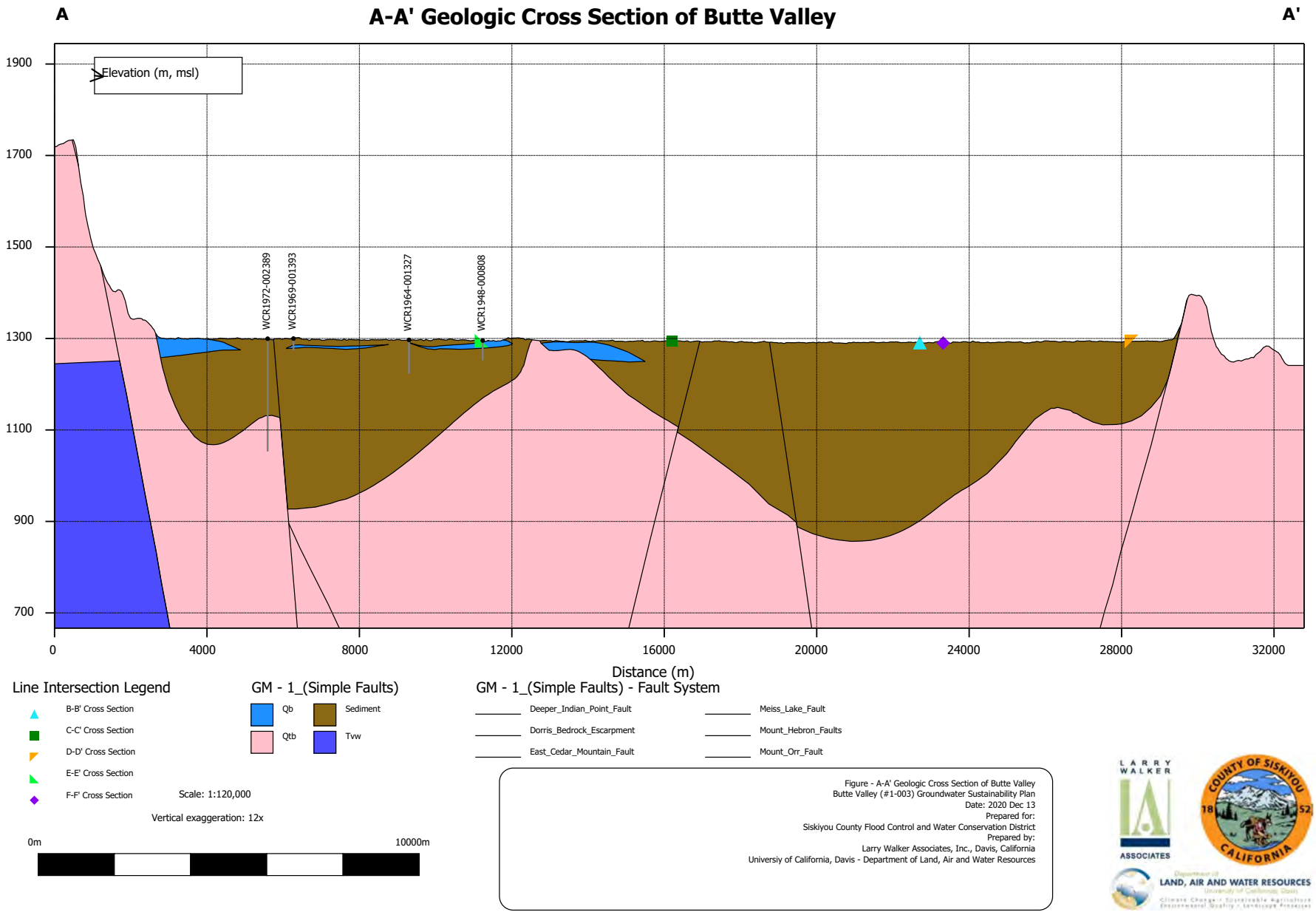


Figure 2.14: Cross Section A-A’ crosses Butte Valley from the southwest to the northeast corner, shown in the geology map.

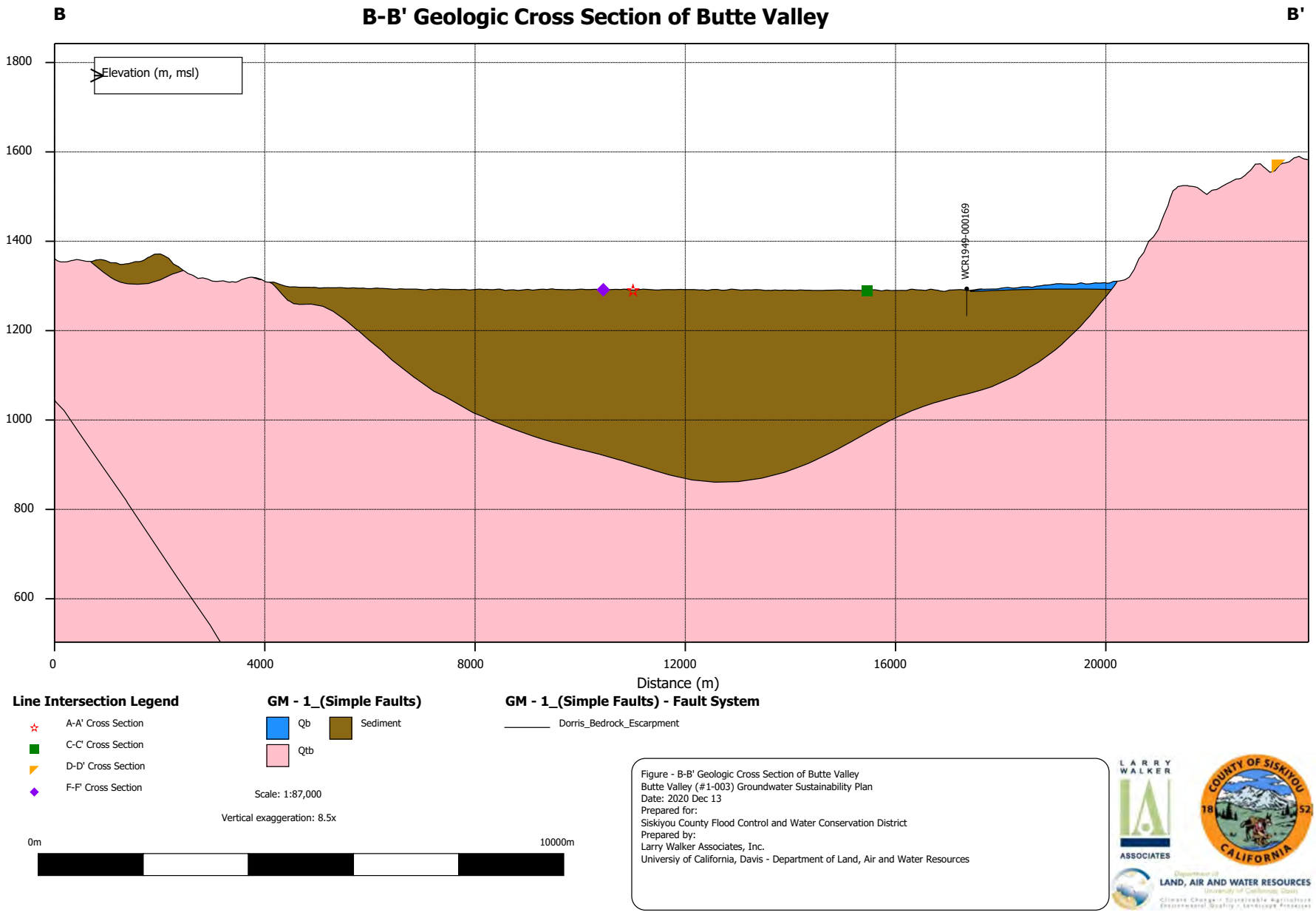


Figure 2.15: Cross Section B-B’ crosses Butte Valley from north to south near Dorris, shown in the geology map.

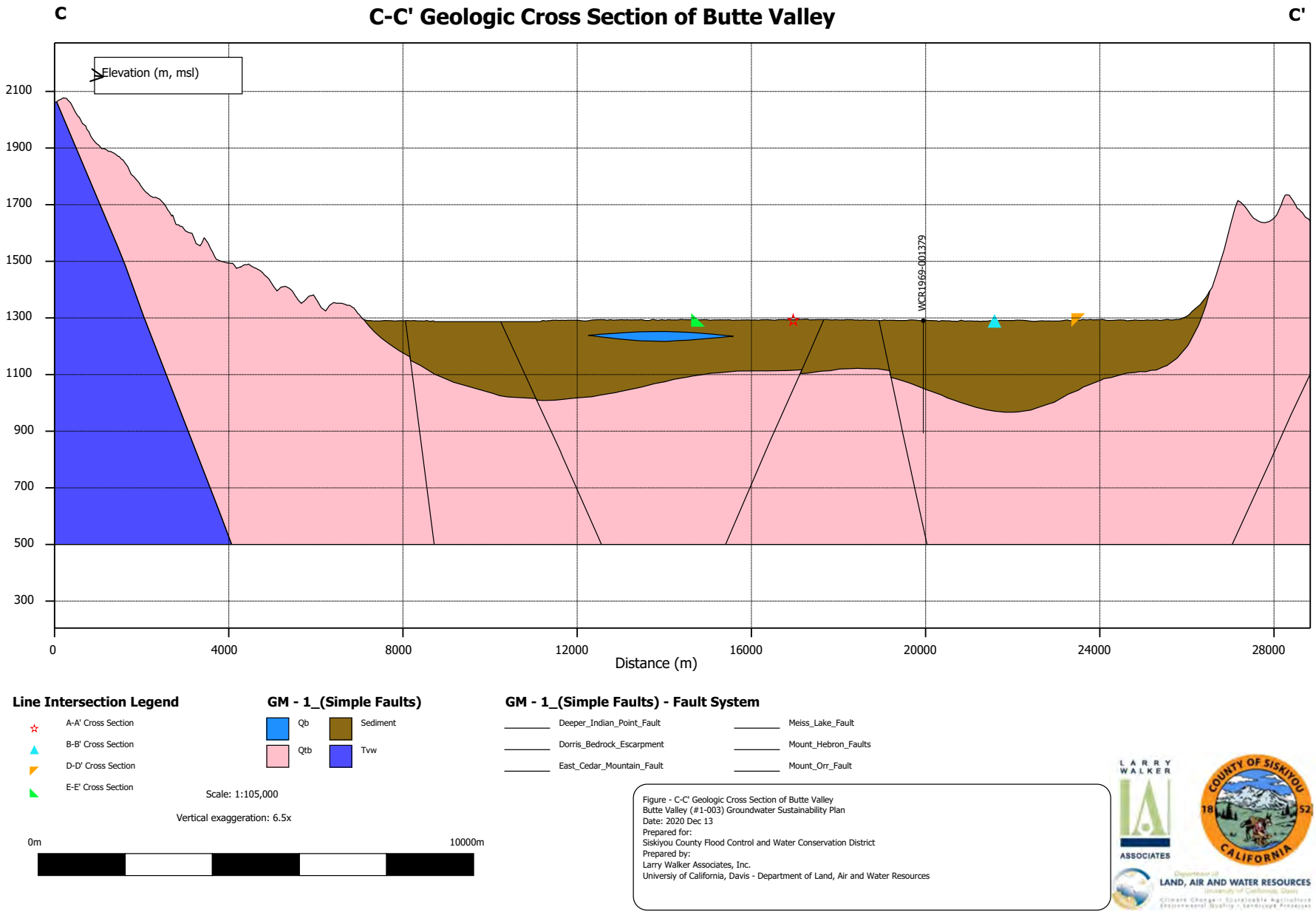


Figure 2.16: Cross Section C-C’ crosses Butte Valley from the west to east, shown in the geology map.

Western Cascades Subprovince

The upper Klamath Basin has been volcanically active for at least 35 million years with two subprovinces directly underlying Butte Valley: the Western Cascades subprovince and High Cascade subprovince (Gannett, Wagner, and Lite Jr. 2012). In Butte Valley, the oldest geologic unit with surface exposure is the volcanic rocks of the Western Cascades (Tv and Tvp in Figure 2.13). Western Cascades rocks are 20 to 33 million years old and can be up to 20,000 ft (6,096 m) thick with primarily early to middle Tertiary lava flows, andesitic mudflows, tuffaceous sedimentary rocks, and vent deposits (Gannett, Wagner, and Lite Jr. 2012). Near Butte Valley the unit is primarily andesite and andesitic tuff breccias (DOI 1980). In general, Western Cascade deposits have low permeability due to devitrified (changed to clays and other minerals) tuffaceous materials and weathered lava flows with abundant secondary minerals. Low permeability limits the flow of groundwater through the Western Cascade unit and acts as a barrier to regional groundwater flow. The unit dips to the east and defines the lower boundary of the regional groundwater flow where present (Gannett, Wagner, and Lite Jr. 2012). This formation has not been penetrated by Butte Valley wells (DOI 1980). The unknown depth to the Western Cascades Subprovince precludes its appearance in the cross-sections.

High Cascade Subprovince

The High Cascade subprovince unconformably overlies the Western Cascade unit, with ages from the late Miocene to late Pleistocene (5.3 to 0.012 Ma). Deposits within the upper Klamath Basin are constructional features such as volcanic vents and lava flows with relatively minor interbedded volcaniclastic and sedimentary deposits (Gannett, Wagner, and Lite Jr. 2012). High Cascade deposits in Butte Valley include Pliocene volcanic rocks and Pliocene cinder cone deposits (Wood 1960). Within the Valley, the depth to the High Cascade Volcanics confined water bearing formation varies from 47 to 1,317 feet bgs (Kit Novick 1996).

A 1977 seismic refraction survey attempted to find the depth and structural configuration of the High Cascade Volcanics water bearing formation. The survey may have detected the contact between the High Cascade Volcanics and underlying Western Cascade Volcanics or a transition to a more massive part of the High Cascades Series. The survey found that faulting through the High Cascades Volcanics has made the top of the unit very irregular and the depth to the unit can locally vary hundreds of feet between nearby wells. The surface of the High Cascade unit generally dips to the east, likely related to the fault system uplifting Mahogany Mountain (DOI 1980). Cross-sections A-A' and C-C' show that the top of the High Cascade Subprovince (Unit Qtb) is irregular and generally deepens toward the east (Figure 2.14 and Figure 2.16).

Butte Valley Basalt and Other Small Basalt Flows

All surface exposures of basaltic flows in Butte Valley and south of the Basin are important for groundwater recharge. Deposited in the late Pleistocene or Holocene, Butte Valley Basalt is a highly permeable uniform sheet of vesicular basalt that overlies and interfingers with lakebed deposits (DWR 2004). Surface exposures are in the southern part of the Basin and likely extend into the subsurface under the valley floor lake deposits through Macdoel and Meiss Lake, the southern valley floor and west of Inlow Butte (Wood 1960). The extent of the Butte Valley Basalt is shown in Figure B.2 in Appendix 2-A.

The depth of the Butte Valley Basalt varies from 0 to 110 feet bgs (Kit Novick 1996). The basalt ranges in thickness to 80 ft (24 m), averaging approximately 40 ft (12 m) (Figure 2.14 and

Figure 2.15). The subsurface extent is estimated to be 27 sq mi (70 sq km). The fractured basalt is commonly rough, broken, cavernous, and scoriaceous at contacts between relatively thin flow units. The basalt is predominantly located in the southern and southeastern region of the Valley at depths of less than 150 ft (46 m) (DWR 2004). Other small basalt flows in Butte Valley include the very permeable Pleistocene lava flows near Sheep Mountain (Wood 1960).

Pyroclastic Rocks

Pyroclastic rocks in Butte Valley are typically well consolidated, massive to thin-bedded lapilli tuffs and cindery tuff breccias that are generally cross-bedded and include abundant fragments of basalt and scoria. The deposits underlie a region located east and southeast of Macdoel ranging up to 400 ft (122 m) in thickness near Juniper Knoll. These deposits rest upon lake deposits and are partially overlapped by Butte Valley basalt (Wood 1960; County of Siskiyou 1996).

Lake Deposits

During 1.8 million years of the Quaternary Period, times of decreased temperature and increased precipitation created lakes in many hydrologically-closed drainage basins in the Western United States, such as Lakes Bonneville and Lahontan in the Great Basin. The maximum size of the Quaternary paleolake in Butte Valley was 73 sq mi (189 sq km) with a maximum depth of 46 ft (14 m). This maximum extent created a shoreline terrace at 4,268 ft (1,301 m) amsl elevation around the valley rim. The 4,268 ft (1,301 m) amsl terrace is the best developed shoreline terrace in Butte Valley and is at its widest on the north and east valley rims, particularly near Picard Cemetery on Mud Lake Ridge and just east of Dorris. Compared to other Quaternary paleolakes, the Butte Valley 4,268 ft (1,301 m) amsl terrace is underdeveloped, suggesting that the paleolake maximum was short-lived. While at this maximum extent, the paleolake overflowed into Rock Creek, a tributary of the Klamath River, through Sam's Neck. This overflow may have been brief due to the lack of a distinct overflow channel connecting the Sam's Neck notch at 4,265 to 4,268 ft (1,300 to 1,301 m) amsl to the Rock Creek channel. However hard bedrock at the channel site may have resisted erosion of a deeply-cut overflow channel and therefore, lake overflow may have lasted over a longer period. Concurrently, Butte Creek may have deposited deltaic sediments at the 4,268 ft (1,301 m) amsl shoreline (King 1994).

The lack of well-developed shorelines at the Butte Valley rim suggests that the paleolake was mostly confined to the valley floor. However, shoreline terraces in Butte Valley have been highly disturbed by human activity, including disturbances from the construction of houses, buildings, and roads on top of existing terraces. Other weak paleolake shorelines occur at 4,262 ft (1299 m) and 4,255 ft (1297 m) amsl. An example of the 4,262 ft (1299 m) amsl terrace is located at the end of Indian Point, where it is 33 ft (10 m) wide and consists of coarse beach sand with scattered angular talus boulders. An example of the 4,255 ft (1297 m) amsl terrace is located on the west side of Cedar Point. Below 4,255 ft (1297 m) amsl is the shallow sloping valley floor, where any further paloelake shorelines may have been destroyed by agricultural activity or never formed due to a rapid reduction in lake size to modern levels (King 1994).

Based on core samples, where lake deposits can exceed 900 feet (300 meters) in thickness, Butte Valley has been the site of a lake for between one and three million years (Carter 1994; Mathias 2014) (Figure 2.14, Figure 2.15, and Figure 2.16). Based on sediment accumulation rates, shallow sediments appear to accumulate at a rate of 8.3 cm per thousand years to a depth of approximately 78 meters. Below 78 meters below ground surface, corresponding with approximately 930,000 years in age, sediment accumulation rates decrease to 0.9 cm per thousand years (Roberts et al.

1996). Quaternary pyroclastic deposits in older lake deposits show evidence of being laid down in lake water. At the end of the Pleistocene, the Butte Valley paleolake may have experienced rapid desiccation after the end of the last glacial cycle, reducing the lake size to the current Meiss Lake. Quaternary paleolakes in the Great Basin also have evidence of a rapid desiccation after the end of the last glacial cycle, about 10-12,000 years ago. A rapid desiccation reducing lake size could explain the gap in lake shorelines from 4,255 ft (1297 m) amsl elevation to 4,236 ft (1291 m) amsl (King 1994).

The rapid desiccation of the Butte Valley paleolake created an environment of playas and phytogenic dunes. Much of the original valley floor has been disturbed by human activity, particularly by the leveling of fields. A large remnant east of Meiss Lake has never been cultivated and highly resembles a playa surface. In the 1950s, the USGS mapped two small playas on the southeastern side of the Valley before the area was converted to agricultural fields. In some locations between Meiss Lake and Dorris, phytogenic dune ridges trend northwest/southeast in parallel with area faulting. These phytogenic dunes likely formed through increased scrub vegetation along fault fissures in the lakebed, where increased moisture can occur (King 1994).

Alluvial Fan Deposits

Isolated remnants of alluvial fan deposits are located on the west side of Butte Valley (DWR 2004). Alluvial fan deposits in Butte Valley are saturated, but poorly permeable with groundwater yields suitable for stock or domestic wells (DOI 1980).

In Butte Valley, these deposits were deposited during the Pleistocene to the Present and are composed of poorly-sorted volcanic rock debris, rounded cobbles of volcanic origin, gravel, sand, and clay from the Cascade Range (DOI 1980; DWR 2004). The deposits are coarse near the mountain fronts and grade into fine materials in the lower part of the fans. The fans interfinger with lake deposits at depth. The deposits have low permeability except where well-sorted gravel lenses are encountered and generally yield small quantities of water to wells. Thickness of the deposits range up to 350 ft (107 m) (DWR 2004).

Alluvium

In Butte Valley, alluvium deposits were deposited from the Pleistocene to Recent and are moderately permeable but generally above the water table. Within the Basin alluvium deposits include several different types (Wood 1960):

- Sand, gravel, and clay in the eastern and southern parts of Butte Valley.
- Poorly-sorted alluvial deposits in relatively shallow basins or depressions.
- Local playa deposits.
- Gravel and sand in major stream channels.

Alluvium in the northern Butte Valley was deposited by sheetfloods, slope wash, and other agents of erosion. Deposits on the eastern border are mainly fine to coarse-grained sand of volcanic origin, with perhaps lakeshore or beach deposits. They were deposited by sheetfloods, slope wash, rill wash, and other colluvial processes. Some alluvium has been redeposited as windblown or dune sand mantling parts of the steep fault scarps (Wood 1960).

In the south, sand and gravel alluvium deposits unconformably overlie the Butte Valley basalt and overlie and locally interfinger with the lake deposits (Wood 1960; DOI 1980). They are characterized by lenticular deposits of clay, silt and sand. The deposits are generally poorly permeable and

can yield water for stock or domestic wells (DOI 1980). Along the valley margin, the alluvial deposits range from 0-60 ft (0-18 m) in thickness. Volcanic sand and gravel alluvium in the southwest of Butte Valley was likely deposited by Butte Creek flood waters and may represent a delta built by the creek during the high stages of the lake that formerly filled the Valley. Dune sand near Macdoel is wind reworked volcanic sand that is currently being leveled and cultivated (Wood 1960).

Playa deposits are common in the Butte Valley region, with clay, silt, and minor amounts of sand. They occur in the topographically lowest areas of small enclosed basins and merge laterally into alluvial slope deposits. They have low permeability and likely have highly saline water (Wood 1960).

Other alluvium deposits are poorly sorted and unconsolidated gravel, sand, and silt. They stem from the decomposition and erosion of volcanic material in adjacent mountainous areas and were deposited in basins and depressions by streams, sheetfloods, slope wash, and other erosional processes (Wood 1960).

Talus

Talus in Butte Valley are highly permeably wedge-shaped deposits of blocky debris at the base of steep fault scarps on the north and east sides of the Valley (Wood 1960). Talus deposits generally act as groundwater conduits and drains and may act as groundwater storage reservoirs where interfingered with saturated sediments. Water bearing properties are unknown and the few wells that penetrate talus deposits likely draw groundwater from both the talus sediments and other interconnected aquifer subunits (DOI 1980).

The deposits are unsorted, uncemented, angular blocks, boulders, and fragments of volcanic rocks of a few inches to greater than 6 ft (1.8 m). In some areas, the gaps between coarse materials have been filled by sand. In Butte Valley, large talus deposits primarily occur on the east margin, near the City of Dorris down to Sheep Mountain. In some areas the talus deposits are concealed underneath and likely interfinger alluvial and land-bed deposits. On westward-facing scarps, talus deposits are covered by windblown sand. The thickness and lateral extent of the talus deposits is not well defined, though two wells near Dorris encountered 143 and 360 ft (44 and 110 m) of talus (Wood 1960).

Dune Sand

A very young deposit generally above the water table, a large dune sand deposit sits on the eastern border of Butte Valley, west and north of Inlow Butte and south of Cedar Point (Wood 1960; King 1994). Dune sand deposits too small to plot on a geologic map exist elsewhere in Butte Valley. Dune sand covers High Cascade rock outcrops in westward-facing escarpments along the Butte Valley border (Wood 1960).

The deposit is unconsolidated, fine-to-coarse, massive, loosely compacted, crossbedded quartz sand that is in part actively drifting and up to 20 ft thick. The dune sand was reworked from lake and alluvial deposits which have migrated eastward and northward from old abandoned lake shorelines. Dunes have largely been stabilized by a sparse cover of vegetation, but some sections have dunes actively advancing upon older dunes, talus and High Cascades rock outcrops (Wood 1960). The majority of the extensive aeolian dune deposits south of Cedar Point were likely produced by wave action on the eastern shorelines of the Quaternary Butte Valley paleolake (King 1994).

2.2.1.5 Faults

Beginning in the Pleistocene (2.6 to 0.012 Ma), faulting began to form Butte Valley and remain active today (DOI 1980). Butte Valley is bordered on all sides by the Cedar Mountain fault system, a complex group of generally north- to north-northwest-striking normal faults along the boundary between the Cascade Ranges and the Modoc Plateau (Bryant 2000). Fault displacement is nearly vertical and ranges from a few feet to possibly more than several thousand feet along major faults (DOI 1980). The fault system has offset the latest Pleistocene and Holocene volcanic rocks, glacial, and alluvial deposits (Wood 1960; Bryant 1990, 2000). Historic surface fault rupture is associated with the local magnitude (ML; Richter magnitude) 4.6 Stephens Pass earthquake of August 1, 1978 (Bryant 2000). An earthquake in late June of 1966 shook the Dorris area and ruptured the clay lining of a waste effluent evaporative treatment pond about 0.5 mi (0.8 m) southwest of Dorris (DWR 1968; DOI 1980). The faults near Dorris exhibit evidence of continuing into the bedrock below the valley floor (DWR 1968).

Five sections of the Cedar Mountain fault system exist within Butte Valley: Cedar Mountain, Mahogany Mountain, Mount Hebron, Meiss Lake, and Ikes Mountain Faults. The Cedar Mountain Fault Zone begins at the northern border of the Basin through the middle to the southern border (see Figure 2.13). Within Butte Valley the fault zone is 6.8 mi (11 km) wide, with numerous short, northwest-trending faults in the Valley floor and through the Butte Valley Basalt. Offset features within the Valley indicate that the fault zone has been active during the Holocene (Bryant 2000). The northwest Basin border is characterized by the Ikes Mountain Fault, a north-trending normal fault. It was active in the late Quaternary with little evidence for more recent activity. The Meiss Lake Fault passes through the middle of Meiss Lake and is a north-trending fault with Holocene activity. Some geomorphic evidence suggests a component of right-lateral strike slip. The Valley border in the southwest is defined by the Mount Hebron Fault Zone, a 4.3 mi (7 km) wide series of north to northwest-trending normal faults. Geomorphic evidence limits fault activity to the Quaternary and late Quaternary. The Mahogany Mountain Fault Zone marks the northwest border of the Basin, a northwest-trending zone of normal faults with vertical displacement to the southwest. Geomorphic evidence suggests that the fault has been active in the Holocene (Bryant 1990, 2000).

A 1998 DWR Well Interference Investigation in the northwestern portion of the Basin indicates that local faults can act as both a flow barrier and very transmissive conduit for groundwater flow. The study's conclusions suggest that other faults in the area likely influence groundwater flow in a similar fashion. The aquifer performance test of the BVWA Well 7A shows structural continuities, including (DWR 1998):

- A strong north-south hydraulic continuity along a fault trace adjacent to two monitoring wells.
- Areas on either side of a fault adjacent to Well 7A are somewhat isolated from each other, with improved hydraulic continuity within a common fault-bounded area.
- There is a hydraulic connection in talus deposits along a fault trace.
- Well 7A has an asymmetrical cone of depression, attenuated on the east side of the fault trace.

Faults in the Basin support the formation of springs, where numerous Basin springs align with faults. Faults can impede groundwater flow and cause a buildup of groundwater, which can emerge at the surface in the form of a spring. Local agriculture in the Basin can be supported by springs, such as Holzhauser Ranch in Sam's Neck, where water from two springs are collected into ponds for irrigation (DWR 1998).

2.2.1.6 Water Bearing Formations

Water bearing formations within the Basin aquifer are described in the following discussion, where the principal water bearing formations are Lake Deposits, Butte Valley Basalt, and High Cascade Volcanics, and minor formations are Alluvial Fan Deposits and Pyroclastic Rocks (DWR 1998; DWR 2004). Unconfined formations include the Lake Deposits, Pyroclastic Rocks, and the Butte Valley Basalt (DOI 1980). Within the Basin the Lake Deposits cover the High Cascade Volcanics and Butte Valley Basalt, confining the two formations in most areas (DWR 1998). The Butte Valley Basalt can also be locally confined when overlain by fine-grained alluvium with low permeability (DOI 1980). Comparatively, the High Cascade Volcanics and Butte Valley Basalt have high yields and the Lake Deposits have relatively low yields (DWR 1998).

Groundwater flow and distribution in the Basin is controlled by localized faulting, aquifer material variability, and the interconnection of formation units, which can enhance, diminish, or block flow. Faults and fractures can act as either groundwater conduits or barriers to flow (DWR 1998). Faults in Butte Valley may act as vertical paths of high permeability locally connecting the Lake Deposits and High Cascade Volcanics water bearing formations (DWR 1968). Faults can also offset formations and juxtapose more permeable formations against less permeable units (DWR 1998). There is limited vertical hydraulic continuity between the low, variably permeable Lake Deposits and high isotropic permeable High Cascade Volcanics due to the contrasting permeability (DWR 1968; DWR 1998). The High Cascade Volcanics water bearing formation is confined and separate from the Lake Deposits near Dorris (DWR 1968), and Meiss Lake (DWR 1998).

High Cascade Volcanics Water Bearing Formation

The High Cascade Volcanics water bearing formation is highly fractured, very permeable, highly transmissive, and an important regional groundwater source (DWR 1998; DWR 2004). The High Cascade Volcanics is divided into a series of “compartments” by fine-grained feeder dikes radiating out from parent cones and by a series of northwest-trending faults (Kit Novick 1996). Wells are routinely developed into this geologic unit and water yields range from 700 to 5,000 gallons per minute (gpm), but often produce over 3,000 gpm. Groundwater within the unit is usually confined by Lake Deposits and some irrigation wells have artesian flows (Kit Novick 1996; DWR 2004). Most wells in Butte Valley encounter the formation at depths between 240 to 600 ft, with some wells intercepting the formation at shallow depths of 47 ft or deep depths of 1,317 ft. Springs stemming from the High Cascade Volcanics supply the perennial flows for Prather, Muskgrave, Harris, and Ikes Creeks. This water bearing formation has not experienced overdraft (Kit Novick 1996).

Beyond being a major element of the Basin’s groundwater storage reservoir, the High Cascade Volcanics is also very important for groundwater recharge. It has a large areal extent beyond the Basin margin and acts as an intake media for groundwater recharge into the Basin (DWR 2004). It defines the Basin boundaries in the west, north, and east and underlies the lake bed deposits (Wood 1960; DWR 2004).

The High Cascade Volcanics consist of successive sheets of basalt, basaltic andesite, discontinuous layers of massive basaltic tuff and tuff breccia, and some isolated lapilli tuff, and cinder-cone deposits. The individual flow units range in thickness from 10- to 50-ft (3 to 15 m) and intermittently up to 100 ft (30 m) (DWR 2004). Individual well yields are highly dependent on the flow thickness and number of flow contacts intercepted, as well as vertical fracturing (DOI 1980; DWR 2004). Tuffaceous deposits are essentially non-water-bearing except for fracture zones and intercalated basaltic flows (DWR 2004).

Butte Valley Basalt Water Bearing Formation

Historically the Butte Valley Basalt has been the primary groundwater-producing water bearing formation in the southern part of the Basin (DWR 1998). The unit is also the most productive formation in the region, with water yields of 1,000 to 4,000 gpm and an average of 2,000 gpm (Kit Novick 1996). Highly productive wells from this formation are common in the Macdoel-Mount Hebron area and can generate up to 4,000 gpm (DWR 1998; DWR 2004). Specific capacities of 100 gpm per foot of drawdown are common and values up to 1,100 gpm per foot of drawdown have been documented (DWR 2004). A temporary seasonal overdraft occurs during the latter part of the irrigation season evidenced by well interference from overutilization (DWR 2004). This formation has been developed to its maximum productivity and in some years seasonal pumpage exceeds storage capacity (Kit Novick 1996; DWR 2004). Toward the end of the irrigation season, some shallow BVID and BVWA wells go dry but recover by the following season after groundwater recharge. The formation recharges annually with no long-term overdraft in average to above average precipitation years (Kit Novick 1996).

The Butte Valley Basalt consists of a highly permeable, fractured, uniform sheet of vesicular basalt with an average thickness of 40 ft (12 m) and a range from 6 ft (1.8 m) to hundreds of feet thick (DOI 1980; DWR 1998; DWR 2004). A system of nearly vertical joints or shrinkage cracks through the unit facilitates the vertical migration of groundwater (DWR 1998). Internally, the formation consists of comparatively thin lava flows where contacts between flows are commonly rough, broken, cavernous, and scoriaceous (DWR 1998; DWR 2004). The combination of vertical and horizontal flow paths makes the Butte Valley Basalt a productive water bearing formation (DOI 1980). The basalt is predominantly located in the southern and southeastern region of the Basin at depths of less than 150 ft (46 m), overlies and interfingers with Lake Deposits, and has an estimated subsurface extent of 27 sq mi (70 sq km) (DWR 2004). The unit extends northward as far as the east side of Meiss Lake (Kit Novick 1996). The rough broken surface exposures provide areas of recharge (DWR 2004). Butte Creek is diverted to several locations to recharge the Butte Valley Basalt (Kit Novick 1996).

Lake Deposits Water Bearing Formation

The Lake Deposits is the most important water bearing formation on the east side of the Valley but yields less water than the Butte Valley Basalt and High Cascade Volcanics water bearing formations. The water bearing formation is locally both unconfined and confined. Lake Deposits can occur both above and below the Butte Valley Basalt but always above the High Cascade Volcanics. The formation depth ranges from 0 to 125 ft bgs. Water yields from the best wells range from 1,500 to 2,600 gpm (Kit Novick 1996).

Lake Deposits vary widely in their ability to transmit water, but are generally more permeable and coarser grained on the east and south sides of the Valley and more permeable along the Basin margin compared to mid-basin (DOI 1980; DWR 1998; DWR 2004). Mid-basin Lake Deposits generally represent fine-grained lake deposits while the valley margins generally contain coarser, sandier near-shore deposits from the paleolake that once filled Butte Valley. Along the Basin margins, Lake Deposits interlayer with volcanic rocks and can yield moderate to high groundwater yields (DWR 1998). Coarser Lake Deposits in the western and northwestern part of the basin generally yield sufficient water for stock wells, while the more sandy eastern valley margin can have yields up to 2,500 gpm (DWR 2004). At the southern Basin margin deposits are interfingered with

the recharging Butte Valley Basalt and well yields can exceed 4,100 gpm (DWR 1998; DWR 2004). Lake Deposits are generally lenticular (DWR 1968).

The Lake Deposits consist of semi-consolidated deposits of relatively impermeable sand, silt, clay, ash, lenses of diatomaceous clay, and local stringers of gravelly sand (DWR 1998; DWR 2004). Unit thickness is variable from 350 to 1,300 ft (107 to 396 m), but generally thickens to the west and unconformably overlies the older volcanic rocks of the High Cascades (DOI 1980; DWR 2004). In the central Basin, a calcium carbonate cemented clay hardpan soil is usually present from six inches to several feet beneath most soils and is particularly close to the surface around Meiss Lake (County of Siskiyou 1996; DWR 2004). The hardpan impedes vertical groundwater recharge into the Lake Deposits water bearing formation (DWR 1998).

Sand deposits in the Lake Deposits exhibit a general grain size and thickness gradation from south to north, suggesting the presence of a major stream entering the paleolake from the south, with coarser material dropping out of suspension first in the south and the finer material being carried and deposited north and west. In the south, coarse-grained lake deposits are interfingered with and underlie the Butte Valley Basalt (DOI 1980).

West of U.S. Highway 97, Lake Deposits on the west and northwest valley sides are generally fine-grained silts and clays of very low permeability that commonly serve as confining layers (DOI 1980; DWR 2004). Though saturated with groundwater these fine-grained lake deposits yield only small quantities of water to stock wells (DOI 1980).

East of U.S. Highway 97, Lake Deposits are loose, fine to medium-grained bedded sands interbedded with clay (DWR 2004). East of U.S. Highway 97, northeast of Juniper Knoll and in the southern part of the Valley, lenses and beds of sands and gravels over 300 ft (91 m) thick are interbedded with and overlie finer-grained clays and silts. East of U.S Highway 97, northeast of Juniper Knoll and the east side of the Basin, the lake deposits are loose, fine to medium-grained, current-bedded sands interbedded with clay. To the north, the thickness and number of sand lenses generally diminish and the grain size decreases. Near Dorris are discontinuous lenses of fine to medium sand that yield water to mainly domestic or low-yielding irrigation wells (DOI 1980). In the eastern half of the Basin, specific capacities range from 9 to 62 gpm per foot of drawdown. Locally, and along the eastside Basin margin, specifically sandy lake deposits can interfinger with highly permeable deposits of beach sand and talus debris (DWR 2004).

South of Macdoel, the sand layers thicken and the grain size increases. The coarse-grained lake deposits in the south are moderately to highly permeable with loose sands and gravels that yield water freely but cause problems with well drilling and completion. Wells in these lake deposits often report “sanding up” problems and can have issues with caving (DOI 1980).

Alluvial Fan Deposits Water Bearing Formation

Isolated remnants of alluvial fan deposits are located on the west side of Butte Valley. These deposits are composed of poorly-sorted volcanic rock debris, cobbles, gravel, sand, and clay from the Cascade Range. The deposits are coarse near the mountain fronts and grade into fine materials in the lower part of the fans. The fans interfinger with Lake Deposits at depth. The deposits have low permeability except where well-sorted gravel lenses are encountered and generally yield small quantities of water to wells. Thickness of the deposits range up to 350 ft (107 m) (DWR 2004).

Pyroclastic Rocks Water Bearing Formation

The deposits underlie a region located east and southeast of Macdoel ranging up to 400 ft (122 m) in thickness near Juniper Knoll (Wood 1960; DWR 2004). Deposits are exposed on the surface over a large area east of Macdoel. The unit is moderately to highly permeable and will yield water freely to wells where it is saturated (DOI 1980). Most of the outcrop lies above the saturated zone, where it acts as an intake area for groundwater recharge (Wood 1960; DOI 1980). These rocks have largely been developed for stock wells (DWR 2004).

The Pyroclastic Rocks unit is characterized by well-consolidated, massive to thin-bedded lapilli tuffs and cindery tuff breccias that are generally cross-bedded and include abundant fragments of basalt and scoria (DWR 2004). Deposits were created via at least two widely separated eruptive events (DOI 1980). The deposit overlies the lake deposits. The Butte Valley Basalt was deposited between the two main pyroclastic events and locally overlaps and is interbedded with the pyroclastic deposit (DOI 1980; DWR 2004).

2.2.1.7 Groundwater Recharge

Natural recharge occurs primarily from the infiltration of precipitation, underflow from the Basin-adjacent volcanic rocks (on the north, west, and south margins) and streamflow losses (DWR 2004). Surface exposures of Butte Valley Basalt, High Cascade Volcanics, and Pyroclastic Rocks within the watershed are sources of recharge from rain and snow (Kit Novick 1996; DWR 2004). The High Cascade Volcanics recharges via snow pack in the north, west, and south sides of the Watershed (Kit Novick 1996). Lake Deposits also contain sources of groundwater recharge where volcanic talus deposits occur along fault scarps that cut into deeper water bearing formations (DWR 1998). Groundwater recharge via streamflow losses are provided by Butte, Antelope, Prather, Ikes, Harris, and Muskgrave Creeks (Kit Novick 1996). In the southern part of the Basin, seepage losses from unlined canals along the western fringe and deep percolation from irrigation also contribute to recharge (DWR 2004). The wetlands and canals in BVWA also recharge the groundwater (Kit Novick 1996).

2.2.1.8 Soil Characteristics

Soils in Butte Valley have developed in the valleys, basins, foothills, and mountain slopes, with distinct characteristics in each location. The following discussion references map units, named for major soil components, in the U.S. Department of Agriculture (USDA) 1994 Soil Survey of Butte Valley-Tule Lake Area (USDA 1994). A map of soil orders in the watershed is shown in Figure 2.17. The general soil units discussed below are shown in Figure 2.18. The infiltration and runoff potential as defined in hydrologic soil groups is shown in Figure 2.19. In Butte Valley, areas of poor soil permeability have an accumulation of salt and alkali, and tend to occur in areas with a hardpan (1996 Siskiyou County). Soils in the center of the Basin and bench lands along the northern valley rim have a prominent heavy calcareous hardpan (DOI 1980). In adjacent cropland, fields are leached through deep canals to decrease salts and alkali, and the hardpan is ripped periodically to improve rooting depth and drainage (Kit Novick 1996).

Most soils in Butte Valley are derived from lacustrine deposits, from the paleolake that used to fill the Valley. The center of the Basin, from the lowest elevation at Meiss Lake to the eastern valley side, is slightly lower than the north and south valley areas. The center of the Basin has

historically acted as an evaporation basin for the spring runoff (DOI 1980).

Valley Floor Soils

The Butte Valley floor contains several soil orders: Ultisols in the middle of the Valley, Mollisols at the Valley edges, and Inceptisols and Vertisols west of Meiss Lake. The valley floor is further divided into several general soil units, which are broad areas that have a distinctive pattern of soils, relief, and drainage. While each soil subunit is a unique natural landscape, the general soil units can be used for general land uses and broad interpretive purposes (USDA 1994).

The Inlow-Ocho soil unit is centered in the Butte Valley National Grasslands and extends southwest to Meiss Lake and crosses U.S. Highway 97 towards Inlow Butte. It is a silt to very fine sandy loam that forms on lake terraces. The unit formed from lacustrine sediment and alluvium derived from volcanic ash and extrusive igneous rock. It is moderately deep to shallow, moderately well drained to somewhat poorly drained, with slopes of 0-2%. Below the subsoil is a hardpan at about 18-33 in (0.46–0.84 m) below the surface. Below the hardpan is loamy sand. Minor components of this soil include well-drained loamy Modoc soils, with a subsoil of loam and sandy clay loam, and shallow, poorly-drained Ocho Variant soils, with a subsoil of clay. The soil unit is mainly used as rangeland. Hazards of the Inlow soils include soil blowing and sodicity, while the Ocho soils have issues with sodicity, a shallow effective rooting depth, surface crusting, and ponding. Soil hazards limit the production of forage and make seeding unfeasible. The moderate hazard of soil blowing requires onsite investigation prior to mechanical treatment. The sodicity hazard is deemed unfeasible to overcome (USDA 1994).

The agricultural land in Butte Valley is predominantly underlaid by Mollisols. Mollisols on the north half of Butte Valley are characterized by the Modoc-Rojo soil unit. The soil unit forms on lake terraces and was created in alluvium and lacustrine sediment derived from extrusive igneous rock and material weathered from tuff and volcanic ash. The loamy soil is moderately deep, with slopes from nearly level to moderately sloping (0-9% slope). The surface layer is loam to sandy loam and the subsoil is loam, sandy clay loam or sandy loam. A hardpan or duripan lies roughly 28-34 in (0.71-0.86 m) below the surface. Below the hardpan is sand, weathered tuff, and volcanic ash. The soil unit also has minor components of the well-drained Dehill, Dotta, Mudco, and Truax soils and the moderately well-drained Medord, Doel, and Rangee Variant soils. Dehill, Dotta, Medford, and Traux soils are deep soils at higher elevations with no duripan. Mudco and Rangee Variant soils have a duripan within 20 in (0.51 m) of the surface. Doel soils have a surface layer underlain by sand. The Mullisol Modoc-Rojo soil unit is used for cultivated crops, hay and pasture, and rangeland. Hazards include soil blowing, hardpan depth, low available water capacity, and frost potential. The depth to volcanic tuff in the Rojo soils discourages ripping. A temporary water table above the hardpan can be prevented with good irrigation management (USDA 1994).

Agricultural activity in the southern half of Butte Valley is predominantly underlain by the soil unit Poman-Fordney, whose subunits are classified as either an Ultisol or Mollisol. This unit also surrounds Dorris. The sandy soils lie on alluvial plains and terraces and were formed from volcanic tuff and other kinds of extrusive igneous rock. It is moderately deep to very deep and nearly level to strongly sloping (0-15% slope). The surface layer is loamy sand. The substratum of the very deep, excessively drained Fordney soils is loamy sand. The moderately deep and somewhat excessively drained Poman soils have a subsoil of loamy sand above a duripan at about 29 in (0.74 m) below the surface. Underlying the duripan is sand. Minor components of the soil unit are the well-drained Dehill soils, the moderately well-drained Doel soils and the somewhat poorly-drained Podus and Poe soils. Dehill soils are sandy loams at higher elevations. Podus soils have a duripan at 10-20 in

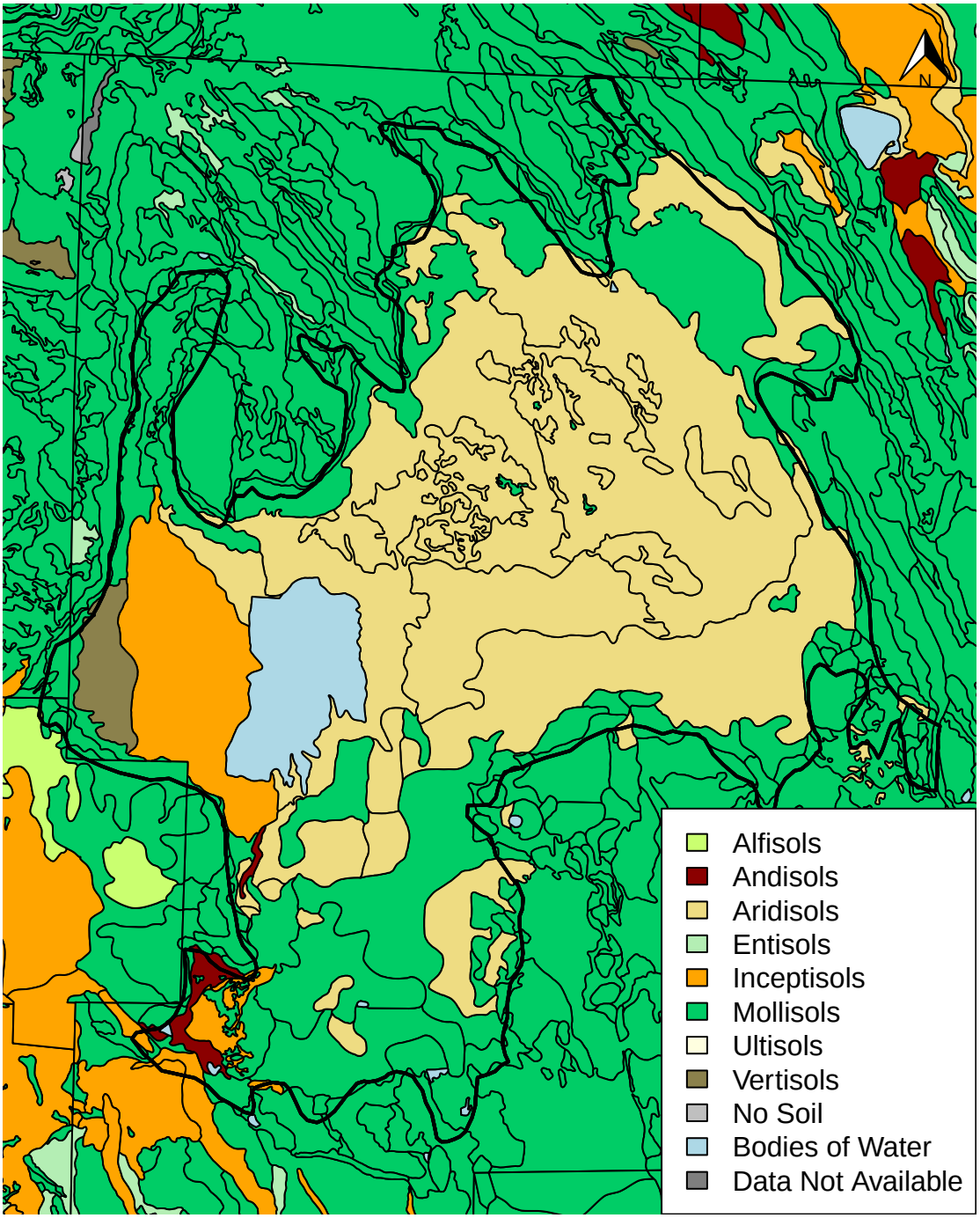


Figure 2.17: Soil classifications in Butte Valley

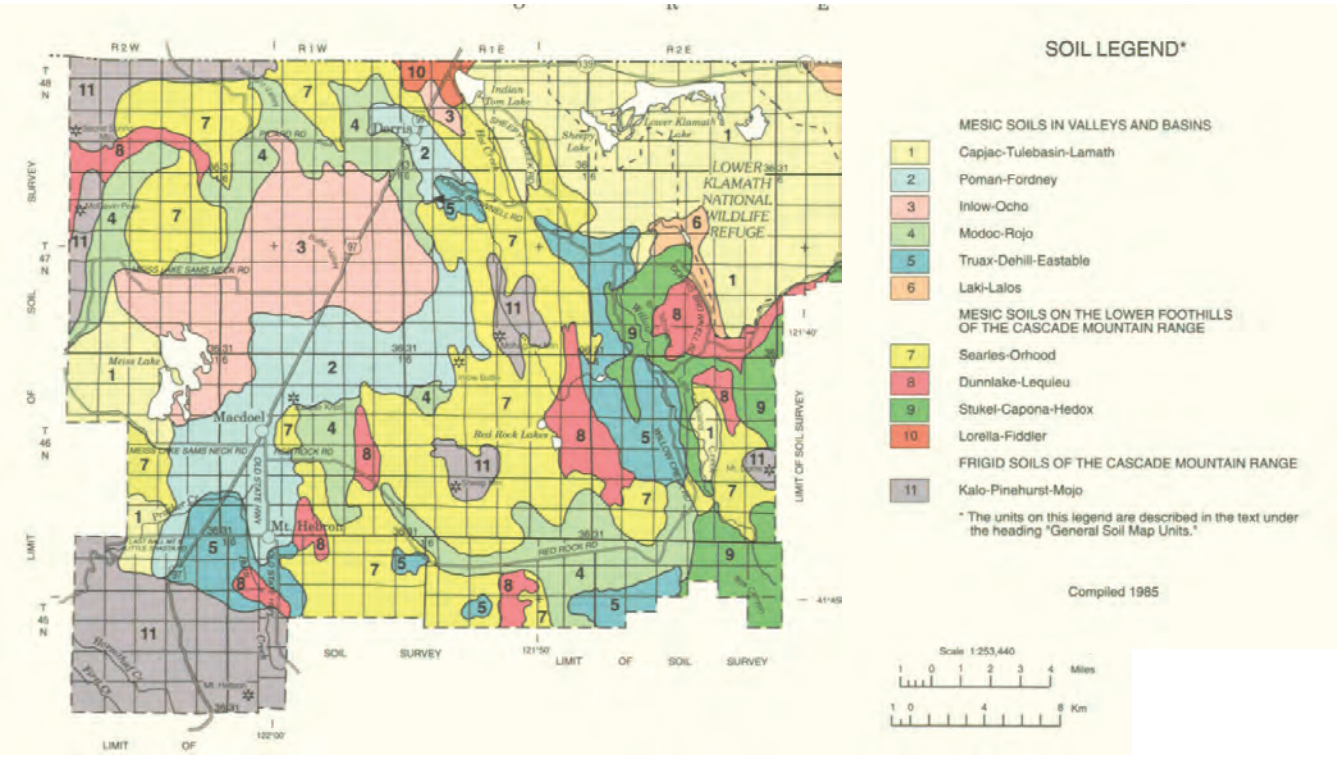


Figure 2.18: General Soil Map of Butte Valley from the 1994 USDA Soil Survey of the Butte Valley-Tule Lake Area. Modified from the original 1994 USDA General Soil Map, included in Appendix 2-A.

(0.25-0.51 m) below the surface and have a high water table. Similarly, Poe soils, too, have a high water table, but with a duripan at 20-40 in (0.51-1.0 m) below the surface. The Poman-Fordney soil unit is used for cultivated crops, hay and pasture, rangeland, and home development. Issues include a rapid rate of water intake and low available water capacity. Hazards include soil blowing and a risk for frost (USDA 1994).

The Capjac-Tulebasin-Lamath soil unit has subunits that can be classified as an Inceptisol, Vertisol or Andisol. This loamy soil occurs in lake basins and forms from lacustrine sediment derived dominantly from diatomite, volcanic ash, and extrusive volcanic rock. The soil is very deep, nearly level (0 to 2% slope) and very poorly drained to poorly drained. The subunits in Butte Valley share further characteristics, where they are all very deep, artificially drained soil in lake basins, protected by dikes and levees, and have a water table controlled by pumping to deep lateral drains (USDA 1994).

The Vertisol subunit is a Pit silty clay, formed in poorly drained alluvium derived from extrusive igneous rock. Dikes and levees protect this soil from brief flooding from January through May (USDA 1994). The water table is maintained at a depth of 5-6 ft (1.5–1.8 m). It is a silty clay at 0-26 in depth, silty clay loam or clay loam at 26-31 in and silt loam at 26-31 in (0.66–0.79 m) (USDA 2020b). Permeability is low and available water capacity is high. The unit is used for cultivated crops such as wheat and barley, and rangeland. Soil issues include a high shrink-swell potential and a susceptibility to compaction (USDA 1994).

There are two pockets of Inceptisols on the eastern side of the Valley. The subunit west of Meiss Lake is a Teeters silt loam and the subunit south of Meiss Lake along Prather Creek is a Lamath silt loam. Both formed from poorly drained silty or lacustrine sediment derived from diatomite, volcanic

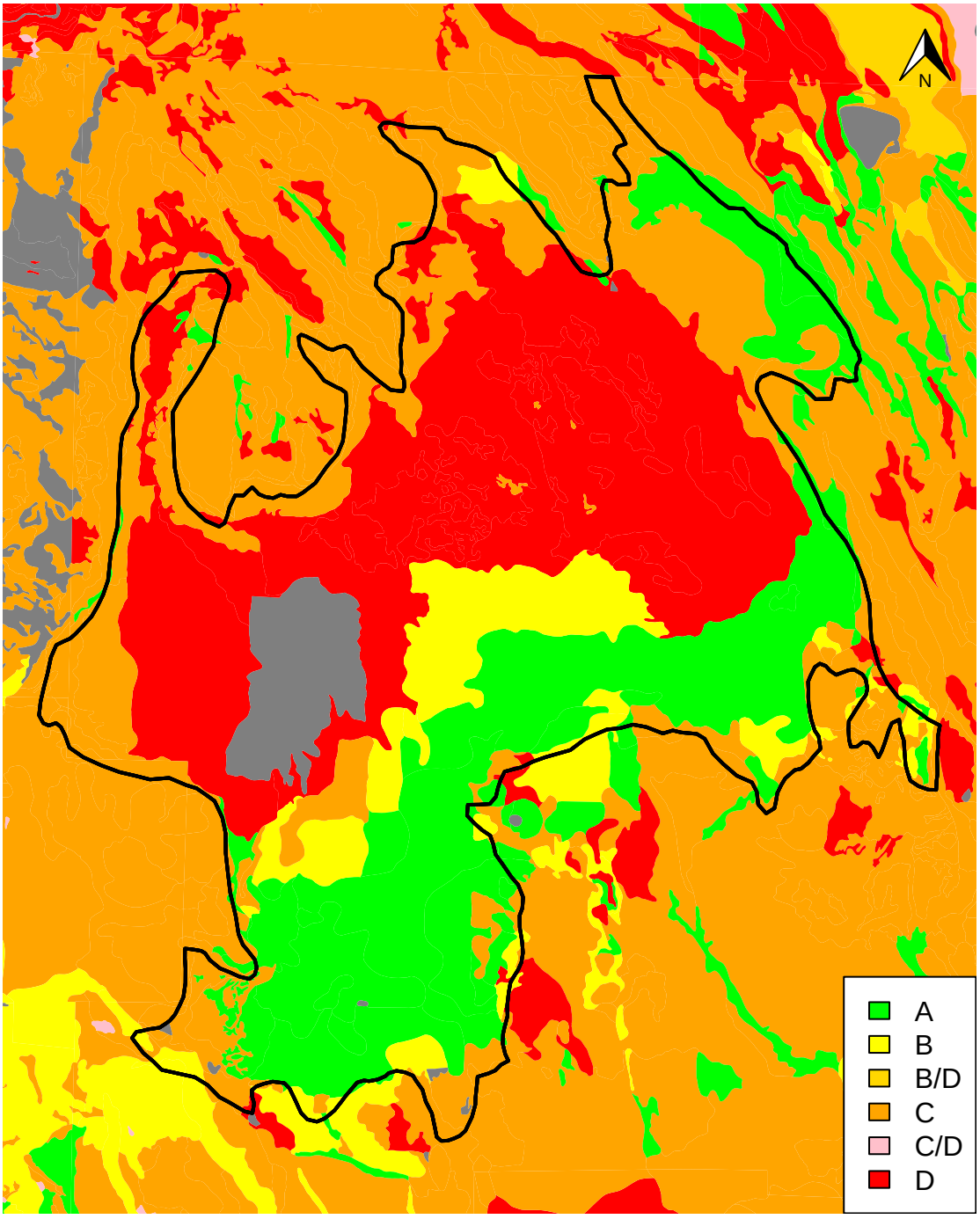


Figure 2.19: Hydrologic soil groups in Butte Valley, where Group A are soils with a high infiltration rate and low runoff potential to Group D with very slow infiltration rate and high runoff potential. Soils have two Groups if a portion is artificially drained and the rest undrained.

ash, and extrusive igneous rock. Dikes and levees protect the soil from brief flooding from March through May (USDA 1994). The water table is maintained at a depth of 1.5-4 ft (0.46-1.2 m). The soil is saline. The Teeters silt loam soil unit is silt loam, with some silt at 10-60 in (0.25-1.5 m) depth. The Lamath silt loam soil unit is silt loam at 0-21 in (0-0.53 m) depth, sand and loamy sand at 21-53 in (0.53-1.3 m) depth, and stratified sand to silt loam at 21-53 in (0.53–1.3 m) depth (USDA 2020b). The diatomite and volcanic ash origin of the soil creates a very high water capacity. Soil blowing is a moderate hazard when the surface layer is dry under high wind conditions. The soil is used for cultivated crops, hay and pasture and wildlife habitat (USDA 1994).

The Andisols are Capjac silt loam, formed in poorly drained lacustrine sediment derived from diatomite and volcanic ash. Dikes and levees protect this soil from rare flooding from October through May. The water table is maintained at a depth of 1.5-3.0 ft (0.46–0.91 m). The surface layer down to about 26 in (0.66 m) depth is silt loam and the substratum down to 60 in (1.5 m) or more is slightly saline silt loam. Permeability is moderate and frost is a hazard. The diatomite and volcanic ash origin of the soil creates a very high water capacity. Soil blowing is a moderate hazard when the surface layer is dry under high wind conditions. This soil is used for wildlife habitat, cultivated crops, and irrigated hay and pasture (USDA 1994).

Alluvial Fan Soils

From U.S. Highway 97 west of Mount Hebron to the southern valley rim below the highway and Mount Hebron is the Traux-Dehill-Eastable soil unit. It is a well drained, very deep, loamy soil that forms on alluvial fans, formed dominantly in alluvium derived from volcanic tuff and extrusive igneous rock. It is nearly level to strongly sloping, with slopes of 0-15%. Traux soils are predominantly sandy loam, with sandy clay loam subsoil. Dehill soils are fine sandy loam. Eastable soils are loams with a clay loam subsoil. Minor soil units are the well drained Dotta, Hedox, and Munnell soils and the moderately well-drained Leavers soil. The general sand unit is used for cultivated crops, irrigated hay and pasture, and rangeland. Soil hazards include soil blowing and frost (USDA 1994).

Soils of the Lower Foothills of the Cascade Mountain Range

The foothills bordering Butte Valley are dominated by the Mollisol Searles-Orhood soil unit. The well-drained soil forms on hills and mountains and formed in material weathered from extrusive igneous rock. The very stony or very cobbly loamy soil is moderately deep and shallow, and gently sloping to very steep (2-50% slope). The surface layer is a very stony or very cobbly loam. The upper part of the subsoil is very cobbly loam and the lower part is very cobbly clay loam and very cobbly loam. Extrusive ignous bedrock is about 16 or 28 in (0.41-0.71 m) deep. The soil unit has various minor components with variations on the main soils, such as a clayey subsoil, soils deeper than 60 in (1.5 m) deep or less than 10 in (0.25 m) deep. The soil unit also has instance of rock outcrops, with no soil cover, and areas of rubble, where 90% or more of the surface is covered by stones and boulders. The soil unit is used for rangeland and growth of western juniper. High surface slopes and general stoniness limits seeding, livestock access, and woodcutting (USDA 1994).

The Dunnlake-Lequieu soil unit occurs sparsely at the valley borders. The very stony loamy soils are shallow to very shallow, with slopes from 0-50%. The soil occurs on plateaus and mountain side slopes and formed from material weathered from extrusive igneous rock. Both Dunnlake and Lequieu soils have a very stony loam surface layer. Dunnlake soils have a clay loam upper subsoil and gravelly clay lower subsoil, with hard, extrusive igneous bedrock at about 16 in (0.41 m) depth. Lequieu soils have a 5 in (0.13 m) substratum of very cobbly loam and andesite bedrock at 8 in (0.20 m) depth. Due to the surface stoniness and depth to bedrock, the soil unit is used as rangeland (USDA 1994).

Soils of the Cascade Mountain Range

The edges of the Basin contain parts of the Kalo-Pinehurst-Mojo general unit. The stony to very stony loamy soil occurs on mountains and formed in material weathered from extrusive igneous rock. The soil is moderately deep to deep with slopes that are moderately sloping to steep (5-50% slope). The surface layer is very stony sandy loam, stony sandy loam or stony loam. The subsoil is very cobbly loam, very cobbly clay loam, gravelly loam, very stony loam, or clay loam. Extrusive igneous bedrock occurs between 27-55 in (0.69-1.4 m) depth. The soil unit is used as woodland, with some livestock grazing.

2.2.1.9 Surface Water Bodies

Surface water bodies in the Basin include Meiss Lake and spring-fed intermittent streams. Butte Creek is the largest stream in the Watershed. Spring-fed perennial streams include Ikes, Prather, Muskgrave, and Harris, which drain into Meiss Lake (DOI 1980). Seikel Creek is a tributary of Muskgrave Creek and its water is partially diverted to Juanita Lake by the USFS (Kit Novick 1996). Major surface water features are shown on Figure 2.1.

Historically, Mud Lake was a perennial lake residing southeast of Macdoel, with the aptly named Lakeview Cemetery on the east shore, but has recently become a small intermittent pond. Mud Lake was about 40 acres (0.16 sq km) in 1909, and was too alkaline for domestic or irrigation uses, but was used by cattle. A water body south of Cedar Point has historically been called Alkali or Soda Lake and occupied 600 to 700 acres (2.4 to 2.8 sq km) in 1909, but was deemed far too alkaline for domestic or irrigation use. The 1909 USDA Soil Survey observed a slight rise in the

valley floor north of Macdoel towards Dorris, which separated Meiss Lake and Soda Lake (USDA 1909).

Outside the Basin, the Butte Valley Watershed includes three additional named streams and numerous small lakes and ponds. Antelope Creek was once a tributary of Butte Creek up until the eruption of the Butte Valley Basalt (King 1994). Spring-fed First and Horsethief Creeks are south of Ball Mountain. Intermittent surface water bodies in the high mountains of the southern watershed include: Duck Lake southwest of Haight Mountain, Surprise Lake on Ash Creek Butte; Antelope Creek Lakes and Hemlock Lake near Rainbow Mountain; and Frog Lake on the valley floor northeast of Rainbow Mountain. Intermittent surface water bodies on the valley floor of the middle Watershed include: Antelope Sink north of Cedar Mountain; Orr Lake at the base of Orr Mountain; the unnamed pond west of Cedar Mountain formed by the Butte Creek spillway, Russell Lake in Red Rock Valley; and a large unnamed lake between Tennant and Butte Creek at 41.615389 north latitude, -122.008856 west longitude. Intermittent surface water bodies in the high elevations northwest of Mount Hebron include: Mud Lake where U.S. Highway 97 leaves the Butte Valley floor; and Pumpkinseed Lake northwest of Mount Hebron. Perennial surface water bodies include Mud Lake on Mud Lake Ridge, Juanita Lake near Ball Mountain, Red Rock Lakes east of Sheep Mountain, and Deyarmie Lake in Red Rock Valley.

Meiss Lake

Meiss Lake is a shallow, alkaline water body that lies on the west side of the Valley and is managed by CDFW in BVWA. BVWA and Meiss Lake are important for the Pacific Flyway and are a major migration and staging area for waterfowl, sandhill cranes, and other water birds (NCRWQCB 2008). Meiss Lake is a 4,000 acre (16.2 sq km) managed reservoir, with a maximum depth of six feet (Kit Novick 1996). Before the mid-1940s, Meiss Lake and adjacent wetlands covered about 10,000 acres (40.5 sq km) (NCRWQCB 2008). In 1909, the considerably deeper western half of Meiss Lake was 6 ft (1.8 m) deep, while the rest of the lake was only 2-3 ft (0.61-0.91 m) deep or less (USDA 1909). From the mid-1940s to 1981, Meiss Lake and adjacent wetlands were systematically diked, channeled, drained and converted to agricultural uses (NCRWQCB 2008). In the 1940s, a North-South dike was constructed to divide the lake in half and convert the western half into farmland. The eastern half of the lake was used as a reservoir to manage inflowing and outflowing water. In the winter, water from Muskgrave, Harris, and Ikes Creeks were diverted onto the fields to built soil moisture, then pumped into Meiss Lake in the spring for planting. As noted above, the lake bed on the eastern half is four feet higher than the former lake bed in the west. The farmland on the former lake bed has been periodically reflooded by Meiss Lake (Kit Novick 1996). By 1981, Meiss Lake its adjacent wetlands and tributaries had been substantially altered, lost or degraded from their pre-1940s state (NCRWQCB 2008). After BVWA was purchased by the State in 1981, the wetlands and tributaries are being managed and restored (Kit Novick 1996).

Meiss Lake is a closed basin and receives surface water from four spring-fed creeks and one canal. From the west flow Ikes, Harris, and Muskgrave Creeks and from the south flows Prather Creek. Estimated creek inflows are 15,000 to 20,000 acre-feet annually but are low or nonexistent in the summer and fall. The Irrigated District Canal delivers excess irrigation water to Meiss Lake from wells and summer runoff, though flows are normally very low. Seikel Creek, a tributary of Muskgrave Creek, is partially diverted by the USFS to Juanita Lake from April 30 to November 1. In the 1940s, dams were built at Juanita Lake to provide irrigation water to Meiss Ranch, the precursor of BVWA (Kit Novick 1996).

Historically, the size of Meiss Lake has varied. Commonly the lake nearly dries up by early fall

(Kit Novick 1996). Meiss Lake typically goes completely dry every 15-20 years and was dry in 1955, 1965, 1981, 1987, 1988, 1990, 1991 and 1992 (County of Siskiyou 1996). Precipitation patterns have continued to fluctuate, with a wet period between 1993 to 1999 and dry cycle from 2000 to 2008 (2006 was very wet) [2009 BVWA Plan Addendum]. Meiss Lake went dry in 2000, 2001, 2002, 2003, 2004, 2005, 2007, and 2008 (K. Novick 2009). The hardpan and soil type at Meiss Lake create a large shallow impermeable basin subject to high evaporation rates (County of Siskiyou 1996). The pan evaporation rate for Butte Valley is estimated to be 48 in (1.2 m) per year, primarily driven by wind (Kit Novick 1996; County of Siskiyou 1996).

The water quality of Meiss Lake is heavily dependent on the season, where the quality is good during and shortly after the winter-spring runoff period then declines during the summer and fall as inflows cease and evaporation increases. During the summer and fall, electrical conductivity, pH, TDS, and alkalinity increase in value. For example, pH is roughly 7.4 in the spring and 10.1 in the fall. In general, the lake water has high turbidity due to the relatively shallow water (less than 6 ft) and is high in sodium bicarbonate. The high turbidity and alkalinity compared to the Klamath River restricts pumping of Meiss Lake water into the Klamath River after April 30. After July 1, BVWA does not use Meiss Lake water for crop irrigation or wetlands maintenance because alkalinity, pH, and electrical conductivity exceed safe levels for plant growth (Kit Novick 1996).

Evidenced by the hundreds of feet of lake sediment on the Butte Valley floor, paleolakes have occupied the Basin for at least hundreds of thousands of years. The flatness of the valley floor means small changes in Meiss Lake levels cause large changes in lateral lake size. Two Holocene (0.012 Ma to Present) shorelines can be distinguished via aerial photography interpretation of soil and vegetation and archaeological evidence. The prehistoric Meiss Lake at its maximum had its shoreline at the 4,236 ft (1,291 m) amsl elevation contour, covering an area of 11.6 sq mi (30 sq km) at a depth of 10 ft (3 m). The historic high level for Meiss Lake is 4,232 ft (1,290 m) amsl, which is marked by a change in vegetation. The current Meiss Lake shoreline is at 4229 ft (1,289 m) amsl. Above the prehistoric 4,236 ft (1,291 m) amsl shoreline, vegetation is marked by scrub vegetation similar to that growing on Quaternary lake deposits on the valley floor. Between the historic 4,232 ft (1,290 m) amsl shoreline and prehistoric 4,236 ft (1,291 m) amsl shoreline, the vegetation is marked by grasses and scattered scrub. Between the current lake shoreline and the historic 4,232 ft (1,290 m) amsl shoreline, the area is covered with grasses (King 1994).

Meiss Lake was likely below the 4,232 ft (1,290 m) amsl shoreline for most of the Holocene due to the well-defined soil profile between 4,232 ft (1290 m) and 4,239 ft (1292 m) amsl called the Pit Series, which suggests that the area has not been underwater for an extended time. Soils in the historically drained Meiss Lake bed are classified as the Teeters Series and are less developed then the Pit Series. Additionally, the Teeters Series soil is only 24 in (0.61 m) deep compared to the 40 in (1 m) deep Pit Series (King 1994).

Along the old Meiss Lake shorelines there is evidence of prehistoric human habitation. Prehistoric habitations on the eastern shore are dated from 6,640 to 565 years before present along both the 4,236 ft (1,291 m) and 4,232 ft (1,290 m) amsl shorelines. Additional prehistoric habitations along the west shore range from 9,000 to 1,400 years before present between 4229 ft (1,289 m) and 4,232 ft (1,290 m) amsl elevation. The variation of elevations of the prehistoric habitations suggest that the prehistoric Meiss Lake was not dry for long periods of time and had at least some water through most of the Holocene (King 1994).

In December 1964, Meiss Lake flooded to an area of 16 sq mi (10,500 acres; 42.5 sq km), which coincides with the 4,234 ft (1,291 m) amsl elevation contour including its former lake bed and adjacent farms (County of Siskiyou 1996). The County declared the Butte Valley flood a Major Disaster

(USACE) and requested emergency relief from the federal government (County of Siskiyou 2017). In early 1965, the U.S. Army Corps of Engineers constructed the Sam's Neck Flood Control Facility, a drainage canal to pump excess floodwater to the Klamath River (NCRWQCB 2008; County of Siskiyou 2017). The drainage canal consists of an outlet from Meiss Lake that travels up Sam's Neck, where a pump lifts water 21 ft (6.4 m) from the valley floor to Rock Creek and ultimately to the Klamath River in Oregon (Kit Novick 1996; County of Siskiyou 2017). Rock Creek is outside the Butte Valley watershed and is a tributary of the Klamath River. By July 12, 1966, USACE was still pumping down Meiss Lake (County of Siskiyou 2017).

Management for the Sam's Neck Flood Control Facility has changed hands several times since its creation. The lift pumps require a contract for electricity and the facility requires maintenance. After completion of the project, USACE payed for one year's worth of power before turning over responsibility to the County. The County never expected to fund the project with taxpayer dollars and intended to hand over responsibility to the direct beneficiaries of the flood control project, originally BVID. BVID did not take over the project and the County authorized a local company to operate one of the lift pumps, with the condition that the company pay for all electric power bills and accept all liability. Months later the Pacific Power and Light Company requested that the County submit payment for a power bill associated with the pumps. After agreeing to pay the power bill, the County Board of Supervisors advised that the County would not be responsible for any further power bills from the pumping facilities thereafter. The Board of Supervisors also discussed that those benefiting from the flood control facility should pay for the power costs of the project or the power transformers should be removed. In the fall of 1967, the Board of Supervisors authorized the Meiss Ranch Company to operate the Flood Control Facility and soon after approved the arrangement between Meiss Ranch and Pacific Power and Light Company on a rolling year-to-year basis. From 1968 to mid-1985, the Flood Control Facility pumped excess floodwater from Meiss Lake at no cost to the County. Meiss Ranch may have made an agreement with BVID for operation of the pumps at the Ranch's expense (County of Siskiyou 2017).

Estimated yearly water volumes pumped from Meiss Lake are shown in Table 2.4. Sam's Neck Flood Control Facility usually only operated from January to April. Public opposition restricted operation of the facility after April due to the impact of the poor lake water quality (turbid and alkaline) on the Klamath River fishery (Kit Novick 1996).

In 1981, Meiss Ranch was purchased by the California Department of Fish and Game (currently CDFW), and the land was designated as the Butte Valley Wildlife Area (BVWA). The Department initially operated and paid for the Flood Control Facility pumps until 1985. The Department notified the County of releasing its operational and monetary responsibility for operating and maintaining the Sam's Neck Canal pumps. The Department outlined its long-term goal of utilizing all surplus water to create wetland habitat, which might eliminate the need for the Flood Control Facility. In 2017, the County submitted a request to the USACE that Sam's Neck Flood Control Facility be abandoned (County of Siskiyou 2017).

Table 2.4: Estimated Volume of Water Pumped From Meiss Lake to The Klamath River (BVWA 1996).

Year	Acre-Feet	Year	Acre-Feet
1968	638	1982	8,930
1969	585	1983	12,456
1970	10,064	1984	7,708
1971	12,545	1985	4,182
1972	14,582	1986	2,271
1973	89	1987	0
1974	9,674	1988	0
1975	4,164	1989	0
1976	142	1990	0
1977	89	1991	0
1978	4,571	1992	0
1979	213	1993	0
1980	4,363	1994	0
1981	0		

Butte Creek

Butte Creek is the largest stream in Butte Valley, with headwaters between the Whaleback and Haight Mountains at the southern end of the Watershed (Figure 2.8) (King 1994). Butte Creek historically flowed into Meiss Lake, but has been diverted for agricultural irrigation and spreading grounds for groundwater recharge (DOI 1980; Kit Novick 1996). Butte Creek has been sufficiently appropriated and diverted so that flows terminate near the town of Macdoel (Wood 1960). At normal flows, surplus water after irrigation is diverted into a lava crack or allowed to percolate into porous lava and alluvial deposits for groundwater recharge. Flood flows are diverted into Dry Lake / Cedar Lake to recharge the Butte Valley Basalt water bearing formation, and does not reach Meiss Lake (Kit Novick 1996; County of Siskiyou 1996).

In 1909, while supplying irrigation water for several hundred acres of alfalfa, timothy, clover, and grain crops, Butte Creek disappeared underground at the valley edge and flows to Meiss Lake via groundwater (USDA 1909). All surface evidence of the lower Butte Creek channel, from the Valley edge to Meiss Lake, has been destroyed by cultivation (King 1994).

Prather, Ikes, Harris, and Muskgrave Creeks

Prather, Ikes, Harris, and Muskgrave Creeks are spring-fed creeks that drain into Meiss Lake. Seikel Creek and Juanita Lake are tributary to Muskgrave Creek. Water from these creeks have excellent mineral quality, are soft with a calcium-magnesium bicarbonate character, and very low in chloride and sulfate (Kit Novick 1996). Springs from the High Cascade Volcanics water bearing formation provide perennial flows for four creeks, but flows vary seasonally (County of Siskiyou 1996). Historically, Harris and Ikes Creeks flowed all year but very low during the summer months. In recent years, Harris, Ikes, and Muskgrave Creeks all dry up in the summer and fall. Upstream of BVWA, Prather Creek is diverted for agriculture and summer flows to Meiss Lake are very low to nonexistent. All four creeks are capable of intense flooding in a short period of time and all floodwater flows into and is managed by BVWA (Kit Novick 1996). CDFW is the only pre-1914 water right holder for Muskgrave, Harris, and Ike's Creek flow within the Basin.

In 1909, Prather Creek flowed directly into the southern end of Meiss Lake, and provided water and electrical power to a dairy (USDA 1909). In the 1940s, farming on the west side of Meiss Lake was accomplished by diverting Muskgrave, Harris, and Ikes Creeks out onto the fields in the winter months to build soil moisture (County of Siskiyou 1996). Today, all pre-1914 water rights to Prather Creek are split between Ralph's Prather Ranch (senior right) and CDFW. Creek flows are utilized by CDFW for wildlife, and enhancement and maintenance of 6,300 acres (25.5 sq km) of wetlands, including Meiss Lake. Water conservation efforts include drainage and reuse between land units for moist-soil management for waterfowl food plants. From 2005 to 2007, the combined total annual flow was 7,500, 18,000, and 11,500 AF (9.3E+06, 2.2E+07, and 1.4E+07 m^3), respectively (SWRCB 2020).

2.2.2 Current and Historical Groundwater Conditions

Butte Valley is predominantly agricultural and development of groundwater as a major source of irrigation was critical for settlement in the Basin. Beginning in 1852, immigrant trains on the Yreka Trail reached Yreka in Shasta Valley by passing through Butte Valley. Nicknamed the "Desert," a lack of water prevented settlement in Butte Valley for many years (County of Siskiyou 1996). In the 1860s and 1880s, homesteads began to be established in Butte Valley (Kit Novick 1996). In 1862, Butte Valley had some ranching activity and the west side of the Valley was harvested for natural grass hay. In 1876, field crops grown along Butte Creek included timothy, red top, oats for hay, wheat and barley. In 1903, alfalfa hay and grain were grown via dry-land farming on 11,000 acres (44.5 sq km) (County of Siskiyou 1996). Settlement in Butte Valley occurred in 1906 when William MacDoel bought 30,000 acres (121 sq km) of land, which he cut up into small farms and sold to experienced German-American Baptist farmers from Iowa and other Midwest states (USDA 1994; County of Siskiyou 1996). However, Butte Valley saw limited agricultural development due to a lack of major surface water and failure of various plans to develop groundwater and surface water irrigation systems (French 1915; County of Siskiyou 1996). Many of these initial farmers left Butte Valley discouraged, impoverished, or bankrupt (USDA 1994; County of Siskiyou 1996). In 1920, the United States Bureau of Reclamation (USBR) attempted to channel surface water from Antelope, Butte, and Bear Creeks to Macdoel, but the project failed. The Butte Valley Irrigation District (BVID) formed in 1921 and currently manages land west of the cities of Macdoel and Mount Hebron. BVID completed a project in 1923 to divert Shovel Creek to irrigate farmland but the creek went dry and most farmers lost their land and left Butte Valley. BVID drilled the first irrigation well in 1929 and has continued to drill groundwater wells as surface water resources have decreased. Since the successful development of deep groundwater wells in 1952, in BVID hundreds of acres of farmland were developed to grow alfalfa, grains, and potatoes (County of Siskiyou 1996). Private groundwater drilling for irrigation spread outside BVID as the technology became more easily accessible. From 1926 to 1994, more than 210 irrigation wells were constructed in Butte Valley. Of the 38 irrigation wells constructed from 1980 to 1994, 20 were drilled in the High Cascade Volcanics water bearing formation and 18 in the Butte Valley Basalt and/or Lake Deposits water bearing formations (Kit Novick 1996).

The development of groundwater resources encouraged agricultural expansion; where 1954 had 12,000 irrigated acres (48.6 sq km; 15% of Basin area), 1976 had 27,500 irrigated acres (111 sq km) (35%), and 2010 had about 37,000 irrigated acres (150 sq km; 46%) (County of Siskiyou 1996; DWR 2010). The agricultural expansion increased groundwater pumping demand for irrigation (County of Siskiyou 1996; Wood 1960). Within Butte Valley, from 1953 to 1979 to 1991, groundwater extraction increased from 22,200 to 62,000 to 81,000 AF (2.7E+07, 7.6E+07, 1.0E+08 m3),

respectively (DOI 1980; DWR 1998). For comparison, the annual surface water supply in 1998 was about 20,000 AF (2.5E+07 m3). In 1998, the agricultural applied water demand was roughly 2.2 AF/acre per year (0.66 m/yr), of which 1.8 AF/acre (0.54 m/yr) stems from groundwater. In 1998, DWR proposed that total irrigated acreage and water demand in Butte Valley had reached its maximum because nearly all arable land in the Valley was in production (DWR 1998).

2.2.2.1 Groundwater Elevation

Groundwater levels in Butte Valley show short-term seasonal fluctuations in response to summer pumping and winter recharge and long-term fluctuations in response to wet and dry precipitation cycles (DOI 1980). Historically, the volume of extracted groundwater depends on the availability of surface water, where wet years demand less groundwater compared to dry years (DWR 1998). At the 1980 and 1998 rates of groundwater extraction, groundwater levels and storage decline during years with below average rainfall, but recover during years with average or above average precipitation (DOI 1980; DWR 1998). Current spring groundwater levels have dropped from near ground surface at the beginning of the 20th century to approximately 30.5 meters (100 feet) below ground surface (bgs) in the north east edge of the valley near the town of Dorris and to 15 meters (50 feet) bgs at the town of Macdoel near the south edge of the Basin (see below). The north west portion of the Basin is still largely undeveloped with relatively shallow water levels between 3.5 and 12 meters (10 and 40 feet) bgs, possibly owing to the National Grassland and the BVWA which together account for roughly 40 percent of the land in Butte Valley.

A limited number of groundwater wells in Butte Valley have been mapped to their connecting water-bearing formation, which includes the three main formations, High Cascade Volcanics, Butte Valley Basalt, and Lake Deposits. Wells that tap into the High Cascade Volcanics are generally limited to the Valley edges, and Butte Valley Basalt wells are limited to the extent of the basalt flow in the south side of the Basin (Figure 2.20). Wells that tap into the Lake Deposits are situated within the Basin floor.

Elevation and Flow Direction

Historical Conditions (1880 - 1979)

Groundwater conditions in the early 1900s provide some observations of the groundwater supply before major settlement in the Basin. In 1907 Butte Valley had a shallow water table with groundwater depths between 1 to 10 ft (0.3 to 3 m) bgs but was typically at 4 to 6 ft (1.2 to 1.8 m) depth (USDA 1909). Springs in Butte Valley were evidence of a confined potentiometric surface above ground surface and occurred in the town of Macdoel and on the hillside south of Meiss Lake (formerly Butte Lake) (USDA 1909; Wood 1960). Bubbling springs were active in the basalt outcrops near Macdoel. Springs near Macdoel had an average 200 parts per million (ppm) dissolved solids. Butte Creek was observed to quickly sink underground soon after entering Butte Valley (named the Butte Creek Sink) but provided irrigation water for several hundred acres of alfalfa, timothy, clover, and grain crops. Following early settlement in 1880 alfalfa crops drew water directly from shallow groundwater (USDA 1909).

As late as the 1960s artesian wells existed near Meiss Lake, suggesting a potentiometric surface existed above ground level in that part of the Basin. Springs existed along the western edge of Butte Valley (Wood 1960). In spring 1979, wells near Meiss Lake (46N/2W-9R1, 9R2, 9N, and 16N1) were observed to flow with potentiometric heads above ground level (DOI 1980). Meiss Lake

received regular surface flows from Prather Creek and Muskgrave Creek, however Butte Creek had been sufficiently appropriated and diverted that flows terminated near the town of Macdoel (Wood 1960).

As of 1998 at least two springs still flowed on Holzhauser Ranch on the Butte Valley floor in Sam's Neck approximately 4.5 miles north of Meiss lake. During a groundwater pumping test performed in 1998 at Meiss lake, spring discharge was observed to decrease in the Holzhauser Ranch South Spring from 4.1 gallons per minute (gpm) to 3.7 gpm, a 10% decrease (DWR 1998).

The best qualitative historical assessment of groundwater in Butte Valley is based on observations completed in May 1954 (Figure 2.20). Groundwater flow was eastward and northeastward across the Basin into buried talus and volcanic rocks in the Mahogany Mountain ridge. Groundwater likely flowed through the ridge to supply groundwater flow to the neighboring groundwater basins. East of Dorris, groundwater gradients ranged from 30 to >70 feet per mile toward Mahogany Mountain ridge. The steep gradient may have been caused by barriers to flow due to faulting or a sudden increase in permeability. Groundwater discharged from the Basin may have moved through the fractured volcanic rocks in Mahogany Mountain ridge or along fault zones (Wood 1960).

In 1954, the groundwater gradient southwest of Mount Hebron was about 20 feet per mile northeastward (Figure 2.20). Between the towns of Mount Hebron and Macdoel the groundwater surface was nearly flat as the water moved through the highly permeable Butte Valley Basalt. Groundwater in the Lake Deposits water bearing formation northeast of Meiss Lake had a gradient from less than 2 to about 5 feet per mile, increasing to about 10 feet per mile near Cedar Point (Wood 1960). Local groundwater depressions from irrigation wells occurred in two areas, near Macdoel and west of Inlow Butte.

In 1954, in the west central part of the valley, the groundwater surface sloped gently away from Meiss Lake (Figure 2.20). The lake originally occupied a topographic depression west of its present location, where it was supplied in large part by groundwater seepage and its surface reflected the general level of the adjacent groundwater surface. An earthen dike constructed on higher ground east of the original lake bed bounds the west shore of the current lake, where water has been pumped from the original lake bed and allowed to spread over poorly productive land. The original lake bed is currently cultivated, but being an area of natural groundwater discharge, it must be kept drained to prevent waterlogging. Seepage loss from the present Meiss Lake is restricted by clayey lake deposits which underlie that part of the Basin (Wood 1960).

Current Conditions (1979 - 2020)

Groundwater levels have a seasonal high in the spring and seasonal low in the fall. Groundwater recharge is dependent on the annual precipitation, which has been experiencing a decline in Butte Valley since the early 1980s, as shown in Figure 2.9. The average annual rainfall for the period 1942-1997 was 12.15 in (30.9 centimeters (cm)) (DWR 1998), while decreased precipitation in the past 20 years has brought the average annual rainfall for the period 1979-2020 down to 8.1 in (20.7 cm) per year as shown in Figure 2.9. Rainfall in both "wet" and "dry" years has decreased in the past 50 years.

In 1979, seasonal water-level fluctuations for wells in the High Cascade Volcanics ranged from no change to about 17 ft (5.2 m) and groundwater wells in other water-bearing units ranged from a few feet to about 25 ft (7.6 m) (DOI 1980). As shown in Figure 2.21, groundwater primarily flows toward Dorris, with low gradients in the middle of the valley and high gradients near Dorris. Groundwater levels and gradients are poorly constrained between Macdoel and Mount Hebron due to lack of

data.

From the spring of 1979 to the spring of 2015, groundwater levels have dropped roughly 30 feet (Figure 2.21 and Figure 2.22). The 2014-2015 water year is the most recent year in Butte Valley with above average annual precipitation, at 9.96 inches Figure 2.9. In 2015, the groundwater gradient in the northeast part of the valley is poorly constrained due to the lack of groundwater data immediately southwest of Dorris. Groundwater gradients in the spring of 2015 are shallow near Macdoel and Mount Hebron due to the highly permeable Butte Valley basalt. Groundwater levels near Meiss Lake are poorly constrained due to lack of data. From the fall of 2014, the seasonal low, to the seasonal high in spring of 2015, groundwater levels vary between 0 to 20 ft, with the least change in the Butte Valley National Grasslands and greatest changes near Dorris, Macdoel and Mount Hebron. Water levels and changes over time are shown on Appendix 2-A.

Hydrographs

Groundwater levels have been declining in much of the Basin since record keeping began in the 1950s. Pre-1915 records describe groundwater levels at 5-10 ft (1.5-3.0 m) below the ground surface (bgs) (French 1915). From 1976 to 77, BVID deepened irrigation wells to increase groundwater resources during a drought. In Spring 1979, the average depth to groundwater in the unconfined system was 25 ft (7.6 m) with a range of 6-48 ft (1.8-14.6 m). The average depth to groundwater in the confined system was 33 ft (10.1 m) with a range of 9-83 ft (2.7-25.3 m) (DOI 1980). Groundwater elevations during the 1980-1981 drought were low enough that BVID had 14 out of 28 wells either dry or surging. From 1983 to 1992, the water table dropped an average of 16 ft (4.9 m) (County of Siskiyou 1996). Groundwater levels at five different wells from different areas of Butte Valley are shown in Figure 2.23.

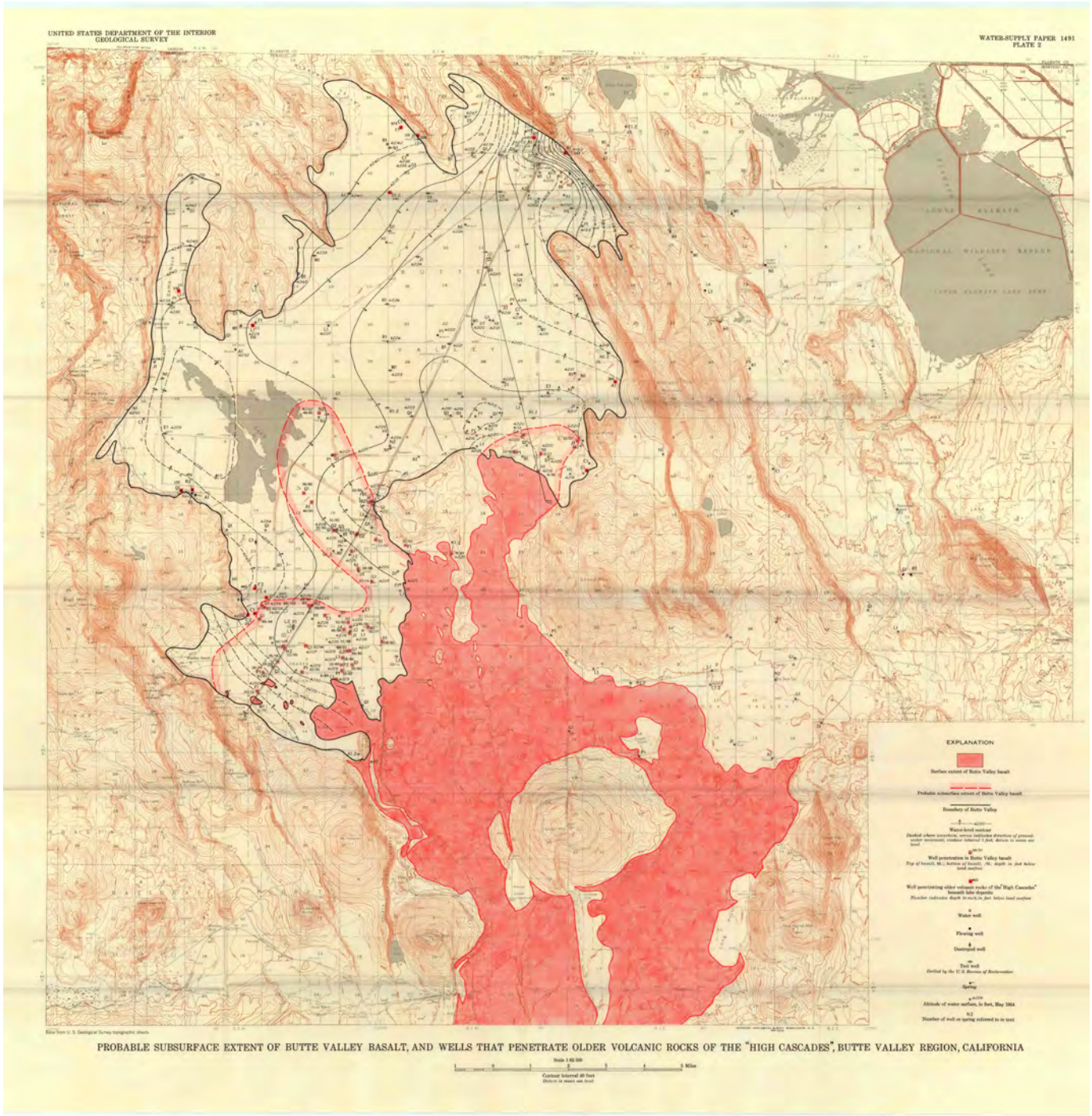


Figure 2.20: Groundwater elevations and flow based on observations during the first week of May 1954 (Wood 1960). The image is high quality so text can be distinguished when zoomed in.

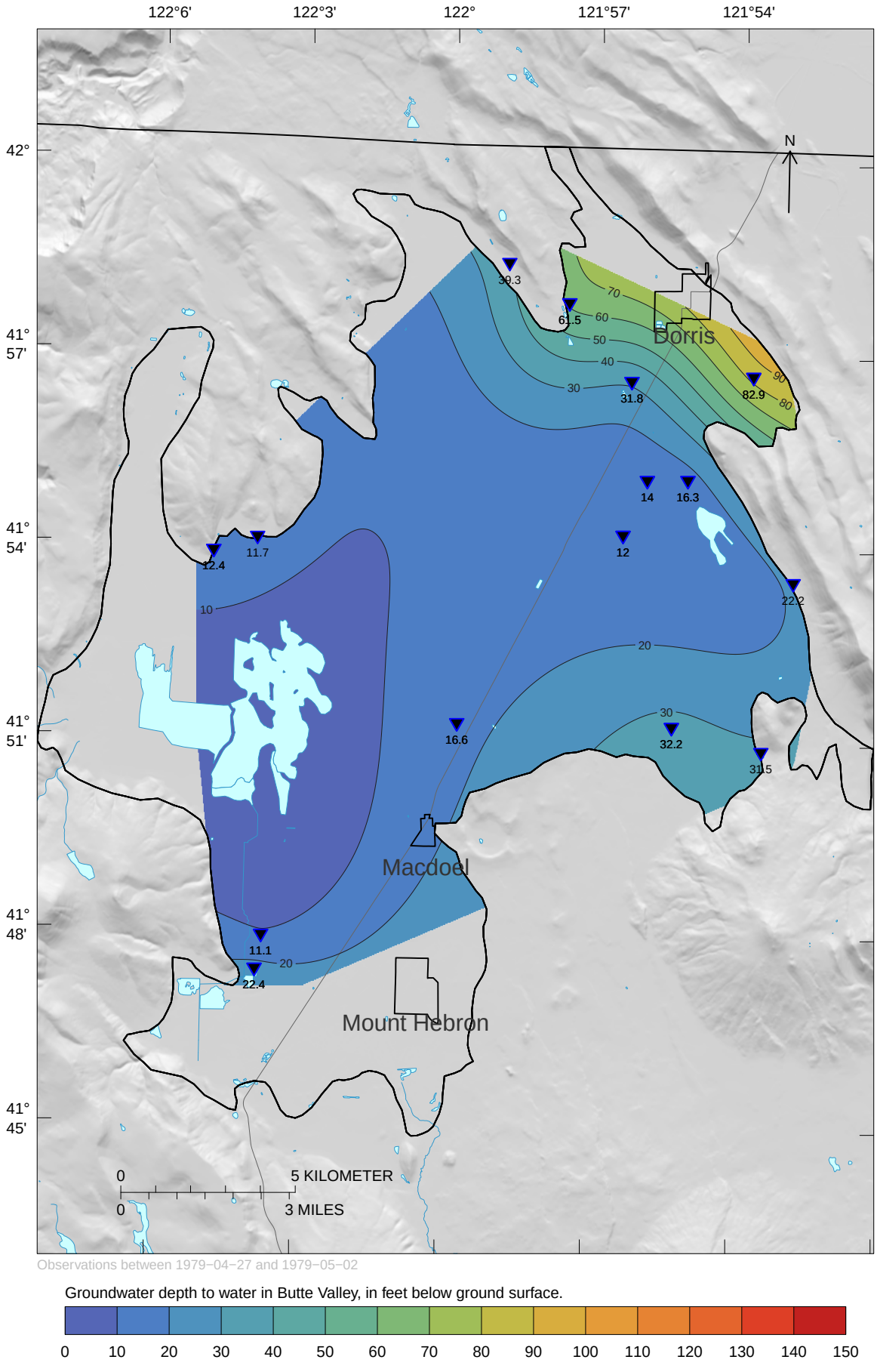


Figure 2.21: Butte Valley Groundwater Elevations, Spring 1979

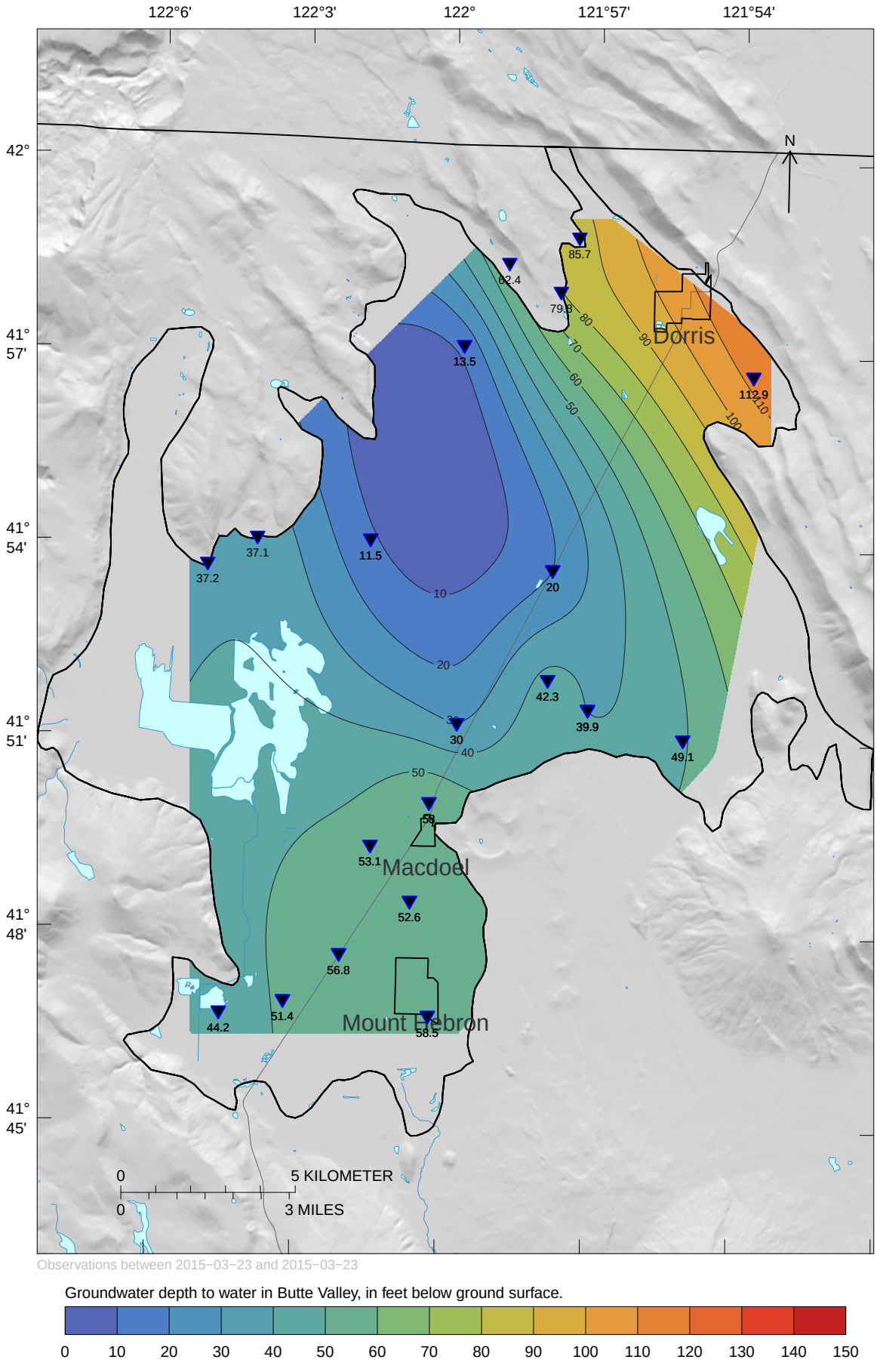


Figure 2.22: Butte Valley Groundwater Elevations, Spring 2015

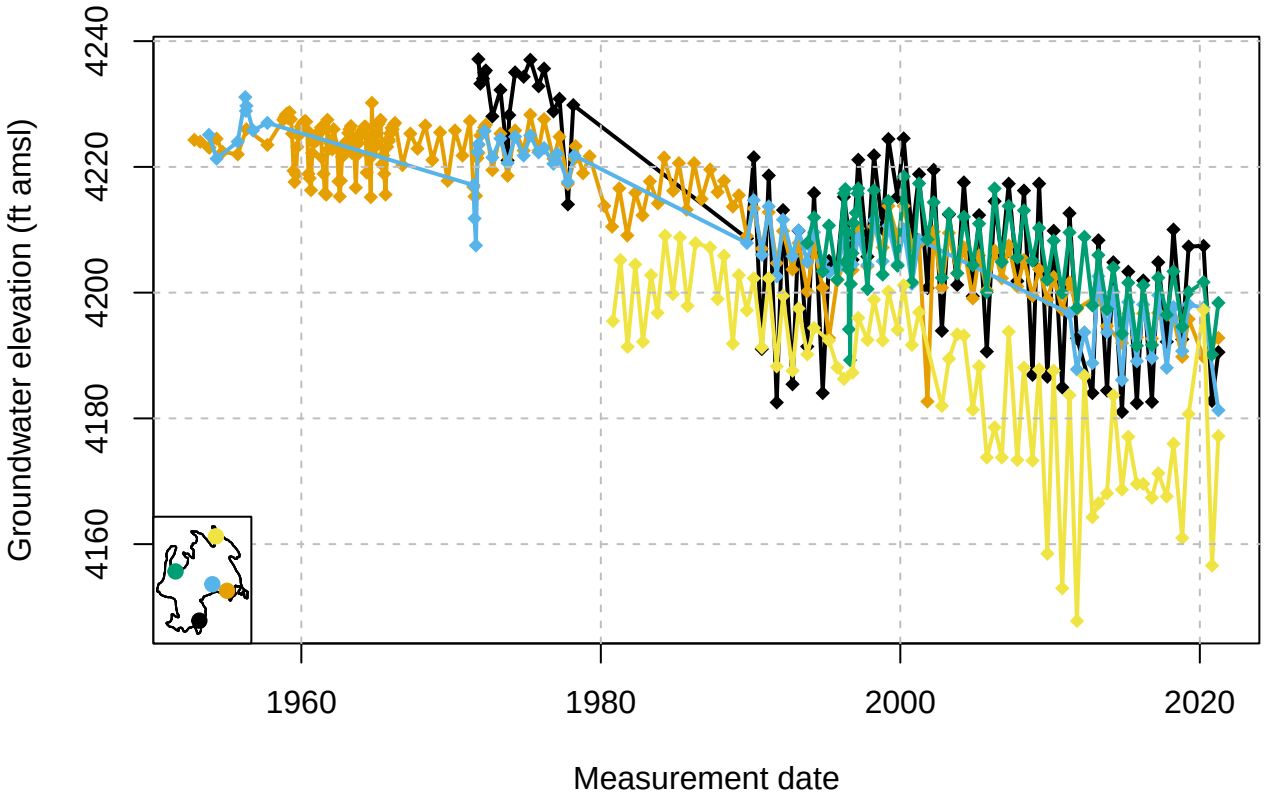


Figure 2.23: Groundwater elevation measurements over time in five wells, one located in each hydrogeologic zone.

2.2.2.2 Estimate of Groundwater Storage

Due to the complexity of the Basin and interbedded nature of alluvial, fluvial, and volcanic deposits within the major aquifer subunits, DWR could not provide an estimate of groundwater storage. Most wells in the Basin produce water from the underlying volcanic rock and some wells extract water from the overlying Lake Deposits. All units are hydrologically interconnected and DWR was unable to assign a reasonable specific yield to the volcanic units (Wood 1960; DWR 2004). The High Cascades Volcanic unit is the main unit for both recharge and storage in the Basin (Wood 1960). However, the depth and extent of the unit, which also extends well beyond the Basin boundaries, is not well defined.

A specific yield and storage capacity can be estimated for the unconfined units: Lake Deposits, pyroclastic rocks, and Butte Valley Basalt (DOI 1980). The weighted average specific yield for the unconfined units is calculated to be 9.5% and total groundwater storage capacity is 2,560,000 acre-feet. Specific yield and storativity has also been estimated using the Butte Valley Integrated Hydrologic Model (BVIHM), as described in Section 2.2.3.

2.2.2.3 Groundwater Quality

SGMA regulations require that the following be presented in the GSP, per §354.16 (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.

Basin Overview

Water quality includes the physical, biological, chemical, and radiological quality of water. The physical property of water of most interest to water quality is temperature. An example of a biological water quality constituent is *E.coli* bacteria , commonly used as an indicator species for fecal waste contamination. Radiological water quality parameters measure the radioactivity of water. Chemical water quality refers to the concentration of thousands of natural and manufactured inorganic and organic chemicals. All groundwater naturally contains some microbial matter, chemicals, and usually has low levels of radioactivity. Inorganic chemicals that make up more than 90% of the "total dissolved solids" (TDS) in groundwater include calcium (Ca^{2+}), magnesium (Mg^{2+}) sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), bicarbonate (HCO_3^{-}), and sulfate (SO_4^{2-}) ions. Water with a TDS concentration of less than 1,000 mg/L is generally referred to as "freshwater." Brackish water has a TDS between 1,000 mg/L and 10,000 mg/L. In saline water, TDS exceeds 10,000 mg/L. Water hardness typically refers to the concentration of calcium and magnesium cations in water.

When one or multiple constituents become a concern for either ecosystem health, human consumption, industrial or commercial uses, or for agricultural uses, the water quality constituent of concern becomes a "pollutant" or "contaminant." Groundwater quality is influenced by many factors – polluted or not – including elevation, climate, soil types, hydrogeology, and human activities. Water quality constituents are therefore often categorized as "naturally occurring," "point source," or "non-point source" pollutants, depending on whether water quality is the result of natural processes, contamination from anthropogenic point sources, or originates from diffuse (non-point) sources that are the result of human activity.

Groundwater in the Basin has been characterized as mixed-cation to magnesium-bicarbonate water, and as sodium bicarbonate water near Dorris. The dissolved-solids content of groundwater in the Basin is commonly less than 360 mg/l, though TDS concentrations have been measured in excess of 1,100 mg/L; locally high TDS values have been attributed to evaporites in localized playa deposits (DWR 1968, 2004). Within Butte Valley, groundwater quality issues have historically included locally high arsenic, iron, manganese, boron, TDS, sodium, calcium, ammonia, hydrogen sulfide, phosphorus, and electrical conductivity (DWR 2004). High TDS and sodium have also been noted in shallow wells with hydraulic continuity to Meiss Lake, where salts from natural inflow and irrigation-return flows are concentrated by evaporation (DWR 2004). The City of Dorris relies on a single groundwater well for water supply, drilled in 1971, which penetrates the volcanic water bearing formations below the lake deposits, reaching a depth of 1, 236 ft (377 m) (Bray & Associates 2015). Previous water supply wells penetrating lake deposits were found to have arsenic levels exceeding the 1962 drinking water standard of 0.05 parts per million (ppm; 1 ppm = 1 mg/L) (DWR 1968). A 1968 DWR investigation suggested the elevated arsenic levels were the result of industrial contamination, the effects of which continue to be an issue in shallow groundwater wells near Dorris (DWR 1968, 2004; Bray & Associates 2015).

Groundwater in the Basin is generally of good quality and has relatively consistent water quality characteristics which meet local needs for municipal, domestic, and agricultural uses. Ongoing

monitoring programs show that some constituents, including benzene, 1,2 dibromoethane (EDB), arsenic, and boron exceed water quality standards in parts of the Basin. Exceedances may be caused by localized conditions and may not be reflective of regional water quality. In addition, there are potential risks of increasing salt and nutrient conditions from agricultural and municipal uses of water. Across the majority of the Basin, salt and nutrient concentrations are below levels of concern, with no upward trends. A few isolated areas have higher concentrations.

A report by the NCRWQCB in 2020 prioritized 62 groundwater basins in the North Coast Region with threats to groundwater quality due to excessive salts and nutrients, and categorized Butte Valley as "medium" priority (NCRWQCB and Watt 2020). If accepted by the Regional Board, the categorization will be adopted with Resolution No. R1-2021-0006. Based on the water quality analysis completed by the NCRWQCB, the percentage of wells in the Basin from 2010 to 2020 exceeding 5 mg/L nitrate was 21 - 30%, 10 mg/L nitrate was 10 - 20%, 250 mg/L TDS was 20 - 40%, and 500 mg/L TDS was <20%. The Basin was assigned a score, for "status and trends in the concentration of salts and nutrients in groundwater," of 3 out of a range of 1 - 10. Categories in which the Basin had high scores included: hydrogeological basin factor including depth to groundwater and hydrogeologically vulnerable area, reliance on groundwater to supply the basin, and number and density of on-site wastewater treatment systems. The information used in the prioritization process included water quality data from the State Water Board GAMA database and dairy operators under the Waste Discharge Requirements for Dairies (NCRWQCB Order No. R1-2012-0002), the DWR SGMA Basin Prioritization Process and the seven evaluation factors listed in the Recycled Water Policy (NCRWQCB and Watt 2020).

A summary of information and methods used to assess current groundwater quality in the Basin, as well as key findings, are presented below. A detailed description of information, methods, and all findings of the assessment can be found in Appendix 2-B.

Existing Water Quality Monitoring Networks

Water quality data for at least one constituent – sometimes many - are available for some wells in the Basin but not most. Of those wells for which water quality data are available, most have only been tested once, some have been tested multiple times, and in few cases are tested on a regular basis (e.g. annual, monthly). The same well may have been tested for different purposes (e.g., research, regulatory, or to provide owner information), but most often, regulatory programs drive water quality testing.

For this GSP, all available water quality data, obtained from the numerous available sources, are first grouped by the well from where the measurements were taken. Wells are then grouped into monitoring well type categories. These include:

- *Public water supply wells*: A public water system well provides water for human consumption including domestic, industrial, or commercial uses to at least 15 service connections or serves an average of at least 25 people for at least 60 days a year. A public water system may be publicly or privately owned. These wells are tested at regular intervals for a variety of water quality constituents. Data are publicly available through online databases.
- *State small water supply wells*: Wells providing water for human consumption, serving 5 to 14 connections. These wells are tested at regular intervals – but less often than public water supply wells – for bacteriological indicators and salinity. Data are publicly available through the County of Siskiyou Environmental Health Division but may not be available through online databases.

- *Domestic wells*: For purposes of this GSP, this well type category includes wells serving water for human consumption in a single household or for up to 4 connections. These wells are not typically tested. When tested, test results are not typically reported in publicly available online databases, except when these data are used for individual studies or research projects.
- *Agricultural wells*: Wells that provide irrigation water, stock water, or other water for other agricultural uses, but are not typically used for human consumption. When tested, test results are not typically reported in publicly available online databases, except when these data are used for individual studies or research projects.
- *Contamination site monitoring wells*: Monitoring wells installed at regulated hazardous waste sites and other potential contamination sites (e.g., landfills) for the purpose of site characterization, site remediation, and regulatory compliance. These wells are typically completed with 2 in- (5 cm) or 4 in- (10 cm) diameter polyvinyl chloride (PVC) pipes and screened at or near the water table. They may have multiple completion depths (multi-level monitoring), but depths typically do not exceed 200 ft (60 m) below the water table. Water samples are collected at frequent intervals (monthly, quarterly, annually) and analyzed for a wide range of constituents related to the type of contamination associated with the hazardous waste site.
- *Research monitoring wells*: Monitoring wells installed primarily for research, studies, information collection, ambient water quality monitoring, or other purposes. These wells are typically completed with 2 in- (5 cm) or 4 in- (10 cm) diameter PVC pipes and screened at or near the water table. They may have multiple completion depths (multi-level monitoring), but depths typically do not exceed 200 ft (60 m) below the water table.

Data Sources for Characterizing Groundwater Quality

The assessment of groundwater quality for the Basin was prepared using available information obtained from the California Groundwater Ambient Monitoring and Assessment (GAMA) Program Database, which includes water quality information collected by DWR; SWRCB, Division of Drinking Water (DDW); Lawrence Livermore National Laboratory (LLNL) special studies; and USGS. These data were augmented with data supplied by CDFW. In addition to utilizing GeoTracker GAMA for basin-wide water quality assessment, GeoTracker was searched individually to identify data associated with groundwater contaminant plumes. Groundwater quality data, as reported in GeoTracker GAMA, have been collected in the Basin since 1952. Appendix 2-B figures show the Basin boundary, as well as the locations and density of all wells with available water quality data for the GSP constituents of interest collected in the past 30 years (1990 to 2020). Within the Basin, a total of 53 wells were identified and used to characterize existing water quality based on a data screening and evaluation process that identified constituents of interest important to sustainable groundwater management.

Classification of Water Quality

To determine what groundwater quality constituents in the Basin may be of current or near-future concern, a reference standard was defined to which groundwater quality data were compared. Numeric thresholds are set by state and federal agencies to protect water users (environment, humans, industrial and agricultural users). The numeric standards selected for the current analysis represent all relevant state and federal drinking water standards and state water quality objectives for the constituents evaluated and are consistent with state and NCRWQCB assessments

of beneficial use protection in groundwater. The standards are compared against groundwater quality data to determine if a constituent concentration exists above or below the threshold and is currently impairing or may impair beneficial uses designated for groundwater at some point in the foreseeable future.

Although groundwater is utilized for a variety of purposes, the use for human consumption requires that supplies meet strict water quality regulations. The federal Safe Drinking Water Act (SDWA) protects surface water and groundwater drinking water supplies. The SDWA requires the United States Environmental Protection Agency (USEPA) to develop enforceable water quality standards for public water systems. The regulatory standards are named maximum contaminant levels (MCLs) and they dictate the maximum concentration at which a specific constituent may be present in potable water sources. There are two categories of MCLs: Primary MCLs (1^{o} MCL), which are established based on human health effects from contaminants and are enforceable standards for public water supply wells and state small water supply wells; and Secondary MCLs (2^{o} MCL), which are unenforceable standards established for contaminants that may negatively affect the aesthetics of drinking water quality, such as taste, odor, or appearance.

The State of California has developed drinking water standards that, for some constituents, are stricter than those set at the federal level. Water quality in the Basin is regulated under the NCR-WQCB Basin Plan, which lists relevant water quality objectives (WQOs) and beneficial uses. For waters designated as having a Municipal and Domestic Supply (MUN) beneficial use, the Basin Plan specifies that chemical constituents are not to exceed the Primary and Secondary MCLs established in Title 22 of the California Code of Regulations (CCR) (hereafter, Title 22). The MUN beneficial use applies to all groundwater in Butte Valley. The Basin Plan also includes numeric WQOs and associated calculation requirements in groundwater for select constituents in the Basin.

Constituents may have one or more applicable drinking water standard or WQOs. For this GSP, a prioritization system was used to select the appropriate numeric threshold. This GSP used the strictest value among the state and federal drinking water standards and state WQOs specified in the Basin Plan for comparison against available groundwater data. Constituents that do not have an established drinking water standard or WQO were not assessed. The complete list of constituents, numeric thresholds, and associated regulatory sources used in the water quality assessment can be found in Appendix 2-B. Basin groundwater quality data obtained for each well selected for evaluation were compared to a relevant numeric threshold.

Maps were generated for each constituent of interest showing well locations and the number of measurements for a constituent collected at a well (see Appendix 2-B). Groundwater quality data were further categorized by magnitude of detection as a) not detected, b) detected below half of the relevant numeric threshold, c) detected below the relevant numeric threshold, and d) detected above the relevant numeric threshold.

To analyze groundwater quality that is representative of current conditions in the Basin, several additional filters were applied to the dataset. Though groundwater quality data are available dating back to 1952 for some constituents, the data evaluated were limited to those collected from 1990 to 2020. Restricting the time span to data collected in the past 30 years increases confidence in data quality and focuses the evaluation on information that is considered reflective of current groundwater quality conditions. A separate series of maps was generated for each constituent of interest showing well locations and the number of groundwater quality samples collected among the wells during the past 30 years (1990 to 2020) (see Appendix 2-B).

Finally, for each constituent, an effort was undertaken to examine changes in groundwater quality over time at a location. Constituent data collected in the past 30 years (1990 to 2020) were further

limited to wells that have two or more water quality measurements. A final series of maps and timeseries plots showing data collected from 1990 to 2020 were generated for each constituent and well combination showing how data compare to relevant numeric thresholds. These maps and timeseries plots for each constituent of interest are provided in Appendix 2-B.

The approach described above was used to consider all constituents of interest and characterize groundwater quality in the Basin. Appendix 2-B contains additional detailed information on the methodology used to assess groundwater quality data in the Basin.

Basin Groundwater Quality

All groundwater quality constituents monitored in the Basin that have a numeric threshold were initially considered. The evaluation process described above showed the following parameters to be important to sustainable groundwater management in the Basin: 1,2 dibromoethane (EDB), arsenic, benzene, boron, nitrate, and specific conductivity. The following subsections present information on these water quality parameters in comparison to their relevant regulatory thresholds and how the constituent may potentially impact designated beneficial uses in different regions of the Basin. Table 2.5 contains the list of constituents of interest identified for the Basin and their associated regulatory threshold.

Table 2.5: Regulatory water quality thresholds for constituents of interest in the Butte Valley Groundwater Basin

Constituent	Regulatory Basis	Water Quality Threshold
1,2 Dibromoethane (µg/L)	Title 22	0.05
Arsenic (µg/L)	Title 22	10
Benzene (µg/L)	Title 22	1
Boron (mg/L)	Basin Plan 90% Upper Limit	0.2
Boron (mg/L)	Basin Plan 50% Upper Limit	0.1
Nitrate (mg/L as N)	Title 22	10
Specific Conductivity (µmhos/cm)	Basin Plan 90% Upper Limit	800
Specific Conductivity (µmhos/cm)	Basin Plan 50% Upper Limit	400

Additional maps and timeseries plots showing all evaluated groundwater quality constituents are presented in Appendix 2-B, including maps of select chemicals typically found associated with point-source contamination, including manufactured organic chemical compounds.

1,2 DIBROMOETHANE (EDB)

The main sources of 1,2 dibromoethane (also known as ethylene dibromide (EDB)) are anthropogenic, stemming from its use as a pesticide and historical use as a gasoline additive. Though most EDB in the environment is from anthropogenic sources, small quantities may be produced in the ocean from natural processes. EDB can enter groundwater through industrial or effluent discharges or through leaching from soils. Potential health effects from exposure to EDB in drinking water include damage to the stomach lining and ingestion of EDB in very high levels is toxic.

Recent data for EDB, collected from 1990 to 2020, is available in municipal and monitoring wells near Dorris, a well in Mount Hebron and a well near the southwest boundary of the Basin (Appendix 2-B). Exceedances of the 0.05 microgram per liter (μg/L) 1^{o} MCL for EDB are highly localized and are restricted to the monitoring wells in Dorris that are associated with known

contaminated sites. As shown in Appendix 2-B, though there is some variation, concentrations are generally decreasing over time.

ARSENIC

Arsenic is a naturally occurring element in soils and rocks and has been used in wood preservatives and pesticides. Classified as a carcinogen by the USEPA, the International Agency for Research on Cancer (IARC) and the Department of Health and Human Services (DHHS), arsenic in water can be problematic for human health. Drinking water with levels of inorganic arsenic from 300 to 30,000 parts per billion (ppb; 1 ppb = 1 µg/L) can have effects including stomach irritation and decreased red and white blood cell production (ATSDR 2007a). Long-term exposure can lead to skin changes and may lead to skin cancer. The Title 22 1° MCL for arsenic is 10 μg/L.

Arsenic data in the Basin, between 1990 and 2020, are limited to municipal wells in Dorris, Macdoel and Mount Hebron, with several measurements near and along the eastern Basin boundary (Appendix 2-B). Monitoring results for one well in Dorris exceeded the 1° MCL of 10 μg/L for arsenic. The three additional wells with arsenic data all have results below the 1° MCL, as shown in Appendix 2-B. This is consistent with the results of a recent study that evaluated trends in groundwater quality for 38 constituents in public supply wells throughout California, the results of which also show one well near Dorris with "high" arsenic levels (greater than 10 μg/L) based on measurements between 1995 to 2014 (Jurgens et al. 2020). Based on available data, arsenic concentrations are generally observed to be stable or decreasing, as shown in Appendix 2-B.

BENZENE

Benzene in the environment generally originates from anthropogenic sources, though lesser amounts can be attributed to natural sources including forest fires (Tilley and Fry 2015). Benzene is primarily used in gasoline and in the chemical and pharmaceutical industries and is commonly associated with leaking underground storage tank (LUST) sites. Classified as a known human carcinogen by the USEPA and the Department of Health and Human Services, exposure to benzene has been linked to increased cases of leukemia in humans (ATSDR 2007b). Long term exposure can affect the blood, causing loss of white blood cells and damage to the immune system or causing bone marrow damage, resulting in a decrease in the production of red blood cells and potentially leading to anemia. Acute exposure can cause dizziness, rapid or irregular heartbeat, irritation to the stomach and vomiting and can be fatal at very high concentrations (ATSDR 2007b). The 1° MCL for benzene is 1 milligram per liter (μg/L), as defined in Title 22.

Recent monitoring for benzene (from 1990 to 2020) includes background monitoring in municipal wells for Mount Hebron and Dorris and in monitoring wells associated with the known contaminated sites. Monitoring data collected in the municipal wells are all below the 1° MCL. As shown in Appendix 2-B, measurements that exceed the 1° MCL are all in the monitoring wells near Dorris, associated with known contaminated sites. Based on available data, these exceedances are highly localized and can be attributed to the contaminant plumes from the known contaminated sites, discussed in Section 2.2.3. Though there is some variability, benzene concentrations are generally seen to be decreasing over time, as illustrated in Appendix 2-B.

BORON

Boron in groundwater can come from both natural and anthropogenic sources. As a naturally occurring element in rocks and soil, boron can be released into groundwater through natural weathering

processes. Boron can be released into the air, water or soil from anthropogenic sources including industrial wastes, sewage and fertilizers. If ingested at high levels, boron can affect the stomach, liver, kidney, intestines and brain (ATSDR 2010). The Basin Plan contains a 50% upper limit (UL) for boron of 0.3 mg/L and a 90% UL of 1.0 mg/L.

Over the past 30 years (from 1990 to 2020), concentrations of boron in groundwater have been measured throughout the Basin. Numerous measurements exceed the 50% and 90% upper limits specified in the Basin Plan (Appendix 2-B). While recent monitoring data for boron are distributed throughout the Basin, wells with multiple measurements are mostly limited to areas near Macdoel and Mount Hebron, with an additional two wells at the western and eastern Basin boundaries. As shown in Appendix 2-B, concentrations of boron over time are seen to be relatively stable or decreasing.

SPECIFIC CONDUCTIVITY

Specific conductivity (electrical conductivity normalized to a temperature of 25°C), quantifies the ability of an electric current to pass through water and is an indirect measure of the dissolved ions in the water. Natural and anthropogenic sources contribute to variations in specific conductivity in groundwater. Increases of specific conductivity in groundwater can be due to dissolution of rock and organic material and uptake of water by plants, as well as anthropogenic activities including the application of fertilizers, discharges of wastewater and discharges from septic systems or industrial facilities. High specific conductivity can be problematic as it can have adverse effects on plant growth and drinking water quality.

Specific conductivity measurements, obtained from 1990 to 2020, are limited to areas near Dorris, Macdoel and Mount Hebron, with several additional locations near the Basin boundary (Appendix 2-B). While some measurements do exceed the Basin Plan 50% UL of 400 micromhos per centimeter (µmhos/cm), all measurements are below the Basin Plan 90% UL of 900 µmhos/cm. Available data are relatively stable over time, as seen in Appendix 2-B. Additional monitoring wells in different areas of the Basin are needed to evaluate spatial and temporal trends in specific conductivity.

NITRATE

Nitrate is one of the most common groundwater contaminants and is generally the water quality constituent of greatest concern. Natural concentrations of nitrate in groundwater are generally low. In agricultural areas, application of fertilizers or animal waste containing nitrogen can lead to elevated nitrate levels in groundwater. Other anthropogenic sources, including septic tanks, wastewater discharges, and agricultural wastewater ponds may also lead to elevated nitrate levels. Nitrate poses a human health risk, particularly for infants under the age of 6 months who are susceptible to methemoglobinemia, a condition that affects the ability of red blood cells to carry and distribute oxygen to the body. The 1^{o} MCL for nitrate is 10 mg/L as N.

Recent nitrate data collected in the Basin (1990 to 2020) are concentrated near Dorris, Macdoel and Mount Hebron, with limited data throughout the rest of the Basin (Appendix 2-B). Exceedances are seen to primarily occur in the municipal wells near Macdoel and Mount Hebron; no measurements exceeded the 1^{o} MCL for nitrate in the northern section of the Basin. In wells with multiple monitoring events, nitrate concentrations can be seen to generally be decreasing or relatively stable, as illustrated in Appendix 2-B. However, additional monitoring data are needed for a complete determination of spatial and temporal trends in nitrate concentrations.

Contaminated Sites

Groundwater monitoring activities also take place in the Basin in response to known and potential sources of groundwater contamination, including underground storage tanks (SWRCB 2019b). These sites are subject to oversight by regulatory entities, and any monitoring associated with these sites can provide opportunities to improve the regional understanding of groundwater quality. To identify known plumes and contamination within the Basin, SWRCB GeoTracker was reviewed for active clean-up sites of all types. The GeoTracker database shows one open Leaking Underground Storage Tank (LUST) site and two open cleanup program sites with potential or actual groundwater contamination located within the Basin.

Underground storage tanks (UST) are containers and tanks, including piping, that are completely or significantly below ground and are used to store petroleum or other hazardous substances. Soil, groundwater and surface water near the site can all be affected by releases from USTs. A UST becomes a potential hazard when any portion of it leaks a hazardous substance at which point it is classified as LUST. The main constituents of concern due to contamination plumes in the Basin are tetrachloroethylene (PCE) and contaminants associated with releases of gasoline including fuel oxygenates such as methyl tertiary butyl ether (MTBE), benzene, toluene, ethylbenzene and xylenes (this collection of organic compounds is commonly referred to as “BTEX”). Other constituents of concern related to gasoline are lead scavenging compounds, including EDB and 1, 2-dichlororethane.

A brief overview of notable information related to contaminated sites in the Basin is provided below; however, an extensive summary for each of the contamination sites is not presented. The location of the contaminated sites are shown in Figure 2.24.

Dorris PCE Plume

The case (No. 1NSI23) for this cleanup site was opened in September 2013, after tetrachloroethylene (PCE) from an unidentified source was detected in LUST monitoring wells for the Shell site. This case is currently open and inactive (there are currently no regulatory oversight efforts by the Lead Agency).

Calzona Tankways

The case (No. 1NSI045) has been open for this cleanup site since 1988 with gasoline as the potential contaminant of concern. In 2011, the status of this case was changed to open and inactive.

Shell, Dorris

A former petroleum fueling facility, this LUST site is currently vacant. The case (No. 1TSI171) for this site was opened in 1999 following a reported unauthorized petroleum release after removal of seven underground storage tanks (USTs). The petroleum release is known to have affected the soil and shallow groundwater and 11 groundwater monitoring wells have been used to evaluate conditions at the site. Remediation activities have included pilot tests of bioventing and ozone sparging in 2007 and 2008, and full-scale ozone sparging from 2013 to 2019. The most recent review summary report from October 2019 notes that the site does not meet criteria for closure as groundwater quality objectives are not being meet and due to a lack of soil and soil vapor data.

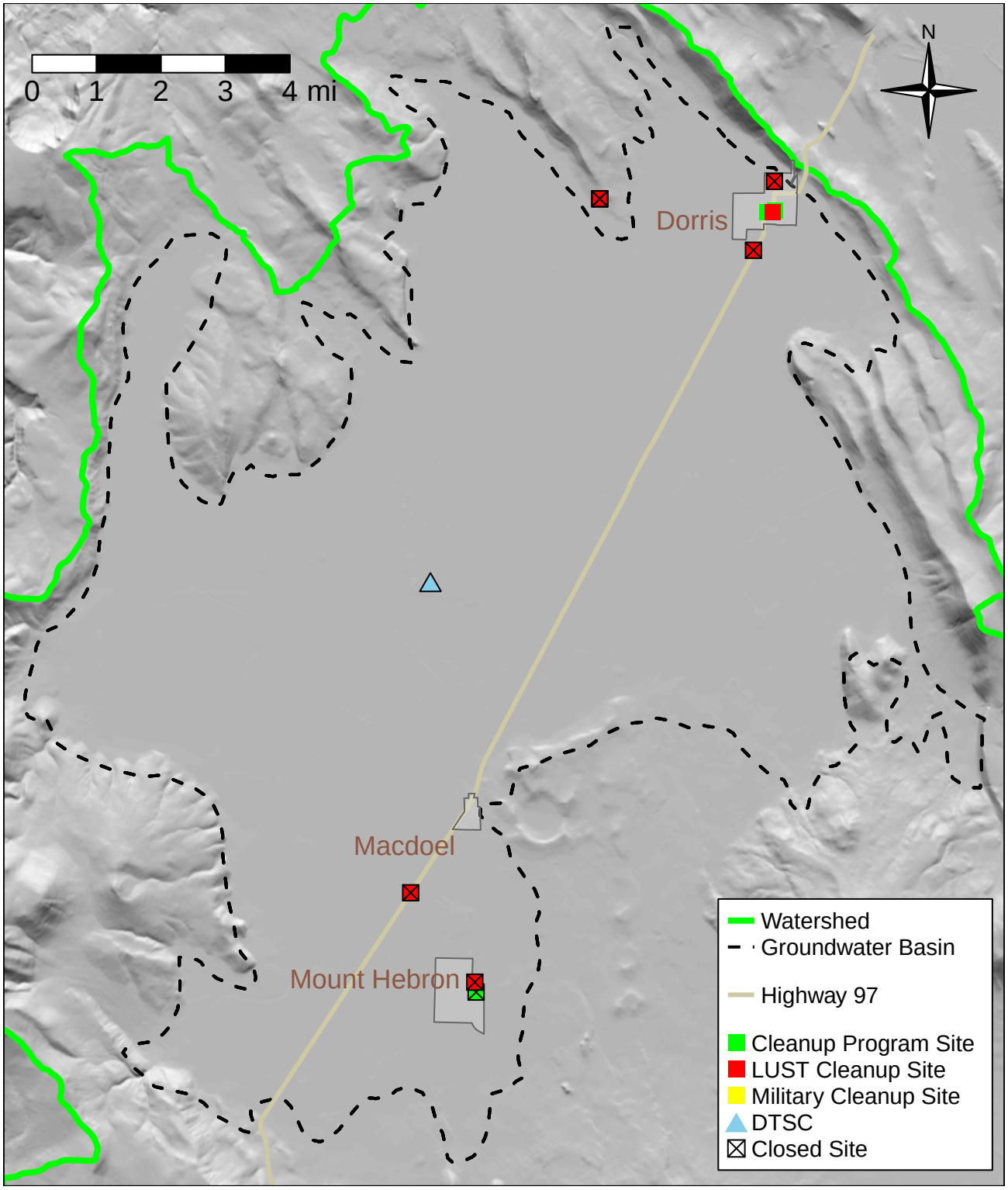


Figure 2.24: Contaminated Sites

While current data is useful to determine local groundwater conditions, additional monitoring is necessary to develop a basin-wide understanding of groundwater quality, and greater spatial and temporal coverage would improve the ability to evaluate trends. From a review of all available information, none of the sites listed above have been determined to have an impact on the aquifer, and the potential for groundwater pumping to induce contaminant plume movement towards water supply wells is negligible. Currently, there is not enough information to determine if the contaminants are sinking or rising with groundwater levels.

2.2.2.4 Seawater Intrusion Conditions

Due to the distance between Butte Valley and the Pacific Ocean, saltwater intrusion is not evident nor of concern and therefore, is not applicable to the Basin.

2.2.2.5 Land Subsidence Conditions

Land subsidence is the lowering of the ground surface elevation. This is often caused by pumping groundwater from within or below thick clay layers. Land subsidence can be elastic or inelastic, meaning that the lithologic structure of the aquifer can compress or expand elastically due to water volume changes in the pore space or is detrimentally collapsed when water is withdrawn (inelastic). Inelastic subsidence is generally irreversible. Elastic subsidence is generally of a smaller magnitude of change, and is reversible, allowing for the lowering and rising of the ground surface and can be cyclical with seasonal changes.

While lake sediments in the Valley floor have some inelastic subsidence risk as groundwater levels drop, land subsidence is not known to be historically or currently significant in the Basin. While groundwater elevations have steadily declined in the past few decades, noticeable land subsidence has not been observed in the Basin. BVID has not seen any pipe breakages nor loss in conveyance capacity in recent memory, which suggests that no noticeable land subsidence has occurred in the BVID management area (Lutz 2021). The City of Dorris has not observed any influence of land subsidence on city pipes (Mckay 2019).

Data Sources

Interferometric Synthetic Aperture Radar (InSAR) is a satellite-based remote sensing technique that measures vertical ground surface displacement changes at high degrees of measurement resolution and spatial detail. DWR has made InSAR satellite data available on their SGMA Data Viewer web map in two different forms: point data and a Geographic Information System (GIS) raster, which is point data interpolated into a continuous image or map (DWR 2019c). The point data are the observed average vertical displacements within a 100 by 100 meter area. The raster datasets were processed by TRE ALTAMIRA under contract by DWR for all SGMA High- and Medium-Priority groundwater basins. These are the only data used for estimating subsidence in this GSP as they are the only known subsidence-related dataset available for this Basin. The DWR-funded TRE Altamira InSAR dataset provides estimates of total vertical displacement from June 2015 to September 2019 and is shown in Figure 2.25 using raster data from the TRE Altamira report (DWR 2019c). The provided DWR/TRE Altamira InSAR data reflect both elastic and inelastic subsidence and it can be difficult to isolate a signal solely for only the elastic subsidence amplitude.

Visual inspection of monthly changes in ground elevations typically suggest that elastic subsidence is largely seasonal and can potentially be factored out of the signal, if necessary.

Data Quality

The TRE Altamira InSAR data provided by DWR are subject to compounded measurement and raster conversion errors. DWR has stated that for the total vertical displacement measurements, the errors are as follows:

1. The error between InSAR data and continuous GPS data is 16 mm (0.052 feet) with a 95% confidence level.
2. The measurement accuracy when converting from the raw InSAR data to the maps provided by DWR is 0.048 feet with 95% confidence level.

The addition of the both of these errors results in the combined error is 0.1 feet. While not a robust statistical analysis, it does provide a potential error estimate for the TRE Altamira InSAR maps provided by DWR. A land surface change of less than 0.1 ft is within the noise of the data and is likely not indicative of groundwater-related subsidence in the basin.

Data Analysis

The total subsidence raster used for this GSP uses the InSAR point data (DWR 2019c). The point data, which represent approximate areas of 328 x 328 ft (100 x 100 m) squares, are interpolated to a raster with a grid spacing of approximately 3,281 x 3,281 ft (1,000 x 1,000 m) squares. This is a lower resolution than the one available as the DWR/TRE Altamira raster on the online SGMA Data Viewer (DWR 2019c). This effectively smooths out the larger amplitude, small foot print signals. Groundwater extraction-related signals would typically be expected to be larger in scale that these small foot print signals. The subsidence anomaly observed in Butte Valley for the period June 2015 to September 2019 represents an approximately 1,600 x 1,600 ft signal. For comparison, this is not much larger than the area of one center-pivot irrigation plot.

Using the TRE Altamira InSAR Dataset provided by DWR, it is observed that the majority of the vertical displacement values in the Basin are mostly near-zero, especially given the range of 0.1 ft to -0.1 feet of estimated error for the data (see Figure 2.25). These values are largely within or less than the same order of magnitude of the combined data and raster conversion error, suggesting essentially noise or, at least non-groundwater related activity, in the data. Any actual signals at this level could be due to a number of possible activities, including land use change and/or agricultural operational activities at the field scale. For perspective, during this same period, sections of the San Joaquin Valley in California's Central Valley experienced up to ~3.5 feet of subsidence.

However, there is a localized hotspot near Dorris showing subsidence that may be of a magnitude above the potential instrument error of the InSAR instrumentation (DWR 2019c). Initial estimates of land subsidence between June 2015 to September 2019 are shown in Figure 2.25 using raster data from the DWR/TRE Altamira report (DWR 2019c).

Following detailed inspection of the DWR provided point subsidence data, satellite image review, and communication with the GSA Advisory Board, it seems likely that parcels APN 003-330-100

and 003-210-070 underwent sufficient grading and leveling during the period of record that may constitute a source of error in the apparent subsidence values shown in Figure 2.25. Subsidence throughout the Basin will require periodic reevaluation. At this time, subsidence in and around the highlighted parcels is slightly above potential instrument error that exists in the InSAR data and is either an artifact of significant grading or actual subsidence. The maximum observed subsidence shown in Figure 2.25 is approximately 0.15 ft (46 millimeters (mm)) between June 2015 to September 2019 in the area west of Dorris.

2.2.2.6 Identification of Interconnected Surface Water Systems

SGMA calls for the identification of interconnected surface waters (ISWs) in each GSP. ISWs are defined under SGMA as:

> *23 CCR § 351 (o): "Interconnected surface water" refers to 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.*

Several small streams and creeks flow discontinuously along the edges of Butte Valley, primarily on the southern and western flanks of the valley, but there are no recent public records for stream flow except estimates of diversions by water right holders. Historical monitoring of stream flow in Butte Creek at the National Water Information System (NWIS) gauge 11490500 is restricted to a period of record from 1952 to 1960. Records indicate historical peak flows during January to March in excess of 255 cubic feet per second (cfs) with summer time flows from July to September typically below 10 cfs. The lack of stream gage data for all creeks in the Basin is a major data gap that the GSA plans to address (see Appendix 3-A).

Surface water in the Basin is restricted to Meiss Lake and five creeks: Butte, Prather, Ikes, Harris, and Muskgrave (Figure 2.26). Only short stretches of Ikes, Harris, and Muskgrave Creeks lie within the Basin boundary before terminating at the BVWA Perimeter Canal (Figure 2.7 and Figure 2.27). Section 2.2.1.9 provides an overview of these surface water bodies, many of which go dry in the summer and fall. Section 2.2.2.1 and Appendix 2-A show that historical groundwater level data are generally located far from surface waters. Water level elevations near potential ISWs has been identified as a data gap that the GSA plans to address (see Appendix 3-A).

Generally for all these surface waters, the nearest groundwater contours are deeper than 30 feet (see Appendix 2-A). The nearest wells to Ikes, Harris, and Muskgrave Creeks have groundwater levels typically deeper than 40 feet below ground surface (bgs). Wells to the north and south of Meiss Lake range from 25 to 50 ft bgs, with projected groundwater surfaces of Meiss Lake greater than 30 feet. Groundwater level data at Prather Creek have groundwater levels greater than 30 feet. Due to the deep local groundwater levels, these surface waters are therefore tentatively assumed disconnected from the Basin groundwater aquifer. This assumption may be revised in the future as the GSA collects additional data and fills the discussed data gaps (see Appendix 3-A).

Butte Creek is a major surface water body in Butte Valley and terminates south of Mount Hebron, where all water is appropriated for irrigation. Large data gaps include the lack of historical flow within the Basin and no nearby groundwater level data. The nearest groundwater well to Butte Creek has groundwater levels ranging from 40 to 80 ft bgs (see Appendix 2-A). Studies of Butte Creek upstream of the Basin suggest that Butte Creek is a losing stream (Todd Sloat Biological

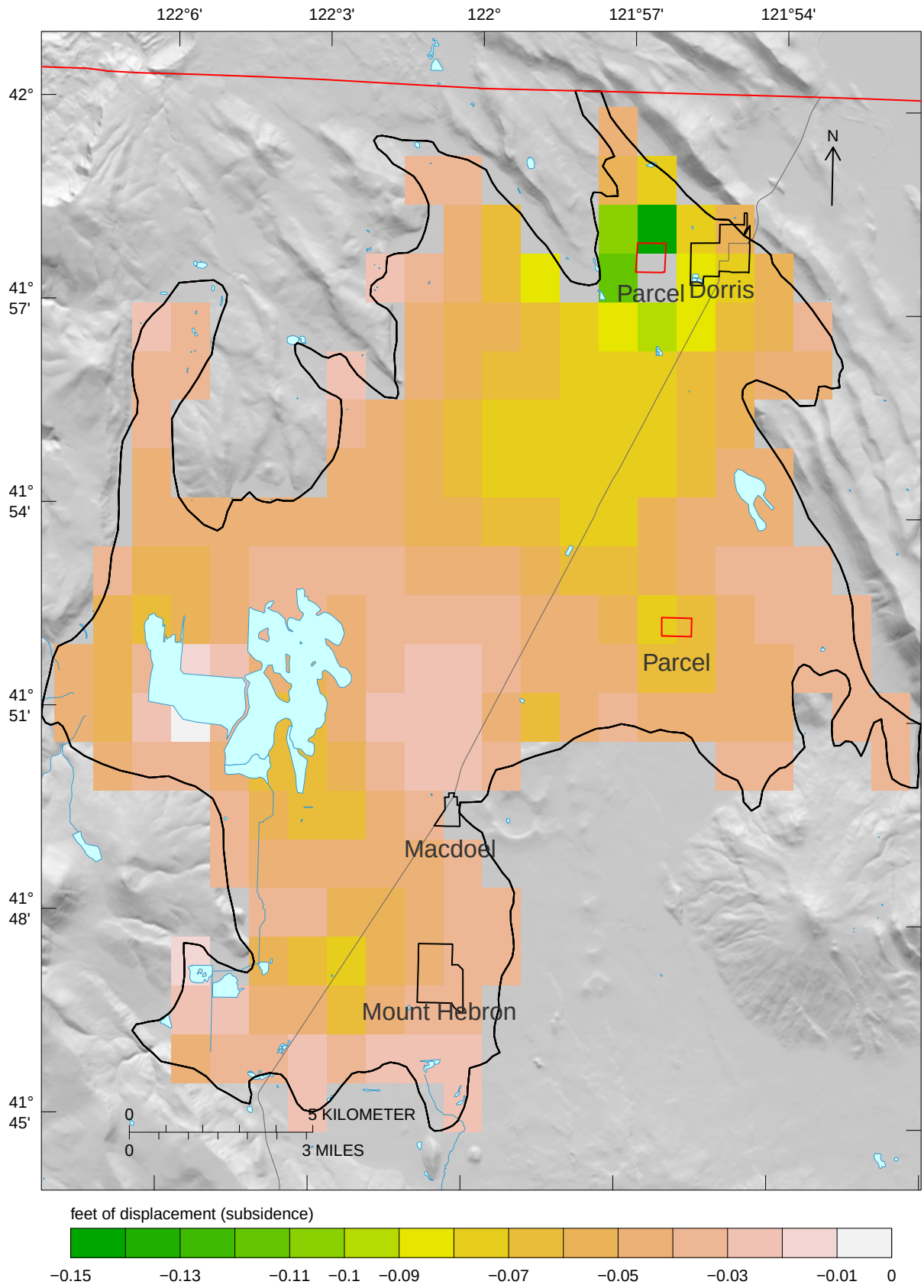


Figure 2.25: InSAR satellite measured total vertical subsidence (feet) between June 2015 and September 2019. Note that the processed InSAR instrument and GIS conversion error is roughly +/-0.1 feet.

Consulting 2012). Until the above data gaps are addressed, Butte Creek is tentatively assumed disconnected from the Basin groundwater aquifer due to deep groundwater levels. Due to the importance of Butte Creek for irrigation and groundwater recharge within the Basin, the GSA is prioritizing addressing the stream gage and groundwater level data gaps (see Appendix 3-A). Future additional data will improve future analysis of Butte Creek as a potential ISW.

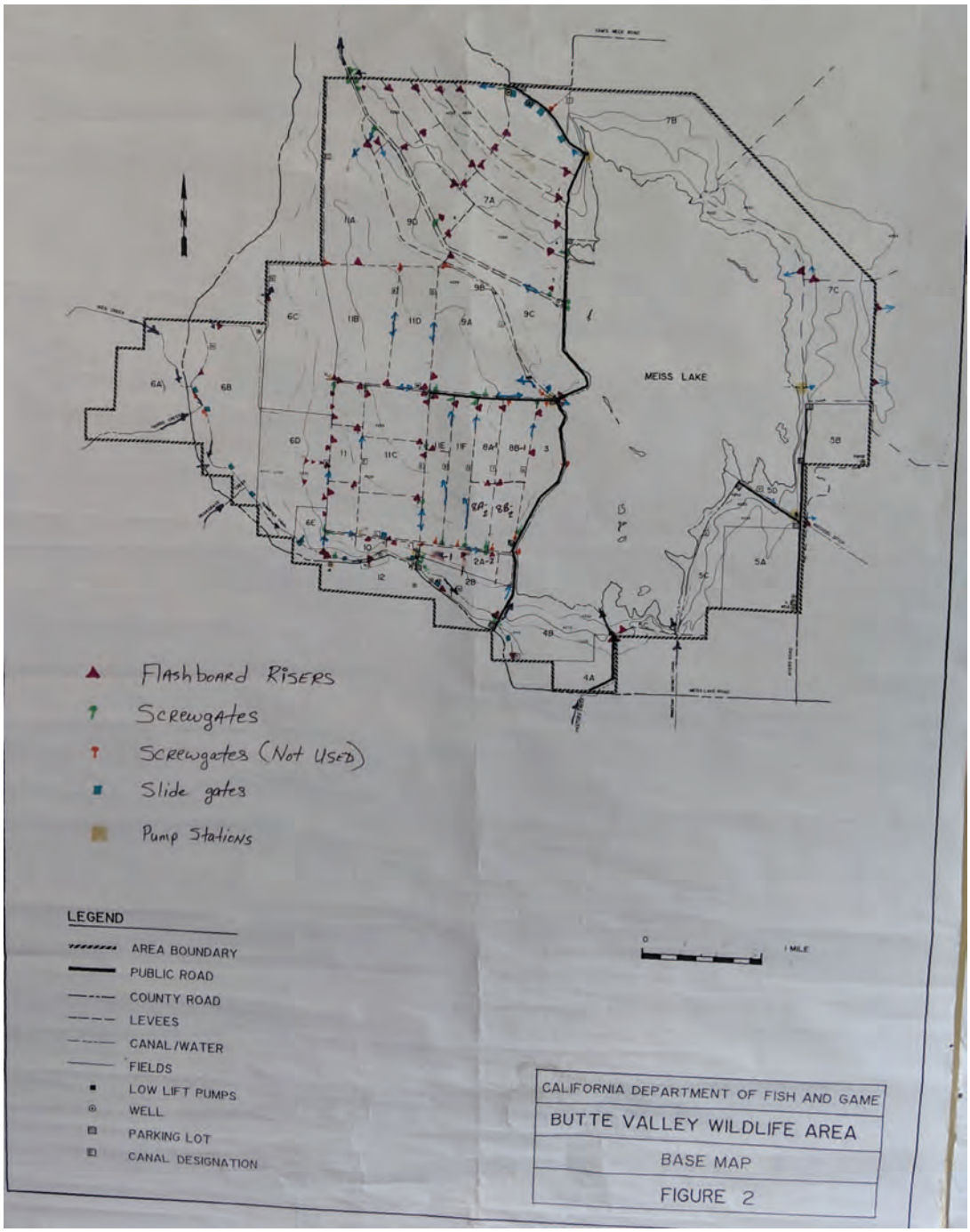


Figure 2.27: Photo of Butte Valley Wildlife Area (BVWA) map taken at the BVWA headquarters, showing that Ikes, Harris, and Muskgrave Creeks terminate at the BVWA Perimeter Canal. Prather Creek terminates in Meiss Lake.

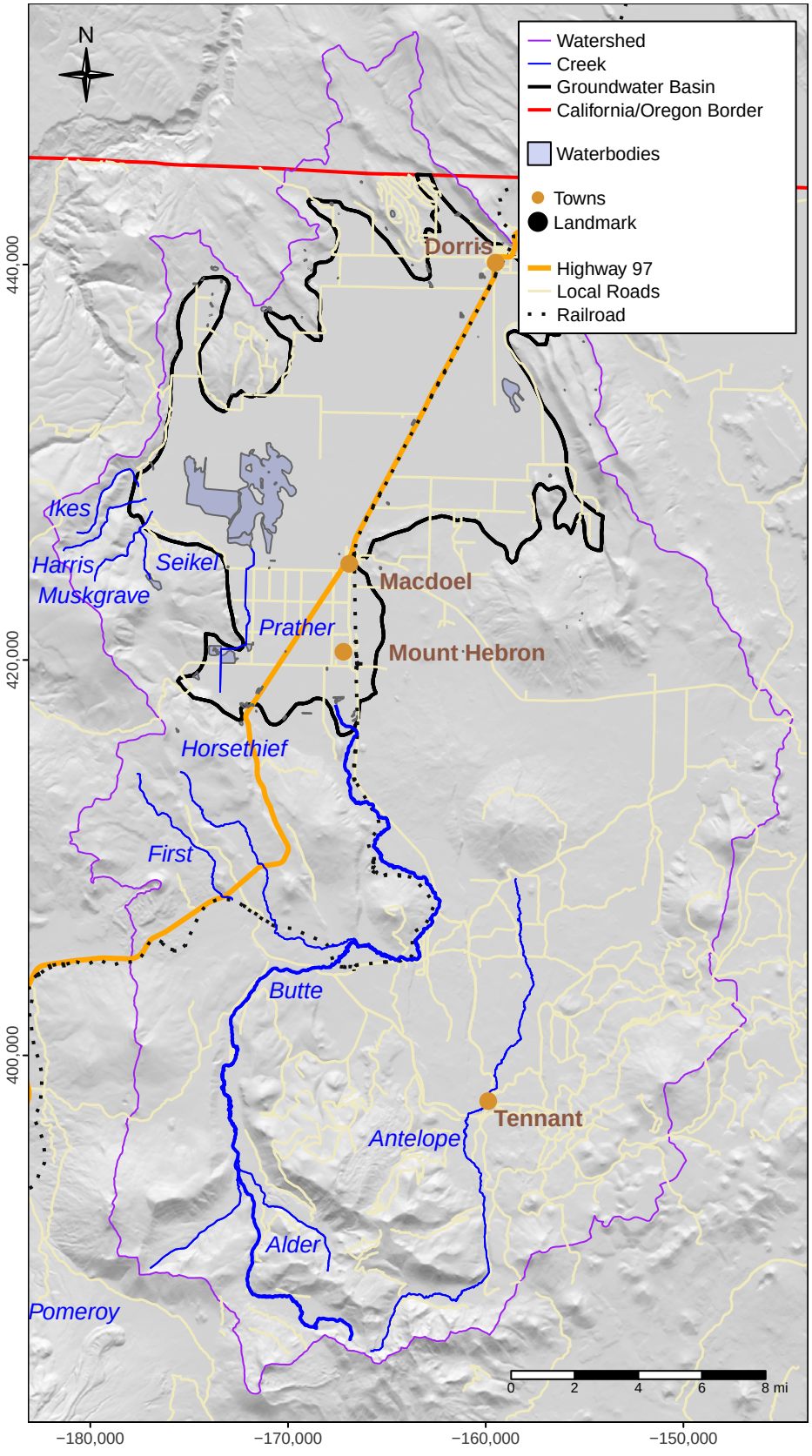


Figure 2.26: Surface Water in the Butte Valley Groundwater Basin.

2.2.2.7 Identification of Groundwater-Dependent Ecosystems

Section 354.16(g) of SGMA requires identification of groundwater dependent ecosystems (GDEs). Section 351(m) of these regulations refers to GDEs as *"ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface."* California Water Code 10727.4(l) further requires that a GSP describes and considers the impacts to GDEs.

In order to adequately consider potential effects of the potential effects of the management of regional groundwater resources on all beneficial uses and users of groundwater and ISWs, including both human and natural beneficial uses, GDEs within the Basin area must be identified and potential effects of the Basin operations on GDEs must be determined. Such information is then used to establish sustainable management criteria (SMC), improve the monitoring network, and define projects and management actions (PMAs) that help improve or maintain conditions for each GDE to achieve the sustainability goal in the basin, as discussed in Chapters 3, 4, and 5, respectively.

Major data gaps within the current analysis of GDEs include unreliable or outdated habitat maps that require local knowledge and study and groundwater level data gaps near potential GDEs. The GSA presents a plan to address these data gaps in Chapter 4 and 5, and Appendix 3-A.

Environmental Beneficial Water Uses and Users within the Basin

To establish sustainable management criteria (SMCs) for the water level and for the depletion of ISW sustainability indicators, GSAs are required to prevent adverse impacts to beneficial users of groundwater and ISW, including environmental uses and users. Thus, identifying these uses and users is the first step to address undesirable results due to water level declines or surface water depletions from groundwater pumping.

The Basin encompasses two California ecoregions as identified by USEPA Level III Ecoregions of California (Griffith et al. 2016):

- Cascade (Ecoregion 4), which covers approximately 1.2% of the Basin area in the west and southwest. This ecoregion is characterized by broad, easterly trending valleys, a high plateau in the east, as well as both active and dormant volcanoes. Its moist, temperate climate supports an extensive and highly productive coniferous forest, while containing subalpine meadows at high elevations.
- Eastern Cascades Slopes and Foothills (Ecoregion 9), which covers the majority of the Basin. This region is in the rain shadow of the Cascade Range, with a more continental climate compared to ecoregions to the west, with greater temperature extremes, less precipitation, and frequent fires. Volcanic cones, plateaus, and buttes are common. Areas of cropland and pastureland in lake basins and larger river valleys provide habitat for migrating waterfowl, such as sandhill cranes, ducks, and geese.

Per 23 California Code of Regulations section 354.8(a)(3), CDFW recommends identifying Department-owned or Department-managed lands within the Basin, and carefully considering all environmental beneficial uses and users of water on Department lands to ensure fish and wildlife resources are being considered when developing the GSP. In the Basin, CDFW owns BVWA and manages Meiss Lake. Additionally, USFS and BLM own about 23.3% and 0.1% of the Basin area, respectively (Figure 2.2).

Freshwater Species within the Basin

The Nature Conservancy (TNC) has provided a list of freshwater species located within each groundwater basin in California and the BVWA tracks species that visit the wildlife area. Many bird species visit Butte Valley because Meiss Lake and BVWA are part of the Pacific Flyway for migrating birds. Based on the combined freshwater species lists, there are a total of thirty-seven species identified by the federal or state governments as endangered, threatened, species of special concern, or watch list within the Basin, including those under review or in the candidate or petition process. Of these species two are endangered species, four are designated as threatened, twenty-two are species of concern or special species, and nine are included on the watch list (Table 2.6) (K. Novick 2009; TNC 2021; CDFW 2021c, 2021b, 2021a).

The predicted habitat for each of these species were evaluated using CDFW's Biogeographic Information and Observation System (BIOS) Viewer, with input from BVWA. BIOS houses many biological and environmental datasets including the California Natural Diversity Database (CNDDB), which is an inventory of the status and locations of rare plants and animals in California. Local knowledge from BVWA indicates bald eagles are common year-round in BVWA, with dozens of eagles in the winter and successful nesting. American white pelicans and yellow headed blackbirds are abundant in the spring and summer and yellow-headed blackbirds nest in BVWA. Colonial-nesting waterbirds nest on the natural islands in Meiss Lake when water is present. No nesting occurs when the lake is dry. During wet cycles, nesting bird species include ring-billed gulls, California gulls (6,000 combined gull nests), Forster's terns (133 nests), doublecrested cormorants (124 nests), Caspian terns (27 nests), and white pelicans (73 nests). The colony of white pelicans nesting is significant because, as of 2009, there were only three or four other colonies nesting in the state (K. Novick 2009). Additional birds such as ducks, pintail, goose and snow geese migrate through BVWA.

Brief descriptions about these species and their water demand are provided below:

- Bald Eagles live near waterbodies including estuaries, lakes, reservoirs, rivers, and occasionally by coastlines. They rely on a diet predominantly comprised of fish, but that also may include smaller birds including colonial waterbirds, waterfowl and small mammals. Populations have been threatened by hunting, loss of nesting habitat and poisoning from the pesticide DDT.
- The western pond turtle's preferred habitat is permanent ponds, lakes, streams or permanent pools along intermittent streams, associated with standing and slow-moving water. A potentially important limiting factor for the Western pond turtle is the relationship between water level and flow in off-channel water bodies, which can both be affected by groundwater pumping.

Because the Basin is internally drained with no connection to the Klamath River or the sea, there are no anadromous fish populations.

Table 2.6: Freshwater Species in Butte Valley, as identified by BVWA (2009 BVWA Plan Addendum), The Nature Conservancy (TNC 2021) with species status verified by CDFW statewide species lists (CDFW 2021 a,b,c).

Species	Group	Status	Notes
American White Pelican	Birds	Special Concern	Observed in Butte Valley Wildlife Area
An Amphipod	Crustaceans	Special	Nature Conservancy Butte Valley Basin List
Bald Eagle	Birds	Endangered (state only - under review)	Observed in Butte Valley Wildlife Area
Bank Swallow	Birds	Threatened	Nature Conservancy Butte Valley Basin List
Black Tern	Birds	Special Concern	Observed in Butte Valley Wildlife Area
Black-capped chickadee	Birds	Watch list	Observed in Butte Valley Wildlife Area
Burrowing Owl	Birds	Special Concern	Observed in Butte Valley Wildlife Area
California gull	Birds	Watch list	Observed in Butte Valley Wildlife Area
Canvasback	Birds	Special	Nature Conservancy Butte Valley Basin List
Columbia Yellowcress	Plants	Special	Observed in Butte Valley Wildlife Area
Cooper’s hawk	Birds	Watch list	Observed in Butte Valley Wildlife Area
Double-crested cormorant	Birds	Watch list	Observed in Butte Valley Wildlife Area
Golden eagle	Birds	Watch list	Observed in Butte Valley Wildlife Area
Greater sandhill crane	Birds	Threatened	Observed in Butte Valley Wildlife Area
Hot Springs Fimbry	Plants	Special	Nature Conservancy Butte Valley Basin List
Loggerhead shrike	Birds	Special Concern	Observed in Butte Valley Wildlife Area
Long-eared owl	Birds	Special Concern	Observed in Butte Valley Wildlife Area

Table 2.6: Freshwater Species in Butte Valley, as identified by BVWA (2009 BVWA Plan Addendum), The Nature Conservancy (TNC 2021) with species status verified by CDFW statewide species lists (CDFW 2021 a,b,c). *(continued)*

Species	Group	Status	Notes
Newberry's Cinquefoil	Plants	Special	Nature Conservancy Butte Valley Basin List
Northern harrier	Birds	Special Concern	Observed in Butte Valley Wildlife Area
Northern spotted owl	Birds	Threatened	Observed in Butte Valley Wildlife Area
Oregon Spotted Frog	Herps	Special Concern	Observed in Butte Valley Wildlife Area
Osprey	Birds	Watch list	Observed in Butte Valley Wildlife Area
Pedate Checker-mallow	Plants	Endangered	Nature Conservancy Butte Valley Basin List
Prairie falcon	Birds	Watch list	Observed in Butte Valley Wildlife Area
Redhead	Birds	Special Concern	Nature Conservancy Butte Valley Basin List
Redhead duck	Birds	Special Concern	Observed in Butte Valley Wildlife Area
Sharp-shinned hawk	Birds	Watch list	Observed in Butte Valley Wildlife Area
Short-eared owl	Birds	Special Concern	Observed in Butte Valley Wildlife Area
Swainson's hawk	Birds	Threatened	Observed in Butte Valley Wildlife Area
Tricolored Blackbird	Birds	Special Concern	Nature Conservancy Butte Valley Basin List
Tule white-fronted goose	Birds	Special Concern	Observed in Butte Valley Wildlife Area
Vaux's swift	Birds	Special Concern	Observed in Butte Valley Wildlife Area
Wawona Riffle Beetle	Insects & other inverts	Special	Nature Conservancy Butte Valley Basin List
Western Pond Turtle	Herps	Special Concern	Observed in Butte Valley Wildlife Area
White-faced Ibis	Birds	Watch list	Observed in Butte Valley Wildlife Area

Table 2.6: Freshwater Species in Butte Valley, as identified by BVWA (2009 BVWA Plan Addendum), The Nature Conservancy (TNC 2021) with species status verified by CDFW statewide species lists (CDFW 2021 a,b,c). *(continued)*

Species	Group	Status	Notes
Yellow warbler	Birds	Special Concern	Observed in Butte Valley Wildlife Area
Yellow-headed Blackbird	Birds	Special Concern	Observed in Butte Valley Wildlife Area

Management Approach

Groundwater dependent species prioritized for management primarily focus on riparian vegetation that is a GDE. Addressing the needs of these species is assumed to cover the needs of other special-status species such as the bank swallow, western pond turtle, and bald eagle that use riverine habitats during their life stage. Additionally, special status species that were not prioritized for management may exhibit flexible life-history strategies, are less susceptible to changing groundwater conditions, and/or have a different nature or lower degree of groundwater dependency. The species prioritized for management, shown in Table 2.7, are considered throughout this GSP. Other species listed in Table 2.6 and Table 2.7 are protected by federal or state agencies. As needed, the GSA will partner with those agencies to protect non-threatened, threatened, and endangered species within the Basin.

Table 2.7: GDE species prioritization for management, as identified by BVWA, The Nature Conservancy, and CDFW (2009 BVWA Plan Addendum, TNC 2021, CDFW 2021 a,b,c). The GSA will work with relevant agencies to manage unprotected and protected species within the Basin.

Species Prioritized for Management	Species whose needs are covered through management for prioritized species
Unprotected species that depend on groundwater dependence ecosystems	American White Pelican
	An Amphipod Bald Eagle Bank Swallow Black Tern
	Black-capped chickadee Burrowing Owl California gull Canvasback Columbia Yellowcress
	Cooper's hawk Double-crested cormorant Golden eagle Greater sandhill crane

Table 2.7: GDE species prioritization for management, as identified by BVWA, The Nature Conservancy, and CDFW (2009 BVWA Plan Addendum, TNC 2021, CDFW 2021 a,b,c). The GSA will work with relevant agencies to manage unprotected and protected species within the Basin. *(continued)*

Species Prioritized for Management	Species whose needs are covered through management for prioritized species
	Hot Springs Fimbry
	Loggerhead shrike Long-eared owl Newberry's Cinquefoil Northern harrier Northern spotted owl
	Oregon Spotted Frog Osprey Pedate Checker-mallow Prairie falcon Redhead
	Redhead duck Sharp-shinned hawk Short-eared owl Swainson's hawk Tricolored Blackbird
	Tule white-fronted goose Vaux's swift Wawona Riffle Beetle Western Pond Turtle White-faced Ibis
	Yellow warbler Yellow-headed Blackbird

Vegetative GDE Identification and Classification

The following section discusses the process of identifying potential GDEs and their classification based on the likelihood that they have access to groundwater. This analysis is carried out using three key building blocks:

- Mapping potential GDEs based on available resources.
- Assign rooting depths based on predominant assumed vegetation type.
- Establish representations of depth to groundwater.
- Identify potential areas where both, depth to groundwater, rooting depth, and presence of potential GDEs confirm likely groundwater-dependence.

The following subsections discuss the process of assembling these four building blocks.

Mapped Potential GDEs

The primary resource used to establish the spatial extent of mapped GDEs is the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset (DWR 2021). The NCCAG dataset includes separate vegetation communities and wetland geospatial data layers for each of the groundwater basins identified in Bulletin 118. These layers identify potential locations of GDEs, which identify the phreatophytic vegetation, perennial streams, regularly flooded natural wetlands, and springs and seeps that may indicate the presence of/and or communities that and depend on groundwater, and therefore can be considered as indicators of GDEs. Representations of mapped potential GDEs from the NCCAG vegetation and wetlands datasets are presented in Figure 2.29 and Figure 2.28, respectively.

An initial review of NCCAG mapped potential GDEs for the Basin and a comparison to an initial review of NCCAG mapped potential GDEs for the Basin and a comparison to available land use mapping resources suggested that riparian communities were not effectively represented in some cases and mapped GDEs were identified in urban, agricultural, or managed vegetated areas. A subset of land uses from the 2010 Siskiyou County land use and land cover (LU/LC) dataset were incorporated into the analysis to more effectively represent mapped potential GDEs for the Basin. Siskiyou County LU/LC classes are presented in Appendix 2-C.

The NCCAG vegetation and wetland layers were overlaid or unioned in a geographic information system (GIS) yielding a dataset where areas mapped as potential vegetation GDEs, wetland GDEs, or both vegetation and wetland GDEs are represented. A union is a geospatial process where the coverage and attributes of multiple layers in all area are combined into one spatial dataset. An intersection is a geospatial process where the coverage and attributes of multiple layers are combined into one spatial dataset only in areas where they share area or overlap. This combined or unioned NCCAG dataset was intersected with the adapted 2010 Siskiyou County LU/LC dataset yielding a combination of classifications for all three datasets for the area covered by either the NCCAG vegetation or wetland datasets. All observed combinations of combined fields were summarized in a master table and grouped into one of the five categories presented in Table 2.8 based on best professional judgment. Additional tables used in this process are presented in Appendix 2-C.

If, as an example, the NCCCAG Wetland dataset identified an area as class “PEM1C” corresponding to a “Palustrine, Emergent, Persistent, Seasonally Flooded” mapped potential wetland GDE and the 2010 Siskiyou County LU/LC dataset assigned the same area a “UR” representing “Urban Residential,” that area was assigned a “Remove Urban/Paved” classification and was subsequently removed. If, as a second example, neither the NCCAG Wetland or Vegetation datasets identified an area as a mapped GDE but the 2010 Siskiyou County LU/LC dataset assigned that area an “NW1” class representing “River or stream (natural fresh water channels),” it was included in the combined representation of mapped GDEs. Combined land use classes a “Retain Check” or “Check Remove Irrigated” classification were qualitatively evaluated using aerial imagery and included or removed based on best professional judgement.

Assumed Rooting Zone Depths

Rooting zone depths were assigned to all combined or concatenated values for the NCCAG vegetation, NCCAG wetland, and Siskiyou County land use and land cover dataset using a simple decision tree approach. An assumed dominant or representative vegetation was assumed for the best available dataset for each area or polygon within the mapped potential GDE dataset. Classifications from the NCCAG vegetation dataset were used to assign rooting zone depths based on

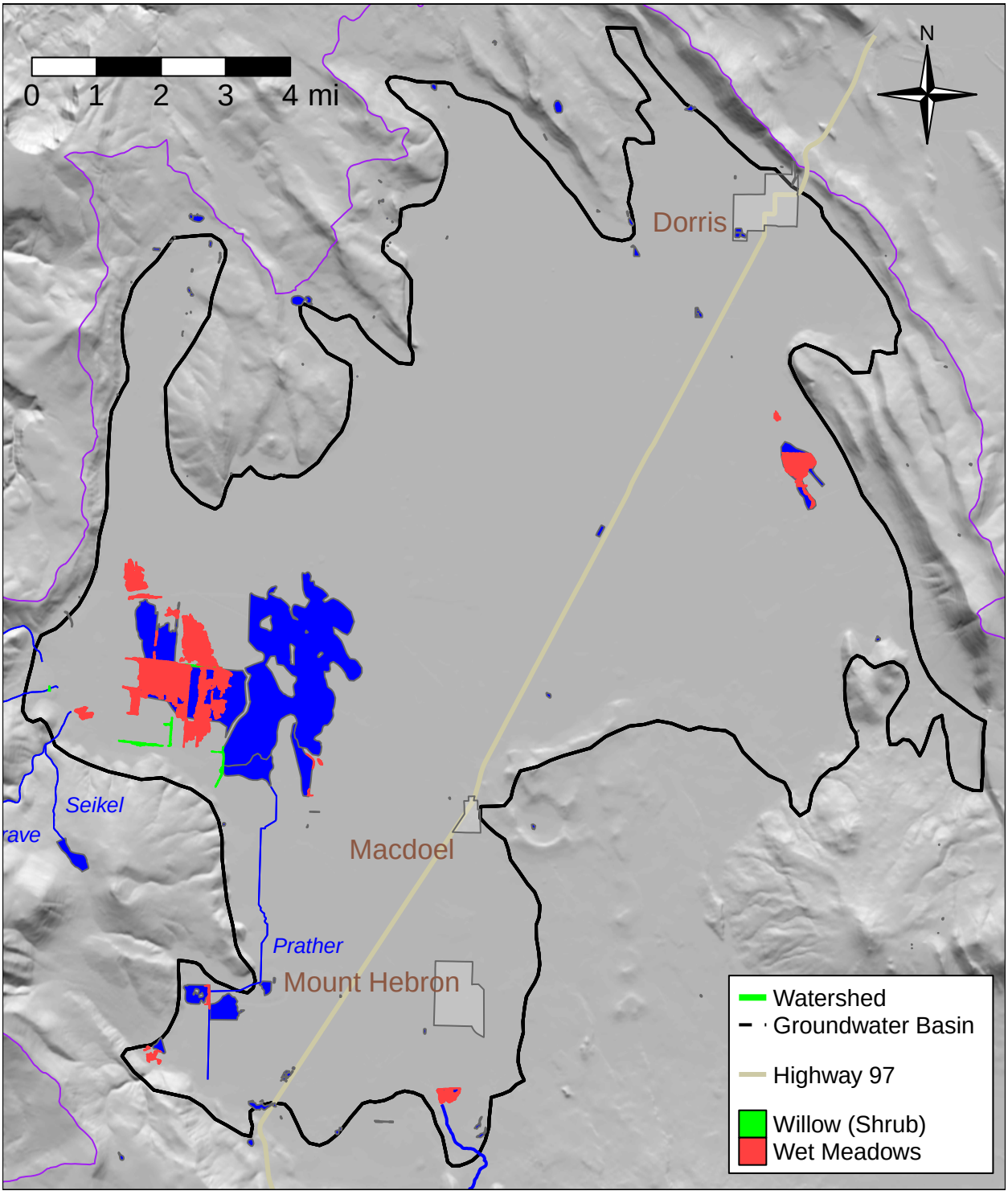


Figure 2.28: Vegetation types commonly associated with the sub-surface presence of groundwater (phreatophytes). Identified by the DWR Natural Communities Commonly Associated with Groundwater (NCCAG) dataset. The data included in the Natural Communities dataset do not represent DWRs determination of a GDE. However, the Natural Communities dataset can be used by GSAs as a starting point when approaching the task of identifying GDEs within a groundwater basin.

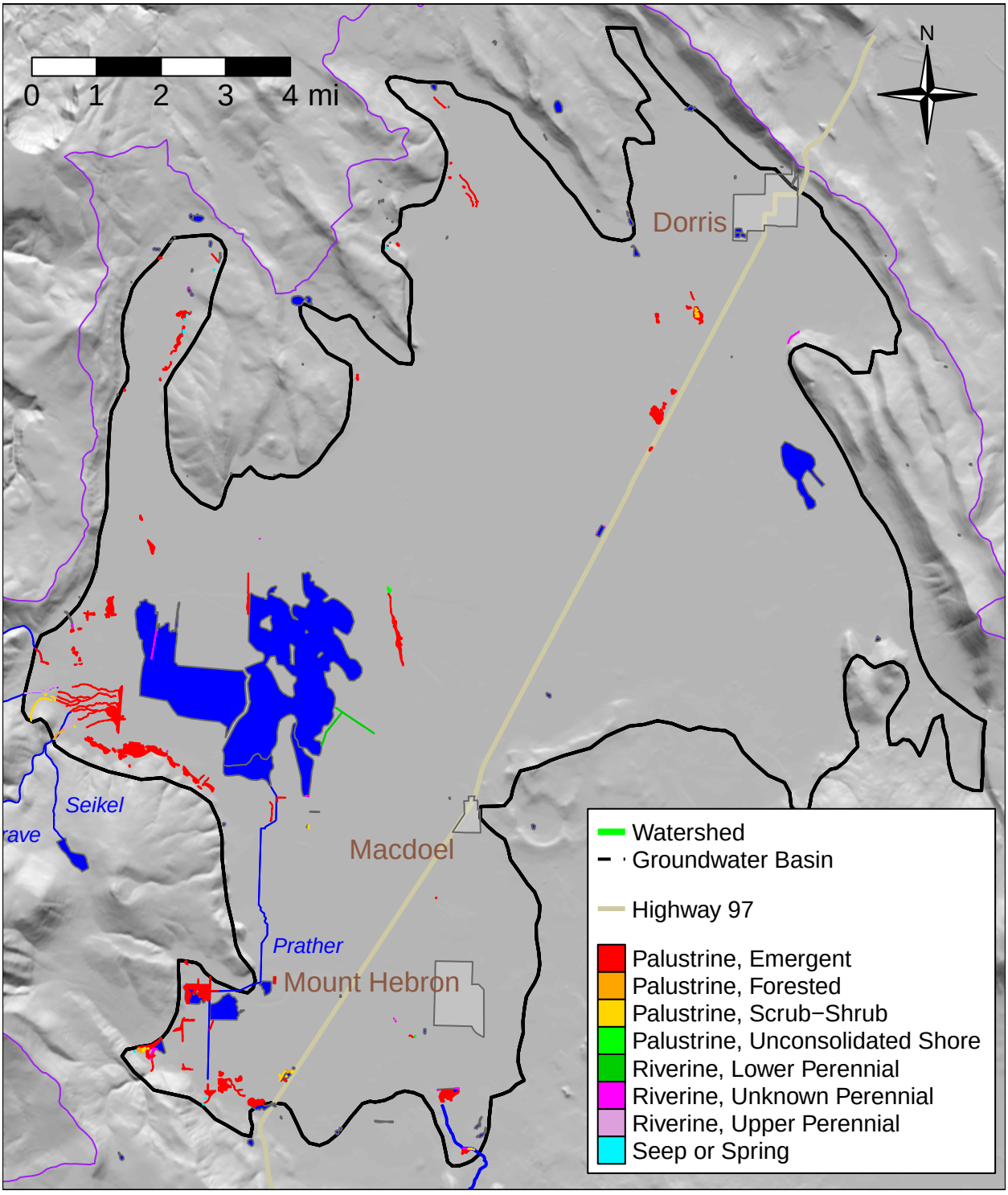


Figure 2.29: Wetland features commonly associated with the surface expression of groundwater under natural, unmodified conditions. Identified by the DWR Natural Communities Commonly Associated with Groundwater (NCCAG) dataset. The data included in the Natural Communities dataset do not represent DWRs determination of a GDE. However, the Natural Communities dataset can be used by GSAs as a starting point when approaching the task of identifying GDEs within a groundwater basin.

a presumably higher level of mapping accuracy and more descriptive classes with values such as “wet meadow” or “willow shrub” present within the Basin. Classifications from the NCCAG wetland dataset were then used given their presumed lower level of accuracy and more general vegetative community classification with values such as “palustrine, emergent, persistent, seasonally flooded” and “riverine, upper perennial, unconsolidated bottom, permanently flooded.” All vegetation classification in areas mapped by either the NCCAG vegetation or wetland datasets were compared to mapped 2010 Siskiyou County LU/LC and a predominant or representative vegetation was assigned based on best professional judgment.

A review of available literature served as the foundation for assigning assumed rooting zone depths for each vegetative class present in the aggregated mapped representation of potential GDEs. Vegetation classifications were grouped into three broad categories based on best professional judgment. The relationship between mapped vegetation categories and assumed predominant or representative vegetation is presented in Table 2.9, Table 2.10, and Table 2.11 for the NCCAG vegetation, NCCAG wetland, and 2010 Siskiyou County LU/LC datasets, respectively.

All classes directly referring to willows as well as those referring to scrub or forested areas were assumed to be effectively represented by an assumed 13.1 ft. rooting zone depths for willows. Relevant literature suggests a range for willow rooting depths of 2.62 ft. to 7.35 feet (Niswonger1and and Fogg 2008) indicating that this assumed depth of 13.1 is relatively conservative while additional resources suggest that rooting zone depths of 13.1 feet are consistent with mean values for deciduous broadleaf trees which would have deeper rooting depths than willows (Fan et al. 2017).

Other vegetation classes do not specifically identify predominant species and are therefore assumed to be emergent and limited to grasses, forbs, sedges, and rushes that are common in wetland communities. Rooting zone depths are assigned as the mean or maximum of mean values from aggregated measures presented in relevant literature (Schenk and Jackson 2002). Assumed rooting zone depths were generally conservative given the absence of the consistent and comprehensive coverage identifying predominant species for each community and reflected best professional judgment based on the broad classes of vegetation that could reasonably be present.

Table 2.8: Field Used to Create a Combined Representation of Mapped Potential GDE Coverage.

Action	Classification Description
Retain_Natural	Siskiyou/DWR mapping indicates natural vegetation present.
Retain_Check	Siskiyou/DWR mapping indicates natural vegetation may be present therefore retain or verify before removing
Remove_Ag	Siskiyou/DWR mapping indicates agricultural land is present which could warrant polygon removal.
Remove Urban_Paved	Siskiyou/DWR mapping indicates urban/paved land is present which could warrant polygon removal
Check_Remove_Irrigated	Siskiyou/DWR mapping indicates non-native irrigated land is present which could warrant polygon removal.

Table 2.9: Assumed Rooting Zone Depth and Representative Vegetation for Classes Within the NCCAG Vegetation Dataset.

Wetland Community Class	Assumed Rooting Zone Depth (ft.)	Assumed Representative Vegetation
Wet Meadow	4.8	Grasses, Forbs, Sedges, and Rushes Mean Rooting Depth
Willow (Shrub)	13.1	Willow

Table 2.10: Assumed Rooting Zone Depth and Representative Vegetation for Classes Within the NCCAG Wetland Dataset.

Wetland Community Class	Assumed Rooting Zone Depth (ft.)	Assumed Representative Vegetation
Palustrine, Emergent, Persistent, Seasonally Flooded	4.8	Grasses, Forbs, Sedges, and Rushes Mean Rooting Depth
Palustrine, Scrub-Shrub, Seasonally Flooded	13.1	Willow
Riverine, Unknown Perennial, Unconsolidated Bottom, Semipermanently Flooded	4.8	Grasses, Forbs, Sedges, and Rushes Mean Rooting Depth
Palustrine, Forested, Seasonally Flooded	13.1	Willow

Table 2.10: Assumed Rooting Zone Depth and Representative Vegetation for Classes Within the NCCAG Wetland Dataset. *(continued)*

Wetland Community Class	Assumed Rooting Zone Depth (ft.)	Assumed Representative Vegetation
Palustrine, Unconsolidated Shore, Seasonally Flooded	13.1	Willow
Riverine, Lower Perennial, Unconsolidated Bottom, Permanently Flooded	4.8	Grasses, Forbs, Sedges, and Rushes Mean Rooting Depth
Riverine, Upper Perennial, Unconsolidated Bottom, Permanently Flooded	4.8	Grasses, Forbs, Sedges, and Rushes Mean Rooting Depth
Palustrine, Emergent, Persistent, Semipermanently Flooded	4.8	Grasses, Forbs, Sedges, and Rushes Mean Rooting Depth
Seep or Spring	9.6	Grasses, Forbs, Sedges, and Rushes Max Rooting Depth

Table 2.11: Assumed Rooting Zone Depth and Representative Vegetation for Classes Within the Siskiyou County Land Use and Land Cover Dataset.

Land Use/ Land Cover Class	Assumed Rooting Zone Depth (ft.)	Assumed Representative Vegetation
River or stream (natural fresh water channels)	13.1	Willow

Depth to Groundwater

Mapped representations of depth to groundwater were calculated consistent with the standard approach (e.g., TNC Best Practices for using the NC Dataset, 2019), as the difference between land surface elevation and interpolated groundwater elevation above mean sea level. Altogether, depth to groundwater conditions were developed for 23 periods between spring of 2008 and the fall of 2019. These periods represent water level data every 6 months from spring of 2008 to fall of 2019, with equal amounts of fall and spring periods. These grid or raster geospatial datasets were developed by interpolating between observed groundwater elevations obtained from the CASGEM Program and assumed elevations at surface water features using ordinary kriging (Wackernagel 1995). Representations of depth to groundwater for each of the 23 periods are presented in Appendix 2-C.

Depth to Groundwater Assumptions and Data Gaps

The Butte Valley groundwater level network has good coverage over the center of the Basin, which gives good confidence on the GDE analysis. However, data gaps in the groundwater level network along the Basin edges may cause overestimation of depth to groundwater, particularly in Sam's Neck, the northern edge of the Basin, the western edge near Ikes, Harris, and Muskgrave Creeks, the western edge near Prather Creek, and south edge near Butte Creek. To complete a preliminary and conservative GDE analysis of these areas based on existing knowledge, the elevation of springs along the immediate edge of the valley sediments and mapped by the USGS were added as "water level" measurements for purposes of interpolating the water table within the Basin. Further rationale for this choice is provided in the next section. These additional "water level" data provide a more conservative, albeit only approximate, estimate of depth to water table for the GDE analysis in areas near the Basin boundaries for this preliminary analysis. The preliminary analysis identifies areas with potential GDEs, but is not used to set specific sustainable management criteria until better data are available, e.g., from planned expansion of the groundwater level network. Instead, potential GDEs with high uncertainty due to lack of direct groundwater level data are identified as data gaps to be addressed during the implementation of the Plan.

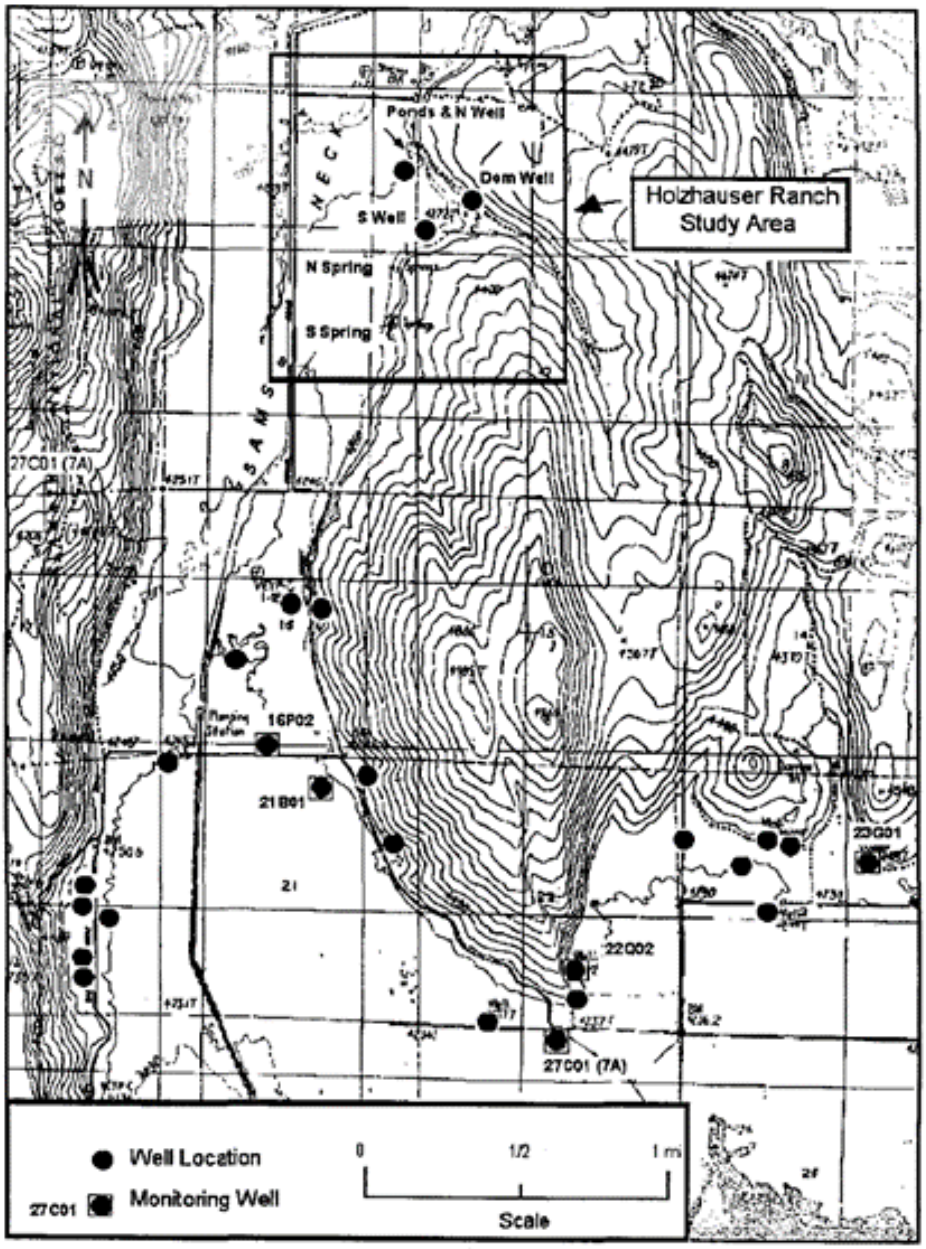


Figure 9. Holzhauser Ranch Location Map

Figure 2.30: Map from the 1998 DWR study. Well 7A is near the map bottom, above the legend. The studied springs are on the northeast side of Sam's Neck, within the boxed study area.

Spring to Groundwater Connection in Butte Valley

Spring interconnectivity is largely inferred by results from a 5.5-day pump test conducted by DWR in August 1997. During the pump test, two springs on Holzhauser Ranch in Sam's Neck were observed during pump operation on CDFW well 7A. This well is also referred to by the abbreviated DWR State Well Number (SWN) code 27C01. During pumping on this well, flow in two springs in Sam's Neck was observed to decline by 10 percent. This indicates that the wells and springs share hydraulic interconnectivity and likely are not separated by a major impermeable layer or represent a discontinuous perched water bearing formation. The location of the Holzhauser Ranch springs and CDFW Well 7A studied by DWR during the 1997 well interference study are shown on the figure below (DWR 1998).

Relationship Between Rooting Zone Depths and Depth to Groundwater

This subsection discusses the method used to evaluate the relationship between assumed rooting zone depths and depth to groundwater for each mapped potential GDE area.

Grid-Based GDE Analysis

The grid-based analysis relied on the grid or raster-based representations of depth. This grid-based analysis was carried out using three general geospatial processing steps.

The first step involved computing an area-weighted statistical representation of depth to groundwater for each mapped potential GDE area using the zonal statistics function available in many GIS programs. This zonal statistics function identifies which cells of the depth to groundwater grid or raster dataset fall within the bounds of each mapped potential GDE polygon and then computes an area-weighted average for that area. This zonal statistics analysis was carried out for each of the 23 representations of depth to groundwater between spring 2008 and fall 2018 yielding 23 columns summarizing the average depth to groundwater for each mapped potential GDE area. The 23 periods used in the analysis represent water levels every 6 months from spring 2008 to fall 2018.

The second step involved simply subtracting the calculated depth to groundwater for each mapped potential GDE from the assumed rooting zone depth that was previously assigned based on assumed predominant vegetation. This field calculation was carried out in GIS for each of the 23 representation of depth to groundwater and was added as a new field for each calculation.

The third step of the grid-based geospatial processing effort involved identifying which mapped potential GDE areas can reasonably be assumed to have access to groundwater for each period. Mapped potential GDEs where the difference between assumed rooting zone depth and computed depth to groundwater was positive were assumed to be connected to groundwater for that season and year representation as the rooting zone depth was greater than the depth to groundwater. Conversely, mapped potential GDEs where the difference between assumed rooting zone depths and computed depth to groundwater was negative suggested that roots did not have access to groundwater. These areas were therefore assumed to be disconnected from groundwater for that season and year representation of conditions.

Results of this grid-based analysis of mapped potential vegetative GDEs and their classification as connected or disconnected to groundwater for each of the 23 periods is presented in Appendix 2-C. Mapped potential vegetative GDEs were then further characterized based on the percentage of years when vegetation with their assumed rooting zone depth would reasonably have access to groundwater. Areas with assumed predominant vegetation types that would have access to groundwater for greater than 50% of all periods are categorized as “likely connected” to groundwater for this grid-based analysis. Areas with assumed vegetation that do not appear to have access to groundwater for greater than 50% of the period of record are assumed to be “likely disconnected” from groundwater. This is reasonable based on the quality of groundwater level data in Basin, where historical data are only available every six months, in the spring and fall. A potential GDE with vegetation connected to groundwater every spring will be labeled as “likely connected.” Disconnection from groundwater for greater then 50% of periods indicates a multi-year lack of groundwater in the rooting zone.

Assumptions and Uncertainty

The approach developed and carried out to identify and evaluate GDEs within the Basin represents a conservative application of best available science through the formulation of reasonable assumptions. Representations of mapped potential GDEs were developed based on available geospatial datasets, though these resources cannot be assumed to be definitive. The vegetation classes present in the datasets and outlined in the Mapped Potential GDEs section above are broad and could reasonably represent an array of vegetation types requiring the development of conservative assumptions to guide the assignment of assumed rooting zone depths. Groundwater conditions were represented by the interpolation of observed conditions in the Basin's well network. These interpolated groundwater elevations may not reflect smaller scale variations in conditions both in space (less than 500 meters) and time (sub-seasonal). Because the groundwater elevations used herein represent regional, seasonal trends, they cannot capture the impact of perched aquifers on GDE health.

Notably, GDEs are not necessarily static and can vary in time and space depending on water year type and other environmental conditions. As such, this analysis is not intended to be a definitive cataloging of each class of GDE, but rather an initial survey of the maximum possible extent of above-ground, vegetated GDEs in the Shasta Basin. A physical determination of GDEs must show that roots are connected to groundwater, which would require an infeasible subsurface geophysical survey across the Butte Basin to inform the GSP.

Mapped Potential GDE Classification

A tabular summary of the grid-based GDE classifications for each mapped potential GDE area was developed. Potential mapped GDEs were grouped into two categories corresponding to areas assumed to be:

- Potential GDE;
- Potentially not a GDE.

Areas where the grid-based analysis showed that the mapped potential vegetative GDE was likely connected to groundwater were categorized as "potential GDE." Similarly, areas that were shown to be disconnected from groundwater were considered a "potentially not a GDE." The distribution of categorized GDEs for the Basin is presented in Figure 2.31 and Table 2.12.

The current map of likely connected GDEs are located in areas where direct groundwater levels are not available or areas with a short historical record. Consequently the current list of potential GDEs is considered tentative and dependent on collection of additional groundwater level data. Since GDEs in the Basin are considered a data gap, all GDEs currently labeled as "potentially not a GDE" will be reviewed with future GDE analysis updates.

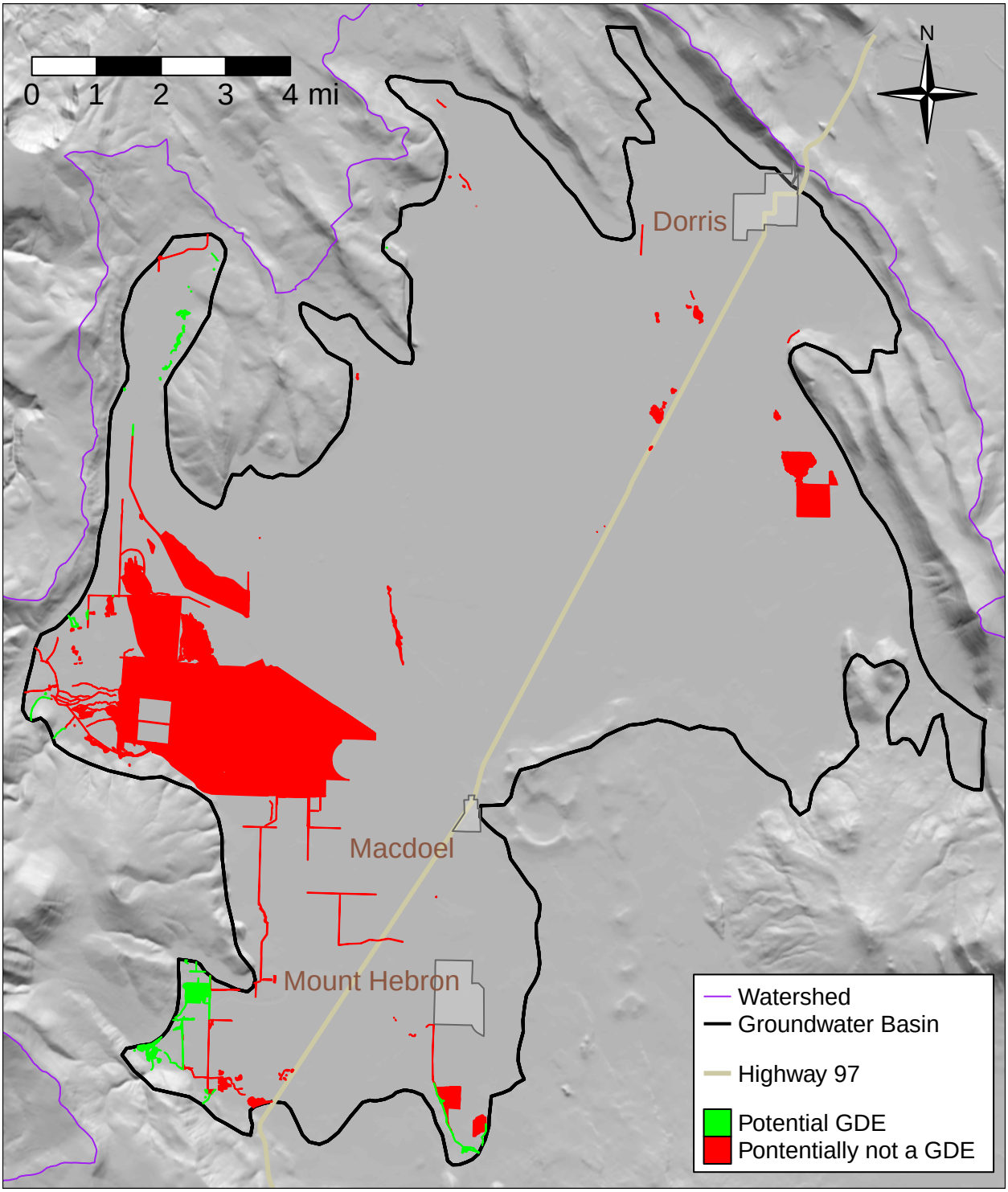


Figure 2.31: Categorized GDEs for the Basin.

Table 2.12: Distribution of Mapped Potential GDEs into Vegetative and Riparian GDE Categories.

Grid Classification	GDE Categorization	Area (Acres)	% of Mapped Potential GDE Area
Assumed GDE	Likely connected to groundwater	131	10.30%
Assumed not a GDE	Likely disconnected from groundwater	1,134	88.98%

2.2.3 Water Budget Information

The historical water budget for the Basin was estimated for the period October 1989 through September 2018 (water years 1990 through 2018) using the recently developed Butte Valley Integrated Hydrologic Model (BVIHM), which extends over the entire Watershed. This 29-year model period includes water year types ranging from very dry (e.g., 2001 and 2014) to very wet (e.g., 1999 and 2006). On an interannual scale, it includes a multi-year wet period in the late 1990s and a multi-year dry period in the late 2000s and mid-2010s.

Annual water budgets for the full model period are shown in Figure 2.32 and Figure 2.33 and monthly values of selected budget components are shown in Figure 2.34 for each of the four example water years. Table 2.13 and Table 2.14 show a summary of these budgets, and details are provided in Appendix 2-D. The following two sections provide an overview of BVIHM, which is used to determine the full water budget for the two relevant subsystems of the Basin: the land subsystem (including crops and soils) and the groundwater subsystem. The water budget also includes the total water budget of the Basin. Separately, water budgets for the entire Watershed are presented for context, including the groundwater subsystem budget, the land subsystem budget, and the total water budget for the watershed (including the Basin contained within the Watershed). The second section provides a description of the water budget shown in the Figures and Tables below and explains the water budget dynamics in the context of the Basin hydrogeology and hydrology described in previous sections. This sub-chapter provides critical rationale for the design of the monitoring networks, the design of the sustainable management criteria (SMCs), and the development of project and management actions (PMAs) (Chapters 3 and 4).

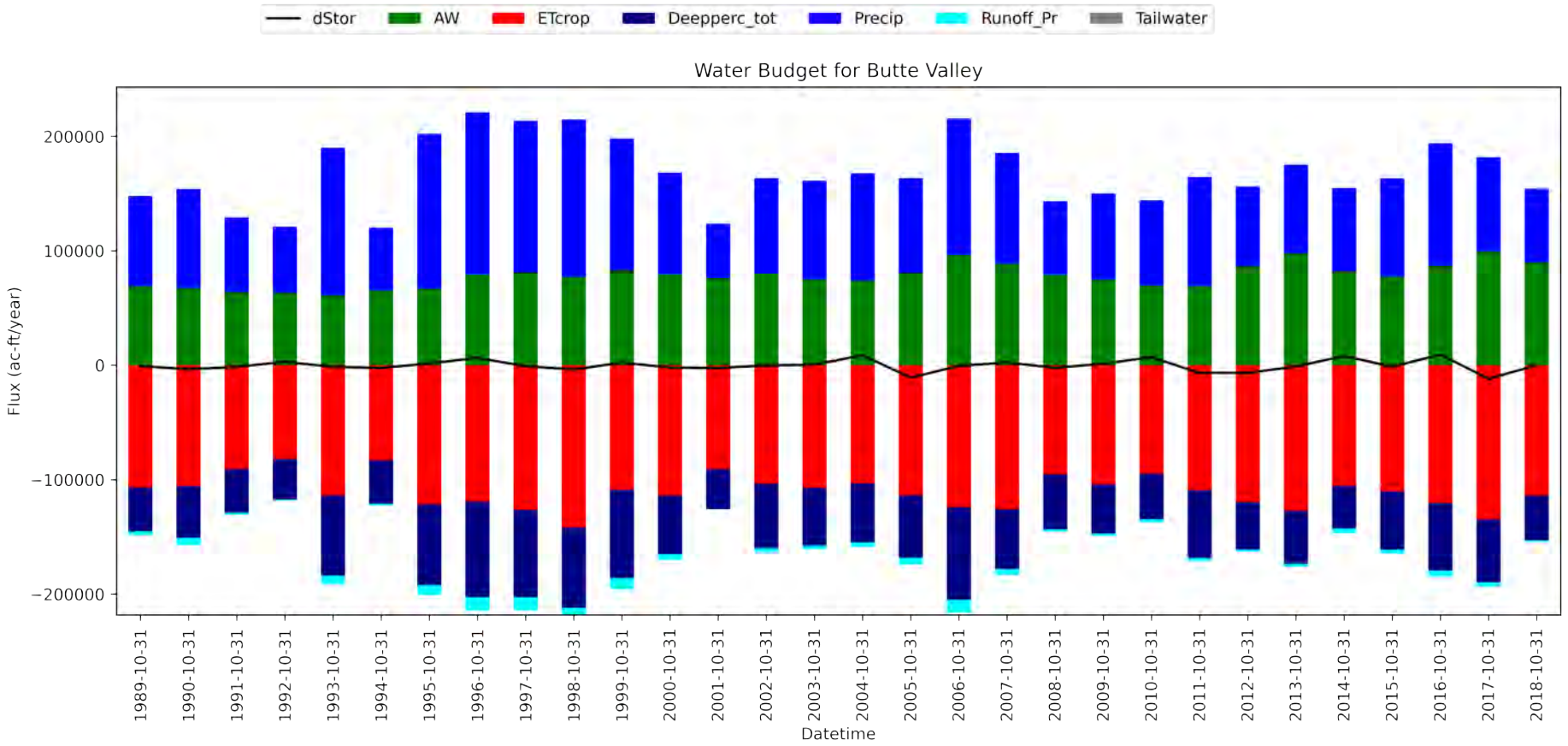


Figure 2.32: Annual water budgets for the land (land use, crop, soil) subsystem of the Basin. dStor: change in storage within the land subsystem (within the uppermost portion of the unsaturated zone, including the crop/vegetation root zone). AW: applied water. ETcrop: actual ET from crops, lawns, and natural vegetation. Deepperc tot: deep percolation from the upper portion of the unsaturated zone, assumed to be equal to groundwater recharge for the same year. Runoff Pr: surface runoff from precipitation. Tailwater: tailwater return flows, assumed to become groundwater recharge.

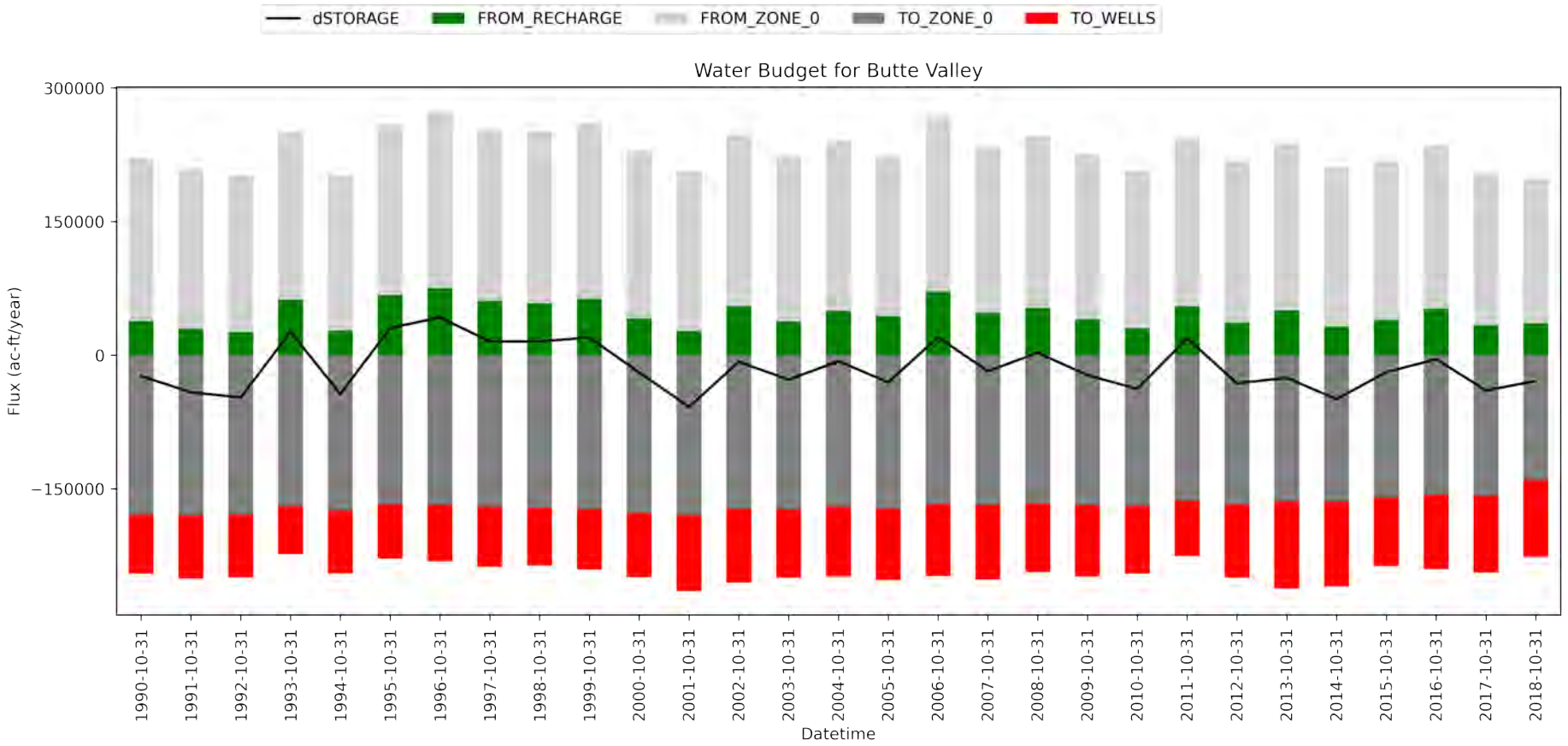


Figure 2.33: Annual water budgets for the groundwater sub-system of the Basin. dSTORAGE: change in groundwater storage. FROM RECHARGE: landscape recharge to groundwater (identical to the sum of Deepperc tot and Tailwater in the land subsystem budget). FROM ZONE 0: lateral groundwater flow into the Basin from the surrounding volcanic aquifer system. TO ZONE 0: lateral groundwater flow out of the Basin into the surrounding volcanic aquifer system. TO WELLS: groundwater pumping (identical to AW in the land subsystem budget)

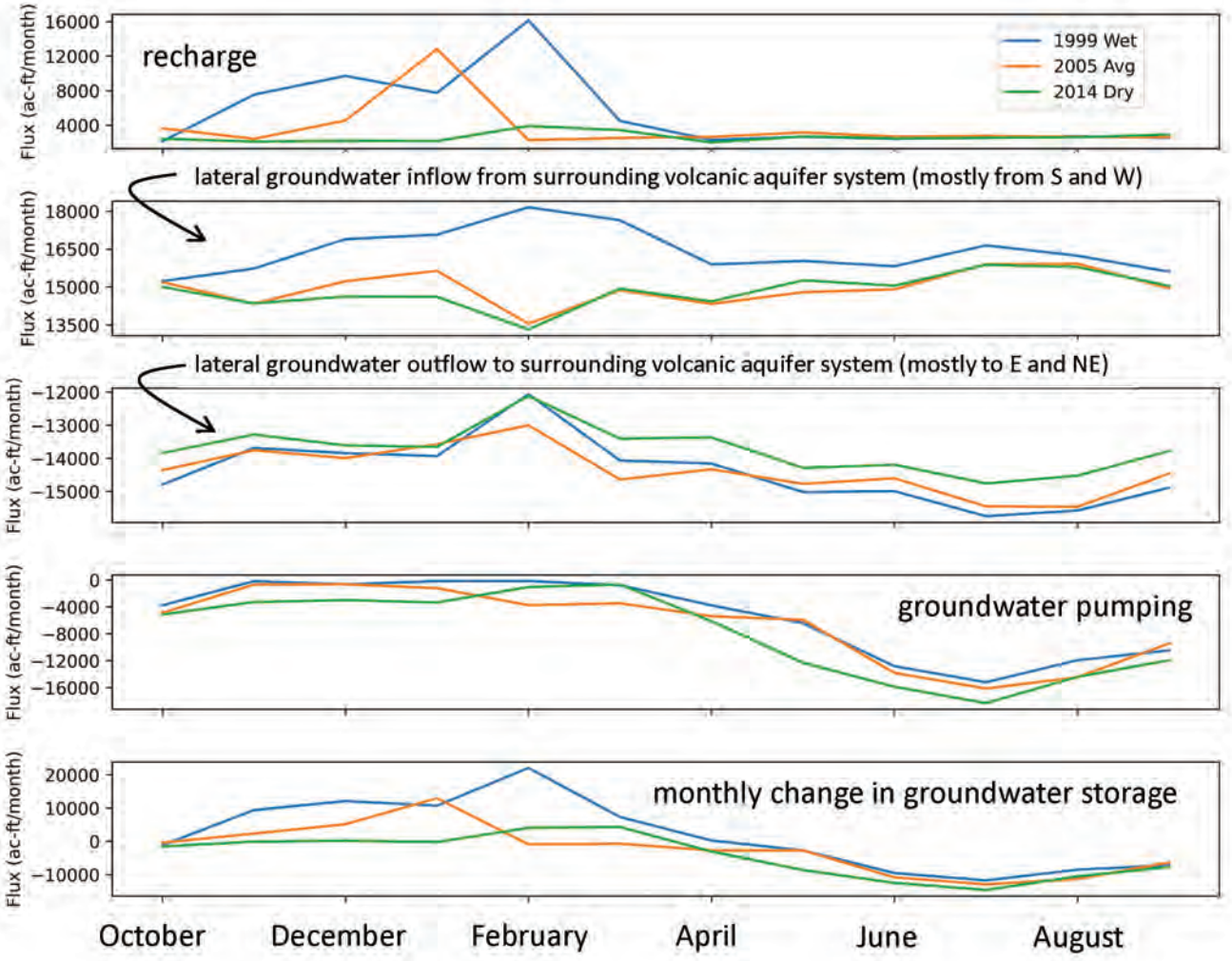


Figure 2.34: Monthly values of selected water budget components in the groundwater subsystem of the Basin in three example water years: 1999, 2005, and 2014.

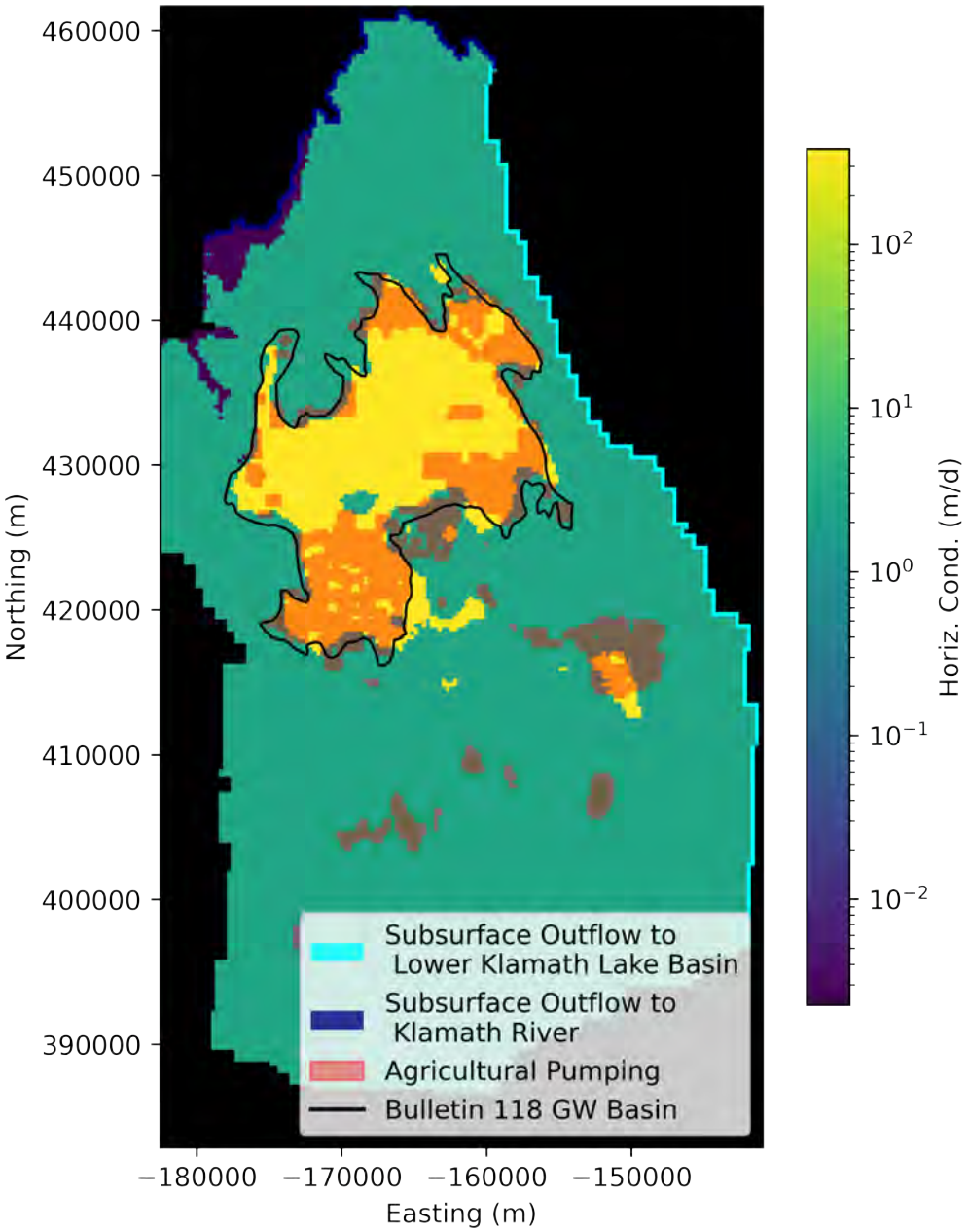


Figure 2.35: The hydrogeologic zones, model domain, and boundary conditions used in the BVIHM simulation of the surrounding watershed and Basin.

Table 2.13: Annual values (TAF) for water budget components simulated in the Land (L) or soil subsystem of Butte Valley. Positive values are water entering the soil volume: precipitation (Precip), surface water (SW), groundwater irrigation (GW); negative values are water leaving the soil volume: evapotranspiration (ET), recharge (Deepperc) to the aquifer. The overall change in soil water storage (dStor) can be negative or positive in different water years.

	AW	ETcrop	Deepperc	Precip	Runoff	dStor
Minimum	6111	-143650	-82731	22382	-11850	-7702
25th percentile	67952	-119228	-58548	67596	-6943	-1349
Median	76273	-108203	-50521	86197	-3776	-185
75th percentile	84366	-101418	-39120	102892	-1836	1570
Maximum	98272	-13806	-9302	143243	-441	4595

Table 2.14: Annual values (TAF) for water budget components simulated in the Groundwater (GW) subsystem of the BVIHM. Positive values are water entering the aquifer: recharge from the soil zone, lateral subsurface inflow (FROM ZONE 0); negative values are water leaving the aquifer: lateral subsurface outflow (TO ZONE 0), groundwater pumping (WELLS). The overall change in water stored in the aquifer can be both negative and positive in different water years.

	RECHARGE	WELLS	FROM_ZONE_0	TO_ZONE_0	dSTORAGE
Minimum	7	-98	31	-180	-58
25th percentile	34	-83	179	-173	-31
Median	43	-77	185	-169	-19
75th percentile	55	-68	192	-165	12
Maximum	75	-9	199	-30	42

2.2.3.1 Summary of Model Development

BVIHM was developed to support the development and implementation of this GSP. The simulation domain of BVIHM is a subset of the simulation domain for the USGS groundwater model of the Upper Klamath Basin (Gannett, Wagner, and Lite 2012). The BVIHM approximately corresponds to the western half of the Upper Klamath groundwater model domain that is south of the Klamath River. In other words, it represents the southwestern portion of the 2012 USGS Upper Klamath groundwater model domain. As such the simulation domain is much larger than the Basin and somewhat larger, but fully inclusive of the Watershed. The design of the simulation domain honors the fact that the Basin is a hydraulically well-connected sub-basin within the much larger regional volcanic aquifer system of the Upper Klamath Basin and Modoc Plateau (Gannett et al. 2007).

More specifically, the BVIHM simulation domain's northern boundary follows the Klamath River from Keno downstream past Rock Creek's confluence with the Klamath River, near the California-Oregon border. From there the western simulation boundary includes most of the Shovel Creek watershed, then follows the western Butte Valley watershed boundary on its western and southern boundary. The southern boundary is also the southern boundary of the Upper Klamath Basin. The simulation domain follows the southern Upper Klamath Basin boundary (the northern boundary of the Sacramento River watershed) eastward to its intersection with Davis Road, immediately west of Little Glass Mountain. The eastern and northeastern boundary of the BVIHM domain

does not follow any specific geographic features. From Davis Road, at the southeast corner of the simulation domain, the boundary runs due north to ephemeral source waters of Willow Creek near the northern boundary of Klamath National Forest, approximately follows northward along the westside of Willow Creek to near Souza Lake, then connects to a line from near Chip Butte along the eastern margin of the Mahogany Range to Little Tom Lake and to the northern model boundary with the Klamath River at Keno (Figure 2.35).

In BVIHM, the three hydrologic subsystems within the simulation domain (surface water, land/soil, and groundwater) are simplified into two subsystems that are explicitly modeled with BVIHM: the land/soil subsystem and the groundwater subsystem. This simplification was reasonable because:

- All water available to the Basin is via lateral groundwater inflow from the surrounding watershed.
- Because the Basin groundwater system is continuous with and hydraulically well-connected to the much larger, relatively permeable volcanic aquifer system underlying much of the simulation domain.

This two-subsystem simplification for purposes of developing model information for the GSP is also reasonable because of the high infiltration capacity of the volcanic soils of the surrounding Watershed and the lack of surface water features throughout the Watershed. The few creeks (described above) featured within the Watershed typically recharge into the groundwater subsystem upgradient and outside of the Basin. The model did not attempt to capture in any detail surface water features near its eastern boundary (Souza Lake, Little Tom Lake).

Importantly, with this simplification, all applied water, including groundwater pumped for the Butte Valley Wildlife Area (BVWA), is considered to originate from groundwater. And all surface runoff is assumed to have recharged into the (volcanic) groundwater basin outside of the Basin itself. A known existing model shortcoming is the very simplified representation of the surface water operation described above for the BVWA. However, to the degree that runoff from the four creeks captured by BVWA is predominantly used by wetland ET, the small amount of recharge from the relatively impermeable soils within the BVWA is appropriately captured by the model.

The BVIHM is based on three separate software modules:

- The land/soil subsystem of the irrigated landscape is simulated using the data from Davids Engineering (Appendix 2-D). The output from this model include spatio-temporally distributed groundwater pumping (all applied water needs simulated by this module) and spatio-temporally distributed groundwater recharge. The spatial discretization is equal to individual land use polygons in the DWR land use surveys of 2000, 2010, and 2014. The temporal discretization is daily.
- The land/soil subsystem and the surface subsystem of the entire watershed are simulated using the USGS PRMS software. This simulation module generates spatio-temporally distributed groundwater recharge for the 1989 to 2018 simulation period. The spatial discretization is 888 ft (271 m). The temporal discretization is daily.
- The groundwater subsystem is simulated with the USGS MODFLOW 2005 software (Harbaugh 2005; Markstrom et al. 2008) using the pumping and recharge output from the land subsystem simulation as input for the 29-year groundwater subsystem simulation. The transient, three-dimensional groundwater simulation has a spatial discretization of 888 ft (271 m), variable vertical discretization, a temporal discretization of daily time-steps with a monthly

"stress period." The latter means that daily pumping and recharge are aggregated to monthly average values (and kept constant within a calendar month). This is consistent with common basin modeling practice.

The three simulation modules are explicitly coupled: the 29-year output from the DE and PRMS simulations is generated first, then provided to the MODFLOW groundwater simulation. The explicit coupling (rather than intrinsic, more integrated coupling) is possible since historical groundwater levels throughout the Basin and over the entire simulation period are sufficiently deep that significant feedback to the land/soil subsystem are absent or negligible for purposes of this simulation:

- There is no groundwater interaction with the soil zone.
- Recharge is applied directly to the groundwater module, assuming that monthly recharge rates are that same month's deep percolation.

Full documentation on BVIHM can be found in Appendix 2-D.

Natural lands: Land/soil subsystem model summary

A deterministic, distributed-parameter, physical-process-based watershed model for the Upper Klamath Basin was recently developed by the USGS using the publically available software PRMS 5.0 (Risley 2019). This model includes the entire BVIHM simulation domain. The model is discretized into small sub-watershed units called hydrologic response units (HRUs). An HRU is defined as an area within the watershed defined by similar hydrologic, climatologic, vegetation, slope, and soil properties. Within the BVIHM simulation domain, this model distinguishes approximately 30 HRUs. For each HRU, the model simulates snow processes, plant interception of rainfall, infiltration, surface runoff, soil water storage, evapotranspiration, and groundwater recharge. It also simulates streamflow at the HRU outlet. The model uses daily time-step and uses daily precipitation and minimum and maximum daily air temperature as input, provided by the PRISM group at Oregon State University (Figure 2.36; see Markstrom et al. 2008). The model is calibrated against streamflow data at several long-term gages operated within the Upper Klamath Basin. For BVIHM, the Upper Klamath Basin PRMS model represents the surface water and land/soil subsystem. Surface water simulated only included major streams downgradient from Butte Valley. Recharge computed by the land/soil module of PRMS was used as input to the MODFLOW-based groundwater module of BVIHM, described below.

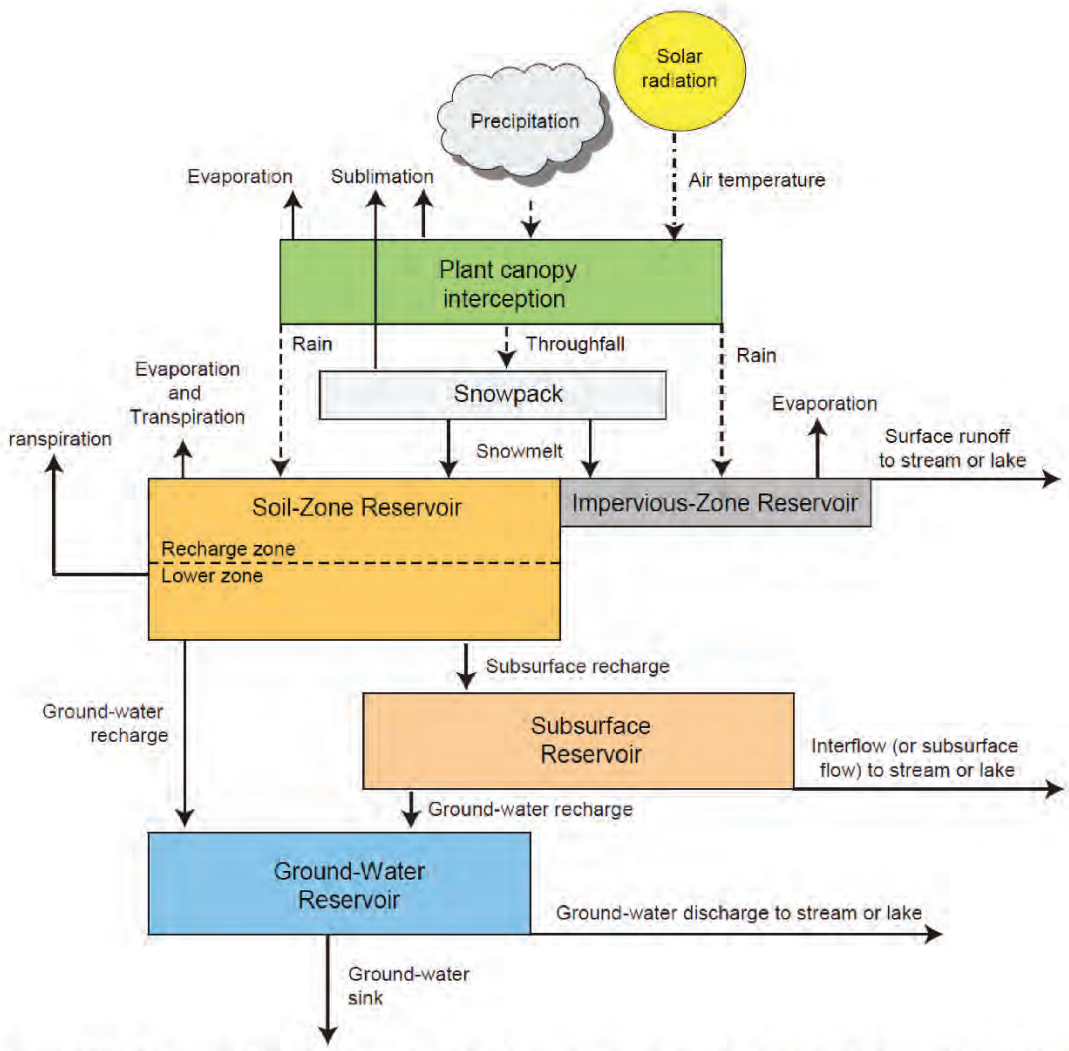


Figure 2.36: Schematic diagram of a watershed and its climate inputes (precipitation, air temperature, and solar radiation) simulated by PRMS (from Markstrom et al., 2008).

Irrigated agriculture, wetlands, and developed (urban) lands: Land/soil subsystem model summary

The PRMS model of the Upper Klamath Basin was considered adequate for estimating recharge in the BVIHM simulation domain, outside of irrigated or developed areas. Groundwater pumping and recharge from irrigated agriculture, wetlands, and developed (urban) lands was obtained using the crop root zone water model (CRZWM) developed by Davids Engineering (2020, see Appendix 2-D). CRZWM considers the water fluxes into and out of the root zone of crops, urban, and wetland vegetation: precipitation and applied water are inputs to this subsystem, ET (from applied water and from precipitation), surface runoff from precipitation and irrigation, and deep percolation (from applied water and from precipitation, here assumed to be equal to recharge) are outputs from the subsystem (Figure 2.37).

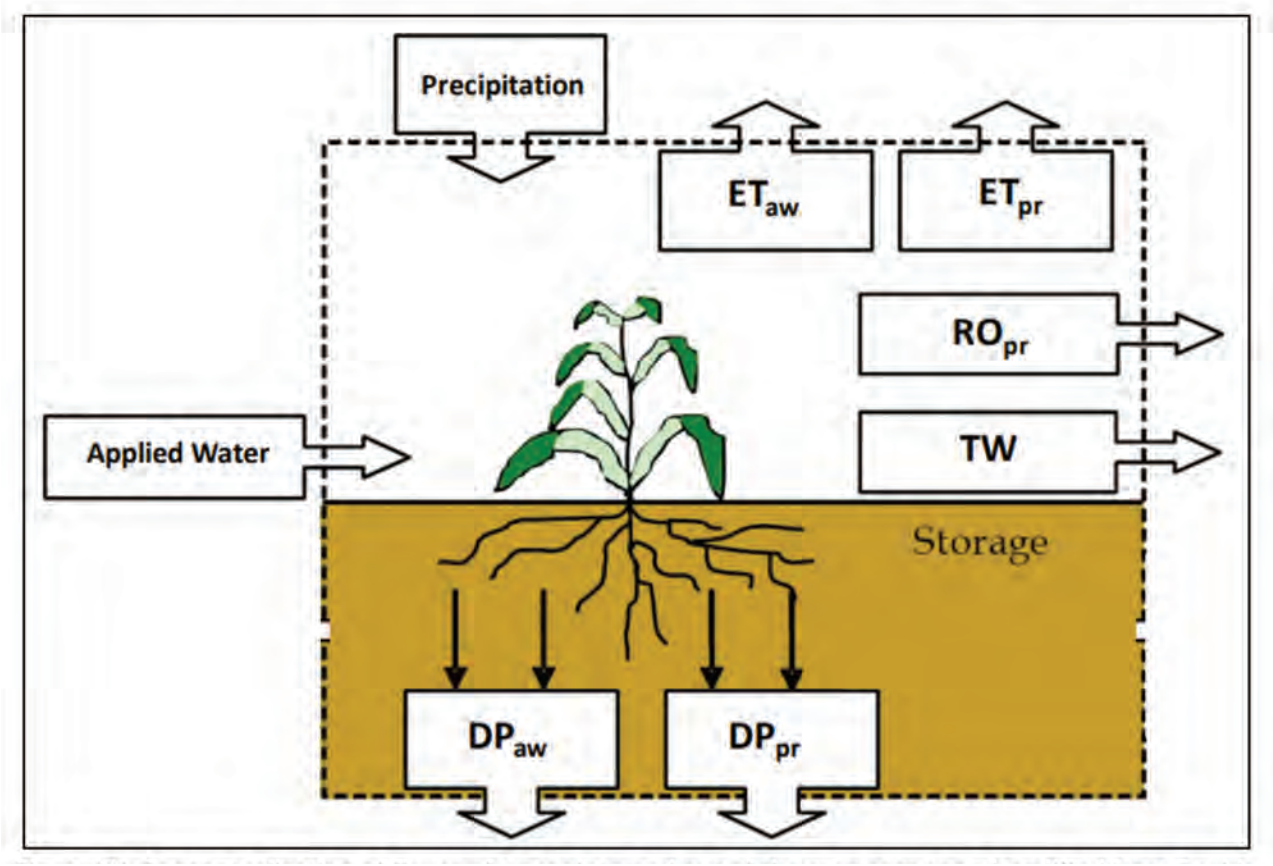


Figure 2.37: Conceptualization of fluxes of water into and out of the crop root zone (modified from Davids Engineering, 2020 in Appendix 2-D).

CRZWM uses information about crop and land use type, soil type, irrigation system, daily precipitation, and daily ET measured for the 29 year simulation period, to compute daily estimates of recharge and pumping. Crop types and irrigation information were obtained from DWR land use surveys available for 2000, 2010, and 2014. For simulation purposes, each year of the simulation period was assigned the land use survey year closest in time. Soils information was obtained from the National Soil Survey. Precipitation data was provided by the PRISM group at Oregon State University. Unique to CRZWM, the ET measurements are based on remote sensing data obtained throughout the 1989 to 2018 period. These data were combined with local climate information to estimate ET. The ET and precipitation information is used to compute applied water, runoff, and deep percolation (recharge) as a function of crop type, soils, and irrigation system.

Groundwater subsystem model summary

Overview

The groundwater module of BVIHM is a MODFLOW finite difference groundwater simulation model of the groundwater (GW) subsystem that also encompasses the entire BVIHM simulation domain. The purpose of the groundwater model is to simulate the temporal and spatial distribution of groundwater flow, groundwater potential, and water table location throughout and beyond the Watershed's heterogeneous aquifer system. These simulation outcomes are driven in the model by the Basin's hydrogeologic properties and by the spatially and temporally variable dynamics of

- The spatially and temporally varying recharge (groundwater module input from the land/soil module, Figure 2.37).
- The spatially and temporally varying groundwater pumping extended watershed and subsurface outflows to the Klamath River and lower Klamath Lake basin (groundwater module input from the land/soil module).
- The subsurface inflows and outflows at the boundaries of the simulation domain (computed by the groundwater module of BVIHM).

Simulation domain boundary conditions

Insignificant amounts of groundwater are leaving or entering the simulation domain at the watershed boundaries of Butte Valley and the Upper Klamath Basin on the western and southern portion of the simulation domain. This boundary is considered a “no-flow” boundary. On the northern boundary, the Klamath River is considered a “constant head boundary,” defined by the elevation of the Klamath River. The Klamath River falls from about 4100 ft amsl at Keno, north of Butte Valley to about 3200 ft at the northwestern corner of the simulation domain, one-thousand feet below Butte Valley (the lowest surface elevation in the simulation domain). Gannett, Wagner, and Lite (2012) provide streamflow gains for this mostly gaining section of the Klamath River, originating from groundwater inflows, including springs and associated creeks on either side of the Klamath River.

The southernmost part of the eastern boundary is thought to follow the general landscape gradient and approximately parallels groundwater flow lines hypothesized by Gannett et al. (2007). It is considered a “no-flow boundary” (i.e., flow occurs alongside this boundary). The central and northern portion of the eastern boundary is simulated as a “general head” boundary, allowing for unrestricted outflow (or inflow) toward the east and northeast. The outflow across this boundary is computed by the model using a user-defined estimate of the hydraulic conductivity and thickness of the volcanic aquifer system in the area to the east of the boundary, and by water level conditions well to the east of Butte Valley, described in the following paragraph.

The USGS groundwater model of the Upper Klamath Basin (Gannett, Wagner, and Lite 2012) was investigated to find areas east of and closest to the eastern BVIHM simulation domain where water levels during its 1989 to 2004 simulation period remained relatively unchanged, either because groundwater levels were controlled by surface water features (groundwater discharge into streams or lakes) or otherwise remained unchanged. A line was thus defined and average 1989 to 2004 water levels in the Upper Klamath Basin groundwater model on this line were mapped. The northern end of this line begins at the Klamath River at the mouth of the Klamath Strait Drain, follows that Drain and West Canal south, wraps around the west- and southside of the Lower Klamath National Wildlife Refuge and follows the tunnel that connects the Refuge with the Tule Lake Basin. In the Tule Lake Basin, the line wraps around the west- and southside of Tule Lake, and from Tule Lake’s southeast corner follows a regional north-south groundwater convergence zone south toward the Upper Klamath Basin’s southern watershed boundary (Figure 2.38). For each general head boundary cell, the general head is that in the nearest cell of the defined head line, and the general head conductance parameter considers the distance to that cell and the effective hydraulic conductivity between these two cells (Figure 2.38).

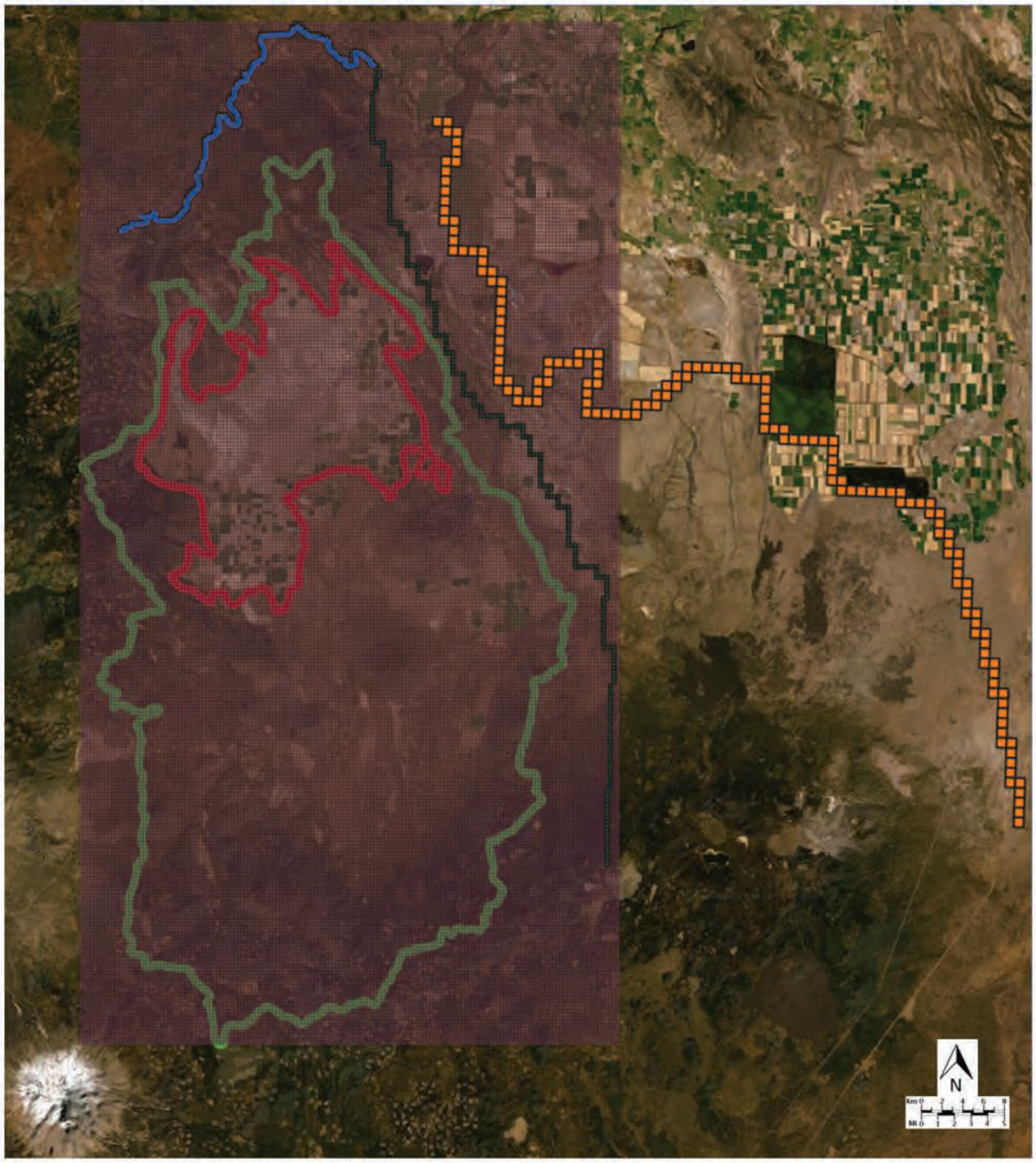


Figure 2.38: Butte Valley watershed (green boundary), Butte Valley groundwater basin (red boundary), the BVIHM “general head” boundary (dark green line to the northeast and east of the watershed), the Klamath River as a “prescribed head” boundary (dark blue line to the north of the watershed), and the line of defined heads used for the “general head” boundary (orange). Flow from the general head boundary is a function of the aquifer transmissivity between the dark green and the orange line, and of the head gradient between those two lines. The defined heads along the orange line are obtained from the USGS Upper Klamath Basin groundwater model.

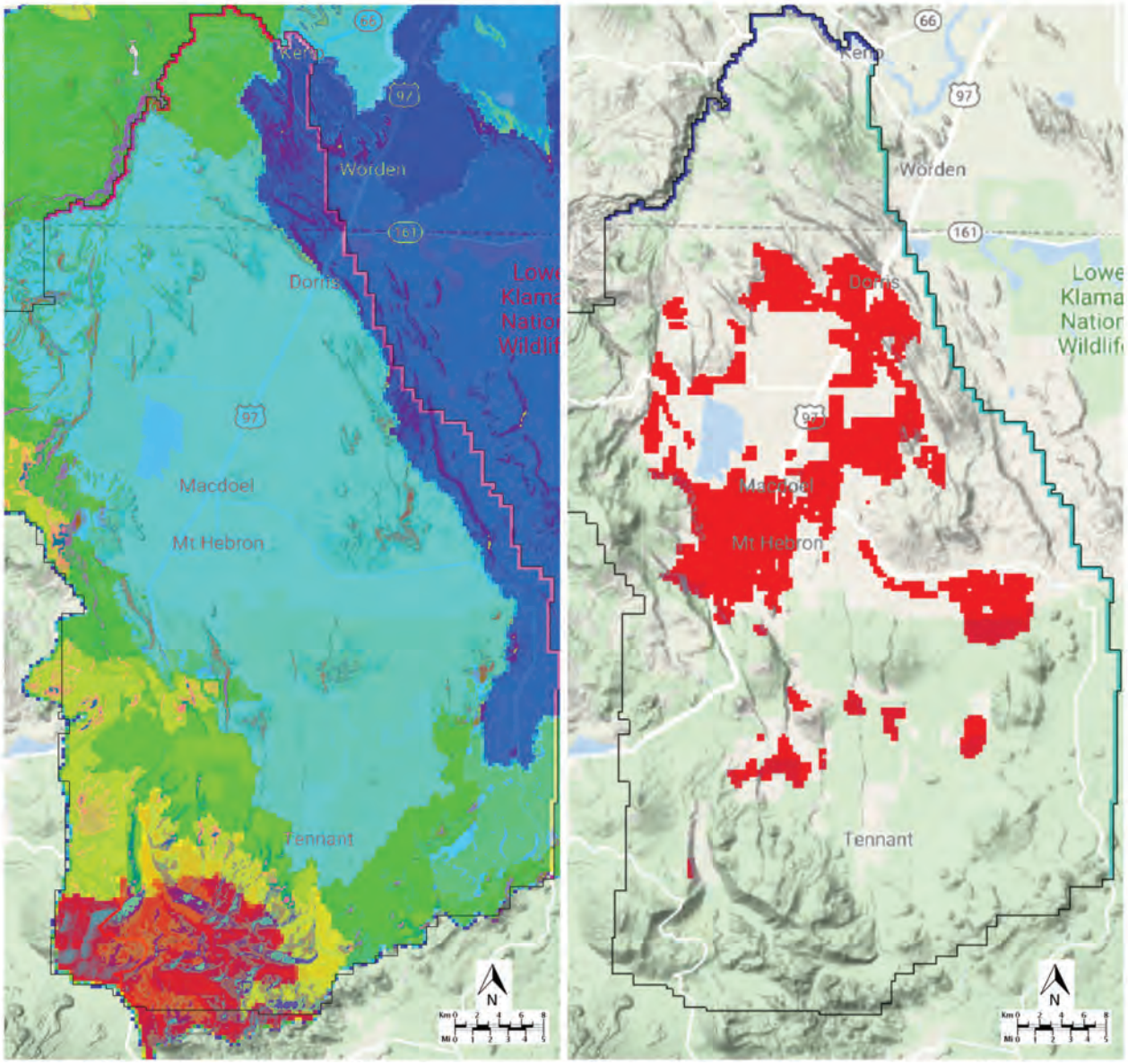


Figure 2.39: Spatial distribution of long-term average recharge (left, red: highest amounts of recharge, dark blue: lowest amounts of recharge) and location of areas with groundwater pumping (right). Black outline: BVIHM simulation domain boundary.

General groundwater flow dynamics and direction

For the BVIHM simulation domain, most of the precipitation occurs in the mountains to the south and west of Butte Valley, where it also recharges the volcanic aquifer system (Figure 2.39). Recharge may be preceded by surface runoff into a nearby creek that later disappears into the subsurface through recharge. Groundwater from that dominant recharge zone flows northward, northeastward, and eastward across Butte Valley and Redrock Valley, where significant amounts of the groundwater are pumped for irrigation and subsequently lost to ET (Figure 2.39). However, groundwater pumping is significantly less than estimated recharge. Hence, significant amounts of groundwater discharge laterally through the lakebed, alluvial, and volcanic aquifer system of the Butte Valley and the Upper Klamath Basin toward the Lower Klamath groundwater basin, toward an area east of the Butte Valley watershed south of the Lower Klamath groundwater

basin, and possibly toward the Tule Lake groundwater basin, which is separated from Butte Valley groundwater basin by the larger volcanic aquifer system in this region (Gannett et al. 2007; Gannett, Wagner, and Lite 2012).

2.2.3.2 Description of Historical Water Budget Components

The section describes the full water budget of the Basin including inflows to the Basin, outflows from the Basin, and the fluxes from the land/soil subsystem, L, to the groundwater subsystem, GW.

Figure 2.32 and Figure 2.33 show the water budgets for the two subsystems. Fluxes between subsystems are shown twice: in the subsystem from where the flux originates as output (negative flux, analogous to an account withdrawal at a bank), and in the subsystem into which the flux occurs as input (positive flux, analogous to an account deposit at a bank).

This section also describes storage changes in the subsystems. An increase in storage over a period of time occurs when fluxes into a subsystem exceed fluxes out of the subsystem over that period of time, similar to deposits exceeding the amount of withdrawals in a bank account where the account balance increases. In Figure 2.32 and Figure 2.33, a storage increase is depicted as additional negative bar length needed to balance the negative bar length (fluxes out of the subsystem) with the positive bar length (fluxes into the subsystem). In other words, storage increase is depicted as if it were a negative flux. This is consistent with accounting principles in hydrologic modeling.

Similarly, a decrease in storage over a period of time occurs when fluxes into a subsystem are less than the fluxes out of the subsystem over that period of time (similar to withdrawals from a bank account exceeding the deposits into the bank account: the account balance decreases). In Figure 2.32 and Figure 2.33, a storage decrease is depicted as additional positive bar length needed to balance the positive bar length (fluxes into the subsystem) with the negative bar length (fluxes out of the subsystem). In other words, storage decrease is depicted as if it were a positive flux, consistent with hydrologic modeling practice.

Basin Inflows

There are two inflows in the historic water budget: precipitation on the valley floor (to L), and subsurface inflow or mountain front recharge from the surrounding quaternary volcanics underlying the upper watershed (to GW):

- *Precipitation (to L)*: Rainfall on the valley floor is a key input for the PRMS and CRZWM model which results in deep percolation. Groundwater recharge (from L to GW) occurs when root zone water storage exceeds its water holding capacity due to precipitation and/or irrigation amounts exceeding evapotranspiration needs.
- *Subsurface Inflow (to GW)*: The BVIHM domain includes the entire Butte Valley watershed. Recharge (across the landscape or in creeks) outside the Basin becomes groundwater flow, some of which flows into the Basin. BVIHM is used to compute monthly and annual subsurface inflows from the upper watershed across the Basin boundary, within the larger volcanic aquifer system of the region and into the unconsolidated deposits within the Basin.

Discussion

Precipitation is highly variable - more variable than any other Basin input/output flux. Precipitation amounts to the Basin range from less than 50 thousand acre-feet (TAF) to over 140 TAF. Median precipitation is 86 TAF. Precipitation has declined significantly over the last two decades relative not only to the simulated first decade, but also relative to the second half of the 20th century. While precipitation is significant, subsurface inflows are more than twice as large, with a median of 185 TAF. Because of the large size of the upper watershed and its underlying volcanic aquifer system, it is not surprising that these inflows are much less variable than precipitation, varying within approximately 10% of the median. The median total water supply to the Basin is about 270 TAF annually.

Basin Outflows

The two outflows in the historic water budget component are evapotranspiration (ET; from L) and subsurface outflow (from GW):

- *Evapotranspiration*: Evapotranspiration is the consumptive water use in the Basin, from crops and from natural vegetation (from L). Evapotranspiration loses water in the Basin to the atmosphere.
- *Subsurface Outflow*: Subsurface outflow from the Basin within the larger regional volcanic aquifer system is dominantly to the East and Northeast. Additionally there is some subsurface outflow to the North through less permeable tertiary volcanics. Volcanics of the Western Cascades to the Northwest are of very low permeability and prevent draining of the Basin toward the Klamath River near Rock Creek.

Discussion

Median consumptive use (evapotranspiration or ET) is 108 TAF. This flux is highly variable depending on water year type, despite the fact that irrigation can buffer significantly against drought conditions. However, significantly more land is fallowed in dry years and natural vegetation has significantly reduced evapotranspiration in dry years, when it can fall below 100 TAF. On the other hand, it can reach 143 TAF in wet years. Median ET is 25% higher than median precipitation. The discrepancy is even larger in dry years. But in wet years ET equals precipitation. This further demonstrates that ET is buffered against precipitation variability through soil water storage and irrigation.

Subsurface groundwater outflow from the basin, as its inflow, is relatively constant, varying by much less than 10% from its median 169 TAF annual outflow. Subsurface outflow represents slightly over 90% of subsurface inflows, and slightly over 60% of the total Basin outflow (with the remainder going to ET). Seasonally, outflow is consistently highest in the late winter months and lowest in the fall, corresponding to groundwater levels being highest in spring and lowest in the fall.

The fact that ET represents only 40% of the total Basin inflow demonstrates that the Basin is not in overdraft. However, precipitation, evapotranspiration, and recharge estimates for the upper watershed have significant uncertainties, hence, groundwater inflow into the basin must also be regarded as highly uncertain. If recharge estimates were twice as large as actual recharge, and

consequently the actual groundwater inflow into Butte Valley was only about half of simulated inflow, the total inflow (180 TAF) would still significantly exceed ET in the Basin.

Flows Between Land (Soil) Zone and Groundwater

All other fluxes depicted in the two subsystem water budgets of the Basin are flows between the land/soil subsystem and the groundwater system:

- *Recharge (from L to GW)*: Recharge from the land surface occurs primarily in winter months when there are larger amounts of precipitation and limited evapotranspiration. This results in excess water in the soil zone leading to deep percolation. Surface runoff and irrigation return flows are small and are also considered to become groundwater recharge, since the Basin has no surface drainage.
- *Groundwater Pumping for Applied Water (from GW to L)*: Groundwater pumping is the only applied water for irrigation in the Basin. Groundwater pumping is limited to the spring and summer, from April to September, when recharge is nearly negligible. As described above, the relatively small amounts of surface water irrigation are effectively simulated as (creek) recharge outside the Basin boundary and groundwater pumping within the Basin boundary.

Discussion

Surface runoff is a small fraction compared to deep percolation. Combined, they supply a median 54 TAF of recharge to groundwater. This is one-third of the total water applied to or precipitated onto the landscape (median of the sum of precipitation and applied water: 162 TAF). Median recharge to groundwater represents about 70% of the amount of groundwater pumping for irrigation. Were the Basin considered isolated, and the large subsurface inflows ignored, the Basin would appear to be in overdraft. Instead, the difference between pumping and recharge is effectively supplied by the lateral inflow through the regional aquifer system. The 22 TAF by which pumping exceeds Basin recharge represents 12% of the total subsurface inflows from the upper Watershed. Again, from a groundwater overdraft perspective, there is a significant hydrogeologic buffer, even if subsurface inflows were substantially overestimated by the PRMS model.

Annual groundwater pumping is quite variable, ranging from less than 60 TAF to nearly 100 TAF, with a median of 77 TAF. Pumping, while highly variable, has significantly increased during the 1989 to 2018 period, somewhat mirroring the declining trend in precipitation.

Change in Storage

Soil Zone Storage: As seen in the Soil Water Budget plots, there is minimal interannual change in the soil water storage, most likely due to the low storage capacity of the soil zone. Interannual storage changes can be gains as high has 4.5 TAF and losses as low as 7.7 TAF.

Aquifer Storage: Groundwater is the largest storage component in the Basin. Annual changes in groundwater storage range from as much as 42 TAF increase to as much as 58 TAF in decrease over a 12-month period. There is significant long-term trend indicating some groundwater depletion. Only few years had a net positive groundwater storage change: 1993, 1996 to 1999, 2006,

and 2011. On September 30, 2018, total groundwater storage was 392 TAF lower than at the beginning of the simulation period (October 1, 1989). The change in storage is reflected in a steady decline in groundwater levels in many parts of the Basin, particularly in the eastern and northeastern part of the Basin. With lower water levels in the Basin, the simulations also show a decrease in groundwater outflow to areas east and northeast of the Basin due to a reduced gradients across the general head boundary.

2.2.3.3 Groundwater Dynamics in the Butte Valley Aquifer System: Key Insights

The Butte Valley groundwater basin is an alluvial basin surrounded by a late tertiary and quaternary volcanic watershed that historically has had high rates of winter precipitation due to its altitude, but little surface expression of flows and no surface storage reservoirs or canals connecting to any surface reservoirs. Most excess precipitation readily percolates into the subsurface, recharging a permeable volcanic aquifer system. Groundwater flows across the Basin toward groundwater sinks (discharge to surface water, pumping) in areas to the east and northeast of the Basin. Groundwater discharges into the Klamath River to the north through low permeability, tertiary volcanics into the lower Klamath Lake basin to the east through late tertiary and quaternary volcanics. Winter rains fill the aquifer system between October and April (Figure 2.34).

Groundwater pumping within the Basin leads to lower net outflow into areas to the east of the Basin, thus leading to a lower hydraulic gradient that connects the Basin to the areas east/northeast of the Basin, where groundwater discharges into surface water features or is pumped out. This creates a natural longer-term lowering of water levels superimposed on seasonal water level lowering during the dry season. Water levels are highest near the southern and western valley margin and slope toward the Klamath River and lower Klamath Lake basin.

Seasonal variability of recharge is accentuated by year-to-year climate variability: Years with low precipitation lead to lower recharge from the surrounding watershed, hence less subsurface inflow to the Alluvial Basin from the quaternary volcanics, but also less outflow to areas to the east. Again, this leads to lower groundwater levels in the Basin. Over the past thirty years, a decrease in precipitation and a commensurate increase in groundwater pumping have both led to less groundwater being discharged eastward, lessening the hydraulic gradient through the regional aquifer systems east of the Basin, thus lowering water levels within the Basin.

Any significant long-term decrease or increase of long-term precipitation totals over the Watershed will lead to commensurate lowering or raising, respectively in the average slope of the water table from the valley margins toward the lower Klamath Lake Basin groundwater elevation, leading to a dynamic adjustment of water levels, even under otherwise identical land use and land use management conditions. Such changes, however, are unlikely to lead to groundwater overdraft as a lowering of groundwater elevations in the Basin will result in decreased subsurface outflow while a rise in groundwater elevations will result in increased subsurface outflows.

Similarly, any increase or reduction in groundwater pumping leads to a decrease or increase in groundwater storage until the change in groundwater elevation is sufficient that the subsurface outflow is increased or decreased reducing any further changes in storage.

2.2.4 Future Water Budget

The future projected water budget contains all of the same components as the historical water budget; for a description of those terms, see Section 2.2.3.

To inform long-term hydrologic planning, the future projected water budget was developed using the following method:

1. Observed weather and streamflow parameters from water years 1991 to 2011 were used multiple times to make a 50-year “Base case” climate record (see Appendix 2-D for details). The Base case projection represents a hypothetical future period in which climate conditions are the same as conditions from 1991 to 2011.
2. The climate-influenced variables Precipitation (as rain), Reference Evapotranspiration (ETref), and tributary stream inflow were altered to represent four climate change scenarios:

   - (a) Near-future climate, representing conditions in the year 2030.
   - (b) Far-future climate, representing central tendency of projected conditions in the year 2070.
   - (c) Far-future climate, Wet with Moderate Warming (WMW), representing the wetter extreme of projected conditions in the year 2070.
   - (d) Far-future climate, Dry with Extreme Warming (DEW), representing the drier extreme of projected conditions in the year 2070.

3. BVIHM was run for the 50-year period of water years 2022 to 2071 for the Base case and all four climate change projected scenarios.

For convenience, the scenarios described in points 2a-2d above will be referenced as the Near, Far, Wet and Dry future climate scenarios. Additional tables and figures for all five future climate scenarios are included in Appendix 2-D.

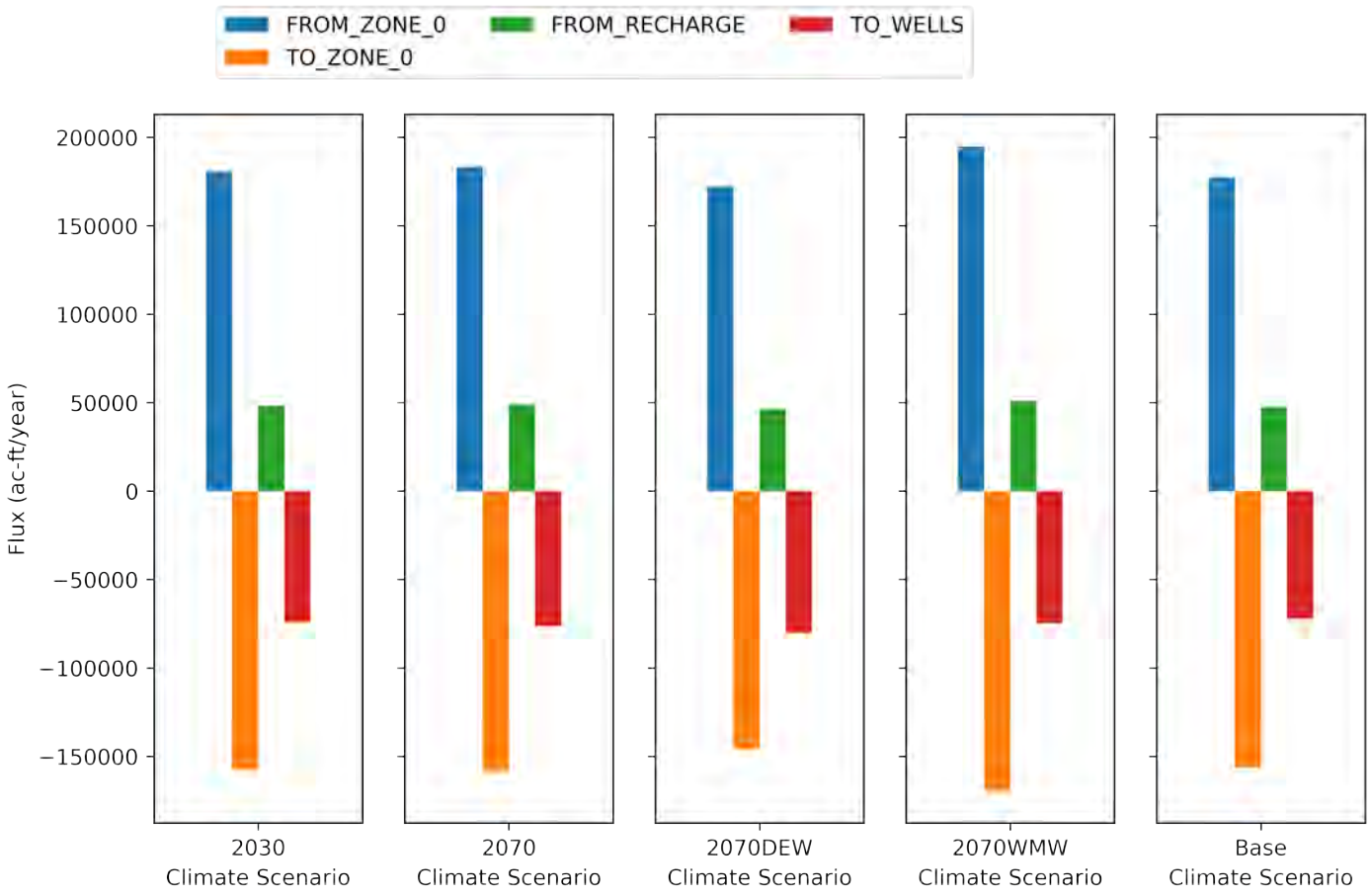


Figure 2.40: Water Budget components for different future climate scenarios.

Method Details

The climate record for the projected 50-year period of water years October 2021 to September 2071 was constructed from model inputs for the years 1991 to 2011. The minimum bound of 1991 was imposed by ETref data, which is not available prior to the BVIHM historical period; the maximum bound of 2011 was imposed by DWR change factors, which are only available through (Appendix 2-D).

Under their SGMA climate change guidance, DWR provided a dataset of “change factors” which each GSA can use to convert local historical weather data into four different climate change scenarios (DWR 2018). Change factors are geographically and temporally explicit. Geographically, a grid of 1/16-degree resolution cells covers the extent of California; for each of these cells, one change factors applies to each month, 1911 to 2011.

The change factor concept is intended to convert all past years to a single near or far future year; for example, imagine that in a hypothetical grid cell, the 2030 (Near) scenario change factor for ET ref in March 2001 was 5%. This would imply that, under the local results of the global climate change scenario used to inform this guidance, if March 2001 had occurred in the year 2030, there would be 5% more ET in that grid cell than historically observed.

Implications

The 2030 (Near) and 2070 central tendency (Far) scenarios predict similar rainfall conditions to

the Base case, while the 2070 DEW (Dry) and 2070 WMW (Wet) scenarios show less and more cumulative rain, respectively. Conversely, all scenarios predict higher future ET than the Base case.

More groundwater is held in aquifer storage in the Wet scenario, and less in the Dry scenario. However, interannual variability is a greater driver of storage change than climate change scenarios (i.e., in future year 2045 the difference between the Wet and Dry scenarios was ~5 TAF, but the range in overall interannual variability in each scenario is greater than 40 TAF).

Conversely, the impact of future climate conditions on recharge in the upper watershed and subsurface flows is highly dependent on which scenario is selected. Near and Far scenarios show minimal differences from historical Base case flow conditions. The Dry scenario shows some periods of notably reduced flow, while the Wet scenario shows some years with much higher flow than historical Base case flow conditions.

Importantly, under all climate change scenarios, water table conditions remain stable over the long-term and are likely avoid minimum threshold (MT) exceedances. Future climate scenarios represent historic cropping patterns and therefore assume no expansion of irrigated lands beyond their historical footprint. Future scenarios therefore represent stable land use conditions. The lack of significant downward water level adjustment is a result of the fact that the surface water basin is closed, and because even the dry-hot year future scenario does not represent conditions that are more stressful than the most recent 10-year period.

2.2.5 Sustainable Yield

The sustainable yield "means 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." (California Water Code Section 10721).

In this plan, the sustainable yield is defined as the long-term average annual groundwater pumping rate, as defined by the water budget analysis, that does not cause an undesirable result. Chapter 2 defines the water budget analysis and Chapter 3 defines undesirable results. The Basin is not in overdraft. It has not incurred undesirable results with respect to the sustainability indicators for water level and groundwater storage. Since 2014, ongoing groundwater pumping has also not incurred new known undesirable results with respect to sustainability indicators for land subsidence, water quality, and terrestrial GDEs. Water levels and groundwater storage have been in a long-term dynamic equilibrium between inflows to and outflows from the aquifer system. For interconnected surface water, data gaps exist that will be filled over the next five years to more clearly identify the undesirable results that must be avoided through groundwater management. Hence, for the Butte Valley, **the sustainable yield is currently equal to the most recent 10-year average annual groundwater pumping of 83-thousand acre-feet** as estimated with the Butte Valley Integrated Hydrologic Model for the 2009 to 2018 period.

The monitoring program and the actions to address data gaps through additional monitoring, data analysis, and modeling during the next 5-year period may reveal undesirable results that will require the implementation of PMAs. Chapter 4 defines projects and management actions (PMAs) that the GSA will implement as needed to avoid future undesirable results. Individual PMAs to address future undesirable results may include managed aquifer recharge, some reduction of pumping demand, both, or neither (see Chapter 4). Updated simulations, analyses, and technical-scientific as-

sessments will guide the selection and design of PMAs to ensure effective and efficient responses that will avoid undesirable results.

Whether and by how much future groundwater pumping may need to be reduced will be a function of the PMAs that are implemented and their spatial extent. For example, irrigation efficiency improvements result in a reduction in groundwater pumping, but may also reduce recharge. For every implementation of a PMA that results in the reduction in groundwater pumping there is a commensurate downward adjustment in sustainable yield. This adjustment reflects the reduction in long-term average groundwater pumping achieved by a PMA, if any. Some managed aquifer recharge may allow for an increase in long-term average groundwater pumping without incurring undesirable results. The exact amount of that adjustment varies over time and will depend on the future portfolio of PMAs implemented.

Consequently, the sustainable yield will vary with the implementation of PMAs that allow the basin to meet the sustainable management criteria. The sustainable yield will be continually adjusted from the 2009 to 2018 baseline average annual groundwater pumping of 83-thousand acre-feet using an assessment and simulation of implemented PMAs.

The sustainable yield will be recomputed at least with every five-year plan update, given the then-implemented PMAs that avoid the minimum thresholds and achieve the measurable objectives for all sustainability indicators. Future simulations and assessments will also consider measured changes in climate and update future climate predictions. Climate change may further impact the sustainable yield of the Basin.

Chapter 3

Sustainable Management Criteria

3.1 Introduction to Sustainable Management Criteria and Definition of Terms

This section characterizes sustainable groundwater management in the Butte Valley groundwater basin (Basin) through description of an overall sustainability goal for the Basin, and through definition and quantification of sustainable management criteria (SMC) for each of the sustainability indicators. Building on the Basin conditions described in Chapter 2, this section describes the processes and criteria used to define the undesirable results, measurable objectives (MO), and minimum thresholds (MT) for each sustainability indicator.

The following terms, defined below, are used throughout this chapter.

Sustainability Goal: The overarching goal for the Basin with respect to managing groundwater conditions to ensure the absence of undesirable results.

Sustainability Indicators (SI): Six indicators defined under the Sustainable Groundwater Management Act (SGMA): chronic lowering of groundwater levels, reduction of groundwater storage, seawater intrusion, degraded groundwater quality, land subsidence, and depletions of interconnected surface water (ISW). These indicators describe groundwater-related conditions in the Basin and are used to determine occurrence of undesirable results (23 CCR 354.28(b)(1)-(6).).

Sustainable Management Criteria (SMC): Minimum thresholds (MT), measurable objectives (MO), and undesirable results, consistent with the sustainability goal, that must be defined for each sustainability indicator.

Undesirable Results: Conditions, defined under SGMA as:

"… one or more of the following effects caused by groundwater conditions occurring throughout a basin:

1. Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon [….]
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." (Wat. Code § 10721(x)(1)-(6).)

Minimum / Maximum Thresholds (MT): a numeric value that defines an undesirable result. Groundwater conditions should not exceed the MT defined in the groundwater sustainability plan (GSP). The term "minimum threshold" is predominantly used in SGMA regulations and applied to most sustainability indicators. The term "maximum threshold" is the equivalent value but used for sustainability indicators with a defined maximum limit (e.g., groundwater quality).

Measurable Objectives (MO): specific and quantifiable goals that are defined to reflect the desired groundwater conditions in the Basin and achieve the sustainability goal within 20 years. MOs are defined in relation to the six undesirable results and use the same metrics as MTs.

Interim Milestones: periodic goals (defined every five years, at minimum), that are used to measure progress in improving or maintaining groundwater conditions and assess progress towards the sustainability goal.

Representative Monitoring Sites (RMP): for each sustainability indicator, a subset of the monitoring network, where MTs, MOs, and milestones are defined.

Project and Management Actions (PMAs): creation or modification of a physical structure / infrastructure (project) and creation of policies, procedures, or regulations (management actions) implemented to achieve Basin sustainability.

3.2 Sustainability Goal

The overall sustainability goal of groundwater management in Butte Valley is to maintain groundwater resources in ways that best support the continued and long-term health of the people, the environment, and the economy in the Basin for generations to come. This includes managing groundwater conditions for each of the applicable sustainability indicators in the Basin so that:

- Groundwater elevations and groundwater storage are not significantly declining below their historically experienced range, protecting the existing well infrastructure from outages, and protecting groundwater dependent ecosystems (GDEs).
- Groundwater quality is suitable for the beneficial uses in the Basin and is not significantly or unreasonably degraded.
- Significant and unreasonable land subsidence is prevented in the Basin. Infrastructure and agricultural production in Butte Valley remain safe from permanent subsidence of land surface elevations.

3.3 Monitoring Networks

The monitoring networks detailed here support data collection to monitor the chronic lowering of groundwater levels, reduction of groundwater in storage, land subsidence, and degraded groundwater quality sustainability indicators. The monitoring networks for each sustainability indicator are critical to demonstrating the Basin's sustainability over time. No monitoring networks are included for the seawater intrusion and ISW sustainability indicators, as they are not applicable in the Basin (see Chapter 2). After data gaps are addressed (see Appendix 3-A and Chapter 4) a monitoring network and SMCs may be set for ISWs.

Per 23 CCR Section 354.34, monitoring networks should be designed to:

- Demonstrate progress towards achieving MOs described in the Plan.
- Monitor impacts to the beneficial uses or users of groundwater.
- Monitor changes in groundwater conditions relative to MOs and minimum or maximum thresholds.
- Quantify annual changes in water budget components.

The monitoring networks for each sustainability indicator are critical to demonstrating the Basin's sustainability over time.

Monitoring networks are required to have sufficient spatial density and temporal resolution to evaluate effects and effectiveness of Plan implementation and represent seasonal, short-term, and long-term trends in groundwater conditions and related surface conditions. Short-term is considered here to be a timespan of 1 to 5 years, and long-term is considered to be 5 to 20 years.

There is no rule for the spatial density and frequency of data measurement required for each monitoring network. These values are specific to monitoring objectives, the parameter to be measured, level of groundwater use, and Basin conditions, among other factors. A description of the existing and planned spatial density and data collection frequency is included for each monitoring network.

Detailed descriptions, assessments and plans for improvement of the monitoring network and protocols for data collection and monitoring are addressed for each sustainability indicator in the following sections.

In summary, there are three monitoring networks: a water level monitoring network, a water quality monitoring network, and a land subsidence monitoring system Figure 3.1. The first two utilize two independent but overlapping networks of wells, the latter utilizes satellite remote sensing. Detailed descriptions, assessments and plans for future improvement of the well monitoring network and protocols for data collection and monitoring are addressed for each sustainability indicator in the following sections.

Table 3.1: Summary of monitoring networks, metrics and number of sites for sustainability indicators.

Sustainability Indicator	**Metric**	**Number of Sites in Current Network**
Chronic Lowering of Groundwater Levels	Groundwater level	13
Reduction of Groundwater Storage	Volume of water per year, computed from water level changes	Uses chronic lowering of groundwater levels network
Groundwater Quality	Concentration of selected water quality parameters	7
Land subsidence	Land surface elevation	Spatially continuous

[a] This table only includes monitoring networks used to measure sustainability indicators. It does not include additional monitoring necessary to monitor the various water budget components of the basin, described in Chapter 2, or to monitor the implementation of project and management actions (PMAs), which are described in Chapter 4.

[b] Land surface elevation changes are monitored through satellite remote sensing.

Identification and Evaluation of Potential Data Gaps

Per 23 CCR Section 351, data gaps are defined as, "a lack of information that significantly affects the understanding of the basin setting or evaluation of the efficacy of Plan implementation and could limit the ability to assess whether a basin is being sustainably managed." A detailed discussion of potential data gaps, and strategies for resolving them, is included as Appendix 3-A. Data gaps are primarily addressed in this chapter through the 'Assessment and Improvement of Monitoring Networks,' associated with each sustainability indicator in the Basin. Of particular focus for the monitoring networks are the adequacy of the number of sites, frequency of measurement, and spatial distribution in the Basin. In addition to the monitoring network-specific data gaps, information was identified that would be valuable to collect. This information is valuable to support increased understanding in the Basin setting, understanding of conditions in comparison to the SMCs, data to calibrate or update the model, and to monitor efficacy of PMAs. These additional monitoring or information requirements depend on future availability of funding and are not yet considered among the GSP Representative Monitoring Points (RMPs). They will be considered as potential RMPs and may eventually become part of the GSP network at the five-year GSP update. The list includes:

- Streamflow gauges on ephemeral streams near the Basin Boundaries and Butte Creek, outside the Basin boundaries.
- Groundwater level monitoring wells near potential GDEs and potential ISWs to establish groundwater levels for use in Butte Valley Integrated Hydrogeologic Model (BVIHM) model calibration, as part of GDE/ISW identification and monitoring, and for measuring PMA efficacy.
- Domestic well monitoring for both water quality and groundwater levels.
- Improved estimation of evapotranspiration (ET) from key crops, natural vegetation.
- Additional biological data that would be useful for monitoring and evaluation of GDEs.

A detailed discussion of these potential data gaps and suggested approach and monitoring prioritization can be found in Appendix 3-A and Chapter 5.

Monitoring Network to Fill Identified Data Gaps

Butte Valley groundwater monitoring includes the California Statewide Groundwater Elevation Monitoring Program (CASGEM) program by the Department of Water Resources (DWR), which maintains periodic records of groundwater elevation since the 1950s. Butte Valley climate monitoring includes one DWR California Irrigation Management Information System (CIMIS) climate station site near Macdoel and two United States National Oceanic and Atmospheric Administration (NOAA) weather stations near Mount Hebron and the City of Dorris. There are no permanent or long-term streamflow gages in the Basin.

To supplement historical monitoring stations, the groundwater sustainability agency (GSA) developed nine locations around Butte Valley to collect continuous groundwater level data, eight sites to collect precipitation data, two sites with soil water content sensors, and one surface water flow station located on Butte Creek just south (outside) of the Basin boundary. Sites are shown on Figure 3.2 and Figure 3.3. The network of continuous wells provides tools and resources for farmers to connect to their own stations using a password protected website.

An evaluation of ET by strawberry grown for propagation in Butte Valley (a major crop in the Basin) is ongoing and the results are anticipated to be published in 2022 or 2023. The eddy covariance-

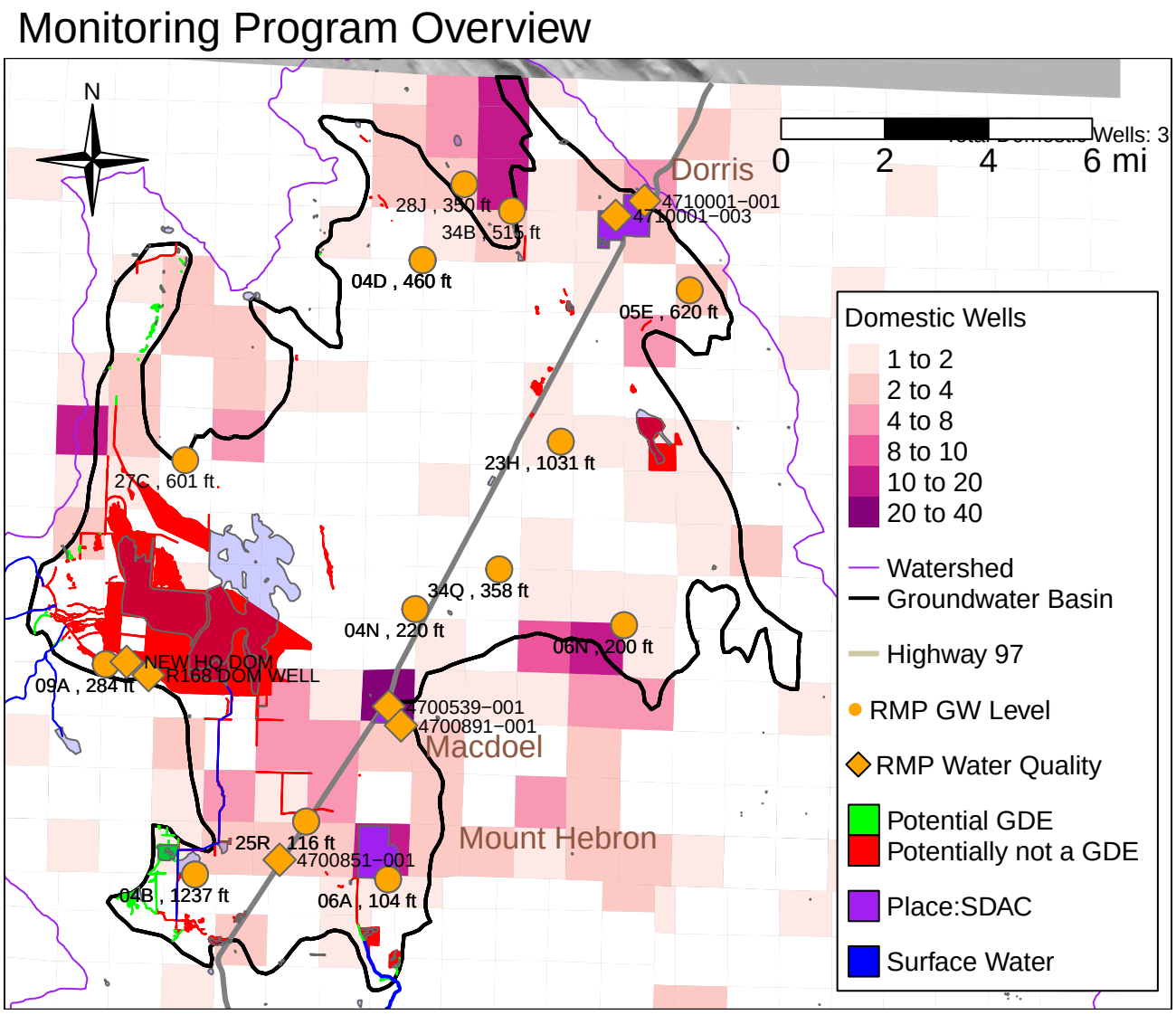


Figure 3.1: The current overall monitoring network in Butte Valley.

and energy balance-based research station used to collect data for the study was deployed during the 2020 and 2021 growing seasons in eastern Butte Valley over a field of drip irrigated strawberry.

Significant data gaps exist in the historical records of flow and surface water conditions. Historical surface water flow observations are from a brief period of record from 1952 through 1960 at a United States Geological Survey (USGS) station along Butte Creek and monthly self-reporting by California State Water Resources Control Board (SWRCB) surface water right appropriation holders. The USGS also maintained a station along Antelope Creek from 1952 to 1979, however Antelope Creek does not flow to Butte Valley.

The GSA is actively seeking funds and resources to expand monitoring in Butte Valley and the surrounding watershed (Watershed) to resolve data gaps on Snow Water Equivalent (SWE) in upper elevations, stream flow along Prather Creek, evapotranspiration for crops and native vegetation, and groundwater elevation at important locations throughout the Watershed. No SWE stations exist in the Watershed but a significant portion of precipitation appears to fall as snow. Most surface water in Butte Valley has periodic observations of flow however the GSA seeks to improve record keeping with continuous data collection and stream profile development pending appropriate funding. Pending funding approval, the GSA plans to operate ET study sites in both native vegetation and agricultural land throughout the Watershed to constrain and calibrate the water budget model. Additional details on how the GSA will address data gaps are included in Appendix 3-A and implementation in Chapter 5.

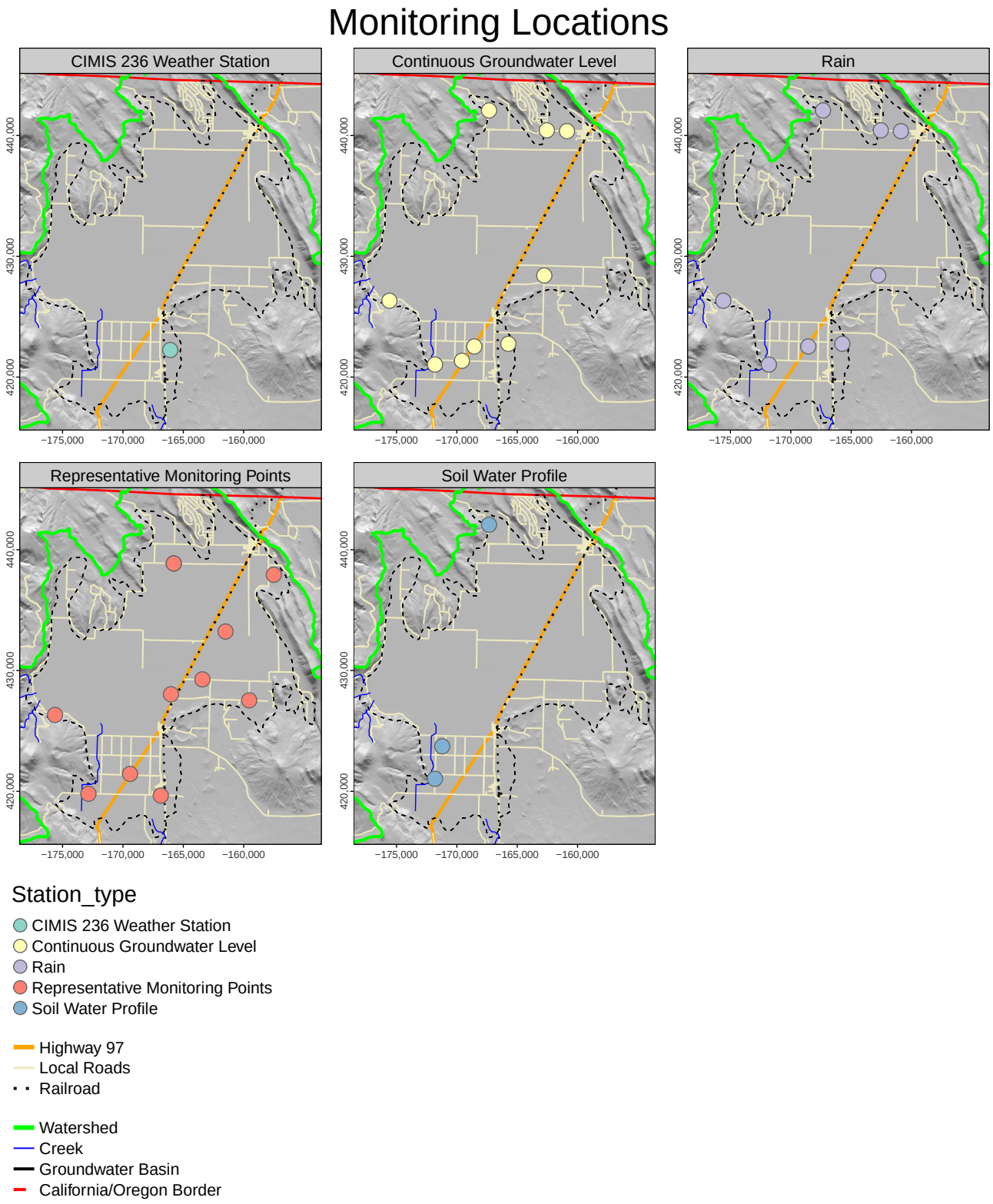


Figure 3.2: The location of continuous monitoring stations in Butte Valley.

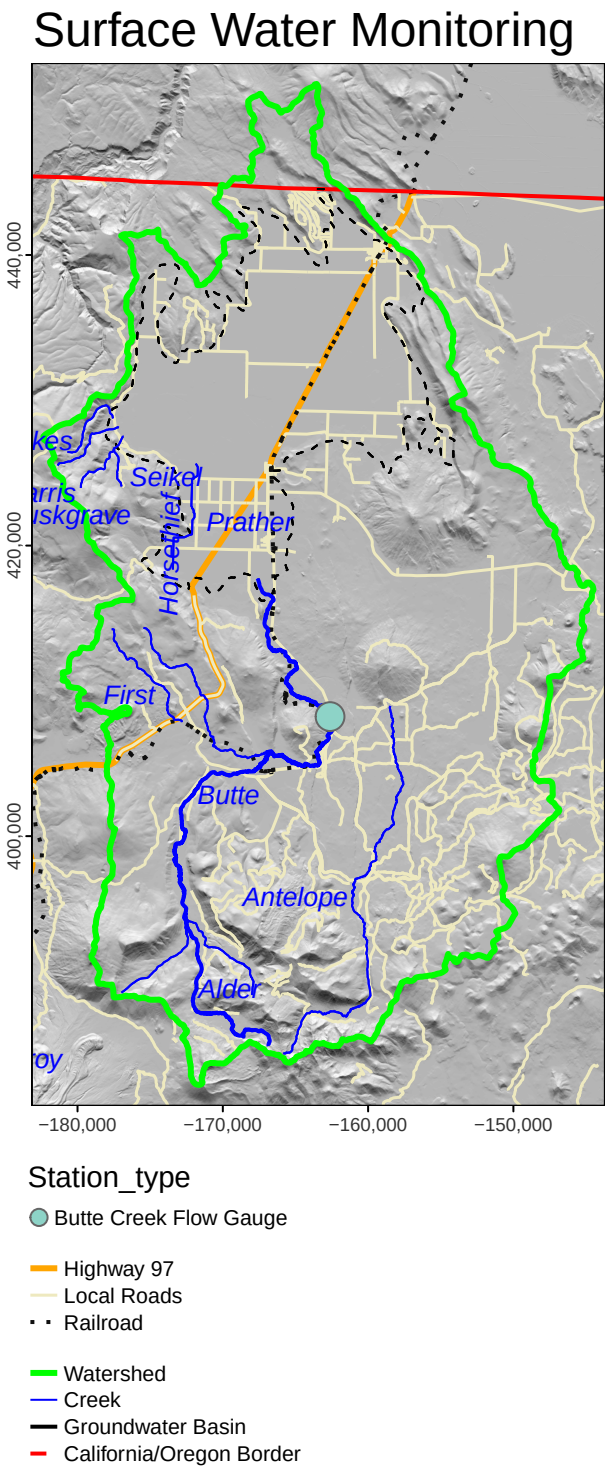


Figure 3.3: The location of continuous surface water monitoring stations in Butte Valley.

Network Enrollment and Expansion

With exception for stream flow and land subsidence, monitoring is done on wells. Some wells will be monitored for water level, some for water quality, some for both. Prior to enrolling wells into the GSA monitoring network, wells will be evaluated, using the selection criteria listed below, to determine suitability. The selection criteria for potential wells to be added to the monitoring network include the following:

- Well location
- Monitoring History
- Well Information
- Well Access

Well Location

The location and design of a well network is important to ensure adequate spatial distribution, coverage and well density. Locations important for groundwater monitoring include sufficient spatial representation of GSP projects and management actions, many of which are Basin-wide. Statistical methods will be used to aid in extrapolating from a limited number of monitoring sites to the entire Basin. Additionally, the network includes the major water bearing formations including the Butte Valley Basalt, Lake Deposits, and High Cascade Volcanics.

Monitoring History

Wells with a long monitoring record provide valuable historical groundwater level or water quality data and enable the assessment of long-term trends.

Well Information

In addition to well location, information about the construction of the well, including the well depth and screened interval(s) provides context, such as which water bearing formation is being sampled. Basin groundwater users tap into three major water-bearing formations, which occur at different depths in separate areas of the Basin. Well information is therefore critical for an effective well network that efficiently monitors groundwater conditions. For wells that are candidates for being added to the well network, the GSA will continue to verify well information, e.g., with well logging.

Well Access / Agency Support

In order to be valuable to the monitoring network, the ability to gain access to the well to collect samples at the required frequency is critical.

Wells in existing monitoring programs are not evenly distributed (e.g., water quality well locations are mostly near population centers), leaving sections of the remainder of the Basin without monitoring data. The planned additional wells are intended to gather groundwater data representative of different land uses and activities and representative of all three geologic units. Such an expansion will improve upon the existing spatial coverage in the Basin. Any wells added to the monitoring network will be evaluated using the criteria listed above to ensure well suitability. The spatial density and monitoring frequency of the monitoring network will be evaluated at least every five years to

ensure that the monitoring network is representative of Basin conditions and enables evaluations of seasonal, short-term (1 to 5 years) and long-term (5 to 20 years) trends.

The expansion of the monitoring network will be completed in several steps during GSP implementation. The first step will involve coordination with those agencies already implementing existing monitoring programs in the Basin (see Chapter 2). Wells in these existing monitoring networks (water level or water quality) will be evaluated using the selection criteria and suitable wells will be selected for the GSA Monitoring Network.

The second step will involve identification of additional existing wells in the Basin that could be included in the monitoring network and evaluation of these wells using the selection criteria. Following identification of additional suitable existing wells, analyses will be conducted to determine whether additional wells are required to achieve sufficient spatial density, are representative of land uses in the Basin, and include monitoring in key areas identified by stakeholders. If additional sites are required to ensure sufficient spatial density, then existing wells may be identified, or new wells may be constructed at select locations, as required.

Finally, the monitoring frequency and timing that enable evaluation of seasonal, short-term, and long-term trends will be determined and coordination will be conducted between existing monitoring programs and the GSA to develop an agreement for data collection responsibilities, monitoring protocols and data reporting. With coordination between the GSA and existing monitoring programs ("agencies"), monitoring will be conducted by GSA or agency program staff or their contractors. For water quality, samples are analyzed at contracted analytical labs. To prevent bias, samples will be collected at the same time (i.e., within +/- 30 days) each year.

3.3.1 Groundwater Level Monitoring Network

3.3.1.1 Description of Monitoring Network

This section describes the process used to select wells as potential Representative Monitoring Points (RMPs) for monitoring the groundwater level sustainability indicator. These wells are mapped in Figure 3.4 and listed in Table 3.2.

The objective of the groundwater level monitoring network design is to capture sufficient spatial and temporal detail of groundwater level conditions to assess groundwater level changes over time, groundwater flow directions, and hydraulic gradients between aquifers and surface water features. The monitoring network is critical for the GSA to show compliance with SGMA and quantitatively show the absence of or improvement of undesirable results. The design of the monitoring network must enable adequate spatial coverage (distribution, density) to describe groundwater level conditions at a local and Basin-wide scale for all beneficial uses. Revisions to the monitoring network and schedule will be considered after review of the initial five years of monitoring data and as part of any future GSP updates.

Monitoring Network Development

Considerations for making the RMP selections include, in order of priority: spatial coverage, date of last water level observation, and inclusion in existing monitoring programs (such as CASGEM or the continuous transducer measurement network).

Spatial coverage criteria

DWR guidance on monitoring networks (DWR 2016d) recommends a range of well densities to adequately monitor groundwater resources, with a minimum of 0.2 wells and a maximum of 10 wells per 100 sq mi (259 sq km). Because the Basin covers approximately 125 sq mi (326 sq km), these recommendations would translate directly into a range from 1 to 13 RMP wells, evenly spaced in the Basin. To provide some continuity with previous monitoring efforts, and to provide some redundancy in the event of inaccessible wells, a network of potential RMPs was selected using a coverage radius of 1.25 mi (2.0 km).

Measurement schedule

The water elevation in RMP wells will be measured, at a minimum, twice per year to capture the fall low and spring high water levels (Table 3.2). In some wells, transducers may provide daily or higher resolution water elevation measurements.

For wells to be future candidates for the RMP network, at least 10 years of data must be collected, especially when those data are used to adopt future changes in SMC levels (e.g., to fill data gaps for GDEs, see Chapter 2). This ensures a minimum baseline for the well and is consistent with 23 CCR Section 358.2(c)(3), which requires alternative GSPs to have operated sustainably for at least 10 years and include data covering at least 10 years.

Selected groundwater level RMP network

Existing wells considered for the RMP network were public supply wells, and CASGEM wells that include agriculture and domestic wells. Wells selected as RMP candidates (Table 3.2) had a minimum of 10 years of mostly continuous (twice annual) water level measurements. To achieve sufficient spatial coverage, the 5-square mile buffer zone (1.25 mile radius) was mapped around each selected well. The final groundwater level RMP network provides broad coverage of the Basin (Figure 3.4). The groundwater level well network has excellent coverage, especially of the most developed areas of the Basin. But data gaps exist in some of the less developed areas of the Basin, in Sam's Neck, Butte Valley Wildlife Area (BVWA), and Butte Valley National Grasslands. Additionally, very few wells are located near creeks, lakes, and other surface water bodies mostly near the southern boundary of the Basin.

Table 3.2: Existing and planned elements of the groundwater level monitoring network.

Name of Network	Well Name	State Well Number	Map Name	Target Area	Geologic Formation	Sample Schedule
CASGEM	418948N1220832W001	47N02W27C001M	27C	Meiss Lake	Deep Lake Sediment, High Cascade Volcanics	Twice Annual
CASGEM	417786N1220041W001	45N01W06A001M	06A	Mount Hebron	Butte Valley Basalt	Twice Annual
CASGEM	417789N1220759W001	45N02W04B001M	04B	South West Butte Valley	Data Gap	Twice Annual
CASGEM	417944N1220350W001	46N02W25R002M	25R	Butte Valley Irrigation District	Butte Valley Basalt	Twice Annual
CASGEM	418544N1219958W001	46N01W04N002M	04N	South Mid Valley	Lake Deposits	Twice Annual
CASGEM	418661N1219587W001	47N01W34Q001M	34Q	South Mid Valley	Lake Deposits	Twice Annual
CASGEM	418512N1219183W001	46N01E06N001M	06N	East Valley	Lake Deposits	Twice Annual
Municipal	NA	NA	NA	City of Dorris Well #6	High Cascade Volcanics	Monthly*
CASGEM	419662N1219633W001	48N01W34B001M	34B	West of City of Dorris	High Cascade Volcanics	Twice Annual
CASGEM	419755N1219785W001	48N01W28J001M	28J	NW Butte, Mahogany Mtn F.Z.	High Cascade Volcanics	Twice Annual
CASGEM	419519N1219958W001	47N01W04D002M	04D	North Mid Valley Nested	Lake Deposits	Twice Annual
CASGEM	419520N1219959W001	47N01W04D001M	04D	North Mid Valley Nested	Lake Deposits	Twice Annual
CASGEM	418371N1221105W001	NA	09A	Meiss Lake	Alluvium and High Cascade Volcanics	Twice Annual*
CASGEM	419451N1218967W001	47N01E05E001M	05E	East of Dorris	Data Gap	Twice Annual
CASGEM	419021N1219431W001	47N01W23H002M	23H	East Valley	Data Gap	Twice Annual
Expanded GSA Monitoring Network	TBA	TBA	TBA	Sam's Neck, National Grasslands, Butte Valley Wildlife Area, Butte Creek, Prather Creek, Meiss Lake		Twice Annual

Note:
(*) The well began groundwater level measurements in 2015 and SMC cannot be set until 10 years of data is available (2025)

3.3.1.2 Assessment and Improvement of Monitoring Network

The very small number of monitoring wells near surface water bodies, including Meiss Lake, Butte Creek, Prather Creek, Ikes, Harris, and Muskgrave Creeks, and various springs leaves significant uncertainty about the hydraulic gradients between the groundwater aquifer and surface water features in the Basin. Based on current knowledge and groundwater depths in nearby wells, these surface water bodies are either losing streams or disconnected from groundwater, in some cases possibly sustained via perched aquifers (see Section 2.2.2.6). Expanding the network to include representative wells adjacent to key surface water bodies would close data gaps regarding the connection of surface water to the groundwater aquifer in the Basin.

Water level measurements near potential GDEs in the Basin are also lacking. The potential GDEs in Butte Valley are relatively small and exist on the Basin edges and areas not covered by the current network. The connection of these potential GDEs to the Basin aquifer and therefore their GDE status is a major data gap (see Section 2.2.2.7).

As the existing monitoring network has data gaps in several key areas of the Basin, an expansion of the network is required to adequately characterize and monitor groundwater levels in the Basin. Data gaps exist in spatial coverage, well information and representation of all land uses and beneficial uses and users in the Basin. Expansion of the network will be informed by the process outlined in Section 3.3.1.1. The current biannual monitoring schedules are sufficient to evaluate seasonal trends, though installation of data loggers could produce monthly or daily data that could be valuable in the evaluation of some PMA pilots. An assessment and expansion of the monitoring network is planned within the first five years of GSP implementation, and repeated evaluations of the network will occur on a five-year basis.

3.3.1.3 Monitoring Protocols for Data Collection and Monitoring

Groundwater level data collection may be conducted remotely via telemetry equipment or with an in-person field crew. Appendix 3-B provides the monitoring protocols for groundwater level data collection. Establishment of these protocols will ensure that data collected for groundwater levels are accurate, representative, reproducible, and contain all required information. All groundwater level data collection in support of this GSP is required to follow the established protocols for consistency throughout the Basin and over time. These monitoring protocols will be updated as necessary and will be re-evaluated every five years.

3.3.2 Groundwater Storage Monitoring Network

This GSP will adopt groundwater levels as a proxy for groundwater storage. The groundwater level network described in Section 3.3.1., will also serve as the groundwater storage monitoring network. The network currently provides reasonable coverage of the major water-bearing formations in the Basin and will provide reasonable estimates of groundwater storage. The network also includes municipal, agricultural, and municipal wells of shallow to deep depths. Expansion of the network to close data gaps will benefit the characterization of both the groundwater level and storage sustainability indicators.

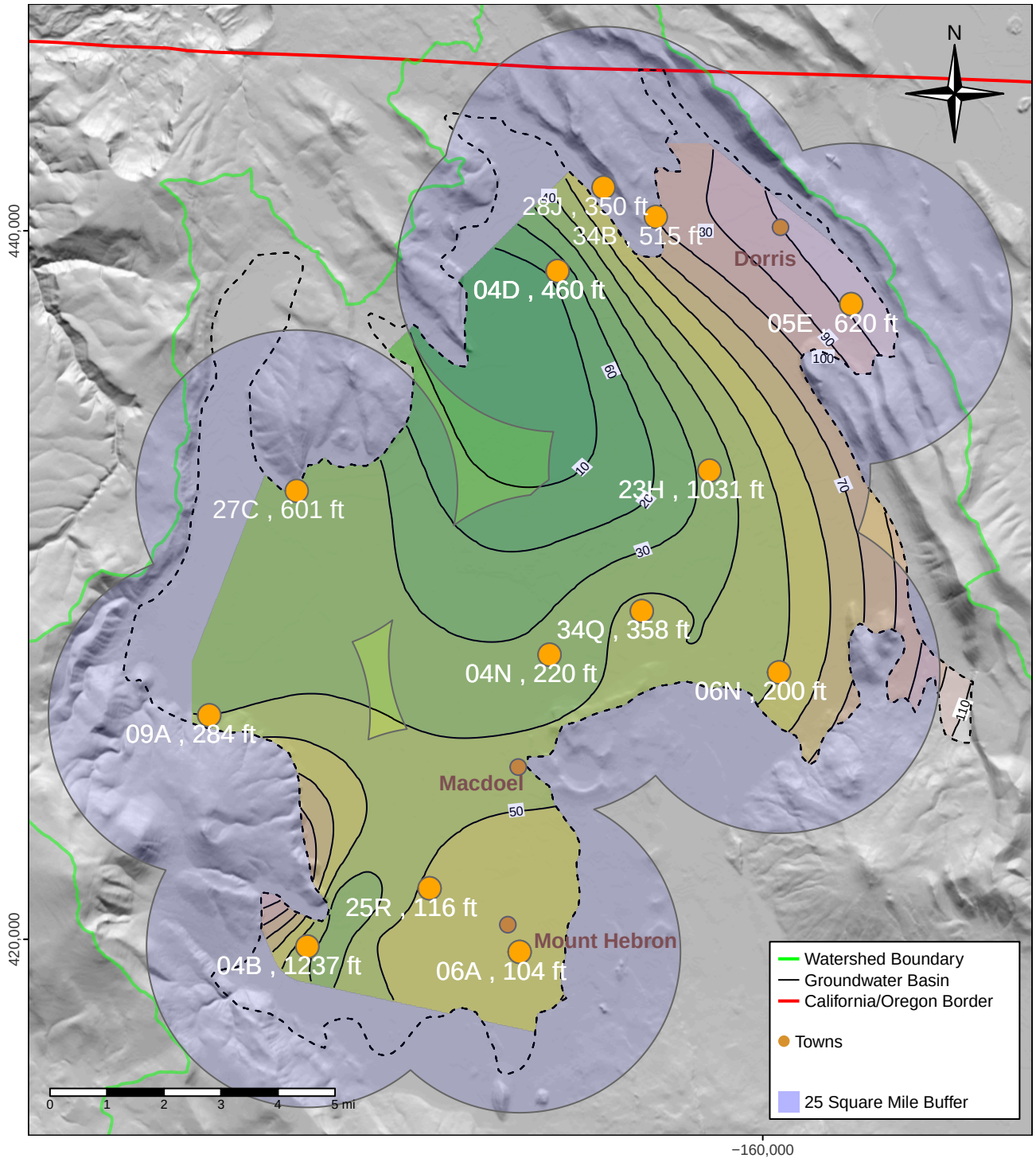


Figure 3.4: Representative monitoring points (RMP) in the water level monitoring network. Well names corresponding to the shorthand names on the map are shown in Table 2.

Historic groundwater storage changes are computed with BVIHM (see Chapter 2.2.3). Throughout the implementation period of this Plan, updates of BVIHM provide updated time series of groundwater storage changes at least every five years.

To obtain groundwater storage changes for the most recent, non-simulated period (currently 2018 to 2021), the latest version of BVIHM, currently, for example, simulating the period 1991 to 2018, is used to establish a linear regression equation of year-specific spring-to-spring Basin groundwater storage change, ΔSTORAGE, as a function of the year-specific average BVIHM-simulated groundwater level change, ΔWL, at the RMP locations of the groundwater level network:

$$\Delta STORAGE = intersect + slope * \Delta WL$$

where "intersect" and "slope" are parameters of the linear regression equation, obtained from statistical analysis of ΔSTORAGE and ΔWL during the simulation period. The regression analysis is performed using the specific, actual monitoring locations available each year for spring-to-spring water level change observations. The "intersect" and "slope" parameters in the above equation can be updated when new, updated, or re-calibrated versions of BVIHM become available, or when individual RMPs in the water level monitoring network are added or removed.

The above equation is then used to annually compute groundwater storage change using the actually measured average change in groundwater levels within the Basin's groundwater level monitoring network. The resulting estimate of annual groundwater storage change (in units of thousand-acre-feet, positive or negative) is then summed with previous year's estimates and combined with the simulated groundwater storage change timeline for the historic period (see Section 2.2.3).

This regression-based method allows for computation of groundwater storage change from measured groundwater level monitoring for the years between the end of the simulation period (to be updated at least every five years, currently 2018) and the current reporting year (currently 2021). As BVIHM is updated in the future, regression-based estimates of groundwater storage change for a given year (e.g., for 2021) may be replaced with the simulated BVIHM groundwater storage changes for the same year.

In summary, the combination of simulated groundwater storage change in BVIHM and regression-estimated groundwater storage changes for the post-simulation period provides a time series of cumulative groundwater storage change for the entire period from 1991 to present time (where "present time" is the most recent year in the GSP implementation).

3.3.3 Groundwater Quality Monitoring Network

3.3.3.1 Description of Monitoring Network

The objective of the groundwater quality monitoring network design is to capture sufficient spatial and temporal detail to measure groundwater conditions and assess groundwater quality changes over time. The monitoring network is critical for the GSA to show compliance with SGMA and quantitatively show the absence or improvement of undesirable results. The network data will provide a continuous water quality record for future assessments of groundwater quality.

Existing wells used for monitoring groundwater quality in the Basin include public water supply wells and monitoring wells from DWR, California Department of Fish and Wildlife (CDFW), and SWRCB, which are shown in Figure 3.5. However, wells in these existing networks do not cover the entire

Basin. Areas of the Basin with no representative wells, such as Sam's Neck and the middle of the Basin, are data gaps. However, historic and current land use (natural vegetation, some irrigated forage) does not pose significant known risks for groundwater contamination. Existing wells in those areas can be added to the network if well information such as the well depth and well screen dimensions are also known. Well logging or a camera inspection, where a camera is lowered into the well, may be used to obtain unknown well construction information.

The initial groundwater quality well network relies primarily on existing programs that are located within and near the semi-urban areas of the Basin. Initially, the groundwater quality monitoring network is based on wells that are regularly sampled as part of existing monitoring programs for the constituents for which SMCs are set: arsenic, nitrate, and specific conductivity (Table 3.3). Data from these existing programs are not representative of groundwater quality associated with agricultural irrigation, or stock watering (the basin has no or insignificant groundwater discharge to streams). The locations of the existing wells in the proposed well network are shown in Figure 3.5, with details in Table 3.3. Initial monitoring schedules are shown in Table 3.3.

With improvements (Section 3.3.3.2), the design of the monitoring network will eventually enable adequate spatial coverage (distribution, density) to describe groundwater quality conditions at a local and Basin-wide scale for all beneficial uses.

Table 3.3: Existing and planned elements of the groundwater level monitoring network.

Name of Network	Agency	Well Name	Constituent	Frequency
Municipal / Public Supply	City of Dorris	4710001-001, 4710001-003	Arsenic	Every 9 yrs
			Nitrate	Every 9 yrs Annually
			Specific Conductivity	Every 9 yrs
	Goosenest District Office (USFS)	4700851-001	Nitrate	Annually
			Specific Conductivity	No official monitoring schedule
	Macdoel Waterworks	4700539-001	Nitrate	Annually
			Specific Conductivity	No official monitoring schedule
	Juniper Village Farm Labor Housing	4700891-001	Nitrate	Annually
Domestic Well	Butte Valley Wildlife Area (CDFW)	NEW HQ DOM, R168 DOM WELL	Nitrate	Annually
			Specific Conductivity	Annually
Expanded GSA Monitor-ing Network	GSA	A minimum of 3 wells; sites to be determined	Nitrate, Specific Conductivity	Frequency to be determined.

3.3.3.2 Assessment and Improvement of Monitoring Network

As the existing monitoring network has limited spatial coverage and is not representative of all land uses in the Basin, an expansion of the network is required to adequately characterize and monitor groundwater quality in the Basin. An assessment and expansion of the monitoring network is planned within the first five years of GSP implementation. An expanded monitoring network will occur through a combination of adding suitable existing wells and construction of new wells. Further evaluations of the monitoring network will be conducted on a five-year basis, at minimum, particularly with regard to the sufficiency of the monitoring network in meeting the monitoring objectives.

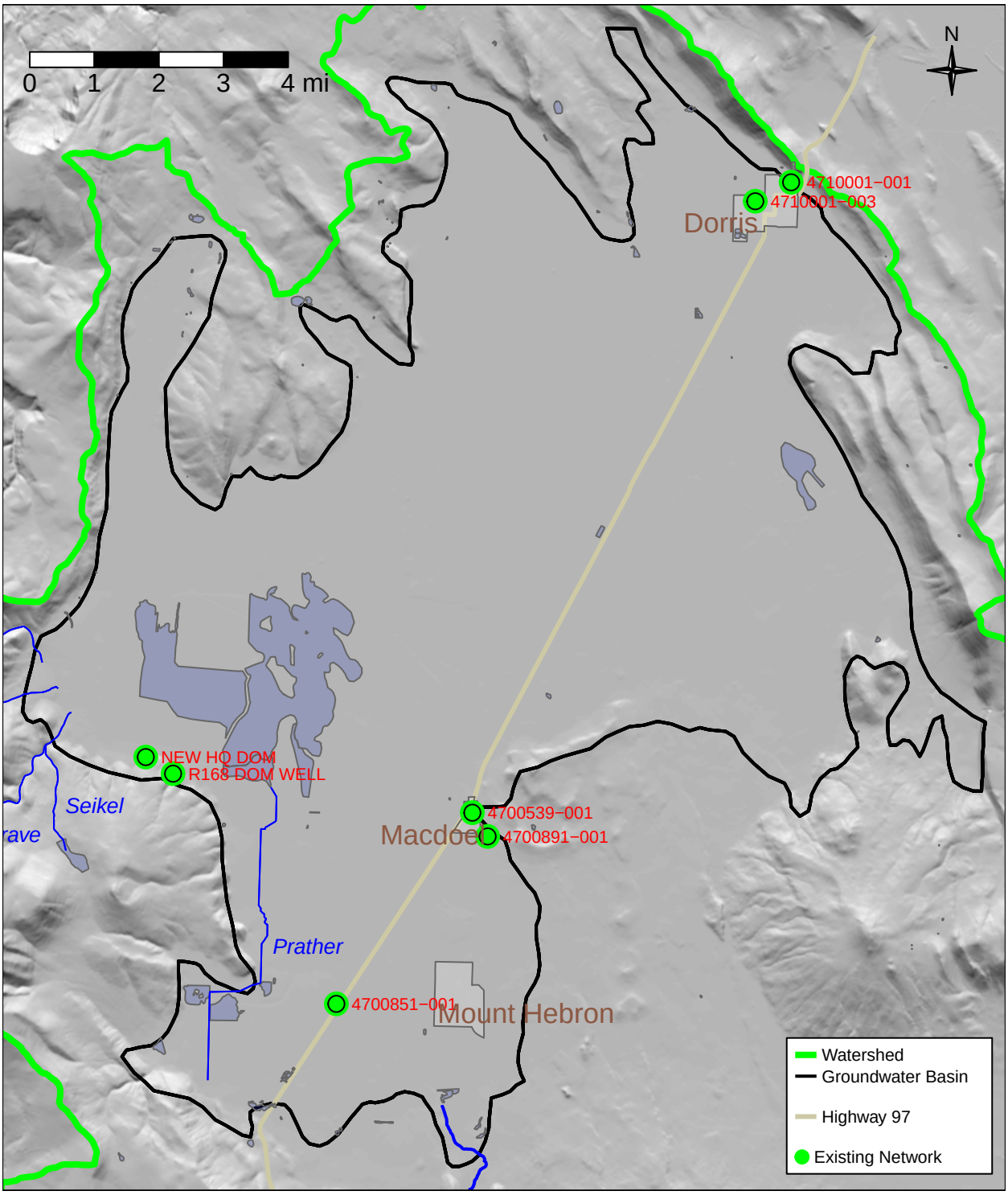


Figure 3.5: Existing water quality monitoring network. Wells along Highway 97 are public supply wells and wells near Meiss Lake are wells volunteered by CDFW. This current monitoring network is planned to be expanded.

An evaluation of the monitoring network, for both spatial density and monitoring frequency suitability will be included in the design of the monitoring network, as discussed in Section 3.3.1. Data gaps have been identified, particularly in spatial coverage, well information and representation of all land uses and beneficial uses and users in the Basin. These data gaps will be resolved through well logging, addition of suitable existing wells, and construction of new wells. The location and number of these wells will be informed by the evaluation completed as part of the monitoring network design.

3.3.3.3 Monitoring Protocols for Data Collection and Monitoring

Sample collection will follow the *USGS National Field Manual for the Collection of Water Quality Data* (Wilde 2008; USGS 2015) and *Standard Methods for the Examination of Water and Wastewater* (Rice, Bridgewater, and American Public Health Association 2012), as applicable, in addition to the general sampling protocols listed in Appendix 3-B.

3.3.4 Subsidence Monitoring Network

3.3.4.1 Description of Monitoring Network

Interferometric Synthetic Aperture Radar (InSAR) is a satellite-based remote sensing technique that measures vertical ground surface displacement changes at high degrees of measurement resolution and spatial detail. DWR provides vertical displacement estimates derived from InSAR data collected by the European Space Agency Sentinal-1A satellite and processed under contract by TRE ALTAMIRA Inc. The InSAR dataset has spatial coverage for much of the Basin and consists of two data forms: point data and a Geographic Information System (GIS) raster, which is point data interpolated into a continuous image or map. The point data are the observed average vertical displacements within a 100 by 100 m area. The InSAR data covers the majority of the Basin as point data and entirely as an interpreted raster dataset. The dataset provides good temporal coverage for the Basin with annual rasters (beginning and ending on each month of the coverage year from 2015 to 2019), cumulative rasters, and monthly time series data for each point data location. These temporal frequencies are adequate for understanding short-term, seasonal, and long-term trends in land subsidence.

Representative Monitoring

The DWR / TRE ALTAMIRA InSAR data will be used to monitor subsidence in Butte Valley. There are no explicitly identified representative subsidence sites because the satellite data consists of thousands of points. Figure 2.25 shows the coverage of the subsidence monitoring network, which will monitor potential surface deformation trends related to subsidence. Data from the subsidence monitoring network will be reviewed annually. The subsidence monitoring network allows sufficient monitoring both spatially and temporally to adequately assess that the measurable objective is being met.

3.3.4.2 Assessment and Improvement of Monitoring Network

It is currently sufficient for the monitoring network to be based on InSAR data from DWR / TRE ALTAMIRA, which adequately resolves land subsidence estimates in the Basin spatially and temporally. However, data gaps exist in the subsidence network, including the lack of data prior to 2015 and no Continuous Global Positioning System (CGPS) stations to ground-truth the satellite data. The DWR/TRE ALTAMIRA InSAR dataset is the only subsidence dataset currently available for the Basin and only has data extending back to 2015. Historical subsidence data prior to 2015 is currently unavailable. Compared to satellite data, CGPS stations offer greater accuracy and higher frequency and provide a ground-truth check on satellite data. However, there are no CGPS or borehole extensometer stations located within or near the Basin boundary. Due to lack of subsidence since 2015 (see Section 2.2.2.5), no future CGPS or borehole extensometer stations are proposed for the Basin at this time. If subsidence becomes a concern in the future, then installation of CGPS stations and/or borehole extensometers can be proposed. The subsidence monitoring network will be used to determine if and where future CGPS or ground-based elevation surveys would be installed. In addition, if subsidence anomalies are detected in the subsidence monitoring network, ground truthing, elevation surveying, and GPS studies may be conducted.

3.3.4.3 Monitoring Protocols for Data Collection and Monitoring

The subsidence monitoring network currently depends on data provided by DWR through the TRE ALTAMIRA InSAR Subsidence Dataset. Appendix 3-B describes the data collection and monitoring completed by DWR contractors to develop the dataset. The GSA will monitor all subsidence data annually. If any additional data become available, they will be evaluated and incorporated into the GSP implementation. If the annual subsidence rate is greater than minimum threshold, further study will be needed.

3.4 Sustainable Management Criteria

3.4.1 Groundwater Elevation

3.4.1.1 Undesirable Results

Chronic lowering of groundwater levels is considered significant and unreasonable when a significant number of private, agricultural, industrial, and municipal production wells can no longer provide enough groundwater to supply beneficial uses. SGMA defines undesirable results related to groundwater levels as chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Lowering of water levels during a period of drought is not the same as (and does not constitute) 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" (California Water Code 10721 (x)(1)).

Potential impacts and the extent to which they are considered significant and unreasonable were determined by the GSA with input by technical advisors and members of the public. During development of the GSP, potential undesirable results identified by stakeholders include:

- Excessive number of domestic, public, or agricultural wells going dry.
- Excessive reduction in the pumping capacity of existing wells.
- Excessive increase in pumping costs due to greater lift.
- Excessive need for deeper well installations or lowering of pumps.
- Excessive financial burden from the above undesirable results.
- Adverse impacts to environmental uses and users, including ISWs and GDEs.

Operationally, an undesirable result for water level would occur if the fall low water level observation (i.e., the minimum elevation in any given water year) in any of the representative monitoring sites in the Basin fall below their respective minimum thresholds (MT) in two consecutive years. The definition of an undesirable result is strict due to a focus on preventing groundwater levels from falling to an intermediate trigger, as discussed in Chapter 5. Groundwater levels reaching the MT would indicate the failure of a succession of management actions (MA; see Chapter 5). No other federal, state, or local standards exist for chronic lowering of groundwater elevations.

Potential Causes of Undesirable Results

Basin groundwater pumping currently does not exceed the sustainable yield of the Basin (i.e., pumping does not exceed recharge; Chapter 2). The long-term, multi-decadal decline in water levels in the Basin has several possible causes other than pumping in excess of recharge that would continue to lower water levels and cause undesirable results if continued into the future:

- A significant (continued) increase in Basin pumping volumes, forcing the groundwater system to a new dynamic equilibrium, that is causing water levels to fluctuate around a larger mean depth (lower mean water level), but following similar seasonal and interannual (dry year/wet year) patterns (see Chapter 2).

- A significant reduction in natural recharge as a result of climate change, or other sources that reduce groundwater inflow, forcing the groundwater system to a new dynamic equilibrium at a lower range of water levels.
- A significant reduction in groundwater inflow from surrounding volcanic uplands as a result of reduced recharge across the watershed, forcing the groundwater system to a new dynamic equilibrium at a lower range of water levels.
- A significant lowering of water levels in the downgradient regions of the Basin, i.e., in areas to the east and northeast of the Mahogany range, increasing the groundwater outflow from the Basin to downgradient regions. This also forces the groundwater system to a new dynamic equilibrium at a lower range of water levels.

Changes in pumping distribution and volume may occur due to significant rural residential, agricultural, and urban growth that depend on groundwater as a water supply. Climate change or an extended drought can lead to rainfall reductions, prolonged periods of lowered groundwater levels, and reduced recharge.

Reductions in groundwater flowing into the Basin may also result from expansion of groundwater wells outside the Basin border, within the larger watershed upgradient and downgradient from the Basin. Relevant policies regarding management of groundwater outside the Basin are discussed in Section 2.1.4.

The Basin is significantly interconnected with the volcanic groundwater system of the surrounding Watershed. Most precipitation in the larger watershed occurs to the south and southwest of the Basin and flows via recharge and groundwater rather than in streams toward and into the Basin. Groundwater not used for consumptive use in the Basin is discharging via the subsurface to the east and northeast of the Basin into the adjacent volcanic groundwater system and out of the Watershed. Water levels in the Basin are therefore significantly controlled by groundwater recharge into the volcanic groundwater system upgradient and downgradient of the Basin (Chapter 2).

Climate change is expected to raise average annual temperatures and intensify rainfall periods while extending dry periods. Together with resulting vegetation changes in surrounding uplands, climate change may significantly increase or decrease recharge compared to historic conditions (Figure 3.9; see CDWR 2021). If climate change were to lead to reduced recharge in surrounding uplands, upgradient and downgradient from the Basin, upgradient groundwater inflow to the Basin and water levels downgradient of the Basin will be lower, thus reducing the equilibrium water level in the Basin. On the other hand, if climate change leads to future increased recharge in the surrounding uplands, this would be raising water levels in the Basin.

The GSA will coordinate with relevant agencies and stakeholders within the Basin and the larger Watershed to implement PMAs to sustainably manage groundwater levels in the Basin.

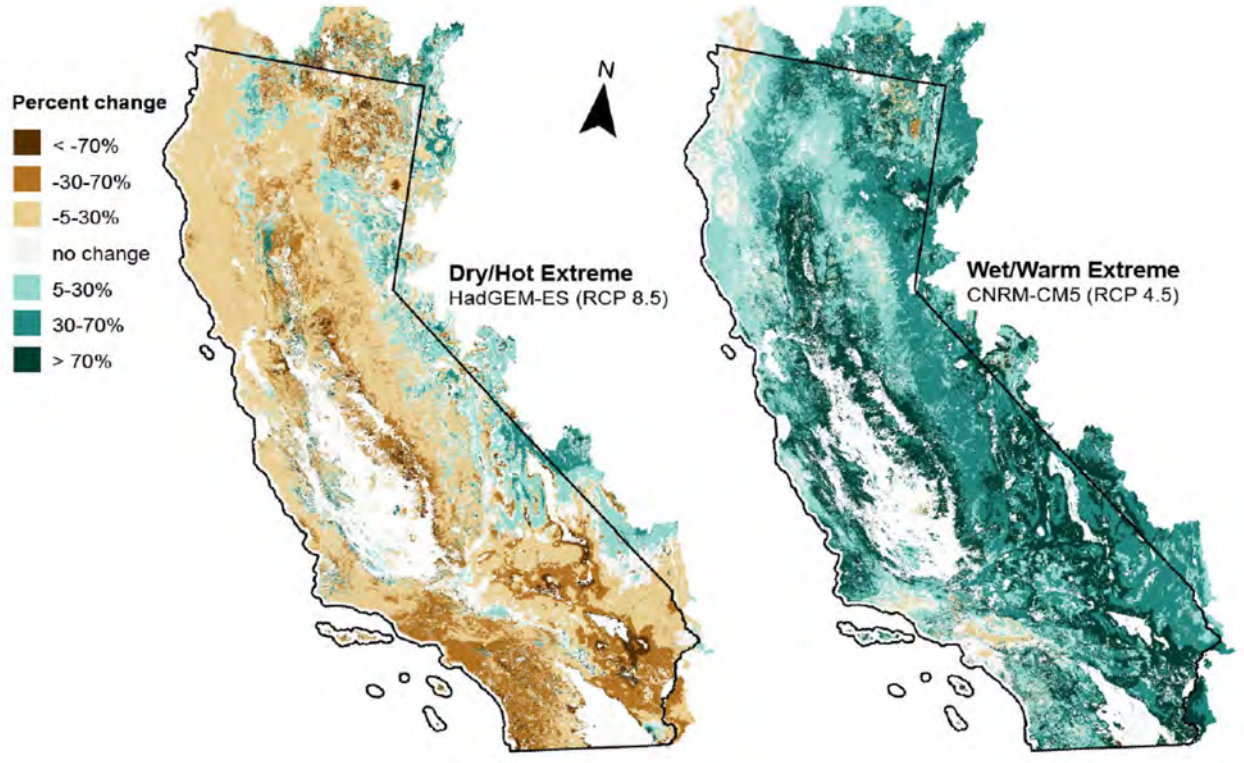


Figure 3.6: Relative change in average annual natural recharge, not accounting for irrigation return flows, under two possible future climate scenarios (CDWR 2021).

3.4.1.2 Minimum Threshold

Minimum thresholds (MT) for groundwater levels in the Basin are defined using existing groundwater level data and consultation with the GSA advisory committee and stakeholders. Resulting from this process, MTs are set to enable an “extended soft landing” by the year 2042. The “extended soft landing” is defined as 15 feet below a conceptual “soft landing” approach (see below). The “soft landing” approach to managing water levels is analogous to smoothly landing a plane at a moderate, controlled speed. Groundwater levels might decline beyond baseline (pre-2015) levels but remain above the MT while PMAs are implemented to achieve the measurable objective (MO). PMAs for groundwater levels are described in Chapter 4.

The MT and two triggers for management actions (MAs) are tailored to each representative monitoring point (RMP). All triggers and the “extended soft landing” MT were chosen to account for the natural delayed response of groundwater levels to MAs (Figure 3.7).

The “soft landing” trigger and the “extended soft landing” MT are specific to each RMP. A regression line is fitted to the fall water level measurements for the 15-year period from fall 1999 to fall 2014. The slope or beta (β) of the regression line corresponds to the average rate of decline in fall water levels, measured in feet per year, over this 15-year period. The water level depth of the regression line in fall 2014 is denoted as “WL_Depth_Regression_F2014” in the equation below (Figure 3.8).

The soft-landing trigger is computed by extending the regression line to 2042, then "bending" it to a flattening landing approach by allowing for only 75% of the total decline that the regression curve provides for the 27-year period from fall 2014 to fall 2041 (immediately prior to the January 1, 2042 SGMA compliance date):

$$T_{soft}(\text{measured as water level depth})$$
$$= \text{WL Depth Regression F2014}[ft] + 0.75 * \beta[ft/yr] * 27[yr]$$

The soft-landing trigger must allow for operational flexibility between the MOs and MTs that cause undesirable results (see below). If the operational flexibility, or difference between the soft-landing trigger and minimum MO (see below), is less than 5 feet (ft) using the above method, the soft-landing trigger is lowered to 5 feet below the minimum MO.

The main undesirable result that will be avoided by the soft-landing trigger are well outages and the cost of drilling deeper wells.

The "extended soft-landing" MT is a constant additional depth added to the soft-landing trigger, regardless of the RMP. The MT is selected to be 15 feet below the soft-landing trigger. Hence the final MT at a representative monitoring point is:

$$MT_{extended} = T_{soft} + 15[ft]$$

The extended MT provides the GSA and groundwater users additional operational flexibility, without incurring permanent undesirable results, to address potential consequences of climate change, allowing for some adjustment of the dynamic equilibrium in water levels that occur as a result of lower recharge in the surrounding Watershed, while allowing for continued, full groundwater use. Importantly, maintaining water levels above the MT also avoids conditions of chronic lowering of water levels due to future conditions of overdraft that may result from drastic reductions in Watershed-wide recharge (Figure 3.9).

Table 3.4 shows, for each RMP, the most recent fall water level (2020), the lowest historic water level measurement and the year of that observation, the value of the regression line in fall 2014 ("*WL_Depth_Regression_F2014*"), the slope (β) of the regression line, the depth of the soft-landing trigger ("*T_soft*"), the final MT ("*MT_extended*"), and MO.

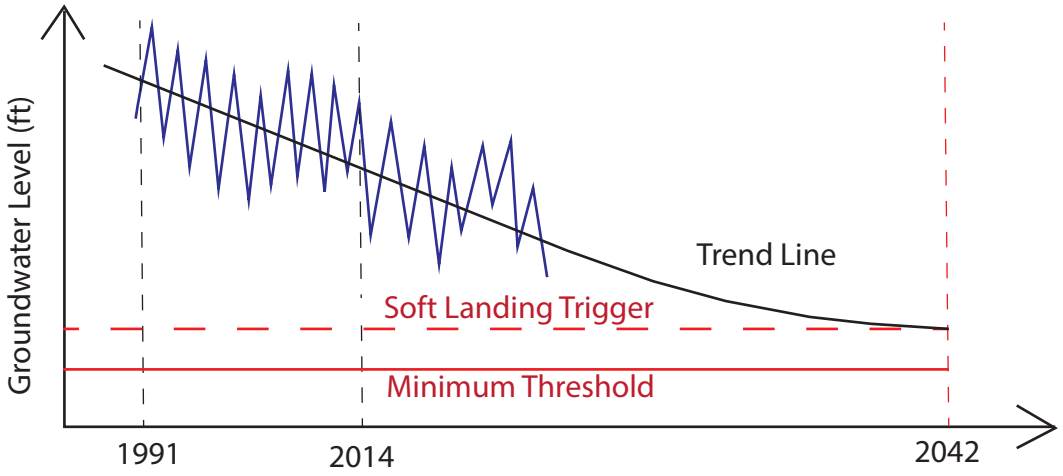


Figure 3.7: The goal for groundwater levels is to slow any decline down to the soft-landing trigger and no lower. The soft-landing trigger initiates strict management actions to prevent further decline to the MT.

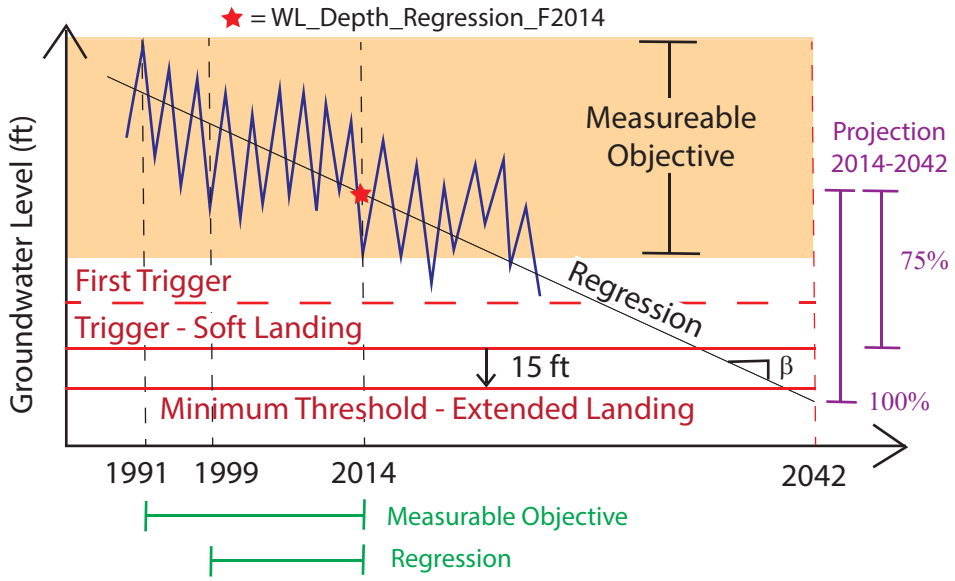


Figure 3.8: Visual description of the MT and soft landing trigger on a hydrograph.

Table 3.4: Groundwater level (WL) minimum thresholds (MT), with units of feet above mean sea level (ft amsl). Abbreviations: minimum threshold (MT), measurable objective (MO), water level (WL), trigger (T), minimum (Min), and maximum (Max).

Representative Monitoring Point/Well	Fall 2020 WL	Historic Low WL (Year)	WL Depth Regression F2014	Regression Slope (ß) (ft/yr)	T_soft	MT_extended	MO Min	MO Max
417786N1220041W001	4182.78	4181 (2014)	4181	-1.7954	4145	4130	4181	4225
417789N1220759W001	4211.91	4202 (2016)	4215	-0.5916	4203	4188	4213	4237
417944N1220350W001	4207.83	4184 (2015)	4200	-0.5218	4185**	4170**	4190	4225
418512N1219183W001	NA*	4190 (2018)	4195	-0.6810	4181	4166	4193	4214
418544N1219958W001	4208.32	4208 (2019)	4211	-0.8111	4195	4180	4211	4224
418661N1219587W001	NA*	4186 (2014)	4186	-1.1004	4163	4148	4186	4214
418948N1220832W001	NA*	4189 (1996)	4193	-1.1538	4170	4155	4193	4216
419021N1219431W001	NA*	4202 (2015)	4204	-0.7407	4189	4174	4203	4216
419451N1218967W001	4143.53	4129 (2009)	4145	-0.1611	4129**	4114**	4129	4158
419519N1219958W001	4226.49	4227 (2018)	4229	-0.3302	4223	4208	4229	4237
419520N1219959W001	4230.34	4231 (2020)	4232	-0.3095	4226	4211	4231	4242
419662N1219633W001	4161.66	4162 (2020)	4166	-1.3362	4139	4124	4161	4199
419755N1219785W001	4168.5	4169 (2020)	4192	-1.0284	4171	4156	4187	4217

Note:

(*) No fall measurements in 2019 and 2020.

(**) The soft-landing MT was moved to 5 feet below the MO.

Method for Quantitative Measurement of Minimum Thresholds

MTs and triggers are tailored to each individual well in the representative monitoring network, to accommodate differences in groundwater conditions across the Basin. Well hydrograph models projected 2042 groundwater elevations based on a selected base period (1999 to 2014), as shown in Figure 3.8. The RMP hydrographs are included in Appendix 3-C.

Thresholds were set after an analysis of projected well outages (see Section 3.4.1.5). A well outage is defined by the inability to pump groundwater from the affected well due to declining groundwater levels. Baseline conditions include well outages that seasonally may occur when groundwater levels are within the MO. For example, wells that tap into the Butte Valley Basalt water-bearing formation sometimes go dry in the summer and fall, under conditions when groundwater levels are within the MO.

Lastly, thresholds are also set to avoid undesirable results for neighboring groundwater basins. Significant adverse effects to the Lower Klamath Basin, northeast of the Basin are avoided at the current “extended soft landing” MT.

3.4.1.3 Measurable Objectives

MOs are defined under SGMA as described above in Section 3.1. Within the Basin, the MOs for groundwater levels are established to provide an indication of desired levels that are sufficiently protective of beneficial uses and users. MOs are defined on a well-specific basis, with consideration for historical groundwater level data.

The MO is defined separately for each RMP, as shown in Figure 3.8. The MO is a range of water levels rather than a single threshold. The upper limit of the MO is the highest observed water level at a RMP in the period from years 1991 to 2014 and the lower limit of the MO is the lowest observed water level at a RMP in the period 1991 to 2014, regardless of whether the water level was observed in the spring or fall season. This will eliminate the threat of well outages and protect beneficial uses in the Basin. MOs are shown in Table 3.4.

The difference in groundwater levels between the lower limit of the MO and MT gives a margin of operational flexibility, or margin of safety, for variation in groundwater levels due to seasonal, annual, or drought variations. Groundwater levels might drop in drought years but rise in wet years to recharge the aquifer and offset drought years. The operational flexibility is shown in Table 3.5. As can be seen from this table, the minimum MO (the lowest historically observed water level depth) is less than 30 feet above the selected MT for most RMPs.

Management Action Triggers

If falling groundwater levels activate defined triggers, the GSA will use MAs to proactively avoid the occurrence of undesirable results, as defined in Chapter 4. Triggers are tailored to each representative monitoring point (RMP) based on historical groundwater level trends, and the defined MTs and MOs. The triggers for individual wells in the representative monitoring network are shown in Table 3.5.

Trigger levels at each RMP are used to gradually increase the intensity of PMAs. The first trigger is exactly halfway between the MO minimum and the soft-landing trigger level. If groundwater elevations fall to this depth, the GSA will initiate MAs to halt further decline. Exceedances of the first trigger level at a single RMP may require only localized management to address falling

groundwater levels. If widespread exceedance of the first trigger level occurs, the GSA will initiate more extensive MAs. It will also initiate planning for a well outage program. More rigorous MAs will be activated if groundwater levels fall to the second trigger, the “soft landing” trigger (Chapter 4). MAs will be tailored to avoid reaching the MT (“extended soft landing”).

3.4.1.4 Path to Achieve Measurable Objectives

The GSA will support achievement of the MOs by monitoring groundwater levels and coordinating with agencies and stakeholders within the Basin to implement PMAs. The GSA will review and analyze groundwater level data to evaluate any changes in groundwater levels resulting from groundwater pumping or from PMAs. Using monitoring data collected as part of GSP implementation, the GSA will develop information (e.g., hydrograph plots, BVIHM model information) to demonstrate that PMAs are operating to maintain or improve groundwater level conditions in the Basin and to avoid unreasonable groundwater levels. Should groundwater levels drop to a trigger or MT as the result of GSA project implementation, the GSA will implement measures to address this occurrence. This process is illustrated in Figure 3.9.

To manage groundwater levels, the GSA will partner with local agencies and stakeholders to implement PMAs. PMAs are presented in further detail in Chapter 4. Implementation timelines and approximate costs are discussed in Chapter 5. Examples of possible GSA actions include stakeholder education and outreach and support for impacted stakeholders.

Where the cause of groundwater level decline is unknown, the GSA may choose to conduct additional or more frequent monitoring and initiate additional groundwater modeling. The need for additional studies on groundwater levels will be assessed throughout GSP implementation. The GSA may identify knowledge requirements, seek funding, and help to implement additional studies.

Table 3.5: Operational flexibility for each representative monitoring well and MA triggers, with units of feet above mean sea level (ft amsl).

Representative Monitoring Point/Well	Top of Screen (ft)	Bottom of Screen (ft)	Measurable Objective Maximum (ft)	Measurable Objective Minimum (ft)	First Management Action Trigger (ft)	Soft Landing Trigger (ft)	Extended Minimum Threshold	Operational Flexibility (MO - T_soft) (ft)	Operational Flexibility (MO - MT_Extended) (ft)
417786N1220041W001	4222	4158	4225	4181	4163.0	4145	4130	36	51
417789N1220759W001	Data Gap	Data Gap	4237	4213	4208.0	4203	4188	10	25
417944N1220350W001	70	116	4225	4190	4187.5	4185	4170	5	20
418512N1219183W001	4216	4096	4214	4193	4187.0	4181	4166	12	27
418544N1219958W001	Data Gap	Data Gap	4224	4211	4203.0	4195	4180	16	31
418661N1219587W001	4181	3937	4214	4186	4174.5	4163	4148	23	38
418948N1220832W001	4079	3829	4216	4193	4181.5	4170	4155	23	38
419021N1219431W001	Data Gap	Data Gap	4216	4203	4196.0	4189	4174	14	29
419451N1218967W001	87	185	4158	4129	4126.5	4124	4109	5	20
419519N1219958W001	4245	4045	4237	4229	4226.0	4223	4208	6	21
419520N1219959W001	4045	3785	4242	4231	4228.5	4226	4211	5	20
419662N1219633W001	4222	3745	4199	4161	4150.0	4139	4124	22	37
419755N1219785W001	4079	4019	4217	4187	4179.0	4171	4156	16	31

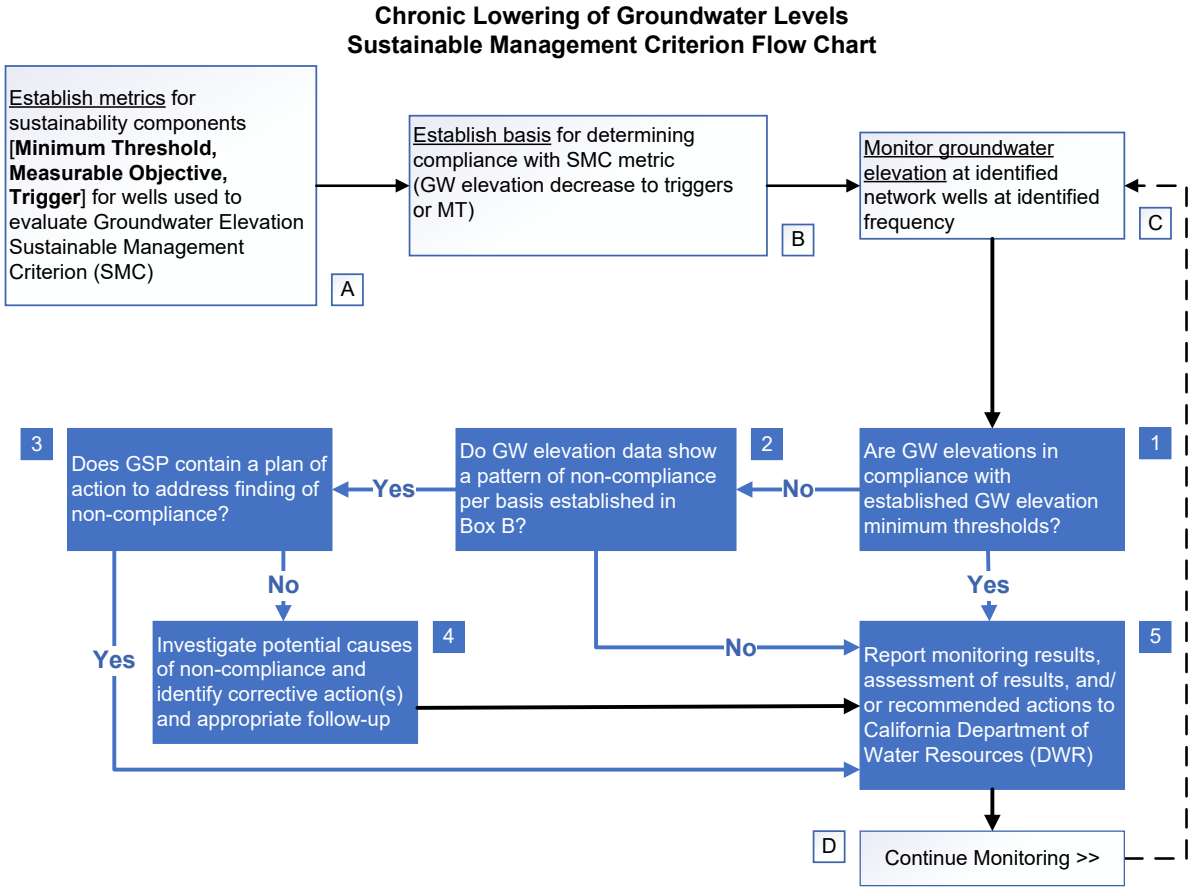


Figure 3.9: Groundwater level SMC flow chart. The flow chart depicts the high-level decision making that goes into developing SMCs, monitoring to determine if criteria are met, and actions to be taken based on monitoring results. Actions are described in Chapter 5.

Interim Milestones

Groundwater levels are managed to reach the MO by 2042. Interim milestones for groundwater levels were established through review and evaluation of measured groundwater level data and future projected fluctuations in groundwater levels and planned implementation of PMAs. Based on the historical groundwater levels presented in Appendix 3-C, where most hydrographs show leveling off of groundwater decline from 2014 to 2020, all interim milestones are set simply to remain within the MO for each RMP. This interim milestone is already met by most RMPs. Remaining wells are expected to reach MO through MAs. At future five-year assessments, the GSA will evaluate if these interim milestones need to be adjusted based on observed groundwater conditions.

3.4.1.5 Effects on Beneficial Uses and Users

The MT will prevent undesirable results in form of significant numbers of private, agricultural, industrial, and/or municipal production well outages. Even above the MT, some wells may experience temporary or permanent outages, requiring drilling of deeper wells. This may constitute an undesirable result, as it would effectively increase the cost of using groundwater as a water source to a user, most commonly domestic well users.

To better understand the effect on beneficial uses and users, specifically domestic well users, a well failure risk analysis was performed, which is presented in Appendix 3-C. The analysis provides an estimate of the undesirable result that would occur if water levels declined to the MT. Due to data gaps related to well construction details and groundwater levels, the well failure risk analysis focuses on interpolated groundwater elevation data to assess the aggregated risk of wells not being able to pump water due to low water levels ("well outages"). Groundwater levels were interpolated for fall 2015 (dry year) and fall 2017 (wet year). Wells were classified by well type (public, domestic, agriculture) and the dominant geologic formation identified at the bottom of the perforated interval. Results indicate that if water levels were lowered to soft landing trigger level throughout the Basin, about 45 to 120 wells out of approximately 1,000 wells would be at risk of well outage. If water levels will fall to the extended MT across the basin, an additional 15 feet decline at each RMP, an additional 45 to 120 wells may be at risk of well outage. Well outage risk may also be unevenly distributed across the basin due to varying well characteristics between geologic formations and varying water level declines.

The following provides greater detail regarding the potential impact of poor groundwater level on several major classes of beneficial users:

- **Municipal Drinking Water Users** - Undesirable results due to declining groundwater levels can adversely affect current and projected municipal users, causing increased costs for potable water supplies.
- **Rural and/or Agricultural Residential Drinking Water Users** - Falling groundwater levels can cause shallow domestic and stock wells to go dry, which may require well owners to drill deeper wells. The MT is expected to cause as much as 9% to 24% well outages. Additionally, the lowering of the water table may lead to decreased groundwater quality drinking water wells.
- **Agricultural Users** - Excessive lowering of groundwater levels could necessitate changes in irrigation practices and crops grown and could cause adverse effects to property values and the regional economy.
- **Environmental Uses** - Deep groundwater levels may result in significant and unreasonable reduction of groundwater flow toward streams and GDEs. This would adversely affect their ecological habitats and resident species. Currently, the location of GDEs is a data gap.

To avoid undesirable outcomes to the first three beneficial user groups, to the degree they occur at water levels above the MT, the GSA will develop a well replacement program (Chapter 4). To avoid undesirable outcomes to the fourth group of beneficial uses, the GSA will expand upon historic monitoring and assessment efforts to fill data gaps, then adjust MTs at relevant RMPs in future updates to the GSP as needed. The MO is already protective of GDEs, where they exist, as it preserves baseline water levels.

3.4.1.6 Relationship to Other Sustainability Indicators

MTs are selected to also avoid undesirable results for other sustainability indicators. In the Basin, groundwater levels are directly related to groundwater storage and GDEs outside of streams. The relationship between groundwater level MTs and MTs for other sustainability indicators are discussed below.

- **Groundwater Storage** - Groundwater levels are closely tied to groundwater storage, with high groundwater levels related to high groundwater storage. The groundwater storage MTs use the water level MTs as a proxy.
- **Groundwater Quality** - Protecting groundwater quality is critically important to all who depend upon the groundwater resource. A significant and unreasonable condition for degraded water quality is exceeding drinking water standards for constituents of concern in supply wells due to PMAs proposed in the GSP. Groundwater quality could potentially be affected by PMA induced changes in groundwater elevations and gradients. These changes could potentially cause poor quality groundwater to flow towards supply wells that would not have otherwise been impacted.
- **Subsidence** - The MT for land subsidence is to not cause significant additional land subsidence. The water level MT ("extended soft landing") prevents the subsidence MT from being exceeded.

3.4.1.7 Information and Methodology Used to Establish Minimum Thresholds and Measurable Objectives

The MTs were selected based on historical groundwater level trends and stakeholder input. A detailed discussion of groundwater level trends and current conditions is described in Section 2.2.2.1. In establishing MTs for groundwater levels, the following information was considered:

- Feedback about groundwater level concerns from stakeholders.
- An assessment of available historical and current groundwater level data from wells in the Basin.
- An assessment of potential well outages based on possible MTs.
- Collection of well information regarding water bearing formation, depth, and screen characteristics.
- Results of the completed numerical groundwater model, BVIHM, indicating groundwater flow conditions (Chapter 2).
- Input from stakeholders resulting from the consideration of the above information in the form of recommendations regarding MTs and associated MAs.
- The model and resulting future water budget indicates and supports the finding that the basin is not in overdraft. Management changes that would require significant reductions in groundwater usage are not anticipated at this time.

Based on a review of these data, Basin water needs, and information from stakeholders, the GSA reached the determination to set two tiers – a trigger level and an "extended soft landing" MT. The two tiers give the GSA time to implement PMAs to meet the MO, while addressing anticipated well outages as groundwater levels continue to decline.

3.4.2 Groundwater Storage

Groundwater levels are selected as the proxy for groundwater storage. Hence, the SMCs are identical (Section 3.4.1). According to the USGS, estimates of groundwater storage rely on groundwater level data and sufficiently accurate knowledge of hydrogeologic properties of the aquifer. Direct measurements of groundwater levels can be used to estimate changes in groundwater storage (USGS 2021). As groundwater levels fall or rise, the volume of groundwater storage changes accordingly, where unacceptable groundwater decline indicates unacceptable storage loss. The hydrogeologic model outlined in Chapter 2 provides the needed hydrogeologic properties of the aquifer.

Protecting against chronic lowering of groundwater levels will directly protect against the chronic reduction of groundwater storage as the lowering of groundwater levels would directly lead to the reduction of groundwater storage. There cannot be a reduction in groundwater storage without a commensurate, observable reduction in water levels. There are currently no other state, federal, or local standards that relate to this sustainability indicator in the Basin.

An undesirable result from the reduction of groundwater in storage occurs when reduction of groundwater in storage interferes with beneficial uses of groundwater in the Basin. Since groundwater levels are being used as a proxy, the undesirable result for this sustainability indicator occurs when groundwater levels drop below the extended MT (Table 3.5), as defined by the undesirable result for the chronic lowering of groundwater levels. This should avoid significant and unreasonable changes to groundwater storage, including long-term reduction in groundwater storage or interference with the other sustainability indicators. Possible causes of undesirable reductions in groundwater storage are increases in well density or groundwater extraction or increases in frequency or duration of drought conditions.

The MT for groundwater storage for this GSP is the MT for groundwater levels. Information used to establish MTs and MOs for groundwater levels can be found in Section 3.4.1. Since groundwater storage is defined in terms of water level, Section 3.4.1.2 for the water level indicator equally applies to define the relationship of the groundwater storage SMC to other sustainability indicators.

The MO for groundwater storage is the MO for groundwater levels as detailed in Section 3.4.1.3. The path to achieve MOs and interim milestones for the reduction in groundwater storage sustainability indicator are the same MOs and interim milestones as for the chronic lowering of groundwater levels sustainability indicator detailed in Section 3.4.1.4.

3.4.3 Degraded Groundwater Quality

Groundwater quality in the Basin is generally well-suited for the municipal, domestic, agricultural, and other existing and potential beneficial uses designated for groundwater in the Water Quality Control Plan for the North Coast Region (Basin Plan). Existing groundwater quality concerns within the Basin are identified in Section 2.2.2.3 and the corresponding water quality figures and detailed water quality assessment are included in Appendix 2-B. In Section 2.2.2.3, constituents that are identified as groundwater quality concerns include 1,2 Dibromoethane (ethylene dibromide; EDB), arsenic, benzene, boron, nitrate, and specific conductivity.

SMCs will be defined for a select group of constituents: arsenic, nitrate, and specific conductivity. 1,2 Dibromoethane (ethylene dibromide; EDB) and benzene are already being monitored and managed by the NCRWQCB through the Leaking Underground Storage Tank (LUST) program.

Boron is naturally occurring. As such, SMC for EDB, benzene and boron are not needed. An SMC is defined for arsenic because, while it can be naturally occurring, there is arsenic contamination near Dorris from an unknown historical industrial source. Due to the localized contamination, arsenic SMCs are only defined for wells near Dorris. The GSA will monitor the naturally occurring constituents to track any possible mobilization of elevated concentrations.

The role of the GSA is to provide additional local oversight of groundwater quality, collaborate with appropriate parties to implement water quality projects and actions, and to evaluate and monitor, as needed, water quality effects of projects and actions implemented to meet the requirements of other SMCs. All future PMAs implemented by the GSA will be evaluated and designed to avoid causing undesirable groundwater quality outcomes. Federal and state standards for water quality, water quality objectives defined in the Basin Plan, and the management of known and suspected contaminated sites within the Basin will continue to be managed by the relevant agency. Groundwater in the Basin is used for a variety of beneficial uses which are protected by the NCRWQCB through the water quality objectives adopted in the Basin Plan.

Available historic and current groundwater quality monitoring data and reporting efforts have been used to establish and document conditions in the Basin, as discussed in Section 2.2.2.3. These conditions provide a baseline to compare with future groundwater quality and identify any changes observed, including those due to GSP implementation.

Groundwater quality monitoring in the Basin in support of the GSP will rely on the monitoring network described in Section 3.3.3. Groundwater quality samples will be collected and analyzed in accordance with the monitoring protocols outlined in Section 3.3.3.3. The monitoring network will use information from existing programs in the Basin that already monitor for the constituents of concern, and programs where constituents could be added as part of routine monitoring efforts in support of the GSP. New wells will be incorporated into the network as necessary to fill data gaps.

Because water quality degradation is typically associated with increasing rather than decreasing concentration of constituents, the GSA has decided to not use the term “minimum threshold” in the context of water quality, but instead use the term “maximum threshold.” The use of the term maximum threshold for the water quality SMC in this GSP is equivalent to the use of the term MT in other SMCs or in the SGMA regulations.

3.4.3.1 Undesirable Results

Degraded groundwater quality is considered an undesirable result if concentrations of constituents of concern exceed defined MTs or if a significant trend of groundwater quality degradation is observed for the identified constituents of concern. Groundwater quality changes that occur due to SGMA activities, including current groundwater use and management, may constitute an undesirable result.

For purposes of quantifying and evaluating the occurrence of an undesirable result, the concentration data are aggregated by statistical analysis to obtain spatial distributions and temporal trends. Specifically, statistical analysis is performed to determine the ten-year linear trend in concentration at each well. This trend is expressed unitless as percent relative concentration change per year. From the cumulative distribution of all 10-year trends observed across the monitoring network, the 75th percentile, $trend75_{10year}$, is obtained. Similarly, the moving two-year average concentrations are computed at each well, and from their cumulative distribution the 75th percentile, $conc75_{2year}$, is obtained. Concentrations are expressed in their respective concentration units

(µg/L, mg/L, or micromhos). For purposes of this GSP, a "water quality value" is defined by combining the measures of trend and concentration.

$$Water\ quality\ value = Maximum(trend75_{10year} - 15\%,\ conc75_{2year}\text{–}MT)$$

The undesirable result is quantitatively defined as:

$$Water\ quality\ value\ is > 0$$

This quantitative measure assures that water quality remains constant and does not increase by more than 15% per year, on average over ten years, in more than 25% of wells in the monitoring network. Mathematically this can be expressed by the following equation:

$$trend75_{10year}[\%] - 15\% \leq 0$$

It also assures that water quality does not exceed MTs for concentration in more than 25% of wells in the monitoring network. Values for MTs are defined in Section 3.4.3.4. Mathematically, this second condition can be expressed by the following equation:

$$conc75_{2year}\text{–}MT \leq 0$$

The water quality value is the maximum of the two terms on the left-hand side of the above two equations. If either of them exceeds zero, that is, if either of them does not meet the desired condition, then the water quality value is larger than zero and quantitatively indicates an undesirable result.

MTs align with applicable water quality regulations. Groundwater regulatory thresholds are defined by federal and state drinking water standards and Basin Plan water quality objectives. Due to emphasis on local governance, Basin Plan water quality objectives are considered in addition to state or federal drinking water standards. The Basin Plan may set more stringent standards to address local water quality issues or set separate less stringent water standards depending on the beneficial uses (e.g., for agricultural irrigation and stock watering vs. drinking water). With the current Basin Plan, the Butte Valley groundwater aquifer is designated with the beneficial use Municipal and Domestic Supply (MUN) but use of irrigation wells can be managed so that the Basin Plan groundwater water quality objectives are not applicable: if irrigation occurs at agronomic rates (tracked by the user), the irrigation water is only enough for the crops and will not reach the underlying groundwater to cause or contribute to a water quality problem. Then water quality is only evaluated based on values that are harmful to the crop being irrigated.

Due to limited surface water resources in the Basin, groundwater has an important role in supporting beneficial uses including agriculture (a significant part of the local economy), domestic use and municipal water supply. Groundwater is also an important component of streamflow and its water quality benefits instream environmental resources and wildlife. These beneficial uses, among others, are protected by the NCRWQCB through the water quality objectives adopted in the Basin Plan. The Basin Plan defines the existing beneficial uses of groundwater in the Basin: Municipal and Domestic Supply (MUN), Agricultural Supply (AGR), Industrial Service Supply (IND), and Native American Culture (CUL). Potential beneficial uses include Industrial Process Supply (PRO) and Aquaculture (AQUA).

Significant and unreasonable degradation of groundwater quality is the degradation of water quality that would impair beneficial uses of groundwater within the Basin or result in failure to comply with groundwater regulatory thresholds including state and federal drinking water standards and Basin Plan water quality objectives. Based on the State's 1968 antidegradation policy, water quality degradation that is not consistent with the provisions of Resolution No. 68-16 is degradation determined to be significant and unreasonable. Furthermore, the violation of water quality objectives is significant and unreasonable under the State's antidegradation policy. The NCRWQCB and the State Water Board are the two entities that determine if degradation is inconsistent with Resolution No. 68-16.

Federal and state standards for water quality, water quality objectives defined in the Basin Plan, and the management of known and suspected contaminated sites within the Basin will continue to be managed by the relevant agency. The role of the GSA is to provide additional local oversight of groundwater quality, collaborate with appropriate parties to implement water quality projects and actions, and to evaluate and monitor, as needed, water quality effects of projects and actions implemented to meet the requirements of other SMCs.

Sustainable management of groundwater quality includes maintenance of water quality within regulatory and programmatic limits (Section 2.2.2.3) while executing GSP PMAs. To achieve this goal, the GSA will coordinate with the regulatory agencies that are currently authorized to maintain and improve groundwater quality within the Basin. This includes informing the NCRWQCB of any issues that arise and working with NCRWQCB to rectify the problem. All future PMAs implemented by the GSA will be evaluated and designed to avoid causing undesirable groundwater quality outcomes. Historic and current groundwater quality monitoring data and reporting efforts have been used to establish and document conditions in the Basin, as discussed in Section 2.2.2.3. These conditions provide a baseline to compare with future groundwater quality and identify any changes observed due to GSP implementation.

Potential Causes of Undesirable Results

Future GSA activities with potential to affect water quality will be monitored and may include changes in location and magnitude of basin pumping, declining groundwater levels and changes to both planned and incidental groundwater recharge mechanisms. Altering the location or rate of groundwater pumping could change the direction of groundwater flow which may result in a change in the overall direction in which existing or future contaminant plumes move thus potentially compromising ongoing remediation efforts. Similarly, recharge activities could alter hydraulic gradients and result in the downward movement of contaminants into groundwater or move groundwater contaminant plumes towards supply wells.

Land use activities that may lead to undesirable groundwater quality include industrial contamination, pesticides, sewage, animal waste, and other wastewaters, and natural causes. Industrial application of wood preservatives can elevate arsenic. Fertilizers and other agricultural activities can elevate analytes such as nitrate and specific conductivity. Wastewater and animal waste can elevate nitrate, and specific conductivity. The GSA cannot control and is not responsible for natural causes of groundwater contamination but is responsible for how PMAs may impact groundwater quality (e.g., through mobilization of naturally occurring contaminants). Natural causes (e.g., local geology and soils) can elevate analytes such as arsenic and specific conductivity. For further detail, see Section 2.2.2.3.

Groundwater quality degradation associated with known sources will be primarily managed by the entity currently overseeing these sites, the NCRWQCB. In the Basin, existing leaks from under-

ground storage tanks (USTs) are currently being managed, and though additional degradation is not anticipated from known sources, new leaks may cause undesirable results due to constituents that, depending on the contents of an UST, may include petroleum hydrocarbons, solvents, or other contaminants.

Agricultural activities in the Basin are dominated by alfalfa, grain and hay, and strawberry. Alfalfa and pasture production have low risk for fertilizer-associated nitrate leaching into the groundwater (Harter et al. 2017). Grain production is rotated with alfalfa production, usually for one year, after which alfalfa is replanted. Grain production also does not pose a significant nitrate-leaching risk. Animal farming, a common source of nitrate pollution in large, confined animal farming operations, is also present in Butte Valley, but not at stocking densities of major concern (Harter et al. 2017). Strawberry production has a potentially high risk for nitrate leaching (Harter et al. 2017) even using advanced irrigation methods due to its shallow rooting depth (Gardenas et al. 2005; Zaragosa et al. 2017). In Butte Valley, strawberry production focuses on plant propagation of daughter plants, which differs in management from berry production. They are regularly grown in a three-year rotation with a grain crop (low nitrate leaching risk) and fallowing (low nitrate leaching risk). With respect to arsenic, a DWR study suggested that the contamination near Dorris stemmed from an unknown historical industrial source (DWR 1968).

3.4.3.2 Maximum Thresholds

MTs for groundwater quality in the Basin were defined using existing groundwater quality data, beneficial uses of groundwater in the basin, existing regulations, including water quality objectives under the Basin Plan, Title 22 Primary Maximum contaminant levels (MCLs), and Secondary MCLs, and consultation with the GSA advisory committee and stakeholders (see Section 2.2.2.3.). Resulting from this process, SMCs were developed for three constituents of concern in the Basin: arsenic, nitrate, and specific conductivity. Although 1,2 Dibromoethane (ethylene dibromide; EDB) and benzene are identified as a potential constituent of concern in Section 2.2.2.3, no SMC is defined for either constituent as current 1,2 Dibromoethane and benzene data are associated with leaking underground storage tanks (LUST) where the source is known and monitoring and remediation are in progress. These sites will be taken into consideration with PMAs undertaken by the GSA, as applicable. Boron does not have an SMC because it is naturally occurring.

The selected MTs for the concentration of each of the three constituents of concern and their associated regulatory thresholds are shown in Table 3.6.

Triggers

The GSA will use concentrations of the identified constituents of concern as triggers for preventive action, in order to proactively avoid the occurrence of undesirable results. Trigger values and associated definitions for specific conductivity are the values and definitions listed in the Basin Plan. The Basin Plan specifies two upper limits for specific conductivity, a 50% upper limit, or 50 percentile value of the monthly means for a calendar year and a 90% upper limit or 90 percentile values for a calendar year. The Title 22 water quality objectives for the remaining analytes are incorporated by reference into the Basin Plan and the triggers provided in Table 3.6 correspond to half and 90% of the Title 22 MCL.

Method for Quantitative Measurement of Maximum Thresholds

Groundwater quality will be measured in representative monitoring wells as discussed in Section 3.3.3. Statistical evaluation of groundwater quality data obtained from available water quality data obtained from the monitoring network will be performed and evaluated using a water quality value using the equation above. The MT for concentration values are shown in Table 3.6. Figure 3.10 shows example “thermometers” for each of the identified constituents of concern in Butte Valley groundwater basin with the associated MT, range of MO, and triggers.

Table 3.6: Constituents of concern and the associated maximum thresholds. Maximum thresholds also include a 15 percent average increase per year over 10 years in no more than 25 percent of wells, and no more than 25 percent of wells exceeding the MT for the concentration listed here.

Constituent	Maximum Threshold	Regulatory Threshold
Arsenic (only wells near Dorris)	5 µg/L, trigger only	10 µg/L (Title 22)
	9 µg/L, trigger only	
	10 µg/L, MT	
Nitrate as Nitrogen	5 mg/L, trigger only	10 mg/L (Title 22)
	9 mg/L, trigger only	
	10 mg/L, MT	
Specific Conductivity	250 micromhos, trigger only	250 micromhos (Basin Plan Upper Limit – 50% of monthly means in a calendar year must be less or equal to 250 micromhos)
	500 micromhos, trigger only	500 micromhos (Basin Plan Upper Limit - 90% of samples in a calendar year must be less or equal to 500 micromhos)
	900 micromhos, MT	900 micromhos (Title 22)

3.4.3.3 Measurable Objectives

MOs are defined under SGMA as described above in Section 3.1. Within the Basin, the MOs for water quality are established to provide an indication of desired water quality at levels that are sufficiently protective of beneficial uses and users. MOs are defined on a well-specific basis, with consideration for historical water quality data.

Description of Measurable Objectives

The groundwater quality MOs for wells within the GSA monitoring network, where the concentrations of constituents of concern historically have been below the MTs for water quality in recent years, is to continue to maintain concentrations at or below the current range, as measured by long-term trends. To establish a quantitative MO that protects uses and users from unreasonable water quality degradation, the GSA has decided to establish a list of constituents of concern (COCs). The MO is defined using those COCs, which include arsenic, nitrate, and specific conductivity.

Specifically, for these COCs, the MO is to maintain groundwater quality at a minimum of 75% of wells monitored for water quality within the range of the water quality levels measured over the past 30 years (1990 to 2020). In addition, no significant increasing long-term trends should be observed in levels of constituents of concern.

3.4.3.4 Path to Achieve Measurable Objectives

The GSA will support the protection of groundwater quality by monitoring groundwater quality conditions and coordinating with other regulatory agencies that work to maintain and improve the groundwater quality in the Basin. All future PMAs implemented by the GSA will comply with State and Federal water quality standards and Basin Plan water quality objectives and will be designed to maintain groundwater quality for all uses and users and avoid causing unreasonable groundwater quality degradation. The GSA will review and analyze groundwater monitoring data as part of GSP implementation in order to evaluate any changes in groundwater quality resulting from groundwater pumping or recharge projects (anthropogenic recharge) in the Basin. The need for additional studies on groundwater quality will be assessed throughout GSP implementation. The GSA may identify knowledge requirements, seek funding, and help to implement additional studies.

Using monitoring data collected as part of project implementation, the GSA will develop information (e.g., time-series plots of water quality constituents) to demonstrate that PMAs are operating to maintain or improve groundwater quality conditions in the Basin and to avoid unreasonable groundwater quality degradation. Should the concentration of a constituent of interest increase to its MO (or a trigger value below that objective specifically designated by the GSA) as the result of GSA project implementation, the GSA will implement measures to address this occurrence. This process is illustrated in Figure 3.11.

If a degraded water quality trigger is exceeded, the GSA will investigate the cause and source and implement MAs as appropriate. Where the cause is known, PMAs with stakeholder education and outreach will be implemented. Examples of possible GSA actions include notification and outreach with impacted stakeholders, alternative placement of groundwater recharge projects, and coordination with the appropriate water quality regulation agency. PMAs are presented in further detail in Chapter 4.

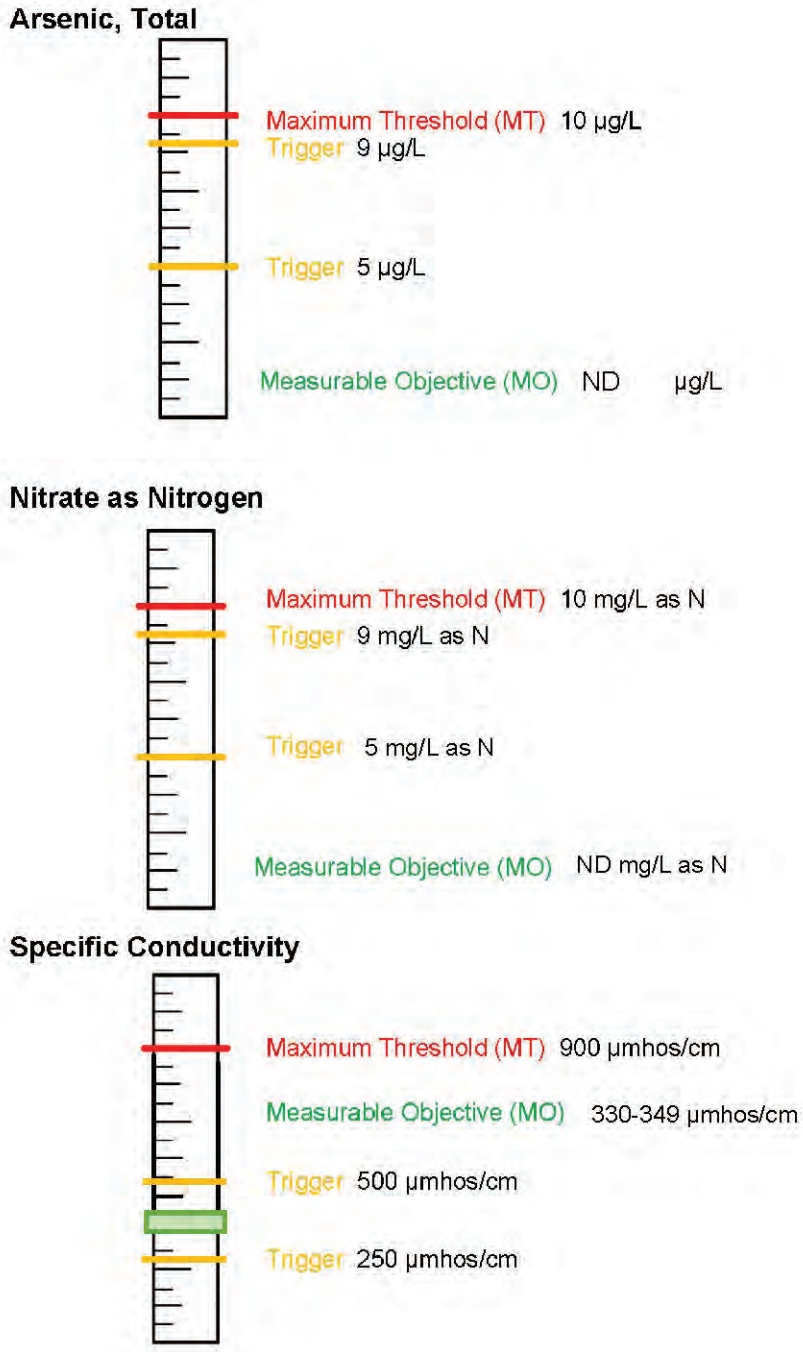


Figure 3.10: Visual Representation of the SMCs of Arsenic, Nitrate, and Specific Conductivity for Well 4710001-003 of the Monitoring Network. MOs are specific to each well in the monitoring network. If the measurable objective is higher than one of the triggers, then that particular trigger is not applicable to that well.

Exceedances of arsenic, nitrate, and specific conductivity will be referred to the NCRWQCB. Where the cause of an exceedance is unknown, the GSA may choose to conduct additional or more frequent monitoring.

Interim Milestones

As existing groundwater quality data indicate that groundwater in the Basin generally meets applicable state and federal water quality standards, the objective is to maintain existing groundwater quality. Interim milestones are therefore set equivalent to the MOs with the goal of maintaining water quality within the historical range of values.

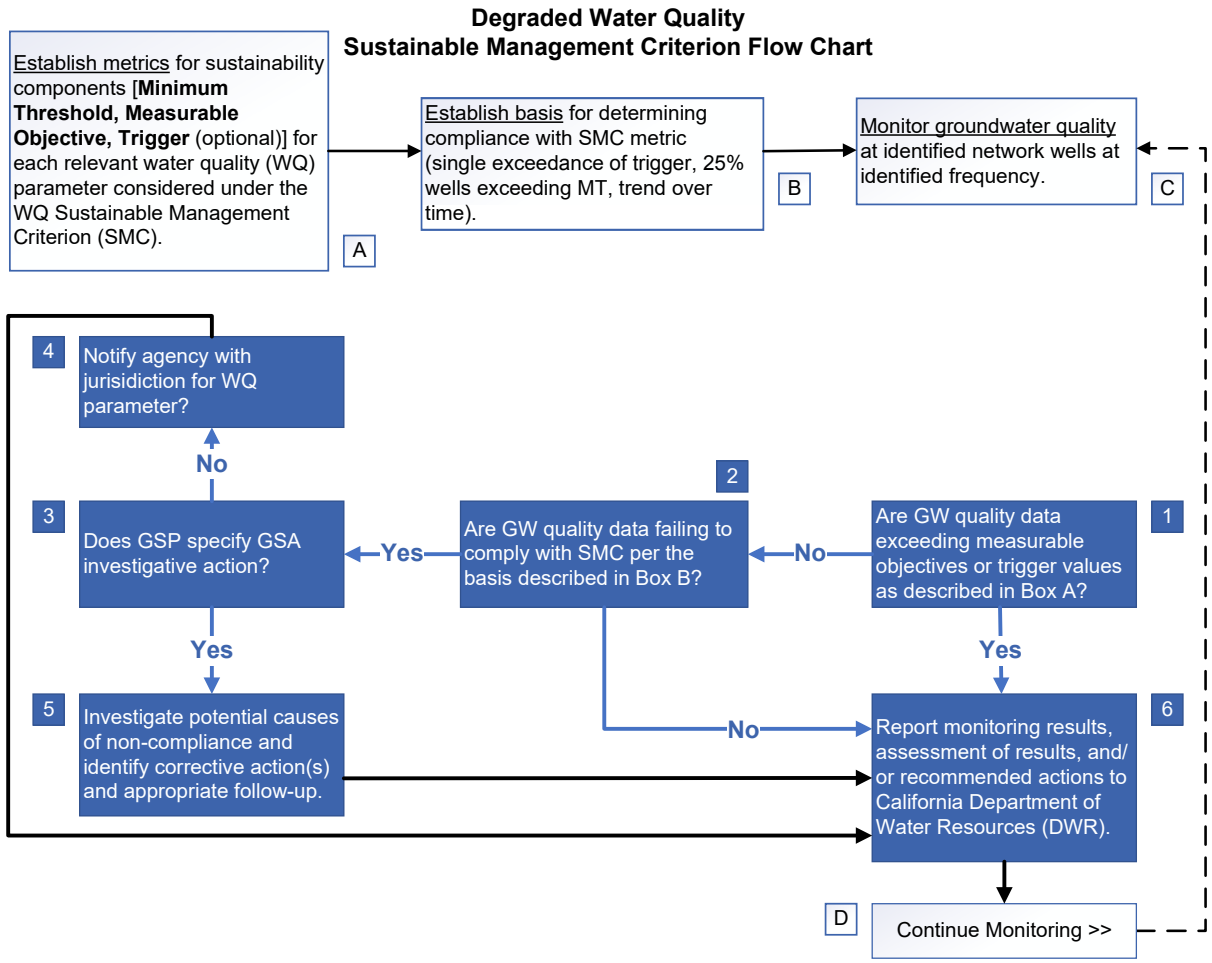


Figure 3.11: Degraded SMC criteria flow chart. The flow chart depicts the high-level decision making that goes into developing SMC, monitoring to determine if criteria are met, and actions to be taken based on monitoring results.

3.4.3.5 Effects on Beneficial Uses and Users

Concerns over potential or actual non-attainment of the beneficial uses designated for groundwater in the Basin are and will continue to be related to certain constituents measured at elevated or increasing concentrations, and the potential local or regional effects that degraded water quality have on such beneficial uses.

The following provides greater detail regarding the potential impact of poor groundwater quality on several major classes of beneficial users:

- **Municipal Drinking Water Users** - Under California law, agencies that provide drinking water are required to routinely sample groundwater from their wells and compare the results to state and federal drinking water standards for individual chemicals. Groundwater quality that does not meet state drinking water standards may render the water unusable or may cause increased costs for treatment. For one municipal supplier in the Basin, shallow impacted wells forced the city to develop a new supply well to access deep unaffected groundwater (Bray & Associates 2015).
- **Rural and/or Agricultural Residential Drinking Water Users** - Residential structures not located within the service areas of the local municipal water agency will typically have private domestic groundwater wells. Such wells may not be monitored routinely and groundwater quality from those wells may be unknown unless the landowner has initiated testing and shared the data with other entities. Degraded water quality in such wells can lead to rural residential use of groundwater that does not meet potable water standards and results in the need for installation of new or modified domestic wells and/or well-head treatment that will provide groundwater of acceptable quality.
- **Agricultural Users** - Irrigation water quality is an important factor in crop production and has a variable impact on agriculture due to different crop sensitivities. Impacts from poor water quality may include declines in crop yields, crop damage, or alter which crops can be grown in the area.
- **Environmental Uses** - Poor quality groundwater may result in migration of contaminants which could impact GDEs or instream environments, and their resident species, to which groundwater contributes.

3.4.3.6 Relationship to Other Sustainability Indicators

Groundwater quality cannot typically be used to predict responses of other sustainability indicators. However, groundwater quality may be affected by groundwater levels and reductions in groundwater storage. In addition, certain implementation actions may be limited by the need to achieve MTs for other sustainability indicators.

- **Groundwater Levels** - Declining water levels can potentially lead to increased concentrations of constituents of concern in groundwater and may alter the existing hydraulic gradient and result in movement of contaminated groundwater. Changes in water levels may also mobilize contaminants that may be present in unsaturated soils. The MTs established for groundwater quality may influence groundwater level MTs by affecting the location or number of projects, such as groundwater recharge, in order to avoid degradation of groundwater quality.

- **Groundwater Storage** - The groundwater quality MTs will not cause groundwater pumping to exceed the sustainability yield and therefore will not cause exceedances of the groundwater storage MTs.
- **Depletion of Interconnected Surface Waters** - The groundwater quality MT does not promote additional pumping or lower groundwater levels near interconnected surface waters. The groundwater quality MT does not negatively affect ISWs.
- **Seawater Intrusion** - This sustainability indicator is not applicable in this Basin.
- **Subsidence** - The groundwater quality MT does not promote additional pumping or lower groundwater levels and therefore does not interfere with the subsidence MT.

3.4.3.7 Information and Methodology Used to Establish Maximum Thresholds and Measurable Objectives

The constituents for which SMC were considered were specifically selected due to measured exceedances in the past 30 years, known groundwater contamination at LUST sites, and/or stakeholder input and prevalence as a groundwater contaminant in California. A detailed discussion of the concerns associated with elevated levels of each constituent of interest is described in Section 2.2.2.3. As the constituents of concern were identified using current and historical groundwater quality data, this list may be reevaluated during future GSP updates. In establishing MT for groundwater quality, the following information was considered:

- Feedback about water quality concerns from stakeholders.
- An assessment of available historical and current groundwater quality data from production and monitoring wells in the Basin.
- An assessment of historical compliance with Federal and state drinking water quality standards and water quality objectives.
- An assessment of trends in groundwater quality at selected wells with adequate data to perform the assessment.
- Information regarding sources, control options and regulatory jurisdiction pertaining to constituents of concern.
- Input from stakeholders resulting from the consideration of the above information in the form of recommendations regarding MTs and associated MAs.

The historical and current groundwater quality data used in the effort to establish groundwater quality MTs are discussed in Section 2.2.2.3. Based on a review of these data, applicable water quality regulations, Basin water quality needs, and information from stakeholders, the GSA reached a determination that the state drinking water standards (MCLs and water quality objectives [WQOs]) are appropriate to define MTs for groundwater quality. These MTs are summarized in Table 3.6. The established MTs for groundwater quality protect and maintain groundwater quality for existing or potential beneficial uses and users. For most analytes, the MTs align with the state standards listed in Title 22 of the California Code of Regulations (CCR), which lists the state regulations for drinking water.

New constituents of concern may be added with changing conditions and as new information becomes available.

3.4.4 Subsidence

3.4.4.1 Undesirable Results

An undesirable result occurs when subsidence substantially interferes with beneficial uses of groundwater and land uses. Subsidence occurs as a result of compaction of fine-grained aquifer materials (i.e., clay) due to the overdraft of groundwater. The fine-grained sediment in the lake deposits may have some land subsidence risk when groundwater levels drop. Undesirable results would occur when substantial interference with land use occurs, including significant damage to critical infrastructure such as canals, pipes, or other water conveyance facilities, including flooding agricultural practices. As there has not been any historical documentation of subsidence in the Basin, it is reasonable to declare that measurable land subsidence caused by the chronic lowering of groundwater levels occurring in the Basin would be considered an unreasonable result. This is quantified as pumping induced subsidence greater than the minimum threshold of 0.1 feet (0.03 meters) in any single year, essentially zero subsidence accounting for measurement error.

3.4.4.2 Minimum Thresholds

The MT for land subsidence in the Basin is set at no more than 0.1 feet (0.03 meters) in any single year, resulting in no long-term permanent subsidence. This is set at the same magnitude of estimated error in the InSAR data (+/- 0.1 feet [0.03 meters]), which is currently the only tool available for measuring basin-wide land subsidence consistently each year in the Basin.

The MTs selected for land subsidence for the Basin area were selected as a preventative measure to ensure the maintenance of current ground surface elevations and as an added safety measure for potential future impacts not currently present in the Basin and nearby groundwater Basins. This avoids significant and unreasonable rates of land subsidence in the Basin, which are those that would lead to a permanent subsidence of land surface elevations that would impact infrastructure and agricultural production in Butte Valley and neighboring groundwater Basins. There are currently no other state, federal, or local standards that relate to this sustainability indicator in the Basin.

3.4.4.3 Measurable Objectives

MOs are defined under SGMA as described above in Section 3.1. Within the Basin, the MO for subsidence is established to protect beneficial uses and users. The guiding MO of this GSP for land subsidence in the Basin is the maintenance of current ground surface elevations. This MO avoids significant and unreasonable rates of land subsidence in the Basin, which are those that lead to a permanent subsidence of land surface elevations that impact infrastructure and agricultural production.

The lake sediments in Butte Valley offer some land subsidence risk; however, there is no historical record of subsidence in the Basin (see Section 2.2.2.5). Recent InSAR data show no significant subsidence occurring during the period of mid-June 2015 to mid-September 2019 (see Figure 2.25 in Chapter 2).

Land subsidence in the Basin is expected to be managed through the implementation period via the sustainable management of groundwater pumping through the groundwater level MO, MT, and

interim milestones. The margin of safety for the subsidence MO was established by setting a MO to maintain current land surface elevations and opting to monitor subsidence throughout the GSP implementation period. This is a reasonable margin of safety based on the past and current aquifer conditions (see Section 2.2.2.5).

3.4.4.4 Path to Achieve Measurable Objectives

Land subsidence in the Basin will be quantitatively measured by use of InSAR data (DWR-funded TRE ALTAMIRA or other similar data products). If there are areas of concern for inelastic subsidence in the Basin (i.e., exceedance of MTs) observed in the InSAR data, then ground-truthing studies could be conducted to determine if the signal is potentially related to changes in land use or agricultural practices, or from groundwater extraction. If subsidence is determined to result from groundwater extraction, then ground-based elevation surveys might be needed to monitor the situation more closely. At each interim milestone, subsidence data will be reviewed for yearly and five-year subsidence rates to assess continued compliance with the MT.

3.4.4.5 Effects of Undesirable Results on Beneficial Uses and Users

Subsidence can result in substantial interference with land use including significant damage to critical infrastructure such as canals, pipes, or other water conveyance facilities, as well as breaking of building foundations and tilting of structures. Other effects include flooding of land, including residential and commercial properties, and negative impacts on agricultural operations. Subsidence is closely linked with declining groundwater levels: a decline in groundwater levels can trigger land subsidence.

3.4.4.6 Relationship to Other Sustainability Indicators

Managing groundwater pumping and avoiding the undesirable result of chronic lowering of groundwater levels will reduce the risk of land subsidence. Additionally, land subsidence directly causes a reduction in groundwater storage.

Chapter 4

Project and Management Action

4.1 INTRODUCTION AND OVERVIEW

To achieve this Plan's sustainability goal by 2042 and avoid undesirable results as required by Sustainable Groundwater Management Act (SGMA) regulations, multiple projects and management actions (PMAs) have been developed for implementation by the groundwater sustainability agency (GSA). This section provides a description of PMAs necessary to achieve and maintain the Butte Valley groundwater basin (Basin) sustainability goal and to respond to changing conditions in the Basin. PMAs are described in accordance with §354.42 and §354.44 of the SGMA regulations. Projects generally refer to infrastructure features and other capital investments, their planning, and their implementation, whereas management actions are typically programs or policies that do not require capital investments, but are geared toward engagement, education, outreach, changing groundwater use behavior, adoption of land use practices, etc. PMAs discussed in this section will help achieve and maintain the sustainability goal and measurable objectives (MO), and avoid the undesirable results identified for the Basin in Chapter 3. These efforts will be periodically assessed during the implementation period, at minimum every five years (see Chapter 5).

In developing PMAs, priorities for consideration include effectiveness toward maintaining the sustainability of the Basin, minimizing impacts to the Basin's economy, seeking cost-effective solutions for external funding and prioritizing voluntary and incentive-based programs over mandatory programs. As the planned or proposed PMAs are at varying stages of development, complete information on construction requirements, operations, permitting requirements, overall costs, and other details are not uniformly available.

A description of the operation of PMAs as part of the overall GSP implementation is provided in Chapter 5. After GSP adoption, the GSA will prioritize certain PMAs for feasibility reviews and preliminary engineering studies. Based on review and study results, PMAs may move forward to implementation.

In Butte Valley, the PMAs are designed to achieve three major objectives:

- To prevent chronic lowering of groundwater levels.
- To protect wells from outages.
- To protect beneficial users of groundwater.

The identified PMAs reflect a range of options to achieve the goals of the GSP and will be completed through an integrative and collaborative approach with other agencies, landowners, beneficial users, and stakeholders. Few PMAs will be implemented by the GSA alone. The GSA considers itself to be one of multiple parties collaborating to achieve overlapping, complementary, and multi-benefit goals across the integrated water and land use management nexus in the Basin. Furthermore, PMAs related to water quality will be most successful if implemented to meet the multiple objectives of collaborating partners. For many of the PMAs, the GSA will enter into informal or formal partnerships with other agencies, non-governmental organizations (NGOs), or individuals. These partnerships may take various forms, from GSA participation in informal technical or information exchange meetings, to collaborating on third-party proposals, projects, and management actions, to leading proposals and subsequently implementing PMAs.

The GSA and individual GSA partners will have varying but clearly identified responsibilities with respect to permitting and other specific implementation oversight. These responsibilities may vary from PMA to PMA or even within individual phases of a PMA. Inclusion in this GSP does not

forego any obligations under local, state, or federal regulatory programs. Inclusion in this GSP also does not assume any specific project governance or role for the GSA. While the GSA does have an obligation to oversee progress towards groundwater sustainability, it is not the primary regulator of land use, water quality, or environmental project compliance. It is the responsibility of the implementing partner agency to collaborate with appropriate regulatory agencies to ensure that the PMAs for which the lead agency is responsible are in compliance with all applicable laws. The GSA may choose to collaborate with regulatory agencies on specific overlapping interests such as water quality monitoring and oversight of projects developed within the Basin.

PMAs are classified under four categories: demand management for groundwater, supply augmentation, habitat improvement, and groundwater recharge. Demand management projects reduce the demand for groundwater and can include projects such as irrigation efficiency improvements. Surface water supply augmentation projects contribute to increases in surface water in the Basin. Habitat improvement projects can include restoration and upland management projects and groundwater recharge projects. Examples of project types within these three categories are shown in Table 4.1. Further, PMAs are organized into three tiers reflective of their timeline for implementation:

1. **TIER I**: Existing PMAs that are currently being implemented and are anticipated to continue to be implemented.
2. **TIER II**: PMAs planned for near-term initiation and implementation (2022 to 2027) by individual member agencies.
3. **TIER III**: Additional PMAs that may be implemented in the future, as necessary (initiation and/or implementation 2027 to 2042).

A general description of existing and ongoing (Tier I) PMAs are provided in Section 4.2, Tier II PMAs in Section 4.3, and Tier III PMAs in Section 4.4. The process of identifying, screening, and finalizing PMAs is illustrated in Figure 4.1. Existing and planned projects were first identified from different through review of reports, documents, and websites. Planned and new projects also received stakeholder input in their identification. These projects were then categorized into the three categories: supply augmentation, demand management, stream habitat improvement, and groundwater recharge. In the next step, all projects were evaluated to identify those with the highest potential to be included in the GSP. Using the Butte Valley Integrated Hydrogeological Model (BVIHM), the effectiveness of each project, or a combination of projects, will be assessed to identify those projects that, if implemented, will bring the Basin into sustainability. Monitoring will be a critical component in evaluating PMA benefits and measuring potential impacts from PMAs. More details on how projects will be evaluated and a road map to discuss feasibility and potential for success of each project (or a combination of projects) is presented in Chapter 5.

Funding is an important part of successfully implementing a PMA. The ability to secure funding is an important component in the viability of implementing a particular PMA. Funding sources may include grants or other fee structures (Appendix 5-C). Under the Sustainable Groundwater Management Implementation Grant Program Proposition 68, grants can be awarded for planning activities and for projects with a capital improvement component. As such, funds for reimbursing landowners for implementation of PMAs, including land fallowing and well-shut offs, currently cannot be obtained under this program. Funding will also be sought from other local, state, federal, and private (NGO) sources.

The existing PMAs have been extracted from the following documents:

- Supply Enhancement (in Streams)
  - Butte Valley Wildlife Area (BVWA) / California Department of Fish and Wildlife (CDFW)
  - United States Forest Service (USFS) website
- Demand Management (of Groundwater)
  - City of Dorris
  - County of Siskiyou General Plan
  - Siskiyou County Code of Ordinances
  - Permit required for groundwater extraction for use outside the basin from which it was extracted (Title 3, Chapter 13 - Groundwater Management, Siskiyou County Code of Ordinances)
  - Siskiyou County Groundwater Use Ordinance (Title 3, Chapter 13, Article 7 - Waste and Unreasonable Use, Siskiyou County Code of Ordinances)
  - Well Drilling Permits
    - Siskiyou County Well Drilling Permits (Standards for Wells, Title 5, Chapter 8 of Siskiyou County Code of Ordinances)
- Recharge
  - Existing reports, proposals

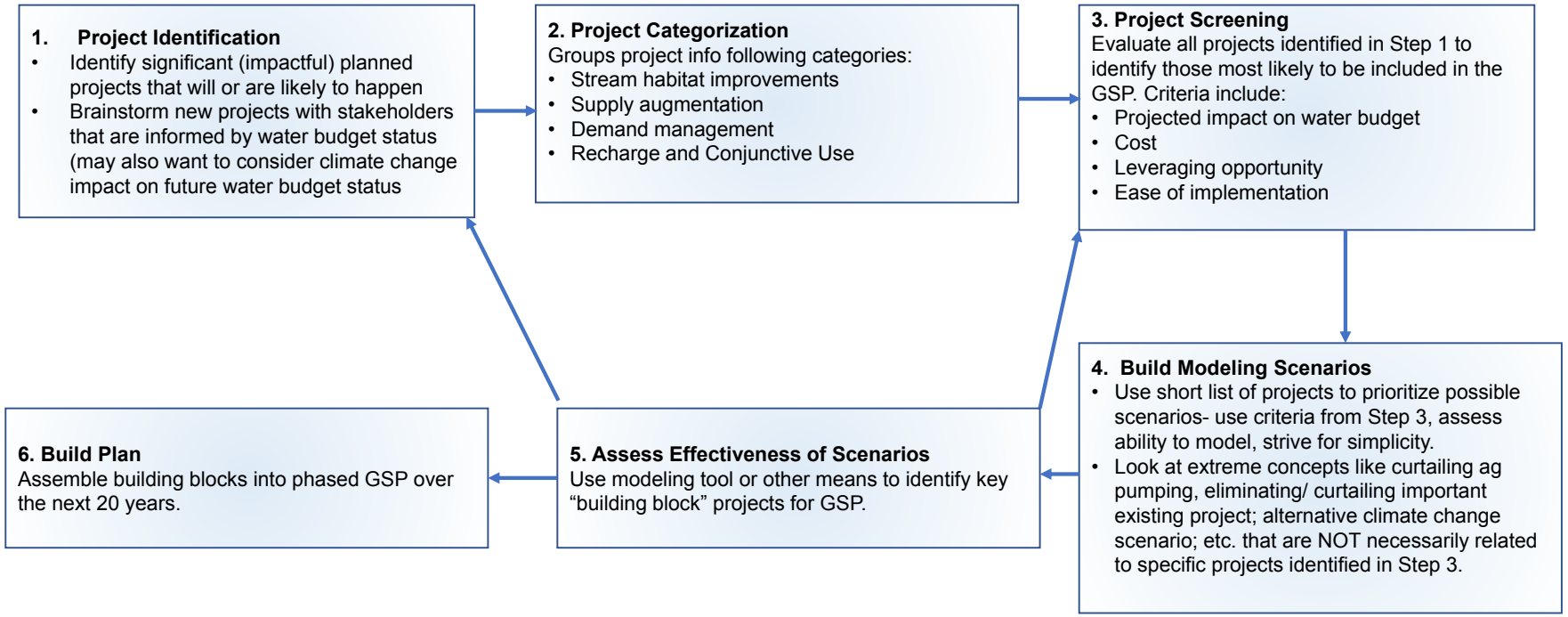


Figure 4.1: Process for identification and prioritization of PMAs. Further details, such as authority and finalized prioritization, are shown in Chapter 5.

Table 4.1: Projects and Management Actions Summary.

Tier	Title	Description	Lead Agency	Category	Status	Anticipated Timeframe	Targeted Sustainability Indicator(s) / Benefits
	Tier I PMAs						
I	Well Drilling Permits	Siskiyou County Well Drilling Permits (Standards for Wells, Title 5, Chapter 8 of Siskiyou County Code of Ordinances). Location limitations for new wells with respect to the interconnected zone (per Scott River Adjudication Decree No. 30662).	County of Siskiyou	Demand Management	Existing/ Ongoing	Active	Groundwater levels, Interconnected surface water.
I	Groundwater Use Restrictions	Prohibition of the use of groundwater underlying Siskiyou County for cannabis cultivation (Article 7, Chapter 13, Title 3 of Siskiyou County Code of Ordinances).	County of Siskiyou	Demand Management	Existing/ Ongoing	N/A	Groundwater levels
I	Permit required for groundwater extraction for use outside the basin from which it was extracted (Siskiyou County Code of Ordinances)	Permit requirement for extraction of groundwater underlying the Basin for use outside the Basin.	County of Siskiyou	Demand Management	Existing/ Ongoing	Active	Groundwater levels
I	Abandonment of Sam's Neck Flood Control Facility	Expand the wetlands in the Butte Valley Wildlife Area to store all Meiss Lake floodwater and eliminate the need for the Sam's Neck Flood Control Facility.	CDFW	Supply Enhancement	Completed	Completed	Groundwater levels

Table 4.1: Projects and Management Actions Summary. *(continued)*

Tier	Title	Description	Lead Agency	Category	Status	Anticipated Timeframe	Targeted Sustainability Indicator(s) / Benefits
I	City of Dorris Water Conservation	Water conservation measures outlined in the City of Dorris Municipal Code	City of Dorris	Demand Management	Active	Active	Groundwater levels
I	Groundwater Use Restrictions	Prohibition of the use of groundwater underlying Siskiyou County for cannabis cultivation (Article 7, Chapter 13, Title 3 of Siskiyou County Code of Ordinances).	County of Siskiyou	Demand Management	Existing/ Ongoing	N/A	Groundwater levels
I	Kegg Meadow Enhancement and Butte Creek Channel Restoration	Restoration of a properly functioning, resilient wetland ecosystem and aquatic habitat in Kegg Meadow by returning streamflow to the original meadow/channel elevations. Reverting stream to original channel will rewet overall meadow and restore riparian habitat. The site is 1 to 2 acres in size.	USFS	Supply Enhancement	Completed	Completed	1. Habitat restoration 2. Groundwater recharge
I	Permit required for groundwater extraction for use outside the basin from which it was extracted (Siskiyou County Code of Ordinances)	Permit requirement for extraction of groundwater underlying the Basin for use outside the Basin.	County of Siskiyou	Demand Management	Active	Active	Groundwater levels

Table 4.1: Projects and Management Actions Summary. *(continued)*

Tier	Title	Description	Lead Agency	Category	Status	Anticipated Timeframe	Targeted Sustainability Indicator(s) / Benefits
I	Upland Management	Upland management includes removal of excess vegetation. This can occur on US Forest Service, Bureau of Land Management, or private land.	USFS	Supply Enhancement	Active	Active	1. Improved groundwater recharge 2. Raise groundwater elevations 3. Improved habitat
I	Watermaster Butte Creek Flow Management	A Watermaster manages flow of Butte Creek into Butte Valley.	GSA/ USFS	Supply Enhancement	Active	Active	1. Groundwater Recharge 2. Flood control
	Tier II PMAs						
II	(High Priority) Data Gaps and Data Collection	Series of high priority actions to address data gaps during GSP implementation to prepare for GSP updates in 2027.	GSA	GSA Implementation	Planning Phase	Implementation, applying for funding	GSA Implementation
II	Avoiding Significant Increase of Total Net Groundwater Use from the Basin	Avoid significant future expansion of total net consumptive water use within the Basin and its surrounding watershed through planning and coordination	GSA, County of Siskiyou, local land use zoning agencies	Demand Management	Planning Phase	No later than January 31, 2024	Groundwater levels

Table 4.1: Projects and Management Actions Summary. *(continued)*

Tier	Title	Description	Lead Agency	Category	Status	Anticipated Timeframe	Targeted Sustainability Indicator(s) / Benefits
II	Dorris Water Meter Installation Project	The City of Dorris is upgrading their water system by installing water meters and replacing old pipelines.	City of Dorris	Demand Management	Invitation for Bids sent out Feb 2021. Contractor proposals due March 18, 2021	Planning Phase	Groundwater levels
II	Irrigation Efficiency Improvements	Increase irrigation efficiency (and in some cases, yields) through infrastructure or equipment improvements. This PMA will focus on low efficiency practices. Exceptions may include landowners that have already implemented irrigation efficiency improvements and best management practices.	GSA	Demand Management	Planning Phase	Planning Phase	Groundwater levels
II	Public Outreach	Public outreach and education for GSA stakeholders.	GSA	GSA Implementation	Planning Phase	Implementation	GSA Implementation
II	Voluntary Managed Land Repurposing	Reduce water use through other voluntary managed land repurposing activities including term contracts, crop rotation, irrigated margin reduction, conservation easments, and other uses	GSA, TBD	Demand Management	Conceptual Phase	Conceptual phase	Groundwater levels

Table 4.1: Projects and Management Actions Summary. *(continued)*

Tier	Title	Description	Lead Agency	Category	Status	Anticipated Timeframe	Targeted Sustainability Indicator(s) / Benefits
II	Well Replacement	Monetary compensation for replacing groundwater levels in cases of well outage due to dropping groundwater levels. This management action is intended to be activated in support of the groundwater level SMC. This only applies to wells within the GSA border.	GSA	Demand Management	Planning Phase	Planning Phase	Groundwater levels
II	Well Inventory Program	Improve the GSA database of wells within the Basin.	GSA	GSA Implementation	Planning Phase	Planning Phase	GSA Implementation
	Tier III PMAs						
III	Alternative, lower ET crops	Pilot programs on introducing alternative crops with lower ET but sufficient economic value. Incentivize and provide extension on long-term shift to lower ET crops.	GSA, UCCE, TBD	Demand Management	Conceptual Phase	Conceptual Phase	Groundwater levels
III	Butte Creek Diversion Relocation	Move the diversion of Butte Creek to Cedar Lake/Dry Lake	GSA/ USFS	Supply Enhancement	Conceptual Phase	Conceptual Phase	Groundwater levels
III	Butte Valley National Grassland Groundwater Recharge Project	Explore recharge benefits in National Grasslands from Meiss Lake overflow.	GSA/ USFS	Recharge	Conceptual Phase	Conceptual Phase	Groundwater levels

Table 4.1: Projects and Management Actions Summary. *(continued)*

Tier	Title	Description	Lead Agency	Category	Status	Anticipated Timeframe	Targeted Sustainability Indicator(s) / Benefits
III	Strategic Groundwater Pumping Restriction	Strategic timing of groundwater pumping curtailments. This management action would only be developed if Tier I and Tier II PMAs are insufficient. It would be an alternative for the GSA in support of the groundwater level SMC.	GSA	Demand Management	Conceptual Phase	Conceptual Phase	Groundwater levels

4.2 TIER I: EXISTING OR ONGOING PROJECTS AND MANAGEMENT ACTIONS

As shown in Table 4.1 there are multiple existing and ongoing PMAs in the Basin (Tier I). The Basin has a range of existing PMAs in place to provide demand management, supply enhancement, and recharge.

Abandonment of Sam's Neck Flood Control Facility

Historically the Sam's Neck Flood Control Facility has pumped flood waters of Meiss Lake to the Klamath River. The long-term goal of the Butte Valley Wildlife Area (BVWA) and County is to eliminate the need for the Sam's Neck pumping project and instead use the flood waters to create and maintain wetland habitat. BVWA had a memorandum of understanding with Siskiyou County to utilize as much creek and lake water as possible for wetlands to minimize pumping to the Klamath River. In 2017, the County sent a formal request to the United States Army Corps of Engineers to abandon the Sam's Neck Flood Control Facility (Kit Novick 1996; County of Siskiyou 2017).

Benefits of this project include:

- Meiss Lake flood waters are kept within the Basin for groundwater recharge instead of being pumped to the Klamath River.
- Increased habitat for wildlife.
- New flood control mechanism for Butte Valley.

City of Dorris Water Conservation

The City of Dorris Municipal Code (Title 13, Chapter 5) outlines water conservation regulations. The City's Public Works Director (Director) determines the extent of conservation required based on the projected supply and demand of customers. Through a public announcement and notice, the Director orders the implementation or termination of water conservation stages. These stages range from "voluntary compliance" to "mandatory compliance – water emergency" and restricts activities such as lawn watering, landscape irrigation, mobile washing (cars, boats, airplanes), non-emergency fire hydrant use, pavement washing, serving water in restaurants, and ornamental fountains. More severe stages restrict new permits for unmetered water service, limited water for construction, no water for air conditioning purposes, and water for commercial, manufacturing, and processing purposes cut 50% by volume.

Well Drilling Permits and County of Siskiyou Groundwater Use Restrictions

There are several existing regulations that are included in the demand management category of PMAs. These include the permitting requirements for new wells, as detailed in Title 5, Chapter 8 of the Siskiyou County Code of Ordinances. Siskiyou County also has ordinances that require permitting for extraction of groundwater underlying the Basin for use outside the Basin (per Title 3, Chapter 13) and a prohibition on wasting groundwater with underlying Siskiyou County for use

cannabis cultivation (Article 7, Chapter 13, Title 3 of Siskiyou County Code of Ordinances). Providing demand management, this management action (MA) benefits sustainability multiple indicators, including declining groundwater levels, groundwater storage, and depletion of interconnected surface waters (ISWs).

Kegg Meadow Enhancement and Butte Creek Channel Restoration

This project is an example of wetland reconstruction and groundwater recharge using Butte Creek surface waters. The location of the project is outside the Basin along Butte Creek between Mt Hebron and Orr Mountain. The project returns streamflow to the original Butte Creek channel to rewet Kegg Meadow, restore riparian habitat, and locally raise groundwater levels. Kegg Meadow was damaged by channel diversion of Butte Creek to new stream channels in the 1930s. Construction returned streamflow to 2,000 feet of historical channel and 1,400 of prior channel was abandoned and converted into a permanent wetland feature. Willow cuttings were planted along the rewetted historic channel to increase habitat and utilize the raised groundwater levels. Construction was completed in 2013 (Bell and Harrington 2011; NCRWQCB 2013).

Permit required for groundwater extraction for use outside the basin from which it was extracted (Siskiyou County Code of Ordinances)

Permit requirement for extraction of groundwater underlying the Basin for use outside the Basin (Article 1, Chapter 13, Title 3 of Siskiyou County Code of Ordinances):[1]

It is unlawful for any person, firm, corporation, or governmental agency (except an agency of the United States, to the extent, if any, that federal law preempts this chapter) to extract groundwater by any artificial means from any of the groundwater basins underlying the County, directly or indirectly, for use outside the basin from which it was extracted, without first obtaining a written permit as provided in this chapter.

Upland Management

Upland management includes removal of excess vegetation, to reduce evapotranspiration and increase rainfall percolation to groundwater. This can occur on USFS, Bureau of Land Management (BLM), or private land.

The USFS regularly manages sections of USFS land and current active projects within the Butte Valley watershed (Watershed) includes the Harlan Project, through the Klamath National Forest Goosenest Ranger District (USFS 2021). The project will complete vegetation management and fuel reduction with an emphasis on improving forest resilience to wildfire, insects and disease, while improving mule deer habitat. The project will treat 21,000 acres in an area five miles northwest of Tennant. Implementation of the Harlan Project was given permission to proceed on Feb 9, 2021.

[1] {https://library.municode.com/ca/siskiyou_county/codes/code_of_ordinances?}

Watermaster Butte Creek Flow Management

A watermaster manages flow of Butte Creek into Butte Valley and the Butte Creek diversion of flood waters to Cedar Lake / Dry Lake, a bedrock fracture that recharges the Butte Valley Basalt aquifer (County of Siskiyou 1996). The diversion of Butte Creek restricts stream flow to less than 25 cubic feet per second (cfs), with excess water diverted to a Cedar Lake / Dry Lake. Streamflow of Butte Creek is a data gap so the frequency of diversion use is unknown. Two flood events have occurred recently that exceeded several hundred cfs (Todd Sloat Biological Consulting 2012). After diverted Butte Creek water is recharged into groundwater at Cedar Lake/Dry Lake, the direction of this groundwater recharge is unknown and a data gap (ie., Butte Valley or Red Rock groundwater basins). See section “Tier III - Butte Creek Diversion Relocation” for more information on the Butte Creek diversion.

4.3 TIER II: PLANNED PROJECTS AND MANAGEMENT ACTIONS

Tier II PMAs, planned for near-term initiation and implementation (2022 to 2027) by individual agencies, exist at varying stages in their development. Project descriptions are provided below for each of the identified Tier II PMAs. The level of detail provided for the eight PMAs described below depends on the status of the PMA; where possible the project descriptions include information relevant to §354.42 and §354.44 of the SGMA regulations:

i. High Priority PMAs - Data Gaps and Data Collection

- Butte Valley Integrated Hydrologic Model (BVIHM) Update (High Priority)
- Drought Year Analysis (High Priority)
- Expand Monitoring Networks (High Priority)
- General Data Gaps (High Priority)
- Groundwater Dependent Ecosystem Data Gaps (High Priority)
- Interconnected Surface Water Data Gaps (High Priority)

ii. Avoiding Significant Increase of Total Net Groundwater Use from the Basin
iii. Management of Groundwater Use and Recharge
iv. Conservation Easements
v. Dorris Water Meter Installation Project
vi. Irrigation Efficiency Improvements
vii. Public Outreach
viii. Voluntary Managed Land Repurposing (not including Conservation Easements)
ix. Well Inventory Program
x. Well Replacement

Butte Valley Integrated Hydrologic Model (BVIHM) (High Priority)

Project Description

Planned futures updates to the Butte Valley Integrated Hydrologic Model (BVIHM) include:

- After the PMA "Interconnected Surface Water Data Gaps" has been addressed, the GSA will update BVIHM to include surface water, including irrigation canals.
- Update with more new data and extend the model to more recent years to capture additional climate and pumping patterns, particularly the last drought. Continuous groundwater level data will aid the calibration of the BVIHM by providing insight on seasonal groundwater level and storage fluctuations.

This PMA depends on expansion of current monitoring network and data collection, as outlined in other PMAs.

Drought Year Analysis (High Priority)

Project Description

The year 2021 was faced with an unprecedented drought. The GSA will analyze all data collected within the 2021 water year to study how the Butte Valley groundwater basin responded to an exceptional drought year.

Expand Monitoring Networks (High Priority)

Project Description

The GSA will expand the current monitoring networks to address identified data gaps, as defined in Appendix 3-A with implementation details in Chapter 5. This includes:

- Expansion of the groundwater level monitoring network to areas of interest, with an emphasis on continuous monitoring data. Expansion of the groundwater level monitoring network to areas of interest such as Sam's Neck, Meiss Lake, Butte, Prather, Ikes, Harris, and Muskgrave Creeks, and Butte Valley National Grasslands (see Section 3.3). Monitoring wells near surface water and potential groundwater dependent ecosystems (GDEs) are needed. Additional monitoring of domestic wells is needed.
- Expansion of the water quality monitoring network is needed to cover multiple needs such as:
  - Coverage of all beneficial users such as domestic, agriculture, and environmental users.
  - Improved spatial coverage of the Basin.
  - Representation of all major water bearing formations in the Basin, such as shallow units that primarily supply domestic wells and deep units that supply agricultural and municipal wells.

Completion of this project during the implementation process will depend on funding availability and cooperation of partner agencies and stakeholders (see Chapter 5).

General Data Gaps (High Priority)

Project Description

The GSA will aim to fill all data gaps described in the GSP and Appendix 3-A. Data gaps regarding the monitoring networks, GDEs, and ISWs are already addressed in separate PMAs. Additional data gaps that this PMA will address include:

- Increasing the current frequency of water quality sampling.
- Add continuous groundwater level monitoring to the groundwater level network.
- Add snow and weather stations to the Watershed.

Completion of this project during the implementation process will depend on funding availability and cooperation of partner agencies and stakeholders (see Chapter 5).

Groundwater Dependent Ecosystem Data Gaps (High Priority)

Project Description

The GSA will work with the California Department of Fish and Wildlife (CDFW) and other interested stakeholders to address the data gaps related to GDEs in the Basin (Appendix 3-A). This includes:

- Habitat maps of species that depend on GDEs based on local knowledge and surveys.
- Ad-hoc committee review of species lists, habitat maps, and GDE maps.
- Review species that depend on GDEs with a biologist or related expert.
- Extend the groundwater level monitoring network to areas with potential GDEs.
- Reanalyze potential GDEs after additional data is collected.
- Develop a biological monitoring methodology to monitor GDEs for unreasonable impacts due to groundwater conditions, such as through satellite images.
- Analyze if Meiss Lake and areas within the Butte Wildlife Area (BVWA) should be considered GDEs.

Completion of this project during the implementation process will depend on funding availability and cooperation of partner agencies and stakeholders (See Chapter 5). Completion of this PMA would enable setting sustainable management criteria (SMCs) to protect GDEs in the next five-year GSP update.

Interconnected Surface Water Data Gaps (High Priority)

Project Description

The GSA will work with the CDFW and other interested stakeholders to address the data gaps related to ISWs in the Basin (Appendix 3-A). This includes:

- Installing stream gages to record seasonal flow.
- Adjacent to surface water, including Meiss Lake and all other creeks that enter the Basin: Butte, Prather, Ikes, Harris, and Muskgrave (Chapter 2).

- Conduct a pilot study of shallow monitoring wells or alternative options to analyze if surface water bodies are connected or disconnected to groundwater.
- Collect surface water data for BVIHM such as surface water diversions, canal seepage, streamflow losses, and percolation from wetlands and Meiss Lake.
- Reanalyze potential ISWs after additional data is collected and surface water has been incorporated into the numerical model.
- If ISWs are found to be present in the Basin, create ISWs SMCs as needed and define undesirable results for a future GSP update.

Completion of this project during the implementation process will depend on funding availability and cooperation of partner agencies and stakeholders (see Chapter 5).

Avoiding Significant Increase of Total Net Groundwater Use from the Basin

Project Description

The goal of this MA is to avoid water level declines in Butte Valley that would result from significant expansion of total net groundwater use relative to the practice over the past decade. Net groundwater use is defined as the difference between groundwater pumping and groundwater recharge in the Basin. Under conditions of long-term stable recharge (from precipitation, irrigation, streams, floods) and long-term stable surface water supplies in the Basin, significant increases in long-term average evapotranspiration (ET; or other consumptive uses) in the Basin lead to significant increases in long-term average net groundwater use. Such expansion of net groundwater use would result in a new dynamic equilibrium of water levels in the Basin, bringing water levels in the Basin or portions of the Basin to levels lower than the minimum threshold (MT) for significant periods of time. This would then set in motion basin-wide reductions in groundwater pumping (see MA “Strategic Groundwater Pumping Restrictions”).

The MA sets a framework to develop a process for avoiding significant long-term increases in net groundwater use in the Basin, while protecting current groundwater and surface water users, allowing Basin and Watershed total groundwater extraction to remain at levels that have occurred over the most recent ten-year period (2010 to 2020). By preventing declining water levels, the MA will help the GSA achieve the measurable objectives (MO) of several sustainability indicators: groundwater levels, groundwater storage, and subsidence.

Implementation of the MA is measured by comparing the most recent 5 and 10-year running averages of agricultural and urban ET over both the Basin and Watershed, to the average value of Basin ET measured in the 2010 to 2020 period, within the limits of measurement uncertainty. Basin ET from anthropogenic activities in the Basin and surrounding Watershed cannot increase significantly in the future without impacting sustainable yield. This design is intended to achieve the following:

- To avoid disruption of existing urban and agricultural activities.
- To provide an efficient, effective, and transparent planning tool that allows for new urban, domestic, and agricultural groundwater extraction without expansion of total net groundwater use through exchanges, conservation easements, and other voluntary market mechanisms while also meeting current zoning restrictions for open space, agricultural conservation, etc (see Chapter 2).

- To be flexible in adjusting the limit on total net groundwater extraction if and where additional groundwater resources become available.

Critical tools of the MA will be monitoring and assessment of long-term changes in Basin and surrounding watershed hydrology (ET, precipitation, streamflow, groundwater levels, see Chapter 3), outreach and communication with stakeholders, well permitting, collaboration with land use planning and zoning agencies, and limiting groundwater extraction to not exceed the sustainable yield.

Measurable Objectives Expected to Benefit

This MA directly benefits the measurable objectives of the following sustainability indicators:

- Groundwater levels – Stabilizing declining water levels at depths not to exceed those corresponding to the most recent 10-year period.
- Groundwater storage – Stabilizing declining storage levels at depths not to exceed those corresponding to the most recent 10-year period.
- Subsidence – Stabilization of water levels will reduce the risk of compaction in fine-grained aquifer materials and associated land subsidence.

Circumstances for Implementation

This MA is appropriate because the threat of declining water levels in Butte Valley is not due to overdraft conditions. Future threats to groundwater levels fall into three categories, further explained below:

- Increased Basin net groundwater use (Basin net groundwater use: difference between Basin recharge and Basin pumping).
- Reduced subsurface inflows from the volcanic aquifer system underlying the watershed surrounding the Basin, which would be the result of:
  - Reduced recharge across the upland watershed; or
  - Increased pumping in the watershed surrounding the Basin.

This MA ensures that future declining water levels are not the result of significant expansion of groundwater pumping in the Basin (first category), which would lead to new, lower dynamic groundwater level equilibrium conditions possibly exceeding the MT.

Increasing Basin Net Groundwater Use

Groundwater levels in the basin are fundamentally controlled by:

- The elevation of water levels in groundwater basins to the northeast and east of Butte Valley.
- The amount of groundwater outflow through the volcanic bedrocks to the northeast and east of the Watershed.
- The amount of recharge in the Watershed, especially to the south and west of Butte Valley
- The amount of recharge from the Butte Valley landscape due to precipitation, irrigation return flows, flooding, and managed aquifer recharge (MAR).

- The amount of groundwater pumping for irrigation (Note: the net consumptive groundwater use by domestic and public users is relatively small after accounting for return flows from septic systems and wastewater treatment plants to either groundwater or streams).

Groundwater flow is generally from the south and west to the northeast and east, through the Basin itself, with some local, stable pumping depressions in the Basin. A dynamic equilibrium exists between the recharge into the volcanic uplands south and west of the Basin, groundwater pumping, and groundwater discharge through the volcanic bedrock to the northeast and east of Butte Valley.

Continued or renewed increase in groundwater pumping within the Basin leads to a continued or renewed lowering of the water table in the Basin due to lower total groundwater outflow to the northeast and east of the Basin and, hence, flattened groundwater gradients toward the neighboring, downgradient groundwater basins. By halting or preventing a long-term increase in net groundwater uses through keeping total net groundwater uses at current conditions, a groundwater basin that is not in overdraft remains at a dynamic equilibrium in water level conditions if groundwater inflows and outflows to and from the Basin remain stable. The impact of drought conditions and increased pumping in neighboring groundwater basins is currently a data gap.

Decreasing Recharge or Runoff, or Increasing Pumping in the Surrounding Watershed

Butte Valley is a groundwater basin that is receiving significant groundwater inflow from surrounding groundwater areas and is contributing significant groundwater outflow to downgradient groundwater areas. Hence, water levels within the groundwater basin are affected by recharge and pumping not only inside, but also outside the GSA.

The Basin is part of the much larger Butte Valley watershed, in the southwest portion of the Upper Klamath watershed (Gannett 2010; Gannett, Wagner, and Lite 2012). Much of the watershed outside of the predominantly alluvial groundwater basin consists of volcanic rocks of varying hydraulic conductivity. Much of the precipitation over the Watershed percolates into the volcanic groundwater system surrounding the alluvial basin and flows into and out of the alluvial basin as subsurface flow. Butte Creek is the major surface water feature (see Chapter 2). All Butte Creek flows are recharged to groundwater or diverted for irrigation. For all surface water, the Basin is a terminal, closed basin: all surface inflows are recharging to groundwater or subject to ET.

Due to this immediate connectivity of the alluvial groundwater basin that constitutes the Butte Valley GSA with its surrounding volcanic (and partially alluvial) groundwater, water levels in the GSA can be affected by changes in recharge and groundwater uses occurring outside its boundaries, within the larger Watershed.

Historic Trends of Basin Net Extraction and of External Watershed Pumping and Recharge

In Butte Valley, Basin net groundwater use, estimated as the total amount of annual agricultural evapotranspiration in the Basin over the past 25 years, has generally been increasing as evidenced by the increase in ET from applied water in the Basin (Figure 4.2). Between the early 1990s and the 2010s, the total increase has been on the order of 40% (see Appendix 2-E).

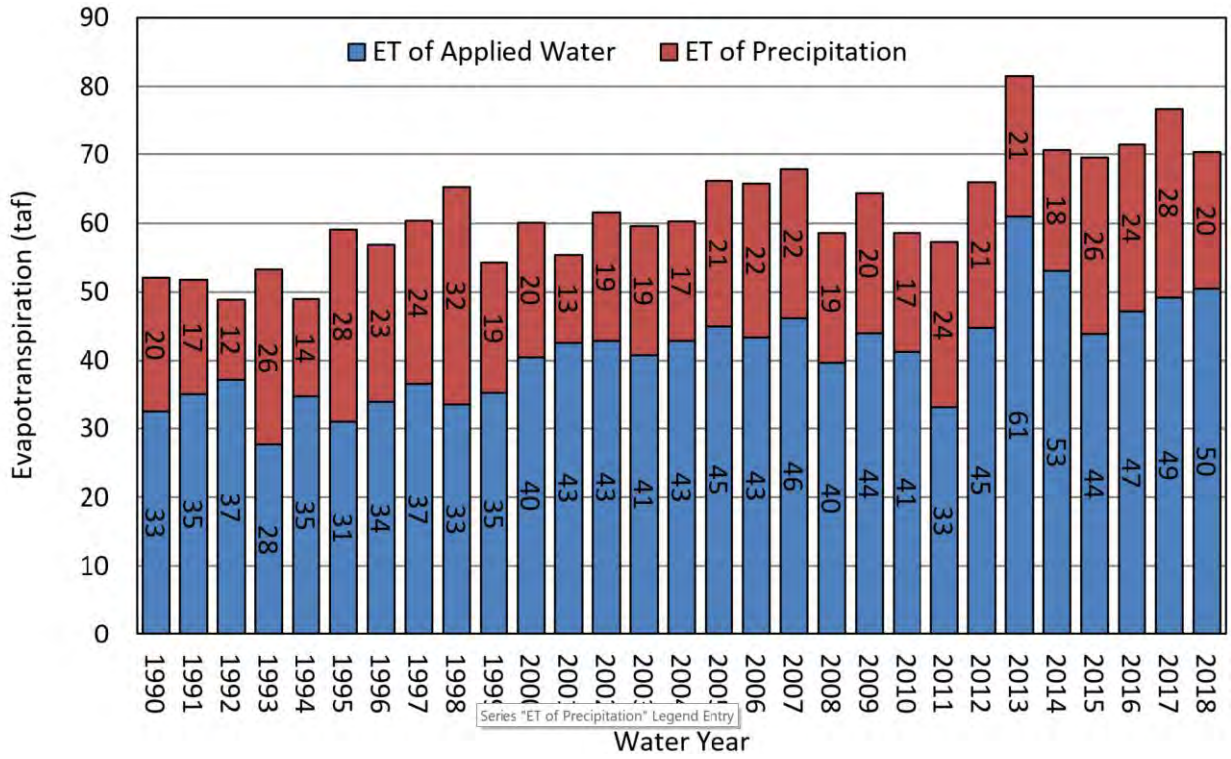


Figure 4.2: ET from applied water (blue) and from precipitation (red) on irrigated lands within the Butte Valley GSA (see Appendix 2-E).

For the 8-year period from 1990 to 1997, agricultural ET varied from 28 to 37 thousand acre-feet per year, averaging 34 thousand acre-feet. For the 8-year period from 2011 to 2018, agricultural ET varied from 33 to 61 thousand acre-feet per year, averaging 48 thousand acre-feet (see Appendix 2-E).

Over the same period, precipitation trends have been decreasing (Figure 4.3). The 10-year rolling average precipitation remained well above the 1941 to 2020 mean precipitation until 1980, but has since been below the long-term mean precipitation except during the wet years of the late 1990s.

Water levels in areas south (upgradient) and east-northeast (downgradient) have been declining. Chapter 2 describes the Butte Valley Integrated Hydrologic Model (BVIHM). The model can be used to determine whether potentially decreased recharge into surrounding volcanic aquifer units and a commensurate decrease in groundwater inflow to the Basin may have contributed to recent groundwater level declines.

Groundwater levels over the past 30 years have generally been observed to be declining at a rate of about 0.25 to 1 feet per year, depending on location, reflecting adjustments of the groundwater system to declining recharge and increased pumping. From a water budget perspective, the increased pumping is matched by increased groundwater inflow from outside the Basin, particularly from the south and southwest. With this increased inflow, a new dynamic water table equilibrium is achieved as groundwater use has stabilized at recent conditions while precipitation rates have not been further declining over the past half decade. It remained relatively steady albeit at low levels.

Based on current conditions in the Basin, this MA will be implemented immediately upon approval of the GSP in partnership with other relevant agencies. During MA implementation, if groundwater levels stabilize at higher elevations due to GSA activities or climate change, the groundwater use cap and the sustainable yield may be adjusted or removed altogether. The mechanism for

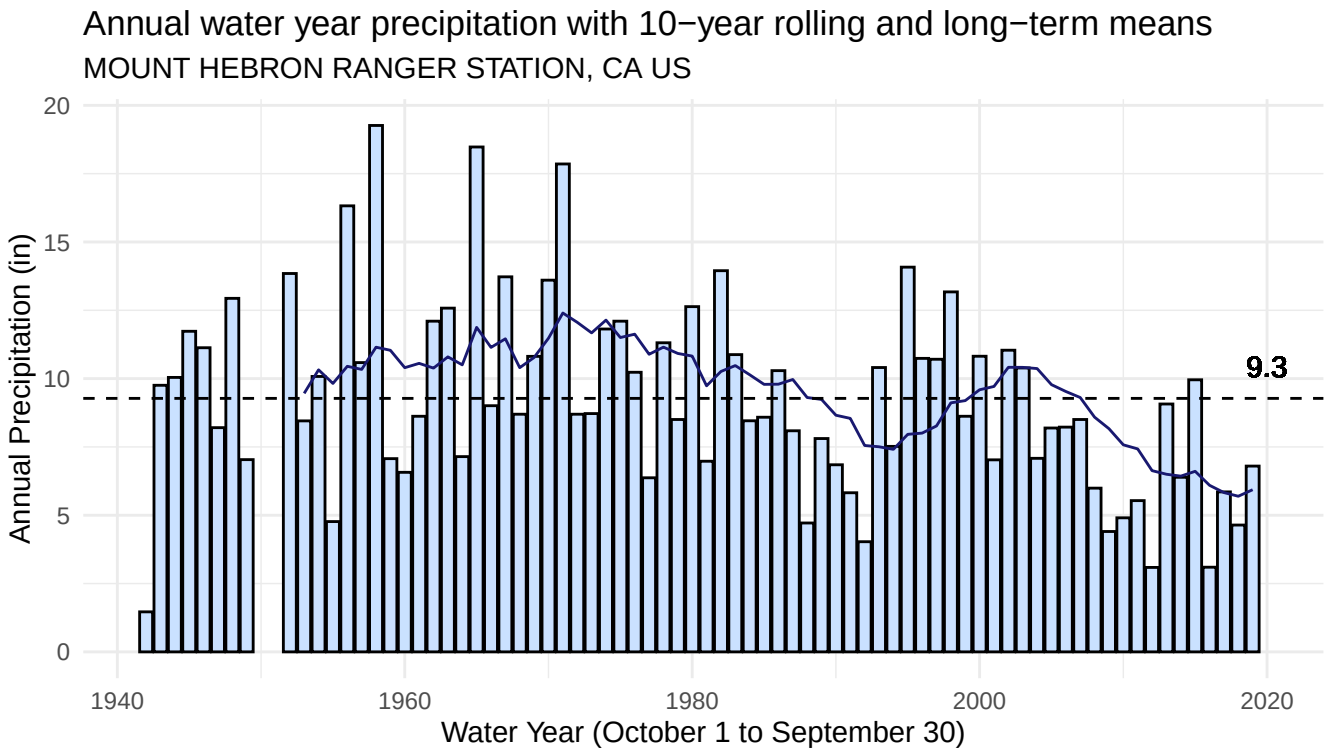


Figure 4.3: Annual water year precipitation with 10-year rolling and long-term means for water year 1941 through 2020 as measured at the Mount Hebron weather station (USC00045941).

off-ramping the MA is described in the implementation section below.

Public Noticing

The GSA will implement the following education and outreach actions regarding the MA:

- Post and advertise the progress of MA implementation through the submittal of annual progress reports to the California Department of Water Resources (DWR).

Implementation: Collaboration with Permitting and Regulatory Agencies

Implementation of the MA is focused on developing active coordination between the GSA with other planning, permitting, and regulatory entities within the Basin, including the Siskiyou County Department of Environmental Health and local land use zoning agencies (see below).

Siskiyou County Department of Environmental Health

The GSA will develop a formal partnership with the well construction permitting agency that operates within the Basin, the Siskiyou County Department of Environmental Health. The objective of the partnership is to develop a well permitting program for agricultural, urban, and large domestic wells that is supportive of and consistent with the GSA's goal not to expand total net groundwater use in the Butte Valley watershed surrounding the Basin and in the Basin itself. The permitting program would ensure that construction of new extraction wells does not expand current total net groundwater use in the Basin itself and across the Watershed as a whole (to the degree that such

expansion may cause the occurrence of undesirable results). This can be achieved through well retirements and through voluntary water market instruments.

Technical Example (Not a PMA)

Well replacement may not require that the new well has the same construction design as the old well, including well capacity. Here are two illustrative examples of an appropriate use of well replacement:

Example 1: Replacement of a 1,000-gpm agricultural well that will be properly decommissioned with a new 1,000-gpm agricultural well is permissible.

Example 2: Replacement of a 1,000-gpm agricultural well that will be properly decommissioned with a new 2,000-gpm capacity agricultural well is permissible with the explicit condition that the 10-year average total net groundwater extraction within the combined area serviced by the old and the new well does not exceed the average groundwater extraction over the most recent 10-years.

Land Use Zoning Agencies

The GSA will develop a partnership with all relevant land use zoning agencies in the Watershed. Land use zoning agencies and relevant stakeholders in the Butte Valley watershed include:

- Siskiyou County
- City of Dorris
- Macdoel (census-designated place)
- Mount Hebron (census-designated place)
- Tennant (census-designated place)
- Red Rock Valley Groundwater Basin
- Bray Town Area Groundwater Basin
- Lower Klamath Groundwater Basin (outside watershed)
- Tulelake Groundwater Basin (outside watershed)

The objective of the partnership is for those agencies to inform land use zoning and land use permitting programs to ensure that zoning decisions are based on a full understanding of groundwater conditions in the Watershed and Basin and that such decisions are supportive of and consistent with the GSA's goal not to expand total net groundwater use in the Butte Valley watershed. Developing close partnerships and timely transfer of information will best prevent an expansion of total anthropogenic consumptive water use in the Watershed.

Preventing an expansion of total net groundwater use in the Basin and surrounding areas still allows for both urban and agricultural growth.

Urban expansion is made possible primarily by expansion into agricultural or rangeland that will be retired. Agriculture-to-urban land use conversion does not increase net groundwater use within the footprint of that conversion. Sometimes the net groundwater use may be lower after conversion (due to lower evapotranspiration). The total annual volume of net groundwater use reduction can be made available for net groundwater use increase elsewhere in the Basin through designing appropriate land use zoning and permitting processes, and after considering ecological, public interest, and any hydrologic or hydrogeologic constraints to such exchanges.

Agricultural expansion, where permissible under zoning regulations, is similarly made possible, e.g., primarily by voluntary managed land repurposing of existing agricultural activities in the same location or elsewhere within the Basin and ensuring that there is no increase in net groundwater extraction between the expansion on one hand and land repurposing on the other. This may be achieved through land purchasing or trade of net groundwater extraction rights (water markets) or through contractual arrangements for land repurposing (e.g., conservation easements) to balance expansion and reduction of net groundwater use. If additional Basin total net groundwater extraction capacity becomes available (after a pro-longed period of water level increase), the GSA will work with the land use zoning agencies to ensure land use zoning and permitting is adjusted accordingly, following a hydrologic assessment.

Technical Example (Not a PMA)

Market instruments encompass a wide range of management tools that rely on monetary transactions to efficiently and effectively trade water uses in ways that do not affect the overall water balance of a basin. The following are two hypothetical examples of water market transactions to illustrate how such instruments may be applied, if circumstances and zoning regulations are appropriate:

Example 1: Expansion of urban groundwater use into agricultural lands, where consistent with zoning and land use planning - Net groundwater use per acre of urban land is generally similar to or lower than under agricultural land use (this accounts for the fact that wastewater is recharged to groundwater and that the largest consumptive use in urban settings is ET from green landscapes). A hypothetical example: lets assume that urban net groundwater use is 1.5 acre-feet per acre, whereas it is 3 acre-feet per acre on agricultural land. Net water use is the difference between groundwater pumping and groundwater recharge over the area in question. Let's further assume that an urban expansion occurs into 500 acres of agricultural land. Prior to the land use conversion, net water use was 3 x 500 = 1,500 acre-feet. After the land use conversion, net water use is 1.5 x 500 = 750 acre-feet. The land use conversion makes 750 acre-feet available for additional annual groundwater pumping elsewhere in the Basin.

Example 2: Expansion of urban groundwater use into natural lands, where consistent with zoning and land use planning - Net groundwater use of urban land is generally larger than under natural land use. A hypothetical example: urban net groundwater use is 1.5 acre-feet per acre, whereas it is 0.5 acre-feet per acre prior to the land-use conversion. Let's again assume that the urban expansion is 500 acres. Prior to the land use conversion, water use on the 500 acres was 0.5 x 500 = 250 acre-feet. After land use conversion, the net water use is 1.5 * 500 = 750 acre-feet. The land use conversion therefore requires an additional 500 acre-feet of water.

If the city also purchases 500 acres of agricultural land for urban development, as in example 1, it already has a credit of 750 acre-feet, of which it may apply 500 acre-feet toward this additional 500 acre expansion into natural land.

Alternatively, the city would need to purchase a conservation easement on 200 acres of agricultural land elsewhere in the groundwater basin (net groundwater use: 3 acre-feet per acre, or 3 x 200 = 600 acre-feet) that converts that agricultural land to natural land (net groundwater use: 0.5 acre-feet per acre, or 0.5 x 200 = 100 acre-feet). The net groundwater use on the easement would be reduced from 600 acre-feet to 100 acre-feet, a 500 acre-feet gain to balance the city's development into natural lands, above. Costs for the easement may include costs for purchasing or leasing that land and the cost for maintaining the conservation easement. We note that conversion to natural land may require significant and habitat development and management as appropriate.

The above examples do not account for possible water rights issues that will also need to be considered. In California, urban groundwater rights are generally appropriative, while agricultural water rights are overlying, correlative rights.

De minimis exceptions to net groundwater use expansion: domestic water use, up to 2 acre-feet per house-hold, contributes minimally to net groundwater extraction of a basin. Nearly all household water use other than irrigation is returned to groundwater via septic systems leachate. Larger household water use, above *de minimis* levels is typically due to irrigation of pasture or lawn and therefore, will be considered a net groundwater extraction.

If additional net groundwater extraction becomes available (after a prolonged period of water level increase), the partnership will ensure that well permitting is adjusted accordingly.

Status

The schedule for implementing the MA is as follows:

- The GSA will create partnerships within the first year of the GSP, by January 31, 2023.
- The partnerships will have the MA program in place no later than January 31, 2024.
- Benefits are to be seen immediately; that is, net groundwater use during the 2020 to 2030 decade will not exceed net groundwater use during the 2010 to 2020 baseline period.

Expected Benefits

Benefits generated by the MA will include:

- Security of groundwater pumping for existing groundwater users.
- Efficient, effective, and transparent planning tools available for new groundwater uses through market instruments involving the retirement of existing groundwater uses.

Implementation: Monitoring

In a groundwater basin where agricultural pumping exceeds 95% of applied groundwater use, the total long-term change in the amount of net groundwater use (groundwater pumping minus irrigation return flows to groundwater) can be estimated by quantifying the long-term changes in the Basin's ET from irrigated landscapes. This assumes that long-term trends in precipitation and applied surface water are sufficiently negligible such that only a significant increase in Basin ET leads to changes in the long-term groundwater balance or that their impacts are separately assessed using a model (Section 2.2.4).

Butte Valley is a closed surface water basin. All surface water inflows captured for irrigation represent flows that would otherwise be subject to groundwater recharge. Hence, surface water irrigation is an indirect form of groundwater pumping (a kind of "in lieu pumping"). Therefore, from a hydrological perspective, the net agricultural groundwater use in Butte Valley is effectively equal to the amount of agricultural ET.

In Butte Valley, the net groundwater use in urban areas is largely due to ET from lawn areas and suburban pasture. Most household water use other than irrigation is subject to recharge back

to groundwater via septic systems or recharge of treated wastewater. For the Basin, DWR will provide estimates of annual agricultural ET and ET from urban lawn and suburban pasture areas. Spatially distributed ET rates are obtained through use of remote sensing data. The accuracy of a basin-total annual agricultural and urban ET value is on the order of +/-10% (Medellin-Azuara et al. 2018). DWR estimates of ET provide an inexpensive, readily available data source to estimate net annual groundwater use from individual fields, and from the Basin as a whole.

Groundwater storage will be evaluated continually to assess the effectiveness of the avoiding the expansion of total net groundwater use. If a sustained long-term (5 to 10 year) increase in groundwater levels is observed in the representative monitoring network (or an expanded version of that network, which may include wells outside the GSA boundary but within the watershed), appropriate scientific-technical assessments, including groundwater modeling, will be used to determine the amount of expanded total net groundwater use capacity available. If groundwater levels have increased due to long-term increase in recharge in the surrounding Watershed, the GSA may work with land use zoning agencies to allow for a gradual expansion of total net groundwater use that will allow water levels to remain within the measurable objective (MO).

Legal Authority

The GSA only has authority for groundwater within the Butte Valley groundwater basin. The GSA has no land use zoning authority. The GSA will work collaboratively with the County of Siskiyou, other land use zoning agencies, and stakeholders within the Basin to implement this MA.

Estimated Costs and Funding Plan

An economic analysis contractor will complete a description of the estimated cost for each project or management action and a description of how the Agency plans to meet those costs will be provided in the GSP update when the planning phase has been completed for a majority of PMAs.

Management of Groundwater Use and Recharge

Management of groundwater uses and recharge will be evaluated 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. Assumptions that will be used to evaluate management of groundwater use and recharge include:

- There is currently no overdraft in the Basin.
- The goal of this MA is to avoid renewed water level declines in Butte Valley that are due to further expansion of net groundwater use.
- The MA sets a framework to develop a process for avoiding significant long-term increases in net groundwater use in the Butte Valley GSA as well as in the surrounding watershed, while allowing basin and watershed total groundwater use to remain at levels that have occurred over the most recent ten-year period (2010 to 2020).
- Monitoring: Compliance with the MA is measured by determining whether the most recent ten-year running average Basin/Watershed sum of agricultural and urban ET remains at or below levels measured for the 2010 to 2020 period, within the limits of measurement uncertainty.

Dorris Water Meter Installation Project

Project Description

To improve water conservation, the City of Dorris is in the process of adopting a metered water rate structure by installing water meters. The project is also replacing old pipelines. Following the installation of meters, water consumption can be tracked and water rates adjusted based on actual water volume used. This project will begin in 2021. This project is fully funded through grants from the Department of Public Health Safe Drinking Water State Revolving Fund and State Revolving Fund.

Irrigation Efficiency Improvement

Project Description

Achieving increases in irrigation efficiency through equipment improvements are anticipated to reduce overall water demand with the potential to decrease overall consumptive water use, predominantly through a reduction in evaporation. This is expected to support stable water level conditions.

Currently, this project is in the planning phase and funding options will be explored during the first five years of GSP implementation. This project involves an exploration of options to improve irrigation efficiency, assessment of irrigator willingness, outreach and extension activities, and development of funding options, primarily by cooperators, possibly in cooperation with NRCS. This PMA is likely to be accomplished through a voluntary, incentive-based program. Cost estimates have not yet been completed for this PMA.

Monitoring data collected in this irrigation efficiency improvement program include, but are not limited to:

- Total acreage with improved irrigation efficiency equipment.
- Location of fields under improved irrigation efficiency equipment.
- Assessment of the increase in irrigation efficiency, with particular emphasis on assessing the reduction or changes in consumptive water use (evaporation, evapotranspiration) based on equipment specification, scientific literature, or field experiments.
- Cropping systems in fields with improved irrigation efficiency equipment.

Public Outreach

This general PMA emphasizes the GSA's goal for public outreach and education among stakeholders to implement the spirit of the PMA and achieve groundwater sustainability within the Shasta Valley groundwater basin. This includes outreach related to other PMAs and filling data gaps, as well as coordinated, widespread, voluntary conservation efforts and grassroots stewardship. The GSA will also work with municipal water agencies and other relevant organizations to coordinate residential, municipal, and small agricultural water conservation education, particularly in times of drought or critical times of the year. This outreach will help engage the public and create more meaningful opportunities for public interest representation within the GSA.

Voluntary Managed Land Repurposing

Project Description

Voluntary managed land repurposing programs include a wide range of voluntary activities that make dedicated, managed changes to land use (including crop type) on specific parcels in an effort to reduce consumptive water use in the Basin to improve and increase groundwater levels This voluntary land repurposing program will encourage a range of activities that would reduce water use in the Basin. These activities may include any of the following:

Term Contracts: In some circumstances, programs like the Conservation Reserve Program (CRP) could provide a means of limiting irrigation on a given area for a term of years. Because of low rates, the CRP has not been utilized much in California, but this could change in the future. In addition, other term agreements may be developed at the state or local level.

Crop Rotation: Landowners may agree to include a limited portion of their irrigated acreage in crops that require only early season irrigation. For example, a farmer may agree to include 10% of their land in grain crops that will not be irrigated after June 30.

Irrigated Margin Reduction: Farmers could be encouraged to reduce irrigated acreage by ceasing irrigation of field margins where the incentives are sufficient to offset production losses. For corners, irregular margins, and pivot end guns, this could include ceasing irrigation after a certain date or even ceasing irrigation entirely in some instances.

Crop Support: To support crop rotation, particularly for grain crops, access to crop support programs may be important to ensure that this option is economically viable. Some type of crop insurance and prevented planting payment programs could provide financial assurances to farmers interested in planting grain crops.

Other Uses: In some circumstances, portions of a farm that are currently irrigated may be well suited for other uses that do not consume water. For example, a corner of a field may be well suited for wildlife habitat or solar panel, subject to appropriate zoning requirements to avoid undesirable outcomes. Depending on the circumstances of an individual project, conservation easements may include habitat conservation easements, wetland reserve easements, or other easements that limit irrigation with surface water or groundwater on a certain area of land. It may be established that certain portions of a property may be suitable for an easement, while the rest of the property remains in irrigated agriculture. Many form of such temporary, seasonal, or permanent easements are possible. They may additionally specify restrictions or requirements on the repurposed use, e.g., to ensure appropriate habitat management.

Currently in the planning phase, this project type is to be developed throughout the next five years.

Implementation of this project type includes consideration of the following elements:

- Role of the GSA versus other agencies, local organizations, and NGOs.
- Development of education and outreach programs in collaboration with local organizations.
- Exploration of program structure.
- Contracting options.
- Exploration and securing of funding source(s).
- Identification of areas and options for easements or other contractual instruments.

Monitoring data collected in this voluntary managed land repurposing program include, but are not limited to:

- Total acreage and timing of land repurposing.
- Location of parcels with land repurposing.
- Assessment of the effective decrease in evapotranspiration (consumptive water use) and applied water use.
- Description of the alternative management on repurposed land with:
  - Quantification and timeline of groundwater pumping restrictions, including water year type or similar rule to be applied and specified in the easement.

Well Inventory Program

In feedback from DWR on other GSPs, a better inventory and definition of active wells was requested along with discussion of impacts to these wells in annual reports, as some shallow wells may be impacted if MTs are reached.

A detailed well inventory will improve the understanding of the Basin conditions and will be valuable for modeled results. A better inventory of domestic wells and other drinking water users will assist the GSA protect affected beneficial users in times of drought and other critical times. It will also help solve ongoing issues with evaluation of *de-minimus* users and their proper inclusion in BVIHM.

Well Replacement

Project Description

A well replacement program will deepen or replace wells impacted during implementation of the groundwater level SMCs. While other PMAs begin to be implemented, groundwater levels may continue to decline for a number of years and cause stakeholders wells to go dry.

A well replacement program will address undesirable results stemming from the need to deepen or replace existing wells due to a continued decrease in groundwater levels below trigger levels, if that were to occur (see Chapter 3).

Funding for this project is more restricted compared to other PMAs. Under the Sustainable Groundwater Management Implementation Grant Program Proposition 68, grants can be awarded for planning and for projects with a capital improvement component. As such, funds for reimbursing landowners for implementation of PMAs including land fallowing and well-shut offs cannot be obtained under this program.

Currently, this project is in the planning phase and funding options will be explored during the first five years of GSP implementation. Cost estimates have not yet been completed for this PMA.

As shown by the Basin model (Chapter 2), the historic decline in water levels is due to a combination of a decreasing trend in precipitation over the watershed and an increasing trend in groundwater pumping over the past 30 years. Without further significant expansion (increase) in groundwater pumping, groundwater levels are anticipated to stabilize at current conditions, even if precipitation levels remain at recent lower annual levels. The Basin is not in overdraft. The likelihood for this PMA to be needed is low.

4.3 TIER III: POTENTIAL FUTURE PROJECT AND MANAGEMENT ACTIONS

Alternative, Lower ET Crops

Project Description

The “alternative, lower ET crop” PMA is a pilot program to develop and introduce alternative crops with lower ET but sufficient economic value to the Basin’s agricultural landscape. The implementation of such crop changes would occur as part of the Tier II Voluntary Managed Land Repurposing PMA. The objective of this PMA is to develop capacity in the basin to facilitate crop conversion in some of the agricultural landscape that would reduce total crop consumptive use (ET) of water in the Basin as needed. The MA is to develop a program to develop and implement pilot studies with alternative crops that have a lower net water consumption for ET, and to provide extension assistance and outreach to growers to facilitate and potentially incentivize the crop conversion process. This PMA will be implemented jointly with University of California Cooperative Extension, the Siskiyou County Farm Bureau, the Siskiyou County Resources Conservation District, and/or other partners. Currently in the conceptual phase, this project involves:

- Scoping of potential crops.
- Pilot research and demonstrations.
- Defining project plan.
- Exploration of funding options.
- Securing funding.
- Development of an incentives program.
- Implementation of education and outreach.

Anticipated benefits from this project include introduction of lower consumptive water use crops and either an increase in recharge (on surface water irrigated crops) or a reduction in the amount of irrigation or both. As a result, water levels in the aquifer system will rise. Implementation of this project is contingent on the evaluation of alternative, lower ET crops that provide sufficient economic value. Future benefits of actual implementation status will be evaluated and assessed with BVIHM using monitoring data describing the implementation of the alternative, lower ET program.

Monitoring data collected in this alternative, lower ET program include, but are not limited to:

- Total acreage with alternative, lower ET crops.
- Location of fields with alternative, lower ET crops.
- Assessment of the effective decrease in ET.
- Cropping systems used as alternative, lower ET crops.

Butte Creek Diversion Relocation

Project Description

For emergency flood control, the Army Corps of Engineers created two Butte Creek diversions in 1965 into storage reservoirs for groundwater recharge. One diverts to Dry Lake and the second east of Orr Mountain, where the Butte Valley Irrigation District (BVID) later constructed a dam and canal for the diversion (Bell and Harrington 2011). The impact of the groundwater recharge due to the creek diversion is unknown due to the lack of stream flow data, diversion flow data, and the direction of recharged groundwater (ie., Butte Valley or Red Rock groundwater basins).

This PMA is broken into two steps:

- Firstly, to fill data gaps related to streamflow and groundwater levels and recharge at the creek diversions. This will also increase the GSA's understanding of groundwater inflows into the Basin.
- Secondly, investigate if moving or altering the Butte Creek diversion would increase groundwater flows in the Basin. A complication is the need to avoid harming the Red Rock groundwater basin if the Butte Creek diversion is providing recharge.

Butte Valley National Grassland Groundwater Recharge Project

Project Description

The Butte Valley National Grasslands may be developed to store Meiss Lake floodwaters for groundwater recharge. This project could be tied with other PMAs to prevent flooding of populated and agriculture lands by Butte Creek winter flows if the current diversion is moved. This project will require infrastructure development to divert excess floodwaters from Butte Creek to Meiss Lake and the National Grasslands.

Strategic Groundwater Pumping Restriction

In Butte Valley, the current level of Basin pumping is determined to be sustainable provided the implementation of Tier I and Tier II PMAs will assist in maintaining sustainability and help ensure that pumping at current levels can continue. Through SGMA, the GSA has the ability to implement groundwater pumping restrictions within locations of the GSA's jurisdiction. Although the GSA has the ability to implement pumping restrictions, the development and implementation of Tier I, Tier II, and other Tier III PMAs are designed to maintain sustainability within the Basin, making pumping restrictions a last resort under this GSP.

Considerably more work, data collection and discussion would need to be done to define the policies and procedures for pumping restrictions, and the GSA would first determine, using the BVIHM, and other hydrologic assessment tools, the amount of water that affected pumpers could take sustainably prior to determining what may need to be restricted. Restrictions may be temporary, seasonal, or permanent.

4.4 Other Management Actions

Monitoring Activities

Chapter 3 and the data gap Appendix 3-A clearly describe the importance of establishing an extensive monitoring network which will be used to support future GSP updates. A summary of the proposed monitoring activities includes, but is not limited to:

- Development of new RMPs (Representative Monitoring Points) to support the groundwater quality SMC.
- Development of new RMPs to support groundwater level SMC.
- New stream gauges in Butte Creek.
- Use of satellite images, twice per year, to evaluate status of GDEs.

Voluntary Well Metering

This project would facilitate the collection and reporting of groundwater extraction data. Accurate groundwater extraction data improves the quality of information used in modeling, and in decision-making. Additionally collection of pumping data is useful for tracking the effectiveness of the proposed demand reduction PMAs.

Future of the Basin

This project would entail developing a study of the economic impacts of the projects and management actions included in the GSP. This would include an evaluation of how implementation of the project could affect the economic health of the region and on local agricultural industry. It would also consider the projected changes to the region's land uses and population and whether implementation of these projects would support projected and planned growth. While an agricultural economic analysis considering groundwater regulation has been completed (see Appendix 5-D) and provides a good starting point, additional work is needed.

Chapter 5

Implementation

Groundwater management has been conducted in the Butte Valley groundwater basin (Basin) for decades. As described in prior sections, a variety of project and management actions (PMAs) are currently, or have previously been, implemented, that support groundwater levels, groundwater storage and interconnected surface waters (ISW). Existing and planned PMAs will contribute to the attainment of the groundwater sustainability goal in the Basin over the planning horizon of this Groundwater Sustainability Plan (GSP). These PMAs, as described in Chapter 4, enable the continued use of groundwater and protection of groundwater uses and users into the future.

In this section, the GSP implementation plan for the Basin is defined. Elements of this plan include:

1) Management and Administration
    a. GSA management, administration, legal and day-to-day operations.
    b. Reporting, including preparation of annual reports and five-year evaluations and updates.
2) Implementation
    a. Implementation of the GSP monitoring program activities described in Chapter 3.
    b. Technical support, including model updates, data collection and other technical analysis.
    c. PMAs as described in Chapter 4.
3) Outreach and Education
    a. Coordination activities with stakeholders and entities in the Basin.
    b. Ongoing outreach activities to stakeholders.

Cost estimates and funding methods for GSP implementation are also presented in this section.

5.1. Description of GSP Implementation Elements

The following tasks and functions will be required for implementation of this GSP:

5.1.1 Management and administration

GSA management, administration, legal and day-to-day operations

GSA functions associated with the management and administration of the GSP implementation activities are covered under this category, which includes the administrative, technical and finance staff support and related expenses, office supplies and materials, insurance, and grant writing to support funding for specific projects and/or management actions. GSA staff will provide work products, administrative support, staff leadership, and management for the GSA.

As the GSP implementation begins in February 2022, staffing support and ongoing administrative and management needs will be further evaluated so that the budget can be refined, as necessary. Staffing needs will be reevaluated annually during the early years of GSP implementation to gain a better understanding of the support required and associated costs.

GSA administration activities include coordination meetings with other organizations on projects or studies, email communications for updating GSA stakeholders about ongoing activities within the

Basin, administration of projects implemented by the GSA, and general oversight and coordination. Other oversight and administrative activities will occur on an as-needed basis.

The GSA is responsible for, and authorized to take, appropriate action to achieve sustainable management of groundwater within the Basin based on the authority granted under Section 6 of the California Water Code. On an as-needed basis, the GSA may seek legal services to assist in the interpretation of legal requirements and provide legal advice during GSP implementation.

Reporting, including preparation of annual reports and five-year evaluations and updates

As part of GSP implementation starting in 2022, the GSA must prepare and submit to the Department of Water Resources (DWR) annual reports and five-year assessments. Annual reports will be submitted to DWR by April 1st of each year and an initial five-year GSP assessment and update will be due to DWR by April 2027. Requirements for each of these reports are explained below.

Annual Reporting

Per Water Code Sections 10727.2, 10728, and 10733.2, SGMA regulations require the GSAs to submit an annual report on the implementation of the GSP to DWR. Development of the annual report will begin at the beginning of each water year, October 1, to assess the previous water year. The report will be submitted to DWR on April 1st of the following calendar year. A template for annual reporting is provided as Appendix 5-B. The annual reports will be completed in a format consistent with Section 356.2 of the SGMA regulations and will include three key sections: general information, Basin conditions and plan implementation progress.

General Information

General information will include a map of the Basin and an executive summary that includes a description of the sustainability goal, ongoing PMAs in the subbasin, jointly funded PMAs and their progress, as well as an updated implementation schedule.

Basin Conditions

This section will describe the current groundwater conditions and monitoring results, used to evaluate how groundwater conditions have changed in the Basin during the previous year. SGMA regulations require the following key components to be included in this section:

- Groundwater elevation data from monitoring wells, including (1) groundwater elevation contour maps for the principal aquifer in the Basin depicting seasonal high and low groundwater conditions, and (2) hydrographs of historical-to-current-reporting-year data showing groundwater elevations and water year type.
- Groundwater extractions during the preceding water year summarized by water use sector, including a map showing the general location and volume of groundwater extractions, as well as the method of measurement (direct or estimate) and accuracy of measurements. Metering of groundwater extraction is only included as a voluntary action and this information will be collected as the PMA is implemented, also based on availability of funding.
- Surface water supply for managed groundwater recharge or in-lieu use, including the annual volume and sources for the preceding water year.
- Total water uses by water use sector and water source type, including the method of measurement (direct or estimate) and accuracy of measurements.

- Maps of changes in groundwater storage for the principal aquifer and a graph depicting historical-to–current-reporting-year water year type, groundwater use, annual change in groundwater in storage, and the cumulative change in groundwater storage for the Basin. This information may change over time to incorporate potentially revised GSA priorities and to reflect new Basin conditions and applicable SGMA requirements.

Plan Implementation Progress

The progress made toward achieving interim milestones, as well as implementation of PMAs, will be explained in this section, along with a summary of plan implementation progress and sustainability progress.

Periodic Evaluations every Five Years

Per Water Code Sections 10727.2, 10728, 10728.2, 10733.2, and 10733.8, SGMA regulations require the GSA to provide a written assessment of GSP implementation and progress towards meeting the sustainability goal at least every five years. A similar evaluation must also be submitted whenever the GSP is amended. The five-year assessment reports will be completed in a format consistent with Section 356.4 of the SGMA regulations and include the following elements:

Sustainability Evaluation

The overall Basin sustainability and current groundwater conditions for each applicable sustainability indicator will be described, including progress toward achieving interim milestones and measurable objectives (MO), and an evaluation of groundwater elevations at each of the representative monitoring points (RMPs) in relation to minimum thresholds (MT).

Plan Implementation Progress

This section will describe the current implementation status of PMAs, along with the effect on groundwater conditions resulting from their implementation, if applicable.

Reconsideration of GSP Elements

Elements of the GSP may require revision due to one or more of the following: collection of additional monitoring data during GSP implementation; implementation of PMAs; significant changes in groundwater uses or supplies and/or land uses. Such new information may require revision to the following GSP elements: Basin setting, water budgets, monitoring network, sustainable management criteria (SMCs), or PMAs.

Monitoring Network Description

This section will provide an assessment of the monitoring network's function, an analysis of data collected to date, a discussion of data gaps and the needs to address them, and identification of areas within the Basin that are not monitored in a manner commensurate with the requirements of Sections 352.4 and 354.34(c) of the SGMA regulations.

Consideration of New Information for Basin Setting and SMC

New information made available after GSP adoption will be described and evaluated. If new information would warrant a change to the GSP, including a re-evaluation of the Basin setting and SMC, then corresponding revised descriptions will be included in the five-year evaluation report.

Regulations or Ordinances

If DWR adopts new regulations that impacts GSP implementation, the update will also identify and address those requirements that may require updates to the GSP.

Legal or Enforcement Actions

Any enforcement or legal actions taken by the GSA or their member agencies to contribute to attainment of the sustainability goal for the Basin will be summarized.

Plan Amendments

Each five-year assessment report will include a description of amendments to the GSP, including adopted amendments, amendments that are underway during development of the report, and recommended amendments for future adoption.

Coordination

A summary of coordination that has occurred between Basin, with different agencies in the Basin, or with agencies with jurisdiction over land use and well construction will be incorporated in the five-year assessment report. The five-year assessments will also include any other information deemed appropriate by the GSA to support DWR in its periodic review of GSP implementation, as required by Water Code Section 10733.

5.1.2 Implementation

Monitoring Networks Summary

The SMC monitoring networks were developed leveraging current and ongoing monitoring to assess minimum thresholds (MT). A summary of the existing monitoring networks and planned expansion is presented in Table 5.1.

Groundwater level and storage

The current RMPs for the groundwater level and storage monitoring network currently includes 13 wells which are already part of the existing CASGEM network. The groundwater levels monitoring network combined with the current DWR CASGEM network serves as basis for assessing all SMCs with the exception of water quality. All 13 wells that have been selected for the groundwater level monitoring network are wells included in the CASGEM network and monitored by DWR twice per year. The current minimum monitoring frequency of twice each year (spring and fall) is used for all wells in the CASGEM network. Criteria for new wells is established in Chapter 3 and priorities listed in Appendix 3-A. Wells added to the monitoring network may be included among the RMPs in the five-years GSP update. If funding is secured, continuous sensors can be installed

with telemetry to increase the frequency of monitoring and remove the need for monitoring site visits. Groundwater storage uses the levels monitoring network as a proxy and has no additional requirements.

Groundwater quality

The seven existing wells selected for the water quality monitoring network are part of the Groundwater Ambient Monitoring and Assessment Program (GAMA) system. They are regularly monitored as municipal wells, but the frequency varies. The program seeks to augment the GAMA wells with additional wells for additional coverage (see Appendix 3-A). Results will be complemented with the ongoing monitoring undertaken by public health for the municipal wells mentioned above and included in the GAMA program. The monitoring plan will be augmented as needed if constituents will exceed the criteria or if specific increasing trends in constituent concentrations are observed.

Subsidence

DWR will periodically provide InSAR data that will be analyzed and assessed by the GSA for any occurrence or worsening subsidence trends.

Implementation of the monitoring program activities described in Chapter 3

This category covers the functions associated with monitoring activities, including logistics and coordination with third party entities performing monitoring in the GSP Monitoring Network and any related monitoring data management. The GSP Monitoring Networks for groundwater level and groundwater quality, including the agencies performing that monitoring, are detailed in Chapter 3. A summary of existing and proposed monitoring for the assessment of SMCs is presented in Table 5.1. The existing data in the first column of Table 5.1 are the representative monitoring points (RMPs) identified in Chapter 3 and will need to be monitored at the frequency specified and reported as part of the annual reports submitted by the GSA.

To address data gaps (extended data gap section is presented in Appendix 3-A) that are identified during GSP implementation, improvements to or expansion of the GSP Monitoring Network may be necessary. In that event, additional monitoring wells, monitoring well instrumentation; sampling and in-situ measurements; sample analysis; and associated data management and analysis may be required in the future. Costs for those facilities and activities are not addressed in this section.

Monitoring and data-related activities include:

- Groundwater Elevation Monitoring.
- Groundwater Quality Monitoring.
- Streamflow Monitoring.
- Monitoring data management (including data management system [DMS] maintenance), data validation (QA/QC), data entry and security, and data sharing.

Table 5.1: Monitoring and Planned Expansion for Sustainable Mangement Criteria in Butte Valley.

SMC	Wells (Existing)	Wells (New)	Measurement (Existing)	Measurement (New)	Other, Based on Future Funding Availability
Groundwater Levels	13 CASGEM wells	At least 2 wells (a) Additional wells dependent on funding	Measured at least 2x/year	(b)	See Appendix 3-A (Data Gap Appendix)
Storage	Groundwater Levels as Proxy				
Water Quality	7 wells	Dependent on funding	Once every two years, unless otherwise specified (see Chapter 3) (c) * Arsenic in 2 wells near Dorris * Nitrate as Nitrogen * Specific Conductivity	Once every 2 or 3 years (c)	See Appendix 3-A (Data Gap Appendix)
Subsidence	InSAR Data (d)	-	InSAR Data (d)	-	

[a] Two additional wells (CASGEM and municipal well) to be added in 2025 – requires additional historical data.
[b] Telemetry may be employed to increase data collection frequency and minimize field visits.
[c] Minimum measurements for water quality will be once per year for the first two years of implementation. If there are no issues in water quality, measurements will be taken once every three years. Measurement may be more frequent if necessary to achieve monitoring objectives, or if the well is sampled at a greater measurement frequency as part of another monitoring program. Coordinate with existing GAMA water quality monitoring to obtain data.
[d] InSAR data analyzed as it becomes available from DWR, but no more frequently than once every two years.

Technical support, including BVIHM model updates, SMC tracking, other data analysis and technical support

Model updates – Management activities and ongoing performance evaluation of the SMC are informed by the Butte Valley Integrated Hydrogeologic Model (BVIHM) model output, which will require periodic updates and refinements as more data become available. Model updates and refinements help maintain, and potentially improve, the model functionality and its capabilities in providing more representative simulation results. These activities include incorporation of new model tools and features, data input and model parameter updates, calibration updates as additional data from the monitoring network and stream gauges is obtained, use of BVIHM to update water budgets, assess water usage, and assess the status of Basin-wide storage volumes, and related work to support ongoing simulations of PMAs, including recharge projects. Model updates may occur as frequent as annually and re-calibration is proposed to be completed every five to ten years.

SMC tracking – synthesis of data to analyze and track the status of compliance with SMC at the representative monitoring points (RMP) wells in the Monitoring Network. This information will comprise an essential element of the annual reports and five-year updates. A template for SMC tracking based on the annual report requirements from DWR is available in Appendix 5-B

Data analysis – Additional data analysis and associated technical support, outside of the GSA's resource capabilities, will be needed for annual reporting and five-year GSP update and outreach activities. The GSA will also have an ongoing need for technical support for the Basin management, such as vulnerability assessments for climate change, hydrologic technical support, assessment of managed aquifer recharge opportunities, economic and funding mechanisms assessments, and studies to address data gaps. It is anticipated that the GSA may also require various planning and programmatic support assistance for ongoing GSP- and SGMA-related requirements.

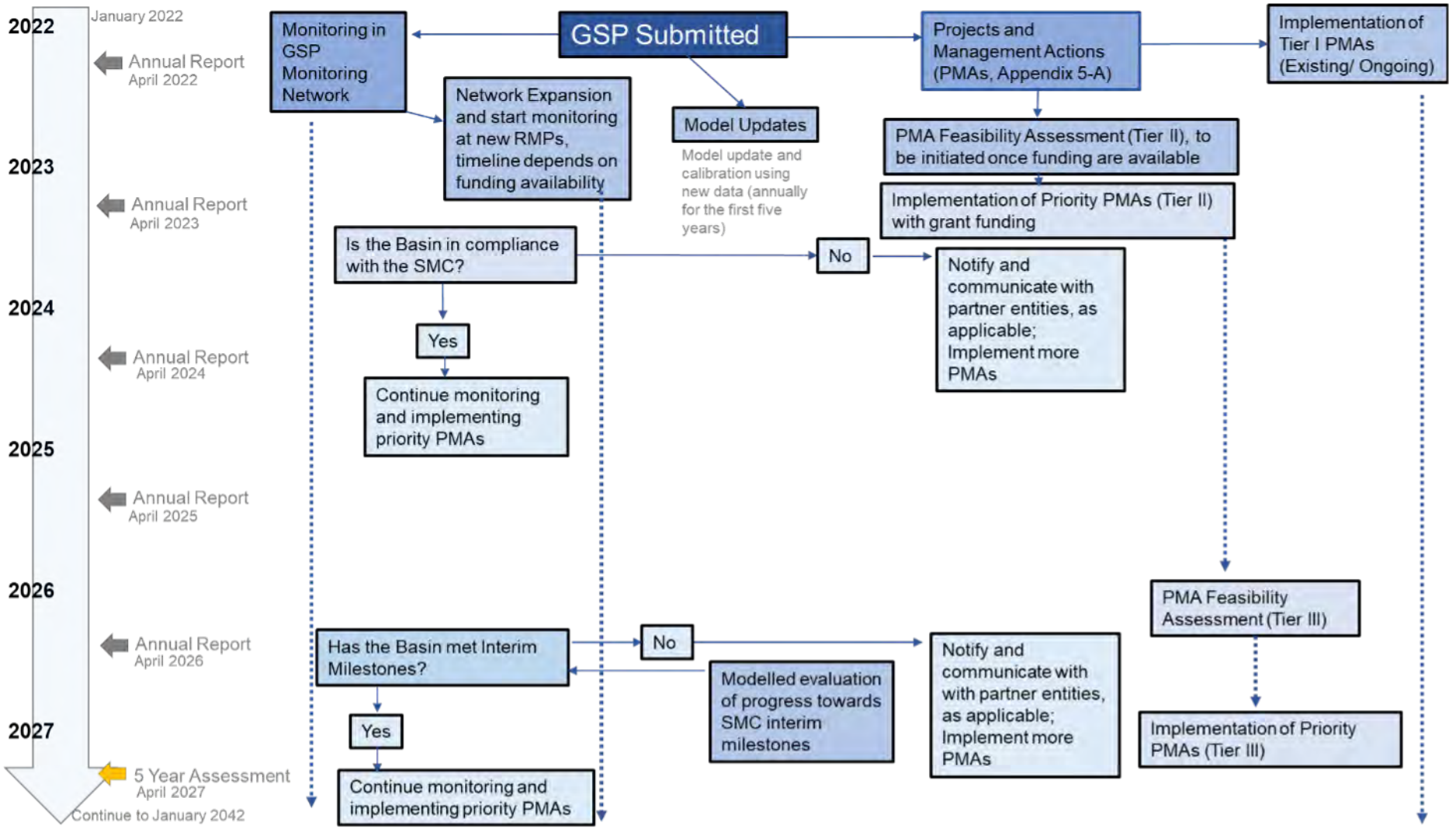


Figure 5.1: GSP implementation process for the first 5-years implementation. The road map is expected to be similar for the following 5-years cycles.

Results of the monitoring program activities inform GSA actions and next steps. The flowchart shown in Figure 5.1 illustrates the process and decision points for the first five years of GSP implementation. This process will be refined, as necessary, throughout the first five years of GSP implementation and will be updated in parallel with the five-year evaluations. Further detail on the prioritization and implementation timeline of PMAs can be found in the discussion of PMAs below, and in Appendix 5-A.

Projects and Management Actions described in Chapter 4.

Chapter 4 of this GSP identifies three different tiers of PMAs in the Basin, as follows:

1. Tier I: Existing PMAs that are currently being implemented and are anticipated to continue to be implemented.
2. Tier II: PMAs planned for near-term initiation and implementation (2022 to 2027) by individual member agencies.
3. Tier III: Additional PMAs that may be implemented in the future, as necessary (initiation and/or implementation 2027 to 2042).

The PMAs listed in Chapter 4 reflect a collection of potential options that may be employed to support the sustainability goals outlined in this plan. Although PMAs have been categorized into three tiers based on the anticipated timeframe for initiation and implementation, **these categorizations may change as additional monitoring data, information, and sources of funding are gained and as conditions change**. Tier I PMAs are anticipated to continue to be implemented throughout the GSP implementation period. A preliminary strategy for PMA prioritization and associated criteria, have been developed for PMAs. As a first step in Plan implementation, PMAs identified in the Tier II category will be ranked using criteria including the effectiveness, completeness, complexity, cost, uncertainty, and level of support for the project or management action. A full description of the criteria used in this evaluation and associated scoring system can be found in Appendix 5-A as well as a preliminary PMA assessment table. This preliminary prioritization step will be initiated immediately after submission of the GSP to provide the GSA with enough time to evaluate projects feasibility and include the selected projects into future funding requests. The GSA is expected to continue to refine this prioritization as more information on the feasibility, costs and anticipated benefits becomes available for these PMAs.

The management actions that will be undertaken by the GSA or in partnership with other entities active in the Basin, include:

- A variety of coordination activities, including:
  - Coordination with agencies with local land use authority.
  - Coordination with entities sponsoring major beneficial projects.
  - Coordination to support water use efficiency measures.
  - Coordination with Siskiyou County Environmental Health Division.

As a priority during the first months of GSP implementation, the Advisory Committee will meet and evaluate project management actions. Based on factors including ability to secure funding, effectiveness and feasibility of implementation, the Advisory Committee will recommend a prioritization scheme based on factors including ability to secure funding, effectiveness, and feasibility of implementation.

5.1.3 Outreach

Coordination activities with other entities

The GSA will need to budget for ongoing coordination during GSP implementation. Coordination will be required with the following entities on the following topical areas:

- With agencies in the Basin with land use jurisdiction to identify and communicate regarding activities that may impact Basin sustainability.
- With water supply agencies, such as irrigation districts or municipal providers, to obtain updated information regarding water use efficiency programs, encourage such programs, and obtain information regarding the impacts of those programs on water demands.
- With entities sponsoring projects, such as recharge or efficiency improvements, in the Basin that will provide benefits to attainment of sustainability goals and objectives, including support for grant funding.
- With any other entities working in the Basin to support the sustainability goal and aspirational watershed goal, as applicable.

To achieve this coordination, the GSA will need to develop governance and communication processes to support these activities efficiently and effectively.

Outreach to stakeholders

Activities under this element of the GSP implementation plan include continuation of education, outreach, and engagement with stakeholders, building off the framework and activities established in the Communication and Engagement Plan (C&E Plan), as described in Chapter 1. Such activities performed during GSP implementation include maintaining the Basin webpage on the County website and the online/social media presence, community meetings, workshops, and public events. These activities may also include electronic newsletters, informational surveys, coordination with entities conducting outreach to diverse communities in the Basin, and development of brochures and print materials. Decisions regarding the nature and extent of these outreach activities will be made by the GSA.

Continued Communication with Native American Indian Tribes

Once implementation begins, the GSA will initiate additional outreach with local Native American Indian Tribes, and in early 2022 look to establish regular coordination meetings to discuss aspects of implementing the GSP.

5.2 Estimate of GSP Implementation Costs

The implementation costs for the Butte Valley GSP will include funding for functions associated with the GSP implementation elements described above, including GSA management and administration, monitoring, technical support, data management, coordination, reporting, management actions, and outreach. GSP implementation costs will also cover the building of sufficient fiscal reserves to address other potential costs for the twenty-year implementation horizon.

Implementation of the GSP over the 20-year planning horizon is projected to cost between $120,000 and $210,000 per year. Table 5.2 summarizes the breakdown of these costs by implementation element. These costs are based on the best available estimates at the time of Plan development and may vary throughout the period of Plan implementation. Grant awards may offset some costs. If the GSA develops additional projects or management actions during the GSP implementation period, the cost estimates will be refined and reported to DWR through the annual reports or five-year periodic assessments.

Development of this GSP was funded largely through a Proposition 1 Groundwater Grant Program and Proposition 68 Grant. The GSA will pursue additional grant funding for GSP implementation as it is available. In the following analysis, it is assumed that the GSA will identify other sources of funding to cover GSP implementation costs.

Financial Reserves and Contingencies

To mitigate financial risks associated with expense overruns due to unanticipated expenditures and actual expenses exceeding estimated costs, the GSAs may carry a general reserve with no restrictions on the types of expenses for which it can be used. Adoption of a financial reserves policy is authorized by SGMA Sections 10730(a) and 10730.2(a)(1). A reserve for operations usually targets a specific percentage of annual operating costs and may consider factors such as billing frequency and the recurrence of expenses to address cash flow constraints.

Total Implementation Costs Through 2042

The total annual cost is estimated at $135,000 to $230,000 based on the best available information at the time of Plan preparation and submittal. These costs include a grant writing component in addition to the costs of GSP implementation, discussed above and presented by major budget category in Table 5.2.

Table 5.2: Summary of Annual GSP Operation and Implementation Costs.

GSP Implementation Tasks	Recurring Annual Costs
GSA Management, Administration, Legal and Day-to-Day Operations	**$10,000-$25,000**
Administrative Staff Support /Accounting	TBD
GSA management and staff support	TBD
Legal support	TBD
Data management	TBD
Monitoring and Technical Support	
Technical Work: SVIHM maintenance	$40,000-$80,000
Monitoring, data analysis and management	$45,000-$60,000
GSP Reporting	
Annual Reports	$10,000-$15,000
5-Year GSP Assessments	$10,000
GSP Management Actions	
Management Action - Coordination activities	TBD
Ongoing Outreach Activities to Stakeholders	
Outreach & Education	$10,000-$20,000
Contingency	
Contingency (10%)	
TOTAL	**$120,000-$210,000**

5.3 Schedule for Implementation

The final GSP will be presented to the GSA Board for adoption in November or December 2021 and will be submitted to DWR no later than January 31, 2022. The preliminary schedule for agency administration, management, and coordination activities, GSP reporting, and community outreach and education are provided in Figure 5.2. While most activities are continuous during GSP implementation, annual reports will be submitted to DWR by April 1st of each year and periodic five-year assessment reports will be submitted to DWR by April 1st every five years after the initiation of Plan implementation in 2022 (i.e., assessment report submittal in 2027, 2032, 2037, and 2042).

	Start	2022-2042																				
		2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Data Management and Reporting																						
Milestones																						
GSP Submitted to DWR	January 2022	●																				
Groundwater Sustainability Goal Attained	January 2042																					●
Reporting																						
Annual Reporting	April 2022	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
5-Year Evaluations	April 2027						●					●					●					
Monitoring																						
Monitoring: Groundwater (all)	Continuous																					
Monitoring: Streamflow	Continuous																					
Monitoring: stream transects	Continuous																					
Groundwater Quality Monitoring Network Expansion	January 2022																					
Data Management	Continuous																					
Outreach and Education																						
Stakeholder Outreach and Education	Continuous																					
Projects and Management Actions																						
Tier I PMAs: ongoing	January 2022																					
Tier II PMAs feasibility study and prioritization upon funding availability	January 2022	●																				
Tier II PMAs: Implementation of highly prioritized PMAs (based on funding availability)	January 2023		●																			
Tier III PMAs Feasibility Study (based on funding availability)	January 2023			●																		

Figure 5.2: GSP implementation schedule.

5.4 Funding Sources and Mechanisms

SGMA authorizes GSAs to charge fees, such as pumping and permitting fees, to fund the costs of groundwater management and sustainability programs.

The GSA will pursue various funding opportunities from state and federal sources for GSP implementation. As the GSP implementation proceeds, the GSA will further evaluate funding mechanisms and fee criteria and may perform a cost-benefit analysis of fee collection to support consideration of potential refinements. A funding-options-analysis was conducted by SCI Consulting Group and the results of this analysis are presented as technical memorandum in Appendix 5-C. This technical memorandum summarizes the estimated costs for implementation, the recommended path to identify and prioritize funding during GSP implementation, and general funding recommendations. The recommended approach to funding is summarized in the "game plan," included on page 31 of Appendix 5-C, and shown below.

Game Plan:

1. Conduct community outreach regarding the Plan and its implementation.
2. Pursue use of existing revenue sources to fund implementation.
3. Pursue Grants and Loan Opportunities to fund implementation.
4. Implement Regulatory Fees to offset eligible implementation costs.

If additional revenue is needed:

5. Conduct a survey and stakeholder outreach to better evaluate

    a. Community priorities and associated messaging.
    b. Optimal rate.
    c. Preference of non-balloted property related fee versus special tax.

6. Use results of surveys, stakeholder input, and other analyses to develop a community outreach plan.
7. Implement community outreach.
8. Implement a property related fee or special tax balloting:

    a. Include a cost escalator schedule or mechanism.
    b. Include the use of rate zones or other distinguishing factors.
    c. Do not include a rate expiration date (also known as a "Sunset Clause").
    d. Include a Discount Program to encourage better groundwater management by well owners.

Table 5.3 presents examples of potential financing options and the degree of certainty associated with each funding option. The "game plan" reflects an approach and order of priority given to seeking funding sources. The GSA is the lead in developing these funding sources, in partnership with other entities and agencies where appropriate. A working group will be convened in the first year of GSP implementation to identify and evaluate these funding sources.

Table 5.3: Potential Funding Sources for GSP Implementation.

Funding Source	Certainty
Feepayers (a)	High - User fees pay for operation and maintenance (O&M) of a utility's system. Depends upon rate structure adopted by the project proponent and the Proposition 218 rate approval process. Can be used for project implementation as well as project O&M.
General Funds or Capital Improvement Funds (of Project Proponents)	High - General or capital improvement funds are set aside by agencies to fund general operations and construction of facility improvements. Depends upon agency approval.
Special taxes, assessments, and user fees (within Project Proponent service area or area of project benefit)	High - Monthly user fees, special taxes, and assessments can be assessed by some agencies should new facilities directly benefit existing customers. Depends upon the rate structure adopted by the project proponent and the Proposition 218 rate approval process.
Bonds	Low - Revenue bonds can be issued to pay for capital costs of projects allowing for repayment of debt service over 20 to 30-year timeframe. Depends on the bond market and the existing debt of project proponents. Not anticipated in the Basin.
Integrated Regional Water Management (IRWM) implementation grants administered by the California Department of Water Resources (DWR)	Medium - Proposition 1, IRWM Implementation Grants.
Proposition 68 grant programs administered by various state agencies	Medium - Grant programs funded through Proposition 68, which was passed by California voters in June 2018, administered by various state agencies are expected to be applicable to fund GSP implementation activities. These grant programs are expected to be competitive, where $74 million has been set aside for Groundwater Sustainability statewide.
Disadvantaged Community (DAC) Involvement Program	Medium - DWR's DAC Involvement Program This program is not guaranteed to be funded in the future.

[a] Feepayers can be well-owners or property owners depending on the selected approach.

Chapter 6

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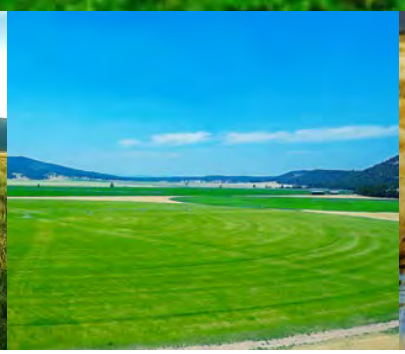
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Appendix 1-A Butte Valley Communication and Engagement Plan

Butte Valley Groundwater Basin Stakeholder Communication and Engagement Plan






Butte Valley Groundwater Basin

Stakeholder Communication and Engagement Plan

Siskiyou County Groundwater Sustainability Agency.
2020. Butte Valley Groundwater Basin - Stakeholder Communication and Engagement Plan.
Siskiyou County, California. 17 pp.

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Main cover and irrigated field: Matt Parker; Dorris City Hall: Carol McKay; Birds: California Department of Fish and Wildlife, Butte Valley grasslands: US Forest Service.

The following partners assisted Siskiyou County in the development of this document: California State University, Sacramento State University–Consensus and Collaboration Program (lead author), Larry Walker Associates, UC Davis, Shasta Valley SGMA Advisory Committee, and the Shasta Valley Resource Conservation District.

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Overview of the Sustainable Groundwater Management Act

The purpose of the Sustainable Groundwater Management Act (SGMA), signed into law by former California Governor Jerry Brown in 2014, is to ensure local sustainable groundwater management in basins throughout the California, including in places like Butte Valley.

SGMA required eligible local agencies in over-drafted and medium/high priority basins to form Groundwater Sustainability Agencies (GSAs) by June 2017. Once formed, GSAs must prepare and submit Groundwater Sustainability Plans (GSPs) by January 2022 for evaluation by the Department of Water Resources (DWR), and then demonstrate sustainability within 20 years. Butte Valley is a medium priority basin and therefore must comply with SGMA.

SGMA defines six undesirable results for groundwater basins to avoid, includes a statutory framework and timelines for achieving sustainability, and identifies requirements GSAs must follow to engage the beneficial uses and users of groundwater within a basin. Moreover, regulations developed by DWR following the passage of SGMA specify needed documentation and evaluation of groundwater conditions within a basin, as well as the requirements for development and implementation of GSPs designed to achieve or maintain sustainability.[1]

In May, 2016, the California Water Commission unanimously adopted Final GSP Emergency Regulations to guide the GSP development process (California Water Code Section 10733.2). These regulations describe, among other things, the required contents of a GSP, including administrative information, an overview of the basin setting and water budget, sustainable management criteria, description of the groundwater monitoring network, and projects and management actions.

SGMA requires local GSAs to conduct broad stakeholder identification, communication and engagement during GSP development and implementation:

- "The groundwater sustainability agency shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin prior to and during the development and implementation of the groundwater sustainability plan." (California Water Code Section 10727.8(a))
- "The groundwater sustainability agency shall consider the interests of all beneficial uses and users of groundwater." (California Water Code Section 10723.2)

To help guide the process of identifying and engaging local stakeholders, SGMA lists all the beneficial users of groundwater whose interests the GSA must consider:

- Agricultural users of water
- Domestic well owners
- Municipal well operators
- Public water systems
- Land use planning agencies
- Environmental users of groundwater
- Surface water users

[1] California Department of Water Resources. 2017. Draft – Best Management Practices for the Sustainable Management of Groundwater: Sustainable Management Criteria BMP.

- The federal government
- California Native American Tribes
- Disadvantaged communities (including those served by private domestic wells or small community water systems)
- Entities listed in Section 10927[2] that are monitoring and reporting groundwater elevations in all or part of a groundwater basin managed by the groundwater sustainability agency

DWR will evaluate and approve or disapprove GSPs within two years of submission. Once approved, GSPs will be re-evaluated by DWR for progress every five years. Local GSAs have 20 years to demonstrate full sustainability.

Plan Goals and Objectives

As a tool to assist the Siskiyou County GSA in meeting SGMA's stakeholder communication and engagement requirements, this plan will:

- Provide the GSA, Advisory Committee, community leaders and other beneficial users a roadmap to ensure broad understanding and consistent messaging of SGMA requirements
- Foster information sharing, communication and collaboration, and opportunities for stakeholders to have meaningful input on the GSA decision-making process
- Provide reasonable opportunities for interested stakeholders to receive and understand the technical groundwater information developed as part of the GSP process
- Ensure a collaborative GSP development and implementation process that is widely seen in the community as fair and respectful to the range of interested or affected stakeholders
- Assist the GSA in meeting all SGMA communication and engagement requirements

Specific objectives that will help the GSA achieve these overarching goals include the following:

- Educate stakeholders on:
  - Important SGMA requirements, events and milestones
  - The role, authorities and responsibilities of the local GSA in Siskiyou County
  - The Advisory Committee's role and how the public can stay informed or involved
  - The benefits of having a technically robust and broadly supported GSP
  - Potential changes to groundwater monitoring and management under SGMA
  - How the interests of beneficial uses and users will be considered under SGMA
- Develop strategies and communication mechanisms for obtaining broad stakeholder input and feedback that informs GSP development
- Coordinate outreach and engagement activities that foster information sharing, raise awareness and encourage public engagement in SGMA
- Ensure the needs, interests and perspectives of all beneficial uses and users are identified, documented and considered by the District Board
- Support local beneficial users to identify, preempt or otherwise proactively address and resolve different perspectives or conflicts over groundwater use and management
- Track all input received by beneficial users during the GSP development process and document District Board (GSA Board) responses as input is considered
- Develop strategies and communication mechanisms for long-term GSP implementation

[2] Entities that may assume responsibility for monitoring and reporting groundwater elevations in all or a part of a basin or subbasin in accordance with this section are listed here.

SGMA Implementation in Siskiyou County

In Siskiyou County SGMA implementation began with the formation of a local GSA and continues through a collaborative process that provides regular opportunities for public input.

Groundwater Sustainability Agency Formation

The Groundwater Sustainability Agency (GSA) for the Butte Valley Groundwater Basin is the Siskiyou County Flood Control and Water Conservation District (District). The Siskiyou County Board of Supervisors sits as the District Board and holds their District meetings during the regularly scheduled County Board of Supervisors meetings. The District is the only eligible local agency with jurisdiction over the entirety of the Butte, Scott and Shasta Valley groundwater basins. Early in the SGMA implementation process, District staff conducted countywide stakeholder workshops and garnered support to serve as the GSA for all three of these groundwater basins in the county, each of which must comply with SGMA. In its capacity as the GSA, the District will solicit and consider feedback on SGMA related issues from the public, and serve as the final decision maker in the GSP development and implementation process. The Siskiyou County Board of Supervisors also serves as a member of the Tulelake GSA, along with Tulelake Irrigation District, Modoc County, and the City of Tulelake.

Technical Support

Preparation of a GSP is a complex process that requires considerable research, discussion and deliberation before adoption. The GSA secured a DWR Sustainable Groundwater Management Grant Program Proposition 1[3] grant to support this collaborative SGMA effort[4]. This grant enabled contracting of a technical consulting team, Larry Walker Associates, to draft the GSP, conduct scientific studies, and build a groundwater monitoring network in each basin to inform GSP development and implementation. The technical consulting team will work with GSA staff and Advisory Committee members to outreach, network, and discuss with stakeholders in the basin regarding available technical information, studies and data gathering that would be beneficial for GSP development and implementation. Interaction between stakeholders and the technical consulting team will be valuable for substantive and extensive input into the GSP.

Facilitation Support

The GSA also leverage funds from DWR's Facilitation Support Services Program to secure impartial facilitation services of the Sacramento State University Consensus and Collaboration Program (CCP). CCP initially conducted a countywide situation assessment in order to gain insight and understanding of the range of issues, perspectives and interests on groundwater planning held by different stakeholders across Siskiyou County. As the GSP is developed, CCP will continue to support the District's efforts to engage stakeholders, tribes and the wider public at advisory, public and, as needed, special meetings. Continuation of facilitation support post-GSP submittal to DWR is contingent on available funding and if the use of impartial facilitation services are still considered necessary or warranted by District Board and staff, Advisory Committees and other interested parties.

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[3] Proposition 1 (Prop 1) or the Water Quality, Supply, and Infrastructure Improvement Act of 2014 authorized $7.545 billion in general obligation bonds for water projects including surface and groundwater storage, ecosystem and watershed protection and restoration, and drinking water protection.

[4] At a later date, additional grant sources may be added (e.g. Proposition 68 funds).

GSA Decision-Making

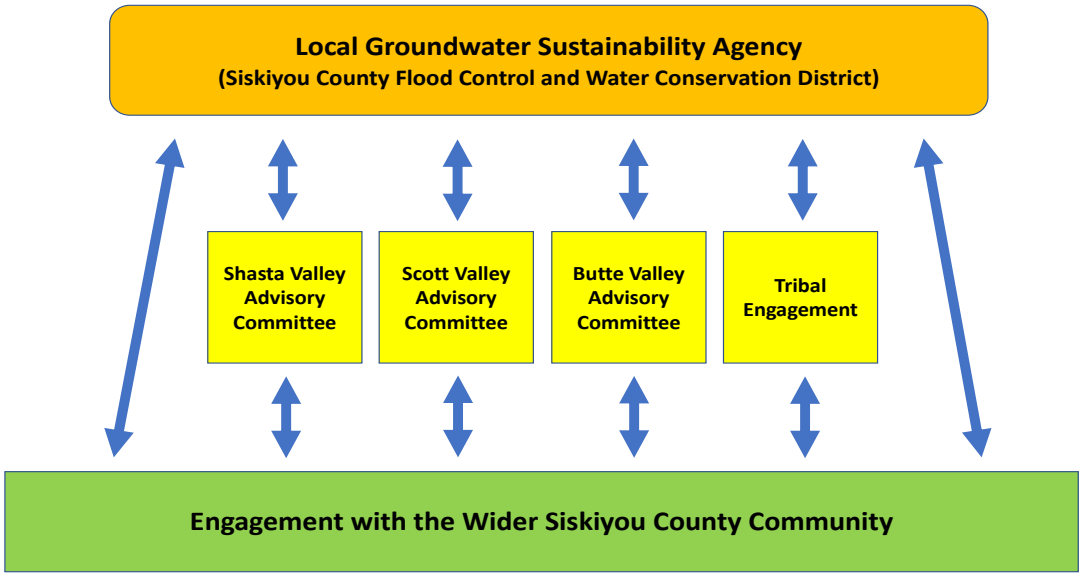
The District Board, in its capacity as the final decision-maker in the GSP process, will:

- Review and offer feedback on technical data, documentation, presentations, and other appropriate items as it pertains to SGMA and development of the GSP
- Review and make recommendations on appropriate studies, models, projects, and other technical needs that provide additional GSP-related information
- Identify and make recommendations on proposed groundwater management goals, objectives and strategies specific to the GSP
- Provide comments, recommendations, or suggestions on professional consultants, or technical experts, being considered to support local SGMA implementation
- Identify and review grant or funding opportunities that would provide financial support for GSP development and implementation
- Hear and offer feedback on GSP-related presentations by organizations, companies, consultants, or other necessary individuals or entities

GSA staff, with support from its technical and facilitation consultants, maintains a schedule that guides the collaborative GSP development and implementation process (see 'Phases of Groundwater Sustainability Development' below). The schedule is designed to integrate the social and technical elements of groundwater management planning, facilitate an open and transparent stakeholder engagement process, and provide a wide range of useful information that informs GSA decision-making.

The District Board will consider recommendations from a formally established Advisory Committee (described below) of diverse stakeholder interests when making SGMA decisions. If the District Board does not agree with committee recommendations or other input, it shall, as part of the process of tracking and responding to input received during the GSP development process, state the reasons for its decision.

Figure 1. Framework for Stakeholder Communication and Engagement



Stakeholder Advisory Committee

The District Board established the Butte Valley Groundwater Basin Advisory Committee (Advisory Committee) as a mechanism to secure local knowledge and insights as the GSP is developed. In its advisory role, the committee will review draft and final documents prepared by the SGMA technical team and provide the GSA with input and recommendations. Consensus building is a foundational principle of all committee discussions, and the group's membership is intended to reflect the diversity of beneficial groundwater users of Butte Valley (See Appendix I – Advisory Committee membership; see also Butte Valley Advisory Committee Charter).

Advisory Committee Goals

- Work collaboratively and transparently with other members to identify common goals, foster mutual understanding, and provide consensus recommendations to the District Board that help the District develop a locally informed and broadly supported GSP
- Develop a common understanding of all existing groundwater resources and groundwater/surface water interaction in the Butte Valley groundwater basin
- Solicit and incorporate community and stakeholder interests into committee discussions and emerging committee recommendations
- Consider and integrate science, as guided and with support from the District's qualified scientific consultants, when reviewing and commenting on GSP development and implementation
- Collaborate in good faith to achieve consensus recommendations; and to the extent consensus cannot be achieved, share with the District Board minority viewpoints as well
- Provide support to the GSA regarding implementation actions set forth in the GSP

Committee Member Roles

- Review and offer feedback on technical data, documentation, presentations, and other appropriate items as it pertains to SGMA and the development of the GSP
- Review and make recommendations on appropriate studies, models, projects, and other technical needs that will aid in developing additional information in relation to the GSP
- Identify and make recommendations on proposed groundwater management goals, objectives and strategies specific to the GSP
- Provide comments, recommendations, or suggestions on professional consultants, or technical experts, being considered by the District Board
- Identify and review grant or funding opportunities that would provide financial support for GSP development and implementation
- Hear and offer feedback on presentations by organizations, companies, consultants, or other necessary individuals or entities regarding the GSP

Tribal Engagement

To foster meaningful engagement with Native American Tribes, the GSA will maintain a government-to-government relationship with any tribe in Siskiyou County or the larger Klamath River watershed which expresses interest in SGMA. In addition, the GSA has appointed a tribal representative to the Advisory Committees for the Shasta Valley, Scott Valley and Butte Valley groundwater basins. Tribal representation on these committees is based on multiple factors, including cultural relationship to the area, ancestral territory and land held in trust or reservation

within a given basin. The GSA has begun developing communication protocols and coordination agreements with tribes who have voiced interest in SGMA. Individual tribes are recognized as sovereign tribal nations; no one tribe represents another. In Butte Valley, the Shasta Indian Nation is represented on the local SGMA Advisory Committee.

Community Involvement

To ensure broad public awareness and involvement as the GSP is developed, the GSA has tasked Advisory Committee members to act as liaisons to educate, inform and solicit input from the wider local community throughout the collaborative process. Key meetings and milestones during the process in which the general public is encouraged to attend and provide feedback on draft GSP content or other SGMA related issues include, but are not necessarily limited to:

- Bi-monthly Advisory Committee meetings when draft GSP sections are introduced, discussed or evaluated by members
- Advisory Committee engagement with constituents, with support as needed from GSA staff, during related meetings, events, and discussions by members,
- Stakeholder meetings led by GSA staff with participation from Advisory Committee members, Technical Consulting Team members and/or Facilitation Support Services
- Public comment periods when draft GSP sections are made available for review
- Regularly scheduled District Board meetings
- Special meetings that are scheduled, noticed in advance and open to the public

At key intervals during GSP development, the GSA will hold public meetings in order to share information, respond to questions or concerns about SGMA, and solicit input from the wider community. Interested parties can also reach out to District staff at any time to share and discuss specific elements of the GSP or SGMA in general.

Brown Act Compliance

All District Board and Advisory Committee meetings will operate in compliance with the Ralph M. Brown Act[5] (Brown Act). Each will be noticed and agendas posted in advance. Meetings are open to the public and allow public comment. The GSA will announce all meetings on its website and through regular communication channels, including a SGMA interested parties list.

Target Audiences

DWR created a stakeholder engagement chart to help GSAs identify and engage the range of beneficial groundwater users in a local basin that must comply with SGMA.[6] Table 1 below is a modified version which lists identified stakeholder groups in the Butte Valley community. Originally developed by GSA staff, the table has been reviewed and improved by the Butte Valley Advisory Committee. Interested parties may also assist the GSA in identifying all stakeholders who have an interest in or may be affected by SGMA. The table may be improved and updated at any time during the GSP development or implementation process. Listed groups represent a priority target audience for SGMA related communication and engagement.

[5] The Ralph M. Brown Act, located at California Government Code 54950 *et seq.*, is an act of the California State Legislature, authored by Assemblymember Ralph M. Brown and passed in 1953, that guarantees the public's right to attend and participate in meetings of local legislative bodies.

[6] *DWR Guidance Document for Groundwater Sustainability Plan: Stakeholder Communication and Engagement*.

Table 1. Butte Valley Stakeholder Groups

Interest Group	Engagement Purpose	Butte Valley Groups
General Public	Inform to improve public awareness of sustainable groundwater management	All beneficial users of groundwater
Land Use	Consult and involve to ensure land use policies are supporting GSPs	Siskiyou County Planning Commission
Private Users	Inform and involve to avoid negative impact to these users	Private Pumpers Domestic/Residential Users
Urban/Ag Users	Collaborate to ensure sustainable management of groundwater	Butte Valley Irrigation District; Siskiyou County Farm Bureau; Private agricultural pumpers; all local school districts; Siskiyou County Cattlemen's Association; Butte Valley/Lava Beds Resource Conservation District; Oregon/California RC&D
Industrial Users	Inform and involve to avoid negative impact to other users	None at this time
Environmental /Ecosystem	Inform and involve to sustain a vital ecosystem	North Groups Sierra Club/Sierra Club Water Chair; California Waterfowl; Ducks Unlimited; Rocky Mountain Elk Foundation; National Wild Turkey Federation; California Department of Fish and Wildlife
Economic Development	Inform and involve to support a stable economy	Siskiyou County Board of Supervisors; Siskiyou County Flood Control and Water Conservation District (acts as local GSA); Siskiyou Economic Development; Butte Valley Chamber of Commerce; Butte Valley Historical Association
Human Right to Water	Inform and involve to provide safe and secure groundwater supplies to disadvantages communities	City of Dorris; Macdoel; Mt. Hebron, local residents
NGOs/Local Associations/ Clubs	Inform, involve and collaborate to ensure basin sustainability	Siskiyou County Realtors Association; Siskiyou County Water Users; Dorris Lions Club; Local Granges
	Inform, involve and consult with tribal governments (See	Shasta Indian Nation

Native American Tribes	DWR Engagement with Tribal Governments Guidance Document[7])	Modoc Tribe of Oklahoma Karuk Tribe
State Land Management or Agencies	Inform, involve and collaborate to ensure basin sustainability	CDFW Butte Valley Wildlife Area; State Water Resources Control Board; North Coast Regional Water Quality Control Board; CALFIRE
Federal Lands/State Lands	Inform, involve and collaborate to ensure basin sustainability	US Forest Service/National Grasslands; Bureau of Land Management; US Geological Survey; National Marine Fisheries Service; USDA/NRCS; US Fish and Wildlife Service
Integrated Water Management	Inform, involve and collaborate to improve regional sustainability	North Coast Resource Partnership (DWR IRWM Region)

Phases of Groundwater Sustainability Plan Development

GSP development in the Butte Valley groundwater basin will occur in three major phases, with each phase offering significant opportunities for the public to provide input on draft material developed and presented by the GSA's technical consultants. Each phase will be linked to core elements of the GSP, including: 1) Introduction and Groundwater Basin Setting; 2) Sustainable Management Criteria; and 3) Project and Management Actions. Draft elements of the GSP will be developed and shared in a way that enables broad stakeholder input, fosters consensus building, and addresses the needs and interests of beneficial users throughout the basin.

The Advisory Committee will serve as the central forum where draft GSP sections will be presented and discussed. Committee members will regularly provide input and help the GSA and its technical team to refine and improve draft materials. Interested parties are also encouraged to attend and provide input at these meetings. GSP chapters with a broad level or even consensus support among committee members, including input from tribes and interested parties, will be presented to the District Board for consideration and approval. At this stage, the District Board may either approve draft GSP chapters or identify issues which require additional information from the technical consultants and more input from the Advisory Committee. A full draft of the GSP will be presented to all the aforementioned parties for final consideration prior to submittal of the document for evaluation by DWR.

At key stages during each phase of GSP development, draft materials that have been reviewed and refined by both the Advisory Committee and District Board will be made available on the county's website for public comment. Public workshops will also be held at this time with the purpose of sharing key messages associated with draft GSP material, soliciting input on draft material and communicating next steps in the GSP development process. A central goal of this

[7] *DWR Guidance Document for the Sustainable Management of Groundwater: Engagement with Tribal Governments.*

collaborative process is to achieve the highest level of agreement possible on the contents of the GSP by interested and affected parties. Viewed in this context, all three elements of stakeholder engagment represent important steps in the collaboration: Advisory Committee, tribal and interested party input; public comments, and District Board review and approval. Finally, SGMA requires the GSA to post a public notice of proposed adoption and hold a public hearing prior to formally adopting the GSP.

Figure 2: Iterative Process of GSP Development



A schedule has been developed which will guide the iterative process of developing and presenting draft sections of the GSP, and then securing input from committee members, the GSA Board and the public. The primary sections of the GSP—the basin setting, sustainable management criteria, and projects and management actions—will be developed and refined sequentially by phase. Following improvement of these sections through collaborative stakeholder engagement, the final sections, including the introduction to the GSP and view towards implementation, will be developed and shared for feedback. Finally, the full GSP will be assembled, then shared for final review by the committee, the GSA Board and the public. Primary actitivies and associated milestones by phase will include:

Phase 1: GSP Introduction and Basin Setting (September, 2019 – January, 2020)

Primary Activities

- 3-4 Advisory Committee meetings
- GSP draft section 2 (Basin Setting) introduced, reviewed and refined
- Basin setting, water budget and hydrologic model introduced, discussed and refined
- GSP draft chapter 2 prepared for Advisory Committee and GSA Board review
- Special meetings scheduled as needed to further discuss and improve draft materials

- 30-45 day public comment period on all draft materials developed under this phase

Key Milestones
Development and initial feedback secured on draft GSP section 2.0 (Plan Area and Basin Setting), including the following:

- 2.1 Description of the Plan Area (Reg. § 354.8)
- 2.11 Summary of Jurisditional Areas and Other Features (Reg. § 354.8 b)
    - 2.1.2 Water Resources Monitoring and Management Programs (Reg. § 354.8 c, d, e)
    - 2.1.3 Land Use Elements of Topic Categories of Applicable General Plans (Reg. § 354.8 f)
    - 2.1.4 Additional GSP Elements (Reg. § 354.8 g)
    - Notice and Communication (Reg. § 354.10)
- 2.2 Basin Setting
    - 2.2.1 Hydrogeologic Conceptual Model (Reg. § 354.14)
    - 2.2.2 Current and Historical Groundwater Conditions (Reg. § 354.16)
    - 2.2.3 Water Budget Information (Reg. § 354.18)
    - 2.2.4 Management Areas (as applicable) (Reg. § 354.20)

Phase 2: Sustainable Management Criteria (January – December 2020)

Primary Activities

- 7-8 Advisory Committee meetings; 2-3 GSA Board meetings and 1 public meeting
- GSP section 3 (Sustainable Management Criteria) introduced, discussed and refined
- Sustainability goal, measurable objectives and minimim thresholds, undesirable results and monitoring network introduced, discussed and refined
- Special meetings scheduled as needed to further discuss and improve draft materials
- 30-45 day public comment period on all draft materials developed under this phase
- Evaluate and, as needed, update stakeholder communication and engagement plan

Key Milestones
Development and initial feedback secured on draft GSP section 3.0 (Sustainable Management Criteria), including the following:

- 3.0 Sustainable Management Criteria (Reg. § 354.22)
    - 3.1 Sustainability Goal (Reg. § 354.24)
    - 3.2 Measurable Objectives (Reg. § 354.30)
    - 3.3 Minimum Thresholds (Reg. § 354.28)
    - 3.4 Undesirable Results (Reg. § 354.26)
    - 3.5 Monitoring Network (Reg. § 354.38)

Phase 3: Projects and Management Actions (September, 2020 – January, 2021)

Primary Activities

- Project and management actions, initially introduced and discussed during Sustainable Management Criteria (SMC) development, reviewed and refined

- 4 Advisory Committee meetings; 1-2 GSA Board meetings and 1 public meeting
- GSP draft section 4 (Projects and Management Actions) introduced, reviewed and refined
- Economical evaluation of the different management scenarios suggested
- Special meetings scheduled as needed to further discuss and improve draft materials
- 30-45 day public comment period on all draft materials developed under this phase

Key Milestones
Development and initial feedback secured on draft GSP section 4.0 (Projects and Management Actions to Achieve Sustainability Goal), including the following:

- 4.0 Projects and Management Actions
    - Project descriptions and discussion of possible project implementation
    - 4.1 Development of scenarios to be simulated with the groundwater model

Phase 4: Final Review, Implementation Steps Ahead and Local Plan Adoption (March, 2021 – December, 2021)

Primary Activities

- 3-6 Advisory Committee meetings, 2-4 GSA Board meetings, and 1-2 public meetings
- GSP draft section 5 (Plan Implementation) introduced, reviewed and refined
- Full GSP assembled, reviewed and refined/improved as needed, and made ready for public review
- Estimate of GSP implementation costs, schedule for implementation and annual reporting introduced, discussed and refined
- Special meetings scheduled as needed to further discuss and improve full draft GSP
- Evaluate and, as needed, update stakeholder communication and engagement plan
- 30-45 public comment period on all full draft GSP
- Public hearing held in advance of GSA Board adoption of GSP

Key Milestones

- Presentation, review and feedback on GSP introduction section and future implementation steps ahead:
    - Development and feedback secured on GSP introduction section
    - Development and feedback secured on draft GSP section 5.0 (Plan Implementation), including the following:
        - 5.1 Project descriptions and discussion of possible project implementation
- Presentation and, as needed, final refinements/improvements to full GSP
- GSA Board formally adopts GSP

Outreach Strategies, Forums and Tools

SGMA gives local GSAs wide discretion in how to conduct stakeholder communication and engagement. The Siskiyou County GSA will utilize the following outreach strategies, forums and tools to successfully meet all SGMA stakeholder engagement requirements:

Advisory Committee Meetings: The Butte Valley Groundwater Advisory Committee will gather for six regularly scheduled meetings each year in 2019 and 2020 along with potential

additional "Special Meetings" should such meetings be warranted, and on an as needed basis in 2021. The purpose of these meetings is for committee members to provide local insights, advice and recommendations during the GSP development process. The meetings also provide an important forum that enables interested parties to stay informed of SGMA activities and contribute to GSP development. Interested members of the public are encouraged to attend Advisory Committee meetings. GSA staff will keep a record of attendance, and track the various constituencies and interested parties which attend and contribute to GSP development.

Constituent Briefings: Advisory Committee members, and, as needed, GSA staff, will provide updates for, and solicit feedback from, their local constituent groups regarding ongoing SGMA activities. Briefings should inform key constituents about SGMA implementation, major milestones and achievements, and opportunities for voluntary participation in the groundwater monitoring program. Committee members will report back constituent input received at briefings to the full Advisory Committee for discussion and consideration.

Local Organizations: At times District Board members and staff, as well as Advisory Committee members, will share information and coordinate with established community organizations such as NGO's, irrigation districts, or localized interested parties by attending standing meetings and utilizing known communication channels. Additional coordination may occur through non-SGMA related forums, monthly information pieces in newsletters, or by disseminating information in any other manner that reaches the desired target audience.

Tribal Engagement: In addition to the role that tribal representatives will play on Advisory Committees, the GSA will, as noted, maintain a government-to-government relationship with any tribe in the Siskiyou County/Klamath River watershed region that expresses interest in participating in SGMA activities. The GSA will seek to foster trust building, provide the opportunity for tribes to have meaningful involvement, and create a forum by which sovereign tribes can communicate their respective needs and interests around SGMA. As noted earlier, the GSA has utilized DWR Facilitation Support Services to help develop and maintain positive relationships with interested tribes.

Public Meetings and Workshops: Public meetings and workshops will be held as needed at key milestones or as required by SGMA. These events can target specific geographic areas or be designed to welcome constituents from across the basin. At times, public meetings may be held in different locations across Siskiyou County. GSA staff, as well as the GSA's technical and facilitation consultants, will help plan and facilitate these events. Advisory Committee members and the District Board may play a support role.

District Board Meetings: GSA staff, with support from its technical and facilitation consultants, will provide regular updates to the District Board during the GSP development and implementation process. In turn, the District Board will provide guidance and direction to the overall SGMA implementation process. At times, Advisory Committee members, tribes or other interested parties may address the District Board regarding issues linked to SGMA. The District Board will provide a notice of intent and public hearing prior to formal adoption of the GSP.

Coordination with State and Federal Agencies: In order to ensure effective integration of distinct, yet oftentimes overlapping, water management and policy programs, the GSA will coordinate and share information, as needed, with state and federal agencies such as the California Department of Fish and Wildlife, Department of Water Resources, State Water Resources Control Board, US Fish and Wildlife Service and National Marine Fisheries Service.

Interested Parties List: GSA staff will maintain a interested parties email list that includes anyone interested in receiving information on SGMA in Siskiyou County during GSP development and implementation. Notification for public meetings and comment periods on draft GSP materials will be distributed through the interested parties list.

Integration of Relevant Studies/Materials: At times committee members or the public may be aware of useful studies, data or other information that can help inform the GSP development and implementation process. Committee members and others are encouraged to share relevant material with the local SGMA program coordinator, who in turn can bring these materials to the attention of the technical consultants and the Advisory Committee, and post documents for reference on the county's SGMA webpage.

Advisory Committee Meeting Announcements: Meeting agendas and handouts will be distributed to committee members and the interested parties list 72 hours prior to each meeting.

Social Media: Although not currently used, Facebook, Twitter, YouTube and other emerging social media technologies may be utilized to provide SGMA updates to interested parties.

Informational Materials: GSA staff, with support from both its consultants and Advisory Committee members, will jointly develop and utilize an array of informational materials to educate the public. These materials may include, but not necessarily be limited to, the following:

- Local SGMA brochures and key talking points
- Frequently asked questions about SGMA, the local GSA and the local GSP
- Existing and new educational materials
- Publicly available groundwater elevation or other related data
- Press releases, newspaper editorials and newsletter articles

Website: The GSA will regularly post and archive SGMA affiliated meeting materials on the county's established SGMA website (e.g. meeting agendas, presentations, summaries). The website will also serve as a repository for groundwater related reports, studies and other topical information discussed by the GSA or its Advisory Committees.

Media: Production of public service announcements, press releases or featured articles will expand awareness of SGMA and how interested parties can get involved. At important milestones advertisements or other announcements in local newspapers will provide information about public meetings, workshops and public comment periods on draft GSP materials.

Plan Evaluation and Adaptation

The Siskiyou County GSA will evaluate the effectiveness and efficacy of its stakeholder communication and engagement plan on, at minimum, an annual basis. Evaluations will likely

occur at or near key milestones, such as the completion of a major phase of work, as described above. Overarching questions that may guide the evaluation will include:

- Have all beneficial users been identified and effectively engaged?
- What has worked well and how can success be built on?
- What has not worked as planned and needs to change?
- What lessons learned will guide future stakeholder communication and engagement?

Appendix I – GSA Board, Staff and Advisory Committee Members

District Board of Directors

- Supervisor Brandon Criss, District 1
- Supervisor Ed Valenzuela, District 2
- Supervisor Michael Kobseff, District 3
- Supervisor Lisa Nixon, District 4
- Supervisor Ray Haupt, District 5

GSA Staff

- Elizabeth Nielson, Project Coordinator
- Matt Parker, Natural Resources Specialist

Advisory Committee Members

- Steve Albaugh, Private Pumper
- Don Bowen (Vice Chair), Residential
- Don Crawford, Private Pumper
- Patrick Graham, CDFW Butte Valley Wildlife Area
- Greg Herman, Private Pumper
- Steve Lutz, Butte Valley Irrigation District
- Carol Mckay, City of Dorris
- Richard Nelson (Chair), Private Pumper
- Jeff Volberg, Environmental/Conservation
- Howard Wynant, Shasta Indian Nation

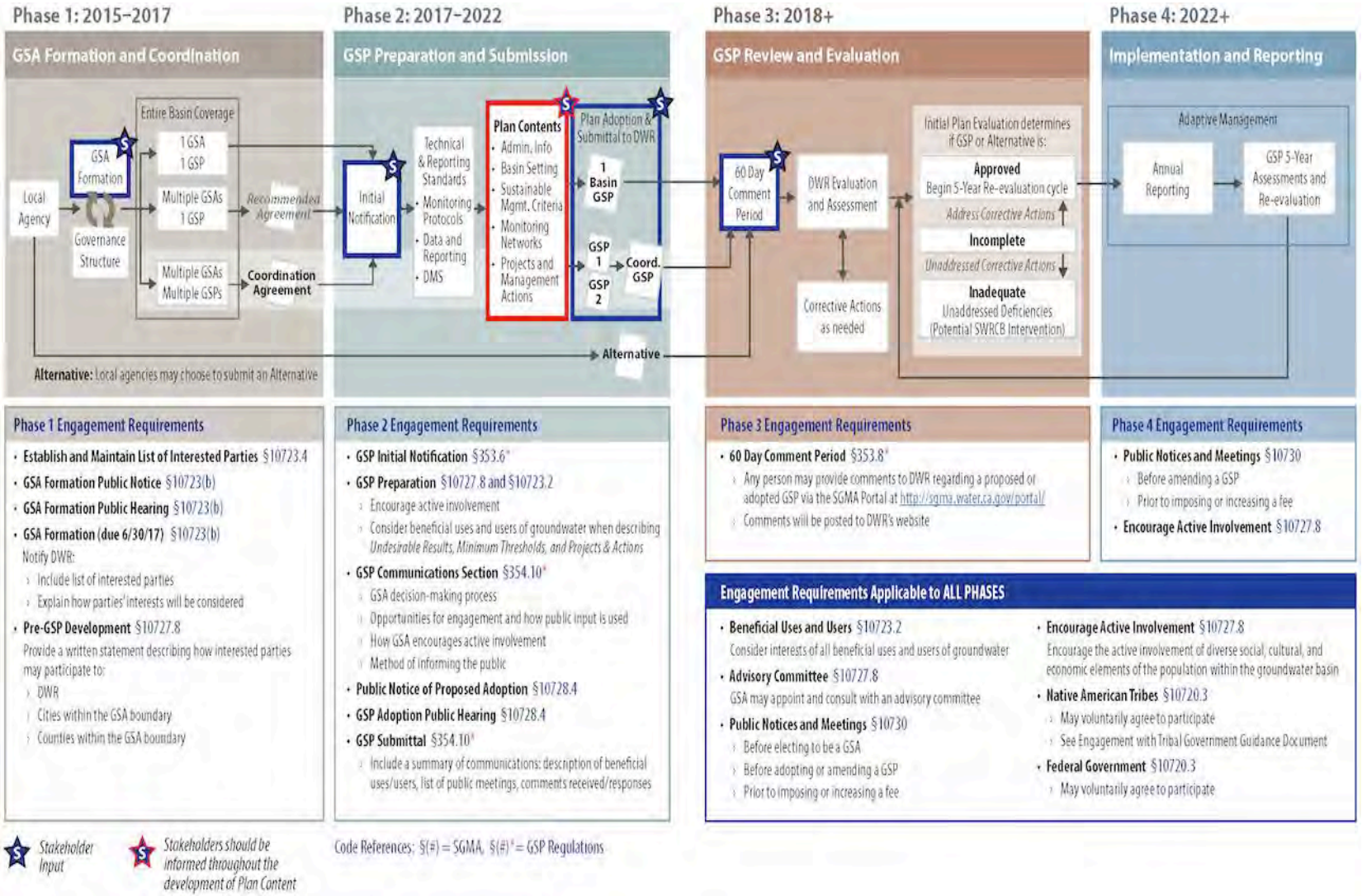
Appendix II – SGMA Educational Materials and References

DWR, and its many partners in academia and civil society, have developed a wide array of educational materials to assist GSAs, Advisory Committees and communities with SGMA implementation. Although not an exhaustive list, interested parties may educate themselves about SGMA with some of the following resources.

Table 2. SGMA Educational Resources

Educational Resource/Weblink	Publisher	Year
The 2014 Sustainable Groundwater Management Act: A Handbook to Understanding and Implementing the Law	Water Education Foundation	2015
Collaborating for Success: Stakeholder Engagement for Sustainable Groundwater Management Act Implementation	Community Water Center Clean Water Fund Union of Concerned Scientists	2015
Groundwater Sustainability Agency – Frequently Asked Questions	Department of Water Resources	2016
Groundwater Sustainability Plan Emergency Regulations (GSP Regulations)	Department of Water Resources	2016
Guidance Document for the Sustainable Management of Groundwater: Engagement With Tribal Governments	Department of Water Resources	2018
Guidance Document for Groundwater Sustainability Plan Stakeholder Communication and Engagement	Department of Water Resources	2018
TNC Groundwater Resource Hub	The Nature Conservancy	2018

Appendix III – SGMA Stakeholder Engagement Requirements



Source: Department of Water Resources (Updated June, 2017)

June 2020

Visit the Siskiyou County SGMA website for more information

OFFICIAL BUSINESS
Siskiyou County Administration
1312 Fairlane rd.
Yreka, California 96097

Appendix 1-B Record of Public Meetings

A list of official public meetings where the Butte Valley GSP was discussed is included below. Individual communication with agencies and other interested parties are not included in this list, though entities involved in targeted outreach or specific topic discussions are listed in Chapter 1.

Date	Meeting
4/5/18	Advisory Committee
7/19/18	Advisory Committee
12/12/18	Advisory Committee
1/24/19	Advisory Committee
4/25/19	Advisory Committee
5/30/19	Advisory Committee
9/4/19	Advisory Committee
11/7/19	Advisory Committee
1/30/20	Advisory Committee
3/5/20	Advisory Committee
4/16/20	Advisory Committee
5/28/20	Advisory Committee
9/3/20	Advisory Committee
10/15/20	Butte Valley SGMA Virtual Public Workshop
10/28/20	Advisory Committee
11/19/20	Advisory Committee
1/28/21	Advisory Committee
2/25/21	Advisory Committee
4/29/21	Advisory Committee
5/28/21	Advisory Committee
6/24/21	Advisory Committee
11/1/19	Chapter 2.1 Description and Plan Area Public Review Version
3/2/21	Chapter 3 Public Review Version (Water Quality and Subsidence)
4/23/21	Chapters 2, 3, 4 with appendices Public Review Version
6/15/21	Butte Valley Ad hoc Committee
9/15/21	Butte Valley GSP Open House and Public Comment Session

A record of all emails sent to the interested parties list is included below. These mostly represent meeting notices, informational notices, and other outreach materials.

2/2/18	Email
3/5/18	Email
3/16/18	Email
4/13/18	Email
4/17/18	Email
6/15/18	Email
7/3/18	Email
8/17/18	Email
10/16/18	Email
10/19/18	Email
1/7/19	Email
2/5/19	Email
3/22/19	Email
4/30/19	Email
5/7/19	Email
7/25/19	Email
11/8/19	Email
11/27/19	Email
12/11/19	Email
12/30/19	Email
1/14/20	Email
1/23/20	Email
1/27/20	Email
2/27/20	Email
4/9/20	Email
4/10/20	Email
5/5/20	Email
5/21/20	Email
6/19/20	Email
6/25/20	Email
8/31/20	Email
9/11/20	Email
9/21/20	Email
9/22/20	Email
10/6/20	Email
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2/23/21	Email
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3/11/21	Email
3/12/21	Email
4/14/21	Email
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5/5/21	Email
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5/17/21	Email
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6/18/21	Email
7/9/21	Email
7/15/21	Email
7/19/21	Email
8/6/21	Email
8/11/21	Email
8/13/21	Email
8/20/21	Email
8/27/21	Email
9/1/21	Email
9/13/21	Email
9/20/21	Email
10/1/21	Email
10/21/21	Email
10/22/21	Email
10/29/21	Email

Appendix 1-C Butte Valley Comment Response Summary

Butte Valley Groundwater Sustainability Plan Public Comment Summary

DRAFT

November 2021

Prepared for:

Siskiyou County Flood Control and Water Conservation District

Prepared by:

Stantec Consulting Services, Inc.

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November 2021

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ABBREVIATIONS

Advisory Committee	Butte Valley Groundwater Basin Advisory Committee
Board	County of Siskiyou Board of Supervisors
CIN	Comment Identification Number
County	County of Siskiyou
DAC	Disadvantaged Community
District	Siskiyou County Flood Control and Water Conservation District
DWR	California Department of Water Resources
GDE	Groundwater-Dependent Ecosystem
GL	Groundwater Level

GS	Groundwater Storage
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
ISW	Interconnected Surface Waters
Matrix	Comment and Comment Response Matrix
MCR	Multiple Comment Response
SGMA	Sustainable Groundwater Management Act of 2014
SMC	Sustainable Management Criteria
WQ	Water Quality

ATTACHMENTS

Attachment A – Notice to Cities, Counties, and Tribes

Attachment B – Annotated Comment Letters Received on Draft Groundwater Sustainability Plan

Attachment C – Butte Valley Groundwater Sustainability Plan Comment and Comment Response Matrix

BUTTE VALLEY GROUNDWATER SUSTAINABILITY PLAN
PUBLIC COMMENT SUMMARY

November 2021

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BUTTE VALLEY GROUNDWATER SUSTAINABILITY PLAN
PUBLIC COMMENT SUMMARY

November 2021

1.0 INTRODUCTION

This Public Comment Summary (Summary) describes the process and tools used by the Siskiyou County Flood Control and Water Conservation District (District) Groundwater Sustainability Agency (GSA) to solicit, review, and respond to public and stakeholder comments on the Draft Butte Valley Groundwater Sustainability Plan (GSP) and notify cities and counties within the plan area of the District's intent to adopt the GSP. These public review and notification processes were developed pursuant to the Sustainable Groundwater Management Act of 2014 (SGMA) and the California Department of Water Resources' (DWR) Groundwater Sustainability Plan Emergency Regulations, developed in May 2016.

California Code of Regulations (CCR) Title 23 Section (§) 355.4 provides the basis for DWR's determination of a GSP's compliance with SGMA and whether a GSP is likely to achieve the sustainability goal for the basin. As part of this criteria, DWR will consider:

> *(10) Whether the Agency has adequately responded to comments that raise credible technical or policy issues with the Plan. (§ 355.4(b)(10))*

This document reviews the GSA's actions to notify the public and other interested parties of the availability of the Draft GSP and the GSA's approach to soliciting, reviewing, and responding to technical and policy comments submitted by the public and other interested parties.

1.1 DOCUMENT FORMAT

This Summary is comprised of the following four sections:

- Section 1 – Introduction: Section 1 provides an overview of the purpose and structure of the document, as well as the GSP evaluation criteria for addressing comments on the GSP.
- Section 2 – Commenting Process: Section 2 describes the public comment process for the Draft GSP and method by which the GSA notified cities, counties, and Tribes within the plan area of the proposed plan. The notification letters are included as **Attachment A** to this Summary.
- Section 3 – Submitted Comments: Section 3 provides an overview of comment letters received on the Draft GSP during the public comment period. The comment letters in their entirety are included as **Attachment B** to this Summary.
- Section 4 – Comment Management and Review: Section 4 describes how the GSA reviewed and responded to comment letters received during the public comment period, including the processes for identifying and categorizing individual comments and responding to comments that raised credible technical and policy issues. This section also describes the tool used to manage the comments and comment responses. A copy of the final tool is provided as **Attachment C** to this Summary.

2.0 COMMENTING PROCESS

The GSA solicited public comments from individuals, agencies, and organizations representing beneficial uses and users of groundwater described in Water Code § 10723.2 as well as any other interested members of the public. This section describes the Draft GSP notification and public comment process. In addition, it describes the method by which the GSA notified cities and counties of availability of the Draft GSP, pursuant to California Water Code § 10728.4.

2.1 DRAFT GSP RELEASE AND PUBLIC COMMENT PERIOD

The District authorized the release of the Draft GSP on August 10, 2021. The Plan was released for public review and comment on Wednesday August 11, 2021, marking the beginning of a 45-day public comment period which ended on Sunday September 26, 2021. The GSA notified interested parties and members of the public of the release of the Draft GSP and public comment period through posting on the Siskiyou County website and an email sent out through the interested parties list.

Additional technical appendices to the Draft GSP were released during the public review and comment period on September 13, 2021. These appendices, listed below, provided supplemental, technical information only.

- Appendix 2D: Butte Model Documentation
- Appendix 2E: ET and Applied Water Estimates
- Appendix 2F: Butte Valley Wildlife Area Water Budget

The Draft GSP was available for review on the County of Siskiyou website throughout the public comment period. In addition, hard copies of the documents were made available for review at the following public locations:

- Dorris City Hall, 307 S. Main St, Dorris, CA 96023
- Butte Valley Library, 800 W 3rd St, Dorris, CA 96023

Members of the public were provided three methods to submit comment on the Draft GSP:

1. Hard copies of comments could be sent by mail or hand delivered to the GSA mailing address: 1312 Fairlane Rd, Yreka CA 96097 with Attention to SGMA.
2. Electronic copies of comment could be submitted to the GSA email address at SGMA@co.siskiyou.ca.us.
3. Comment cards could be written and returned at the September 15 and 16 GSP Open Houses.

2.2 NOTICE TO CITIES, COUNTIES, AND TRIBES

SGMA (as chaptered in California Water Code § 10728.4) requires that:

> *A groundwater sustainability agency may adopt or amend a groundwater sustainability plan after a public hearing, held at least 90 days after providing notice to a city or county within the area of the proposed plan or amendment. The groundwater sustainability agency shall review and consider comments from any city or county that receives notice pursuant to this section and shall consult with a city or county that requests consultation within 30 days of receipt of the notice. Nothing in this section is intended to preclude an agency and a city or county from otherwise consulting or commenting regarding the adoption or amendment of a plan.*

Pursuant to these regulations, the GSA notified cities and counties within the GSP area of its intention to adopt the GSP at least 90 days before adoption of the Final GSP. This notification included a letter sent to the City of Dorris, the Siskiyou County Board of Supervisors, and the Siskiyou County Planning Department on August 13 and 16, 2021. As a courtesy, the GSA also provided notice to the Yurok, Shasta Indian Nation, and Karuk Tribes. In addition to the letter, cities and counties were notified about release of the Draft GSP via postings on the Siskiyou County website. The requests for consultation as well as an example of the notification letter are included in **Attachment A** to this Summary.

2.3 PUBLIC AND STAKEHOLDER INPUT ON DRAFT GSP CHAPTERS

The GSA solicited input on the Draft GSP from stakeholders and members of the public through public meetings and workshops. The Butte Valley Groundwater Basin Advisory Committee (Advisory Committee) is composed of eleven individuals representing beneficial users of groundwater in the basin. The Advisory Committee includes representation from agricultural groundwater users, residential groundwater users, water and irrigation agencies or districts, environmental/conservation organizations, and Tribal governments. The group provides information and recommendations to the GSA Board. The Advisory Committee was actively involved and provided input in development of the Draft GSP. Draft GSP chapters were brought to the Advisory Committee for their review at regular public meetings and during internal public comment periods. Advisory Committee members also provided input on key GSP topics.

Members of the public had the opportunity to provide comments on Draft GSP chapters during public GSA Board meetings, Advisory Committee meetings, public workshops, and Draft GSP chapter public comment periods. The technical team also solicited comments via emails and phone calls with Advisory Committee members and other key stakeholders in the basin.

Draft GSP chapters and meeting materials were included in Advisory Committee and District meeting packets and posted on the District website. Preliminary drafts of GSP Chapters 2, 3, and 4 were made available on the GSA website to the public, Advisory Committee, and GSA Board on April 23, 2021. Draft Chapters 3 and 4 were also presented and discussed at the Board meeting on July 8, 2021.

The GSA also held two public workshops on August 17 and September 16 to inform and solicit input from stakeholders and members of the public about the content of the Draft GSP. The workshops were noticed via emails to the GSA's Interested Parties Database and on the District's website.

3.0 SUBMITTED COMMENTS

The GSA received two comment letters on the Draft GSP during the public comment period. Both letters were submitted from organizations representing beneficial uses and users of groundwater in the region, including state and federal agencies, special districts, and organizations representing environmental, and domestic users of groundwater. **Table 1,** shown below, provides the list of comments that were received on the Draft GSP, organized alphabetically by name. Copies of the comment letters received are provided in **Attachment B** to this Summary.

Table 1. Submitted Comments

Commenter or Agency Name	Commenter Type	Date Comment was Received
California Department of Fish and Wildlife	State Agency	9/23/2021
NGO Consortium	Non-Governmental Organizations	9/23/2021

4.0 COMMENT REVIEW AND RESPONSE

This section describes the process and tools the GSA used to review and respond to comments on the Draft GSP. Following the close of the public comment period, the GSA reviewed each comment letter to identify individual comments on the Draft GSP. To organize and manage the review of issue-specific comments, staff created a database, or matrix, that allowed for the categorization, grouping, and response to comments. This comment management approach is described below.

4.1 COMMENT MANAGEMENT

This subsection describes the process the GSA used to categorize each of the comment letters received on the Draft GSP and identify issue-specific comments for review and response. Of the two letters received, a total of 67 issue-specific comments applicable to the Draft GSP were identified. Each comment was assigned an individual comment identification number and entered into the database referred to as the Butte Valley GSP Comment and Comment Response Matrix (Matrix), further described below. GSA staff then used the Matrix to group technical or policy issues raised on the GSP, identify potential changes to the GSP to address comments, and develop comment responses.

4.1.1 Comment and Comment Response Matrix

The Matrix is an Excel database developed and used by GSA staff and consultants to categorize and respond to comments submitted on the Draft GSP. **Table 2** describes the types of information included in the Matrix. A copy of the completed Matrix is provided in **Attachment C** to this Summary.

Table 2. Butte Valley Groundwater Sustainability Plan Comment and Comment Response Matrix Columns

Matrix Column	Column Description
Author	Name of agency or organization that signed or submitted the comment letter.
Comment Identification Number (CIN)	Unique identifier assigned to each comment received. A single comment letter may contain multiple individual comments, each with its own comment identification number.
Multiple Comment Response (MCR) number	Comments that were similar in scope were grouped together based on the GSP sections or content they discussed. Each group of comments were assigned an MCR number, identified here.
Group	Comment grouping to facilitate structured review by Advisory Committee and GSA staff.
Sub-Category	Topic within the Draft GSP that the comment identifies with, describes, or otherwise raises questions about.
Description	Short description of the main topic or issues raised in the comment.
Code/Regulation	The code or regulation cited in the comment, if referenced.
Location in GSP	The chapter, page, and line number in the Draft GSP cited in the comment, if referenced.
Comment	Copies of the comment text directly from the comment letter.
Response/Recommended Action	Response or recommended action to address the comment.
Response Location in GSP	Location in Draft GSP text changes were made in response to comment, if applicable.

Key:
GSA = Groundwater Sustainability Agency
GSP = Groundwater Sustainability Plan

4.1.2 Sub-Categories

To aid the comment management process, GSA staff and consultants assigned all comments a sub-category based on the primary topic or issue the comment raised. The sub-categories were used to review similar comments and assign the appropriate subject-matter expert to develop the comment response. **Table 3** provides a list of these sub-categories.

Table 3. Groundwater Sustainability Plan Comment Sub-Categories

Acronym	Sub-Category
AL	Pumping Allocations/ Metering/ De Minimus Extractors/ Water Marketing/ Extraction – Water Accounting Framework
BR	Broader Regulations (such as: Endangered Species Act, Public Trust Doctrine)
DC	Disadvantaged Communities
DW	Domestic Wells
GA	GSA Organization
GD	Groundwater Dependent Ecosystems/ Environmental Beneficial Users
GE	General
GL	Groundwater Levels
GS	Groundwater Storage
GP	County General Plan
HM	Hydrogeologic Modeling
IS	Interconnected Surface Waters
LS	Land Subsidence
MA	Management Areas
MN	Monitoring Network
MU	Municipal Land/ Water Use
OR	Groundwater Sustainability Plan Organization
PM	Projects and Management Actions
PO	Public Outreach
SB	Subbasin Characteristics
TR	Transparency
WB	Water Budget/ Water Accounting Framework
WI	Well Inventory
WR	Water Resources/ Water Rights
WQ	Water Quality

4.1.3 Comment Groups

After assigning sub-categories and writing brief descriptions of the comments, GSA staff and consultants conducted a detailed evaluation of the scope, relevance, and importance of each individual comment. Through this activity, staff and consultants conducted an initial grouping, or prioritization, of these comments based, in part, on their applicability to 23 CCR § 355.4(b)(10). These groupings are further described below.

- **"Group A":** Comments were assigned to Group A if they raised substantial technical, policy, or legal issues most likely to be subject to 23 CCR § 355.4(b)(10). Of the 67 comments received, 28 were assigned to Group A.
- **"Group B":** Comments were assigned to Group B if they required additional evaluation or significant changes to the GSP and considered valid technical or policy issues for focused review. This included comments that referred to content and themes included throughout the GSP and would require more consideration to address. Of the 67 comments received, 24 comments were assigned to Group B.
- **"Group C":** Comments were assigned to Group C if they primarily raised editorial issues or could be addressed without requiring further technical evaluations or significant changes to the GSP text. For example, if a comment indicated that a certain passage or section of the GSP could be improved through a closer editorial review, it was categorized as Group C. Of the 67 comments, 15 were assigned to Group C and directly addressed by the GSA and consultant staff.

4.2 REVIEW AND RESPONSE

This subsection describes the approach and process GSA and consultant staff used to review, respond to, and address comments received on the Draft GSP and approval of amendments to the Draft GSP. This review and response process included preparation of draft multiple comment responses and a meeting of the Butte Valley Advisory Committee. These meetings, and their focus, are as noted in the following subsections.

4.2.1 Multiple Comment Responses

Comments of a similar nature were assigned a "Multiple Comment Response" or MCR. An MCR is a single response that applies to multiple comments of a similar nature. Draft MCRs pertaining to Group A comments were shared with the Advisory Committee in advance of the Comment Response Workshop. Based on feedback from the Workshop, the MCRs were finalized and are included in **Attachment C** to this Summary.

4.2.2 Comment Response Workshop

On October 28, 2021, the Butte Valley Advisory Committee held a publicly noticed meeting to review and respond to comments GSA staff and consultants had identified as Group A comments. A draft of the Matrix was provided to the Advisory Committee on October 22 and posted on the District website. Copies of the annotated comment letters were also distributed to the Advisory Committee and posted on the website. Committee members were invited to amend the priority designations of Group B and C comments; however, none were revised to Group A status. The Group A comments fell into the following major topics:

- Public Trust Doctrine
- Endangered Species Act

- Monitoring Networks
- Water Budgets
- Groundwater Dependent Ecosystems

Through a facilitated session, the GSA staff, consultants, and the Advisory Committee reviewed and provided staff direction, as appropriate, to approve or amend each of the staff-developed responses. The Advisory Committee reached a consensus vote on a recommendation to the District to adopt the Final GSP at its December 7 meeting, based on the agreed upon revisions to the Draft GSP.

4.2.3 Public Hearing <PLACEHOLDER>

On December 7, 2021, the Siskiyou County Board of Supervisors held a publicly noticed public hearing for adoption of the GSP. **Table 4** provides a summary of comments provided during the public comment period of the public hearing. The table provides the commenter's name and affiliation, the comment provided, and direction provided to staff by the GSA Board (if any). This meeting was recorded and posted to the County's website. Members of the public will be able to further comment and provide feedback on the GSP during DWR's established comment period under California Water Code § 10733.4. The GSA will continue to track written comments provided to DWR.

Table 4. Public Comments Received during the Public Hearing to Adopt <PLACEHOLDER>

Commenter Name	Commenter Affiliation	Comment Provided	Direction Provided to Staff by GSA Board

Attachment A – Notice to Cities, Counties, and Tribes

COUNTY OF SISKIYOU

Flood Control and Water Conservation District

P.O. Box 750 ▫ 1312 Fairlane Rd
Yreka, California 96097
www.co.siskiyou.ca.us

(530) 842-8005
FAX (530) 842-8013
Toll Free: 1-888-854-2000, ext. 8005

August 10, 2021
Attn: [Recipient]

Subject: Notice of Upcoming Hearing for Adoption of Groundwater Sustainability Plans

Dear [Recipient],

This letter is intended to provide the [Recipient] with notice of the Siskiyou County Flood Control and Water Conservation Districts (District) proposed adoption of a Groundwater Sustainability Plan (GSP) pursuant to California Water Code (CWC) section 10728.4. As required by the Sustainable Groundwater Management Act (SGMA) of 2014 (CWC §10720 et seq.), the District, acting as the Groundwater Sustainability Agency, must provide notice to a city or county within the area of the proposed GSP at least 90-days prior to holding a public hearing to adopt the GSP (CWC §10728.4).

The District has scheduled a public hearing to consider adoption of the Butte Valley, Shasta Valley and Scott River Valley GSP on December 7, 2021, at a time to be determined, during a meeting of the District, located in the Siskiyou County Board Chambers, 311 Fourth St, Yreka, CA 96097.

In accordance with CWC §10728.4, your city is eligible to request consultation with the District in advance of the public hearing. If you wish to consult with the District regarding the adoption of its GSP, please provide notice within 30 days of receipt of this letter.

You may also submit comments on the GSP during the scheduled public comment period. All relevant material, including instructions for commenting, can be found in a downloadable pdf format on the District's website at the following link: https://www.co.siskiyou.ca.us/naturalresources/page/sustainable-groundwater-management-act-sgma

If you have any questions, contact Matt Parker, Natural Resources Specialist at (530) 842-8019, or mparker@co.siskiyou.ca.us. This letter was approved by the Siskiyou County Board of Supervisors on August 10, 2021 by the following vote:

AYES: Director Criss, Kobseff, Valenzuela, Ogren and Haupt
NOES: None
ABSENT: None
ABSTAIN: None

Sincerely,

Ray A. Haupt, Chair
Siskiyou County Flood Control and Water Conservation District

Attachment B – Annotated Comment Letters Received on Draft Groundwater Sustainability Plan

September 26, 2021

Siskiyou County Flood Control and Water Conservation District
1312 Fairlane Road
Yreka, CA 96097

Submitted via email: lauraf@lwa.com; katie.duncan@stantec.com; sgma@co.siskiyou.ca.us

Re: Public Comment Letter for Butte Valley Draft Groundwater Sustainability Plan

Dear Laura Foglia,

On behalf of the above-listed organizations, we appreciate the opportunity to comment on the Draft Groundwater Sustainability Plan (GSP) for the Butte Valley Basin 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 **does not have a plan** 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 Butte Valley 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"

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



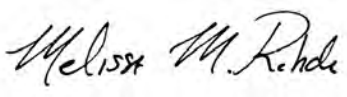
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Water Program Director
Local Government Commission



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 Butte Valley 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, 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, Drinking Water Users, and Tribes

The identification of Disadvantaged Communities (DACs), drinking water users, and tribes is **insufficient**. We note the following deficiencies with the identification of these key beneficial users.

- The GSP states that there are three Severely Disadvantaged Communities (SDACs) in the basin, but these areas are not mapped. — NGO-001
- The GSP provides a map of domestic well density in Figure 1.5, but fails to provide depth of these wells (such as minimum well depth, average well depth, or depth range) within the basin. — NGO-002
- The GSP fails to identify the population dependent on groundwater as their source of drinking water in the basin. Specifics are not provided on how much each SDAC community relies on a particular water supply (e.g., what percentage is supplied by groundwater). — NGO-003

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 development of sustainable management criteria and projects and management actions that are protective of these users.

RECOMMENDATIONS

- Provide a map of the SDACs in the basin. The DWR DAC mapping tool[1] can be used for this purpose. — NGO-001 cont.
- The statement on p. 2-11 that there are no DACs in the basin is confusing, since SDACs are a subset of DACs. Please remove or clarify this sentence.
- Include a map showing domestic well locations and average well depth across the basin. — NGO-002 cont.

[1] The DWR DAC mapping tool is available online at: https://gis.water.ca.gov/app/dacs/

- Identify the sources of drinking water for SDAC members, including an estimate of how many people rely on groundwater (e.g., domestic wells, state small water systems, and public water systems). NGO-003 cont.

- Describe the occurrence of tribal lands in the basin. If tribes have interests in the basin or if groundwater management within Butte Valley Basin will have impacts on downstream tribes, describe them in detail. NGO-004

Interconnected Surface Waters

The identification of Interconnected Surface Waters (ISWs) is **insufficient**. There is no map presented in the ISW section (Section 2.2.2.6) of stream reaches in the basin. NGO-005 The GSP provides a vague assessment of groundwater levels in the vicinity of stream reaches, with no specific details provided. NGO-006 The analysis concludes with the statement (p. 89): "Until the associated data gaps are addressed, Butte Creek is tentatively assumed disconnected from the Basin groundwater aquifer due to nearby deep groundwater levels."

The GSP acknowledges large data gaps for the determination of ISWs. However, given the gaps in groundwater level data and streamflow data, the stream reaches should be considered potential ISWs until further data can be gathered. Because the potential ISWs have not been identified, they cannot be adequately managed in the GSP. Until a disconnection can be proven, all potential ISWs should be included in the GSP. NGO-007 This is necessary to assess whether surface water depletions caused by groundwater use are having an adverse impact on environmental beneficial users of surface water.

RECOMMENDATIONS

- Provide a map showing all the stream reaches in the basin, with reaches clearly labeled with stream name and interconnected or disconnected. NGO-005 cont. Consider any segments with data gaps as potential ISWs and clearly mark them as such on maps provided in the GSP. NGO-007 cont.

- Provide depth-to-groundwater contour maps using the best practices presented in Attachment D, to aid in the determination of ISWs. 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. NGO-008

- Use seasonal data over multiple water year types (we recommend 10 years from 2005 to 2015) to capture the variability in environmental conditions inherent in California's climate, when mapping ISWs. NGO-009

- Reconcile ISW data gaps with specific measures (shallow monitoring wells, stream gauges, and nested/clustered wells) along surface water features in the Monitoring Network section of the GSP. Data gaps are discussed in general terms in the ISW section (Section 2.2.2.6), but very little detail is provided. NGO-007 cont.

Groundwater Dependent Ecosystems

The identification of Groundwater Dependent Ecosystems (GDEs) is **insufficient**, due to lack of clarity around the monitoring well data (well location and screen depth) used to map groundwater elevations and depth to groundwater. The GSP references TNC Best Practices for using the NC Dataset (2019) as the approach used to map depth to groundwater, using the difference between land surface elevation and interpolated groundwater elevation above mean sea level. However, the GSP does not further describe the monitoring well data (well location and screen depth) used to create the depth-to-groundwater maps. NGO-010

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 some mapped features in the NC dataset were improperly disregarded, as described below.

- NC dataset polygons were incorrectly removed in areas adjacent to irrigated fields due to the presence of surface water. However, this removal criteria is flawed since GDEs, in addition to groundwater, can rely on multiple water sources – including shallow groundwater receiving inputs from irrigation return flow from nearby irrigated fields – simultaneously and at different temporal/spatial scales. NC dataset polygons adjacent to irrigated land can still potentially be reliant on shallow groundwater aquifers, and therefore should not be removed solely based on their proximity to irrigated fields. NGO-011
- NC dataset polygons were incorrectly removed based on the amount of time that they access groundwater. As presented in the GSP, assumed GDEs have access to groundwater >50% of time and assumed non-GDEs have access to groundwater <50% of the time. However, NC dataset polygons should not be assumed to be disconnected if there is any connection to groundwater (regardless of temporal percentage). Many GDEs often simultaneously rely on multiple sources of water (i.e., both groundwater and surface water), or shift their reliance on different sources on an interannual or inter-seasonal basis. NGO-012

RECOMMENDATIONS

- On the depth-to-groundwater level maps presented in Appendix 2-C, include the location of groundwater monitoring wells used to produce the maps. Discuss screening depth of monitoring wells and ensure they are monitoring the shallow principal aquifer. NGO-010 cont.
- Use depth-to-groundwater data from multiple seasons and water year types to verify whether polygons in the NC Dataset are supported by groundwater, instead of the incorrect criteria mentioned above (presence of irrigation water or less than 50% time connected to groundwater). NGO-012 cont.
- 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 feet 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 feet 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. NGO-013

- 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.

NGO-014

Native Vegetation and Managed Wetlands

Native vegetation and managed wetlands are water use sectors that are required[2,3] to be included into the water budget. The integration of native vegetation and managed wetlands into the water budget is **insufficient**, due to the absence of Appendix 2-D (Water Budget). We could not determine if the water budget included the current, historical, and projected demands of native vegetation and managed wetlands. The inclusion of explicit water demands for native vegetation and managed wetlands is crucial, so that key environmental uses of groundwater are accounted for as water supply decisions are made using this budget and considered in project and management actions.

NGO-015

RECOMMENDATION

- Include Appendix 2-D (Water Budget) in the GSP. Quantify and present all water use sector demands in the historical, current, and projected water budgets with individual line items for each water use sector, including native vegetation and managed wetlands.

NGO-015 cont.

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[4] is not fully met by the description in the Stakeholder Communication and Engagement Plan included in the GSP (Appendix 1-A).

NGO-016

The GSP describes outreach to tribal and environmental stakeholders in the basin and states that members of these groups are on the Stakeholder Advisory Committee. However, we note the following deficiencies with other aspects of the stakeholder engagement process:

- The opportunities for public involvement and engagement are described in very general terms. They include attendance at public meetings, stakeholder email list, and updates to

NGO-017

[2] "'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)]

[3] "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]

[4] "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)]

the GSP website. There is no specific outreach described for members of the SDAC communities or domestic well owners.

- The Stakeholder Communication and Engagement Plan does not include a plan for continual opportunities for engagement through the *implementation* phase of the GSP for SDACs, domestic well owners, and environmental stakeholders.

NGO-017

NGO-018

RECOMMENDATION

- In the Stakeholder Communication and Engagement Plan, describe active and targeted outreach to engage SDAC members, 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.

NGO-016 cont.

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[5] and establishing minimum thresholds.[6,7]

Disadvantaged Communities and Drinking Water Users

For chronic lowering of groundwater levels, the GSP does not sufficiently describe or analyze direct or indirect impacts on domestic drinking water wells, DACs, or tribes when defining undesirable results. The GSP does not sufficiently describe how the existing minimum threshold groundwater levels are consistent with avoiding undesirable results in the basin. The GSP states (p. 3-34): "The minimum threshold is expected to cause as much as 15% well outages." This is the only quantitative statement made however, and it is not supported by data or analysis.

NGO-019

For degraded water quality, minimum thresholds for the following three constituents of concern (COCs) are set at the maximum contaminant levels (MCLs): nitrate, specific conductivity and arsenic. However, the GSP does not set SMC for the other COCs in the basin (boron, benzene, and 1,2-dibromoethane). The GSP states on p. 3-37 that because 1,2-dibromoethane and benzene are already being monitored and managed by the Regional Board through the Leaking Underground Storage Tank (LUST) program, SMC are not needed. The GSP states that since boron is naturally occurring, SMC are not needed. However, SMC should be established for all COCs in the basin, in addition to coordinating with water quality regulatory programs. Naturally occurring COCs can be exacerbated as a result of groundwater use or groundwater management within the basin.

NGO-020

[5] "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)]

[6] "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)]

[7] "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)]

The GSP only includes a very general discussion of indirect impacts to drinking water users when defining undesirable results and evaluating the cumulative or indirect impacts of proposed minimum thresholds. The GSP does not, however, mention or discuss direct and indirect impacts on DACs or tribes when defining undesirable results for degraded water quality, nor does it evaluate the cumulative or indirect impacts of proposed minimum thresholds on DACs or tribes. NGO-021

RECOMMENDATIONS

Chronic Lowering of Groundwater Levels

- Describe direct and indirect impacts on drinking water users, DACs, and tribes when describing undesirable results and defining minimum thresholds for chronic lowering of groundwater levels. NGO-019 cont.

Degraded Water Quality

- Describe direct and indirect impacts on drinking water users, DACs and tribes 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."[8] NGO-021 cont.
- Evaluate the cumulative or indirect impacts of proposed minimum thresholds for degraded water quality on drinking water users, DACs, and tribes.
- Set minimum thresholds and measurable objectives for boron, benzene and 1,2-dibromoethane. Ensure they align with drinking water standards[9]. NGO-020 cont.

Groundwater Dependent Ecosystems and Interconnected Surface Waters

Sustainable management criteria provided in the GSP do not consider potential impacts to environmental beneficial users. The GSP neither describes nor analyzes direct or indirect impacts on environmental users of groundwater or surface water when defining undesirable results. This is problematic because without identifying potential impacts to GDEs and beneficial users of interconnected surface waters, minimum thresholds may compromise, or even destroy, environmental beneficial users. Since GDEs are present in the basin, they must be considered when developing SMC for the basin. NGO-021 cont.

The GSP states that the depletion of interconnected surface water sustainability indicator is not applicable in the Basin, but this has not been proven. Chapter 2 of the GSP disregards ISWs due to data gaps. However, they should be retained as potential ISWs and preliminary SMC for the depletion of interconnected surface water sustainability indicator should be established. NGO-022

[8] 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.

[9] "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)]

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[10] in the basin. Defining undesirable results is the crucial first step before the minimum thresholds[11] can be determined.

NGO-023

- Establish preliminary SMC for the depletion of interconnected surface water sustainability indicator, that can be refined when data gaps are filled. When defining undesirable results for depletion of interconnected surface water, include a description of potential impacts on instream habitats within ISWs when defining minimum thresholds in the basin[12]. The GSP should confirm that minimum thresholds for ISWs avoid adverse impacts to 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[6,13].

NGO-022 cont.

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[14] 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 integration of climate change into the projected water budget is **incomplete**. The GSP does incorporate climate change into the projected water budget using DWR change factors for 2030 and 2070. The GSP also considers multiple climate scenarios (e.g., the 2070 extremely wet and extremely dry climate scenarios) in the projected water budget. The GSP includes climate change into key inputs (e.g., precipitation, evaporation, and surface water flow) of the projected water budget. However, we are

NGO-024

NGO-024 cont.

[10] "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)]

[11] 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)]

[12] "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)]

[13] 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

[14] "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)]

concerned that the selected period is from 1991-2011 and therefore it does not include the drought from 2012-2016. We look forward to reading Appendix 2-D (Water Budget) in the next draft of the GSP to learn about how you are integrating drought risk in your future water budget.

NGO-024 cont.

The GSP does not calculate a sustainable yield based on the projected water budget with climate change incorporated, but instead states that the sustainable yield will vary over time as new project and management actions are added. The GSP states (p. 2-126): "The sustainable yield is not a number that is constant over time, as future conditions may decrease or increase the amount of groundwater that can be withdrawn without causing undesirable results" and continues: "For every implementation of a PMA resulting in the reduction in groundwater pumping, including some conservation easements, there is a commensurate downward adjustment in sustainable yield. The exact amount of that adjustment varies over time and will depend on the future portfolio of PMAs implemented (see chapters 3 and 4). Without the automatic adjustment of the sustainable yield to future agreed-upon reductions in groundwater pumping, other water users in the Basin may claim that the reduction in groundwater pumping, e.g., for in lieu recharge, makes groundwater available for pumping elsewhere or at other times, up to the (constant) limit of the sustainable yield. This must be avoided to successfully manage the basin." Keep in mind that sustainable yield is a legally required component of SGMA and necessary for informing what project and management actions are necessary in the basin. If sustainable yield is not calculated, then there is also increased uncertainty in virtually every subsequent calculation used to plan for projects, derive measurable objectives, and set minimum thresholds. Plans that do not explicitly calculate sustainable yield may underestimate future impacts on vulnerable beneficial users of groundwater such as ecosystems, DACs, domestic well owners, and tribes.

NGO-025

NGO-025 cont.

RECOMMENDATIONS

- Include Appendix 2-D (Water Budget) in the next draft of the GSP, so that the manner in which climate change is incorporated into the water budgets is fully explained. NGO-024 cont.
- Estimate sustainable yield based on the projected water budget with climate change incorporated, to inform the basis for development of projects and management actions. NGO-025 cont.
- Incorporate climate change scenarios into projects and management actions. NGO-026 cont.

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 Points (RMPs) in the monitoring network that represent water quality conditions and shallow groundwater elevations around DACs, domestic wells, GDEs, and ISWs. Beneficial users of groundwater 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[15].

NGO-027

The GSP includes a data gap assessment (Appendix 3-A) that identifies and prioritizes data gaps in the monitoring networks. Thus while the GSP recognizes the importance of filling data gaps, it does not provide specific plans, well locations shown on a map, or a timeline to fill the data gaps. The GSP states (p. 3-6): "These additional monitoring or information requirements depend on future availability of funding

NGO-027 cont.

[15] "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)]

and are not yet considered among the GSP Representative Monitoring Points (RMPs). They will be considered as potential RMPs and may eventually become part of the GSP network at the 5-year GSP update." However, the additional RMPs should be included in the GSP now, instead of included in the 5-year GSP update. Without a map of proposed new monitoring well locations, a determination cannot be made regarding the adequacy of the monitoring network for sustainability indicators going forward into the GSP implementation phase.

NGO-027 cont.

RECOMMENDATIONS

- Provide maps that overlay current and proposed monitoring well locations with the locations of DACs, domestic wells, GDEs, and ISWs to clearly identify potentially impacted areas. Increase the number of representative monitoring points (RMPs) across the basin as needed to adequately monitor all groundwater condition indicators. Prioritize proximity to GDEs and drinking water users when identifying new RMPs. NGO-028 NGO-029
- Provide specific plans to fill data gaps in the monitoring network. Evaluate how the gathered data will be used to identify and map GDEs and ISWs, and identify DACs and shallow domestic well users that are vulnerable to undesirable results. NGO-030
- Further describe the biological monitoring that will be used to assess the potential for significant and unreasonable impacts to GDEs or ISWs due to groundwater conditions in the basin. Section 4.4 mentions the use of satellite images to evaluate the status of GDEs, however no further details are provided in the GSP. NGO-031

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 to beneficial users of groundwater such as DACs and drinking water users. NGO-032

We commend the GSA for including projects and management actions with explicit benefits to the environment (e.g., the Abandonment of Sam's Neck Flood Control Facility and Kegg Meadow Enhancement and Butte Creek Channel Restoration). The GSP discusses how these projects will benefit ecosystems, but does not discuss the manner in which DACs, drinking water users, and tribes may be benefitted or impacted by projects and management actions identified in the GSP. 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. NGO-032 cont.

RECOMMENDATIONS

- For DACs and domestic well owners, include further discussion of a drinking water well impact mitigation program to proactively monitor and protect drinking water wells through GSP implementation. The GSP describes a well replacement program in Section 4.3 (Tier II PMAs), but no details are provided. Refer to Attachment B for specific recommendations on how to implement a drinking water well mitigation program. NGO-033

- For DACs, domestic well owners, and tribes, 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. NGO-034

- Recharge ponds, reservoirs, and facilities for managed stormwater 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 guidance on how to integrate multi-benefit recharge projects into your GSP, refer to the “Multi-Benefit Recharge Project Methodology Guidance Document”[16]. NGO-035

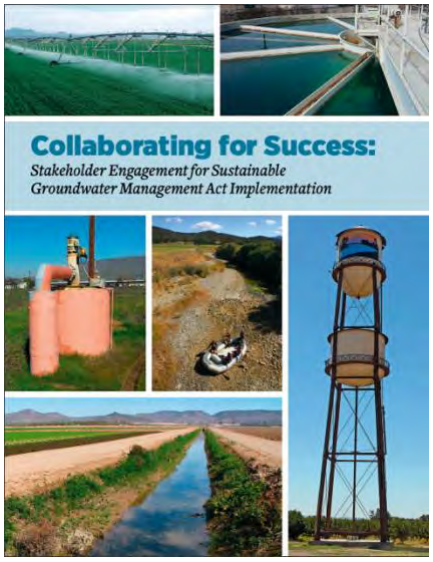
- Develop management actions that incorporate climate and water delivery uncertainties to address future water demand and prevent future undesirable results. NGO-036

[16] 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

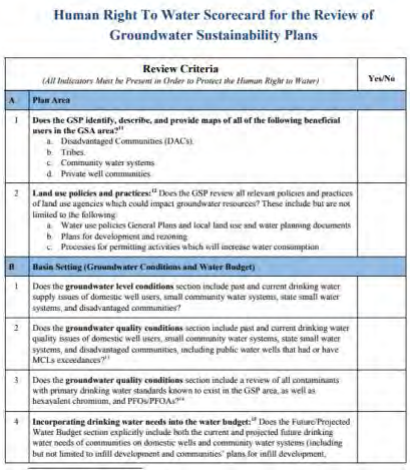
Stakeholder Engagement and Outreach



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

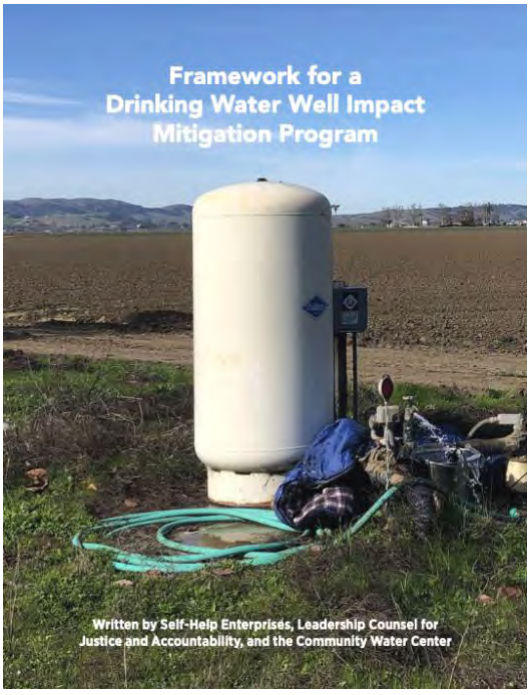


Human Right To Water Scorecard for the Review of Groundwater Sustainability Plans

	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?**[43] a. Disadvantaged Communities (DACs). b. Tribes. c. Community water systems. d. Private well communities.	
2	**Land use policies and practices:**[44] 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?[45]	
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?[46]	
4	**Incorporating drinking water needs into the water budget:**[47] 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

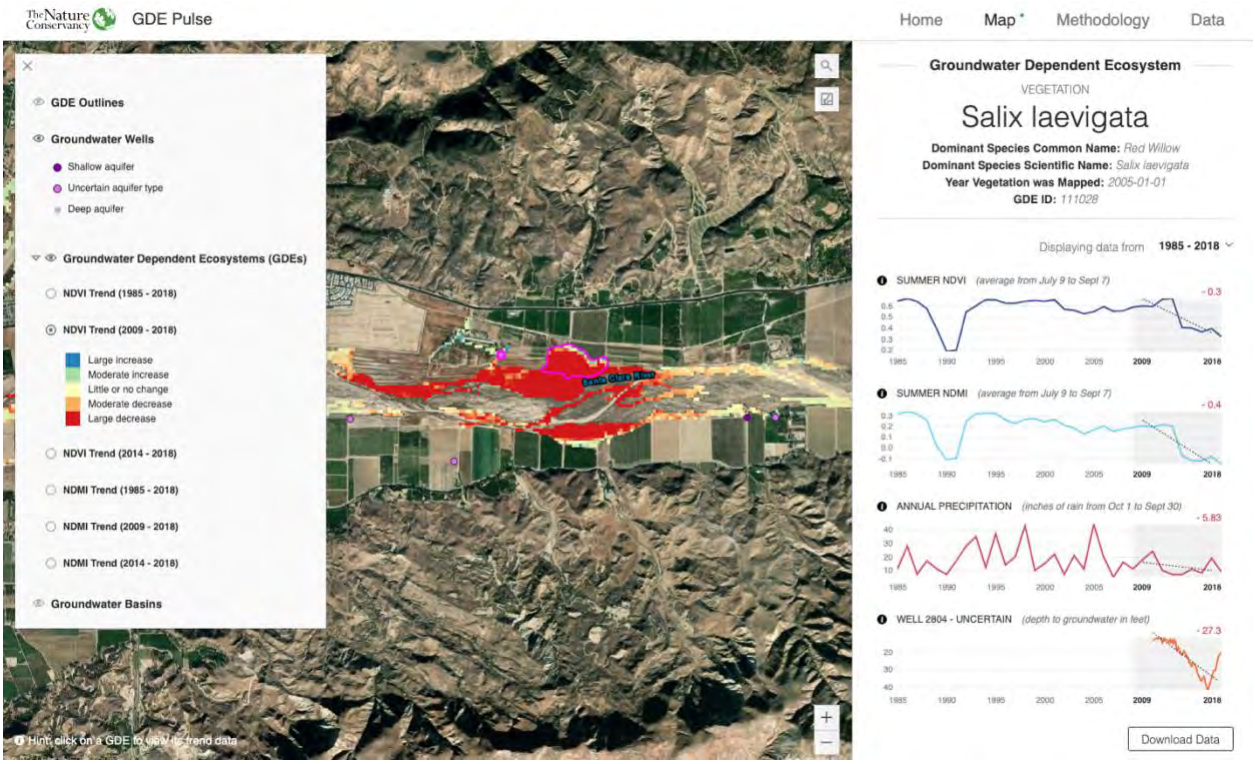
How the database was compiled

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.

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[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.

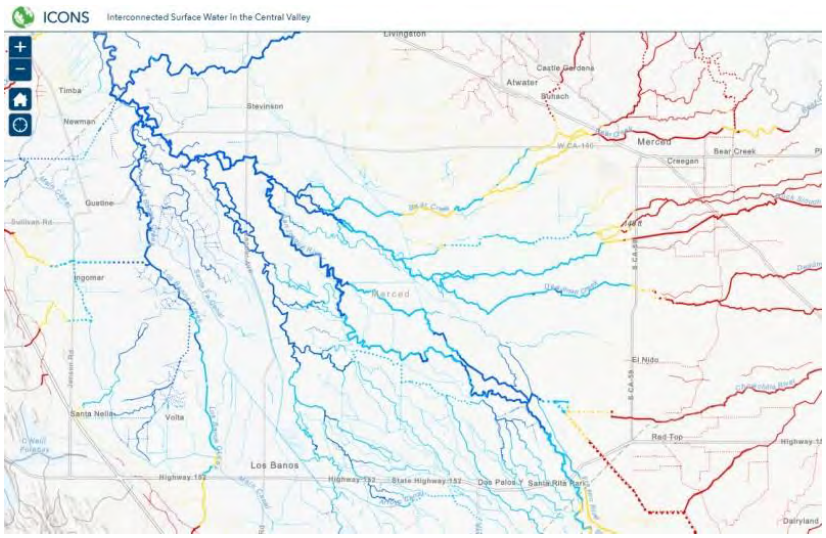
Normalized Difference Moisture Index (NDMI) is a satellite-derived index that represents water content in vegetation. NDMI is derived from the Near-Infrared (NIR) and Short-Wave Infrared (SWIR) channels. Vegetation with adequate access to water tends to have higher NDMI, while vegetation that is water 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 Butte Valley 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 Butte Valley 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 clarkii	Clark's Grebe			
Aechmophorus occidentalis	Western Grebe			
Agelaius tricolor	Tricolored Blackbird	Bird of Conservation Concern	Special Concern	BSSC - First priority
Aix sponsa	Wood Duck			
Anas acuta	Northern Pintail			
Anas americana	American Wigeon			
Anas clypeata	Northern Shoveler			
Anas crecca	Green-winged Teal			
Anas cyanoptera	Cinnamon Teal			
Anas discors	Blue-winged Teal			
Anas platyrhynchos	Mallard			
Anas strepera	Gadwall			
Anser albifrons	Greater White-fronted Goose			
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	

[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

Botaurus lentiginosus	American Bittern			
Bucephala albeola	Bufflehead			
Bucephala clangula	Common Goldeneye			
Calidris mauri	Western Sandpiper			
Calidris minutilla	Least Sandpiper			
Chen caerulescens	Snow Goose			
Chen rossii	Ross's Goose			
Chroicocephalus philadelphia	Bonaparte's Gull			
Cistothorus palustris palustris	Marsh Wren			
Cygnus columbianus	Tundra Swan			
Egretta thula	Snowy Egret			
Fulica americana	American Coot			
Gallinago delicata	Wilson's Snipe			
Grus canadensis	Sandhill Crane			
Haliaeetus leucocephalus	Bald Eagle	Bird of Conservation Concern	Endangered	
Himantopus mexicanus	Black-necked Stilt			
Limnodromus scolopaceus	Long-billed Dowitcher			
Megaceryle alcyon	Belted Kingfisher			
Nycticorax nycticorax	Black-crowned Night-Heron			
Oxyura jamaicensis	Ruddy Duck			
Pelecanus erythrorhynchos	American White Pelican		Special Concern	BSSC - First priority
Phalacrocorax auritus	Double-crested Cormorant			
Phalaropus tricolor	Wilson's Phalarope			
Plegadis chihi	White-faced Ibis		Watch list	
Pluvialis squatarola	Black-bellied Plover			
Podiceps nigricollis	Eared Grebe			
Podilymbus podiceps	Pied-billed Grebe			
Porzana carolina	Sora			
Rallus limicola	Virginia Rail			
Recurvirostra americana	American Avocet			
Riparia riparia	Bank Swallow		Threatened	
Setophaga petechia	Yellow Warbler			BSSC - Second priority
Tachycineta bicolor	Tree Swallow			
Tringa melanoleuca	Greater Yellowlegs			
Tringa semipalmata	Willet			
Xanthocephalus xanthocephalus	Yellow-headed Blackbird		Special Concern	BSSC - Third priority

CRUSTACEANS				
Hyalella muerta	An Amphipod		Special	
Hyalella spp.	Hyalella spp.			
HERPS				
Actinemys marmorata marmorata	Western Pond Turtle		Special Concern	ARSSC
Anaxyrus boreas boreas	Boreal Toad			
Anaxyrus punctatus	Red-spotted Toad			
Pseudacris regilla	Northern Pacific Chorus Frog			
Rana pretiosa	Oregon Spotted Frog	Proposed Threatened	Special Concern	ARSSC
Spea intermontana	Great Basin Spadefoot			ARSSC
Thamnophis sirtalis sirtalis	Common Gartersnake			
INSECTS & OTHER INVERTS				
Ablabesmyia spp.	Ablabesmyia spp.			
Aeshna spp.	Aeshna spp.			
Antocha spp.	Antocha spp.			
Apedilum spp.	Apedilum spp.			
Argia spp.	Argia spp.			
Atractelmis wawona	Wawona Riffle Beetle		Special	
Callibaetis spp.	Callibaetis spp.			
Cenocorixa wileyae				Not on any status lists
Centroptilum spp.	Centroptilum spp.			
Chironomidae fam.	Chironomidae fam.			
Cleptelmis addenda				Not on any status lists
Clinotanypus spp.	Clinotanypus spp.			
Coenagrionidae fam.	Coenagrionidae fam.			
Corisella decolor				Not on any status lists
Corixidae fam.	Corixidae fam.			
Cricotopus spp.	Cricotopus spp.			
Cryptochironomus spp.	Cryptochironomus spp.			
Cryptotendipes spp.	Cryptotendipes spp.			
Eukiefferiella spp.	Eukiefferiella spp.			
Fallceon quilleri	A Mayfly			
Gumaga spp.	Gumaga spp.			
Haliplus spp.	Haliplus spp.			
Helicopsyche spp.	Helicopsyche spp.			
Hesperocorixa laevigata				Not on any status lists
Hydroptila arctia	A Caddisfly			

Hydroptila spp.	Hydroptila spp.			
Laccophilus maculosus				Not on any status lists
Liodessus obscurellus				Not on any status lists
Microtendipes spp.	Microtendipes spp.			
Mideopsis spp.	Mideopsis spp.			
Notonecta kirbyi				Not on any status lists
Oecetis spp.	Oecetis spp.			
Ophiogomphus spp.	Ophiogomphus spp.			
Optioservus spp.	Optioservus spp.			
Oxyethira spp.	Oxyethira spp.			
Parakiefferiella spp.	Parakiefferiella spp.			
Paralauterborniella spp.	Paralauterborniella spp.			
Paraleptophlebia spp.	Paraleptophlebia spp.			
Parametriocnemus spp.	Parametriocnemus spp.			
Pentaneura spp.	Pentaneura spp.			
Phaenopsectra spp.	Phaenopsectra spp.			
Procladius spp.	Procladius spp.			
Procloeon venosum	A Mayfly			
Psectrocladius spp.	Psectrocladius spp.			
Pseudochironomus spp.	Pseudochironomus spp.			
Radotanypus spp.	Radotanypus spp.			
Rheotanytarsus spp.	Rheotanytarsus spp.			
Sanfilippodytes spp.	Sanfilippodytes spp.			
Sialis spp.	Sialis spp.			
Simulium spp.	Simulium spp.			
Tanytarsus spp.	Tanytarsus spp.			
Tricorythodes spp.	Tricorythodes spp.			
Wormaldia spp.	Wormaldia spp.			
MAMMALS				
Castor canadensis	American Beaver			Not on any status lists
Lontra canadensis canadensis	North American River Otter			Not on any status lists
Neovison vison	American Mink			Not on any status lists
Ondatra zibethicus	Common Muskrat			Not on any status lists
Sorex palustris	American Water Shrew			Not on any status lists
MOLLUSKS				
Gyraulus spp.	Gyraulus spp.			
Lymnaea spp.	Lymnaea spp.			
Physa spp.	Physa spp.			

Pisidium spp.	Pisidium spp.			
PLANTS				
Potentilla newberryi	Newberry's Cinquefoil		Special	CRPR - 2B.3
Rorippa columbiae	Columbia Yellowcress		Special	CRPR - 1B.2
Alopecurus aequalis aequalis	Short-awn Foxtail			
Amphiscirpus nevadensis				Not on any status lists
Anemopsis californica	Yerba Mansa			
Aquilegia shockleyi	NA			Not on any status lists
Bistorta bistortoides				Not on any status lists
Bolboschoenus maritimus paludosus	NA			Not on any status lists
Carex alma	Sturdy Sedge			
Carex densa	Dense Sedge			
Carex nebrascensis	Nebraska Sedge			
Damasonium californicum				Not on any status lists
Downingia bacigalupii	Bacigalup's Downingia			
Downingia cuspidata	Toothed Calicoflower			
Downingia insignis	Parti-color Downingia			
Downingia pulcherrima				Not on any status lists
Downingia yina	NA			
Eleocharis acicularis acicularis	Least Spikerush			
Eleocharis bella	Delicate Spikerush			
Eleocharis coloradoensis				Not on any status lists
Eleocharis macrostachya	Creeping Spikerush			
Eleocharis montevidensis	Sand Spikerush			
Eleocharis parishii	Parish's Spikerush			
Eleocharis rostellata	Beaked Spikerush			
Epipactis gigantea	Giant Helleborine			
Fimbristylis thermalis	Hot Springs Fimbry		Special	CRPR - 2B.2
Iris missouriensis	Western Blue Iris			
Juncus xiphioides	Iris-leaf Rush			
Lobelia cardinalis cardinalis	NA			
Lythrum californicum	California Loosestrife			

Montia chamissoi	Chamisso's Miner's-lettuce			
Myosurus apetalus	Bristly Mousetail			
Myosurus minimus	NA			
Myosurus sessilis	Sessile Mousetail			
Myriophyllum aquaticum	NA			
Navarretia intertexta	Needleleaf Navarretia			
Navarretia leucocephala leucocephala	White-flower Navarretia			
Navarretia leucocephala minima	Least Navarretia			
Paspalum distichum	Joint Paspalum			
Phacelia distans	NA			
Phragmites australis australis	Common Reed			
Pluchea sericea	Arrow-weed			
Psilocarphus oregonus	Oregon Woolly-heads			
Puccinellia nuttalliana	Nuttall's Alkali Grass			
Rhododendron columbianum				Not on any status lists
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			
Schoenoplectus americanus	Three-square Bulrush			
Schoenoplectus pungens longispicatus	Three-square Bulrush			
Scirpus microcarpus	Small-fruit Bulrush			
Senecio hydrophilus	Great Swamp Ragwort			
Sidalcea pedata	Pedate Checker-mallow	Endangered	Endangered	CRPR - 1B.1
Stachys albens	White-stem Hedge-nettle			
Stuckenia striata				Not on any status lists
Symphyotrichum frondosum	Alkali Aster			
Symphyotrichum lanceolatum lanceolatum	NA			
Typha domingensis	Southern Cattail			

Veronica anagallis-aquatica	NA			

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.

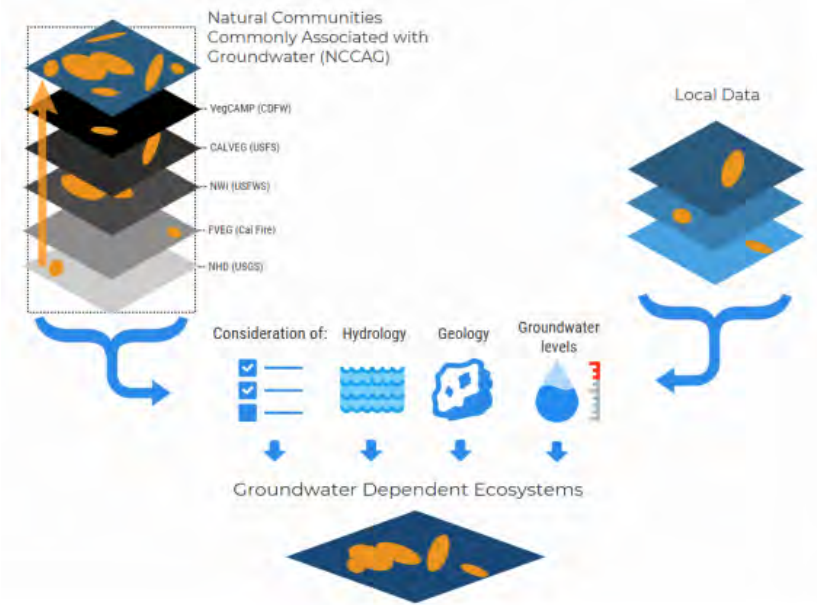


Figure 1. Considerations for GDE identification.
Source: DWR[2]

[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

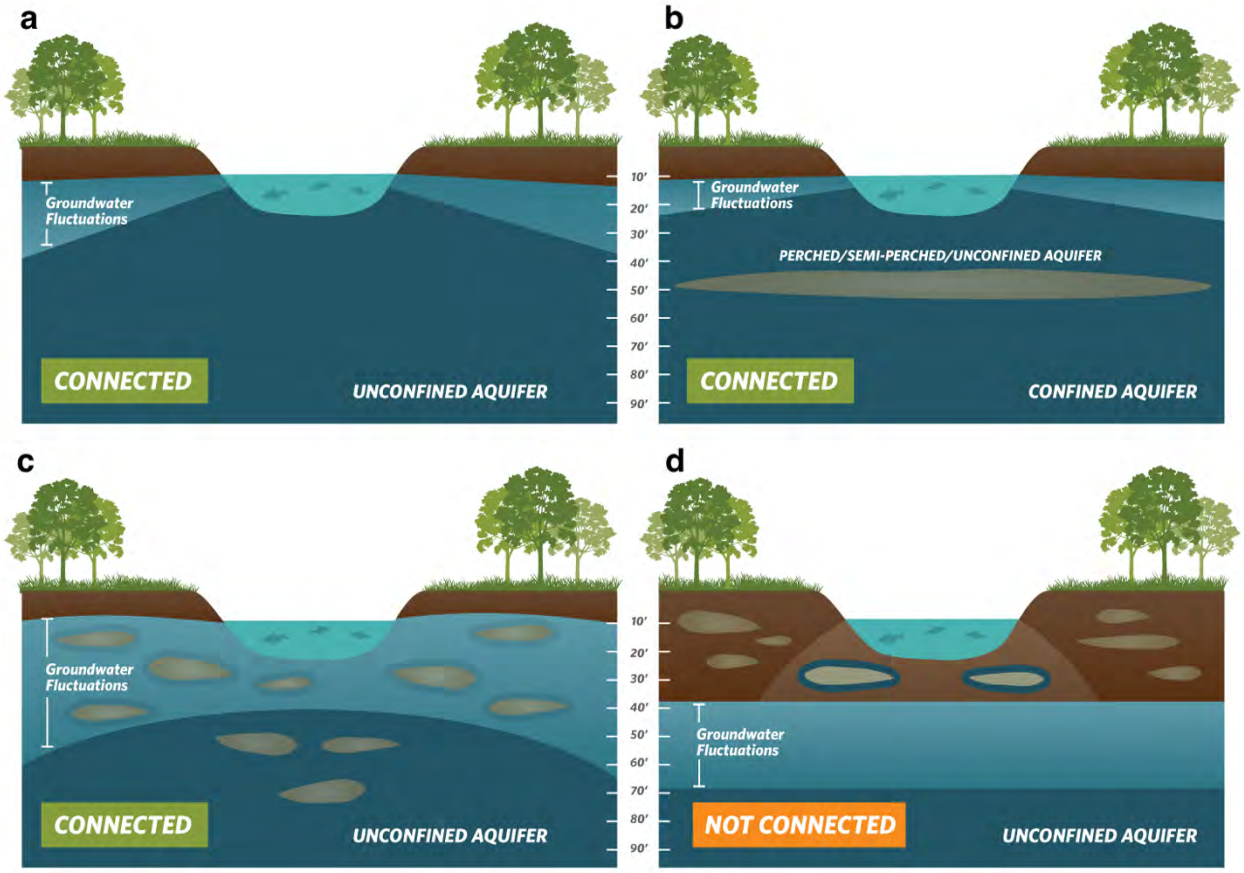


Figure 2. Confirming whether an ecosystem is connected to groundwater. Top: (a) Under the ecosystem is an unconfined aquifer with depth-to-groundwater fluctuating seasonally and interannually within 30 feet from land surface. **(b)** Depth-to-groundwater in the shallow aquifer is connected to overlying 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 until data gaps are reconciled in the monitoring network (see Best Practice #6).

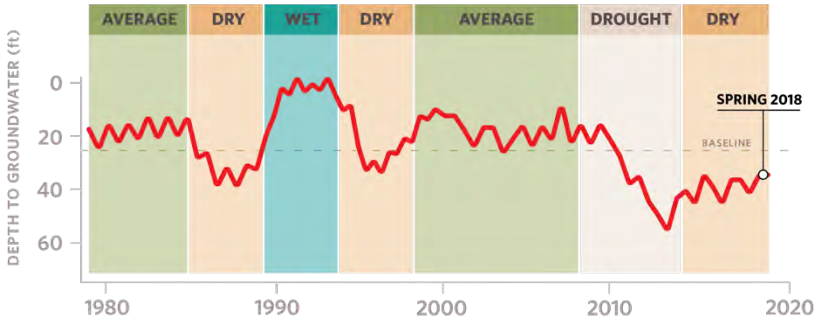


Figure 3. Example seasonality and interannual variability in depth-to-groundwater over time. Selecting one point in time, such as Spring 2018, to characterize groundwater conditions in GDEs fails to capture what groundwater conditions are necessary to maintain the ecosystem status into the future so 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).

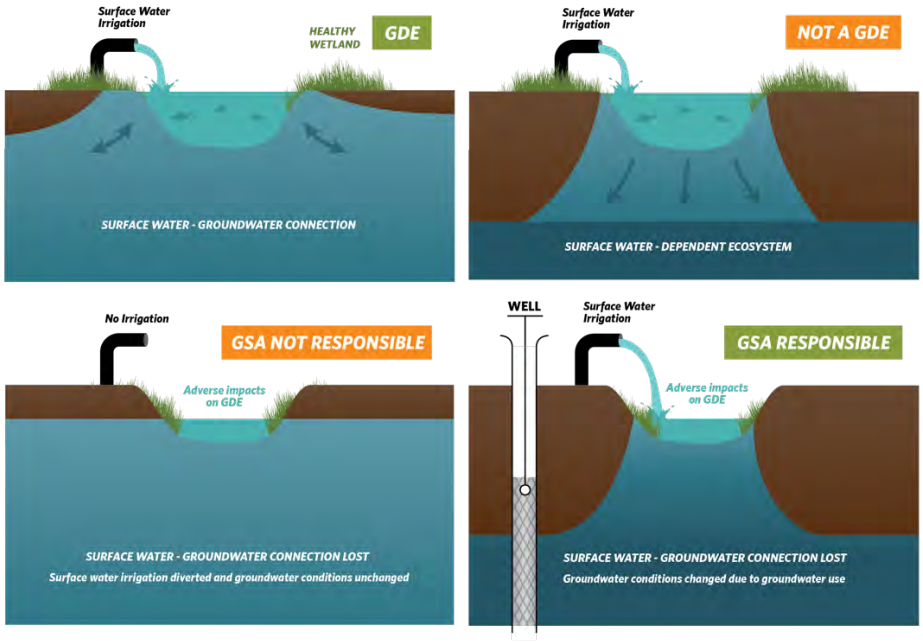


Figure 4. Ecosystems often depend on multiple sources of water. Top: (Left) Surface water and groundwater are interconnected, meaning that the GDE is supported by both groundwater and surface water. **(Right)** Ecosystems that are only reliant on non-groundwater sources are not groundwater-dependent. **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.

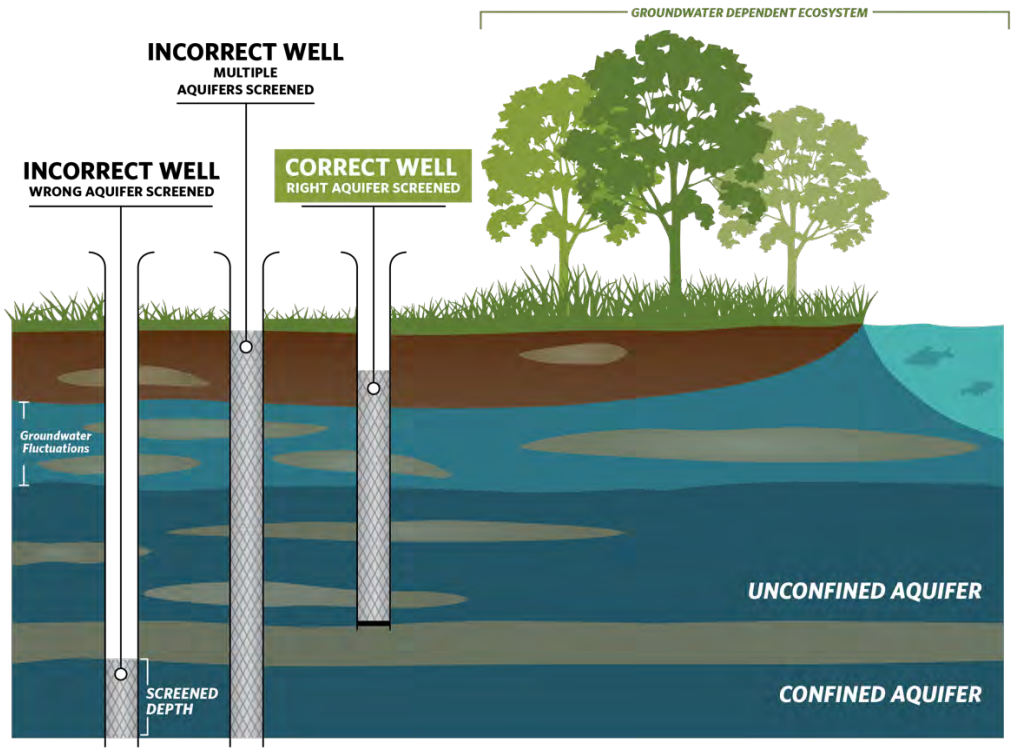


Figure 5. Selecting representative wells to characterize groundwater conditions near GDEs.

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.

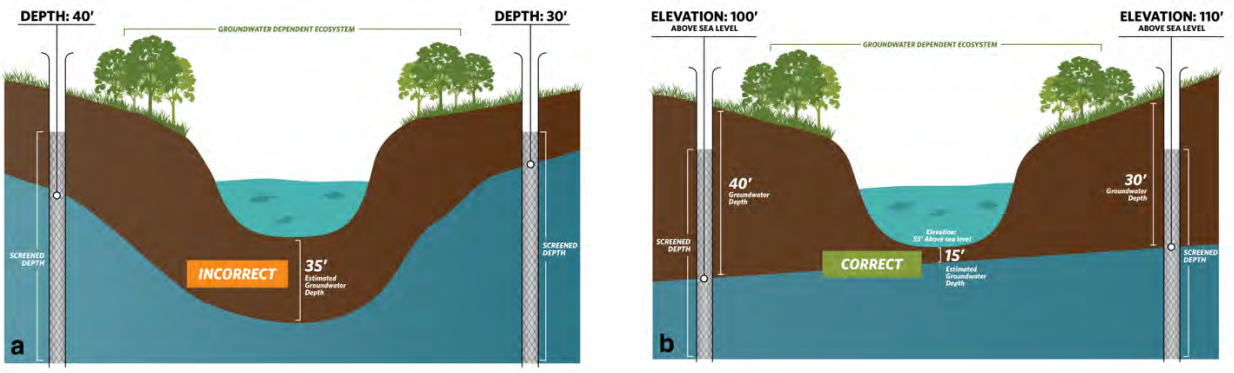


Figure 6. Contouring depth-to-groundwater around surface water features and GDEs. (a) Groundwater level interpolation using depth-to-groundwater data from monitoring wells. **(b)** Groundwater level interpolation using groundwater elevation data from monitoring wells and DEM data.

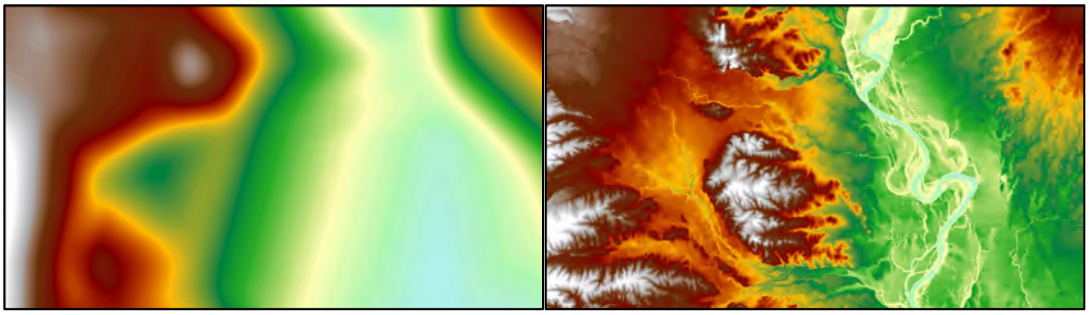


Figure 7. Depth-to-groundwater contours in Northern California. (Left) Contours were interpolated using depth-to-groundwater measurements determined at each well. **(Right)** Contours were determined by interpolating groundwater elevation measurements at each well and superimposing ground surface elevation 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.

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State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Northern Region
601 Locust Street
Redding, CA 96001
www.wildlife.ca.gov

GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

September 23, 2021

Via Electronic Mail

Matt Parker
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Siskiyou County Flood Control and Water Conservation District
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MParker@co.siskiyou.ca.us
SGMA@co.siskiyou.ca.us

SUBJECT: CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE COMMENTS ON THE BUTTE VALLEY BASIN DRAFT GROUNDWATER SUSTAINABLITY PLAN

Dear Matt Parker:

The California Department of Fish and Wildlife (Department) appreciates the opportunity to provide comments on the Draft Groundwater Sustainability Plan (GSP) for Butte Valley Basin (Basin) prepared by the Siskiyou County Flood Control and Water Conservation District, designated as the Groundwater Sustainability Agency (GSA).

Since the Basin is designated as medium priority under the Sustainable Groundwater Management Act (SGMA), the Basin must be managed under a GSP by January 31, 2022. Development and implementation of GSPs under SGMA represents a new era of California groundwater management. The Department has an interest in the sustainable management of groundwater, as many sensitive ecosystems and public trust resources depend on groundwater and interconnected surface waters (ISWs), including ecosystems on Department-owned and -managed lands within SGMA-regulated basins. In addition, it is important to note that the Department owns the Butte Valley Wildlife Area (BVWA), including Meiss Lake, which is within the Basin.

Background

The GSA appointed an Advisory Committee, composed of members of the Basin community, to work with a group of consultants to develop the Draft GSP. The Advisory Committee requested comments from any stakeholder as it developed the Draft GSP. The Department previously provided comments during Advisory Committee meetings, and on certain draft Chapters as they

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were made available. During Committee meetings, the Department provided comments on issues including the following: use of the best available science and information to develop the model; the water budget; identification and consideration of beneficial users and groundwater-dependent ecosystems (GDEs); well information as it relates to Department-owned and -managed properties; and sustainable management criteria. The Draft GSP does not fully address all comments the Department provided during the Advisory Committee meetings or comments provided on the previous draft chapters. After its review of the Draft GSP, the Department also has additional comments that it had not raised previously. Therefore, the Department is commenting again at this point in time to ensure all of these comments are fully considered in the development of the Draft GSP.

Organization of Comments

The Department has organized its comments below into several key topic areas: (1) the Department's trustee agency role; (2) SGMA requirements relevant to beneficial users and GDEs; (3) SGMA hydrogeologic conceptual model requirements; (4) sustainable management criteria and water budget requirements; (5) monitoring network and well information; (6) data gaps and use of the best available science; and (7) Public Trust Doctrine and California Endangered Species Act (CESA) requirements. This letter highlights key comments and is not inclusive of all comments provided to the Advisory Committee during meetings and/or communication with County staff. The GSA reloaded Chapter 2 online on August 24, 2021. In addition, the model documentation and water budget information, including the Butte Valley Wildlife Area Water Budget, were not provided until September 13, 2021. Since the complete Draft GSP was not publicly available since the beginning of the public review period, limited time was available for review and comment of certain sections of the Draft GSP.

Department's Trustee Role

As the trustee agency for the State's fish and wildlife resources, the Department has jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and the habitat necessary for biologically sustainable populations of such species. (Fish & G. Code, §§ 711.7 & 1802.) The Basin supports populations of bald eagle (CESA endangered), greater sandhill crane (CESA threatened), Swainson's hawk (CESA threatened), tricolored blackbird (CESA threatened), western pond turtle (State species of special concern), pronghorn, and other fish and wildlife species that rely on habitats supported and supplemented by groundwater and surface water.

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The Draft GSP raises significant concerns about potential impacts of groundwater pumping on GDEs, interconnected surface waters (ISWs), and species within the Department's jurisdiction. The Department urges the GSA to plan for and engage in responsible groundwater management that minimizes or avoids these impacts to the maximum extent feasible as required under applicable provisions of SGMA and the Public Trust Doctrine. CDFW-001

SGMA Requirements Relevant to Beneficial Users and GDEs

In addition to other requirements that will be discussed later in this letter, SGMA and its implementing regulations afford beneficial users and GDEs specific consideration, including the following as pertinent to GSPs:

Consideration of Beneficial Uses and Users

GSPs must consider the interests of all beneficial uses and users of groundwater, including environmental users of groundwater. (Water Code § 10723.2.) GSPs must also **identify and consider potential effects on all beneficial uses and users of groundwater**. (23 CCR §§ 354.10(a), 354.26(b)(3), 354.28(b)(4), 354.34(b)(2), and 354.34(f)(3).) The Draft GSP does not adequately identify all the environmental users in the Basin, their locations, the groundwater dependent habitat they depend on at certain life stages, and how the Draft GSP will meet their needs. CDFW-002 The Draft GSP identifies a handful of species that are either Endangered Species Act (ESA) or CESA listed species found on BVWA, and does not take into account other special status or locally significant fish and wildlife species and habitats that benefit from or are dependent on groundwater. CDFW-003 In Table 1.7 of Chapter 2, the Draft GSP identifies species prioritized for management in the first column, and other species that depend on the same ecosystems as the species prioritized for management in the second column. CDFW-004 The Draft GSP species prioritized for management were identified as "riparian vegetation", which is a vegetation type, not an ecosystem or species. Many species, including special-status species, that are known to depend on or may be vulnerable to groundwater fluctuations were not identified in this column. Species identified in the Basin that are not included in the Draft GSP include, but are not limited to, short-eared owl, Swainson's hawk, tri-colored blackbird, Tule white-fronted goose, Vaux's swift, Wawona Riffle Beetle, western pond turtle, and white-faced ibis. CDFW-005 The Draft GSP does not indicate where these species were found in the Basin and how these species could be supported by the identified riparian vegetation and impacted by groundwater.

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Identification and Consideration of GDEs

GSPs must **consider impacts to GDEs**. (Water Code § 10727.4(l); *see also* 23 CCR § 354.16(g).) The Department is uncertain whether the Draft GSP accurately identifies all GDEs in the Basin. Specifically, the Draft GSP does not provide sufficient detail when describing the methods used for GDE classification and mapping in the Draft GSP and the rationale for the methods used. The Draft GSP mentions desktop methods of using existing mapping tools, root depth to groundwater modeling, and other tools for identifying GDEs. The Draft GSP appears not to include Advisory Committee input, field verification, or any quality assurance/quality control measures to validate the resulting classification and mapping. Without these means of verification, the Department cannot evaluate or comment on the accuracy of the GSP's GDE classification or mapping. However, the Department recommends that GDE mapping be informed by science-based vegetation classification or similar methods, such as the Department's *Survey of California Vegetation Classification and Mapping Standards.*[1] The Draft GSP's GDE classification and mapping should be revised if necessary after utilizing these methods. Classification and mapping methods should be thoroughly described so that GDE classification and mapping can be verified by stakeholders or repeated during future GSP updates and effectiveness monitoring.

CDFW-006

The Draft GSP mentions certain GDEs, but does not provide consideration of those GDEs or assess potential impacts to those GDEs from groundwater pumping. The Draft GSP also fails to identify or appropriately consider certain GDEs, including Meiss Lake within the BVWA. Historically, Meiss Lake was a natural wetland that spanned the Butte Valley Basin and received natural inputs from both groundwater and surface water. Due to unsustainable groundwater management practices, Meiss Lake has been reduced in size to about 4,000 acres, but it continues to support a wide variety of species and habitats. Currently, Meiss Lake receives natural inputs from surface water tributaries and is occasionally supported by pumped groundwater as needed in dry years to support groundwater-dependent species. Thus, Meiss Lake qualifies as a GDE that must be identified and appropriately considered in the draft GSP because it is a historic natural wetland that continues to rely on groundwater inputs to sustain its species and habitat. In defining GDEs entitled to consideration in a GSP, SGMA statutes and regulations do not require features to rely on groundwater from a particular source in order to qualify as GDEs. (23 CCR § 354.16(g); Water Code § 10727.4(l).)

CDFW-007

CDFW-008

[1] [1] https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=102342&inline

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Alternatively, if the District were to nevertheless conclude that Meiss Lake is not a GDE, Meiss Lake must be considered a managed wetland, with its groundwater inputs appropriately accounted for in the Draft GSP's water budget. GSPs must account for groundwater extraction for all water use sectors including managed wetlands, managed recharge, and native vegetation. (23 CCR §§ 351(al) and 354.18(b)(3).)

CDFW-008 Cont'd.

Chapter 2 of the Draft GSP contains a description of the BVWA's water management practices depending on the water year type or impacts to Meiss Lake, the lowest point in the basin. Many of the streams, including Butte Creek, have been "sufficiently appropriated" during the irrigation season, meaning that allocated water likely exceeds available supplies, leaving little to enter Meiss Lake. The Draft GSP's water budget must consider and account for the fact that Meiss Lake may go dry in certain years and may require inputs of pumped groundwater for wetland habitat restoration and to support groundwater-dependent species. By failing to account for groundwater inputs to Meiss Lake, the GSP has not adequately analyzed the groundwater-surface water relationship in the Basin or developed a complete water budget.

The Draft GSP does not identify projects and management actions (PMAs) or sustainable management criteria to protect GDEs in the basin. The Department will make best efforts to support PMAs anticipated to address both immediate- and long-term fish and wildlife resource needs. Not recognizing the role of the GSA to ensure sustainable management and nearly all PMAs through an "integrative and collaborative approach" will make it difficult to achieve sustainability by 2042 as contemplated under SGMA. As explained more fully below, the Department recommends revisiting the Draft GSP to address data gaps, ensure compliance with applicable SGMA statutory requirements, and appropriately consider and address impacts to GDEs and all beneficial users.

CDFW-009

CDFW-010

Hydrogeologic Conceptual Model Requirements

SGMA regulations require each GSP to include a descriptive hydrogeologic conceptual model (HCM) 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. (23 CCR § 354.14.) The HCM must include a description of data gaps and uncertainty within the HCM. (*Id*. at § 354.14(b)(4)(5).)

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While the Draft GSP includes an HCM, it is not clear that the HCM accurately characterizes the physical components and surface water-groundwater interactions in the Basin. For example, the HCM in the Draft GSP fails to identify a definable bottom of the basin as required by SGMA regulations. (23 CCR §354.14(b)(3).) As described in Chapter 2 of the Draft GSP, the HCM includes a description of the Western Cascades Subprovince geologic unit, which is the relatively older and less permeable volcanic bedrock that underlies Butte Valley. (p. 48.) Such description states that the Western Cascades unit "acts as a barrier to regional groundwater flow." As such, it is assumed that the Western Cascades unit surface is the bottom of the Basin. However, the description concludes that, "This formation has not been penetrated by Butte Valley wells (DOI 1980). The unknown depth to the Western Cascades Subprovince precludes its appearance in the cross-sections." No additional information was noted attempting to characterize the bottom of the Basin boundary.

CDFW-011

CDFW-012

Several statements in the Draft GSP contribute to the uncertainty regarding the accuracy of the HCM's characterizations of the physical components and surface water-groundwater interactions. For example, the Draft GSP states Butte Valley basin has experienced a decrease in groundwater levels on the order of approximately 30-feet during the study period of spring 1979 to spring 2015 due primarily to decreased precipitation, increased pumping, and a commensurate decrease in the subsurface hydraulic gradient. Similarly, the Draft GSP concludes that, "There is significant long-term trend indicating some groundwater depletion." Conversely, the Draft GSP finds that the basin is not in overdraft due to significantly higher volumes of lateral groundwater inflow compared to volumes of groundwater extraction and does not exceed the sustainable yield of the Basin. The Draft GSP asserts that the sustainable yield will be a constantly changing value based on future climate conditions, future groundwater pumping needs, and future management actions. The Draft GSP should adequately quantify sustainable yield as required by SGMA regulations to explain this fluctuation for the approach to be acceptable. (23 CCR § 354.18 (b)(7).) Once the GSA clarifies its understanding of these issues, the water budget should be adjusted accordingly and the Draft GSP should identify sustainable management criteria that prevent adverse impacts to beneficial users, such as dewatering of GDEs, and strive for long term groundwater sustainability with PMAs. The GSA should consider developing PMAs that promote more efficient water use through water conservation where feasible.

CDFW-011 Cont'd.

CDFW-013

CDFW-014

CDFW-015

CDFW-016

<u>Sustainable Management Criteria and Water Budget Requirements</u>

GSPs must **establish sustainable management criteria that avoid undesirable results** within 20 years of the applicable statutory deadline, including **depletions**

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of ISW that have significant and unreasonable adverse impacts on beneficial uses of the surface water. (23 CCR § 354.22 et seq. and Water Code §§ 10721(x)(6) and 10727.2(b).) The Draft GSP concludes that sustainability will be achieved by 2042 and undesirable results will be avoided, but the underlying analysis and data do not fully support these conclusions. The goal of sustainability cannot be achieved by 2042 without an accurate water budget and clearly-defined sustainable management criteria, including minimum thresholds, that meet SGMA's requirements including the following:

CDFW-017

Minimum Thresholds for ISW Depletions

SGMA regulations require the GSP to include numeric minimum thresholds to define and avoid undesirable results, which must be explained and justified based on basin-specific information and other data or models as appropriate, with appropriate accounting for any uncertainty in the understanding of the basin setting. (23 CCR § 354.28(a)-(b).) The GSP must explain the relationship between the minimum thresholds and the relevant sustainability indicator, how the minimum thresholds will avoid causing undesirable results, how the minimum thresholds may affect the interests of beneficial uses and users of groundwater, and how each minimum threshold will be quantitatively measured consistent with SGMA monitoring network requirements. (*Id*.)

Specifically, SGMA regulations require minimum thresholds related to depletions of interconnected surface water to 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).) These minimum thresholds must be supported by the "location, quantity, and timing of depletions of interconnected surface water" and "a description of the groundwater and surface water model used to quantify surface water depletion." (*Id*. at § 354.28(c)(6).) If a numerical groundwater-surface water model is not used to quantify surface water depletion, the GSP must identify and describe an equally effective method, tool, or analytical model to be used for this purpose. The Draft GSP does not meet these requirements because it does not identify a sustainable management criteria for surface water depletions. As such, the Draft GSP does not set minimum thresholds for surface water depletions based on the rate or volume of surface water depletions caused by groundwater use, and it does not utilize a basin-wide groundwater-surface water model or equally effective method, tool, or model to quantify such depletions. The Department requests revisions to the Draft GSP to clarify how the sustainable management criteria were developed, how these criteria relate to the relevant sustainability indicators, and how the criteria may affect the interest of beneficial users.

CDFW-018

CDFW-019

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Water Budget Requirements

Per SGMA regulations, each GSP "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).) The water budget is a product of the Butte Valley Integrated Hydrologic Model (BVIHM), which is derived from the larger USGS groundwater model of the Upper Klamath Basin (Gannett et al., 2012, USGS Scientific Investigations Report 2012-5062). A key simplification is utilized by the Draft GSP authors in developing the water budget in that the surface water hydrologic subsystem is removed from the BVIHM. The Department appreciates the justifications for this simplification being few streams contribute perennial flow to the basin surface due, in part, to infiltration into highly permeable volcanic soils outside of the basin boundary. However, some of the Water Budget's information contradicts the information presented within the HCM discussion. For example, during the HCM discussion in Chapter 2, the GSA acknowledges that streamflow losses, canal seepage and percolation from wetlands (that receive periodic surface flows) all contribute to groundwater recharge. Similarly, the HCM mentions spring-fed creeks that drain into Meiss Lake (currently part of the BVWA). Ultimately, the Department is hesitant to support elimination of all surface water inputs for modeling purposes. The Department is especially concerned with the canal seepage when an economic, environmental, or other benefit may result from a more efficient use of water. The GSA should conduct further analysis of potential surface water input sources to fully comply with applicable SGMA regulations. (*see, e.g.*, 23 CCR §354.18(b)(1).)

CDFW-020

Monitoring Network and Well Information

GSPs must describe monitoring networks that can identify adverse impacts to beneficial uses of ISWs. (23 CCR § 354.34(c)(6)(D).) The Draft GSP lacks basin-wide groundwater monitoring, which is necessary to assess potential surface water depletions and impacts to beneficial surface water users, including fish and wildlife species. The GSA should identify how the GSA will achieve a robust monitoring system to capture accurate information on these portions of the basin or use existing data to accurately model these portions and assess impacts. If the GSA intends to rely on basin-specific data, the Draft GSP should elaborate on the description of developing a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface water conditions as required by

CDFW-021

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SGMA regulations. (23 CCR §354.34.) The Draft GSP should clearly identify the wells used for monitoring including individual well information. This includes the well ID, ground surface elevation, reference point elevations for water level measurements, well completion depth, perforation intervals, and hydrograph information. For the hydrograph information, the Draft GSP should provide information on the aquifer unit. CDFW-021 Cont'd.

Data Gaps and Use of the Best Available Science

Per SGMA regulations, the Draft GSP must identify reasonable measures and schedules to eliminate data gaps. (23 CCR § 355.4(b)(2).) As noted above, the Draft GSP does not set forth sustainable management criteria for surface water depletions, nor does it utilize a basin-wide groundwater-surface water model or equally effective method, tool, or model to quantify such depletions. The Draft GSP also lacks basin-wide groundwater monitoring, which is necessary to assess potential surface water depletions and impacts to beneficial surface water users. The Department acknowledges data gaps may initially exist and may make development of certain criteria more challenging. However, the Draft GSP must set forth a reasonable pathway and timeline for addressing these data gaps and developing sustainable management criteria as required under SGMA, supplementing with models and other data if needed to address uncertainties in basin-specific data. CDFW-022 CDFW-023 CDFW-024

The Draft GSP also lacks quantitative criteria for interconnected surface water, which are needed to assess compliance with SGMA and avoid significant and unreasonable depletions of ISW. After conducting the necessary analysis and establishing appropriate criteria, the Draft GSP should be updated to consider and avoid any unreasonable adverse impacts to beneficial users anticipated to result from ISW depletions. The Draft GSP expanded its sustainability management criteria with additional monitoring points with "soft landing" triggers and "aspirational watershed goals". This characterization ignores SGMA, which clearly indicates the sustainability goal and sustainable management criteria must be developed to avoid undesirable results within the planning and implementation horizon. (23 CCR §§ 354.24, 354.26, and 354.28.) CDFW-025 CDFW-026

In addition, SGMA requires the assumptions, criteria, findings, and objectives of a GSP to be reasonable and supported by the best available information and best available science. (23 CCR § 355.4(b)(1).) The Department is aware of available information not being utilized to the fullest for the development of each sustainable management criteria, the water budget and BVIHM in the Draft GSP. Specifically, the Draft GSP lacks consideration of current versus historic surface water extractions, agriculture ditch losses and gains, and new or CDFW-027

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improved wells in the basin. These deficiencies in the analysis suggest BVIHM may not be considering all relevant groundwater pumping and related impacts in the basin. Since SGMA requires sustainable management of the entire basin, the sustainable management criteria and water budget must take a basin-wide approach. The GSA must identify reasonable measures and schedules to address these data gaps and set or revise basin-wide sustainable management criteria as its understanding of the Basin improves.

CDFW-027 Cont'd.

Public Trust Doctrine and California Endangered Species Act

The Department urges the GSA to consider its duties under the Public Trust Doctrine while developing its Draft GSP. While the SGMA sustainability requirements must be met within the 20-year planning and implementation horizon, Public Trust Doctrine requirements apply independently of SGMA, are not preempted by SGMA, and are applicable at all times. Under the Public Trust Doctrine, the GSA has the responsibility to consider potential impacts of its groundwater planning decisions on navigable interconnected surface waters and their tributaries, and ISWs that support fisheries and ecological uses, including the level of groundwater contribution to those waters.[2] The GSA has "an affirmative duty to take the public trust into account in the planning and allocation of water resources, and to protect public trust uses whenever feasible." (*National Audubon Society v. Alpine County Superior Court* (1983) 33 Cal. 3d 419, 446.)

It is not clear that the GSA has undertaken the analysis and consideration required under the Public Trust Doctrine to support its proposed PMAs and management criteria. Under *Audubon* and *Environmental Law Foundation*, the GSA must conduct a robust analysis that considers the needs of public trust resources and impacts to those resources due to the proposed groundwater management practices, and that clearly explains why protection of public trust resources is infeasible due to inconsistency with the public interest. As explained above, the GSA has yet to resolve significant data gaps relevant to the surface water depletion rate, basin-wide groundwater levels, and the presence and needs of GDEs and beneficial users of interconnected surface waters. These issues must be addressed to ensure appropriate consideration of the needs of public trust resources as required under the Public Trust Doctrine.

CDFW-028

[2] *See, e.g., People v. Truckee Lumber Co.* (1897) 116 Cal. 397, *National Audubon Society v. Alpine County Superior Court* (1983) 33 Cal. 3d 419, and *Environmental Law Foundation v. State Water Resources Control Board* (2018) 26 Cal. App. 5th 844.

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Based on an accurate understanding of public trust resource needs and impacts, the GSA will need to assess a range of potential protective measures to address impacts of groundwater extractions. These measures may need to go beyond the PMAs identified in the Draft GSP and may include pumping limits or alternative supply options to address existing, new, and expanded extractions. Given overallocation and ongoing drought, it is critical to plan for such eventualities in the Draft GSP. Before rejecting such measures, the GSA will need to engage in a balancing of competing interests that shows that protecting species and habitat though contingent pumping limits, use of supply alternatives, or equivalent protective measures would be infeasible.

CDFW-029

It is also unclear whether the GSA has appropriately considered potential impacts to *all* public trust resources in the basin, including those in Meiss Lake within the BVWA. Meiss Lake provides about 4,000 acres of aquatic wetland habitat that supports a variety of bird species, including migratory waterfowl, sandhill cranes, and other wetland-associated birds along the Pacific Flyway. (1996 Land Management Plan for BVWA.) Surveys since the Land Management Plan of 1996 have documented that in wet cycles, Meiss Lake contains thousands of nests of gull and tern species, including ring-billed gulls, California gulls, Caspian terns, and Forster's terns plus double crested cormorants and American white pelicans. (Novick 2011.) Species known to visit BVWA and use its habitat for nesting and/or foraging include the state endangered bald eagle, the state threatened greater sandhill crane, the state threatened Swainson's hawk, and the state threatened northern spotted owl. (*Id*.) Surveys of BVWA also document peak use of the wildlife area by hundreds of thousands of waterfowl, including nesting species (mallard, gadwall, cinnamon teal, Great Basin Canada goose, redhead, pintail and ruddy duck). (*Id*.) One of the key purposes for acquiring and maintaining the BVWA is to maintain and restore wetlands onsite, including Meiss Lake, to provide habitat and food for species. (1996 Land Management Plan for BVWA.) Failing to manage groundwater to ensure Meiss Lake receives adequate inputs to support these uses would undermine this goal.

CDFW-030

CDFW-030 Cont'd.

Many state policies and orders recognize the importance of wetlands, including the following:

- Executive Order W-59-93, California Wetlands Conservation Policy, commonly referred to as the "No Net Loss Policy" for wetlands, which aims to "[e]nsure no overall net loss and achieve a long-term net gain in the quantity, quality, and permanence of wetlands acreage and values in California in a manner that fosters creativity, stewardship and respect for private property";

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- SWRCB Resolution No. 2019-0015 ("State Wetland Definition and Procedures for Discharges of Dredged or Fill Material to Waters of the State"), which affirms the SWRCB and Regional Water Boards' commitment to increasing the quantity, quality, and diversity of wetlands in California; and
- The Fish and Game Commission's Wetlands Resources policy, which recognizes that wetlands "provide significant and essential habitat for a wide variety of important resident and migratory fish and wildlife species" and that the quality and quantity of wetlands habitat in California has been significantly reduced. The Commission's policy is to ensure that proposed projects will result in no net loss of wetland or riparian habitat or acreage, and to seek to provide for the protection, preservation, restoration, enhancement, and expansion of wetland habitat in California.

Case law recognizes that these ecological uses of Meiss Lake are subject to the Public Trust Doctrine. In *Marks v. Whitney* (1971) 6 Cal. 3d 251, 259-260, the California Supreme Court recognized that the Public Trust Doctrine extends to preservation of wetlands "…in their natural state, so that they may serve as ecological units for scientific study, as open space, and as environments which provide food and habitat for birds and marine life…" More recently, the same court in *Audubon* recognized applicability of the Public Trust Doctrine to non-navigable tributaries to Mono Lake that supported a variety of bird species. (33 Cal. 3d 419, 436-437.) In *Environmental Law Foundation*, *supra*, 26 Cal. App. 5th 859-860, the Court applied the Public Trust Doctrine to groundwater extractions from tributaries that adversely impact public trust uses in interconnected surface waters, noting that the key factor is not the nature of the activity, but whether the activity results in harm to public trust resources. Consistent with this case law, the GSA must, if feasible, manage groundwater use to ensure Meiss Lake continues to receive groundwater inputs necessary to support its habitat and ecological uses.

CDFW-030 Cont'd.

Most critically, the GSA should consider the implications of its GSP development and implementation on species listed under the California Endangered Species Act (CESA). It is unclear whether the current Draft GSP will support all beneficial users, including CESA-listed bald eagle, greater sandhill crane, Swainson's hawk, and northern spotted owl, since its sustainable management criteria do not appear to account for the needs of these species and its PMAs are deferred to a future date. Actions may need to go beyond SGMA minimum requirements to meet Public Trust Doctrine requirements.

CDFW-031

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The Department appreciates the opportunity to provide comments on the Draft GSP. For questions, please contact Region 1 SGMA Coordinator, Brad Henderson, at Brad.Henderson@wildlife.ca.gov . Additionally, you can contact the Klamath Watershed Coordinator, Janae Scruggs, at Janae.Scruggs@wildlife.ca.gov.

Sincerely,

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Attachment C – Butte Valley Groundwater Sustainability Plan Comment and Comment Response Matrix

Author	CIN	Group	Sub-Category	Description	Code/ Regulation	Location in GSP	Comment	Response / Recommended Action	Response Location in GSP
California Department of Fish and Wildlife	CDFW-01	A	BR	GDEs, Environmental Beneficial Users, Public Trust Doctrine			The Draft GSP raises significant concerns about potential impacts of groundwater pumping on GDEs, interconnected surface waters (ISWs), and species within the Department's jurisdiction. The Department urges the GSA to plan for and engage in responsible groundwater management that minimizes or avoids these impacts to the maximum extent feasible as required under applicable provisions of SGMA and the Public Trust Doctrine.	See MCR "GDE", "ISW", and "Public Trust Doctrine".	
California Department of Fish and Wildlife	CDFW-02	A	GD	Identification of Environmental Beneficial Users	23 CCR §§ 354.10(a), 354.26(b)(3), 354.28(b)(4), 354.34(b)(2), and 354.34(f)(3)		The Draft GSP does not adequately identify all the environmental users in the Basin, their locations, the groundwater dependent habitat they depend on at certain life stages, and how the Draft GSP will meet their needs.	See MCR "GDE".	
California Department of Fish and Wildlife	CDFW-03	A	BR	Identification of Environmental Beneficial Users, ESA	23 CCR §§ 354.10(a), 354.26(b)(3), 354.28(b)(4), 354.34(b)(2), and 354.34(f)(3)	Chapter 2, Table 1.7	The Draft GSP identifies a handful of species that are either Endangered Species Act (ESA) or CESA listed species found on BVWA, and does not take into account other special status or locally significant fish and wildlife species and habitats that benefit from or are dependent on groundwater.	See MCR "GDE".	
California Department of Fish and Wildlife	CDFW-04	C	GD	GDE- vegetation		Chapter 2, Table 1.7	The Draft GSP species prioritized for management were identified as "riparian vegetation", which is a vegetation type, not an ecosystem or species.	The language has been updated for clarity.	
California Department of Fish and Wildlife	CDFW-05	A	GD	Identification of Environmental Beneficial Users		Chapter 2, Table 1.7	Many species, including special-status species, that are known to depend on or may be vulnerable to groundwater fluctuations were not identified in this column. Species identified in the Basin that are not included in the Draft GSP include, but are not limited to, short-eared owl, Swainson's hawk, tri-colored blackbird, Tule white-fronted goose, Vaux's swift, Wawona Riffle Beetle, western pond turtle, and white-faced ibis. The Draft GSP does not indicate where these species were found in the Basin and how these species could be supported by the identified riparian vegetation and impacted by groundwater.	See MCR "GDE".	
California Department of Fish and Wildlife	CDFW-06	C	GD	GDE Classification Methodology	Water Code § 10727.4(l); 23 CCR § 354.16(g)		The Draft GSP does not provide sufficient detail when describing the methods used for GDE classification and mapping in the Draft GSP and the rationale for the methods used. The Draft GSP mentions desktop methods of using existing mapping tools, root depth to groundwater modeling, and other tools for identifying GDEs. The Draft GSP appears not to include Advisory Committee input, field verification, or any quality assurance/quality control measures to validate the resulting classification and mapping. Without these means of verification, the Department cannot evaluate or comment on the accuracy of the GSP's GDE classification or mapping. However, the Department recommends that GDE mapping be informed by science-based vegetation classification or similar methods, such as the Department's Survey of California Vegetation Classification and Mapping Standards.1 The Draft GSP's GDE classification and mapping should be revised if necessary after utilizing these methods. Classification and mapping methods should be thoroughly described so that GDE classification and mapping can be verified by stakeholders or repeated during future GSP updates and effectiveness monitoring.	See MCR "GDE".	
California Department of Fish and Wildlife	CDFW-07	A	GD	Consideration of Impacts to GDEs			The Draft GSP mentions certain GDEs, but does not provide consideration of those GDEs or assess potential impacts to those GDEs from groundwater pumping.	See MCR "GDE".	

California Department of Fish and Wildlife	CDFW-08	A	GD	Identification of GDEs, Inclusion in Water Budget- Meiss Lake	23 CCR § 354.16(g); Water Code § 10727.4(l); 23 CCR §§ 351(al) and 354.18(b)(3)	Chapter 2	The Draft GSP also fails to identify or appropriately consider certain GDEs, including Meiss Lake within the BVWA. Historically, Meiss Lake was a natural wetland that spanned the Butte Valley Basin and received natural inputs from both groundwater and surface water. Due to unsustainable groundwater management practices, Meiss Lake has been reduced in size to about 4,000 acres, but it continues to support a wide variety of species and habitats. Currently, Meiss Lake receives natural inputs from surface water tributaries and is occasionally supported by pumped groundwater as needed in dry years to support groundwater-dependent species. Thus, Meiss Lake qualifies as a GDE that must be identified and appropriately considered in the draft GSP because it is a historic natural wetland that continues to rely on groundwater inputs to sustain its species and habitat. In defining GDEs entitled to consideration in a GSP, SGMA statutes and regulations do not require features to rely on groundwater from a particular source in order to qualify as GDEs. Alternatively, if the District were to nevertheless conclude that Meiss Lake is not a GDE, Meiss Lake must be considered a managed wetland, with its groundwater inputs appropriately accounted for in the Draft GSP's water budget. GSPs must account for groundwater extraction for all water use sectors including managed wetlands, managed recharge, and native vegetation. Chapter 2 of the Draft GSP contains a description of the BVWA's water management practices depending on the water year type or impacts to Meiss Lake, the lowest point in the basin. Many of the streams, including Butte Creek, have been "sufficiently appropriated" during the irrigation season, meaning that allocated water likely exceeds available supplies, leaving little to enter Meiss Lake. The Draft GSP's water budget must consider and account for the fact that Meiss Lake may go dry in certain years and may require inputs of pumped groundwater for wetland habitat restoration and to support groundwater-dependent species. By failing to account for groundwater inputs to Meiss Lake, the GSP has not adequately analyzed the groundwater-surface water relationship in the Basin or developed a complete water budget.	CDFW's comment suggests that Meiss Lake is a groundwater dependent ecosystem. 23 CCR 351(o) provides that a groundwater dependent ecosystem refers to "ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface." According to the data in the GSP, it does not appear that Meiss Lake depends on aquifers or groundwater occurring near the ground surface. While Meiss Lake may have depended on aquifers or groundwater occurring near the ground surface prior to an increase in groundwater pumping in the Butte Valley, any disconnection arose long before January 1, 2015. Therefore, even if such disconnection were classified as an "undesirable result", it is not something that the GSA must address. Also see MCR "GDE".	
California Department of Fish and Wildlife	CDFW-09	A	PM	Developing PMAs to Protect GDEs			The Draft GSP does not identify projects and management actions (PMAs) or sustainable management criteria to protect GDEs in the basin. The Department will make best efforts to support PMAs anticipated to address both immediate and long-term fish and wildlife resource needs. Not recognizing the role of the GSA to ensure sustainable management and nearly all PMAs through an "integrative and collaborative approach" will make it difficult to achieve sustainability by 2042 as contemplated under SGMA.	See MCR "GDE".	
California Department of Fish and Wildlife	CDFW-10	B	GE	Addressing Data Gaps, Consider Impacts to GDEs and Beneficial Users			The Department recommends revisiting the Draft GSP to address data gaps, ensure compliance with applicable SGMA statutory requirements, and appropriately consider and address impacts to GDEs and all beneficial users.	See MCR "GDE".	
California Department of Fish and Wildlife	CDFW-11	B	HM	Accuracy of the Hydrogeologic Model	23 CCR § 354.14.(b)(4)(5)		While the Draft GSP includes an HCM, it is not clear that the HCM accurately characterizes the physical components and surface water-groundwater interactions in the Basin. Several statements in the Draft GSP contribute to the uncertainty regarding the accuracy of the HCM's characterizations of the physical components and surface water-groundwater interactions.	See MCR "ISW".	
California Department of Fish and Wildlife	CDFW-12	B	HM	Accuracy of the Hydrogeologic Model	23 CCR §354.14(b)(3)	Chapter 2, page 48	The HCM in the Draft GSP fails to identify a definable bottom of the basin as required by SGMA regulations. As described in Chapter 2 of the Draft GSP, the HCM includes a description of the Western Cascades Subprovince geologic unit, which is the relatively older and less permeable volcanic bedrock that underlies Butte Valley. (p. 48.) Such description states that the Western Cascades unit "acts as a barrier to regional groundwater flow." As such, it is assumed that the Western Cascades unit surface is the bottom of the Basin. However, the description concludes that, "This formation has not been penetrated by Butte Valley wells (DOI 1980). The unknown depth to the Western Cascades Subprovince precludes its appearance in the cross-sections." No additional information was noted attempting to characterize the bottom of the Basin boundary. Several statements in the Draft GSP contribute to the uncertainty regarding the accuracy of the HCM's characterizations of the physical components and surface water-groundwater interactions.	The HCM is appropriate and properly reflects uncertainty about the depth of Western Cascades Subprovince. Due to the volcanic nature of Butte Valley many uncertainties surround Basin characterization such as the depth of the Western Cascades Subprovince. The Department of Water Resources is conducting airborne electromagnetic (AEM) surveys throughout California to assist implementing SGMA, which may improve some uncertainties in the HCM. At this time the GSP will focus on the critical data gaps listed in Appendix 3-A. Any future studies to improve the HCM will depend on partnerships with other agencies.	
California Department of Fish and Wildlife	CDFW-13	C	GL	Groundwater Depletion- Conflicting Information in GSP			The Draft GSP states Butte Valley basin has experienced a decrease in groundwater levels on the order of approximately 30-feet during the study period of spring 1979 to spring 2015 due primarily to decreased precipitation, increased pumping, and a commensurate decrease in the subsurface hydraulic gradient. Similarly, the Draft GSP concludes that, "There is significant long-term trend indicating some groundwater depletion." Conversely, the Draft GSP finds that the basin is not in overdraft due to significantly higher volumes of lateral groundwater inflow compared to volumes of groundwater extraction and does not exceed the sustainable yield of the Basin.	Model results suggest that the decline in groundwater levels is a reaction of the Butte Valley system to a decrease of recharge due to a long term decline of precipation and climate change. The GSA aims to balance groundwater pumping needs with the decline in recharge through the PMAs outlined in Chapter 4. A series of PMAs also address filling data gaps and updating the groundwater basin numerical model for better representation of the system dynamics. See MCR "General Data Gaps".	
California Department of Fish and Wildlife	CDFW-14	A	WB	Sustainable Yield calculation	23 CCR § 354.18 (b)(7)		The Draft GSP asserts that the sustainable yield will be a constantly changing value based on future climate conditions, future groundwater pumping needs, and future management actions. The Draft GSP should adequately quantify sustainable yield as required by SGMA regulations to explain this fluctuation for the approach to be acceptable.	See MCR "Sustainable Yield".	
California Department of Fish and Wildlife	CDFW-15	B	WB	Adjust Water Budget, Identify SMCs to protect GDEs			Once the GSA clarifies its understanding of these issues, the water budget should be adjusted accordingly and the Draft GSP should identify sustainable management criteria that prevent adverse impacts to beneficial users, such as dewatering of GDEs, and strive for long term groundwater sustainability with PMAs.	Based on current knowledge and data, the current GSP has chosen sustainable management criteria (SMC) that protects beneficial users. The SMCs will be revisited after additional data is collected at subsequent 5-year GSP updates. See MCR "PMA Selection Criteria".	Chapter 3
California Department of Fish and Wildlife	CDFW-16	C	PM	Water Conservation PMAs			The GSA should consider developing PMAs that promote more efficient water use through water conservation where feasible.	More efficient water use through water conservation is an innate characteristic of many PMAs such as Tier 2 - Irrigation Efficiency Improvements and Tier 2 - Dorris Water Meter Installation Project.	

California Department of Fish and Wildlife	CDFW-17	A	GE	Meeting SGMA Requirements	23 CCR § 354.22 et seq.; Water Code §§ 10721(x)(6) and 10727.2(b)		The Draft GSP concludes that sustainability will be achieved by 2042 and undesirable results will be avoided, but the underlying analysis and data do not fully support these conclusions. The goal of sustainability cannot be achieved by 2042 without an accurate water budget and clearly-defined sustainable management criteria, including minimum thresholds.	See MCR "General Data Gaps".	
California Department of Fish and Wildlife	CDFW-18	A	IS	ISW Depletion- Modeling and Minimum Threshold	23 CCR § 354.28(c)(6)		If a numerical groundwater-surface water model is not used to quantify surface water depletion, the GSP must identify and describe an equally effective method, tool, or analytical model to be used for this purpose. The Draft GSP does not meet these requirements because it does not identify a sustainable management criteria for surface water depletions. As such, the Draft GSP does not set minimum thresholds for surface water depletions based on the rate or volume of surface water depletions caused by groundwater use, and it does not utilize a basin-wide groundwater-surface water model or equally effective method, tool, or model to quantify such depletions.	See MCR "ISW".	Section 2.2.2.6 and Chapter 3
California Department of Fish and Wildlife	CDFW-19	A	IS	ISW Depletion- SMC Calculation			The Department requests revisions to the Draft GSP to clarify how the sustainable management criteria were developed, how these criteria relate to the relevant sustainability indicators, and how the criteria may affect the interest of beneficial users.	See MCR "ISW".	Section 2.2.2.6 and Chapter 3
California Department of Fish and Wildlife	CDFW-20	B	WB	Water Budget, Hydrogeologic Model	23 CCR § 354.18(e) and 354.18(b)(1)	Chapter 2	A key simplification is utilized by the Draft GSP authors in developing the water budget in that the surface water hydrologic subsystem is removed from the BVIHM. The Department appreciates the justifications for this simplification being few streams contribute perennial flow to the basin surface due, in part, to infiltration into highly permeable volcanic soils outside of the basin boundary. However, some of the Water Budget's information contradicts the information presented within the HCM discussion. For example, during the HCM discussion in Chapter 2, the GSA acknowledges that streamflow losses, canal seepage and percolation from wetlands (that receive periodic surface flows) all contribute to groundwater recharge. Similarly, the HCM mentions spring-fed creeks that drain into Meiss Lake (currently part of the BVWA). Ultimately, the Department is hesitant to support elimination of all surface water inputs for modeling purposes. The Department is especially concerned with the canal seepage when an economic, environmental, or other benefit may result from a more efficient use of water. The GSA should conduct further analysis of potential surface water input sources to fully comply with applicable SGMA regulations.	A PMA has been added in Chapter 4 to add the surface water hydrologic subsystem to the BVIHM. The PMA is dependent on first filling existing data gaps in Basin surface water. Additional text has been added to Chapter 5 outlining the implementation plan for the new PMA.	
California Department of Fish and Wildlife	CDFW-21	B	MN	Groundwater Monitoring Network	23 CCR §354.34		The Draft GSP lacks basinwide groundwater monitoring, which is necessary to assess potential surface water depletions and impacts to beneficial surface water users, including fish and wildlife species. The GSA should identify how the GSA will achieve a robust monitoring system to capture accurate information on these portions of the basin or use existing data to accurately model these portions and assess impacts. If the GSA intends to rely on basin-specific data, the Draft GSP should elaborate on the description of developing a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface water conditions as required by SGMA regulations. The Draft GSP should clearly identify the wells used for monitoring including individual well information. This includes the well ID, ground surface elevation, reference point elevations for water level measurements, well completion depth, perforation intervals, and hydrograph information. For the hydrograph information, the Draft GSP should provide information on the aquifer unit.	See MCR "General Data Gaps" and the PMA "Well Inventory Program".	
California Department of Fish and Wildlife	CDFW-22	A	IS	ISW Depletion- SMC	23 CCR § 355.4(b)(2)		The Draft GSP does not set forth sustainable management criteria for surface water depletions, nor does it utilize a basin-wide groundwater-surface water model or equally effective method, tool, or model to quantify such depletions.	See MCR "ISW".	Section 2.2.2.6, Chapter 3, Appendix 3-A
California Department of Fish and Wildlife	CDFW-23	A	MN	Monitoring Network- ISW Depletion and Environmental Beneficial Users	23 CCR § 355.4(b)(2)		The Draft GSP also lacks basin-wide groundwater monitoring, which is necessary to assess potential surface water depletions and impacts to beneficial surface water users.	See MCR "ISW".	Section 3.3 and Appendix 3-A.
California Department of Fish and Wildlife	CDFW-24	A	MN	Addressing Data Gaps	23 CCR § 355.4(b)(2)		The Draft GSP must set forth a reasonable pathway and timeline for addressing these data gaps and developing sustainable management criteria as required under SGMA, supplementing with models and other data if needed to address uncertainties in basin-specific data.	See MCR "General Data Gaps".	
California Department of Fish and Wildlife	CDFW-25	A	IS	ISW Depletion- SMCs, impact to Environmental Beneficial Users	23 CCR §§ 354.24, 354.26, and 354.28.		The Draft GSP also lacks quantitative criteria for interconnected surface water, which are needed to assess compliance with SGMA and avoid significant and unreasonable depletions of ISW. After conducting the necessary analysis and establishing appropriate criteria, the Draft GSP should be updated to consider and avoid any unreasonable adverse impacts to beneficial users anticipated to result from ISW depletions.	See MCR "ISW".	Section 2.2.2.6, Chapter 3, Appendix 3-A
California Department of Fish and Wildlife	CDFW-26	A	GE	Development of SMCs	23 CCR §§ 354.24, 354.26, and 354.28		The Draft GSP expanded its sustainability management criteria with additional monitoring points with "soft landing" triggers and "aspirational watershed goals". This characterization ignores SGMA, which clearly indicates the sustainability goal and sustainable management criteria must be developed to avoid undesirable results within the planning and implementation horizon.	The goal of the GSA remains to keep or return groundwater levels to the defined measurable objective. The defined triggers and "soft landing" triggers represent operational mechanisms to activate certain PMAs to address falling groundwater levels before they reach the minimum threshold and cause undesirable results. The system of PMAs to be activated at each trigger will be resolved during GSP implemention as needed and may operate anywhere from a local to Basin-wide scale. See MCR "PMA Selection Criteria".	

California Department of Fish and Wildlife	CDFW-27	B	GE	Development of SMCs, Hydrogeologic Model, and Water Budget	23 CCR § 355.4(b)(1)		The Department is aware of available information not being utilized to the fullest for the development of each sustainable management criteria, the water budget and BVIHM in the Draft GSP. Specifically, the Draft GSP lacks consideration of current versus historic surface water extractions, agriculture ditch losses and gains, and new or improved wells in the basin. These deficiencies in the analysis suggest BVIHM may not be considering all relevant groundwater pumping and related impacts in the basin.	The GSP used all available data in its development. While additional data may exist in the Basin, the GSA was not given access, which is at the discretion of private land owners and public agencies if they choose not to be collaborators. If CDFW is aware of additional information and data sources that are comfortable sharing with the GSA, it should forward the contact information to the GSA. Also see MCR "General Data Gaps".	
California Department of Fish and Wildlife	CDFW-28	A	BR	Public Trust Doctrine- GSP shortcomings	National Audubon Society v. Alpine County Superior Court (1983) 33 Cal. 3d 419, 446; People v. Truckee Lumber Co. (1897) 116 Cal. 397, 33 Cal. 3d 419, and Environmental Law Foundation v. State Water Resources Control Board (2018) 26 Cal. App. 5th 844		It is not clear that the GSA has undertaken the analysis and consideration required under the Public Trust Doctrine to support its proposed PMAs and management criteria. Under Audubon and Environmental Law Foundation, the GSA must conduct a robust analysis that considers the needs of public trust resources and impacts to those resources due to the proposed groundwater management practices, and that clearly explains why protection of public trust resources is infeasible due to inconsistency with the public interest. As explained above, the GSA has yet to resolve significant data gaps relevant to the surface water depletion rate, basin-wide groundwater levels, and the presence and needs of GDEs and beneficial users of interconnected surface waters. These issues must be addressed to ensure appropriate consideration of the needs of public trust resources as required under the Public Trust Doctrine.	See MCR "Public Trust".	
California Department of Fish and Wildlife	CDFW-29	A	PM	Consider Public Trust Doctrine when setting PMAs			Based on an accurate understanding of public trust resource needs and impacts, the GSA will need to assess a range of potential protective measures to address impacts of groundwater extractions. These measures may need to go beyond the PMAs identified in the Draft GSP and may include pumping limits or alternative supply options to address existing, new, and expanded extractions. Given overallocation and ongoing drought, it is critical to plan for such eventualities in the Draft GSP. Before rejecting such measures, the GSA will need to engage in a balancing of competing interests that shows that protecting species and habitat though contingent pumping limits, use of supply alternatives, or equivalent protective measures would be infeasible.	See MCR "Public Trust".	
California Department of Fish and Wildlife	CDFW-30	A	BR	Public Trust- Meiss Lake	Environmental Law Foundation, supra, 26 Cal. App. 5th 859-860		It is also unclear whether the GSA has appropriately considered potential impacts to all public trust resources in the basin, including those in Meiss Lake within the BVWA. One of the key purposes for acquiring and maintaining the BVWA is to maintain and restore wetlands onsite, including Meiss Lake, to provide habitat and food for species. (1996 Land Management Plan for BVWA.) Failing to manage groundwater to ensure Meiss Lake receives adequate inputs to support these uses would undermine this goal. In Environmental Law Foundation, supra, 26 Cal. App. 5th 859-860, the Court applied the Public Trust Doctrine to groundwater extractions from tributaries that adversely impact public trust uses in interconnected surface waters, noting that the key factor is not the nature of the activity, but whether the activity results in harm to public trust resources. Consistent with this case law, the GSA must, if feasible, manage groundwater use to ensure Meiss Lake continues to receive groundwater inputs necessary to support its habitat and ecological uses.	See MCR "Public Trust" and "GDE".	
California Department of Fish and Wildlife	CDFW-31	A	BR	Endangered Species Act	CESA		Tthe GSA should consider the implications of its GSP development and implementation on species listed under the California Endangered Species Act (CESA). It is unclear whether the current Draft GSP will support all beneficial users, including CESA-listed bald eagle, greater sandhill crane, Swainson's hawk, and northern spotted owl, since its sustainable management criteria do not appear to account for the needs of these species and its PMAs are deferred to a future date. Actions may need to go beyond SGMA minimum requirements to meet Public Trust Doctrine requirements.	See MCR "Public Trust" and "GDE".	Section 2.2.2.7
NGO Consortium	NGO-001	C	DC	Identification and Mapping of SDACs			The GSP states that there are three Severely Disadvantaged Communities (SDACs) in the basin, but these areas are not mapped. Provide a map of the SDACs in the basin. The DWR DAC mapping tool can be used for 1 this purpose. The statement on p. 2-11 that there are no DACs in the basin is confusing, since SDACs are a subset of DACs. Please remove or clarify this sentence.	One map showing DACs and SDACs has been added to Chapter 2. The statement on DACs and overall section has been edited for clarity.	Section 2.1.1.1

NGO Consortium	NGO-002	C	DW	Domestic Well Mapping			The GSP provides a map of domestic well density in Figure 1.5, but fails to provide depth of these wells (such as minimum well depth, average well depth, or depth range) within the basin. Include a map showing domestic well locations and average well depth across the basin.	The requested information is included in the well outtage analysis in Appendix 3-C.	Appendix 3-C
NGO Consortium	NGO-003	B	DC	Mapping of DAC groundwater users			The GSP fails to identify the population dependent on groundwater as their source of drinking water in the basin. Specifics are not provided on how much each SDAC community relies on a particular water supply (e.g., what percentage is supplied by groundwater). Identify the sources of drinking water for SDAC members, including an estimate of how many people rely on groundwater (e.g., domestic wells, state small water systems, and public water systems).	Added a sentence about SDAC dependence on groundwater as a source of drinking water. Details on water suppliers and SDAC population was already included in the section.	Section 2.1.1.1
NGO Consortium	NGO-004	C	DC	Identification and engagement of Tribes			Describe the occurrence of tribal lands in the basin. If tribes have interests in the basin or if groundwater management within Butte Valley Basin will have impacts on downstream tribes, describe them in detail.	Chapter 2 has been edited to clarify that no tribal lands exist within Butte Valley. Additionally, at this time we are not aware of any tribal interests.	Section 2.1.1.1
NGO Consortium	NGO-005	C	IS	Interconnected Surface Water- Mapping		2.2.2.6	There is no map presented in the ISW section (Section 2.2.2.6) of stream reaches in the basin. Provide a map showing all the stream reaches in the basin, with reaches clearly labeled with stream name and interconnected or disconnected. Consider any segments with data gaps as potential ISWs and clearly mark them as such on maps provided in the GSP.	A dedicated map showing stream reaches and other waterbodies in the Basin has been added to Section 2.2.2.6. An additional map of the Butte Valley Wildlife Area has been added, showing several stream reaches terminating in the Perimeter Canal of the managed wetlands. Comparison with groundwater elevation maps suggest that all surface water is disconnected, as discussed in the section. The need for additional data is discussed as a data gap.	Section 2.2.2.6
NGO Consortium	NGO-006	C	GL	Groundwater Levels			The GSP provides a vague assessment of groundwater levels in the vicinity of stream reaches, with no specific details provided.	The section has been updated to refer to Appendix 2-A for groundwater level maps.	Section 2.2.2.6
NGO Consortium	NGO-007	A	IS	Interconnected Surface Water determination- Data Gaps, Mapping		2.2.2.6	Given the gaps in groundwater level data and streamflow data, the stream reaches should be considered potential ISWs until further data can be gathered. Because the potential ISWs have not been identified, they cannot be adequately managed in the GSP. Until a disconnection can be proven, all potential ISWs should be included in the GSP. Reconcile ISW data gaps with specific measures (shallow monitoring wells, stream gauges, and nested/clustered wells) along surface water features in the Monitoring Network section of the GSP. Data gaps are discussed in general terms in the ISW section (Section 2.2.2.6), but very little detail is provided.	See MCR "ISW".	Section 2.2.2.6 and Appendix 3-A
NGO Consortium	NGO-008	B	IS	ISW determination- Groundwater Contour Maps			Provide depth-to-groundwater contour maps using the best practices presented in Attachment D, to aid in the determination of ISWs. 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.	The recommended approach in this comment cannot be done due to existing data gaps. See MCR "ISW" and "General Data Gaps".	Appendix 2-A
NGO Consortium	NGO-009	B	IS	ISW determination- seasonal data			Use seasonal data over multiple water year types (we recommend 10 years from 2005 to 2015) to capture the variability in environmental conditions inherent in California's climate, when mapping ISWs.	Seasonal groundwater level data is included in Appendix 2-A.	Appendix 2-A
NGO Consortium	NGO-010	A	GD	Identification of GDEs			The identification of Groundwater Dependent Ecosystems (GDEs) is insufficient, due to lack of clarity around the monitoring well data (well location and screen depth) used to map groundwater elevations and depth to groundwater. The GSP references TNC Best Practices for using the [Natural Communities Commonly Associated with Groundwater (NC)] NC Dataset (2019) as the approach used to map depth to groundwater, using the difference between land surface elevation and interpolated groundwater elevation above mean sea level. However, the GSP does not further describe the monitoring well data (well location and screen depth) used to create the depth-to-groundwater maps. On the depth-to-groundwater level maps presented in Appendix 2-C, include the location of groundwater monitoring wells used to produce the maps. Discuss screening depth of monitoring wells and ensure they are monitoring the shallow principal aquifer.	See MCR "GDE".	
NGO Consortium	NGO-011	B	GD	Indentification of GDEs			NC dataset polygons were incorrectly removed in areas adjacent to irrigated fields due to the presence of surface water. However, this removal criteria is flawed since GDEs, in addition to groundwater, can rely on multiple water sources – including shallow groundwater receiving inputs from irrigation return flow from nearby irrigated fields – simultaneously and at different temporal/spatial scales. NC dataset polygons adjacent to irrigated land can still potentially be reliant on shallow groundwater aquifers, and therefore should not be removed solely based on their proximity to irrigated fields.	See MCR "GDE".	
NGO Consortium	NGO-012	B	GD	Identification of GDEs			NC dataset polygons were incorrectly removed based on the amount of time that they access groundwater. As presented in the GSP, assumed GDEs have access to groundwater >50% of time and assumed non-GDEs have access to groundwater <50% of the time. However, NC dataset polygons should not be assumed to be disconnected if there is any connection to groundwater (regardless of temporal percentage). Many GDEs often simultaneously rely on multiple sources of water (i.e., both groundwater and surface water), or shift their reliance on different sources on an interannual or inter-seasonal basis. Use depth-to-groundwater data from multiple seasons and water year types to verify whether polygons in the NC Dataset are supported by groundwater, instead of the incorrect criteria mentioned above (presence of irrigation water or less than 50% time connected to groundwater).	See MCR "GDE".	

NGO Consortium	NGO-013	B	GD	GDEs- rooting depth			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 feet 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 feet 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.	See MCR "GDE".	
NGO Consortium	NGO-014	B	GD	Identification of GDEs			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 MCR "GDE".	
NGO Consortium	NGO-015	A	WB	Water Budget- Accounting for GDEs			The integration of native vegetation and managed wetlands into the water budget is **insufficient**, due to the absence of Appendix 2-D (Water Budget). We could not determine if the water budget included the current, historical, and projected demands of native vegetation and managed wetlands. Include Appendix 2-D (Water Budget) in the GSP. Quantify and present all water use sector demands in the historical, current, and projected water budgets with individual line items for each water use sector, including native vegetation and managed wetlands.	See MCR "Water Budget".	
NGO Consortium	NGO-016	B	PO	Targeted Stakeholder Outreach	23 CCR §354.10(d)(3)	Appendix 1-A	SGMA's requirement for public notice and engagement of stakeholders is not fully met by the description in the Stakeholder Communication and Engagement Plan included in the GSP (Appendix 1-A). In the Stakeholder Communication and Engagement Plan, describe active and targeted outreach to engage SDAC members, 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.	Targeted outreach was not conducted to specific DACs but a large portion of the GSP area is classified as SDAC or DAC and thus outreach to the entire basin area was intended to cover those communities. See Chapter 1 for additional information.	
NGO Consortium	NGO-017	C	PO	Targeted Stakeholder Outreach	23 CCR §354.10(d)(3)	Appendix 1-A	The opportunities for public involvement and engagement are described in very general terms. They include attendance at public meetings, stakeholder email list, and updates to the GSP website. There is no specific outreach described for members of the SDAC communities or domestic well owners.	Noted. Specifc outreach activities are detailed in Appendix 1-B.	
NGO Consortium	NGO-018	B	PO	Sustained stakeholder engagement	23 CCR §354.10(d)(3)	Appendix 1-A	The Stakeholder Communication and Engagement Plan does not include a plan for continual opportunities for engagement through the implementation phase of the GSP for SDACs, domestic well owners, and environmental stakeholders.	Noted. Planned outreach during the implementation phase of the plan is described in Chapter 5.	
NGO Consortium	NGO-019	B	GL	Groundwater Level Minimum Threshold- Domestic Wells, DACs, Tribes			For chronic lowering of groundwater levels, the GSP does not sufficiently describe or analyze direct or indirect impacts on domestic drinking water wells, DACs, or tribes when defining undesirable results. The GSP does not sufficiently describe how the existing minimum threshold groundwater levels are consistent with avoiding undesirable results in the basin. The GSP states (p. 3-34): "The minimum threshold is expected to cause as much as 15% well outages." This is the only quantitative statement made however, and it is not supported by data or analysis. Describe direct and indirect impacts on drinking water users, DACs, and tribes when describing undesirable results and defining minimum thresholds for chronic lowering of groundwater levels.	Appendix 3-C includes an expanded well outtage analysis that reviews the impact of falling groundwater levels on groundwater wells within the groundwater basin, including domestic wells. The entire groundwater basin is a DAC or SDAC and there are no tribal lands. Chapter 3 has been updated to refer to the appendix for the data and discusses the results of the updated analysis.	
NGO Consortium	NGO-020	B	WQ	SMCs for Constiutents of Concern	23 CCR §354.34(c)(4)	pages 3-37	For degraded water quality, minimum thresholds for the following three constituents of concern (COCs) are set at the maximum contaminant levels (MCLs): nitrate, specific conductivity and arsenic. However, the GSP does not set SMC for the other COCs in the basin (boron, benzene, and 1,2-dibromoethane). The GSP states on p. 3-37 that because 1,2-dibromoethane and benzene are already being monitored and managed by the Regional Board through the Leaking Underground Storage Tank (LUST) program, SMC are not needed. The GSP states that since boron is naturally occurring, SMC are not needed. However, SMC should be established for all COCs in the basin, in addition to coordinating with water quality regulatory programs. Naturally occurring COCs can be exacerbated as a result of groundwater use or groundwater management within the basin. Set minimum thresholds and measurable objectives for boron, benzene and 1,2-ibromoethane. Ensure they align with drinking water standards.	The GSA only sets SMCs for three COCs but will continue to monitor other identified COCs for any increasing temporal and spatial trends. As shown in Appendix 2-B, 1,2-dibromoethane and benzene contamination is highly localized and decreasing down to drinking level standards through management by the Regional Board through the Leaking Underground Storage Tank (LUST) program. The GSA feels that SMCs are not needed at this time for 1,2-dibromoethane and benzene but will continue to monitor trends. Historical data of boron shows a decreasing or steady trend. The GSA feels that an SMC is not needed for boron, but will continue to monitor boron for any future issues.	Chapter 3

NGO Consortium	NGO-021	B	WQ	Degraded Water Quality Minimum Threshold- Impact on Water Users			The GSP only includes a very general discussion of indirect impacts to drinking water users when defining undesirable results and evaluating the cumulative or indirect impacts of proposed minimum thresholds. The GSP does not, however, mention or discuss direct and indirect impacts on DACs or tribes when defining undesirable results for degraded water quality, nor does it evaluate the cumulative or indirect impacts of proposed minimum thresholds on DACs or tribes. Describe direct and indirect impacts on drinking water users, DACs and tribes 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 drinking water users, DACs, and tribes. Sustainable management criteria provided in the GSP do not consider potential impacts to environmental beneficial users. The GSP neither describes nor analyzes direct or indirect impacts on environmental users of groundwater or surface water when defining undesirable results.	The discussion of indirect impacts to drinking water users is valid because there are no tribal lands or interests within the Butte Valley groundwater basin and the entire valley is considered a disadvantaged community (DAC). Chapter 3 already describes the impact on water users when defining undesirable results for degraded water quality. The cumulative and indirect impact of the proposed minimum thresholds will avoid the described undesirable results for degraded water quality. Due to the lack of data, as described in Chapter 2 and Appendix 3-A, the GSA cannot complete qualitative analysis of the impact on the proposed SMCs on surface waters and groundwater dependent ecosystems. The current discussion in the GSP is valid until the outlined data gaps are addressed in the 5-year GSP update.	Chapter 3
NGO Consortium	NGO-022	A	IS	SMCs for ISW Depletion	23 CCR §354.28(c)(6) 23 CCR §354.28(b)(4)		The GSP states that the depletion of interconnected surface water sustainability indicator is not applicable in the Basin, but this has not been proven. Chapter 2 of the GSP disregards ISWs due to data gaps. However, they should be retained as potential ISWs and preliminary SMC for the depletion of interconnected surface water sustainability indicator should be established. Establish preliminary SMC for the depletion of interconnected surface water sustainability indicator, that can be refined when data gaps are filled. When defining undesirable results for depletion of interconnected surface water, include a description of potential impacts on instream habitats within ISWs when defining minimum thresholds in the basin. The GSP should confirm that minimum thresholds for ISWs avoid adverse impacts to 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.	See MCR "ISW".	
NGO Consortium	NGO-023	C	GL	Chronic Lowering of Groundwater Level- undesirable result for GDEs			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.	Discussion regarding SMCs for protecting GDEs has been added to the new PMA "Groundwater Dependent Ecosystem Data Gaps" of Chapter 4. See MCR "GDE".	
NGO Consortium	NGO-024	B	WB	Water Budget- climate change, data source		Appendix 2-D	The integration of climate change into the projected water budget is incomplete. The GSP includes climate change into key inputs (e.g., precipitation, evaporation, and surface water flow) of the projected water budget. However, we are concerned that the selected period is from 1991-2011 and therefore it does not include the drought from 2012-2016. We look forward to reading Appendix 2-D (Water Budget) in the next draft of the GSP to learn about how you are integrating drought risk in your future water budget. Include Appendix 2-D (Water Budget) in the next draft of the GSP, so that the manner in which climate change is incorporated into the water budgets is fully explained.	The GSP follows DWR guidance. Future updates may be used to improve climate change predictions.	
NGO Consortium	NGO-025	A	WB	Sustainable Yield calculation			The GSP does not calculate a sustainable yield based on the projected water budget with climate change incorporated, but instead states that the sustainable yield will vary over time as new project and management actions are added. If sustainable yield is not calculated, then there is also increased uncertainty in virtually every subsequent calculation used to plan for projects, derive measurable objectives, and set minimum thresholds. Plans that do not explicitly calculate sustainable yield may underestimate future impacts on vulnerable beneficial users of groundwater such as ecosystems, DACs, domestic well owners, and tribes. Estimate sustainable yield based on the projected water budget with climate change incorporated, to inform the basis for development of projects and management actions.	See MCR "Sustainable Yield"	Chapter 2
NGO Consortium	NGO-026	C	PM	Incorporate Climate Change into PMAs			Incorporate climate change scenarios into projects and management actions.	The future climate models were prepared by DWR and used in accordance with DWR guidance.	
NGO Consortium	NGO-027	A	MN	Monitoring Network- Add Representative Monitoring Points			The consideration of beneficial users when establishing monitoring networks is insufficient, due to lack of specific plans to increase the Representative Monitoring Points (RMPs) in the monitoring network that represent water quality conditions and shallow groundwater elevations around DACs, domestic wells, GDEs, and ISWs. While the GSP recognizes the importance of filling data gaps, it does not provide specific plans, well locations shown on a map, or a timeline to fill the data gaps. The additional RMPs should be included in the GSP now, instead of included in the 5-year GSP update. Without a map of proposed new monitoring well locations, a determination cannot be made regarding the adequacy of the monitoring network for sustainability indicators going forward into the GSP implementation phase.	Current GSP has been approved by the stakeholder committee and meets regulatory requirements. The current GSP has identified these data gaps (Appendix 3-A), PMAs to address these data gaps, and is consistent with regulations, communications by DWR, and DWR approved GSPs. In response to the public comment period, additional PMAs and language regarding data gap processes have been added to the GSP.	

NGO Consortium	NGO-028	B	MN	Monitoring Network-Mapping			Provide maps that overlay current and proposed monitoring well locations with the locations of DACs, domestic wells, GDEs, and ISWs to clearly identify potentially impacted areas.	A map of current monitoring locations, beneficial users, GDEs, and waterbodies has been added to Section 3.3. General tentative locations of proposed monitoring locations has been added to Appendix 3-A. Final locations of additional monitoring locations will depend on local well owner volunteers and funding availability.	
NGO Consortium	NGO-029	A	MN	Monitoring Networks-Add Representative Monitoring Points			Increase the number of representative monitoring points (RMPs) across the basin as needed to adequately monitor all groundwater condition indicators. Prioritize proximity to GDEs and drinking water users when identifying new RMPs.	Chapter 3 and Appendix 3-A outline existing data gaps and the need to expand the monitoring networks. An additional PMA clarifying this need has been added to Chapter 4. See MCR "GDE and "General Data Gaps".	
NGO Consortium	NGO-030	A	MN	Monitoring Network-Addressing Data Gaps			Provide specific plans to fill data gaps in the monitoring network. Evaluate how the gathered data will be used to identify and map GDEs and ISWs, and identify DACs and shallow domestic well users that are vulnerable to undesirable results.	See MCR "General Data Gaps". The entire Basin is considered DAC or SDAC so the current discussion in the GSP is valid. Vulnerable domestic well users are analyzed in a well outtage analysis included in Appendix 3-C.	
NGO Consortium	NGO-031	C	MN	Using Monitoring Networks to Assess Impact to Water Users		4.4	Further describe the biological monitoring that will be used to assess the potential for significant and unreasonable impacts to GDEs or ISWs due to groundwater conditions in the basin. Section 4.4 mentions the use of satellite images to evaluate the status of GDEs, however no further details are provided in the GSP.	Discussion regarding biological monitoring has been added to the new PMA "Groundwater Dependent Ecosystem Data Gaps" of Chapter 4. See MCR "GDE".	
NGO Consortium	NGO-032	B	PM	PMAs- DACs			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 to beneficial users of groundwater such as DACs and drinking water users. [The GSP] does not discuss the manner in which DACs, drinking water users, and tribes may be benefitted or impacted by projects and management actions identified in the GSP. Therefore, potential project and management actions may not protect these beneficial users.	There is no tribal land in the Butte Valley groundwater basin and the entire valley is listed as a Disadvantaged Community (DAC) so the current discussion of projects and management actions in the GSP is sufficient.	Chapter 4
NGO Consortium	NGO-033	B	PM	Drinking Water Well Impact Mitigation Program for DACs and Domestic Well Ownders		4.3 Tier II PMAs	For DACs and domestic well owners, include further discussion of a drinking water well impact mitigation program to proactively monitor and protect drinking water wells through GSP implementation. The GSP describes a well replacement program in Section 4.3 (Tier II PMAs), but no details are provided. Refer to Attachment B for specific recommendations on how to implement a drinking water well mitigation program.	We already follow the Appendix B recommendations for a drinking water well impact mitigation program. The key elements include (Section 2 of Appendix B): - Drinking water well monitoring program (see RMP for water level); - Adaptive management trigger system (see water level SMC, where the MO is in the "green light" and the minimum threshold in the "yellow light" zone, for which potential corrective actions have been identified (see PMAs that address: - Undertake an analysis to pinpoint the cause; - Undertake water quality testing for selected domestic and public supply wells; - Provide immediate support to groundwater users experiencing impacts; - Reassess pumping allocation and pumping patterns; - Consider restricting or limiting groundwater extraction near the impacted area.); - drinking water well impact model (Appendix 3-C of GSP); - public outreach and education (see PMAs); - development of mitigation measures, - identifying eligibility and access.	
NGO Consortium	NGO-034	C	PM	PMA Impact on Water Quality			For DACs, domestic well owners, and tribes, 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.	There is no tribal land in the Butte Valley groundwater basin and the entire valley is listed as a Disadvantaged Community (DAC) so the current discussion of projects and management actions in the GSP is sufficient. For domestic well users, a well outtage analysis is included in Appendix 3-C, which will be used during GSP implementation. The PMA "Well Inventory Program" will also work towards creating a better database of domestic wells in the Basin, which will improve the ability of the GSA to protect those beneficial users.	
NGO Consortium	NGO-035	C	PM	Multi-benefit projects			Recharge ponds, reservoirs, and facilities for managed stormwater 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 guidance on how to integrate multi-benefit recharge projects into your GSP, refer to the “Multi-Benefit Recharge Project Methodology Guidance Document.”	The groundwater basin has no surface outflow. All stormwater is already recharged to groundwater.	Chapter 4
NGO Consortium	NGO-036	B	PM	Incorporate Uncertainty into PMAs			Develop management actions that incorporate climate and water delivery uncertainties to address future water demand and prevent future undesirable results.	The future climate models were prepared by DWR and used in accordance with DWR guidance.	

BUTTE VALLEY GROUNDWATER SUSTAINABILITY PLAN
PUBLIC COMMENT SUMMARY – MULTIPLE COMMENT RESPONSE

November 2021

Multiple Comment Response Directory Table

ID	Multiple Comment Response
GDE	Section 2.2.2.7 lists all the protected species in Butte Valley. The section provides Table 2.6, which is three pages of all freshwater species with any federal and state level status, from endangered to watch list. This list of observed species within the Butte Valley groundwater basin was collected from the Nature Conservancy and California Department of Fish and Wildlife (CDFW) Butte Valley Wildlife Area (BVWA) Management Plan, with the assistance of CDFW BVWA staff. Table 2.7 lists all these species again, but text has been modified for clarity on GSA management. Species maps generated by the CDFW Biogeographic Information and Observation System (BIOS) Viewer were shown to CDFW BVWA staff, who expressed displeasure on the accuracy of the maps and asked them to be removed from the GSP. Section 2.2.2.7 lists and discusses all the species in Butte Valley listed under the California Endangered Species Act (CESA). The section is clear that these species are considered environmental beneficial water users within the Basin and that the GSA will partner with relevant federal and state agencies to ensure that they are protected during implementation of the GSP. Describing potential impacts on GDEs requires a better understanding of the location and nature of GDEs in the Basin. Representative areas currently classed as 'Assumed not a GDE' will be reviewed in the field as part of future work and reanalyzed as data gaps are filled. Section 2.2.2.7 analyzes Meiss Lake and Butte Valley Wildlife Area (BVWA) as potential groundwater dependent ecosystems (GDE). However due to the lack of groundwater level data within BVWA, potential groundwater levels for the GDE analysis were contoured from wells outside BVWA with groundwater levels (see Appendix 2-A and 2-C) were deeper then the GDE rooting depths. Valley oak does not exist in Butte Valley and the associated rooting depth is not relevant to the local environment. The GSA acknowledges the data gaps in the GDE analysis in Section 2.2.2.7 and outlines how to address them in Appendix 3-A. Additional text has been added to Section 2.2.2.7 and Appendix 3-A for clarity and an additional management action "Groundwater Dependent Ecosystem Data Gaps" has been added to Chapter 4. The GSA looks forward to working with CDFW and other relevant agencies to fill these data gaps of local habitat and groundwater level data in Butte Valley in the next 5 years for the next GSP update.

BUTTE VALLEY GROUNDWATER SUSTAINABILITY PLAN
PUBLIC COMMENT SUMMARY – MULTIPLE COMMENT RESPONSE

November 2021

ID	Multiple Comment Response
ISW	Sustainable management criteria (SMCs) must be quantitative, which cannot be done at this time due to the lack of data on potential ISWs in the Basin. The GSP cannot quantify surface water depletion because there is not enough data at this time. Groundwater contour maps in the GSP are based on the best available groundwater level data, with large data gaps near potential ISWs. The potential ISWs are along the Basin edges while the available historical groundwater level data is within the center of the groundwater basin. The limited data that is available suggests that potential ISWs are disconnected from the groundwater aquifer (see Section 2.2.2.6). Current groundwater maps suggest that the water table is sufficiently deep below the potential ISWs to assume disconnection until further data is collected. SMCs for ISWs will be revisited during the next 5-year GSP update. The GSA acknowledges the data gaps in the ISW analysis in Section 2.2.2.6 and outlines how to address them in Appendix 3-A. Additional text has been added to Section 2.2.2.6 and Appendix 3-A for clarity and an additional management action "Interconnected Surface Water Data Gaps" has been added to Chapter 4. Details on specific measures to fill these data gaps depends heavily on awarded funding and will be developed for future funding proposals. The GSA looks forward to working with CDFW and other relevant agencies to fill these data gaps of ISWs in Butte Valley in the next 5 years for the next GSP update.
Water Budget	A PMA has been added in Chapter 4 to add the surface water hydrologic subsystem to the BVIHM. The PMA is dependent on first filling existing data gaps in Basin surface water. Additional text has been added to Chapter 5 outlining the implementation plan for the new PMA.
Public Trust	Assuming ELF/Audubon require a GSA, or special act district acting in this capacity, to consider the impacts of groundwater production on public trust resources in the Butte Valley in preparing its GSP, where there is not evidence that groundwater production is harming public trust resources due to the disconnection between groundwater and surface waters or GDEs, then any duty that may exist does not arise.

BUTTE VALLEY GROUNDWATER SUSTAINABILITY PLAN
PUBLIC COMMENT SUMMARY – MULTIPLE COMMENT RESPONSE

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ID	Multiple Comment Response
Sustainable Yield	The GSP is more conservative than a specific sustainable yield. Sustainable yield is a function of future climate and of project implementation. It may be less in the future than it is currently. The sustainable yield selected by the GSP is a formula that accounts for such changes. Prescribing a fixed sustainable yield is technically incorrect and practically insufficient to achieve long-term sustainability. The starting value of the sustainable yield is focused on the historic average of groundwater pumping which will translate into looking at the future averages of annual groundwater pumping rather than specific years. The undesirable results are prevented through the minimum threshold. The minimum threshold will be reached by implementation of PMAs that avoid all minimum thresholds and achieve the measurable objective. To the degree that those PMAs require a future reduction in groundwater pumping, that amount of pump reduction must be reflected in recomputed future sustainable yield. By providing a definition of sustainable yield that is not a fixed number, but accounts for future PMAs in a well-prescribed protocol, the sustainable yield is specific and implicitly adjusts to the implementation of PMAs. The GSP's definition of sustainable yield avoids the possibility that a new pumper will claim the amount of pumping that was retired through a PMA elsewhere in the basin. The approach is consistent with basin plans already approved by DWR (e.g., Oxnard, Mid-County Santa Cruz).
PMA Selection Criteria	Chapter 5 outlines how PMAs will be selected for prioritization during GSP implementation. Text has been added to Chapter 4.1 and Chapter 5 implementation schedule. After GSP adoption, the GSA will prioritize certain PMAs for feasibility reviews and preliminary engineering studies. Based on review and study results, PMAs may move forward to implementation.
5-year Update	At this time, the GSA has elected to use a voluntary program for groundwater extraction reporting. For the next five years, the GSA will conduct public outreach to encourage voluntary participation. This may be revisited in the 5-year update. Siskiyou County is currently considering a revised well drilling permit.
Data System	The GSA will follow DWR guidelines for data and model transparency. Per DWR's modeling BMP document, "final model files used for decision making in the GSP should be packaged for release to the Department". We anticipate that model files will be uploadable with the GSP in digital format. Similarly, we anticipate that DWR will collect annual report data in digital format.

BUTTE VALLEY GROUNDWATER SUSTAINABILITY PLAN
PUBLIC COMMENT SUMMARY – MULTIPLE COMMENT RESPONSE

November 2021

ID	Multiple Comment Response
General Data Gaps	The GSA acknowledges existing data gaps in Chapter 3 and Appendix 3-A, proposes PMAs in Chapter 4, and discusses an implementation plan in Chapter 5. General data gaps include water levels from domestic wells and groundwater extraction. Based on existing and available data, the GSP contains an accurate water budget, clearly defined sustainable management criteria, including minimum thresholds. The GSP will be updated as needed when data gaps are filled but will be dependent on outside sources of funding. The current data gap in groundwater extraction does not limit effective groundwater management as estimating groundwater extraction based on land use is sufficient to quantify basin groundwater budgets that determine groundwater sustainability for the basin. Future voluntary collection of groundwater extraction will serve for modeled groundwater pumping validation and verification of the success of PMAs.

Table Key:
BIOS = Biogeographic Information and Observation System
BMP = best management practice
BVIHM = Butte Valley Integrated Hydrologic Model
CDFW = California Department of Fish and Wildlife
CESA = California Endangered Species Act
DWR = Department of Water Resources
GDE = Groundwater Dependent Ecosystem
GSA = Groundwater Sustainability Agency
GSP = Groundwater Sustainability Plan
ISW = Interconnected Surface Water
PMA = Project and Management Action
PTD = Public Trust Doctrine
SGMA= Sustainable Groundwater Management ACt
SMC = Sustainable Management Criteria

Appendix 1-D DWR Element Guide

Article 5.			Plan Contents for Sample Basin	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.	28				
(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.	261				
			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.	40				
(b)			The organization and management structure of the Agency, identifying persons with management authority for implementation of the Plan.	40				
(c)			The name and contact information, including the phone number, mailing address and electronic mail address, of the plan manager.	40				
(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.	40				
(e)			An estimate of the cost of implementing the Plan and a general description of how the Agency plans to meet those costs.	37, 40:41, 256:257				
			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:					

Article 5.			Plan Contents for Sample Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(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.	48, 50, 68				
	(2)		Adjudicated areas, other Agencies within the basin, and areas covered by an Alternative.	N/A				The Basin does not have adjudicated areas, other GSAs, or Alternatives.
	(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.	48:68				
	(4)		Existing land use designations and the identification of water use sector and water source type.	53:56				
	(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.	48:53, 57:58				
(b)			A written description of the Plan area, including a summary of the jurisdictional areas and other features depicted on the map.	48:68				
(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.	59:66				
(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.	59:66				
(e)			A description of conjunctive use programs in the basin.	59:66				
(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.	66:68				
	(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	66:68				
	(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.	66:70				
	(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.	68				
	(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.	68:70				
(g)			A description of any of the additional Plan elements included in Water Code Section 10727.4 that the Agency determines to be appropriate.	68:70				

Article 5.			Plan Contents for Sample Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
			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:					
(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.	42:45				
(b)			A list of public meetings at which the Plan was discussed or considered by the Agency.	289:290				
(c)			Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.	293:369				
(d)			A communication section of the Plan that includes the following:					
	(1)		An explanation of the Agency's decision-making process.	41				
	(2)		Identification of opportunities for public engagement and a discussion of how public input and response will be used.	41:44				
	(3)		A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.	41:44				
	(4)		The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.	41:44				
			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.	71:146				
(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.	71:106				

Article 5.			Plan Contents for Sample Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(2)		Lateral basin boundaries, including major geologic features that significantly affect groundwater flow.	71:106				
	(3)		The definable bottom of the basin.	113, 359				
	(4)		Principal aquifers and aquitards, including the following information:					
		(A)	Formation names, if defined.	80:95				
		(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.	92:95				
		(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.	79:95				
		(D)	General water quality of the principal aquifers, which may be based on information derived from existing technical studies or regulatory programs.	92:95, 114:123				
		(E)	Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply.	79:95				The Basin has only one aquifer.
	(5)		Identification of data gaps and uncertainty within the hydrogeologic conceptual model	555:567				
(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.	84:86				
(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.	73				
	(2)		Surficial geology derived from a qualified map including the locations of cross-sections required by this Section.	81				
	(3)		Soil characteristics as described by the appropriate Natural Resources Conservation Service soil survey or other applicable studies.	97:99				
	(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.	95				
	(5)		Surface water bodies that are significant to the management of the basin.	101:106				
	(6)		The source and point of delivery for imported water supplies.	N/A				Water is not imported into the Basin.
			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:					

Article 5.			Plan Contents for Sample Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(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.	110:112, 401:413				
	(2)		Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.	113, 579:591				
(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.	147:148				
(c)			Seawater intrusion conditions in the basin, including maps and cross-sections of the seawater intrusion front for each principal aquifer.	N/A				The Basin is not near the ocean.
(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.	114:122				
(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.	123:126				
(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.	125:128				
(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.	129:146				
			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.	146:166				
(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.	146:165, 486:529				
	(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.	146:165, 486:529				
	(3)		Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow.	146:165, 486:529				
	(4)		The change in the annual volume of groundwater in storage between seasonal high conditions.	146:165, 486:529				

Article 5.			Plan Contents for Sample Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(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.	146:165, 486:529				
	(6)		The water year type associated with the annual supply, demand, and change in groundwater stored.	146:165, 486:529				
	(7)		An estimate of sustainable yield for the basin.	165				
(c)			Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:					
	(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.	146:162, 486:529				
	(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.	146:162, 486:529				
		(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.	146:162, 486:529				
		(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.	146:162, 486:529				
	(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.	163:165, 486:529				

Article 5.			Plan Contents for Sample Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
		(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.	163:165, 486:529				
		(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.	163:165, 486:529				
(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.	146:162, 486:529				
	(2)		Current water budget information for temperature, water year type, evapotranspiration, and land use.	146:162, 486:529				
	(3)		Projected water budget information for population, population growth, climate change, and sea level rise.	146:162, 486:529				
(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.	146:165, 486:529				
(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.	146:165, 486:529				
			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.	N/A				The Basin does not use management areas.

Article 5.			Plan Contents for Sample Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(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				The Basin does not use management areas.
	(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				The Basin does not use management areas.
	(3)		The level of monitoring and analysis appropriate for each management area.	N/A				The Basin does not use management areas.
	(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				The Basin does not use management areas.
(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				The Basin does not use management areas.
			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.	169				
			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.	188:212				
(b)			The description of undesirable results shall include the following:					

Article 5.			Plan Contents for Sample Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(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.	188:189, 200, 203:204, 211				
	(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.	188:189, 200:204, 211				
	(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.	198, 200, 209, 212				
(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.	188:212				
(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.	169, 125:128, 555:567				Seawater intrusion is not applicable to the Basin. The Basin must fill data gaps before potentially setting SMCs for interconnected surface water.
			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.	190:193, 200, 204:205, 211				
(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.	194, 200, 210:211, 576:615				
	(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.	199:200, 209:210, 212				
	(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.	N/A				The minimum thresholds will not affect adjacent basins.
	(4)		How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.	198, 200, 209, 212				

Article 5.			Plan Contents for Sample Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(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.	188, 200:201, 211				
	(6)		How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.	169:187				
(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.	194, 576:615				
		(B)	Potential effects on other sustainability indicators.	199				
	(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.	200				
	(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				Seawater intrusion is not present in the Basin.
		(B)	A description of how the seawater intrusion minimum threshold considers the effects of current and projected sea levels.	N/A				Seawater intrusion is not present in the Basin.
	(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.	200:210				
	(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:					

Article 5.			Plan Contents for Sample Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
		(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.	212				
		(B)	Maps and graphs showing the extent and rate of land subsidence in the basin that defines the minimum threshold and measurable objectives.	126				
	(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.	N/A				The Basin must fill data gaps before potentially setting SMCs for 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.	N/A				The Basin must fill data gaps before potentially setting SMCs for interconnected surface water.
(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.	N/A				The Basin must fill data gaps before potentially setting SMCs for interconnected surface water.
(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.	169, 125:128, 555:567				Seawater intrusion is not present in the Basin. The Basin must fill data gaps before potentially setting SMCs for interconnected surface water.
			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**					
(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.	194:197, 200, 206:208, 211:212				
(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.	194:197, 200, 206:208, 211:212				
(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.	194:197, 200, 206:208, 211:212				

Article 5.			Plan Contents for Sample Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(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.	200				
(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.	194:197, 200, 206:208, 211:212				
(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				The Plan does not set measurable objectives nor interim milestones for additional Plan elements.
(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				The measureable objectives in the Plan have reasonable margins 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.					
			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.	169:187				
(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.	169:187				
	(2)		Monitor impacts to the beneficial uses or users of groundwater.	169:187				

Article 5.			Plan Contents for Sample Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(3)		Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds.	169:187				
	(4)		Quantify annual changes in water budget components.	169:187				
(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.	177:181				
		(B)	Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.	177:181				
	(2)		Reduction of Groundwater Storage. Provide an estimate of the change in annual groundwater in storage.	180:182				
	(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.	N/A				The Basin does not have seawater intrusion.
	(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.	182:186				
	(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.	186:187				
	(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.	N/A				The Basin must fill data gaps before potentially setting SMCs for interconnected surface water.
		(B)	Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.	N/A				The Basin must fill data gaps before potentially setting SMCs for interconnected surface water.
		(C)	Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.	N/A				The Basin must fill data gaps before potentially setting SMCs for interconnected surface water.
		(D)	Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.	N/A				The Basin must fill data gaps before potentially setting SMCs for interconnected surface water.
(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.	N/A				The Basin must fill data gaps before potentially setting SMCs for interconnected surface water.

Article 5.			Plan Contents for Sample Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(e)			A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.	N/A				The Basin must fill data gaps before potentially setting SMCs for interconnected surface water.
(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.	169:187, 555:567				
	(2)		Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.	169:187, 555:567				
	(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.	169:187, 555:567				
	(4)		Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.	169:187, 555:567				
(g)			Each Plan shall describe the following information about the monitoring network:					
	(1)		Scientific rationale for the monitoring site selection process.	176:177				
	(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.	176:177				
	(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.	188:212				
(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.	169:187, 555:567				
(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.	568:575				
(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.	169, 125:128, 555:567				Seawater intrusion is not present in the Basin. The Basin must fill data gaps before potentially setting SMCs for interconnected surface water.
			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:					

Article 5.			Plan Contents for Sample Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(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.	169:187, 555:567				
(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.	180:182				
	(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.	200				
(c)			The designation of a representative monitoring site shall be supported by adequate evidence demonstrating that the site reflects general conditions in the area.	177:182				
			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.	169:177				
(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.	169:177, 555:567				
(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.	169:177, 555:567				
	(2)		Local issues and circumstances that limit or prevent monitoring.	169:177, 555:567				
(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.	169:177, 555:567				
(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.	169:177				
	(2)		Highly variable spatial or temporal conditions.	169:177				
	(3)		Adverse impacts to beneficial uses and users of groundwater.	169:177				

Article 5.			Plan Contents for Sample Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(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.	169:177				
			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.	213:244				
(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.	254				
		(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.	255				
	(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.	213:244				

Article 5.			Plan Contents for Sample Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(3)		A summary of the permitting and regulatory process required for each project and management action.	213:244				
	(4)		The status of each project and management action, including a time-table for expected initiation and completion, and the accrual of expected benefits.	213:244, 616:622				
	(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.	213:244, 616:622				
	(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.	213:244				
	(7)		A description of the legal authority required for each project and management action, and the basis for that authority within the Agency.	213:244				
	(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.	256:260				
	(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.	213:244				
(c)			Projects and management actions shall be supported by best available information and best available science.	213:244				
(d)			An Agency shall take into account the level of uncertainty associated with the basin setting when developing projects or management actions.	213:244				
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2, 10727.4, and 10733.2, Water Code.					

Appendix 2-A. Expanded Basin Setting

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Expanded Basin Setting

This Appendix provides further background information for Section 2.2 - Basin Setting, such as additional geologic maps, cross-sections, and groundwater elevation maps.

Geology Background

The geologic map based on observations of May 1954 forms the basis of the hydrogeologic model and is shown in Figure 1 (Wood 1960).

The locations of all cross-sections in the GSP are show in Figure 2.

Cross-sections D-D', E-E' and F-F' are shown in Figure 3, Figure 4, and Figure 5. Cross-sections A-A', B-B', and C-C' are in the main text.

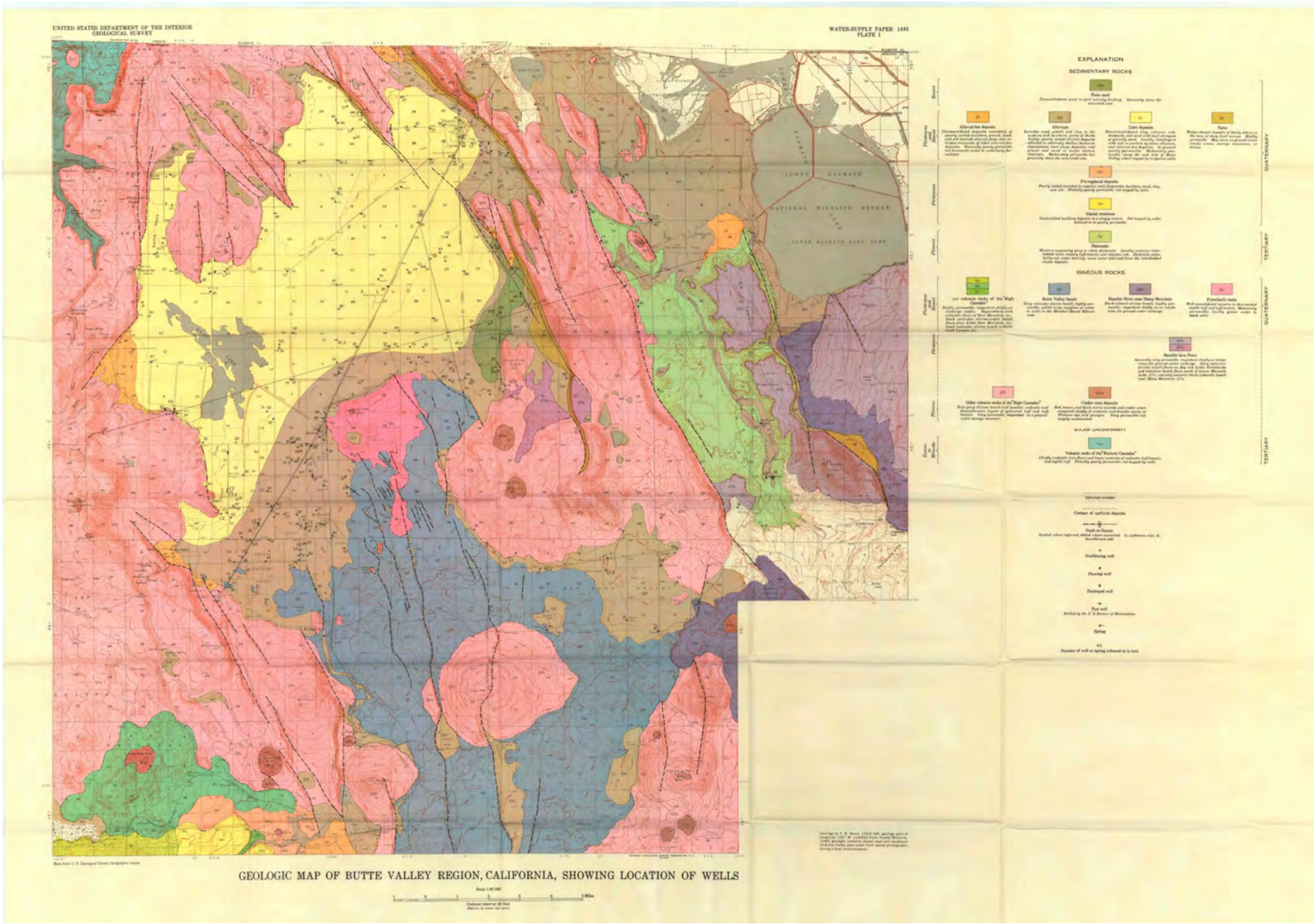


Figure 1: Detailed geology map that forms the basis of the hydrogeologic model (Wood 1960). The image is high quality so text can be distinguised when zoomed in.

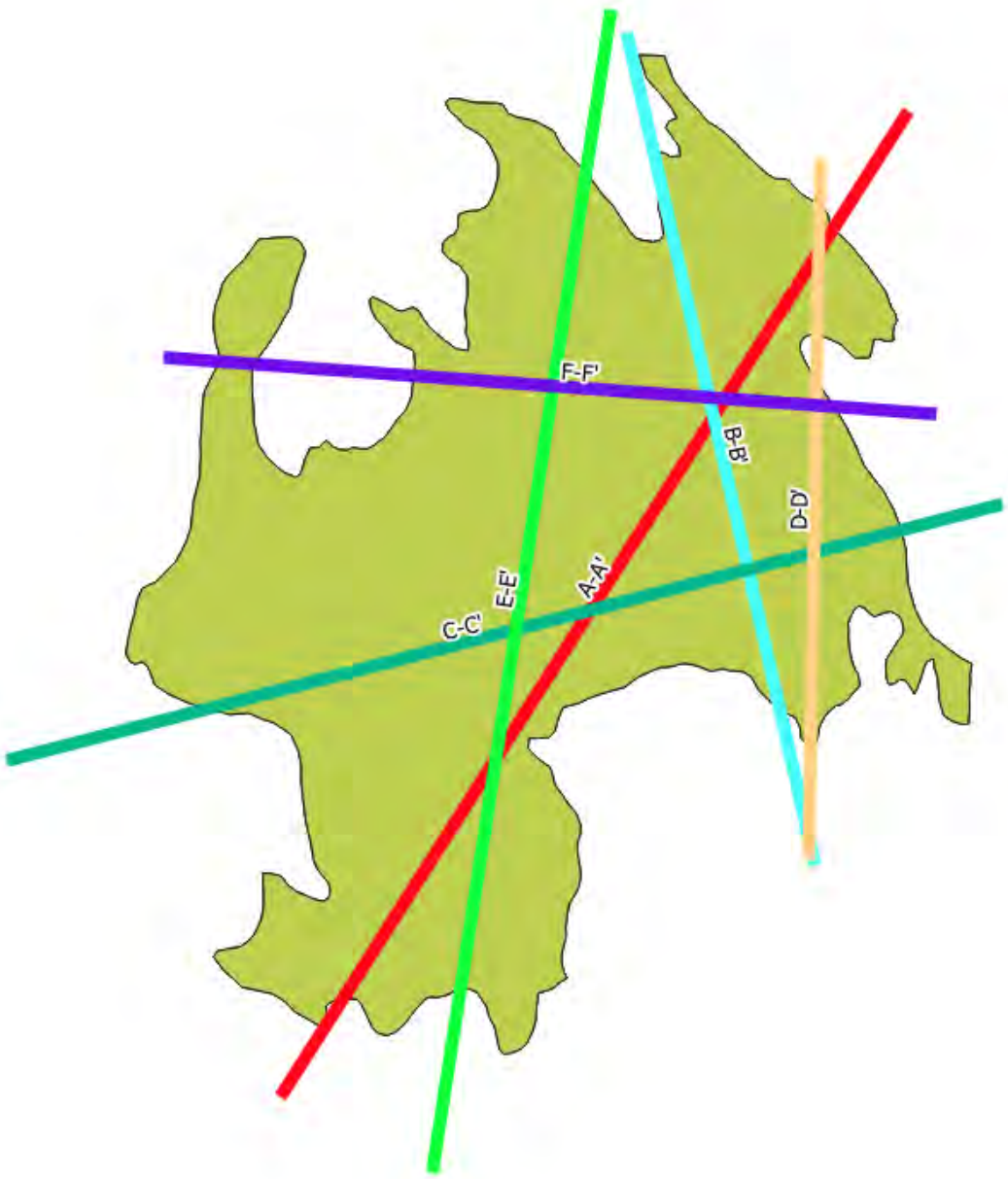


Figure 2: General cross-section locations - *this figure will be updated in the final Appendix*.

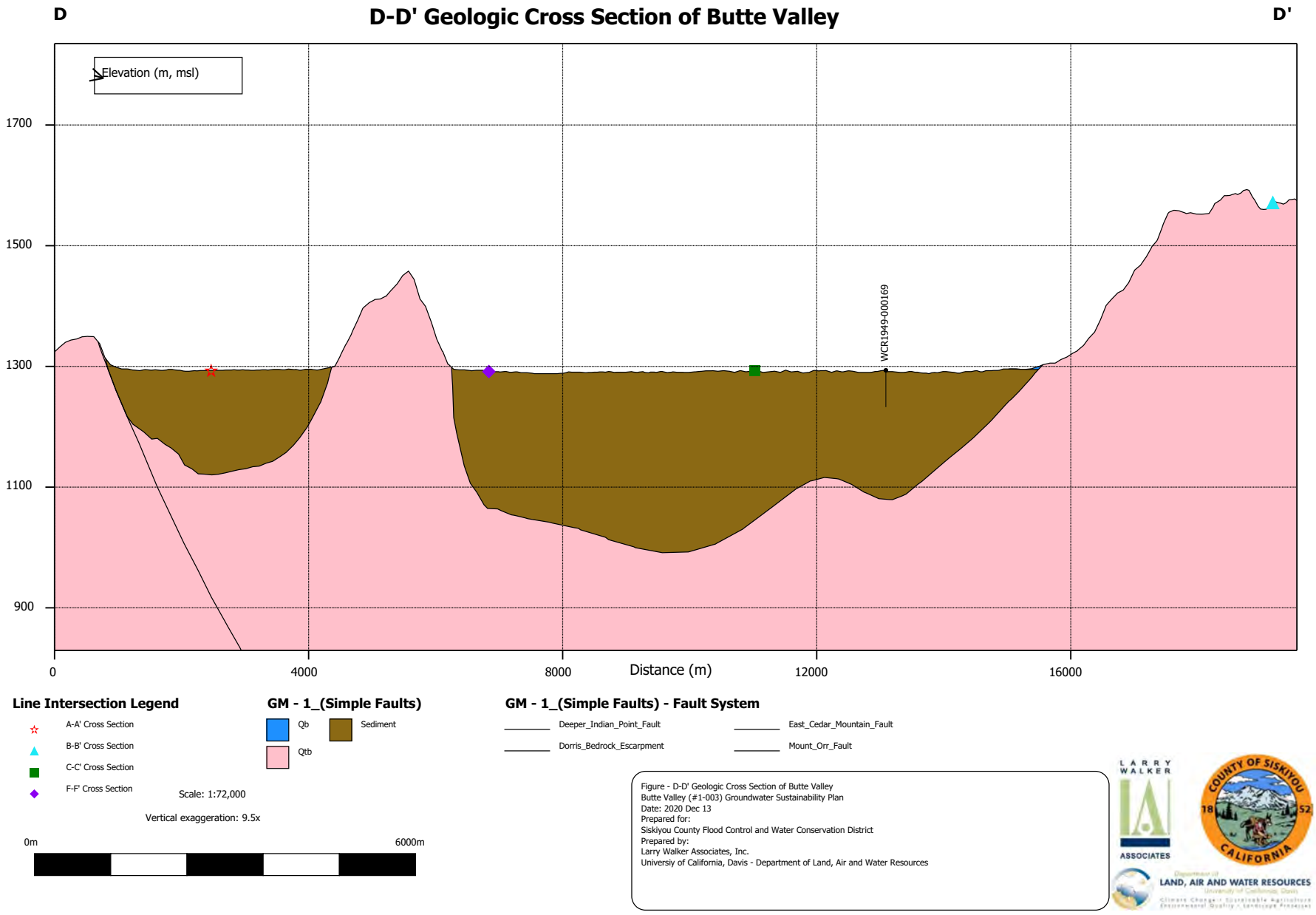


Figure 3: Cross Section D-D'

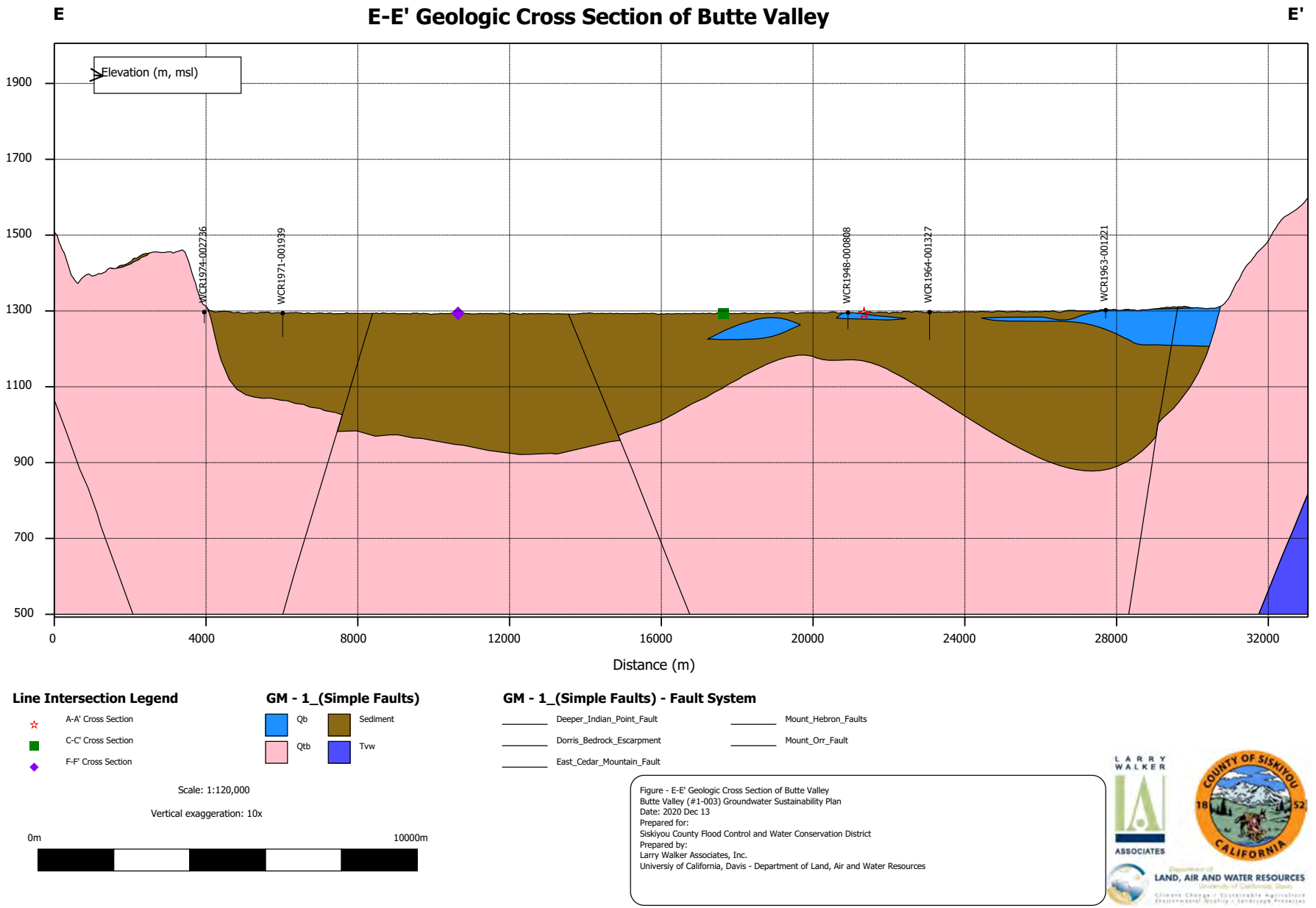


Figure 4: Cross Section E-E'

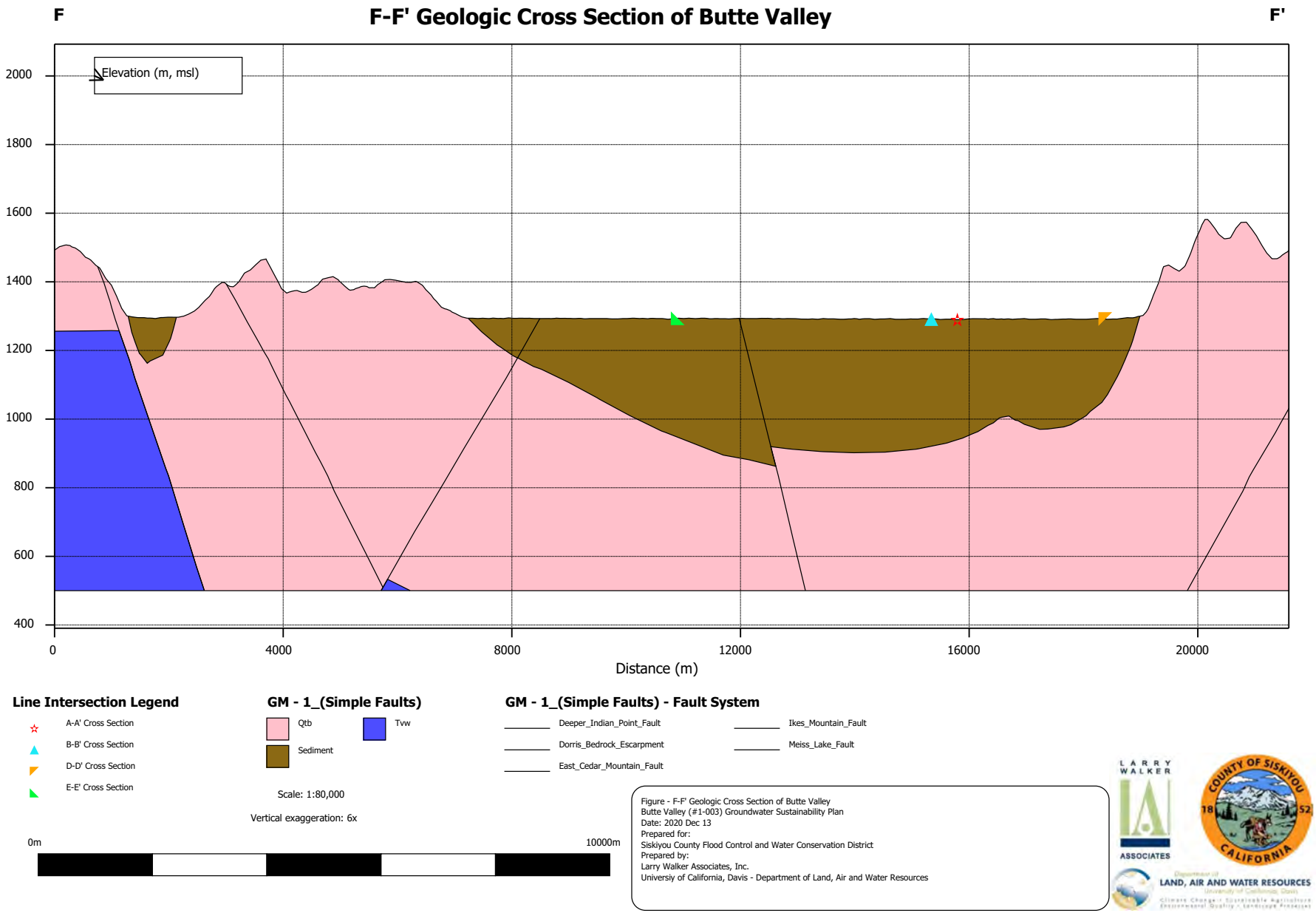


Figure 5: Cross Section F-F'

Soils

The original map of general soil units in Butte Valley, as defined by the 1994 USDA Soil Survey of the Butte Valley-Tule Lake Area, is shown in Figure 6.

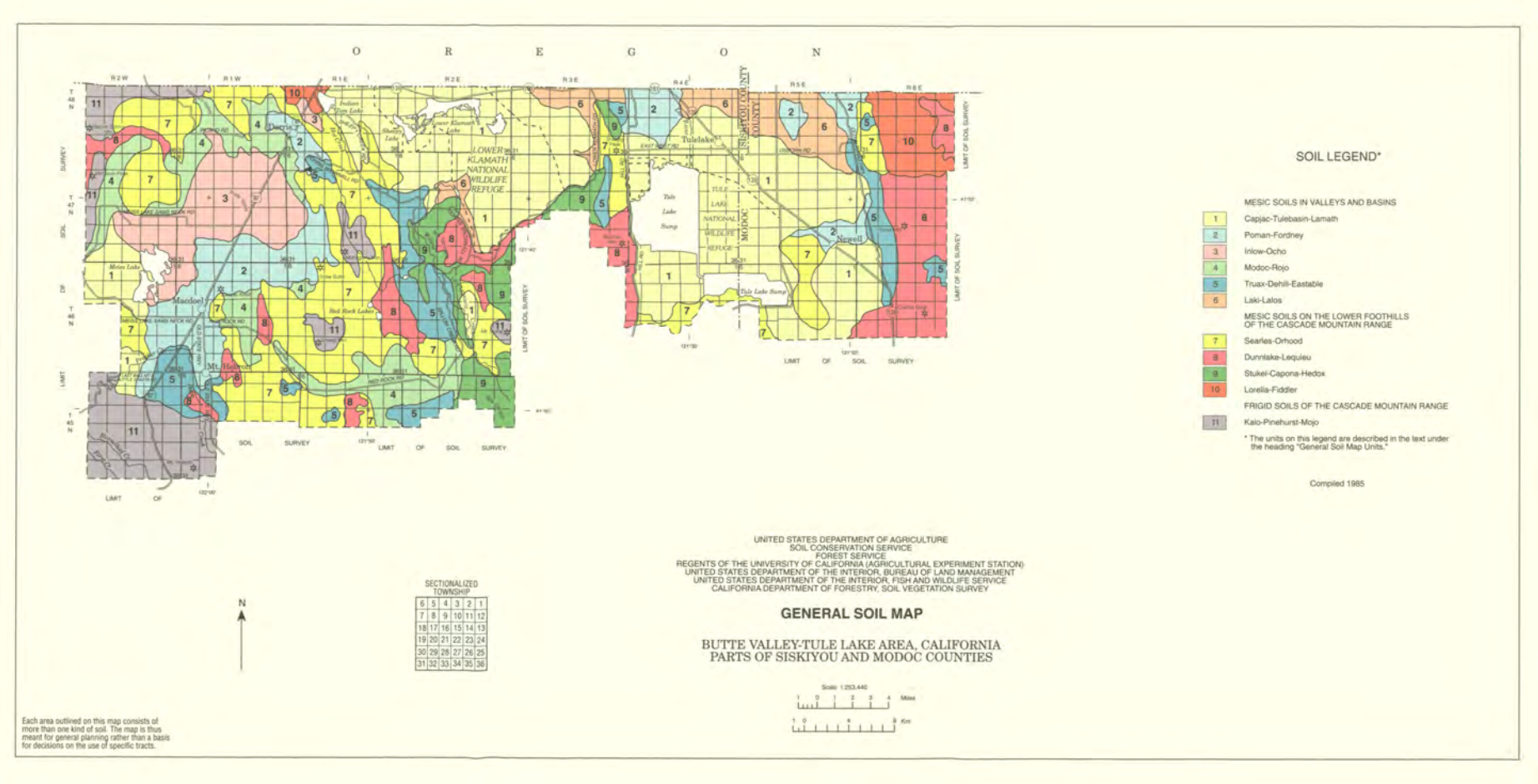


Figure 6: 1994 USDA Soil Survey of the Butte Valley-Tule Lake Area

Groundwater Elevation

Water level changes are shown in Figure 21 for the period between Spring 1978 and Spring 2018. Groundwater Elevations in Spring 2019 are shown in Figure 9. Spring 2018 groundwater elevations are shown in Figure 11. Spring 2017 groundwater elevations are shown in Figure 12. Spring 2016 groundwater elevations are shown in Figure 13. Spring 2008 groundwater elevations are shown in Figure 16. Spring 1991 groundwater elevations are shown in Figure 17. Spring 1986 groundwater elevations are shown in Figure 18. Spring 1979 groundwater elevations are shown in Figure 19.

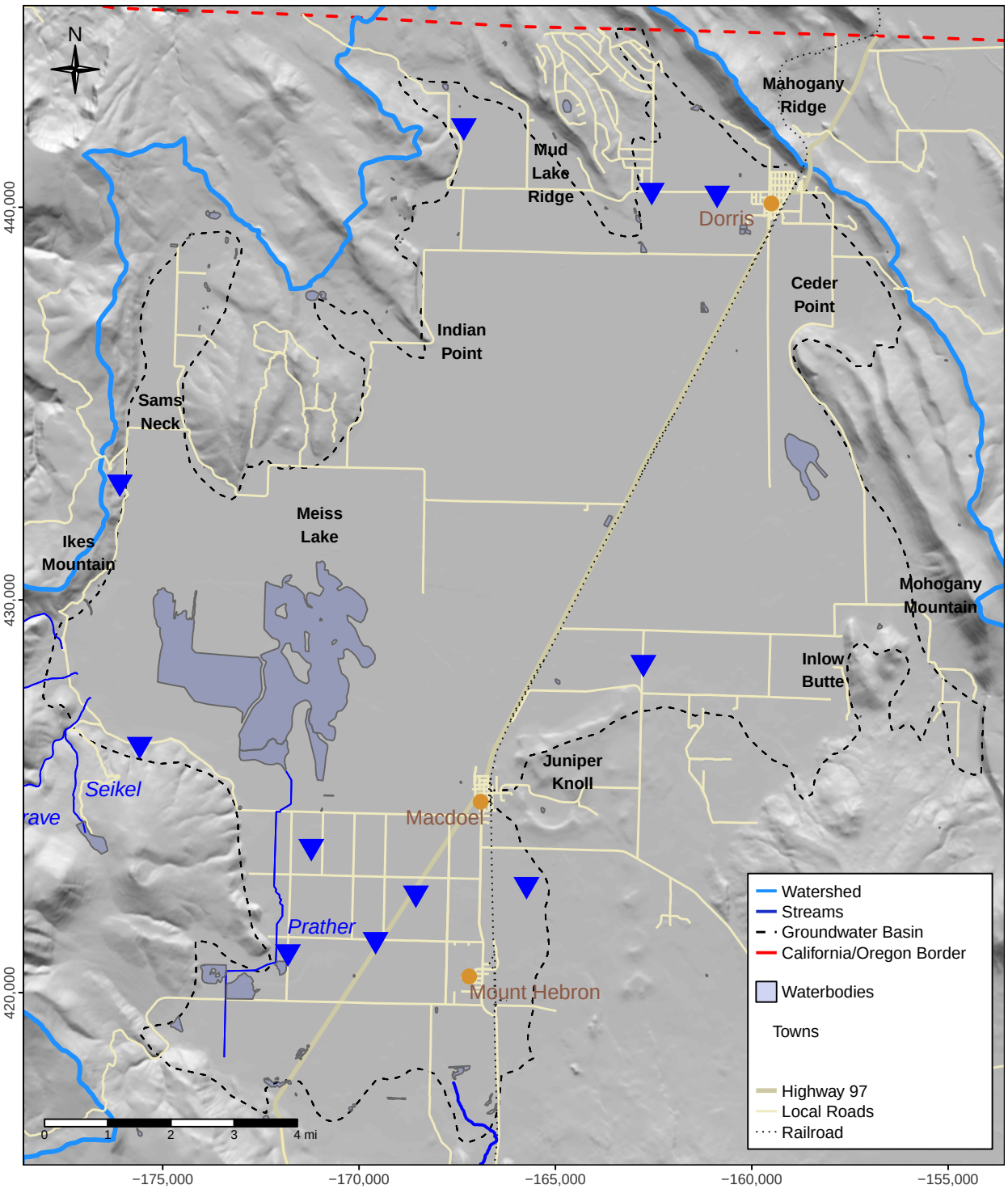


Figure 7: Continuous Monitoring Well Locations

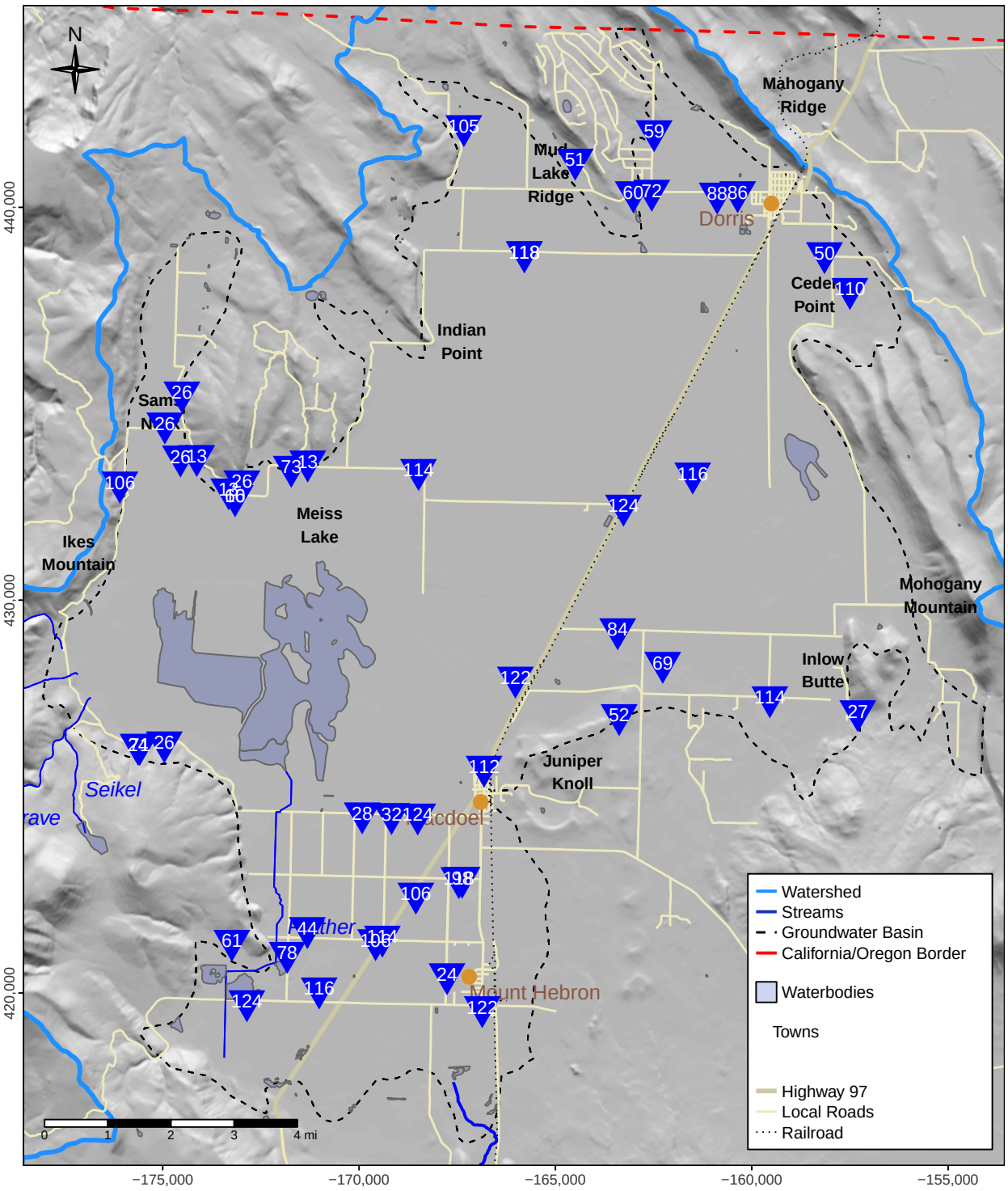


Figure 8: Periodic Monitoring Well Locations

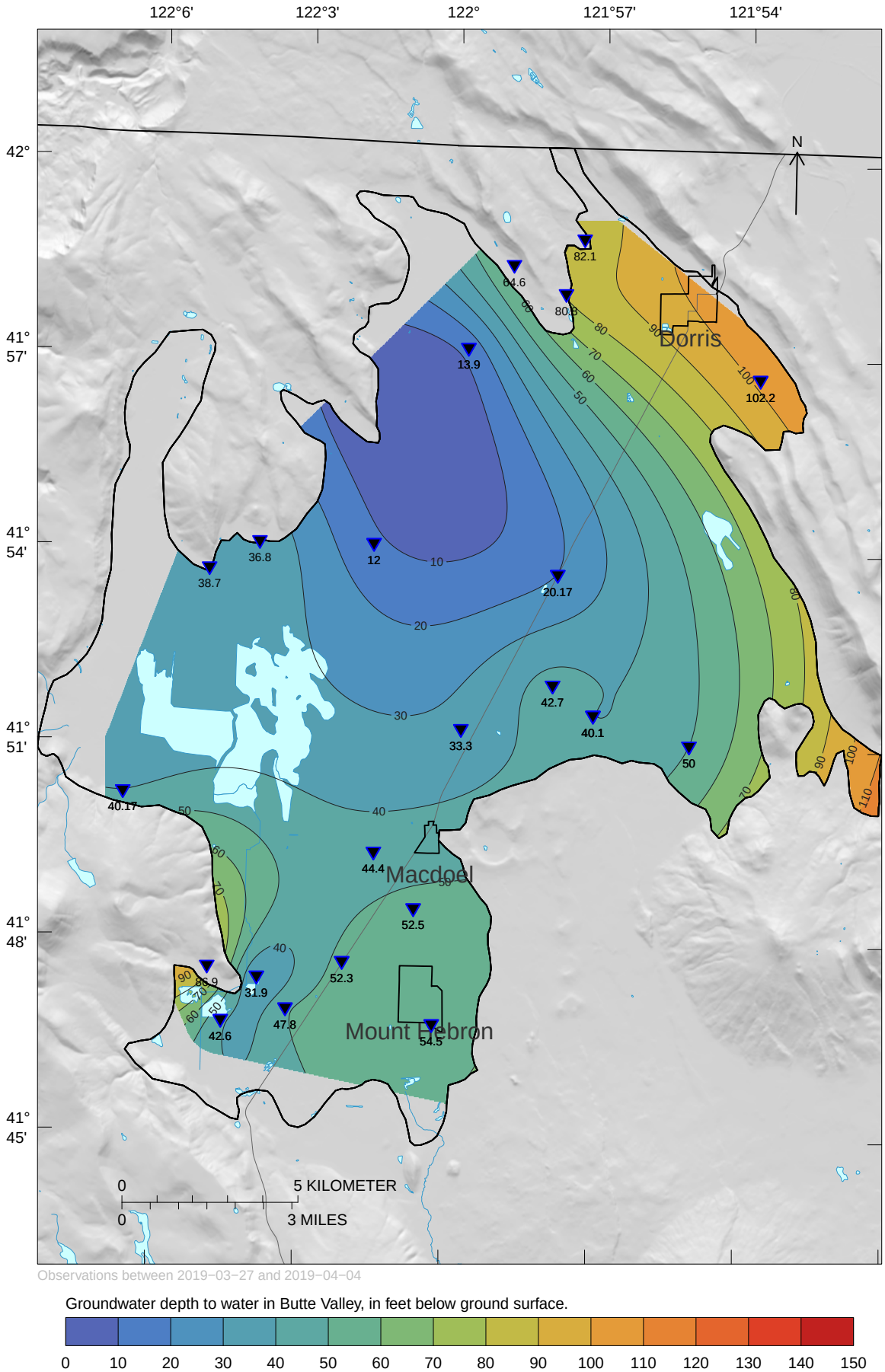


Figure 9: Butte Valley Groundwater Elevations, Spring 2019

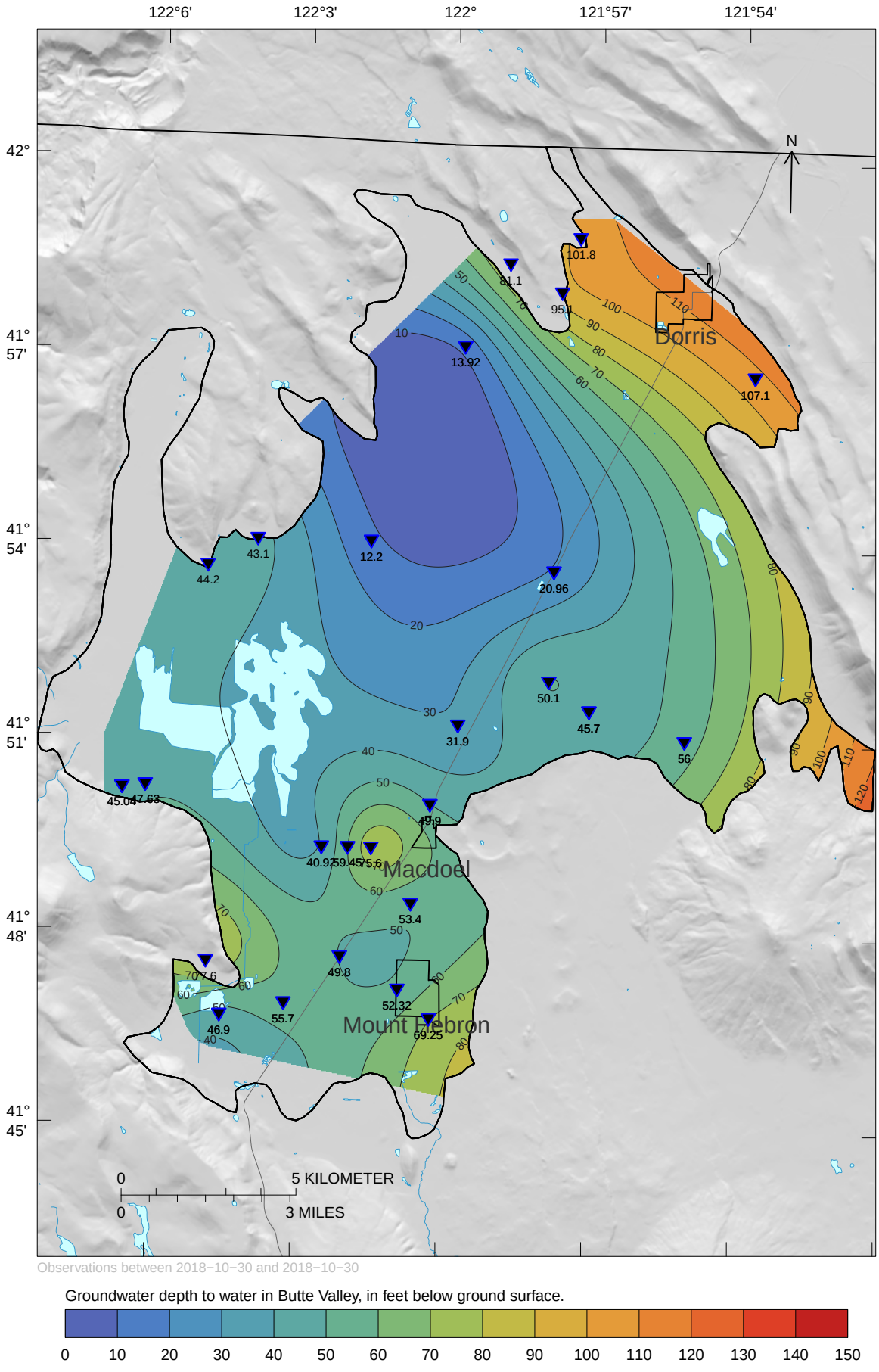


Figure 10: Butte Valley Groundwater Elevations, Fall 2018

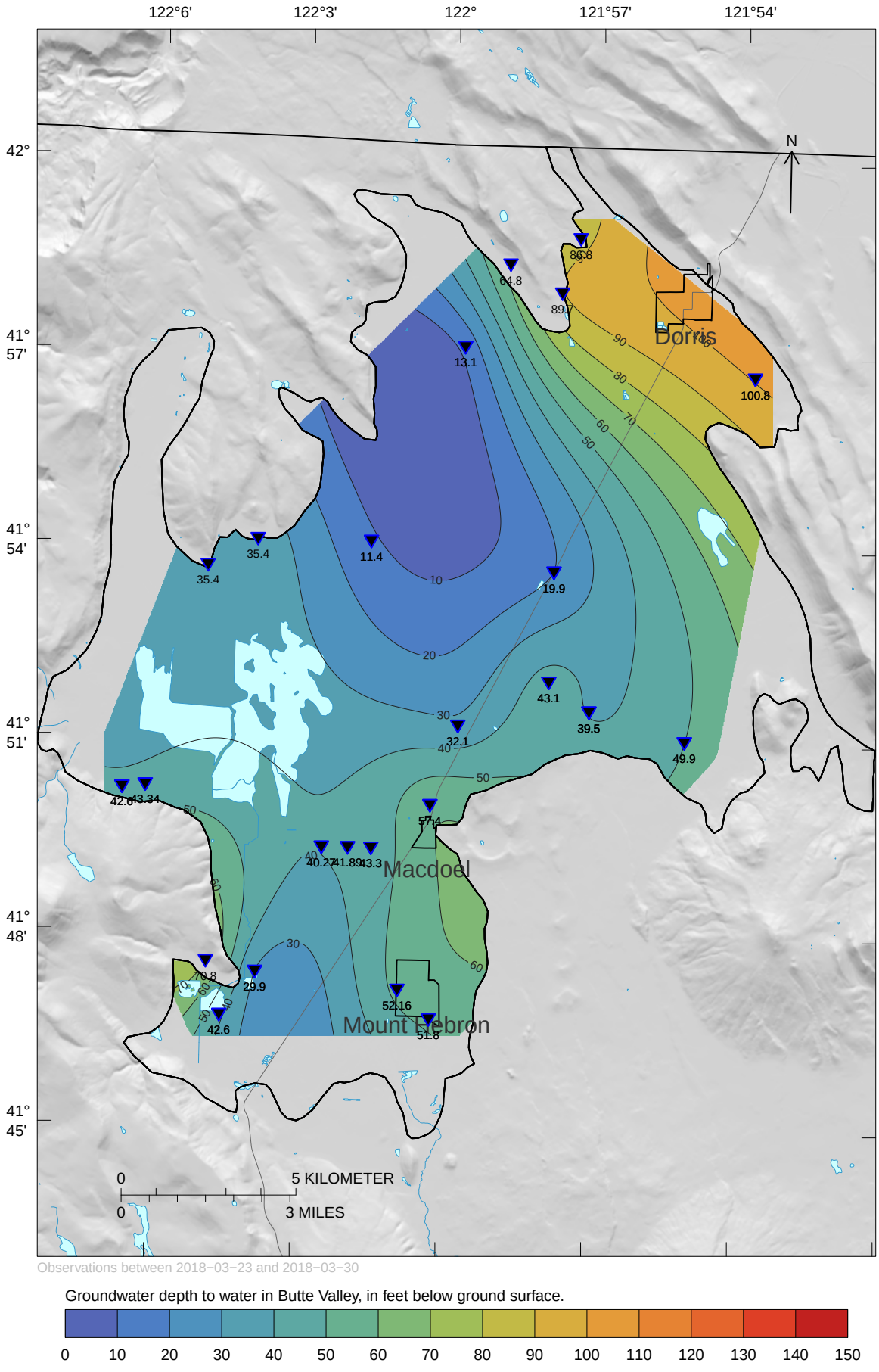


Figure 11: Butte Valley Groundwater Elevations, Spring 2018

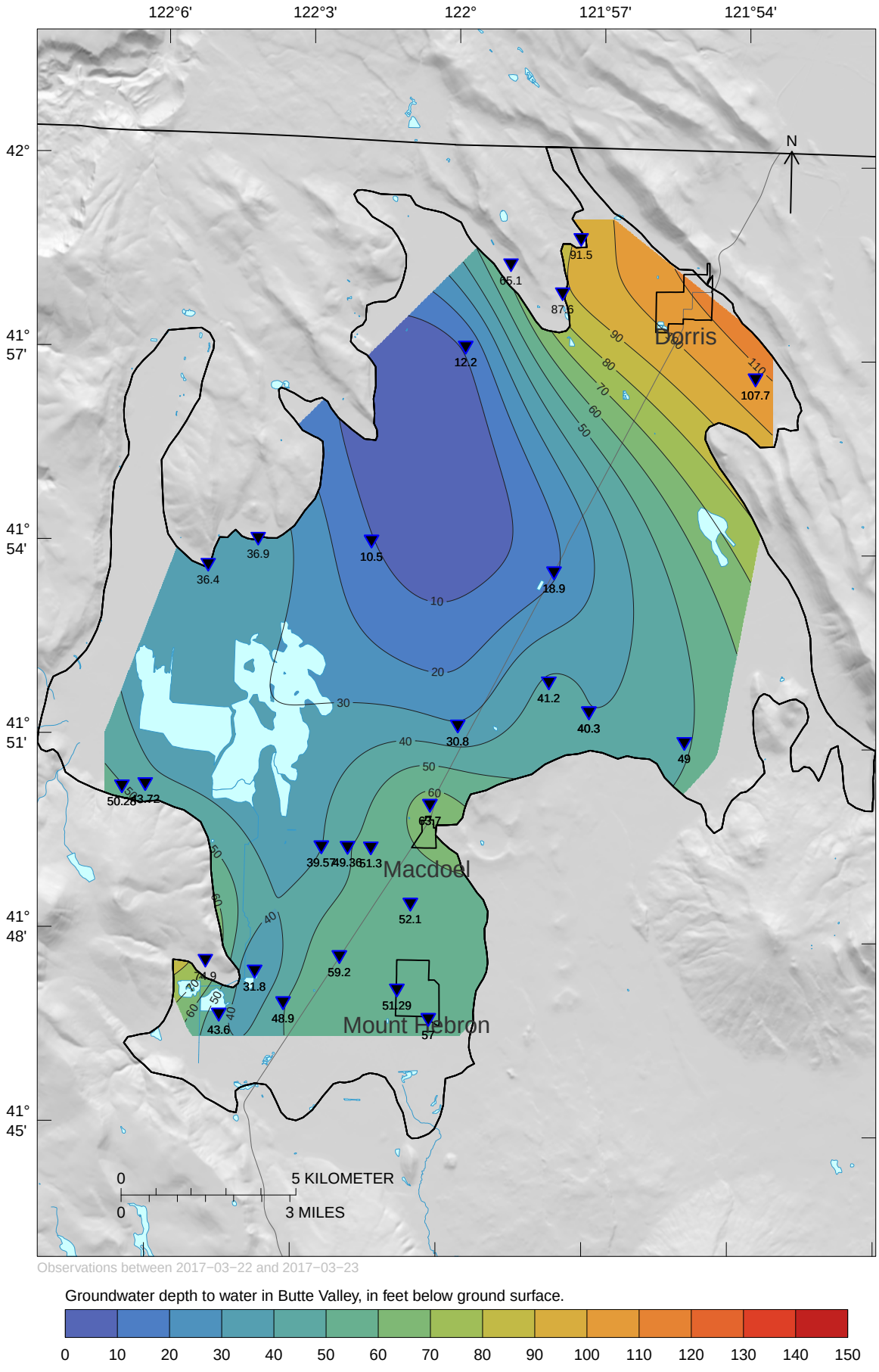


Figure 12: Butte Valley Groundwater Elevations, Spring 2017

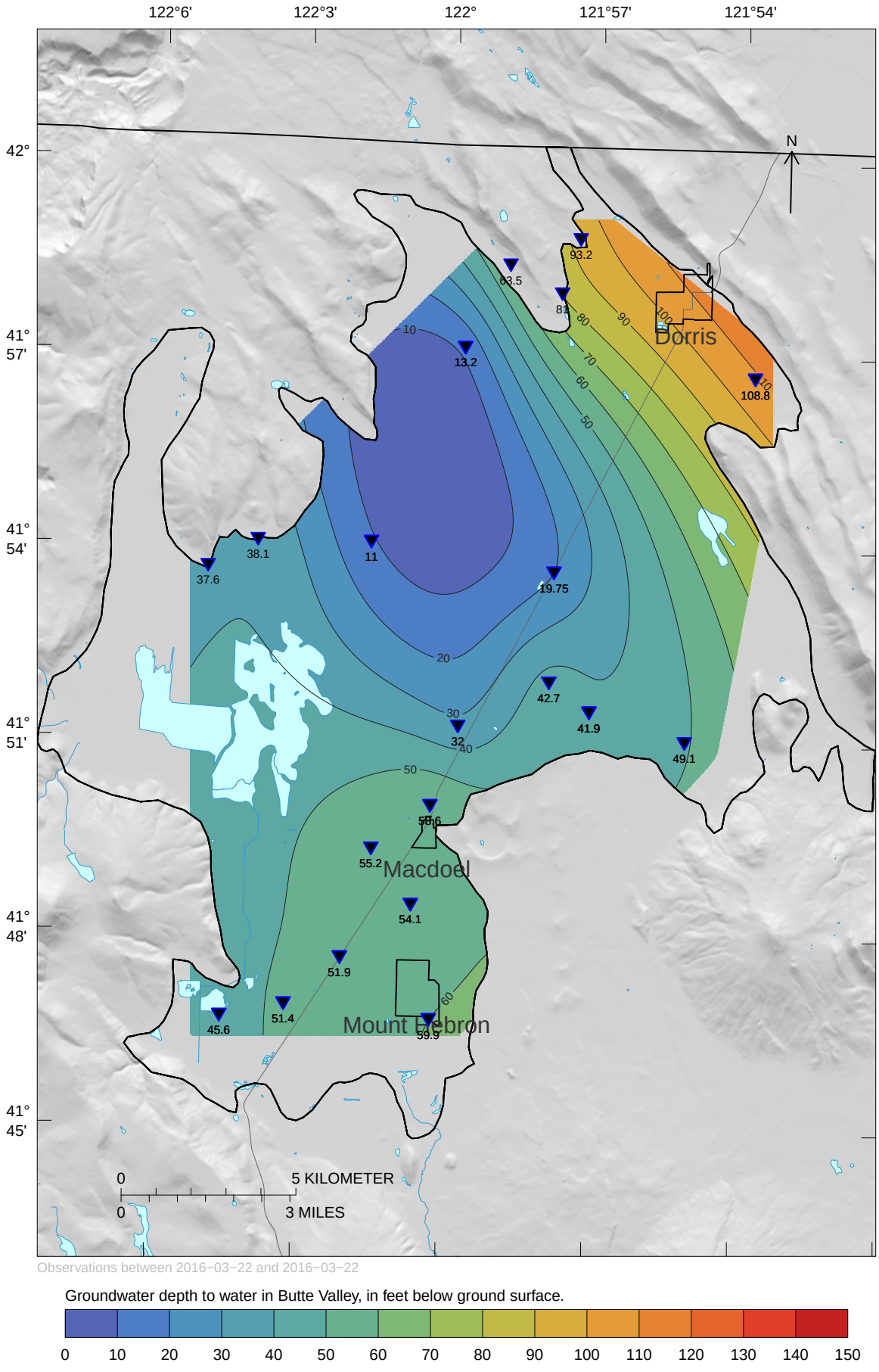


Figure 13: Butte Valley Groundwater Elevations, Spring 2016

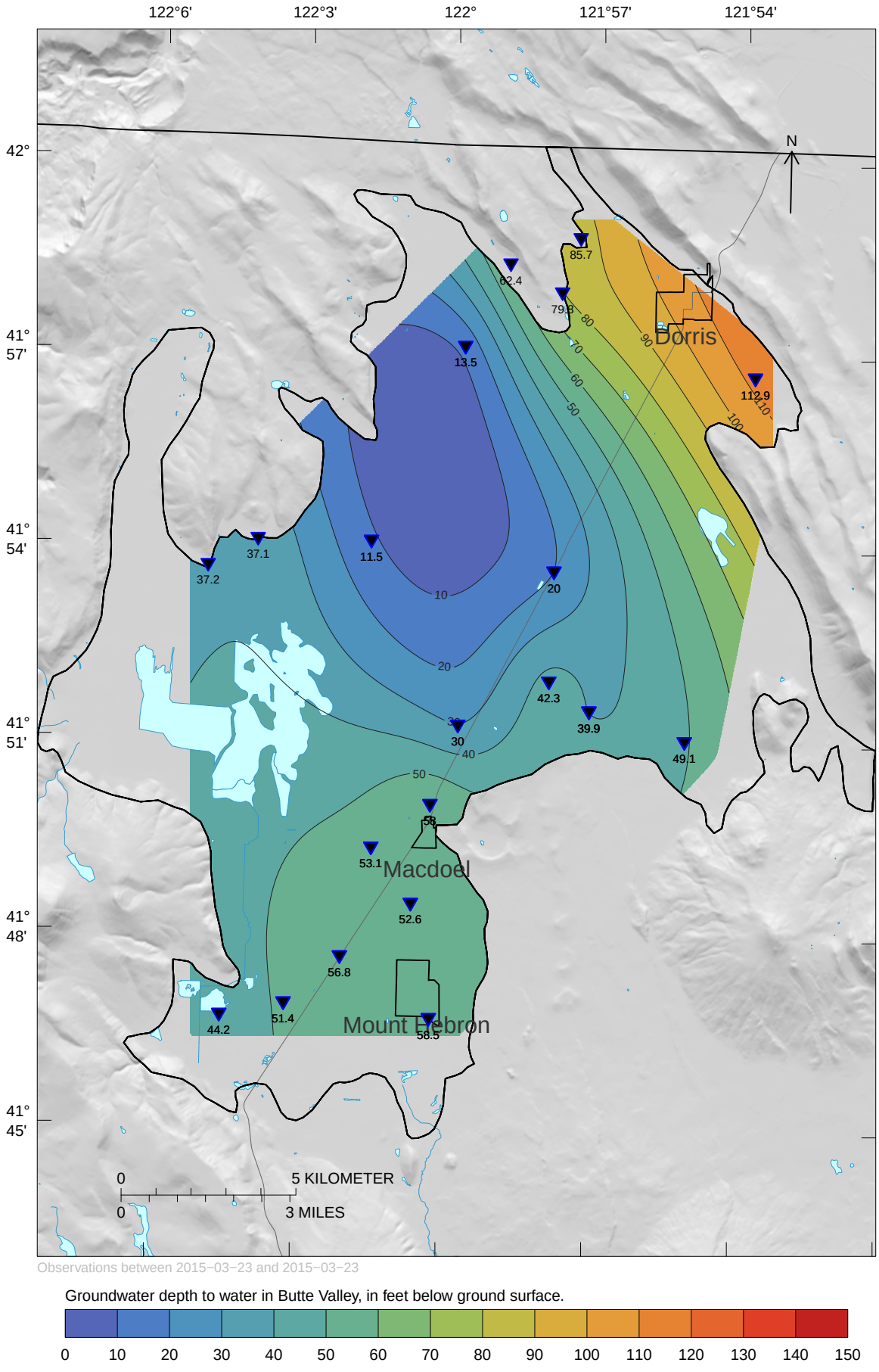


Figure 14: Butte Valley Groundwater Elevations, Spring 2015

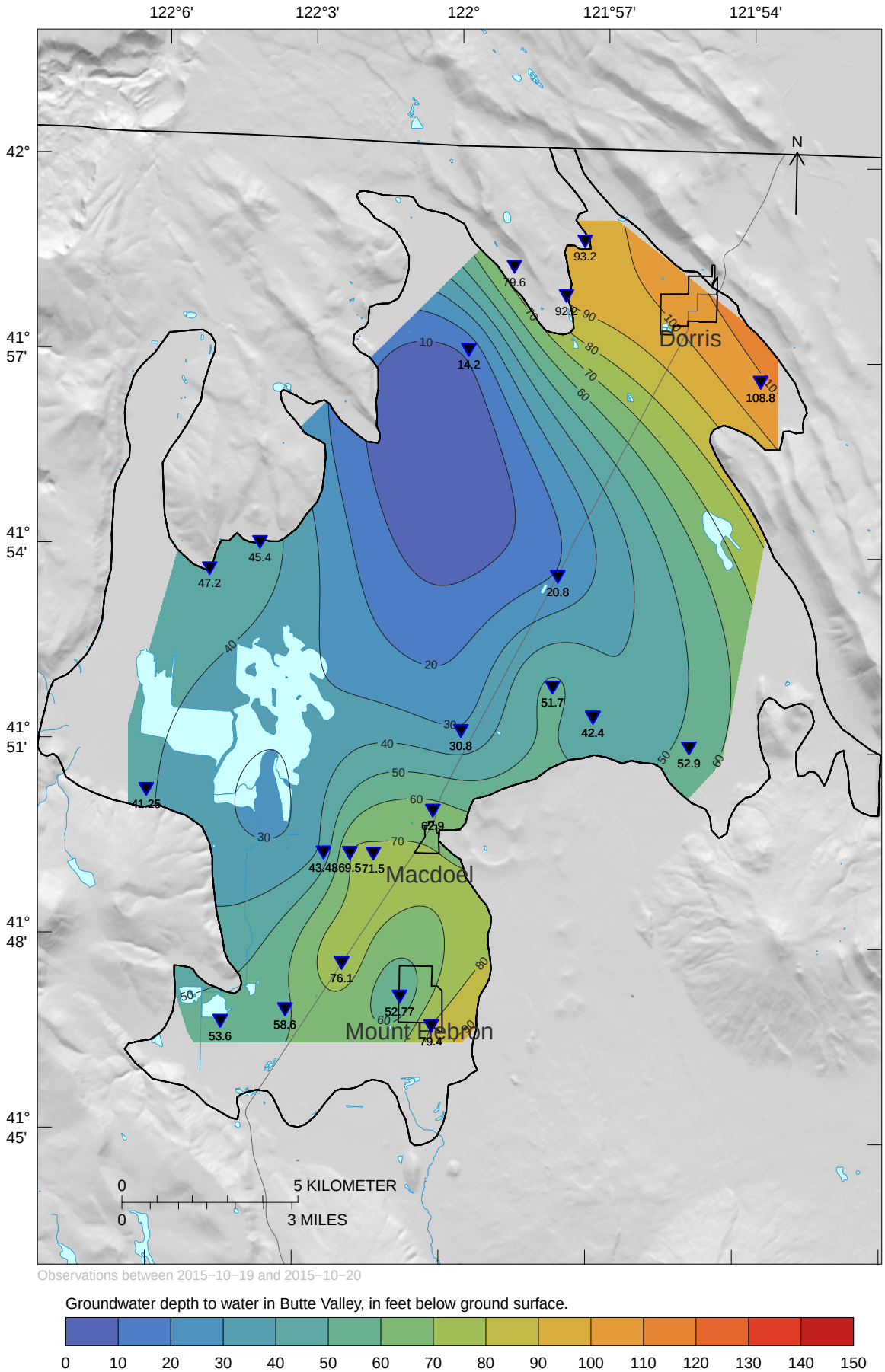


Figure 15: Butte Valley Groundwater Elevations, Fall 2015

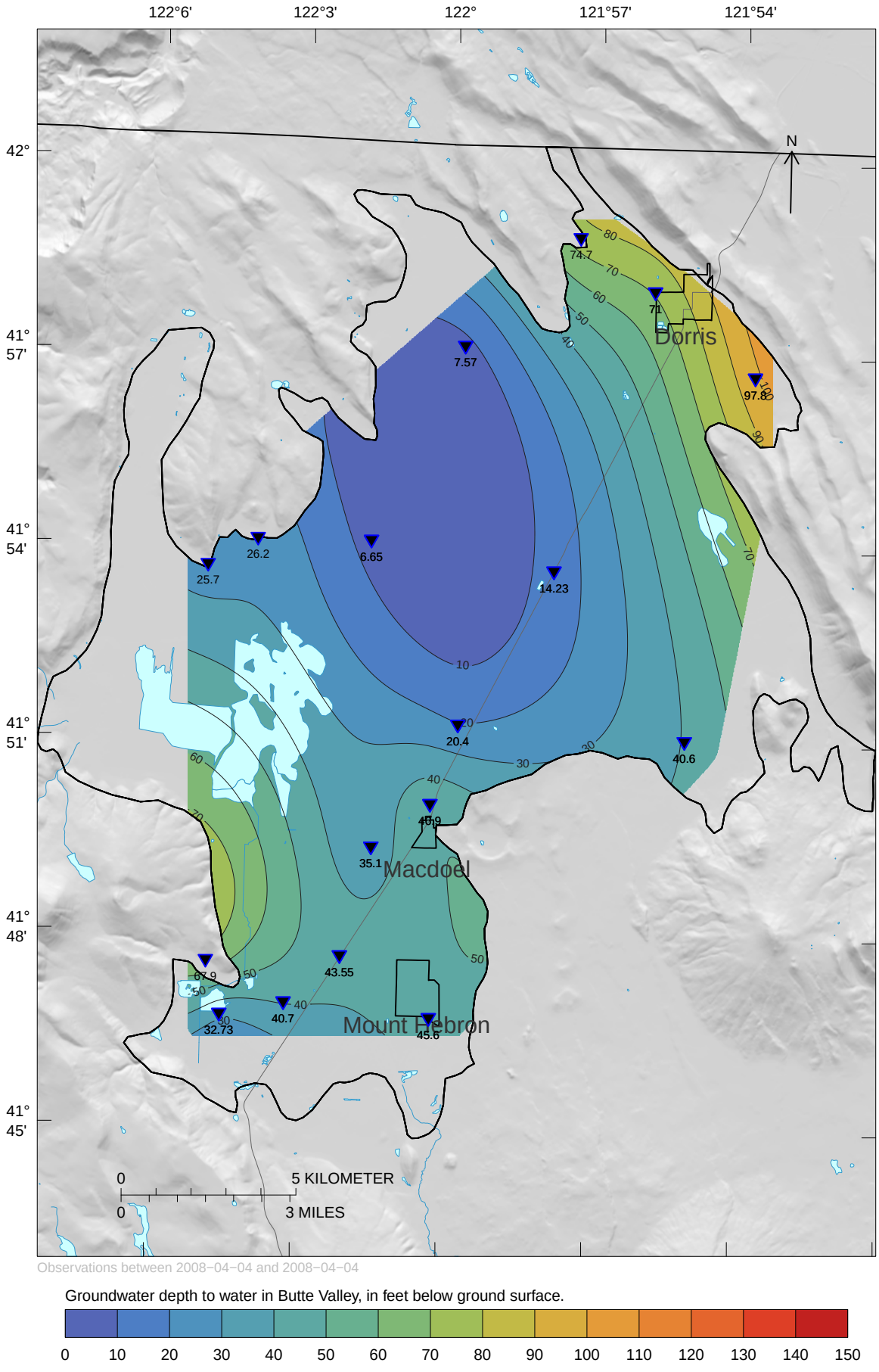


Figure 16: Butte Valley Groundwater Elevations, Spring 2008

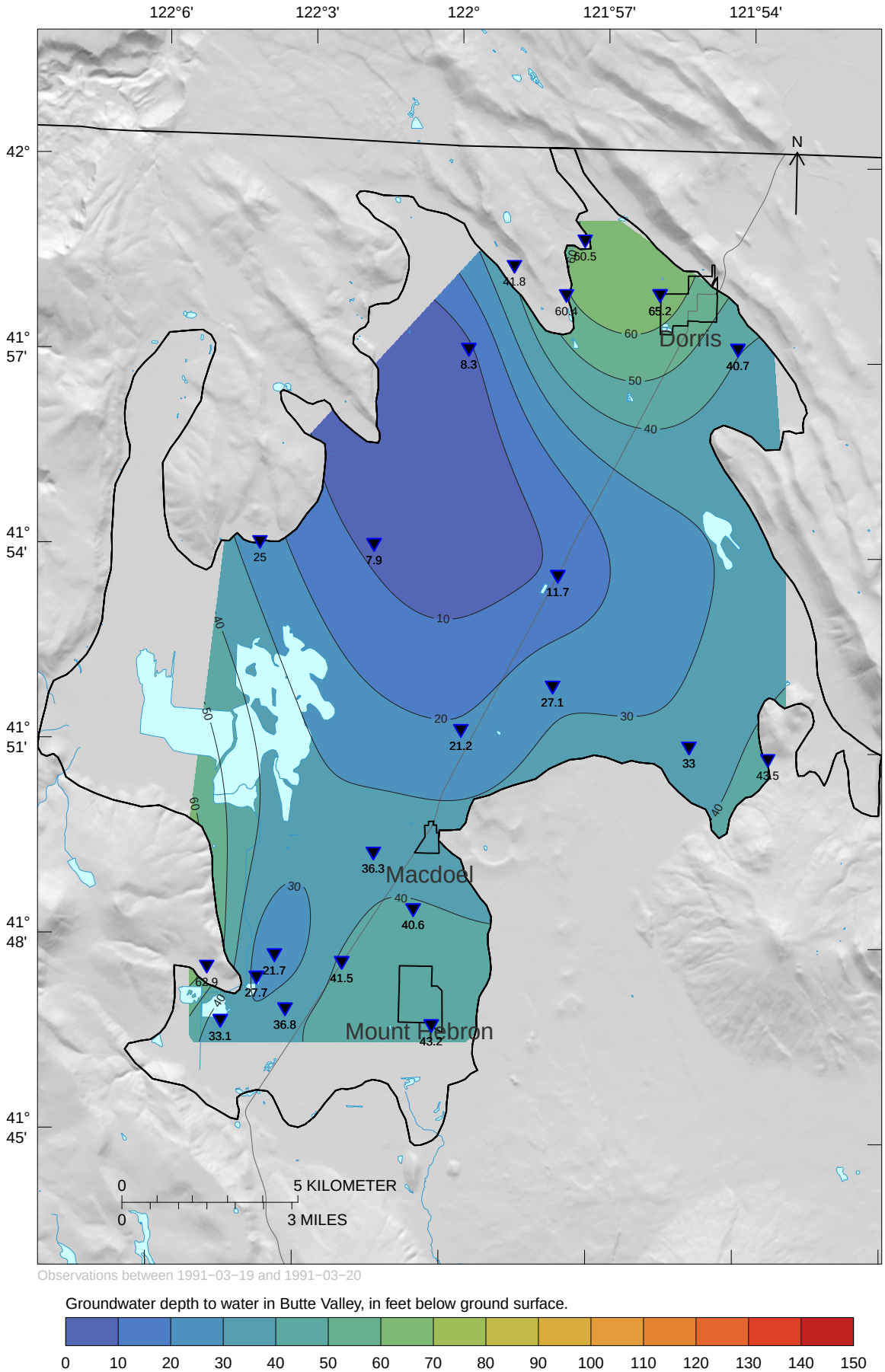


Figure 17: Butte Valley Groundwater Elevations, Spring 1991

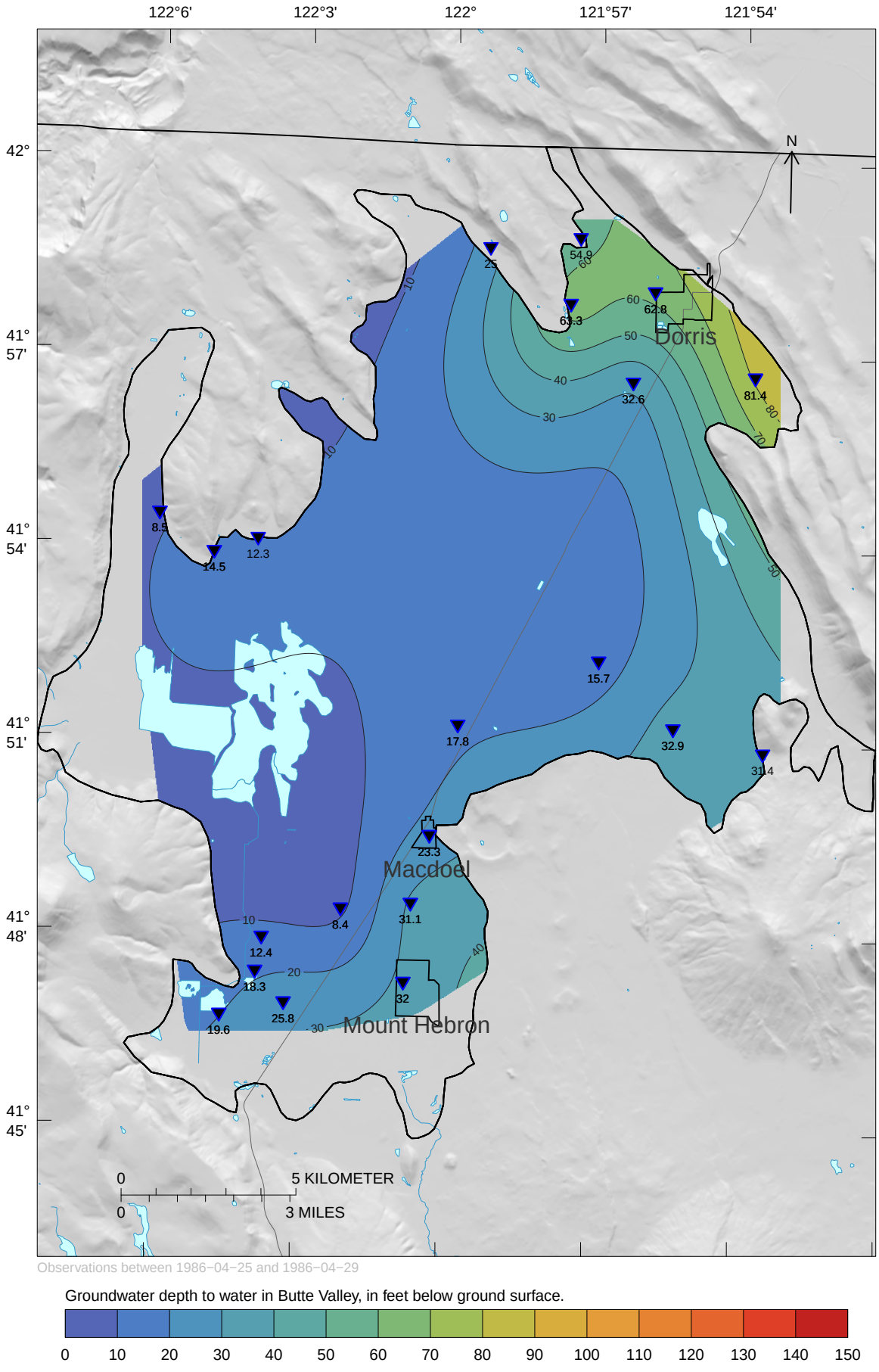


Figure 18: Butte Valley Groundwater Elevations, Spring 1986

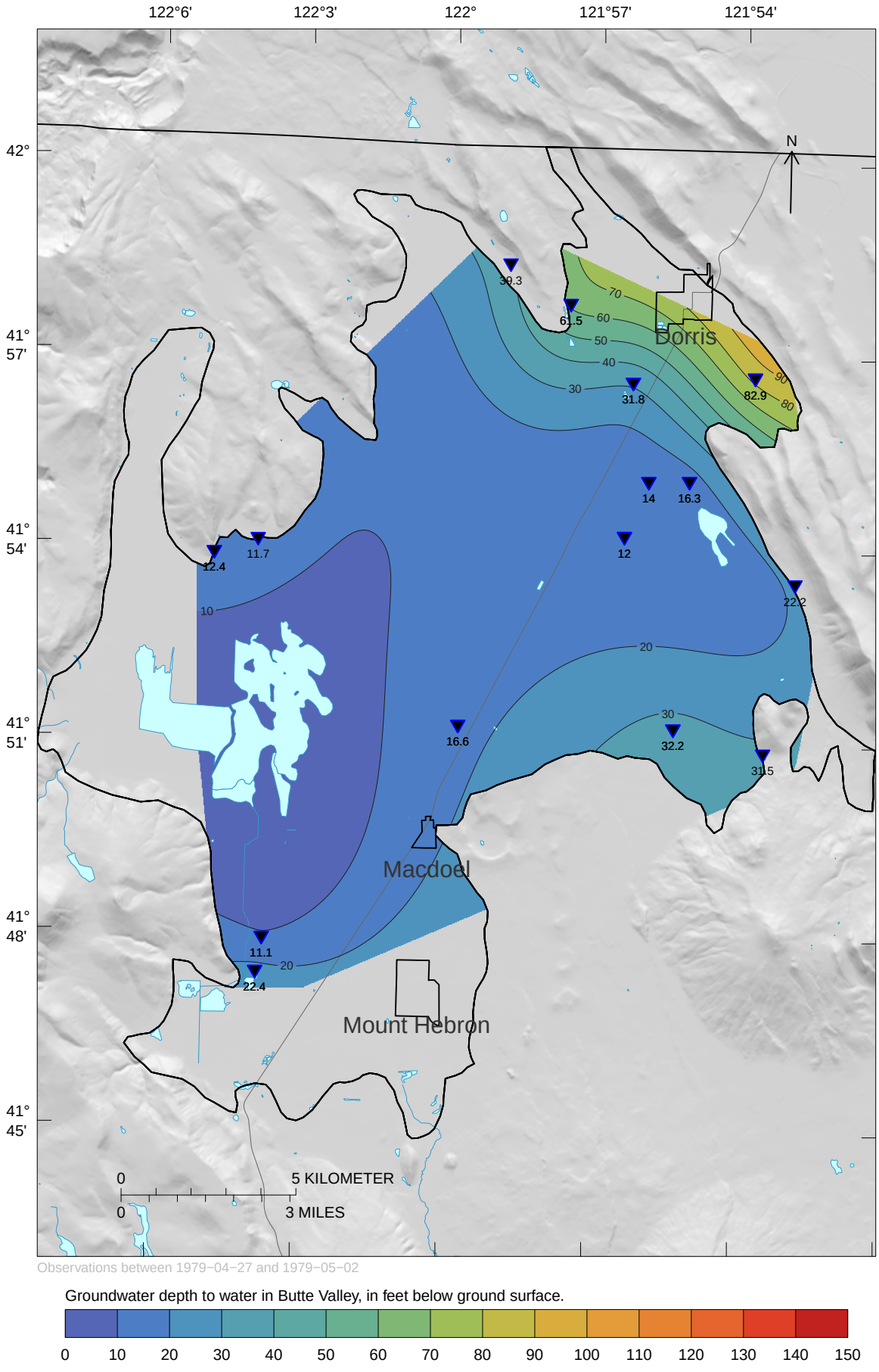


Figure 19: Butte Valley Groundwater Elevations, Spring 1979

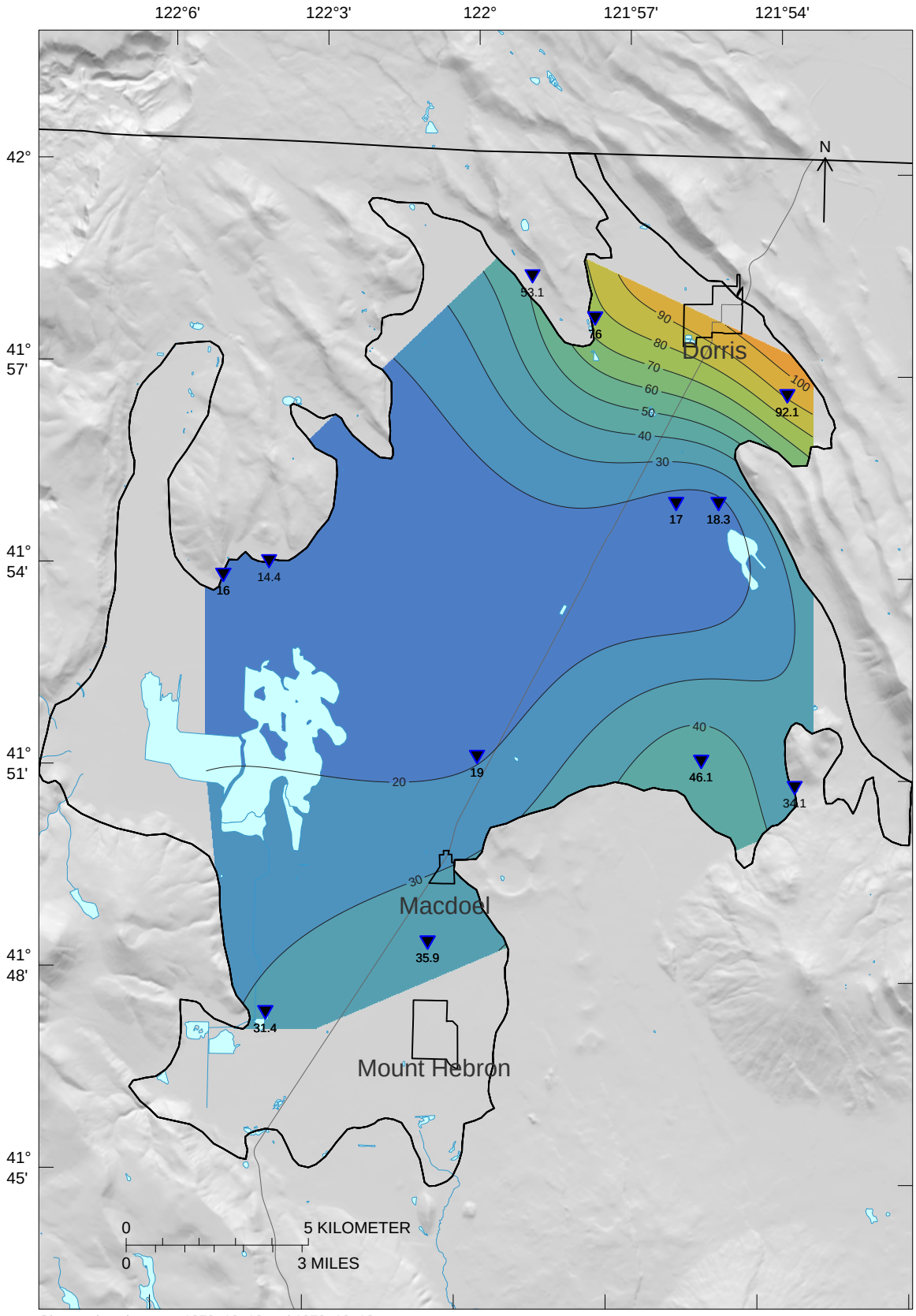


Figure 20: Butte Valley Groundwater Elevations, Fall 1979

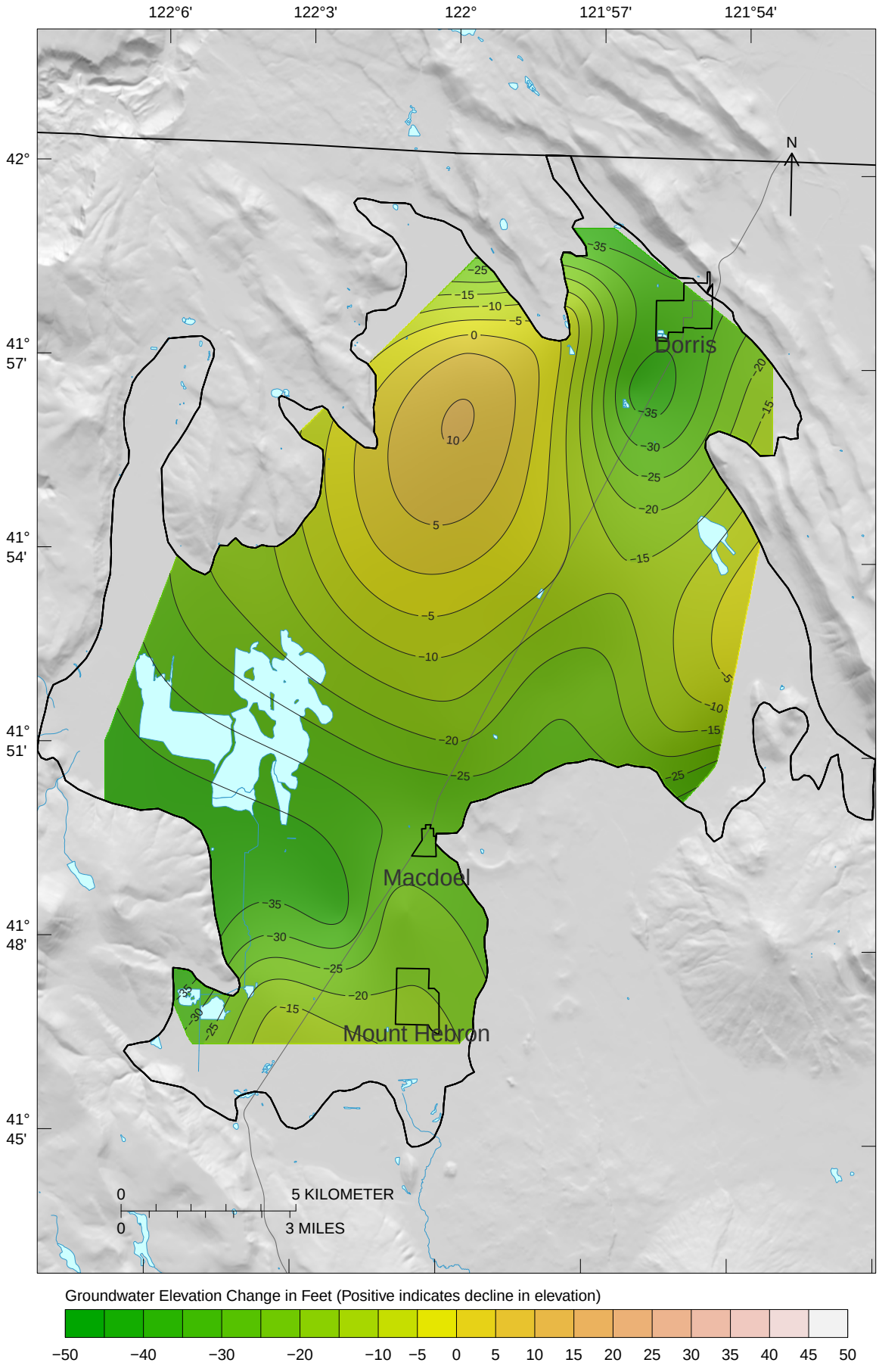


Figure 21: Butte Valley Groundwater Change from Spring 1986 to Spring 2018

References

Wood, P. R. 1960. “Geology and Groundwater Features of the Butte Valley Region, Siskiyou County California,” no. 1491: 1–155.

Appendix 2-B. Water Quality Assessment

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Regulatory Background

Federal and State Regulations

The overarching federal law concerning water quality is the Clean Water Act, passed in 1972, and is applicable to surface waters and wetlands. In contrast, the federal Safe Drinking Water Act (SDWA) applies to both surface and groundwater, providing protection to drinking water supplies. Under the SDWA, federal standards were established through the United States Environmental Protection Agency (USEPA), in the form of maximum contaminant levels (MCLs). Secondary maximum contaminant levels (SMCLs) have also been established at the federal level; these address esthetics of drinking water sources and are not enforceable. The state of California has its own Safe Drinking Water Act that includes MCLs and SMCLs which are, for select constituents, stricter than those set at the federal level. The California MCLs and SMCLs are codified in Title 22 of the California Code of Regulations (CCR). The standards established under the federal and state Safe Drinking Water Acts are enforced through the State Water Resource Control Board's (SWRCB's) Division of Drinking Water (DDW).

The California Porter-Cologne Water Quality Act, contained in California Water Code Division 7, applies to groundwater and surface waters, designating responsibility for water quality and safe drinking water to the SWRCB and the nine Regional Water Quality Control Boards (RWQCB) in California. The Act requires RWQCBs to develop water quality control plans to manage the quality of surface water and groundwater in specific hydrologic regions; the plans contain defined water quality objectives for each region. These water quality objectives protect the quality of surface waters, groundwaters, and associated beneficial uses. The water quality control plan must be approved by both the SWRCB and the USEPA. The Butte Valley Basin is in the North Coast Region and is regulated under the North Coast Regional Water Quality Control Board (Regional Water Board), with water quality objectives detailed in the Water Quality Control Plan for the North Coast Region (Basin Plan).[1]

The SWRCB's Policy for Water Quality Control For Recycled Water (Recycled Water Policy),[2] most recently amended in 2018, includes additional requirements to address salt and nutrients. Under this policy, Regional Water Boards are required to assess basins or subbasins within the region where water quality is threatened by salt and nutrients, and where management is required. In basins or subbasins where salt and nutrients are identified as a threat, a salt and nutrient management plan (SNMP) or equivalent management plan is required; this plan can address other constituents in addition to salt and nutrients.

Water Quality Control Plan for the North Coast Region

The Water Quality Control Plan for the North Coast Region (Basin Plan) is a regulatory tool used by the North Coast Regional Water Quality Control Board (Regional Water Board) to protect water quality within the North Coast Region. The Basin Plan is adopted by the NCRWQCB and approved by the State Water Resources Control Board; the water quality standards are approved by the United States Environmental Protection Agency (USEPA). Within the Basin Plan, beneficial uses of water, water quality objectives, including an antidegradation policy and plans for implementing

[1]{North Coast Regional Water Quality Control Board. 2018. "Water Quality Control Plan for the North Coast Region." Available: https://www.waterboards.ca.gov/northcoast/water_issues/programs/basin_plan/}

[2]{SWRCB Resolution No. 2018-0057 and "Amendment to the Policy for Water Quality Control For Recycled Water." Available: https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2018/121118_7_final_amendment_oal.pdf}

protections are included. Table 2-1 of the Basin Plan designates the following beneficial uses for all groundwater (California North Coast Regional Water Quality Control Board 2018):

- Municipal and Domestic Supply (MUN)
- Agricultural Supply (AGR)
- Industrial Service Supply (IND)
- Native American Culture (CUL)

Potential beneficial uses of groundwater include:

- Industrial Process Supply (PRO)
- Aquaculture (AQUA)

For chemical constituents in waters with MUN beneficial uses, the Basin Plan specifies that no waters are to exceed the MCL in Title 22 of the California Code of Regulations (CCR). The Basin Plan also includes numeric water quality objectives, specifically for groundwaters in the Butte Valley hydrologic area.

A complete list of constituents, comparison concentrations and sources are listed in Table 2.

Water Quality Assessment

Data Sources

Water quality data was obtained from several databases and supplemented with data provided by local organizations and community members. The majority of the water quality data used in the assessment was sourced from the SWRCB's Groundwater Ambient Monitoring and Assessment Program (GAMA), a database containing datasets from agencies including the Department of Pesticide Regulation (DPR), Department of Water Resources (DWR), the State Water Board, Lawrence Livermore National Laboratory (LLNL) and the United States Geological Survey (USGS). Additional data in the Butte Valley Wildlife Area was directly provided by the California Department of Fish and Wildlife.

The datasets in GAMA with information in Butte Valley Groundwater Basin are:

- **The Public Water System Wells** dataset includes wells regulated by the State Water Board's Division of Drinking Water (DDW). This dataset includes information for active and inactive drinking water sources with 15 or more connections or more than 25 people per day.
- **National Water Information System (NWIS)**, a dataset provided by USGS with samples from water supply wells and reported quarterly to the State Water Board's data management system, GeoTracker.
- **Monitoring wells** regulated by the State Water Board includes wells under different regulatory programs, with data available for download through GeoTracker. There are monitoring wells in Butte Valley Basin for the following programs:

  - Leaking Underground Storage Tank (LUST) Cleanup sites
  - Cleanup Program Sites
  - Land Disposal Sites

- **GAMA's Priority Basin Project**, a State Water Board, USGS and LLNL initiative to assess groundwater quality statewide. Data primarily collected from public water system wells but private domestic, monitoring and irrigation wells are also sampled.
- **DWR's Water Data Library**, a dataset including groundwater quality and depth data with samples from multiple well types including irrigation, stock, domestic and public supply.
- **Department of Pesticide Regulation's Groundwater Protection program**, a compilation of information from DPR and other public agencies from domestic, public supply and irrigation wells.

Selection of Numeric Thresholds

Numeric thresholds are used with well data to evaluate groundwater quality. These numeric standards are selected to satisfy all relevant groundwater quality standards and objectives; the general selection approach used is consistent with recommendations by the State Water Board for determination of assessment thresholds for groundwater [Reference]. More than one water quality objective or standard may apply to a constituent and a prioritization process is used to select the numeric threshold value. Where available, the strictest value, of the federal and state regulated water quality standards, and water quality objectives specified in the Basin Plan, is used.

The following sources were used in establishing the numeric thresholds:

i) Basin Plan numeric water quality objectives

Specific groundwater quality objectives are defined in the Basin Plan for specific conductance, pH, hardness and boron. These limits are listed in Table 1 below.

ii) State and Federal Maximum Contaminant Levels (MCLs)

MCL-CA: State of California MCLs

MCL-US: Federal MCLs

Per the Basin Plan, groundwaters in the Butte Valley hydrologic area have a designated beneficial use as domestic or municipal water supply (MUN) beneficial use and must not exceed the maximum contaminant levels (MCLs) and secondary maximum contaminant levels (SMCLs) defined in Title 22 of the California Code of Regulations (CCR). The strictest value of the state and federal MCLs and SMCLs is used.

The complete list of constituents and corresponding sources and values for comparison concentrations used in the water quality analysis can be found in Table 2.

Table 1: Basin Plan Specific Water Quality Objectives for Groundwaters in the Butte Valley Hydrologic Area

Constituent	Limit Type	Value
Specific Conductance (mmhos) at 77 degrees F	90% Upper Limit	800
Specific Conductance (mmhos) at 77 degrees F	50% Upper Limit	400
pH	Maximum	8.5
pH	Minimum	6.5
Boron (mg/L)	90% Upper Limit	0.2
Boron (mg/L)	50% Upper Limit	0.1
Hardness (mg/L)	50% Upper Limit	120

[a] 90% upper and lower limits represent the 90 percentile values for a calendar year. 90% or more of the values must be less than or equal to an upper limit and greater than or equal to a lower limit

[b] 50% upper and lower limits represent the 50 percentile values of the monthly means for a calendar year. 50% or more of the monthly means must be less than or equal to an upper limit and greater than or equal to a lower limit

Table 2: Comparison concentrations and data sources for constituents used in the water quality assessment

Full Name	MCL	Units	Source
1,1 Dichloroethane (1,1 DCA)	5	ug/L	Title 22 Table 64444-A
1,1 Dichloroethylene (1,1 DCE)	6	ug/L	Title 22 Table 64444-A
1,1,1 Trichloroethane	200	ug/L	Title 22 Table 64444-A
1,1,2 Trichloro-1,2,2-Trifluoroethane (Freon 113)	1.2	mg/L	Title 22 Table 64444-A
1,1,2 Trichloroethane	5	ug/L	Title 22 Table 64444-A
1,1,2,2 Tetrachloroethane (PCA)	1	ug/L	Title 22 Table 64444-A
1,2 Dibromo-3-chloropropane (DBCP)	0.2	ug/L	Title 22 Table 64444-A
1,2 Dibromoethane (EDB)	0.05	ug/L	Title 22 Table 64444-A
1,2 Dichlorobenzene (1,2-DCB)	600	ug/L	Title 22 Table 64444-A
1,2 Dichloroethane (1,2 DCA)	0.5	ug/L	Title 22 Table 64444-A
1,2 Dichloropropane (1,2 DCP)	5	ug/L	Title 22 Table 64444-A
1,2,3 Trichloropropane (1,2,3 TCP)	0.005	ug/L	Title 22 Table 64444-A
1,2,4 Trichlorobenzene (1,2,4 TCB)	5	ug/L	Title 22 Table 64444-A
1,2,4 Trimethylbenzene	330	ug/L	NL
1,3 Dichlorobenzene	600	ug/L	US-HAL
1,3 Dichloropropene	0.5	ug/L	Title 22 Table 64444-A
1,3,5 Trimethylbenzene	330	ug/L	NL
1,4 Dichlorobenzene (p-DCB)	5	ug/L	Title 22 Table 64444-A
1,4 Dioxane	1	ug/L	HBSL
2 Chlorotoluene	140	ug/L	US-HAL
2,3,7,8 TCDD	0.00003	ug/L	MCL-US
2,4 Dichlorophenoxyacetic acid (2,4 D)	70	ug/L	Title 22 Table 64444-A
2,4,5 TP (Silvex)	50	ug/L	Title 22 Table 64444-A
2,4,6 Trinitrotoluene (TNT)	1	ug/L	US-HAL
4 Chlorotoluene	140	ug/L	HBSL
4,4’ DDD	0.1	ug/L	CA-CPF
4,4’ DDE	0.1	ug/L	CA-CPF
4,4’ DDT	0.1	ug/L	CA-CPF
Acetone	6300	ug/L	RfD
Alachlor	2	ug/L	Title 22 Table 64444-A
Aldicarb	7	ug/L	HBSL
Aldicarb Sulfone	7	ug/L	HBSL
Aldicarb sulfoxide	7	ug/L	HBSL
Alpha-Benzene Hexachloride (Alpha-BHC)	0.15	ug/L	CA-Prop65
Aluminum	200	ug/L	Title 22 Table 64449-A
Ammonia	30	mg/L	US-HAL
Antimony	6	ug/L	Title 22 Table 64431-A
Arsenic	10	ug/L	Title 22 Table 64431-A
Asbestos	7	MFL	Title 22 Table 64431-A
Atrazine	1	ug/L	Title 22 Table 64444-A
Azinphos Ethyl	10	ug/L	HBSL
Barium	1	mg/L	Title 22 Table 64431-A

Continued on next page

Table 2: Comparison concentrations and data sources for constituents used in the water quality assessment

Full Name	MCL	Units	Source
Bensulfuron Methyl	1000	ug/L	HBSL
Bentazon	18	ug/L	Title 22 Table 64444-A
Benzene	1	ug/L	Title 22 Table 64444-A
Benzo(a)pyrene	0.2	ug/L	Title 22 Table 64444-A
Beryllium	4	ug/L	Title 22 Table 64431-A
Beta-Benzene Hexachloride (Beta-BHC)	0.25	ug/L	CA-Prop65
Boron	0.1 (50% UL), 0.2 (90% UL)	mg/L	Basin Plan Table 3-1
Bromacil	70	ug/L	US-HAL
Bromate	10	ug/L	MCL-US
Bromodichloromethane (THM)	80	ug/L	MCL
Bromoform (THM)	80	ug/L	MCL
Cadmium	5	ug/L	Title 22 Table 64431-A
Carbaryl (1-naphthyl methylcarbamate)	40	ug/L	HBSL
Carbofuran	18	ug/L	Title 22 Table 64444-A
Carbon Disulfide	160	ug/L	HBSL
Carbon Tetrachloride	0.5	ug/L	Title 22 Table 64444-A
Chlorate	800	ug/L	NAS-HAL
Chlordane	0.1	ug/L	Title 22 Table 64444-A
Chloride	500	mg/L	Title 22 Table 64449-B
Chlorite	1	mg/L	MCL-US
Chlorobenzene	70	ug/L	Title 22 Table 64444-A
Chloroform (THM)	80	ug/L	MCL
Chloropicrin	12	ug/L	NAS-HAL
Chromium	50	ug/L	Title 22 Table 64431-A
Chromium, Hexavalent (Cr6)	20	ug/L	HBSL
cis-1,2 Dichloroethylene	6	ug/L	Title 22 Table 64444-A
Copper	1	mg/L	Title 22 Table 64449-A
Cyanazine	0.3	ug/L	HBSL
Cyanide (CN)	150	ug/L	Title 22 Table 64431-A
Cypermethrin	40	ug/L	HBSL
Dacthal	70	ug/L	HBSL
Dalapon	200	ug/L	Title 22 Table 64444-A
Deethylatrazine	50	ug/L	CA-Prop65
Di(2-ethylhexyl)adipate	0.4	mg/L	Title 22 Table 64444-A
Di(2-ethylhexyl)phthalate (DEHP)	4	ug/L	Title 22 Table 64444-A
Diazinon	1.2	ug/L	HBSL
Dibromochloromethane (THM)	80	ug/L	MCL
Dicamba	210	ug/L	RfD
Dichlorodifluoromethane	1	mg/L	HBSL
Dichloromethane (Methylene Chloride)	5	ug/L	Title 22 Table 64444-A
Dichlorprop	300	ug/L	HBSL
Dichlorvos (DDVP)	0.4	ug/L	HBSL

Continued on next page

Table 2: Comparison concentrations and data sources for constituents used in the water quality assessment

Full Name	MCL	Units	Source
Dieldrin	0.002	ug/L	HBSL
Diesel	100	ug/L	US-HAL
Dimethoate	2	ug/L	HBSL
Dinoseb	7	ug/L	Title 22 Table 64444-A
Diquat	20	ug/L	Title 22 Table 64444-A
Diuron	2	ug/L	HBSL
Endosulfan I	42	ug/L	RfD
Endosulfan II	42	ug/L	RfD
Endosulfan Sulfate	42	ug/L	RfD
Endothall	100	ug/L	Title 22 Table 64444-A
Endrin	2	ug/L	Title 22 Table 64444-A
EPTC	200	ug/L	HBSL
Ethylbenzene	300	ug/L	Title 22 Table 64444-A
Ethylene glycol	14	mg/L	US-HAL
Fecal Coliform (bacteria)	0.99	Count	MCL
Fenamiphos	0.7	ug/L	HBSL
Fluoride	2	mg/L	Title 22 Table 64431-A
Foaming Agents (MBAS)	0.5	mg/L	Title 22 Table 64449-A
Fonofos	10	ug/L	HBSL
Formaldehyde	100	ug/L	US-HAL
Gasoline	5	ug/L	US-HAL
Glyphosate (Round-up)	700	ug/L	MCL-US
Gross Alpha radioactivity	15	pCi/L	Title 22 Table 64442
Gross beta	50	pCi/L	MCL-US
Guthion (Azinphos Methyl)	10	ug/L	HBSL
Heptachlor	0.01	ug/L	Title 22 Table 64444-A
Heptachlor Epoxide	0.01	ug/L	Title 22 Table 64444-A
Hexachlorobenzene (HCB)	1	ug/L	MCL-US
Hexachlorobutadiene	0.9	ug/L	HBSL
Hexachlorocyclopentadiene	50	ug/L	Title 22 Table 64444-A
Hexazinone	400	ug/L	HBSL
Iodide	1190	ug/L	NAS-HAL
Iprodione	0.8	ug/L	HBSL
Iron	300	ug/L	Title 22 Table 64449-A
Isopropylbenzene (Cumene)	770	ug/L	HBSL
Kerosene	100	ug/L	US-HAL
Lead	15	ug/L	AL
Lindane (Gamma-BHC)	0.2	ug/L	Title 22 Table 64444-A
Linuron	5	ug/L	HBSL
Malathion	500	ug/L	HBSL
Manganese	50	ug/L	Title 22 Table 64449-A
Mercury	2	ug/L	Title 22 Table 64431-A
Metalaxyl	500	ug/L	HBSL

Continued on next page

Table 2: Comparison concentrations and data sources for constituents used in the water quality assessment

Full Name	MCL	Units	Source
Methomyl	200	ug/L	HBSL
Methoxychlor	30	ug/L	Title 22 Table 64444-A
Methyl Bromide (Bromomethane)	10	ug/L	US-HAL
Methyl Isobutyl Ketone (MIBK)	120	ug/L	NL
Metolachlor	700	ug/L	HBSL
Metribuzin	90	ug/L	HBSL
Molinate	20	ug/L	Title 22 Table 64444-A
Molybdenum	40	ug/L	US-HAL
MTBE (Methyl-tert-butyl ether)	5	ug/L	Title 22 Table 64449-A
Naled	10	ug/L	HBSL
Naphthalene	17	ug/L	HBSL
Napropamide	800	ug/L	HBSL
n-Butylbenzene	260	ug/L	NL
Nickel	100	ug/L	Title 22 Table 64431-A
Nitrate as N	10	mg/L	Title 22 Table 64431-A
Nitrate+Nitrite	10	mg/L	Title 22 Table 64431-A
Nitrite as N	1	mg/L	Title 22 Table 64431-A
N-Nitrosodiethylamine (NDEA)	0.01	ug/L	CA-CPF
N-Nitrosodimethylamine (NDMA)	0.01	ug/L	CA-CPF
N-Nitrosodi-N-Propylamine (NDPA)	0.01	ug/L	CA-CPF
Norflurazon	10	ug/L	HBSL
n-Propylbenzene (Isocumene)	260	ug/L	NL
Octogen (HMX)	0.35	mg/L	US-HAL
Oxamyl	50	ug/L	Title 22 Table 64444-A
Oxyfluorfen	20	ug/L	HBSL
Parathion	0.02	ug/L	HBSL
PCNB	21	ug/L	RfD
Pentachlorophenol (PCP)	1	ug/L	MCL-US
Perchlorate	6	ug/L	Title 22 Table 64431-A
Perfluorooctanoic acid	5.1	ng/L	US-HAL
Perfluorooctanoic sulfonate	6.5	ng/L	NL
Permethrin	4	ug/L	HBSL
pH	6.5-8.5	-log[H+]	Basin Plan Table 3-1
Phorate	4	ug/L	HBSL
Picloram	0.5	mg/L	Title 22 Table 64444-A
Polychlorinated Biphenyls (PCBs)	0.5	ug/L	MCL-US
Prometon	400	ug/L	HBSL
Prometryn	300	ug/L	HBSL
Propachlor (2-Chloro-N-isopropylacetanilide)	90	ug/L	HBSL
Propanil	6	ug/L	HBSL
Propargite	1	ug/L	HBSL
Radium 226	5	pCi/L	Title 22 Table 64442
Radium 228	5	pCi/L	Title 22 Table 64442

Continued on next page

Table 2: Comparison concentrations and data sources for constituents used in the water quality assessment

Full Name	MCL	Units	Source
Radon 222	4000	pCi/L	MCL-US
RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine)	0.3	mg/L	US-HAL
sec-Butylbenzene	260	ug/L	NL
Selenium	50	ug/L	Title 22 Table 64431-A
Silver	100	ug/L	Title 22 Table 64449-A
Simazine	4	ug/L	Title 22 Table 64444-A
Sodium	50	mg/L	AL
Specific Conductivity	400 (50% UL) - 800 (90% UL)	umhos	Basin Plan Table 3-1
Strontium	4000	ug/L	US-HAL
Strontium 90	8	pCi/L	Title 22 Table 64443
Styrene	100	ug/L	Title 22 Table 64444-A
Sulfate	500	mg/L	Title 22 Table 64449-B
tebuthiuron	1000	ug/L	HBSL
tert-Butyl alcohol (TBA)	12	ug/L	NL
tert-Butylbenzene	260	ug/L	NL
Tetrachloroethene (PCE)	5	ug/L	Title 22 Table 64444-A
Thallium	2	ug/L	Title 22 Table 64431-A
Thiabendazole	231	ug/L	HHBP
Thiobencarb	1	ug/L	Title 22 Table 64449-A
Toluene	150	ug/L	Title 22 Table 64444-A
Total Coliform Bacteria	0.99	Count	MCL
Total Dissolved Solids	1000	mg/L	Title 22 Table 64449-B
Total Trihalomethanes	80	ug/L	MCL-US
Toxaphene	3	ug/L	Title 22 Table 64444-A
trans-1,2, Dichloroethylene	10	ug/L	Title 22 Table 64444-A
Trichlopyr	400	ug/L	HBSL
Trichloroethene (TCE)	5	ug/L	Title 22 Table 64444-A
Trichlorofluoromethane (Freon 11)	150	ug/L	Title 22 Table 64444-A
Trifluralin	20	ug/L	HBSL
Tritium	20000	pCi/L	Title 22 Table 64443
Uranium	20	pCi/L	Title 22 Table 64442
Vanadium	50	ug/L	RfD
Vinyl Chloride	0.5	ug/L	Title 22 Table 64444-A
Warfarin	2	ug/L	HBSL
Xylene, Isomers m & p	1750	ug/L	Title 22 Table 64444-A
Xylenes (total)	1750	ug/L	Title 22 Table 64444-A
Zinc	5	mg/L	Title 22 Table 64449-A

Rank	Comparison Concentration	Description
1	Basin Plan / Title 22	Basin Plan Groundwater Requirements in Table 3-1 and specific Title 22 tables
2	MCL-CA	California drinking water maximum contaminant level
3	MCL-US	Federal drinking water maximum contaminant level
4	AL-US	Federal Action Level
5	HBSL	Cancer or non-cancer Health Based Screening Level
6	HHBP	Chronic non-cancer Human Health Benchmark for Pesticides
7	US-HAL	Federal Health Advisory Level
8	RfD	Reference Dose as a drinking water level
9	NAS-HAL	National Academy of Science Health Advisory Level
10	CA-CPF	California Cancer Potency Factor
11	CA-Prop. 65	California Proposition 65 Safe Harbor Levels as a drinking water level
12	SMCL	Secondary MCL
13	NL	Notification Level

Calculations

Specific water quality objectives for the Butte Valley hydrologic area groundwaters, as defined in the Basin Plan, have specific limits and calculation requirements associated with specific conductance, hardness and boron. Per the Basin Plan, the 50% upper limit and 90% upper limit are defined as follows:

- 50% upper limits represent “the 50 percentile values of the monthly means for a calendar year. 50% or more of the monthly means must be less than or equal to an upper limit and greater”

- 90% upper limits represent “the 90 percentile values for a calendar year. 90% or more of the values must be equal to an upper limit and greater than or equal to a lower limit.”

The monthly means of specific conductance and boron measurements were compared to the 50% and 90% upper limits.

Filtering Process

To analyze groundwater quality, several filters were applied for relevance and quality. Though groundwater quality data for the Basin is available from 1952, data was limited to only include information collected in the past 30 years. Restricting the timespan from which data was collected increases confidence in data collection methods and quality of the data and focuses on information that is reflective of current groundwater quality conditions.

Groundwater quality for each constituent was analyzed by comparing the well data to the corresponding comparison concentration. Maps showing the location of wells where samples were collected were generated for each constituent. The maximum concentration sampled at each well is displayed on the map as one of the following groups:

a) Not detected
b) Detected but below half of the comparison concentration
c) Detected and above half of the comparison concentration
d) Above the comparison concentration

The number of samples in each category is displayed in the map's legend. Two iterations of map generation were conducted with the following scenarios:

1. Data is limited to those collected in the past 30 years only (1989-2019)
2. Data is limited to wells that have more than one data point in the past 30 years (1989-2019)

For the second scenario, where data is limited to wells that have more than one data point in the past 30 years, timeseries are generated for each constituent and well to identify changes over time in groundwater quality at a location.

The following sections contain the maps produced from these analyses.

Results

Constituents of Concern (COCs)

Constituents of Concern (COCs) were identified based on visual identification of potential groundwater quality issues using the maps generated in this assessment, identification of common constituents of concern, and through discussion with stakeholders. Resulting from this analysis and discussion with stakeholders, the full list of constituents of concern (COCs) were:

1. Arsenic
2. Boron
3. Benzene
4. 1,2 Dibromoethane (EDB)
5. Nitrate as N
6. Specific Conductivity

A series of maps for each COC, with water quality data from the past 30 years (1990-2020), show the location of tested wells and whether the maximum concentration ever recorded in that well has exceeded the MCL. In Butte Valley, the water quality source database categorized some wells as either municipal or monitoring. Municipal wells are a public supply well related to a city or town. Monitoring wells are used for monitoring groundwater, such as for site cleanup programs or Irrigated Lands Regulatory Program. Time series graphs included in this section plot the concentration of the COC versus time for applicable wells. For easy visual assessment, each graph only includes seven wells. Multiple graphs were created for each constituent and are arranged from the maximum sampled concentration in each well, to the lowest.

Figure 1 shows all wells that have been tested for Total Arsenic, even if only one monitoring event has occurred. Figure 2 filters the wells for those with two or more monitoring events. In the past 30 years, two wells in the northeast section of the valley have high concentrations. Timeseries of wells

in Figure 2 show that the affected municipal well has decreasing arsenic concentrations (Figure 3). Figure 4 shows a number of high Dissolved Boron wells, though many of these wells have only one monitoring event and a trend analysis cannot be completed. Figure 5 has two high boron wells available for trend analysis. The two wells have decreasing or steady boron concentrations (Figure 3). High benzene in Butte Valley is associated with cleanup sites near Dorris (Figure 7 and Figure 8). The timeseries graphs show that benzene concentrations have been decreasing over time (Figure 9, Figure 10, and Figure 11). High 1,2-Dibromoethane appears in the same well cluster with the high benzene (Figure 12 and Figure 13). 1,2-Dibromoethane concentrations are either decreasing or not detected (Figure 14, Figure 15, and Figure 16). Nitrate is elevated in the south part of the valley (Figure 17 and Figure 18). The timeseries show that nitrate concentrations have been generally decreasing through time (Figure 19 and Figure 20). Specific conductivity is low compared to the 90% Upper Limit defined by the Basin Plan (Figure 21 and Figure 22). The timeseries graphs show that specific conductivity is relatively stable but higher than the 50% Upper Limit defined by the Basin Plan (Figure 23 and Figure 24).

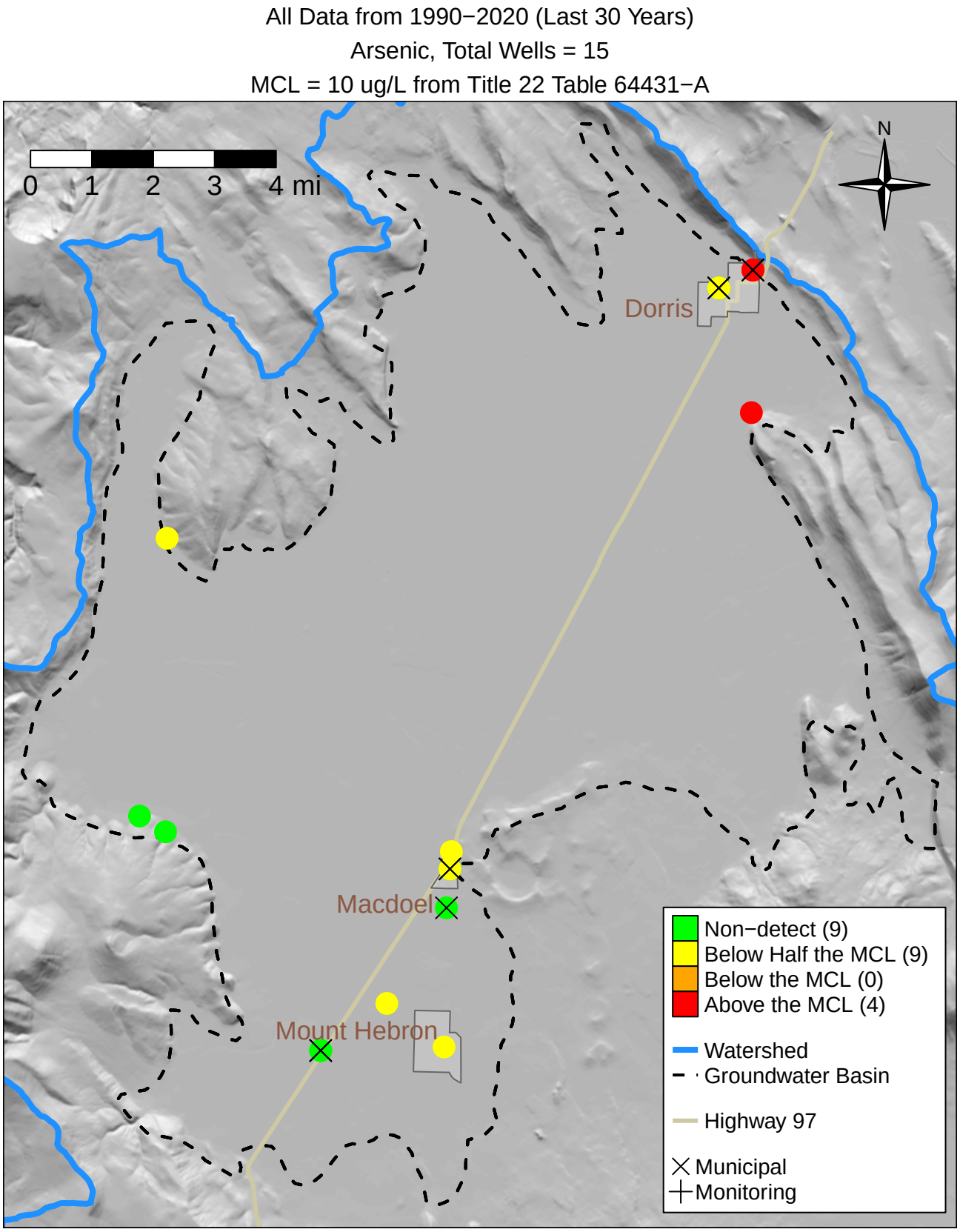


Figure 1: Groundwater Quality Observations of the Constituent Short List

Wells with two or more monitoring events, from 1990−2020 (Last 30 Years)
Arsenic, Total Wells = 4
MCL = 10 ug/L from Title 22 Table 64431−A

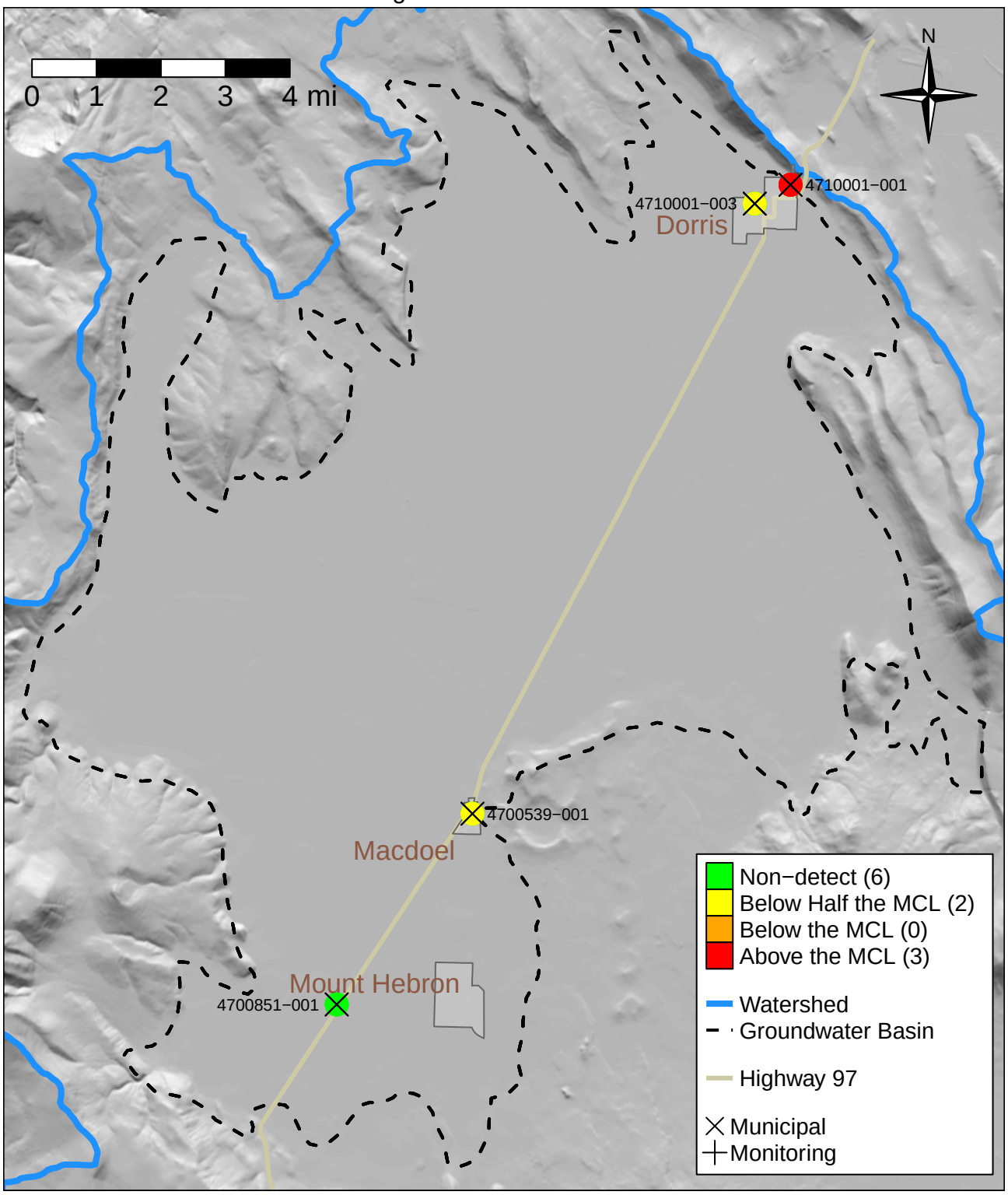


Figure 2: Filtered Groundwater Quality Observations of the Constituent Short List

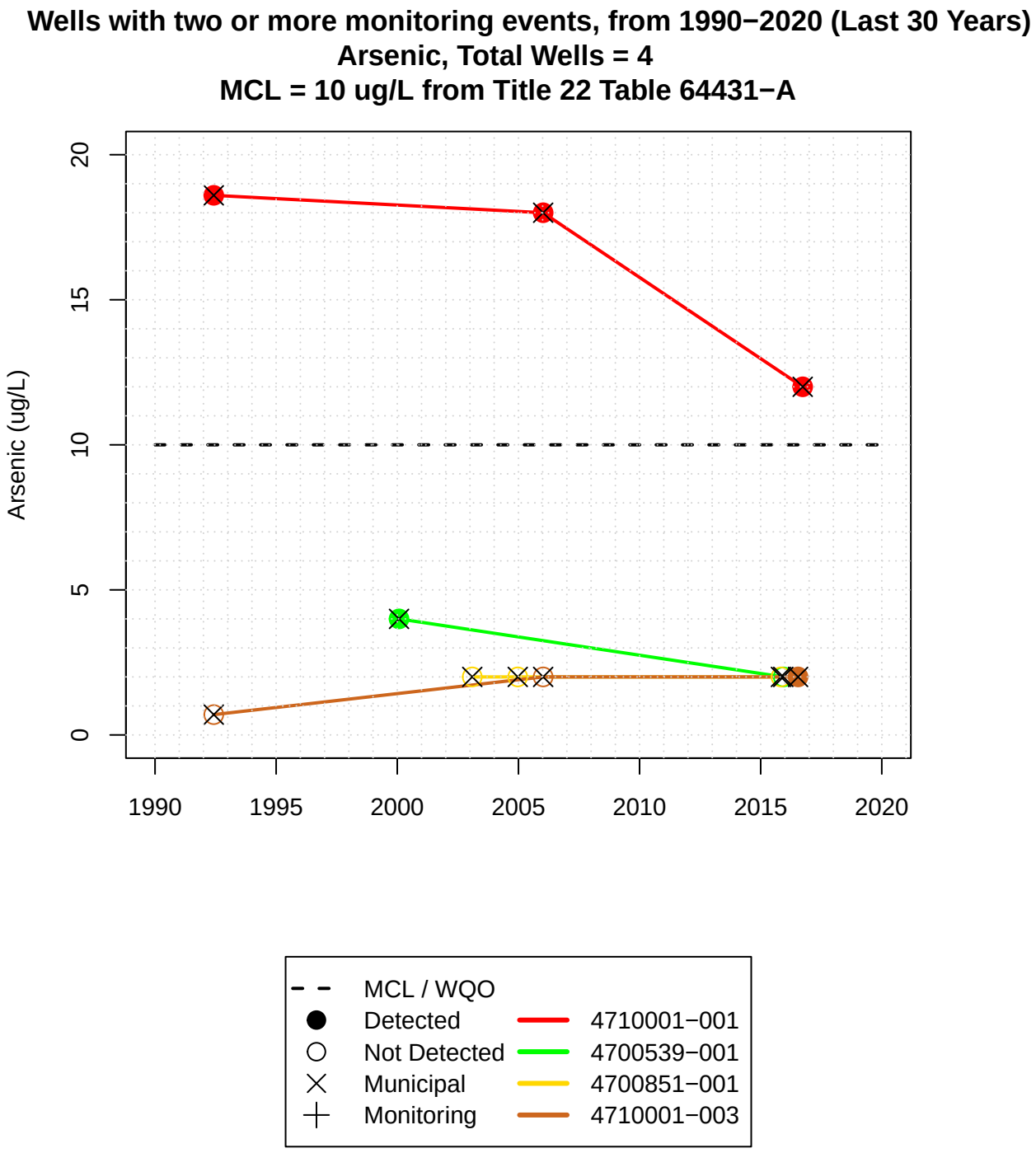


Figure 3: Filtered Groundwater Quality Observations of the Constituent Short List

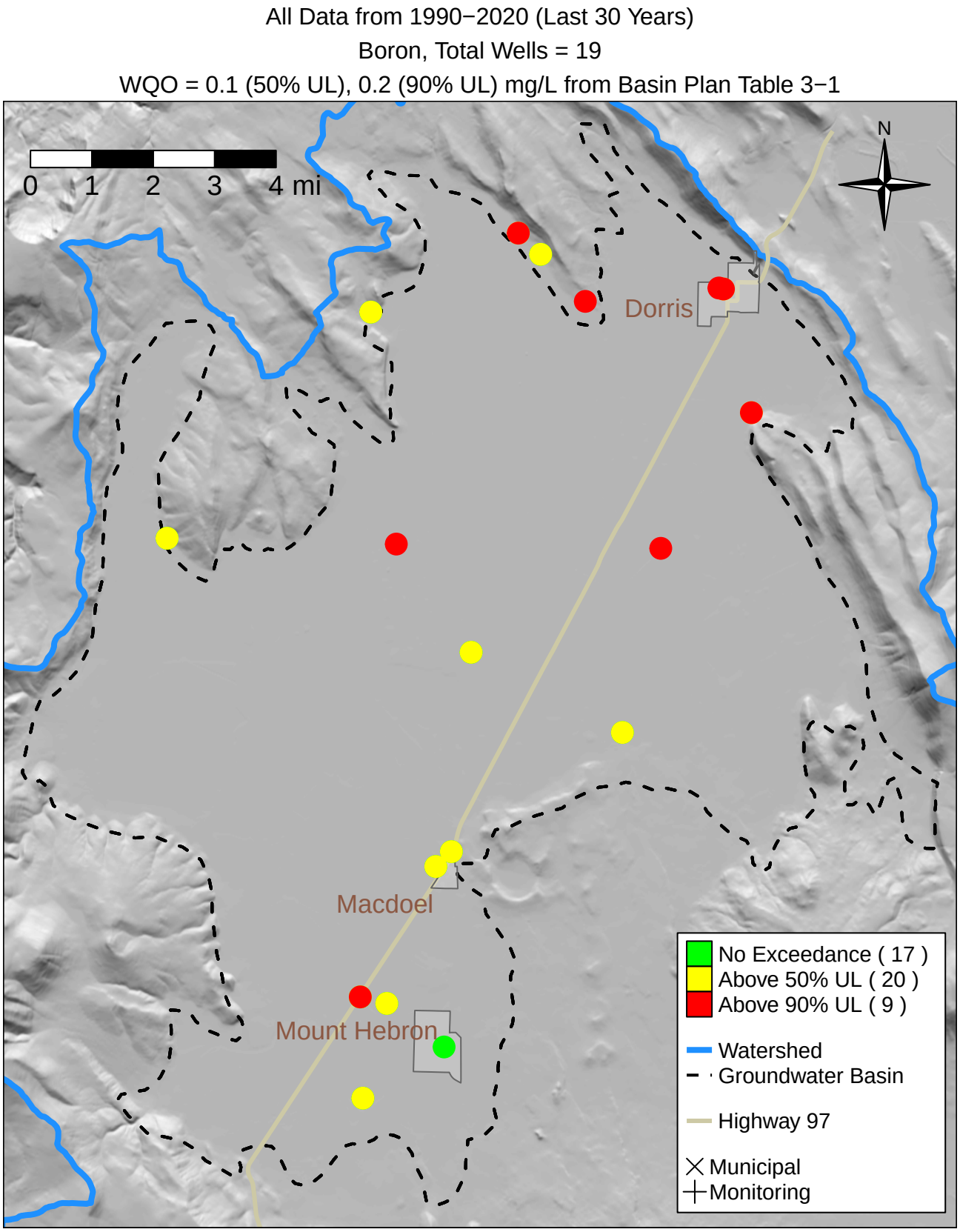


Figure 4: Groundwater Quality Observations of the Constituent Short List

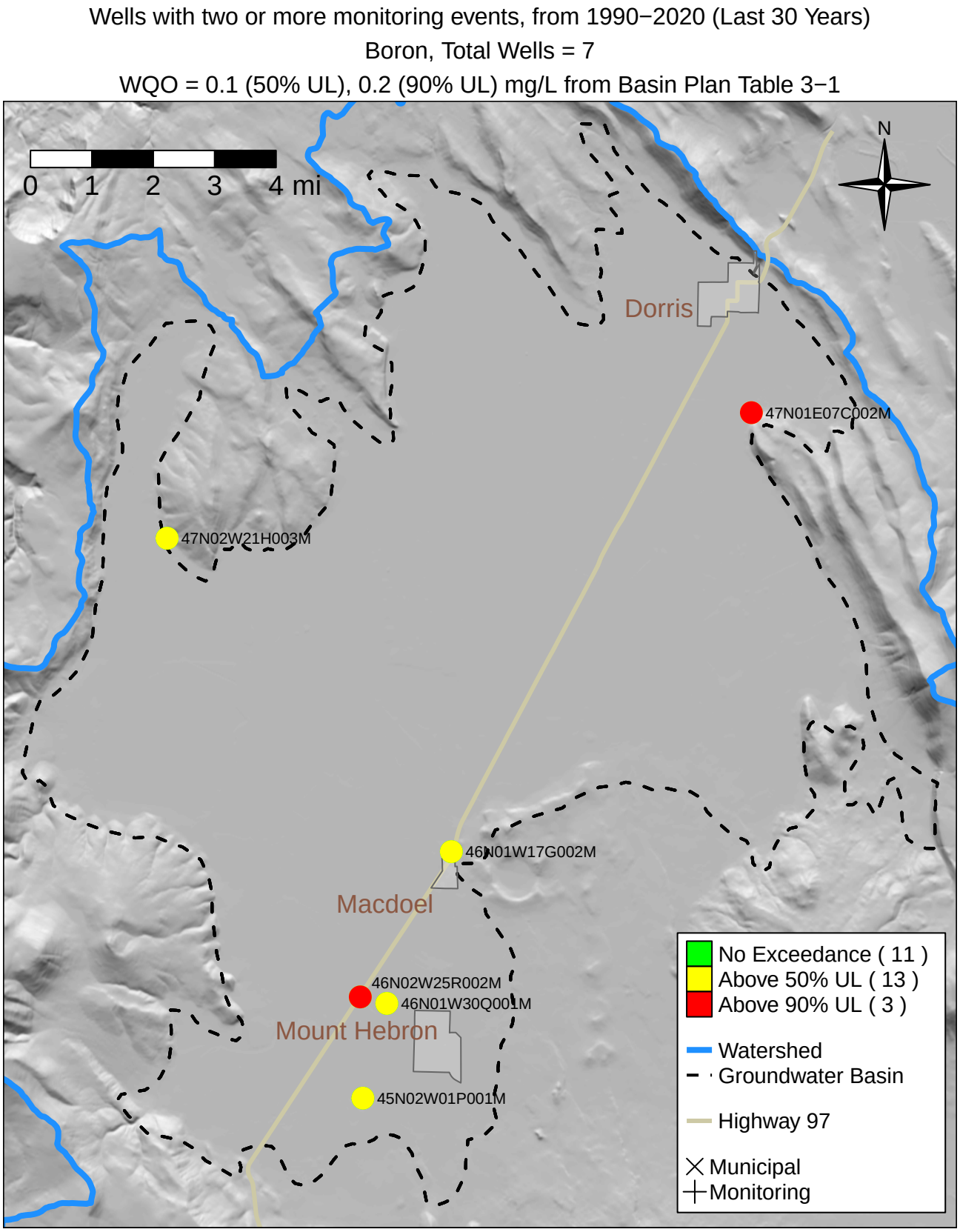


Figure 5: Filtered Groundwater Quality Observations of the Constituent Short List

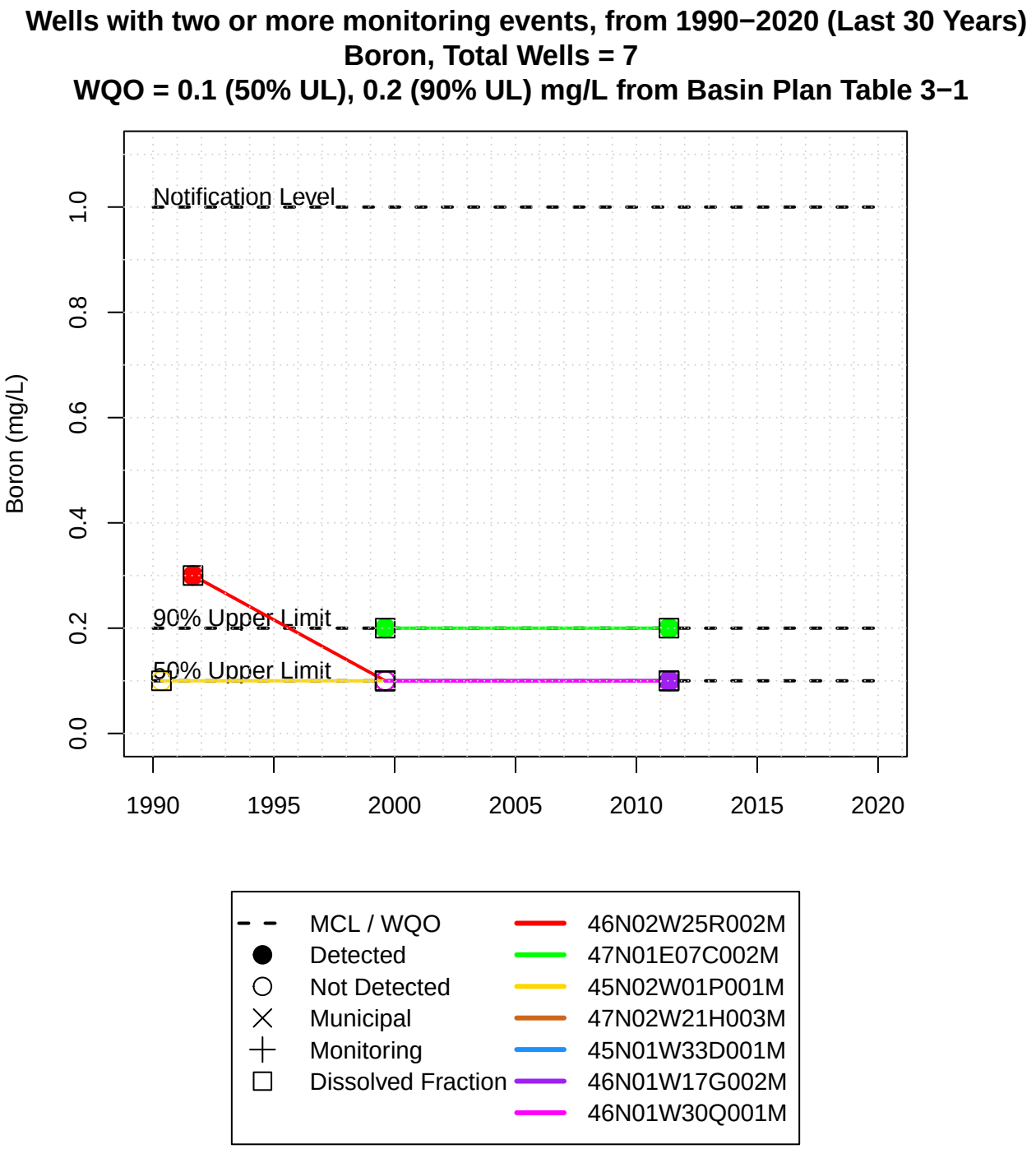


Figure 6: Filtered Groundwater Quality Observations of the Constituent Short List

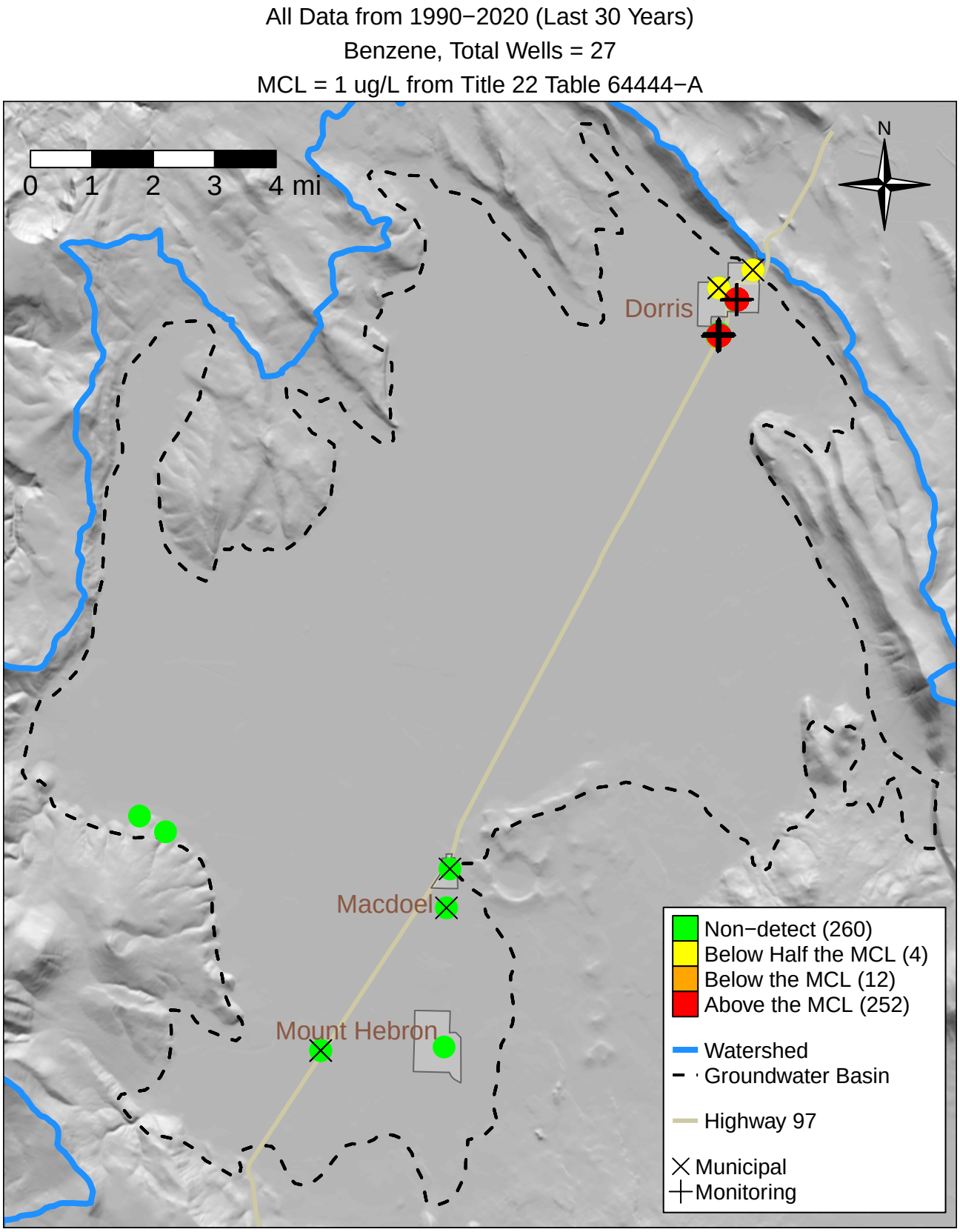


Figure 7: Groundwater Quality Observations of the Constituent Short List

Wells with two or more monitoring events, from 1990−2020 (Last 30 Years)
Benzene, Total Wells = 20
MCL = 1 ug/L from Title 22 Table 64444−A

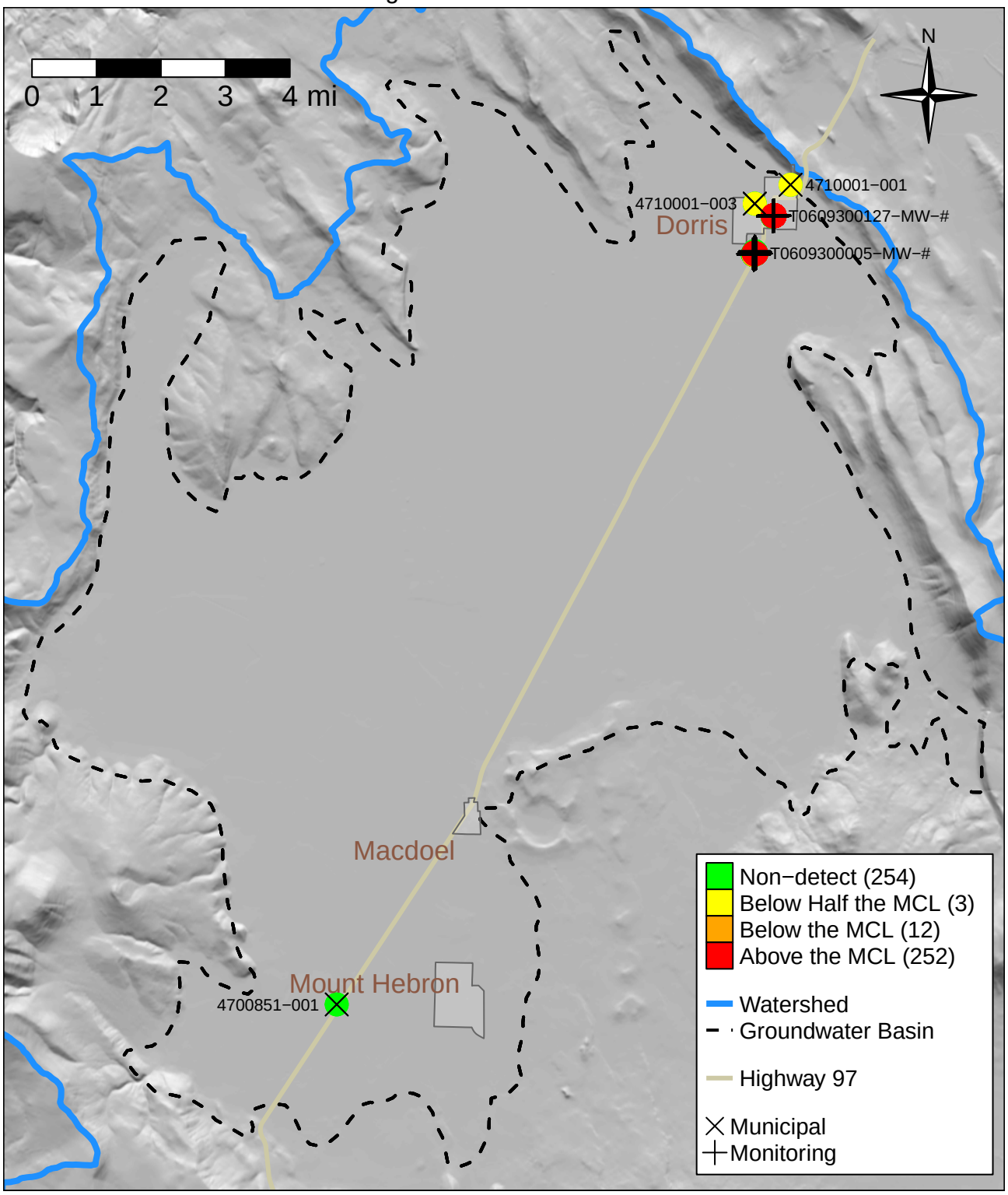


Figure 8: Filtered Groundwater Quality Observations of the Constituent Short List

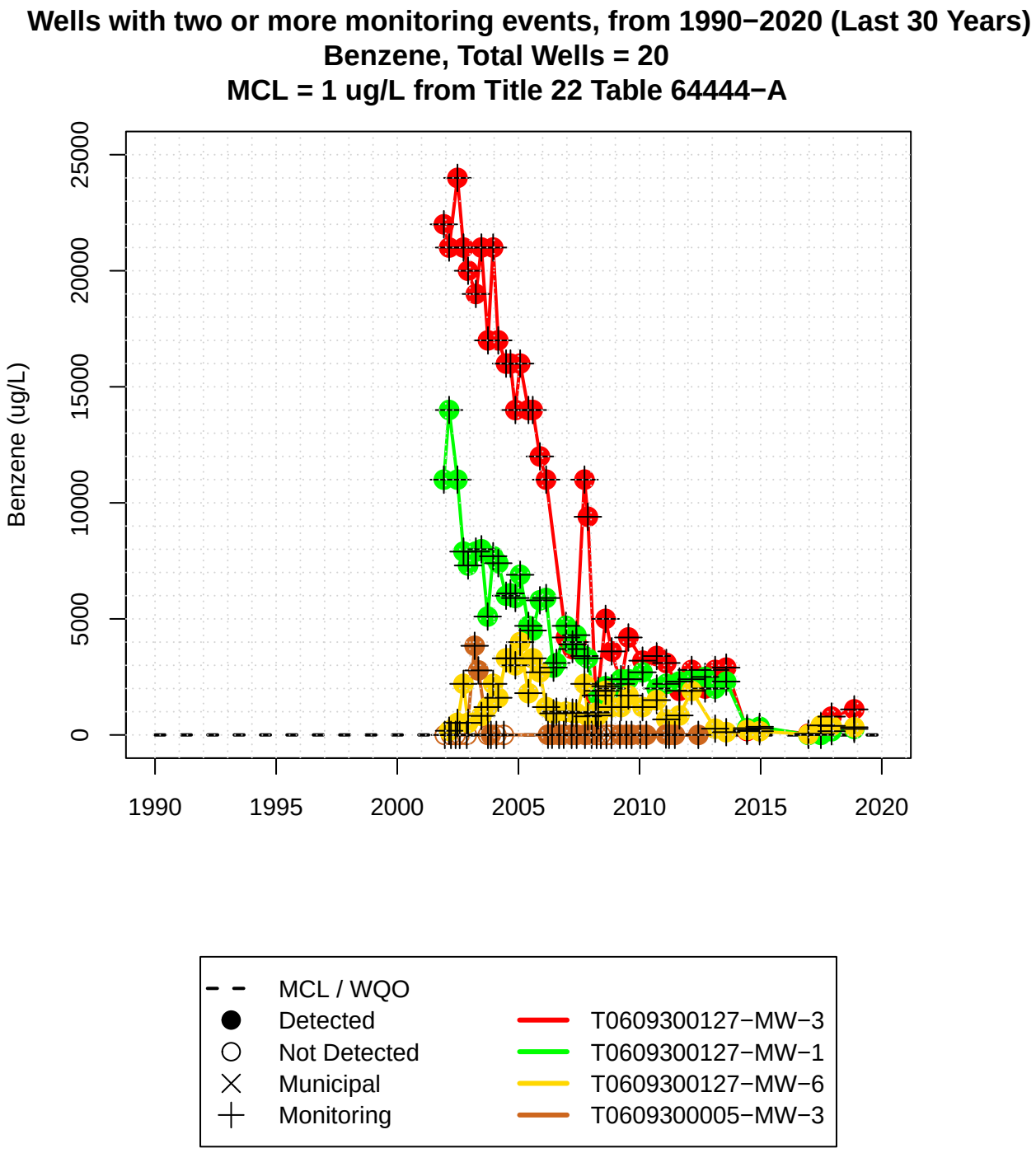


Figure 9: Filtered Groundwater Quality Observations of the Constituent Short List

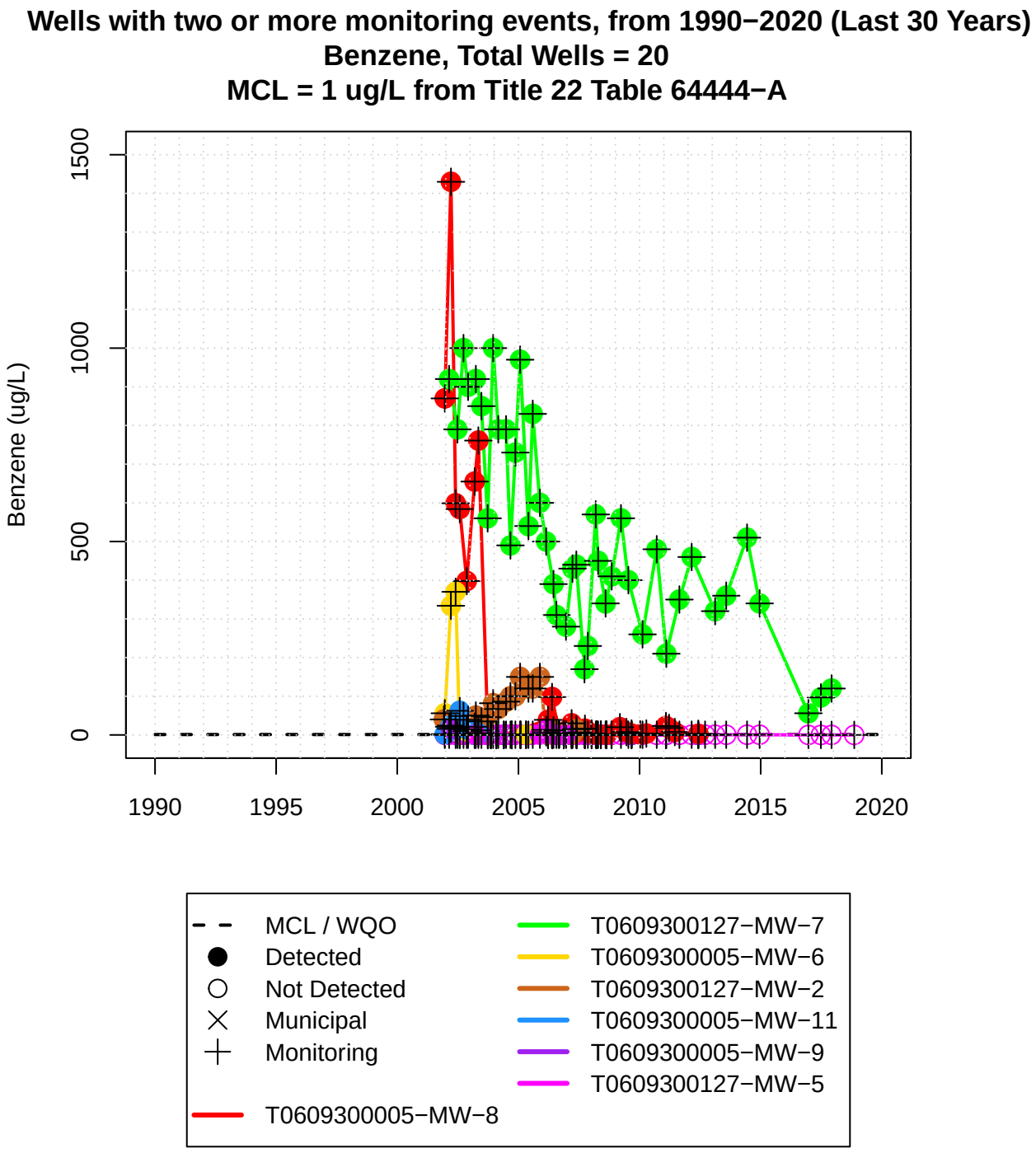


Figure 10: Filtered Groundwater Quality Observations of the Constituent Short List

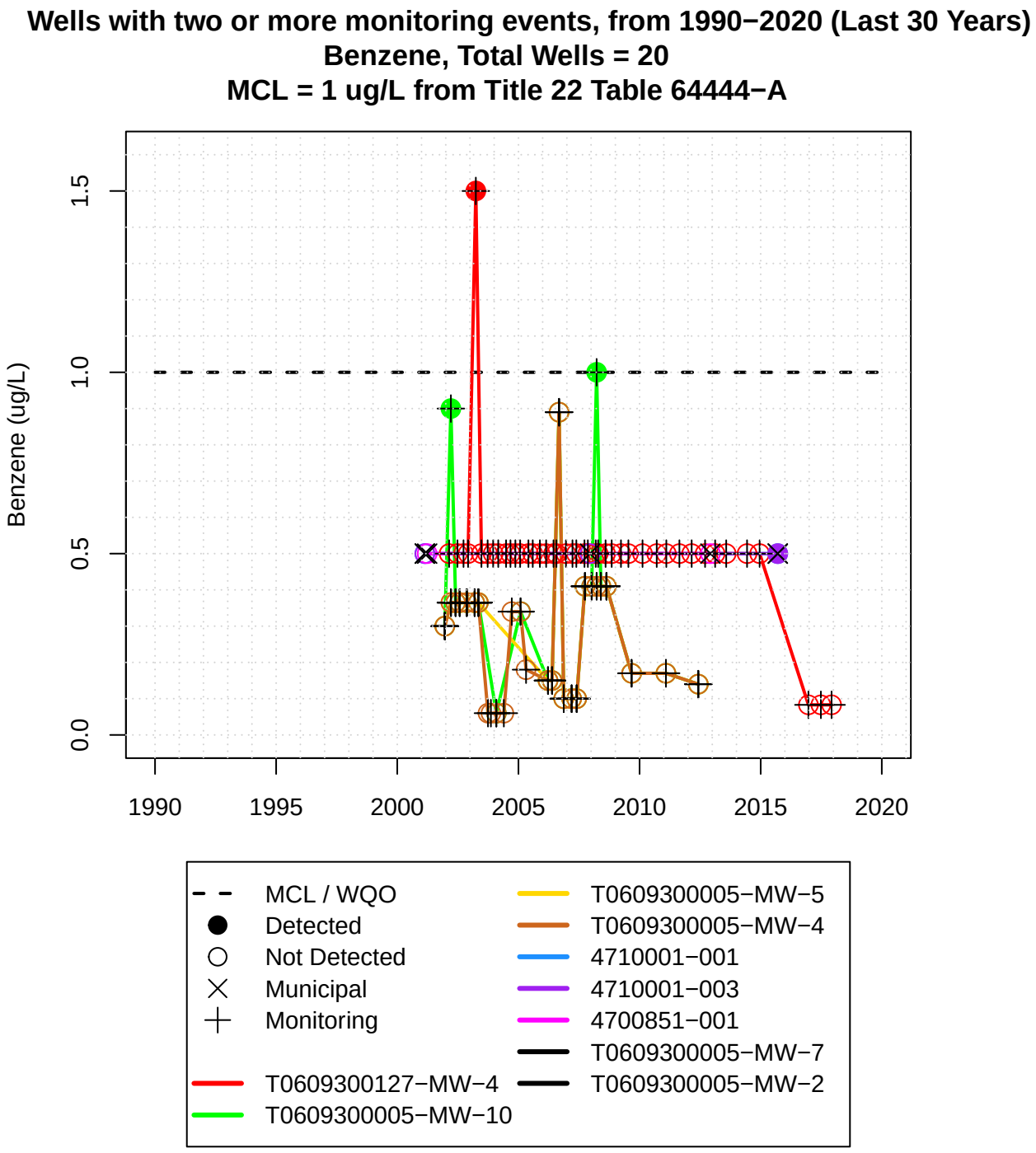


Figure 11: Filtered Groundwater Quality Observations of the Constituent Short List

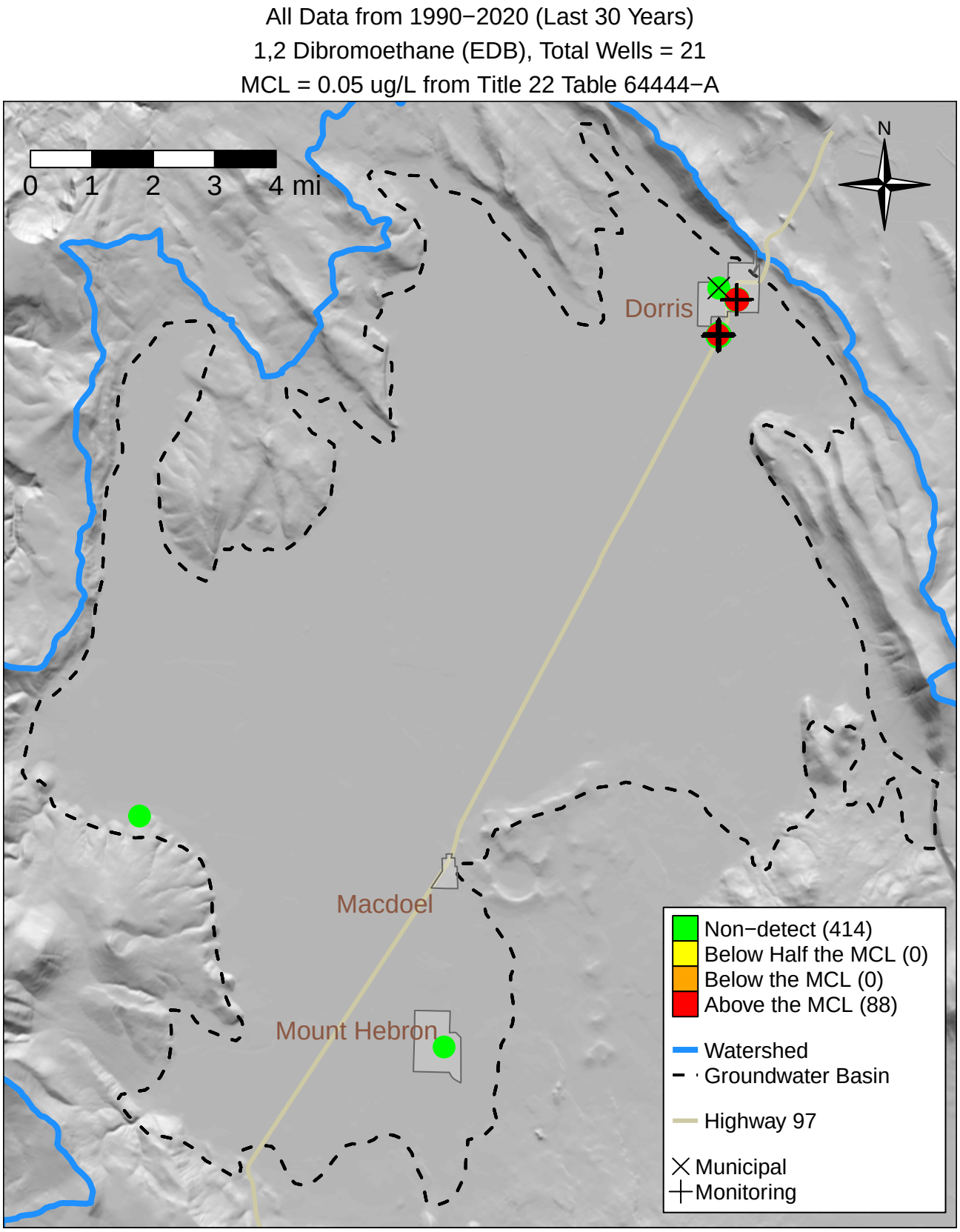


Figure 12: Groundwater Quality Observations of the Constituent Short List

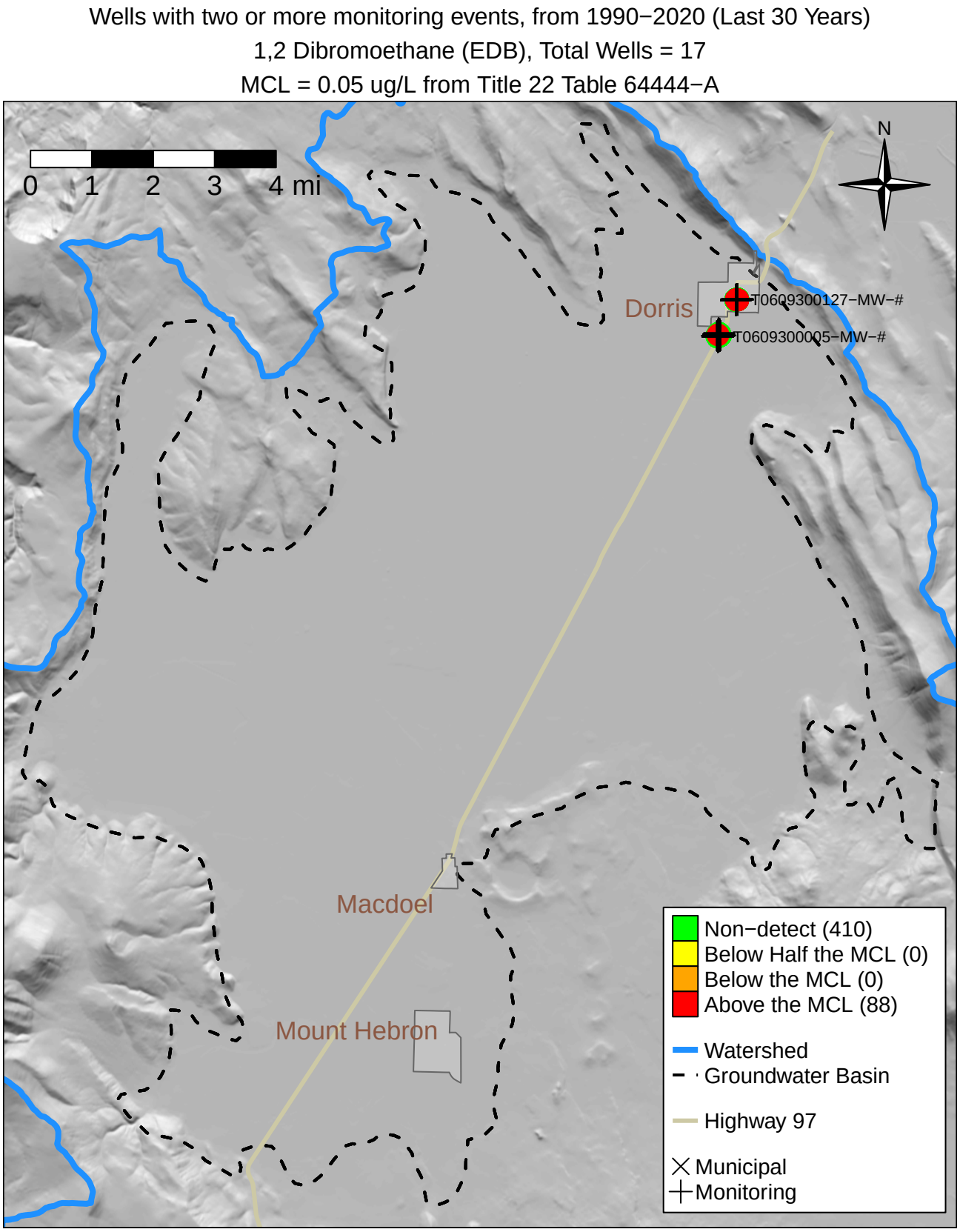


Figure 13: Filtered Groundwater Quality Observations of the Constituent Short List

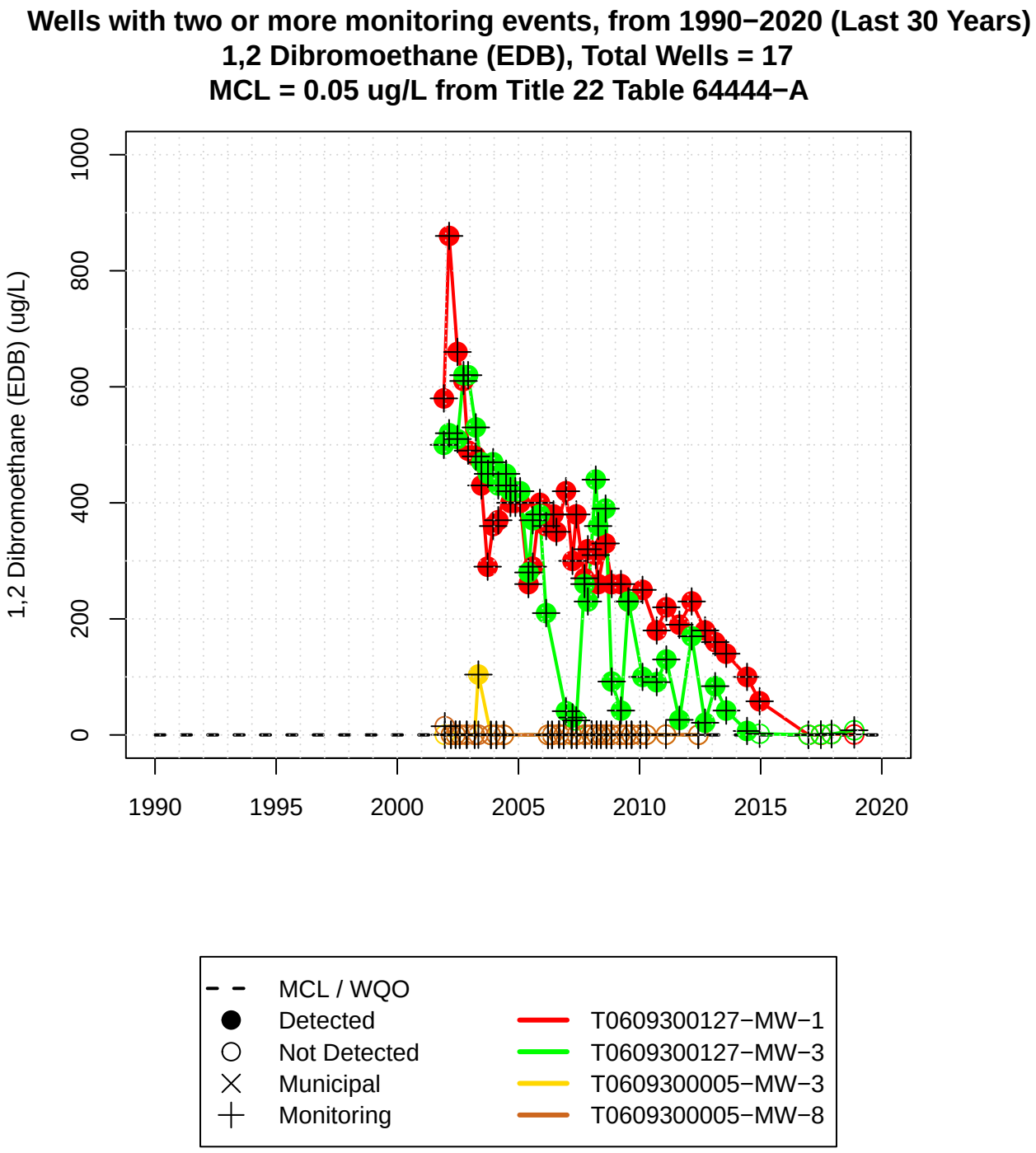


Figure 14: Filtered Groundwater Quality Observations of the Constituent Short List

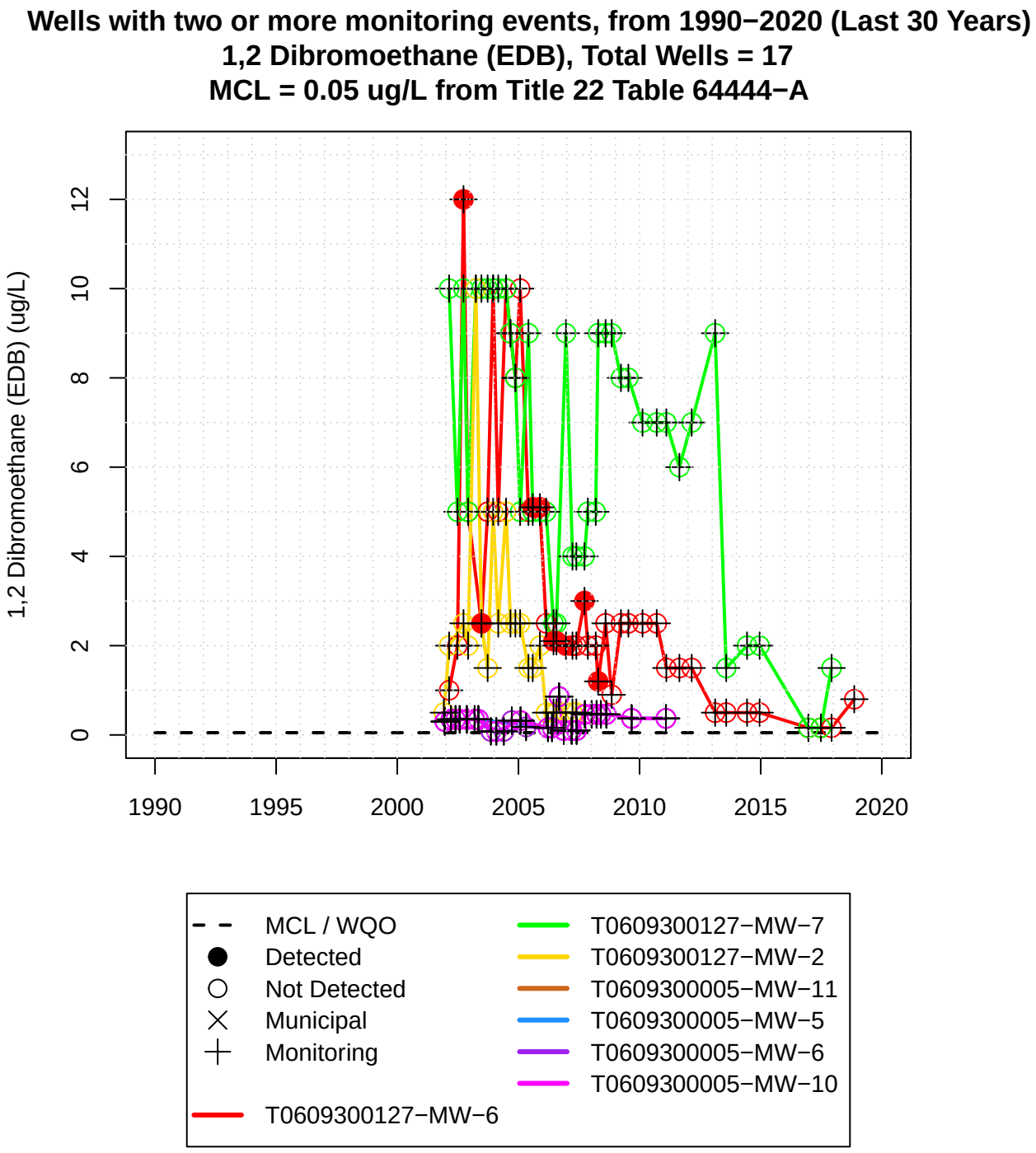


Figure 15: Filtered Groundwater Quality Observations of the Constituent Short List

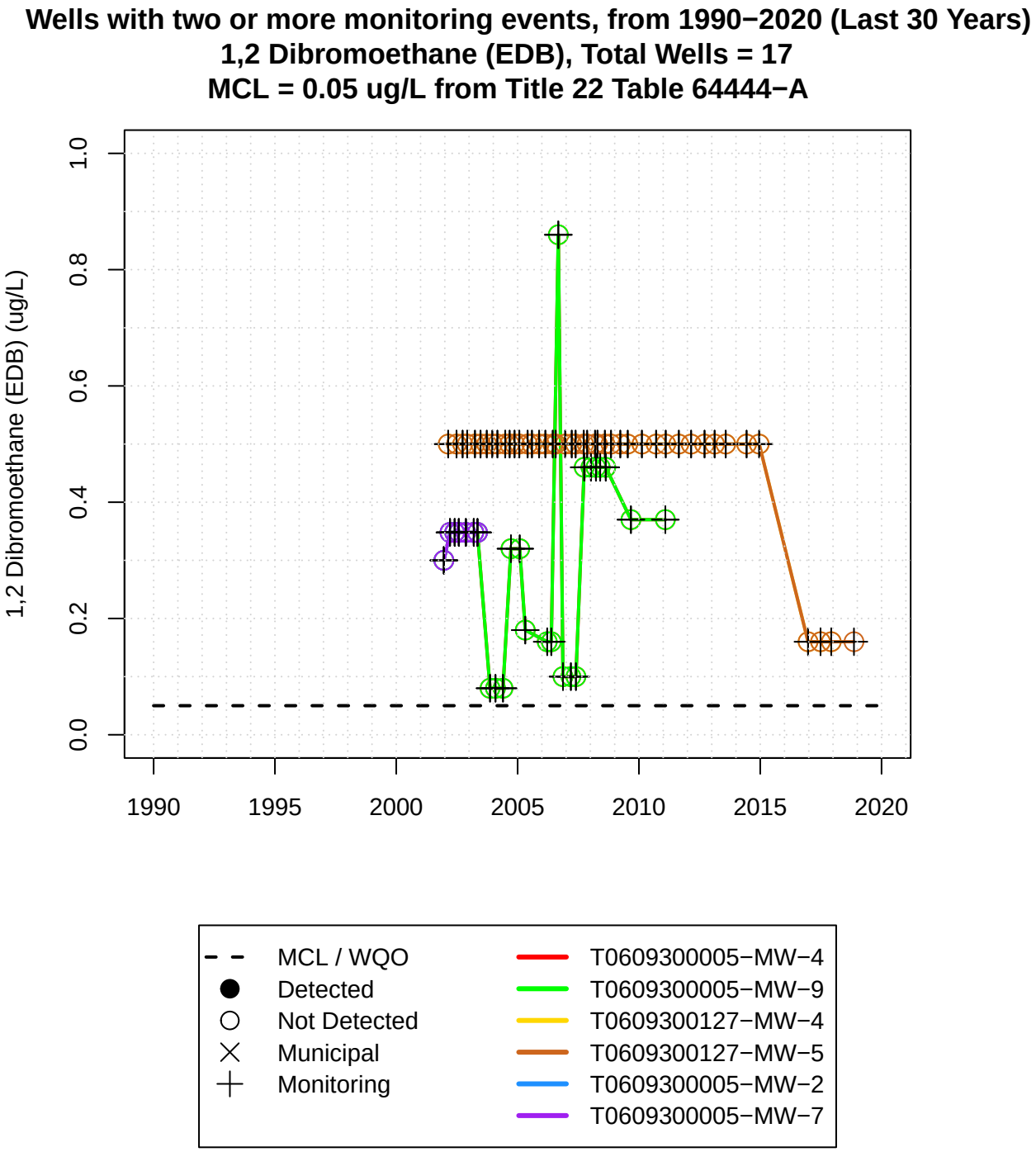


Figure 16: Filtered Groundwater Quality Observations of the Constituent Short List

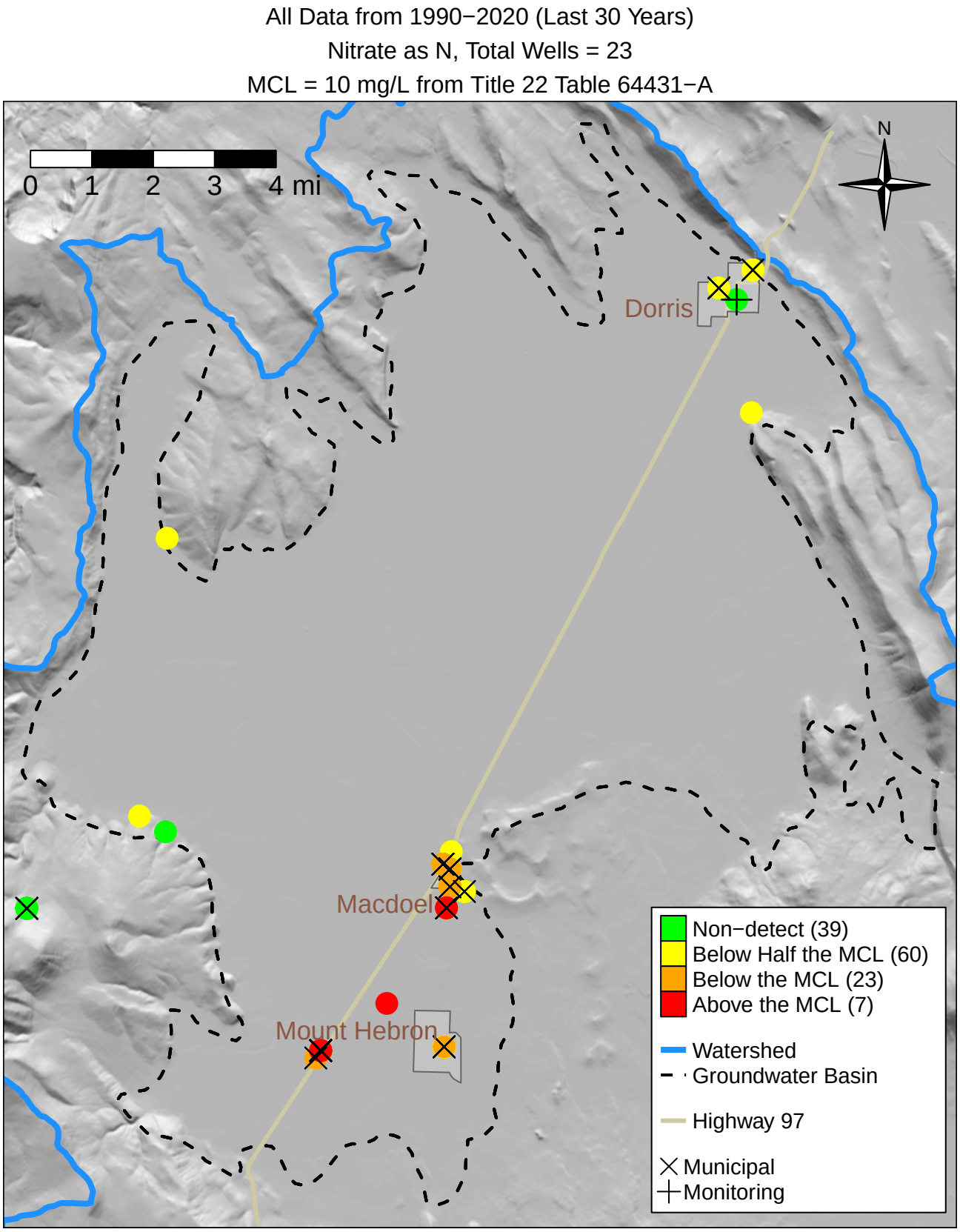


Figure 17: Groundwater Quality Observations of the Constituent Short List

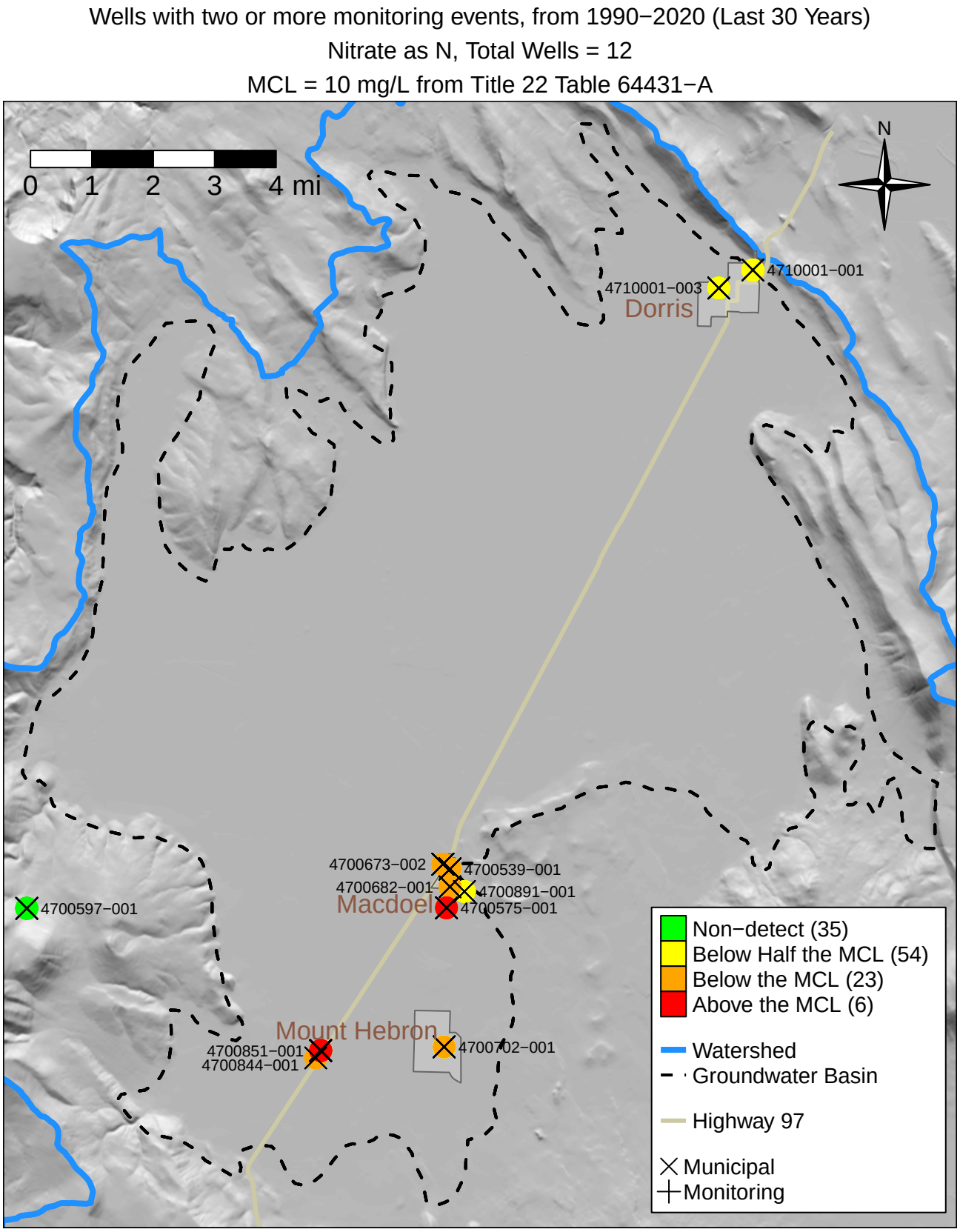


Figure 18: Filtered Groundwater Quality Observations of the Constituent Short List

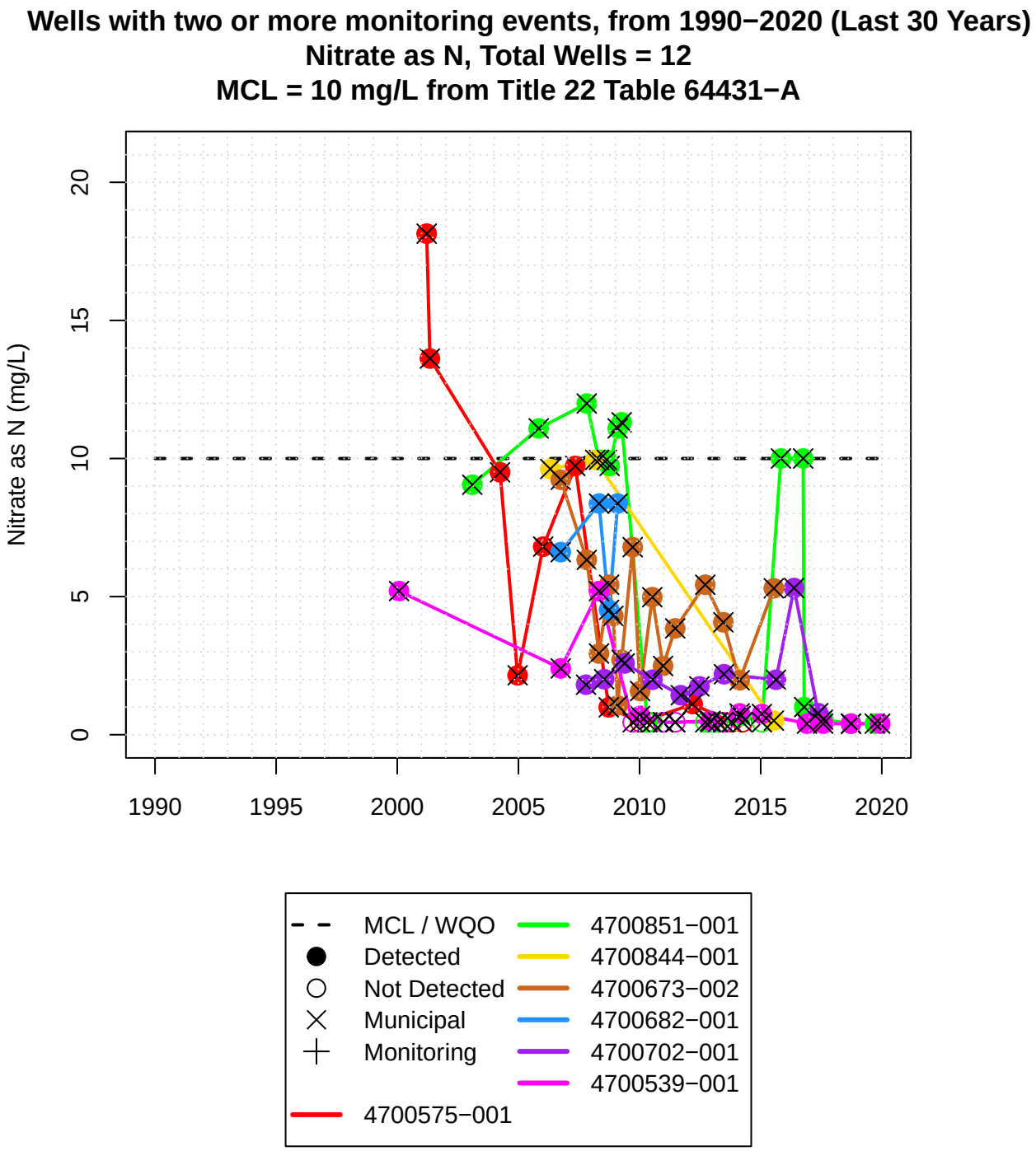


Figure 19: Filtered Groundwater Quality Observations of the Constituent Short List

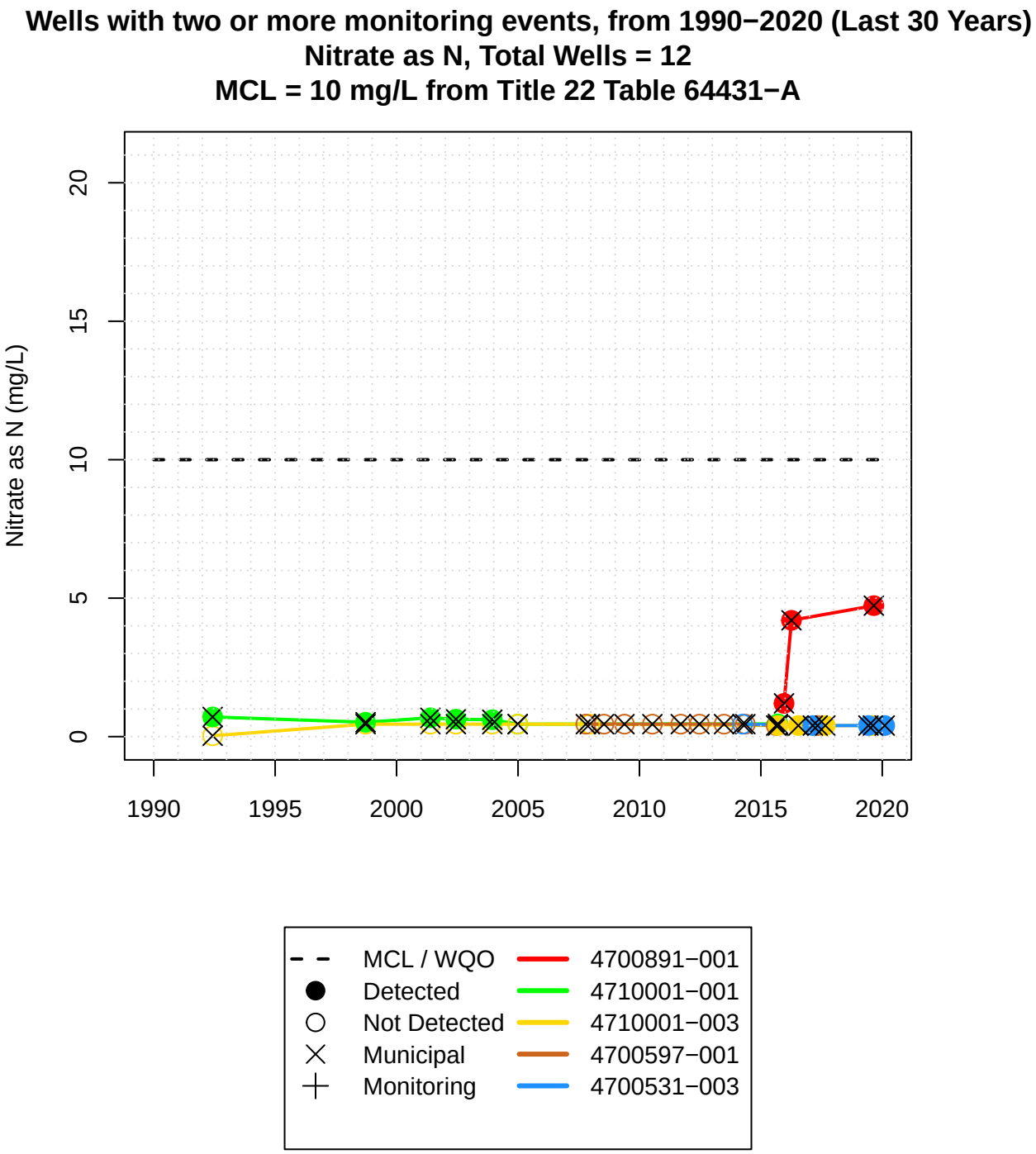


Figure 20: Filtered Groundwater Quality Observations of the Constituent Short List

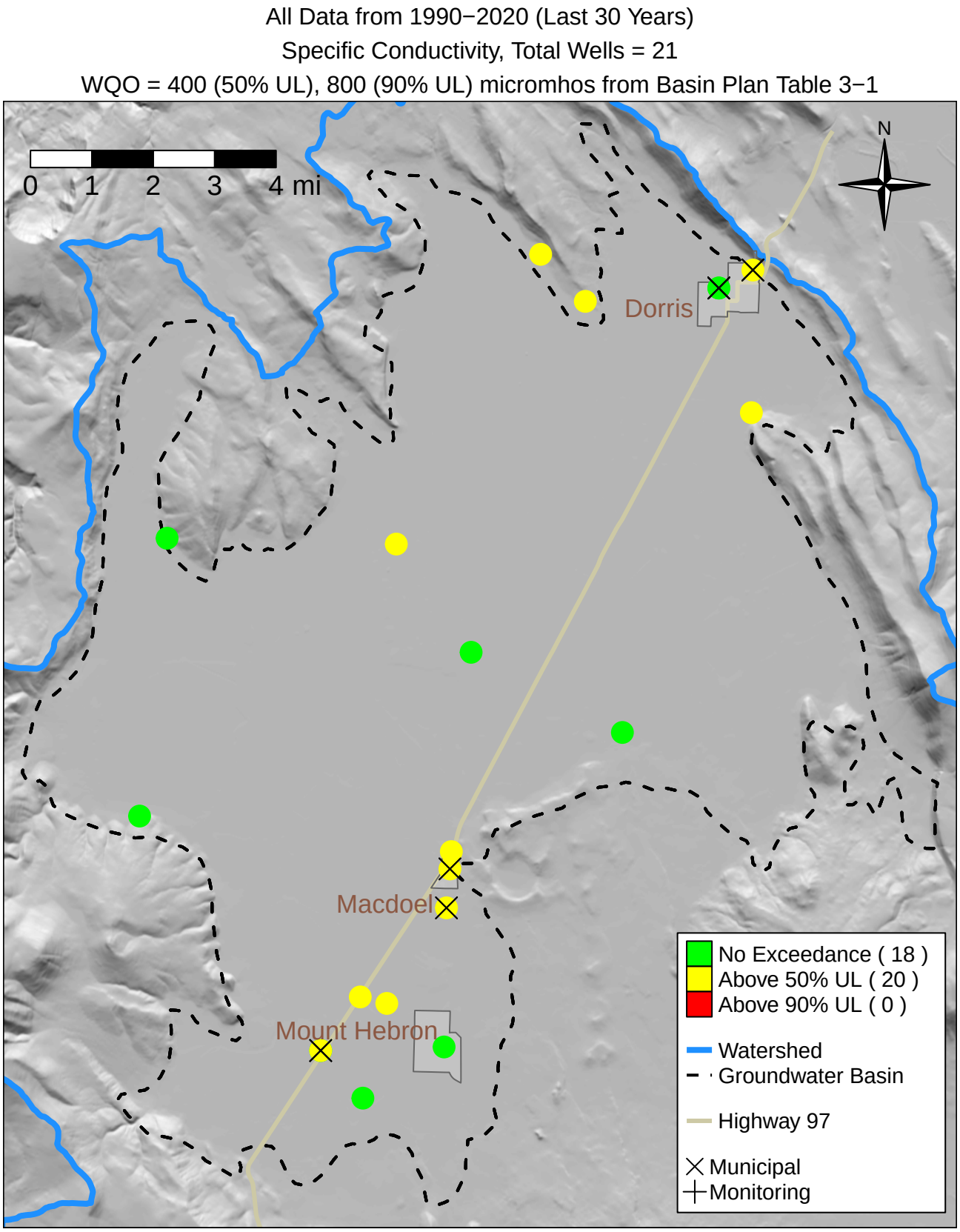


Figure 21: Groundwater Quality Observations of the Constituent Short List

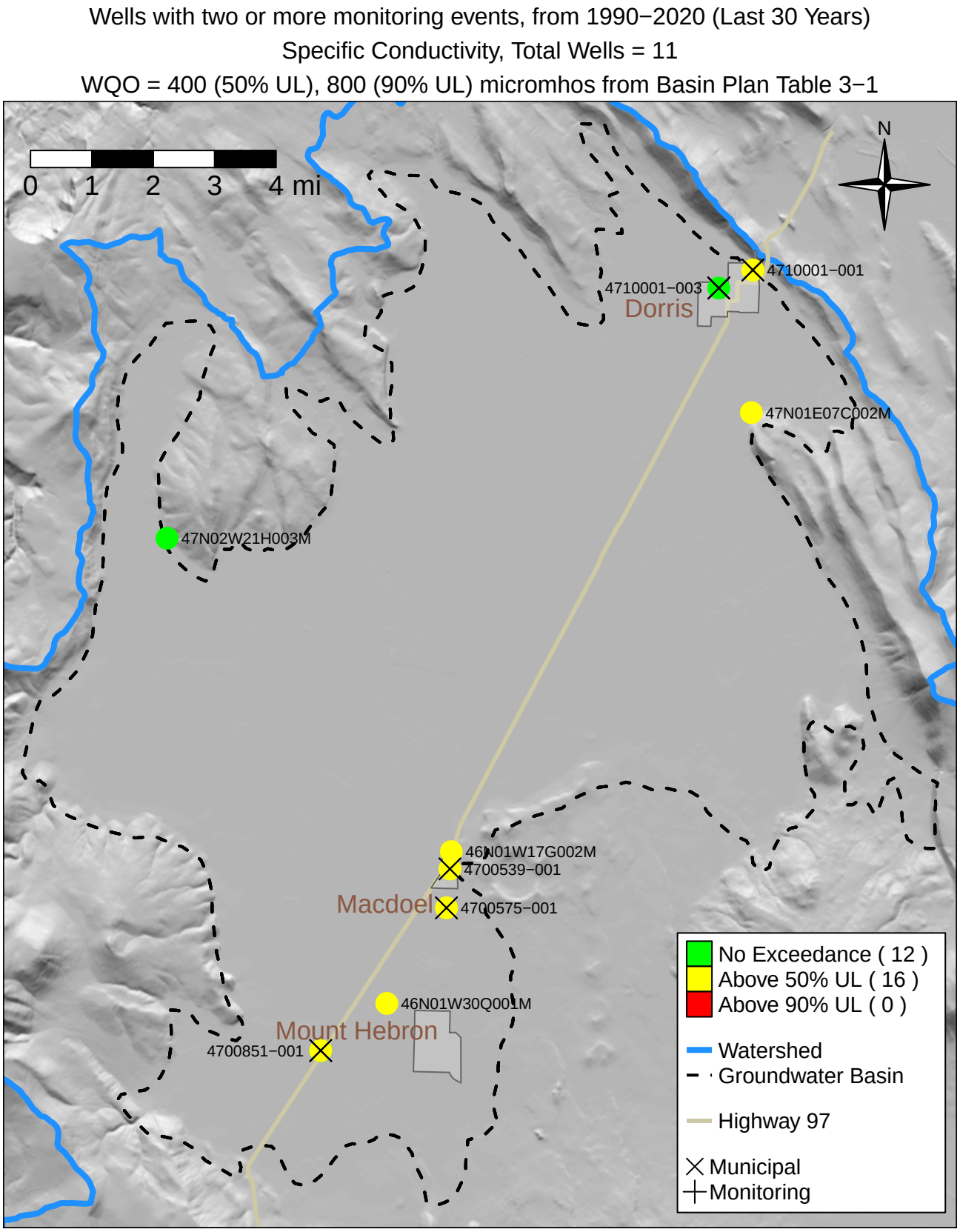


Figure 22: Filtered Groundwater Quality Observations of the Constituent Short List

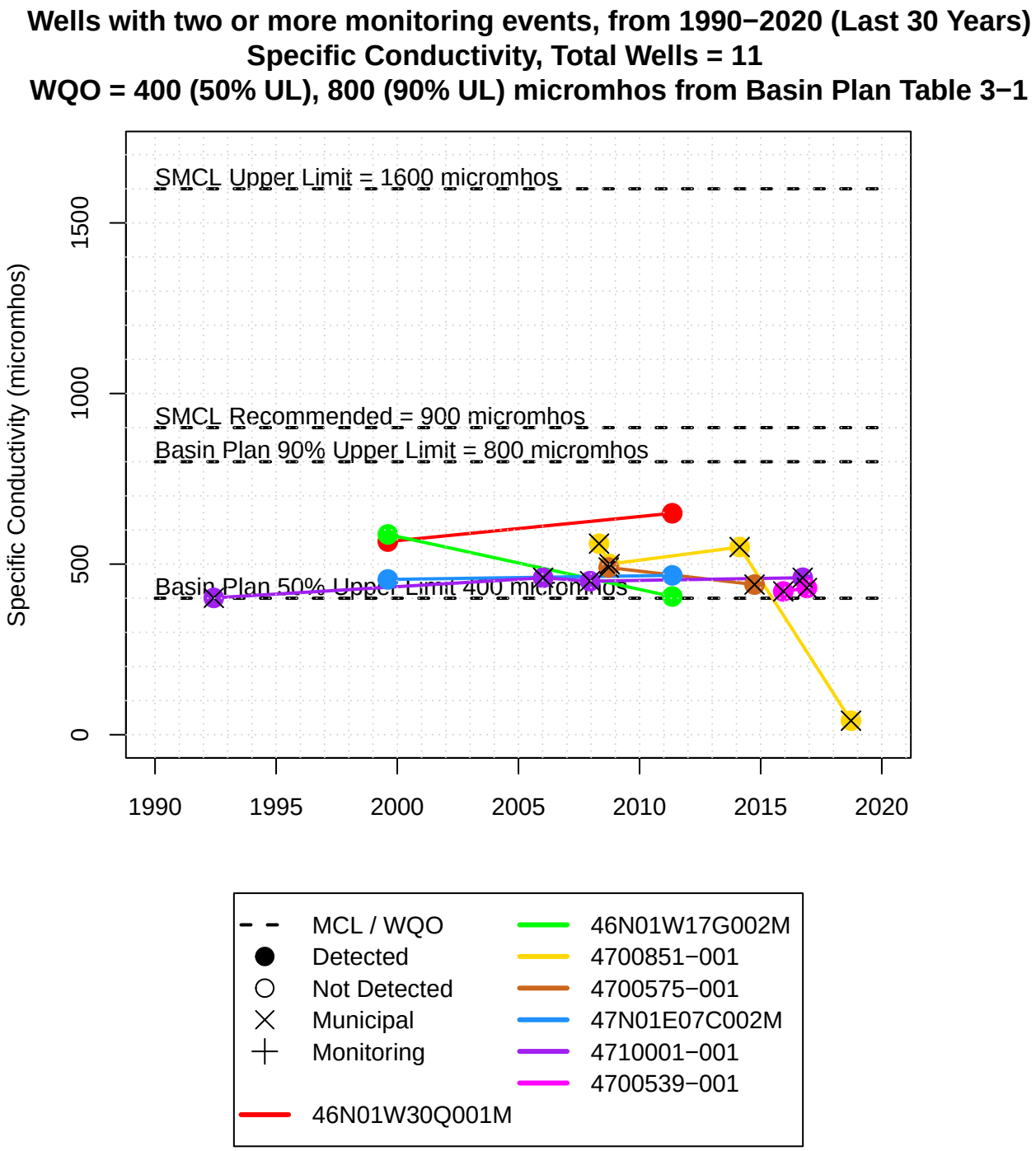


Figure 23: Filtered Groundwater Quality Observations of the Constituent Short List

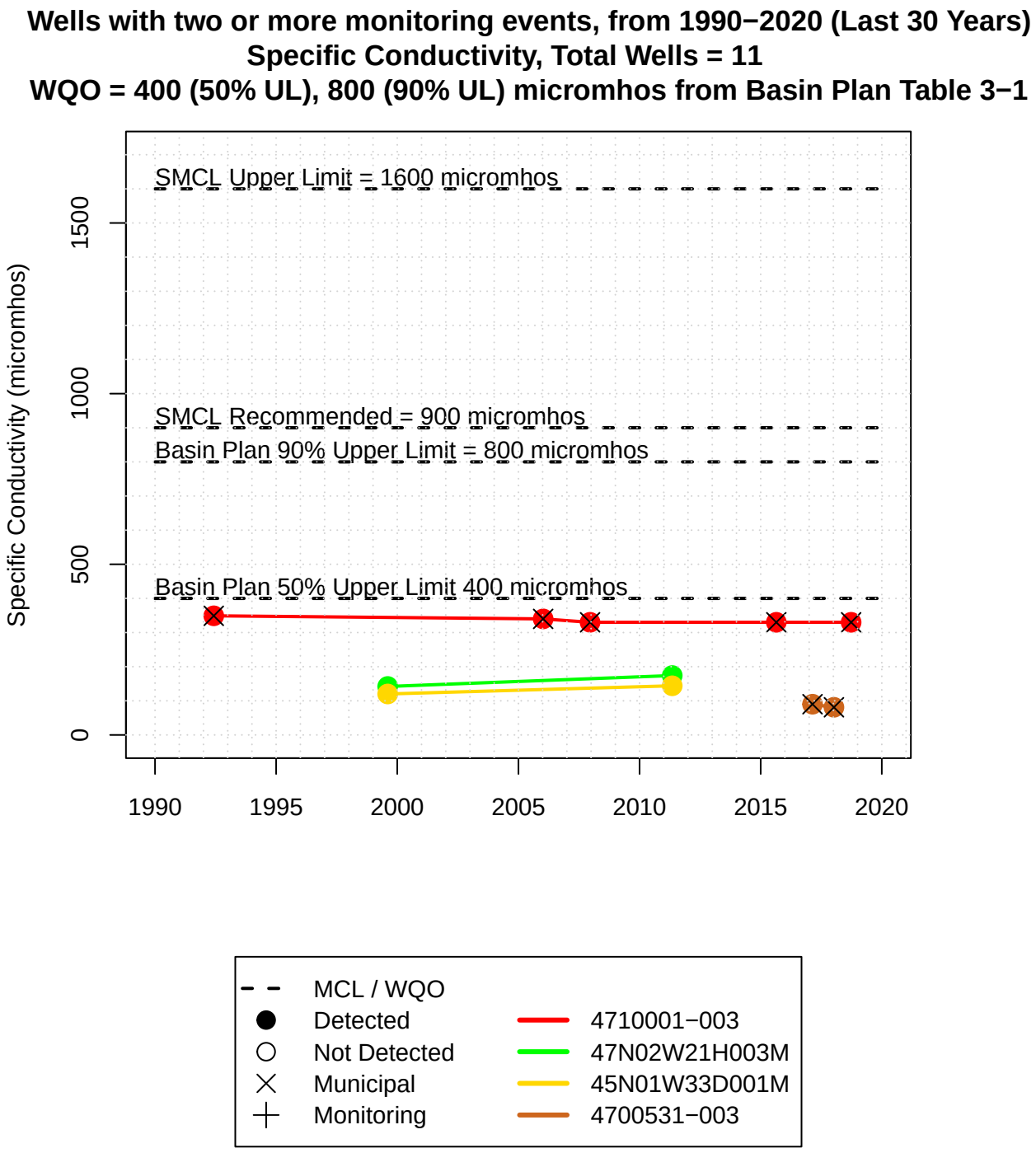


Figure 24: Filtered Groundwater Quality Observations of the Constituent Short List

References

California North Coast Regional Water Quality Control Board. 2018. “North Coast Basin Plan Chapter 2: Beneficial Uses.” June.

Appendix 2-C. Groundwater Dependent Ecosystem Assessment

Contents

Additional Tables and Figures for the Identification of Groundwater Dependent Ecosystems **3**

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Depth to Groundwater 9

Additional Tables and Figures for the Identification of Groundwater Dependent Ecosystems

The following section provides additional tables and figures that are mentioned in the main text of Section 2.2.2.7.

Tables

The union of the NCCAG vegetation and wetland layers and adapted 2016 Siskiyou County LU/LC dataset created several tables.

- New fields created by combining or concatenating the relevant fields in each dataset is identified in Table 1.
- Descriptions of classes in the NCCAG Wetland Dataset is shown in Table 2.
- Siskiyou County LU/LC classes are presented in Table 3.
- A summary of relationships between combined fields and assumed actions is presented in Table 4.

Table 1: Field Used to Create a Combined Representation of Mapped Potential GDE Coverage.

Dataset	Field Used
NCCAG Vegetation	Vegetation
NCCAG Wetland	ORIGINAL_C
DWR Siskiyou County	LABEL

Table 2: NCCAG Wetland Dataset Field Descriptions.

Class	Classification Description
PEM1C	Palustrine, Emergent, Persistent, Seasonally Flooded
PSSC	Palustrine, Scrub-Shrub, Seasonally Flooded
R5UBF	Riverine, Unknown Perennial, Unconsolidated Bottom, Semipermanently Flooded
PFOC	Palustrine, Forested, Seasonally Flooded
PUSC	Palustrine, Unconsolidated Shore, Seasonally Flooded

Table 2: NCCAG Wetland Dataset Field Descriptions. *(continued)*

Class	Classification Description
R2UBH	Riverine, Lower Perennial, Unconsolidated Bottom, Permanently Flooded
R3UBH	Riverine, Upper Perennial, Unconsolidated Bottom, Permanently Flooded
PEM1F	Palustrine, Emergent, Persistent, Semipermanently Flooded
45800	Seep or Spring

Table 3: Siskiyou County Land Use and Land Cover Field Descriptions.

Land Use/Land Cover Class	Description
G	Grain and Hay Crops
G1	Barley
G2	Wheat
G3	Oats
G3-H	Oats - harvested crop
G6	Miscellaneous grain and hay
G6-H	Miscellaneous grain and hay - harvested crop
G6-X	Miscellaneous grain and hay - partially irrigated
G-T	Grain and Hay Crops - tilled
I1	Idle but cropped within the past three years
I1-T	Idle but cropped within the past three years - tilled
I2	New land being prepared for crop production
NB	Barren and wasteland
NR4	Riparian vegetation - seasonal duck marsh
NR4-X	Riparian vegetation - seasonal duck marsh - partially irrigated
NR5	Riparian vegetation - permanent duck marsh
NV	Native vegetation
NW1	Water surface - river or stream (natural fresh water channels)
NW2	Water surface - water channel for delivering water for irrigation and urban use
NW3	Water surface - water channel for removing on-farm drainage water
NW4	Water surface - freshwater lake, reservoir, or pond
P	Pasture
P1	Pasture - alfalfa & alfalfa mixtures

Table 3: Siskiyou County Land Use and Land Cover Field Descriptions. *(continued)*

Land Use/Land Cover Class	Description
P3	Mixed pasture
P3-X	Mixed pasture - partially irrigated
P4	Native pasture
P4-X	Native pasture - partially irrigated
P6	Pasture - miscellaneous grasses
S1	Semiagricultural & incidental to agriculture - farmsteads (with farm residence)
S5	Semiagricultural & incidental to agriculture - farmsteads (with no farm residence)
S6	Semiagricultural & incidental to agriculture - miscellaneous semi-ag
T10	Onions and garlic
T12	Potatoes
T18	Miscellanous truck crops
T20	Strawberries
UC	Commercial
UC1	Offices, retailers, etc.
UC4	Recreation vehicle parking and camp sites
UC5	Commercial institutions
UC6	Schools
UC7	Municipal auditoriums, theaters, churches, buildings and stands
UI	Industrial
UI1	Manufacturing, assembling, and general processing
UI14	Waste accumulation sites
UI2	Extractive industries
UI3	Storage and distribution
UI6	Saw mills
UL1	Law area - irrigated
UR	Residential
UR1	Single family dwellings with lot sizes greater than 1 acre up to 5 acres
UV	Vacant
UV1	Vacant unpaved areas
UV3	Railroad right of way
UV4	Paved areas
UV6	Airport runways

Table 4: Master Vegetation Lookup Summary.

VEGETATION	ORIGINAL_C	LABEL	join_field	Possible_Action
	45800	NV	_45800_NV	Retain_Natural
	PEM1C	S5	_PEM1C_S5	Retain_Check
	PEM1C	NW2	_PEM1C_NW2	Retain_Check
	PEM1C	NW4	_PEM1C_NW4	Retain_Check
	PEM1C	NR4	_PEM1C_NR4	Retain_Natural
	PEM1C	P3	_PEM1C_P3	Retain_Check
	PEM1C	NV	_PEM1C_NV	Retain_Natural
	PEM1C	P4-X	_PEM1C_P4-X	Retain_Natural
	PEM1C	S1	_PEM1C_S1	Retain_Check
	PEM1C	P3-X	_PEM1C_P3-X	Retain_Check
	PEM1C	NR5	_PEM1C_NR5	Retain_Natural
	PEM1C	UR	_PEM1C_UR	Remove Ag.
	PEM1C	P1	_PEM1C_P1	Retain_Check
	PEM1C	P4	_PEM1C_P4	Retain_Natural
	PEM1C	UV1	_PEM1C_UV1	Retain_Check
	PEM1C	G6	_PEM1C_G6	Remove Ag.
	PEM1C	G	_PEM1C_G	Remove Ag.
	PEM1C	I1	_PEM1C_I1	Retain_Check
	PEM1C	UV4	_PEM1C_UV4	Remove Ag.
	PEM1C	P	_PEM1C_P	Retain_Check
	PEM1F	NV	_PEM1F_NV	Retain_Natural
	PFOC	NV	_PFOC_NV	Retain_Natural
	PFOC	P4-X	_PFOC_P4-X	Retain_Natural
	PSSC	NW2	_PSSC_NW2	Retain_Check
	PSSC	NV	_PSSC_NV	Retain_Natural
	PSSC	NW4	_PSSC_NW4	Retain_Check
	PSSC	P4-X	_PSSC_P4-X	Retain_Natural
	PSSC	UV1	_PSSC_UV1	Retain_Check
	PSSC	UV4	_PSSC_UV4	Remove Ag.
	PUSC	NV	_PUSC_NV	Retain_Natural
	R2UBH	NR4	_R2UBH_NR4	Retain_Natural
	R2UBH	NW2	_R2UBH_NW2	Retain_Check
	R2UBH	NV	_R2UBH_NV	Retain_Natural
	R3UBH	NV	_R3UBH_NV	Retain_Natural
	R3UBH	NW2	_R3UBH_NW2	Retain_Check
	R3UBH	UV4	_R3UBH_UV4	Remove Ag.
	R5UBF	NW2	_R5UBF_NW2	Retain_Check
	R5UBF	NV	_R5UBF_NV	Retain_Natural
	R5UBF	NR4	_R5UBF_NR4	Retain_Natural
	R5UBF	NW4	_R5UBF_NW4	Retain_Check
	R5UBF	P4-X	_R5UBF_P4-X	Retain_Natural

Table 4: Master Vegetation Lookup Summary. *(continued)*

VEGETATION	ORIGINAL_C	LABEL	join_field	Possible_Action
	R5UBF	UV1	_R5UBF_UV1	Retain_Check
	R5UBF	P4	_R5UBF_P4	Retain_Natural
	R5UBF	I1	_R5UBF_I1	Retain_Check
	R5UBF	UV4	_R5UBF_UV4	Remove Ag.
Wet Meadows		NV	Wet Meadows_ _NV	Retain_Natural
Wet Meadows		NR4	Wet Meadows_ _NR4	Retain_Natural
Wet Meadows		NW2	Wet Meadows_ _NW2	Retain_Check
Wet Meadows		P4-X	Wet Meadows_ _P4-X	Retain_Natural
Wet Meadows		NW4	Wet Meadows_ _NW4	Retain_Check
Wet Meadows		P3-X	Wet Meadows_ _P3-X	Retain_Check
Wet Meadows		UR	Wet Meadows_ _UR	Remove Ag.
Wet Meadows		UV4	Wet Meadows_ _UV4	Remove Ag.
Wet Meadows		G6	Wet Meadows_ _G6	Remove Ag.
Wet Meadows		UV1	Wet Meadows_ _UV1	Retain_Check
Wet Meadows	PEM1C	NW2	Wet Meadows_PEM1C_NW2	Retain_Check
Wet Meadows	PEM1C	NR4	Wet Meadows_PEM1C_NR4	Retain_Natural
Wet Meadows	PEM1C	P4-X	Wet Meadows_PEM1C_P4-X	Retain_Natural
Wet Meadows	PEM1C	UR	Wet Meadows_PEM1C_UR	Remove Ag.
Wet Meadows	PEM1C	UV4	Wet Meadows_PEM1C_UV4	Remove Ag.
Wet Meadows	PEM1C	NV	Wet Meadows_PEM1C_NV	Retain_Natural
Wet Meadows	PSSC	P4-X	Wet Meadows_PSSC_P4-X	Retain_Natural
Wet Meadows	R5UBF	NR4	Wet Meadows_R5UBF_NR4	Retain_Natural

Table 4: Master Vegetation Lookup Summary. *(continued)*

VEGETATION	ORIGINAL_C	LABEL	join_field	Possible_Action
Wet Meadows	R5UBF	P4-X	Wet Meadows_R5UBF_P4-X	Retain_Natural
Willow (Shrub)		NW2	Willow (Shrub)_ _NW2	Retain_Check
Willow (Shrub)		NV	Willow (Shrub)_ _NV	Retain_Natural
Willow (Shrub)		NR4	Willow (Shrub)_ _NR4	Retain_Natural
Willow (Shrub)		UV4	Willow (Shrub)_ _UV4	Remove Ag.
Willow (Shrub)		G6	Willow (Shrub)_ _G6	Remove Ag.
Willow (Shrub)		UV1	Willow (Shrub)_ _UV1	Retain_Check
Willow (Shrub)		I2	Willow (Shrub)_ _I2	Retain_Check
Willow (Shrub)	PEM1C	NW2	Willow (Shrub)_PEM1C_NW2	Retain_Check
Willow (Shrub)	PEM1C	G6	Willow (Shrub)_PEM1C_G6	Remove Ag.
Willow (Shrub)	PEM1C	NR4	Willow (Shrub)_PEM1C_NR4	Retain_Natural
Willow (Shrub)	R3UBH	NV	Willow (Shrub)_R3UBH_NV	Retain_Natural
		NR4	_ _NR4	Retain_Natural
		NR4-X	_ _NR4-X	Retain_Natural
		NR5	_ _NR5	Retain_Natural
		NW1	_ _NW1	Retain_Natural
		NW2	_ _NW2	Retain_Check

Depth to Groundwater

Representations of depth to groundwater for each of the 23 representation of depth to groundwater are presented from Figure 1 to Figure 23.

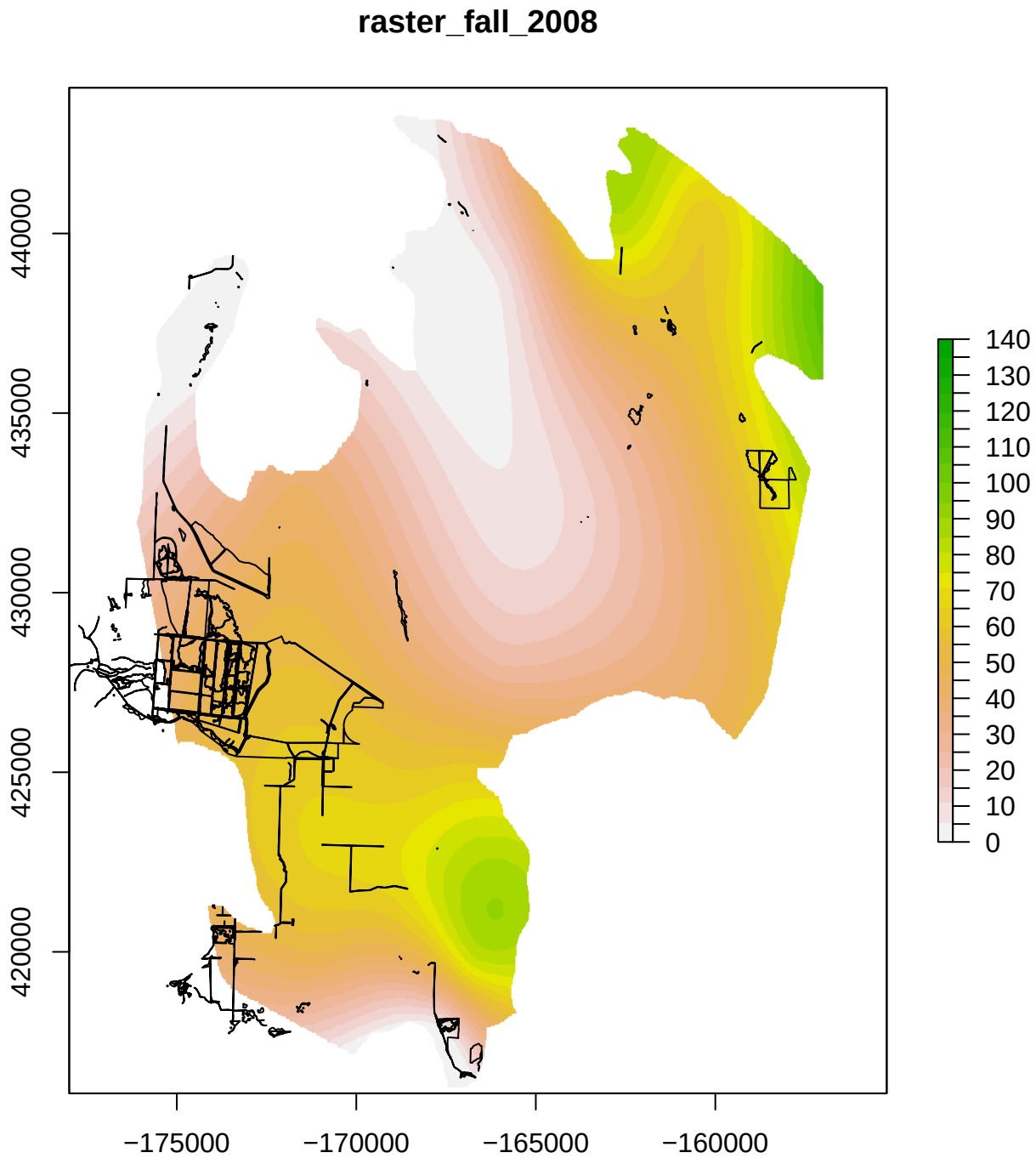


Figure 1: Depth to water, in feet below ground surface.

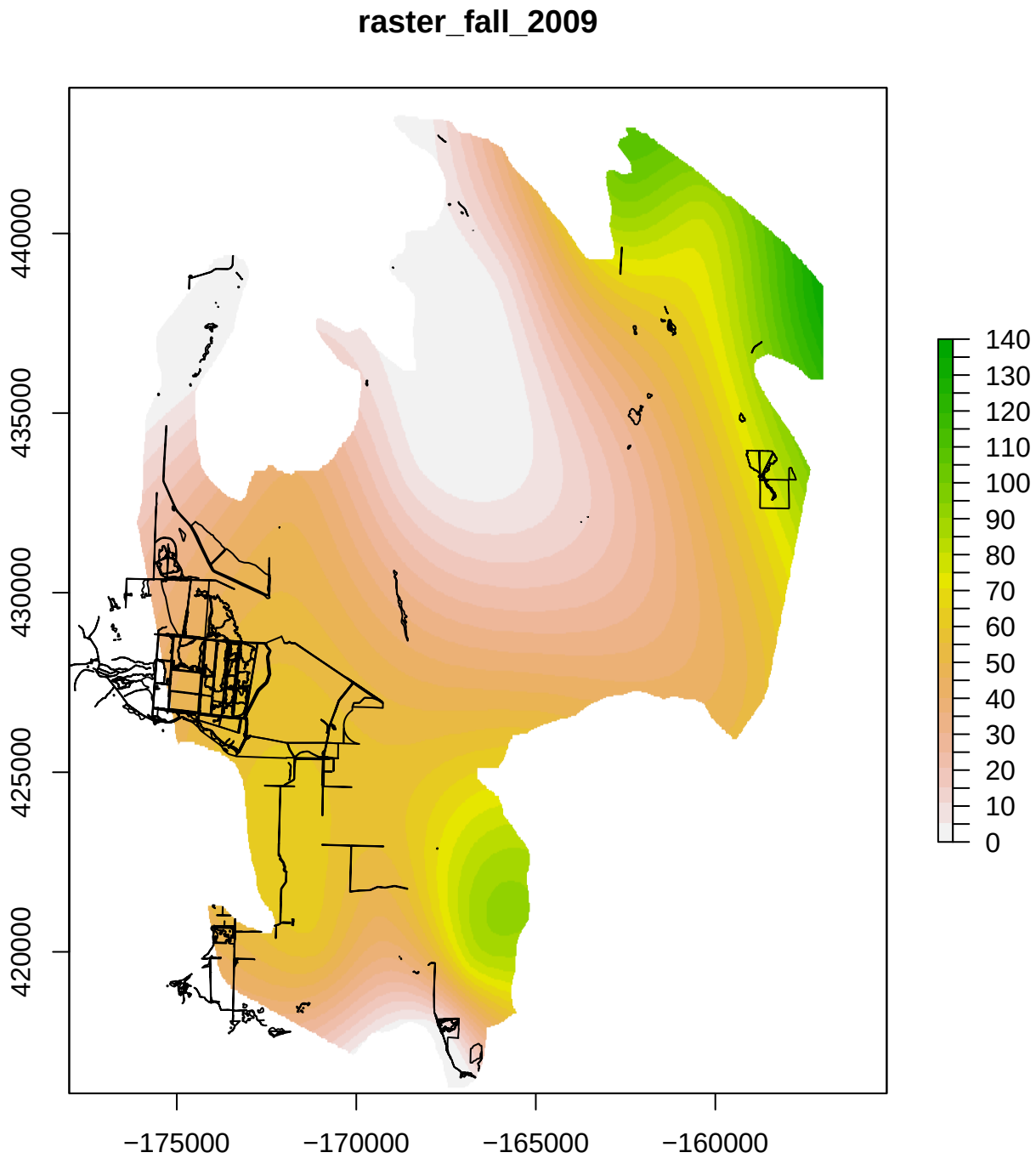


Figure 2: Depth to water, in feet below ground surface.

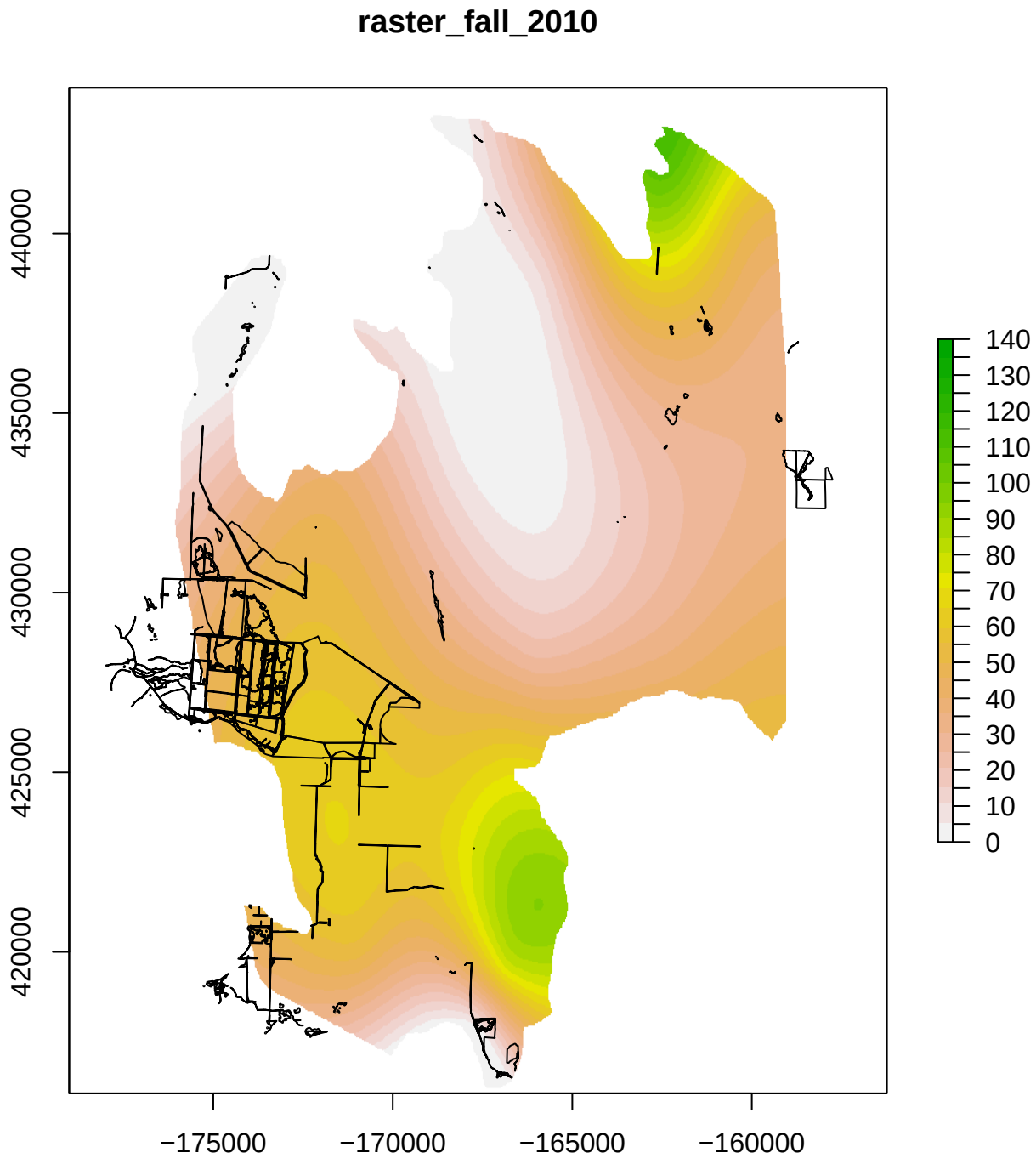


Figure 3: Depth to water, in feet below ground surface.

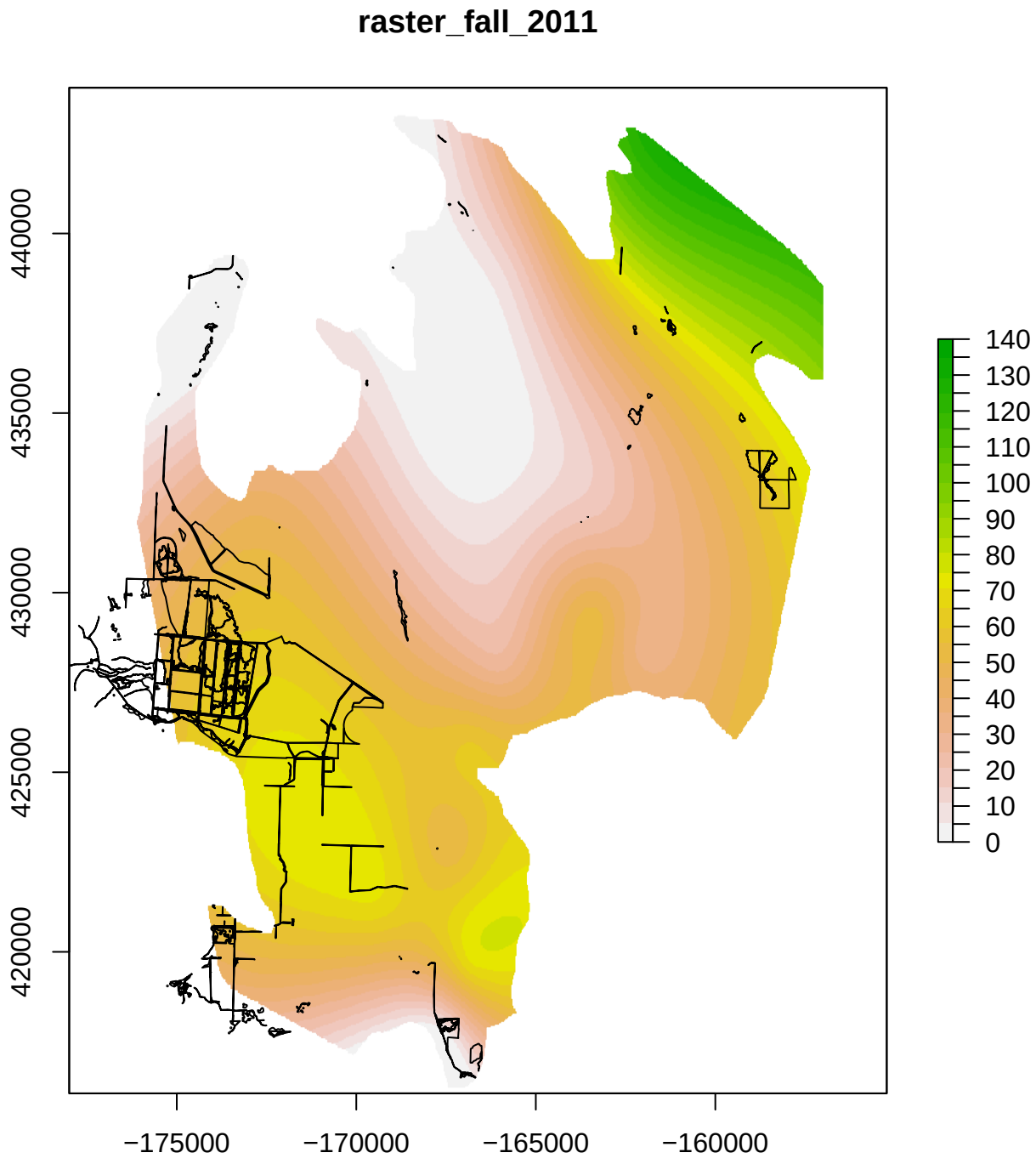


Figure 4: Depth to water, in feet below ground surface.

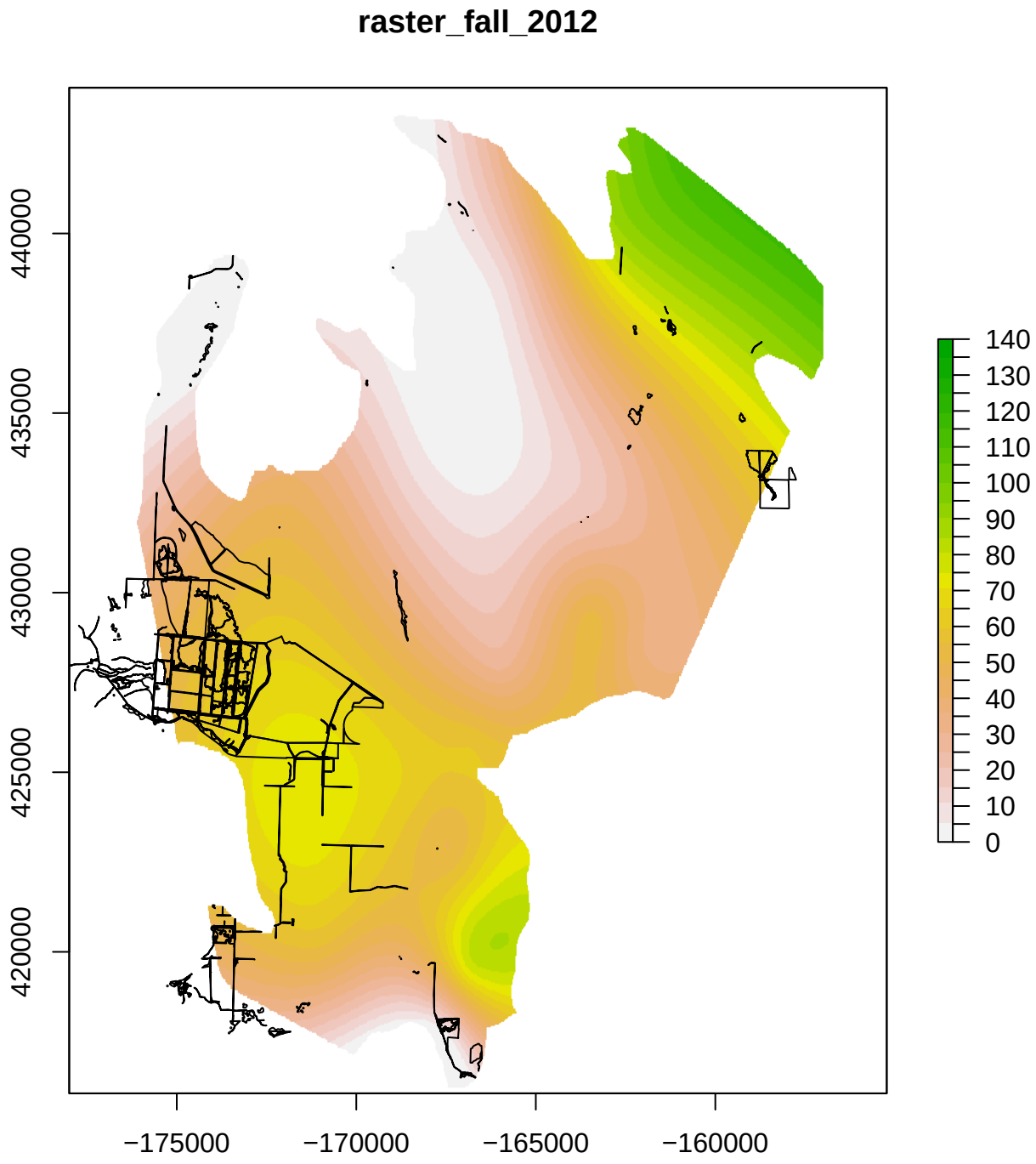


Figure 5: Depth to water, in feet below ground surface.

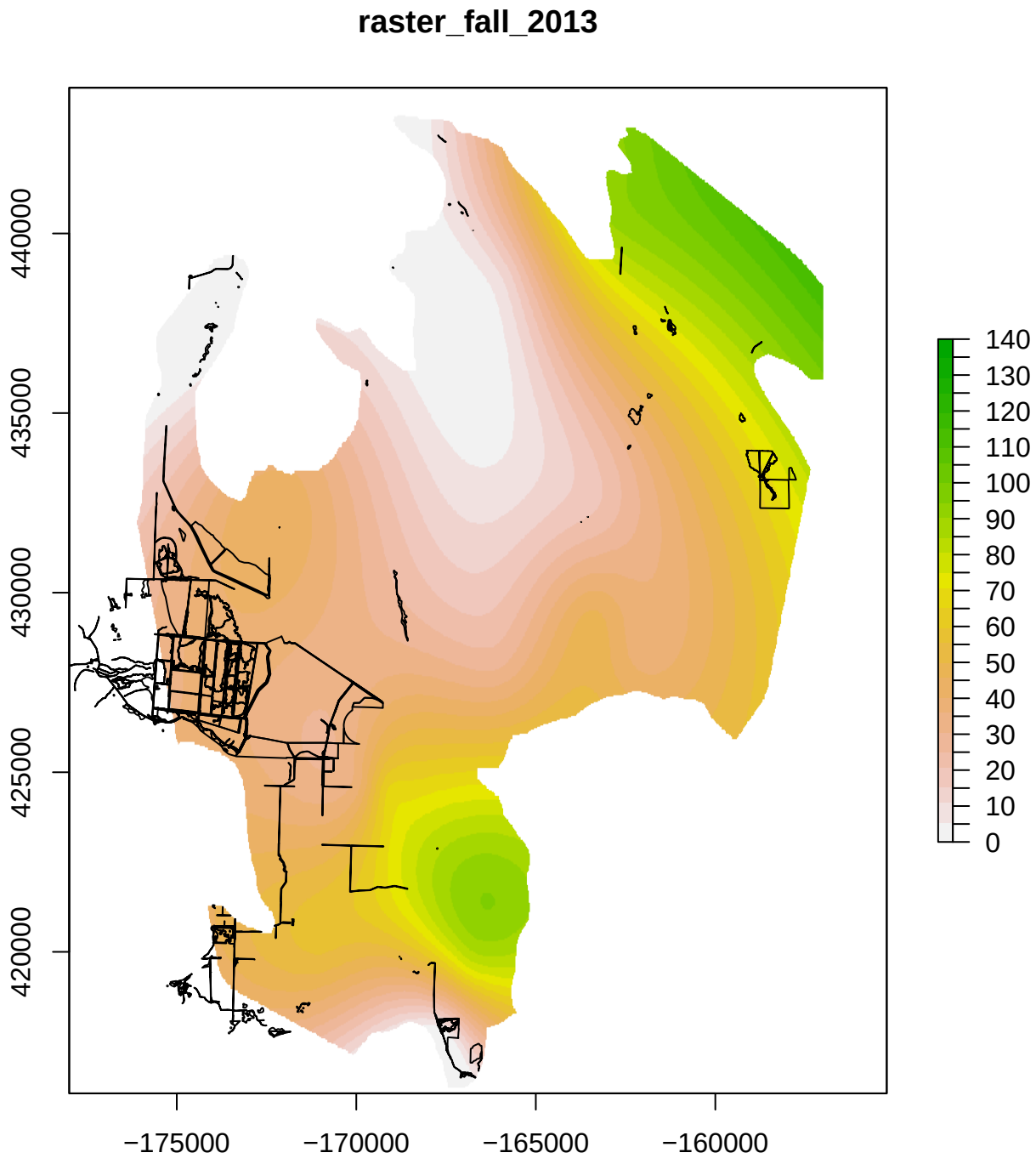


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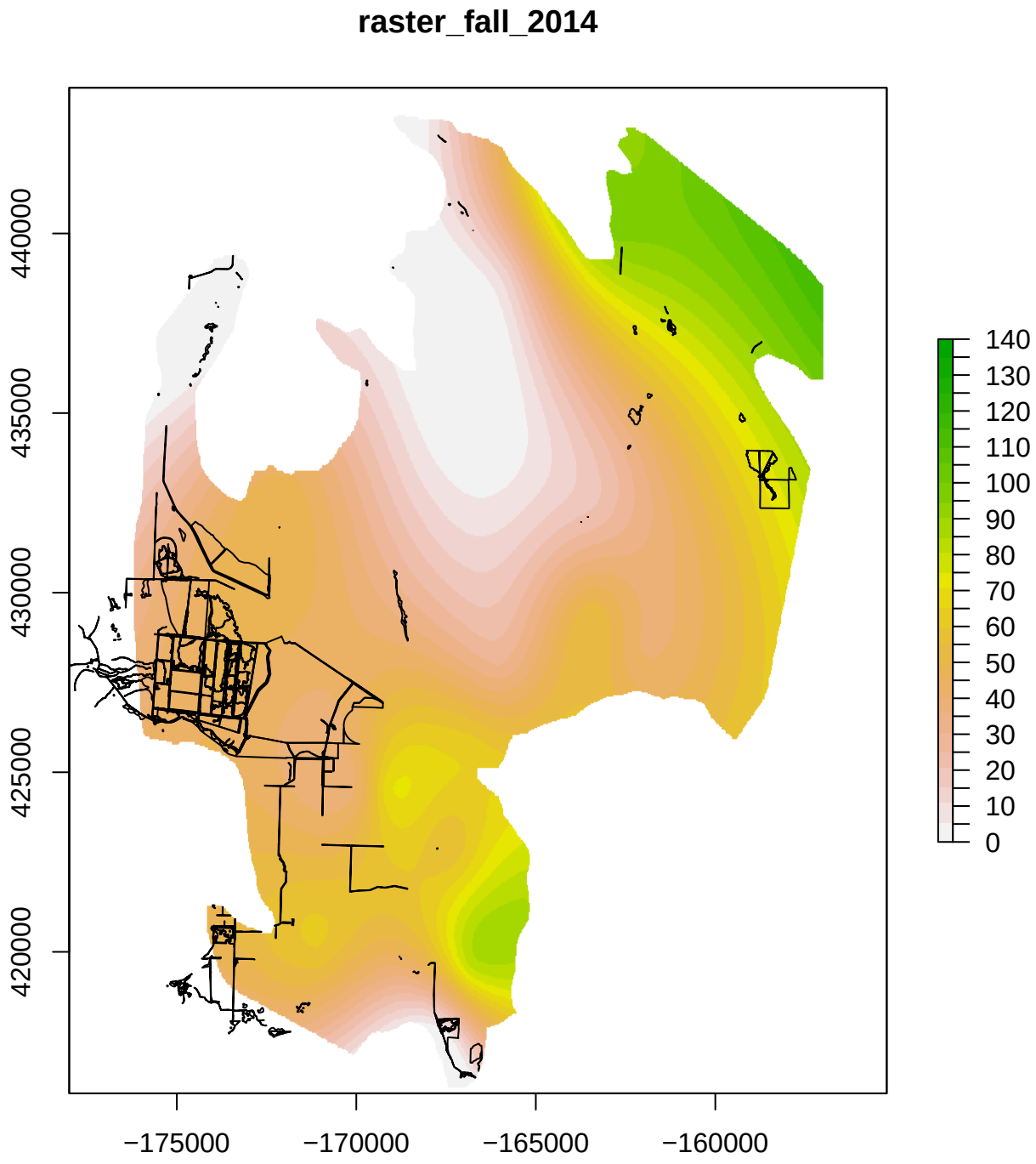


Figure 7: Depth to water, in feet below ground surface.

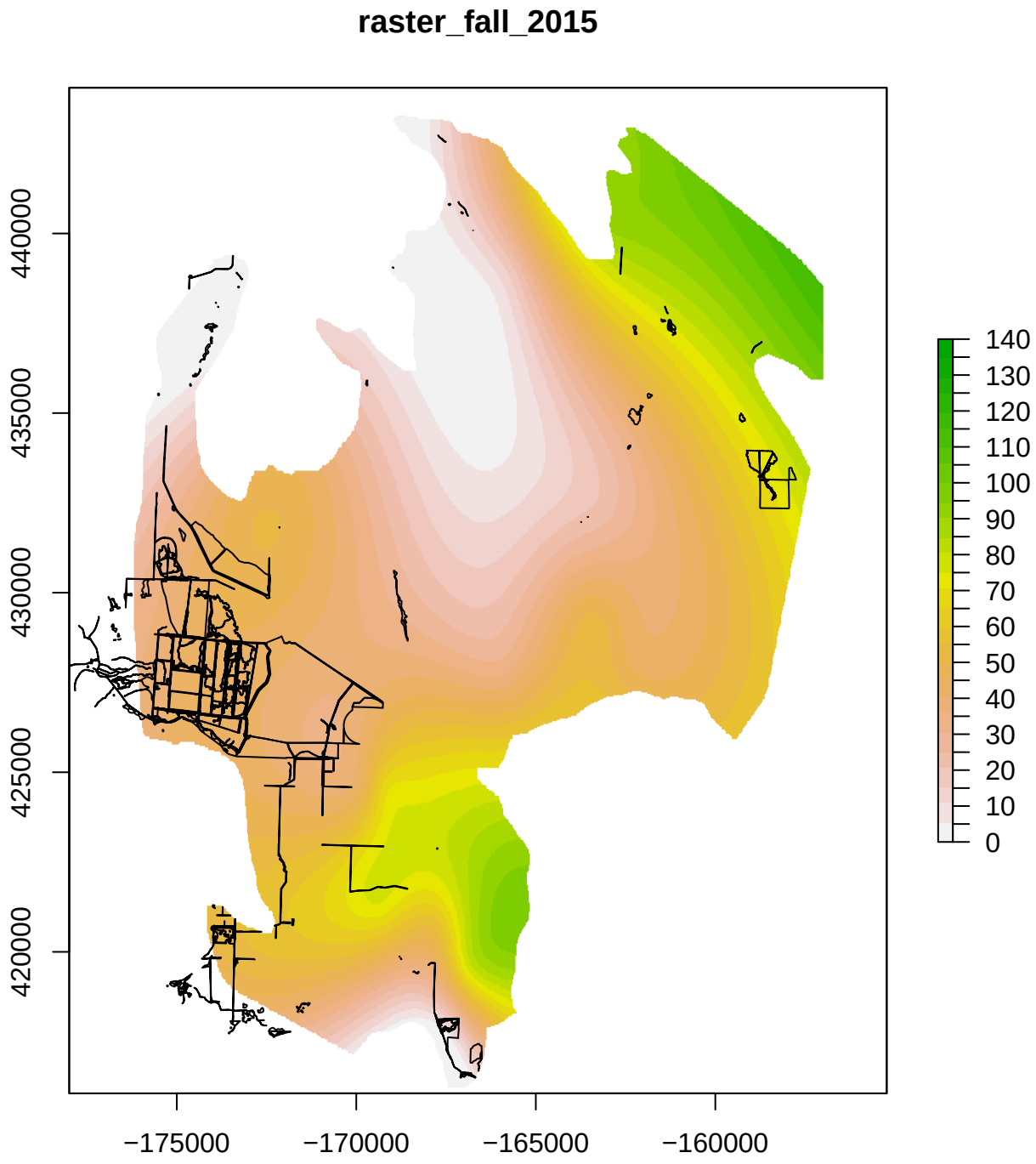


Figure 8: Depth to water, in feet below ground surface.

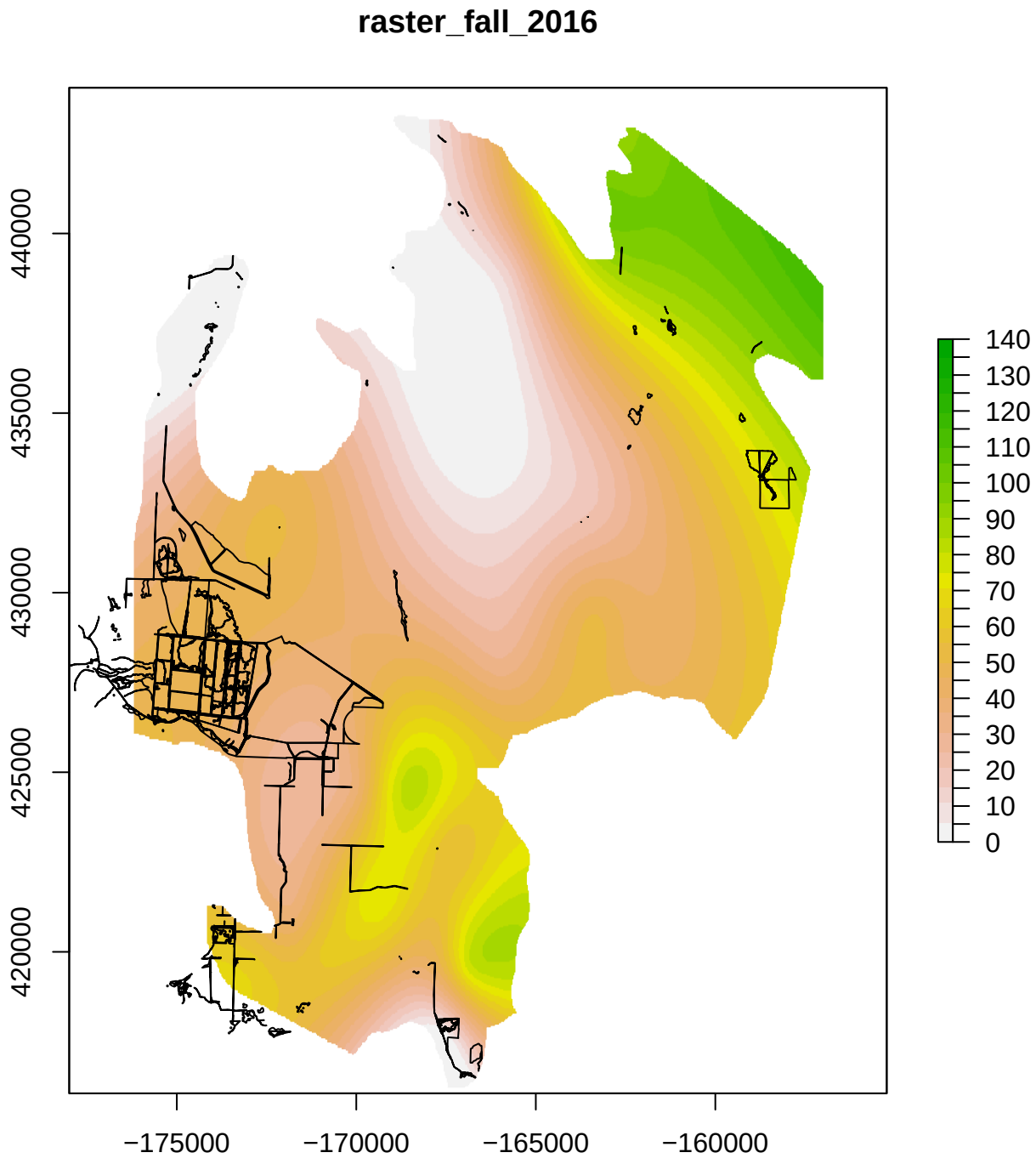


Figure 9: Depth to water, in feet below ground surface.

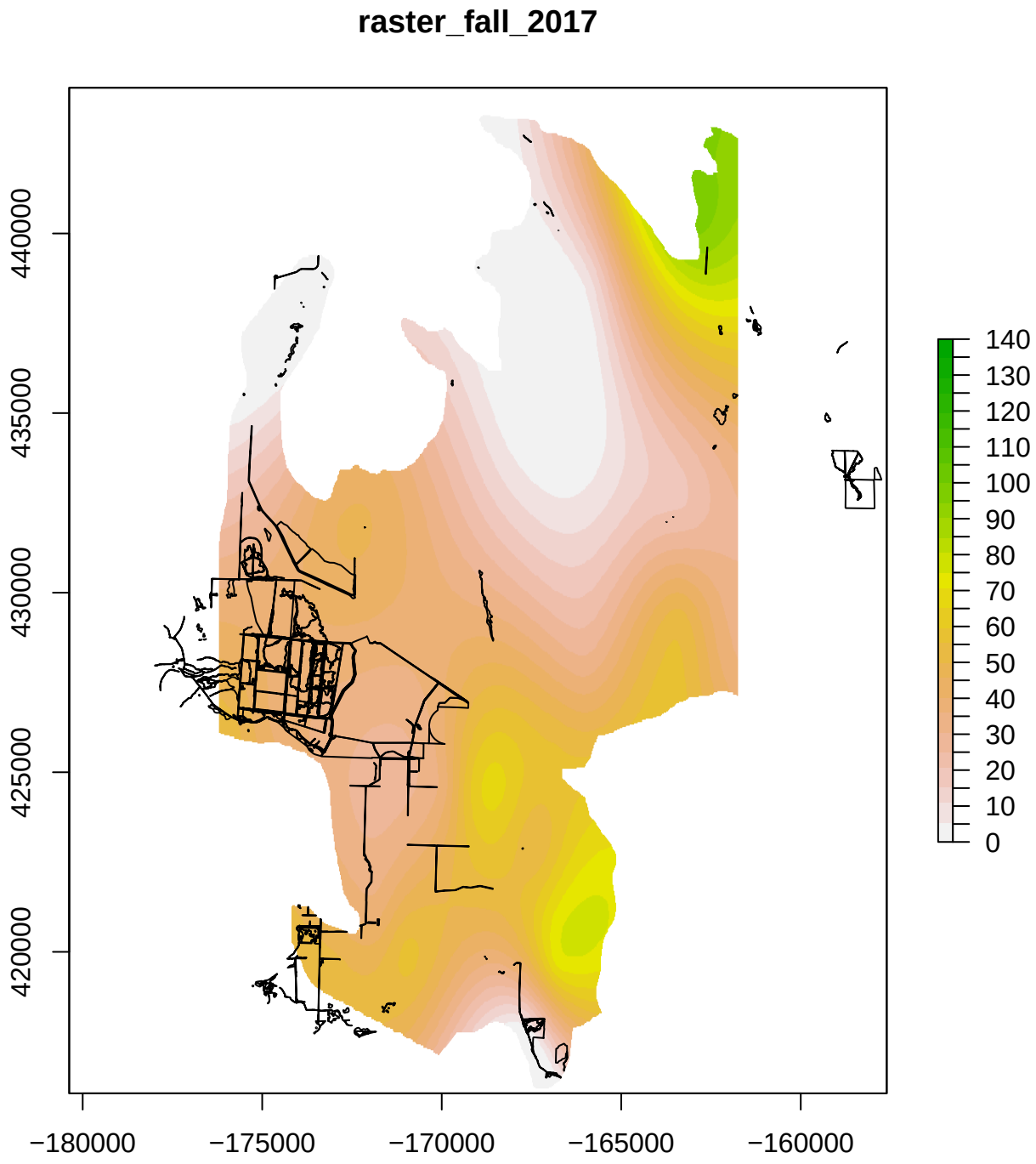


Figure 10: Depth to water, in feet below ground surface.

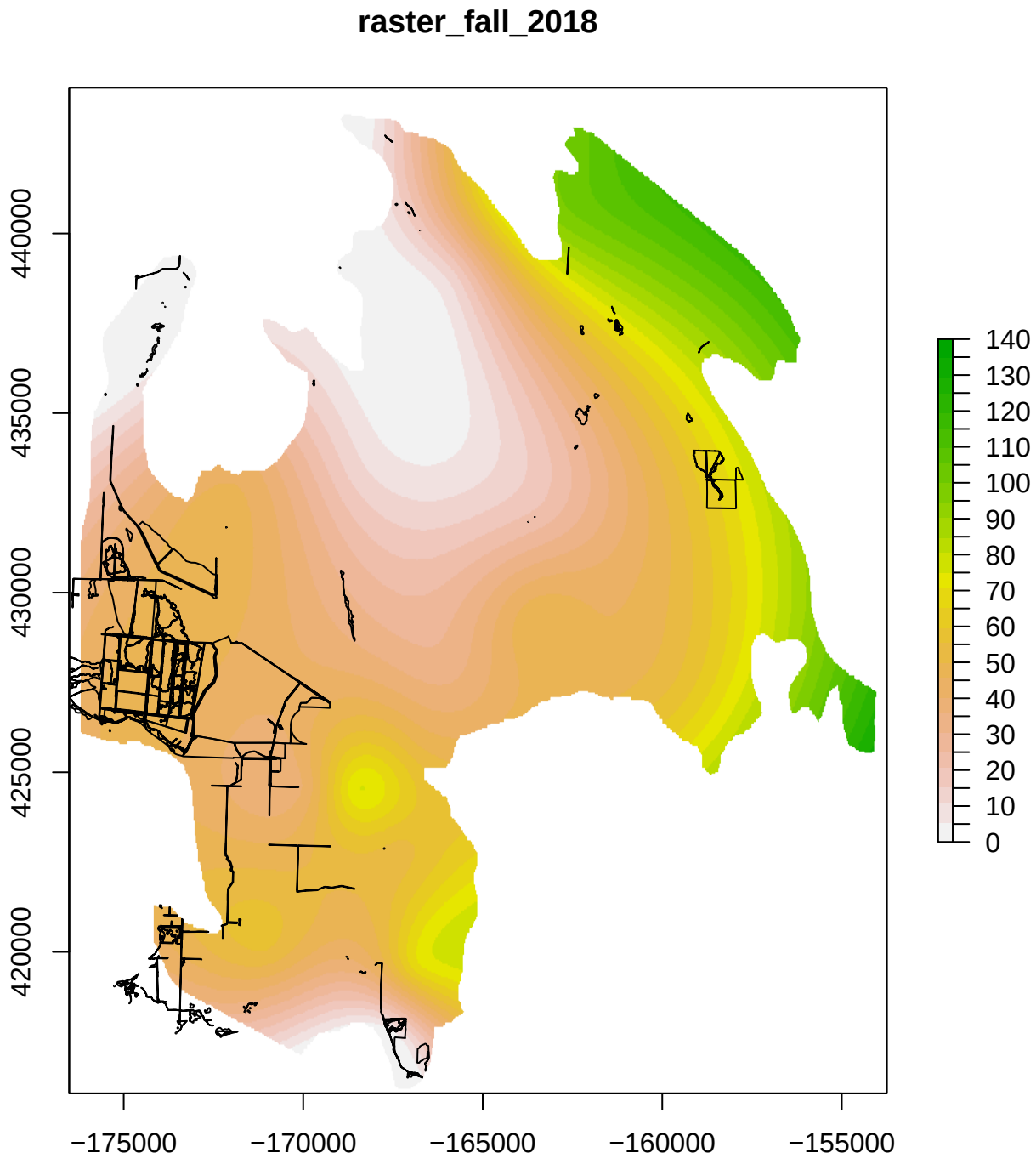


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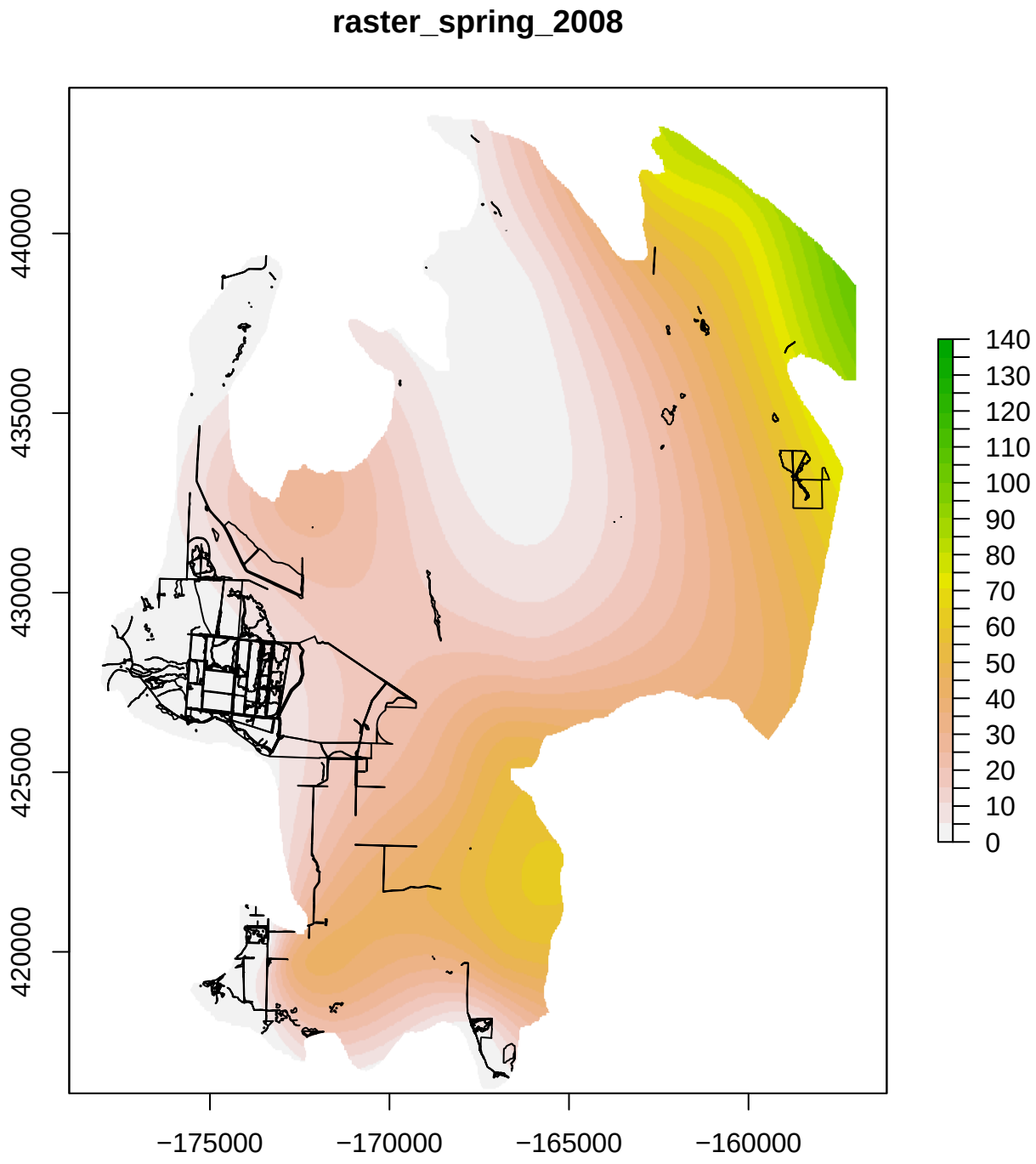


Figure 12: Depth to water, in feet below ground surface.

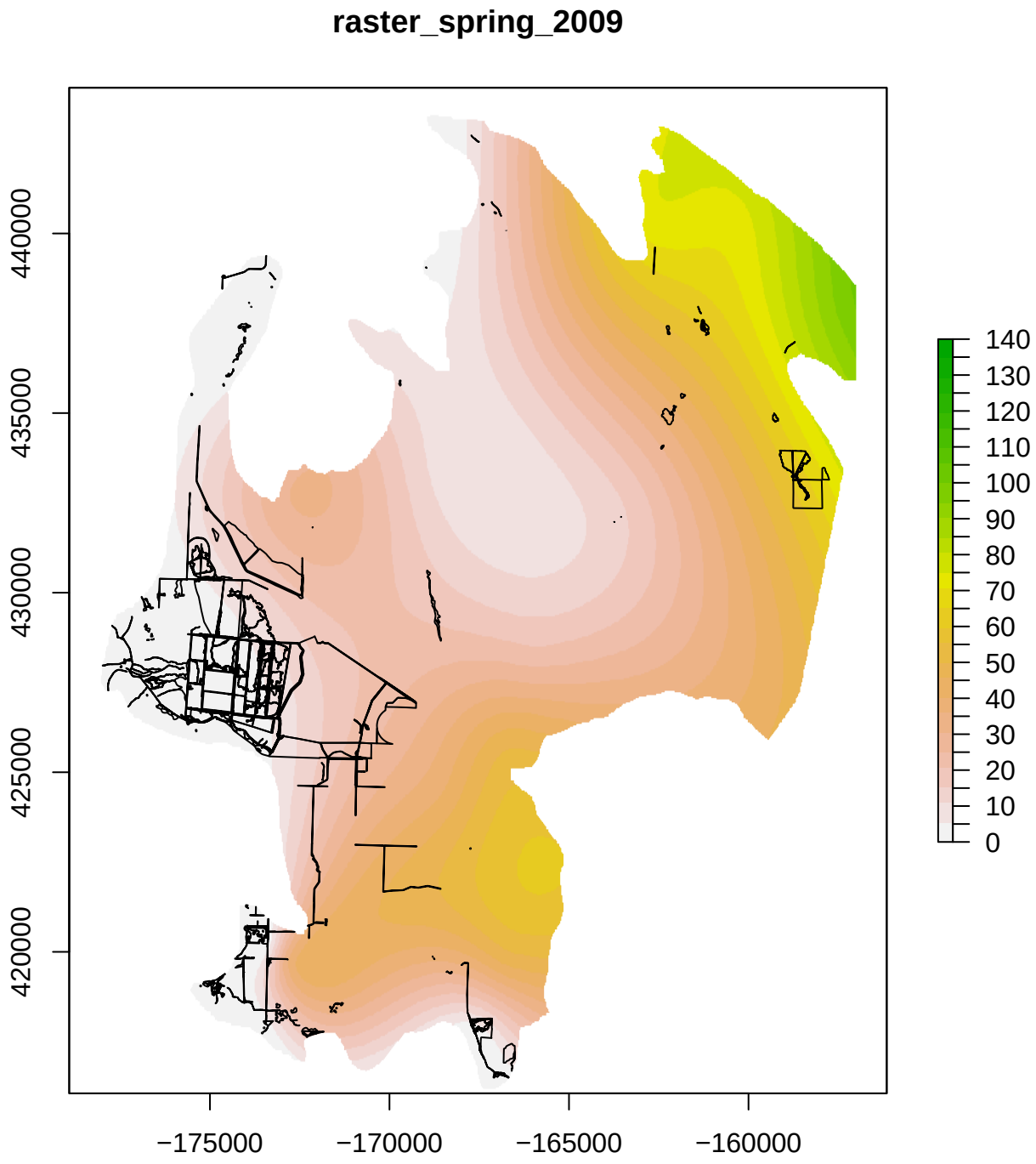


Figure 13: Depth to water, in feet below ground surface.

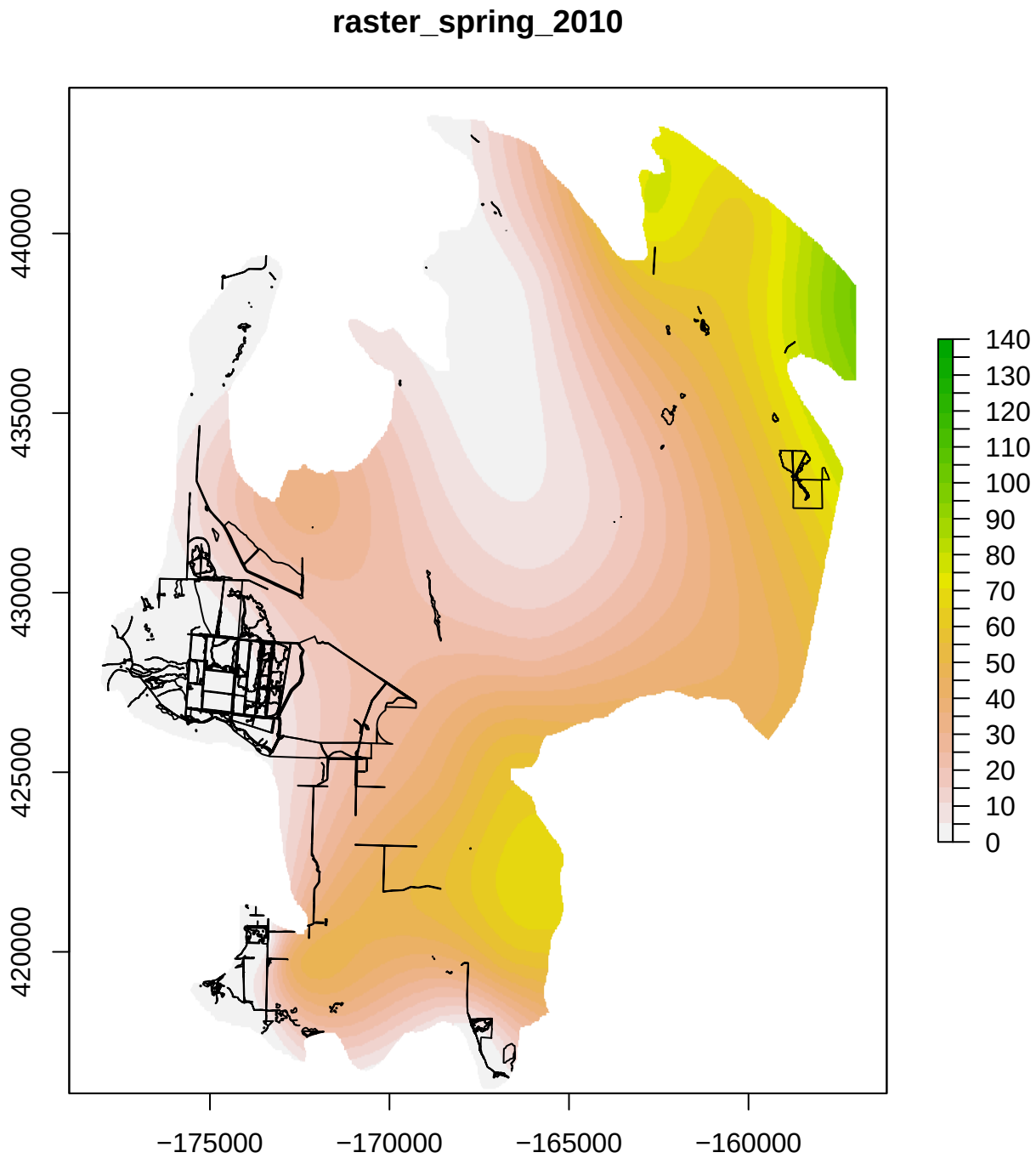


Figure 14: Depth to water, in feet below ground surface.

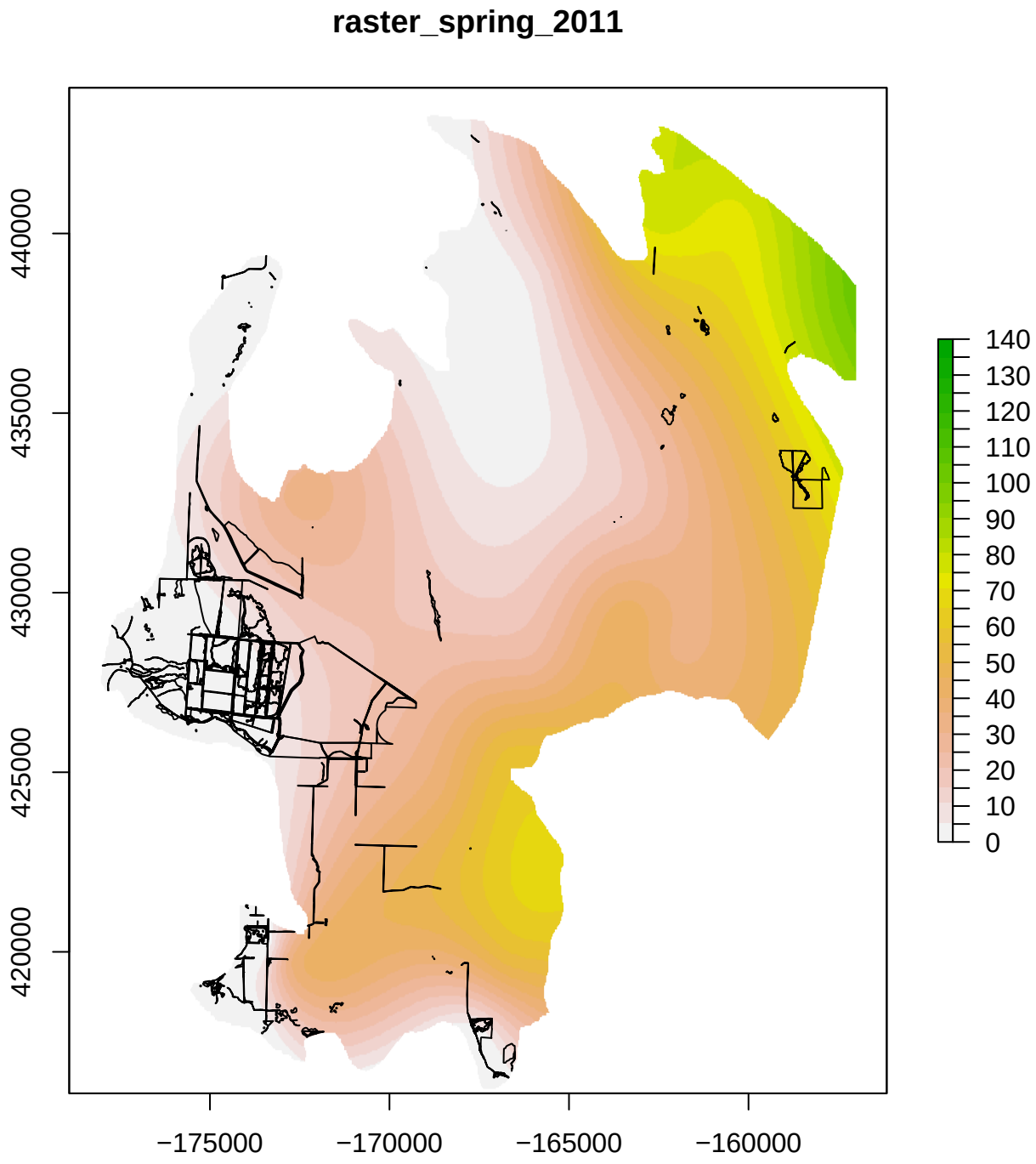


Figure 15: Depth to water, in feet below ground surface.

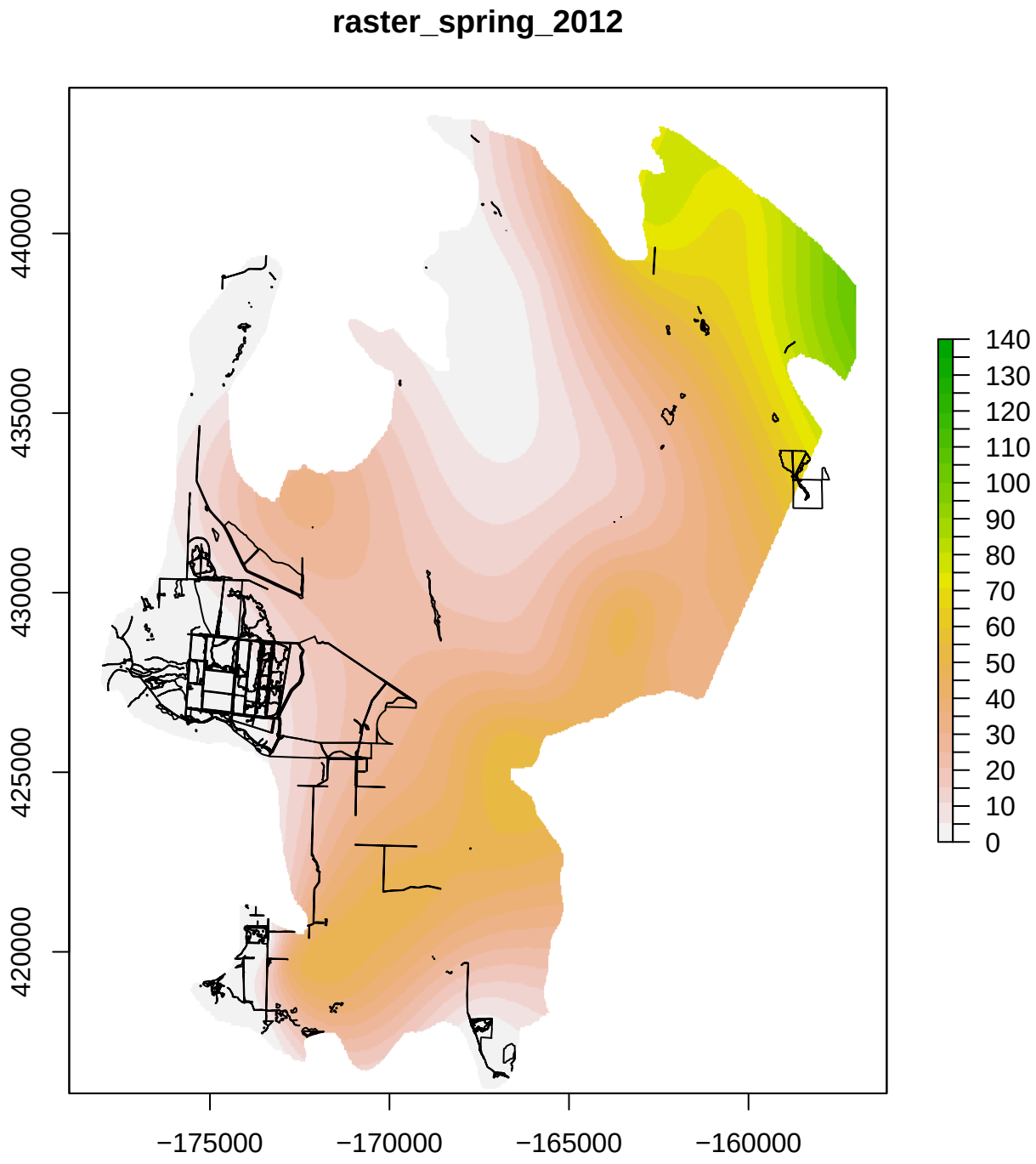


Figure 16: Depth to water, in feet below ground surface.

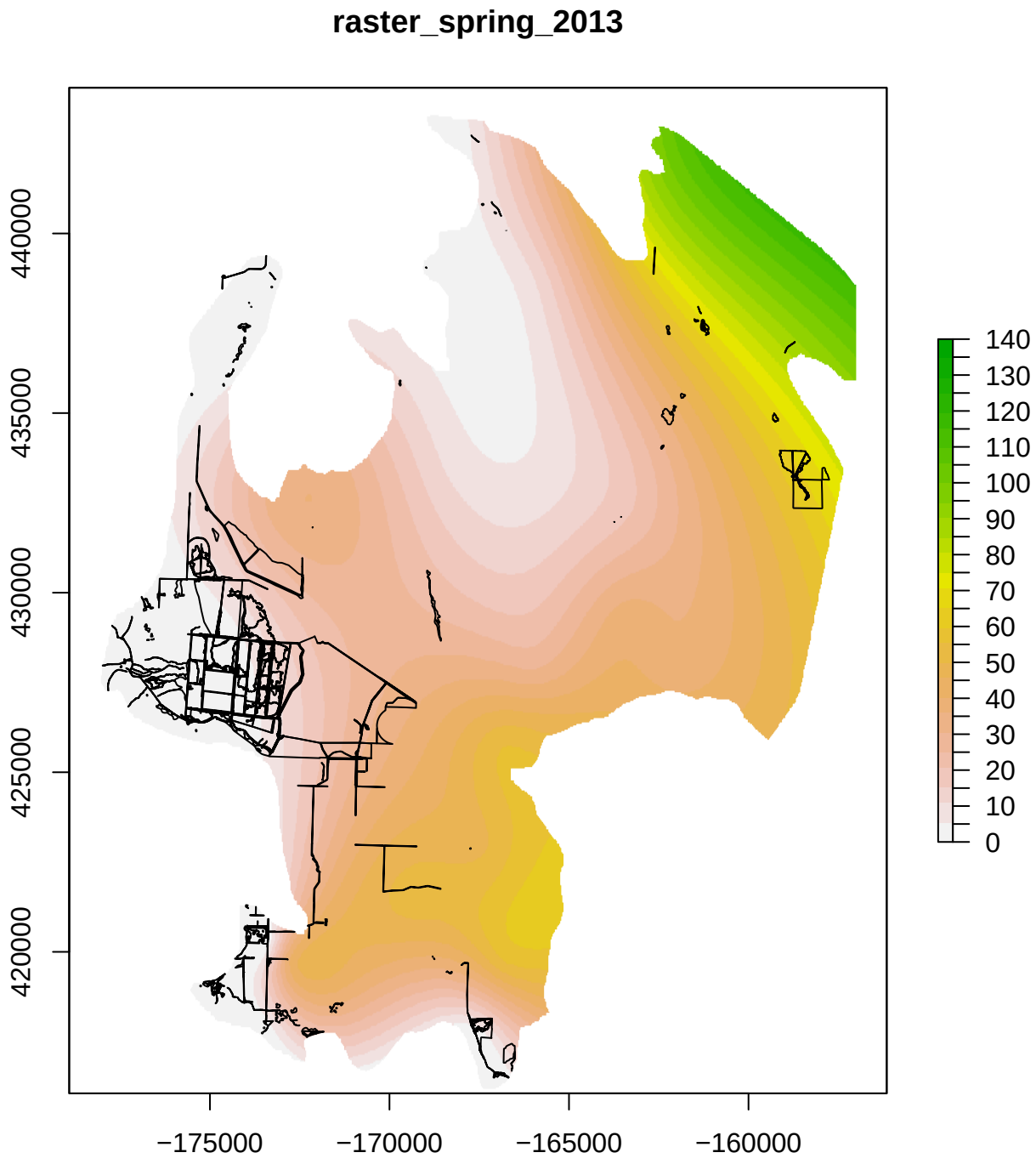


Figure 17: Depth to water, in feet below ground surface.

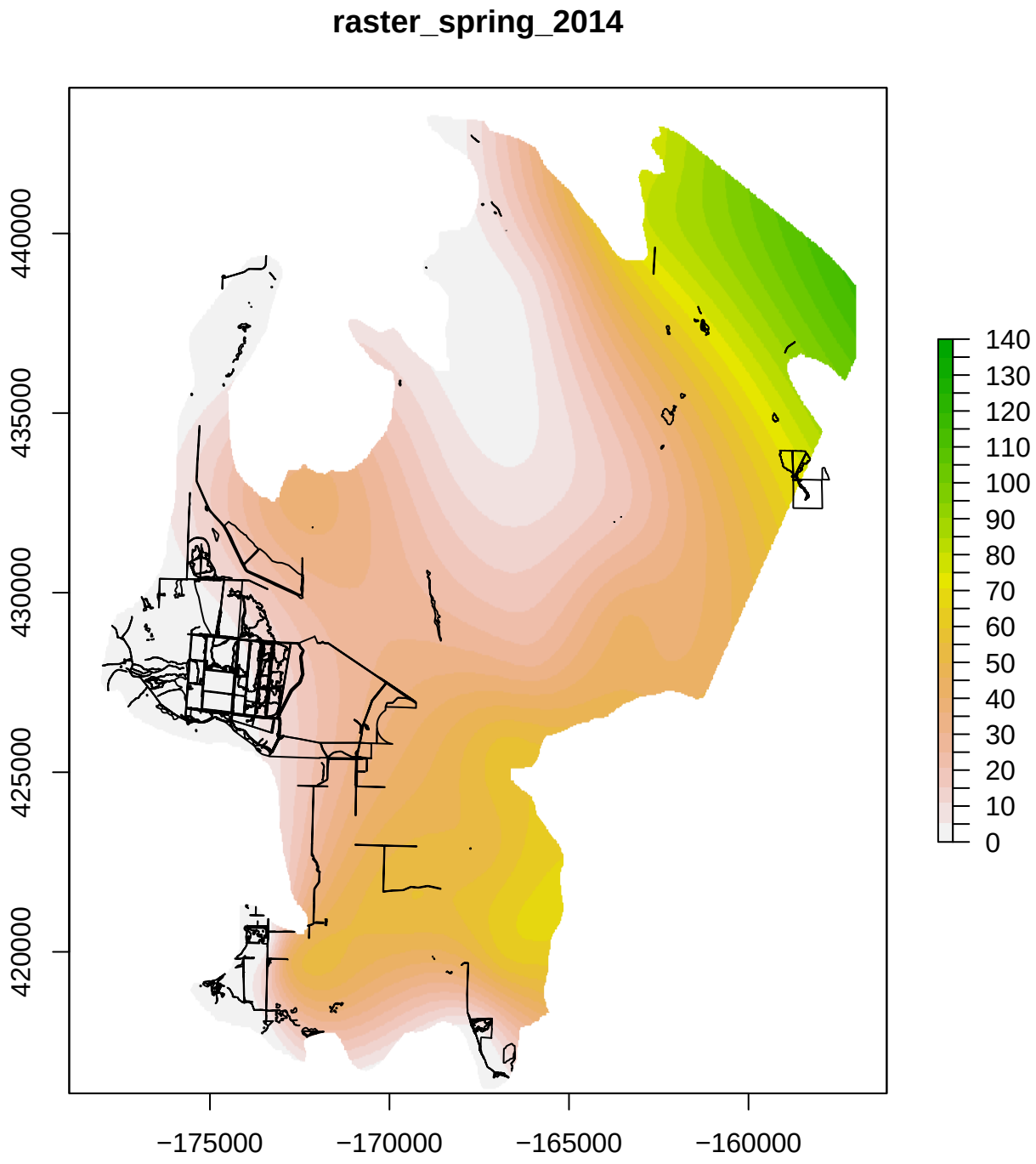


Figure 18: Depth to water, in feet below ground surface.

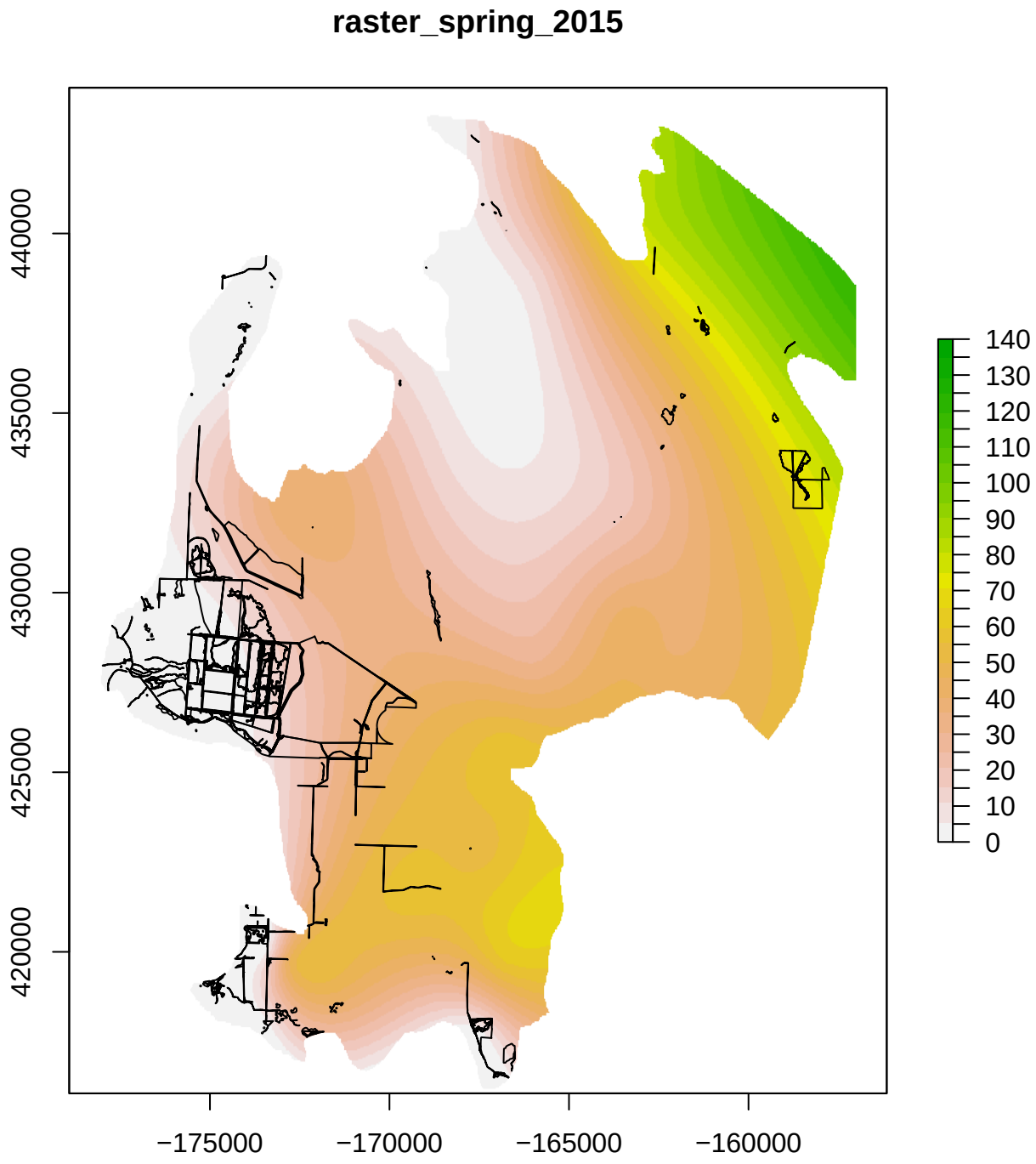


Figure 19: Depth to water, in feet below ground surface.

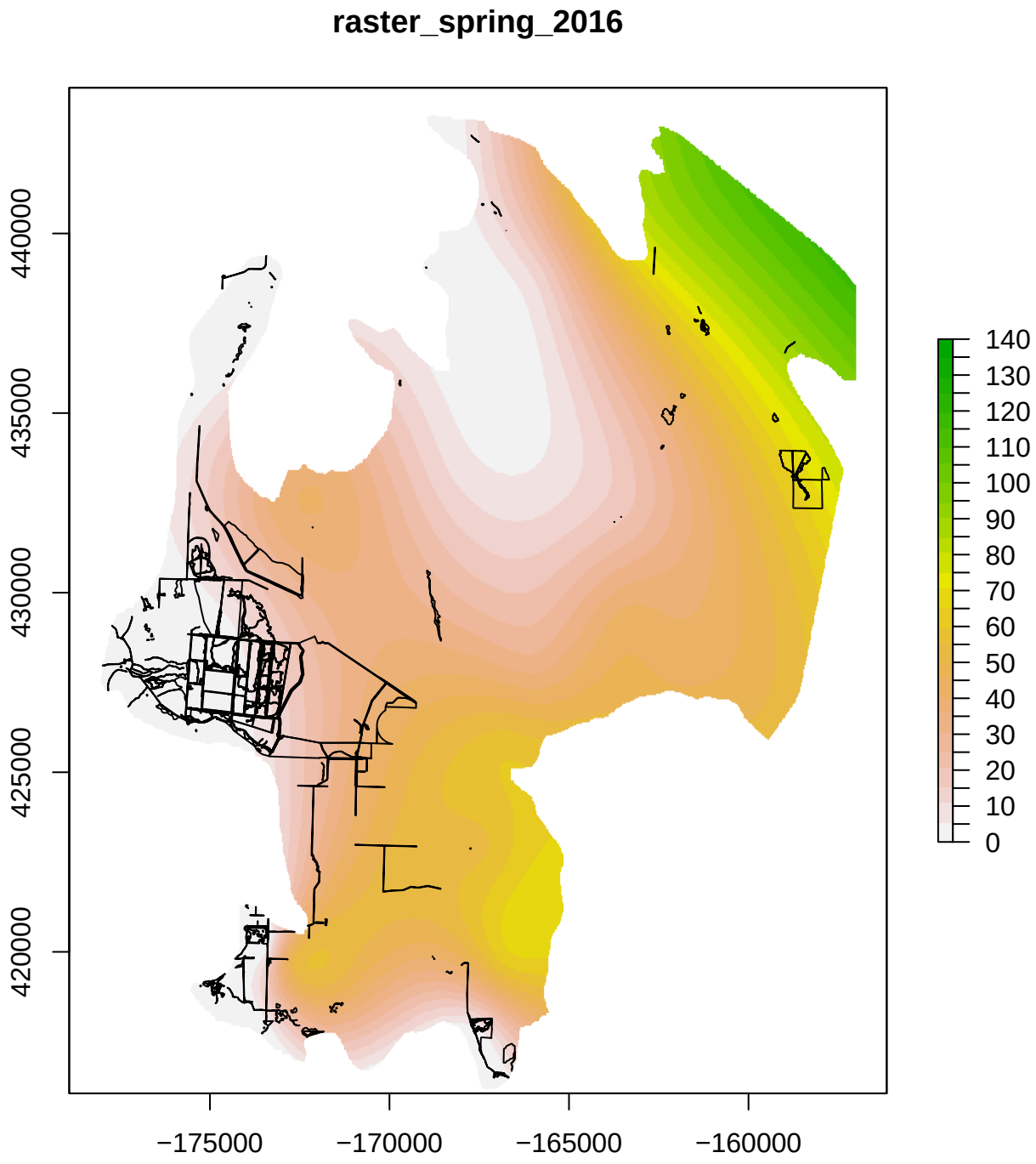


Figure 20: Depth to water, in feet below ground surface.

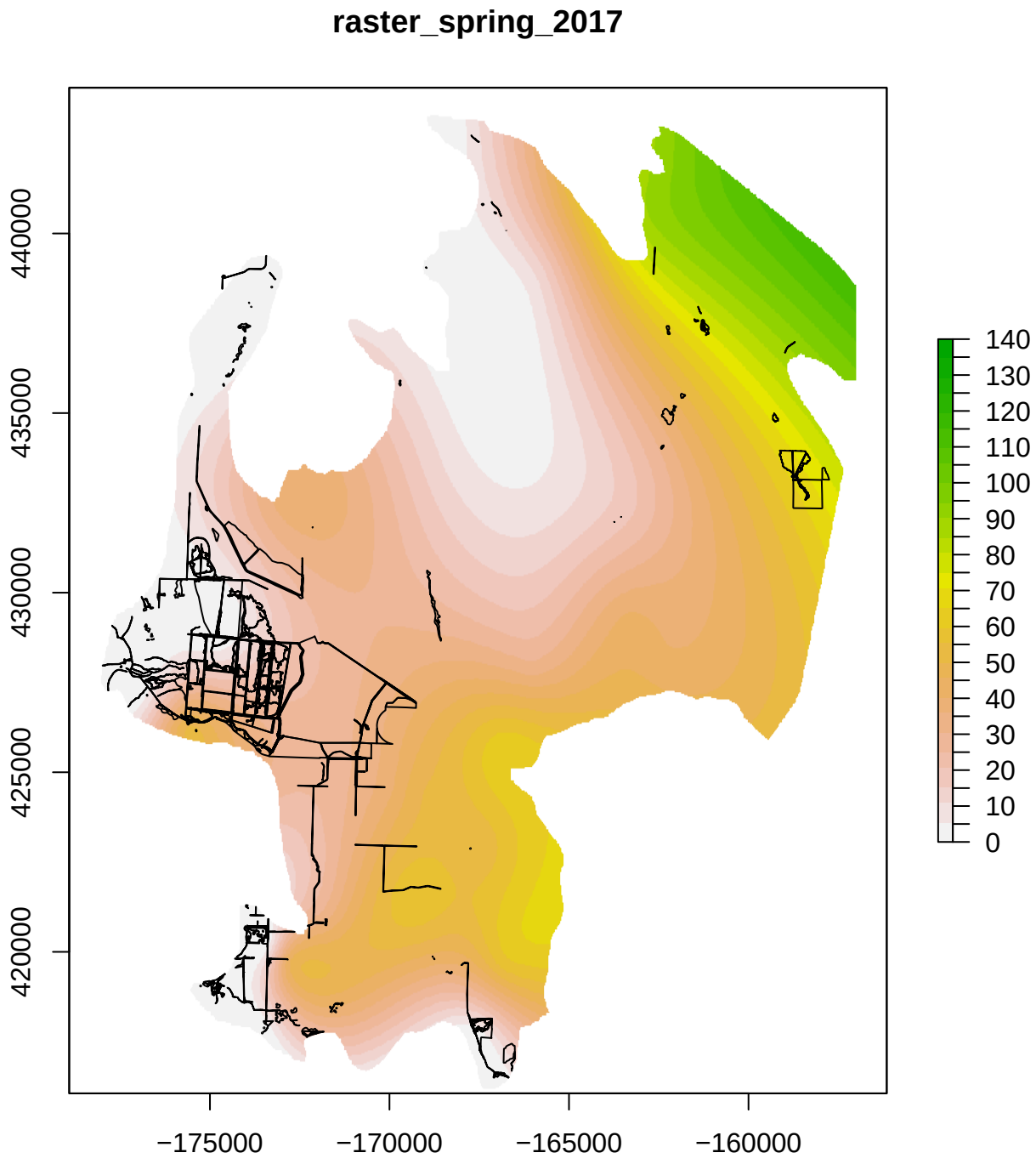


Figure 21: Depth to water, in feet below ground surface.

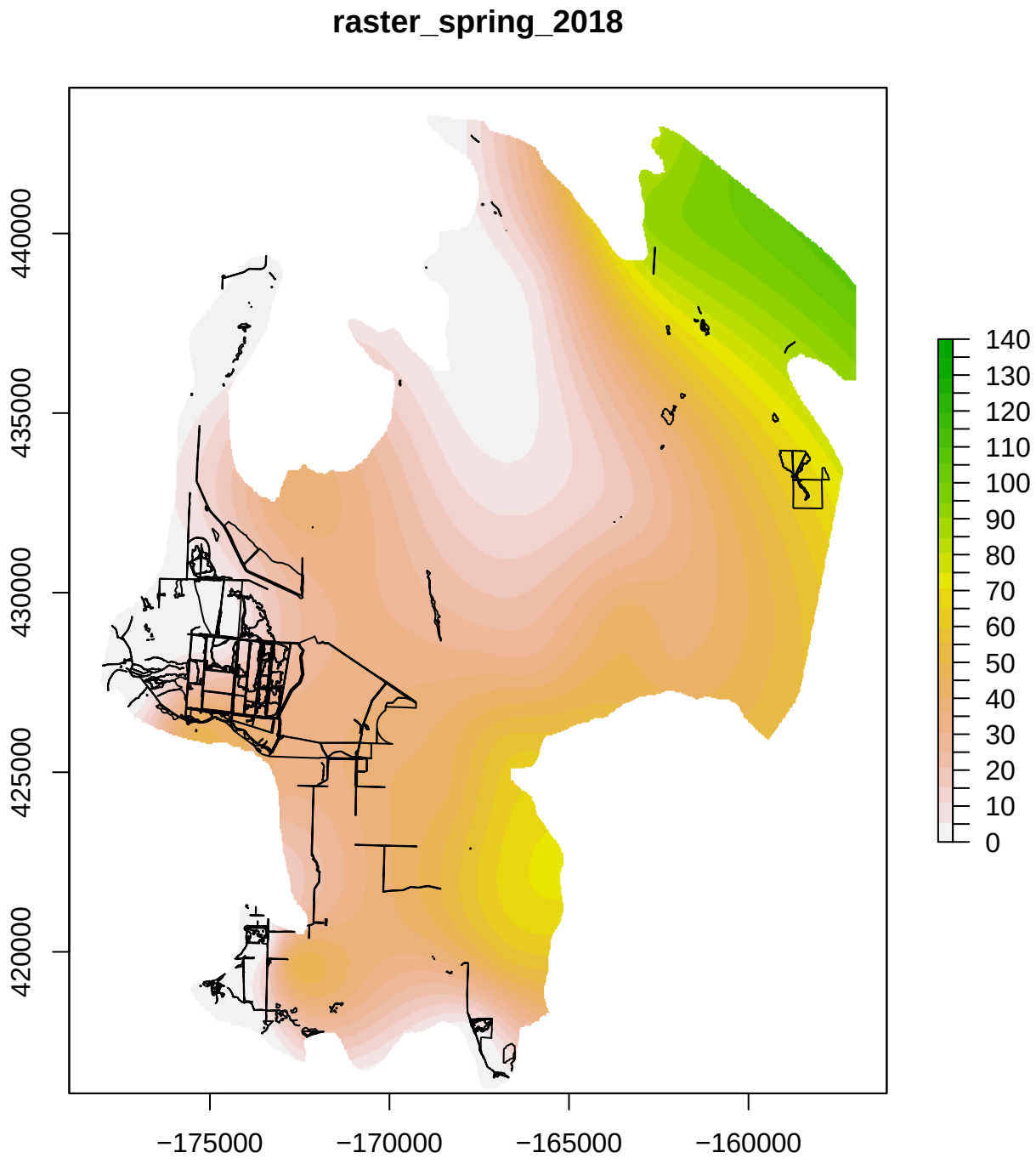


Figure 22: Depth to water, in feet below ground surface.

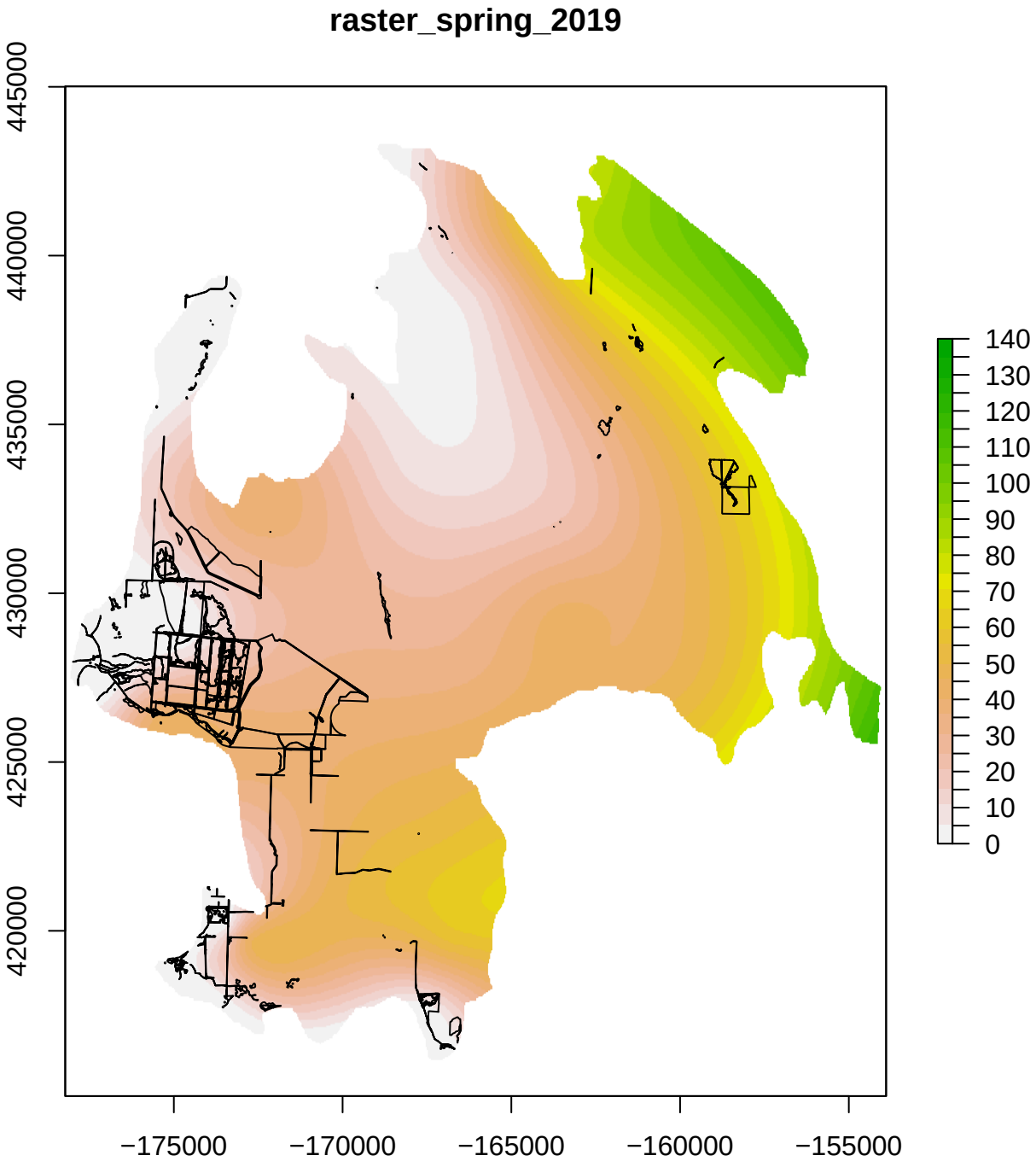


Figure 23: Depth to water, in feet below ground surface.

Appendix 2-D Butte Valley Integrated Hydrologic Model (BVIHM) Documentation

Larry Walker Associates, Inc

2021-09-11

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Appendix 2-D - Butte Valley Integrated Hydrologic Model (BVIHM) Documentation

1 Introduction and Background

This document is Appendix 2-D, supplemental to Chapter 2 of the Butte Valley Groundwater Sustainability Plan (GSP). The purpose of this appendix is to provide additional documentation on the Butte Valley Integrated Hydrologic Model (BVIHM), which was used to estimate water budget components and predict potential future water use and hydrologic conditions, as required under the

Sustainable Groundwater Management Act (Cal. Water Code, Division 6, Part 2.74). Specifically, objectives of this appendix are to:

1. Document the numerical model development
2. Document the calibration of the model
3. Publish the full tables and figures of annual water budget values, a subset of which have been included in Chapter 2 of the GSP.

The Butte Valley Integrated Hydrologic Model (BVIHM) was developed to calculate historical and projected water budgets, to improve understanding of long term trends in groundwater levels, and to assess the impact of climate change, and of projects and management actions on groundwater conditions. The model extends over the southwestern area of the Upper Klamath Basin defined by Gannett et al., stretching from California into Oregon (Gannett et al. 2007) (Gannett, Wagner, and Lite 2012). The BVIHM model area is bounded by the Klamath River to the north, and the Upper Klamath Basin boundary to the west and south. The eastern boundary of the model area extends a few miles to the east of the actual Butte Valley watershed (see Butte Valley GSP Chapter 2.2.3 for further details on the model area extent). The model area includes not only the entire Butte Valley groundwater basin ("Basin"), but also the entire Butte Valley watershed. The model area extent beyond the Butte Valley watershed honors the continuity of the volcanic groundwater system surrounding the Basin with the larger Upper Klamath Basin, Oregon and California . Besides the Basin, BVIHM includes two other Bulletin 118 groundwater basins (DWR 2016): Red Rock Valley (1-018) and Bray Town Area (1-017). The eastern boundary of the BVIHM partially falls within the southwesternmost areas of the Lower Klamath groundwater basin (1-002.02)

The BVIHM is an integrated hydrologic model explicitly coupling models of the land/soil subsystem and of the groundwater subsystem. For BVIHM, the surface water subsystem is ignored due to the lack of larger river systems within the model area. Smaller creeks in the mountains surrounding the Basin collect local runoff and baseflow. However, all creek runoff is recharged into the groundwater system upgradient of or near the upgradient boundary of the Basin. Within the Basin, Meiss Lake is a prominent surface water feature, but its interaction with groundwater is handled through the land/soil subsystem modeling.

The BVIHM land/soil subsystem is divided into A) agricultural and developed lands, and B) the natural landscape. The agricultural and developed land/soil subsystem was simulated with the Davids Engineering Crop Root Zone Water Model (CRZWM) (Davids Engineering 2013), while the natural land/soil subsystem was simulated with the USGS PRMS model (Risley 2019). The land/soil subsystem models are driven by precipitation, evapotranspiration, and crop water demand. They generate spatially and temporally distributed groundwater pumping (CRZWM) and recharge (CRZWM, PRMS) used in the simulation of the groundwater subsystem. CRZWM and PRMS simulate the land/soil subsystem over the entire model area.

The BVIHM groundwater subsystem is simulated with the USGS MODFLOW-2005 software (Harbaugh 2005). The groundwater model encompasses the alluvial aquifer system within the Basin, the volcanic aquifer system within the Basin, and also the surrounding volcanic aquifer system over the remainder of the model area, which is fully connected to the Basin groundwater system.

2 Model Software Summary

2.1 Precipitation Runoff Modeling Software (PRMS)

The USGS PRMS model for the Upper Klamath Watershed (Risley 2019) was applied to the BVIHM. The Upper Klamath PRMS model is recently updated, calibrated surface water subsystem and land/soil subsystem model based on publicly available and well documented software. The model was not only well suited to couple to the groundwater subsystem model, but its inputs could also be adjusted to account for the DWR projected climate scenarios. The main input for PRMS are climate data (daily precipitation and temperature) from 32 climate stations across the Upper Klamath Basin. Of these, 4 climate stations are located within 20 miles of the BVIHM model area boundary, but none are located within the model area. PRMS utilizes the USGS "Draper" tool to extrapolate climate station data across the simulation domain (Risley 2019).

While the Upper Klamath PRMS model includes surface water features and is calibrated to measured streamflows at several gaging stations of the Klamath River Basin, none of the simulated surface water features are within the BVIHM model area. Results from the PRMS model define the spatially and temporally distributed recharge across the natural landscape in the BVIHM model area, resulting from rainfall and excess soil moisture, after accounting for evapotranspiration. The temporal discretization in PRMS is daily, the spatial discretization is by hydrologic response units, discretized into raster pixels with a side length of 888 ft (270 m; also see Butte Valley GSP Chapter 2.2.3).

2.2 Crop Root Zone Water Model (CRZWM)

Davids Engineering developed a Crop Root Zone Water Model (CRZWM) (Appendix 2-E ET and Applied Water Estimates) that calculates the root zone water budget based on the water budget components in Figure 1. PRMS accounts for the root zone water balance parameters using soil type-specific information and crop information for years 2000, 2010, and 2014. Like PRMS, the CRZWM uses precipitation and reference evapotranspiration as the driving model inputs. In CRZWM, spatially interpolated rainfall data from Oregon State's PRISM tool[1] are employed. CRZWM also uses remotely sensed crop data (NDVI estimates using Landsat imagery) to complement crop and irrigation type information when computing crop evapotranspiration (Davids Engineering 2013). Importantly, CRZWM (unlike PRMS) estimates the water demand (*applied water*) needed to produce the crops imaged by the satellite, given the amount of precipitation, evapotranspiration, crop type, and irrigation system. All irrigation (*applied water*) in the Basin is from groundwater pumping. Hence, *applied water* defines the spatially and temporally distributed amount of groundwater pumping. The model's simulation of "*deep percolation*" is assumed to become groundwater recharge.

CRZWM covers all agricultural and developed lands in the model area including those within and adjacent to the Basin, including smaller agricultural areas in Red Rock Valley and near the Braytown area. The temporal discretization in CRZWM is daily, the spatial discretization is by individual field polygons(also see Butte Valley GSP Chapter 2.2.3). Daily water budget components were aggregated to monthly values for BVIHM.

[1] PRISM website: http://prism.oregonstate.edu/

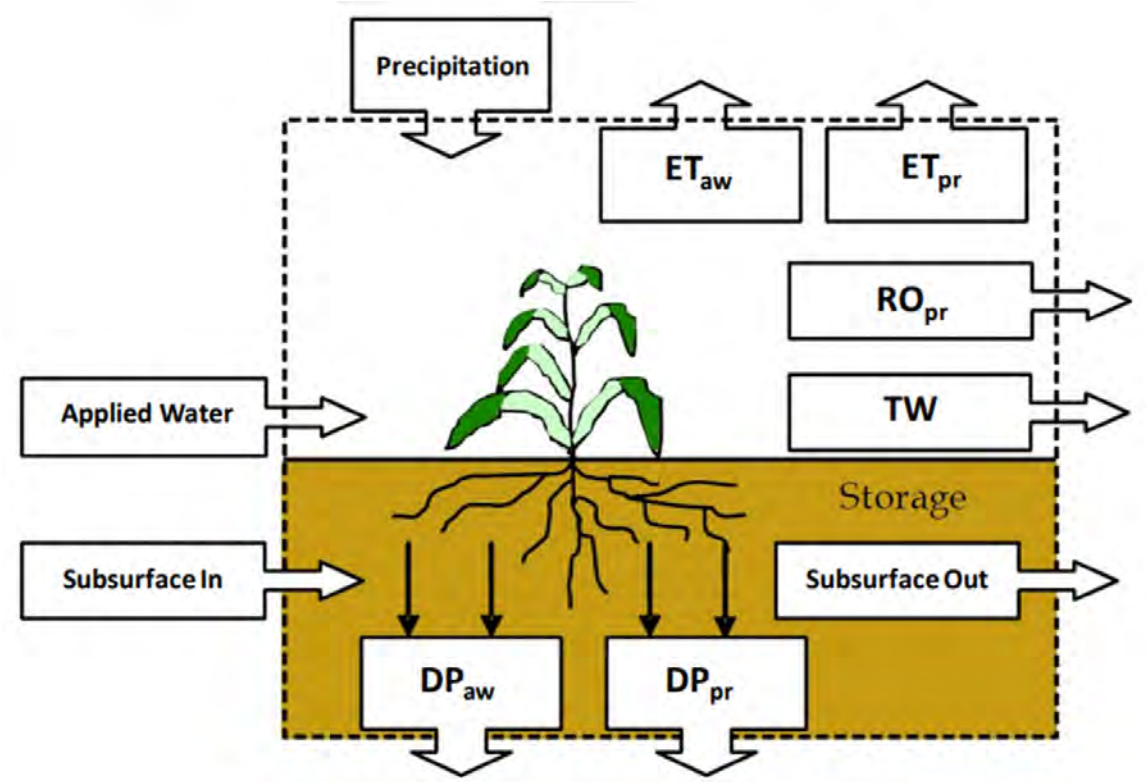


Figure 1: Conceptualization of Fluxes of Water Into and Out of the Crop Root Zone

2.3 MODFLOW

MODFLOW is a finite difference groundwater model that simulates groundwater (GW) flow given user input of initial conditions, aquifer hydraulic parameters and of boundary conditions. MODFLOW simulates the spatially and temporally variable dynamics of groundwater fluxes and groundwater elevations. The information is used to characterize a water budget for the basin and to assess changes in future water levels due to climate change, projects, and management actions.

3 Model Construction

The development of the two land/soil subsystem models in BVIHM is documented extensively in the above mentioned references. Here, we focus on the development of the groundwater subsystem model, using MODFLOW-2005.

3.1 Model Domain

The BVIHM domain encompasses the entire Butte Valley Watershed which includes the Butte Valley alluvial aquifer that nearly covers the same area as the Bulletin 118 Groundwater Basin Figure 2. The watershed that encompasses the alluvial aquifer has a volcanic subsurface. Details of the model domain boundary are described in the Butte Valley GSP Chapter 2.2.3.

3.2 Model Discretization and Boundary Conditions

3.2.1 Spatial Discretization

The MODFLOW model has a grid cell size of 270 m x 270 m corresponding to and spatially coinciding with individual grid cells of the PRMS grid. The same grid was also used for the development of a three-dimensional geological model.

3.2.2 Temporal Discretization

The BVIHM has monthly stress periods with two time steps per month and runs for water years (WY) 1990 to 2018, i.e., from October 1, 1989 to September 30, 2018. Monthly stress periods are appropriate for the BVIHM as there is no surface water routing component and all modeling objectives of interest focus on the groundwater budget at the monthly and annual timescale at which groundwater is typically managed. The BVIHM climate projection model runs were completed from WY1990-WY2070 using the same discretization.

3.2.3 Boundary Conditions

The BVIHM utilizes three types of groundwater boundary conditions: 1. “Specified Head” boundary conditions are used to represent the northern boundary along the Klamath River. The specified head corresponds to the average river surface elevation. 2. “Specified Flux” boundaries with flux specified as zero (“No Flow boundary”) encompass the western and southern boundary and are also specified for the bottom of the simulation domain, and 3. “Head-dependent Flux” boundary conditions are used to represent permeable conditions along the eastern boundary with subsurface outflow to the Lower Klamath Lake Basin and other areas east of the model area. The surface of the groundwater simulation domain has a spatially and temporally varying “Specified Flux” boundary condition equal to the recharge defined by CRZWM and PRMS. Groundwater pumping (an internal “Specified Flux” boundary condition) is defined by CRZWM, also a spatially and temporally varying condition.

3.3 Model Layering and Zonation

The MODFLOW model has 8 layers to represent the hydrogeologic model with the alluvial aquifer represented in layers one to three and ends in layer 4. The Quaternary volcanic aquifer represents the majority of the active model domain surrounding the alluvial aquifer. A relatively small portion of the model area, abutting to the Klamath River consists of low permeability tertiary volcanics. An outcrop of Quaternary Basalt is found south of and adjacent to the alluvial aquifer. It is present in the first two layers of the model. However, this geologic system was parameterized identical to the larger Quaternary Volcanics aquifer, as only very limited water level observation data exist in the Basalt. A separate calibration of Basalt hydraulic conductivity was therefore not possible. Hence, the current version of BVIHM relies on three hydrogeologic zones, each characterized by its own hydraulic conductivity, specific yield, and specific storage coefficient: tertiary volcanics (low permeability), Quaternary volcanics (intermediate permeability), and alluvium (high permeability).

Table 1: Model Layers and Hydrogeologic Units

Model Layers	Hydrogeologic Unit
1-4	Butte Valley Alluvium
1-2	Quaternary Basalt
1-8	Quaternary Volcanics
1-8	Tertiary Volcanics

3.4 MODFLOW Packages Used to Calculate Groundwater Flows

Table 2: MODFLOW Pachages used to Calculate Groundwater Flows in the Basin

MODFLOW Package	Application
LPF	Geologic model
GHB	Subsurface outflow to Lower Klamath Lake Basin
CHD	Subsurface outflow to Klamath River
RCH	Recharge from irrigation and rainfall
WEL	Groundwater pumping for irrigation needs
OC	Output for each stress period
PCGN	Numerical solver

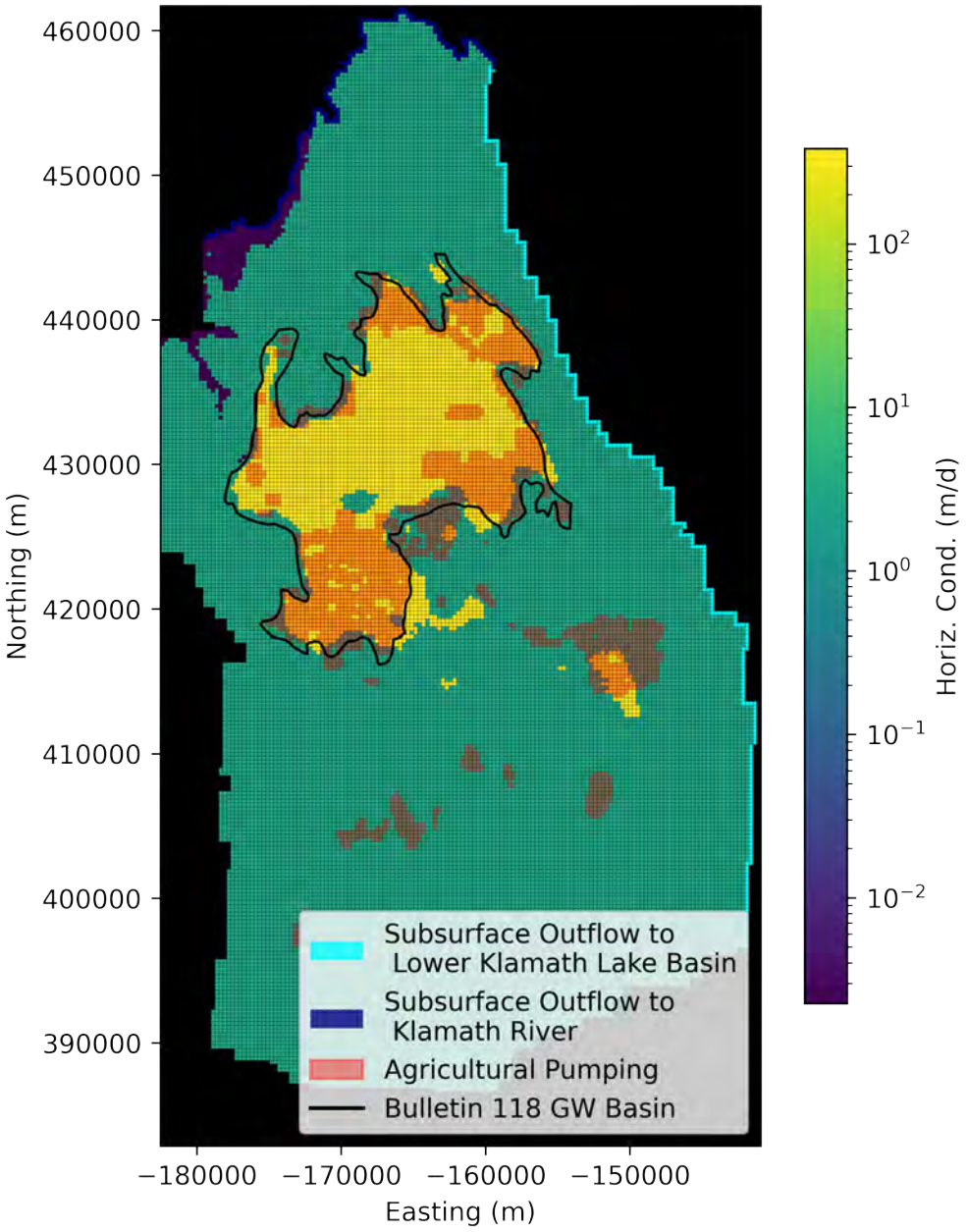


Figure 2: Active model domain with hydrostratigraphy identified by horizontal hydraulic conductivity; Tertiary Volcanics are in purple, Quaternary Volcanics are in green and the Alluvium is in yellow.

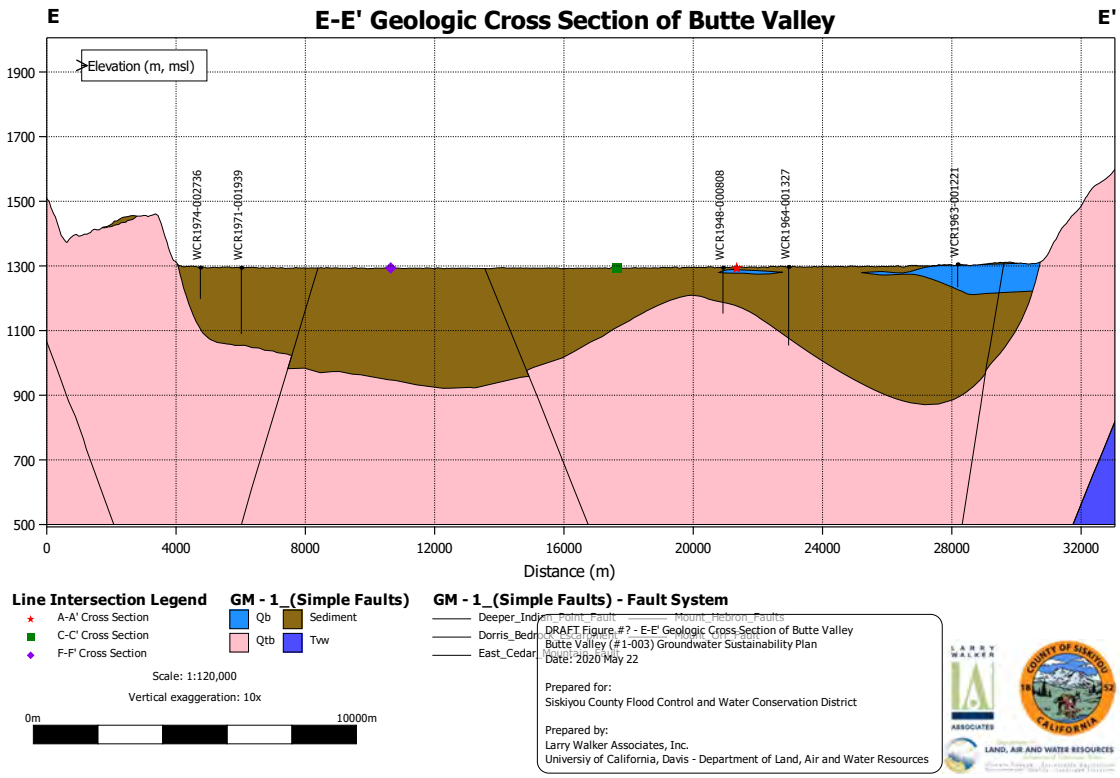


Figure 3: Cross Section E-E’ crosses Butte Valley from the south to the north

4 Model Input Data

A geologic model was developed to represent the alluvium, Quaternary volcanic, Quaternary basalt and Tertiary volcanic hydrogeologic units based on the digitization and analysis of hundreds of DWR well logs. The Klamath River specified head boundary was created using NHD Streamlines and an upscaled USGS 10 meter DEM. The Lower Klamath Lake Basin head dependent boundary was created using the head output and model discretization from the upper Klamath Basin regional groundwater model (Gannett, Wagner, and Lite 2012).

4.1 Land Use

The urban areas in Butte Valley are relatively small and dispersed throughout the agriculturally developed region. The latter represents the majority of the Butte Valley groundwater basin land use. Most of the upper watershed surrounding the Basin is represented by natural lands that are non-irrigated. Three land use maps are available from the California Department of Water Resources for the Basin: 2000, 2010, and 2014.

4.2 Atmospheric Data and Watershed Data

Atmospheric data is not directly used in the MODFLOW model but rather applied to the PRMS and CRZWM models whose output are then passed to the MODFLOW model as recharge. Details are well documented in the documentation of PRMS (Risley 2019) and CRZWM (Appendix 2-E ET and Applied Water Estimates). Briefly, for precipitation, the CRZWM model uses PRISM data[2] from Oregon State University to distribute climate station data to individual locations. The PRMS model for the Upper Klamath Basin utilizes a methodology ("Draper") equivalent to PRISM to distribute climate station data to individual hydrologic response units by mathematical extrapolation. For evapotranspiration, the CRZWM model uses bi-weekly NDVI values derived from Landsat imagery and the California Irrigation Management Information System (CIMIS) reference evapotranspiration (ET_o) data[3] to calculate actual evapotranspiration. Air temperature data from a NOAA weather station was used to calculate ET_o using the Hargreaves and Samani method (1985) when CIMIS ET_o was not available for a given period. PRMS utilizes the Jensen-Haise method to estimate potential evapotranspiration and adjusts to match documented mean monthly evapotranspiration in the Upper Klamath Basin.

Other watershed input data used by PRMS and CRZWM include soil type, vegetation type, slope, and others Davids Engineering (2013).

4.3 Hydrofacies Hydraulic Properties (Aquifer Properties)

The expected range of hydraulic properties (i.e., specific storage, *Ss*, specific yield, *SY*, horizontal hydraulic conductivity, *HK*, and vertical hydraulic conductivity, *VK*) for the four hydrogeologic units were obtained from a literature survey of aquifer hydraulic properties found elsewhere for

[2] PRISM website: http://prism.oregonstate.edu/

[3] Spatial CIMIS is a gridded ETo product available from DWR. Long-term average gridded ETo was estimated based on ETo grids for the years 2004 to 2018.

these diverse aquifer types (Kuang et al. 2020). These hydraulic properties were set as the initial conditions of the MODFLOW model before undergoing model calibration. The sensitivity analysis found that the model had little sensitivity to the Quaternary Basalt formation because of the lack of observations in the unit, thus it was set to match the properties of the Quaternary Volcanics.

4.4 Pumping Well Data

Groundwater pumping data assigned to specific pumping well location and depth are not currently detailed to a degree sufficient for groundwater modeling. Instead, groundwater pumping for each individual MODFLOW grid cell was assigned based on the *Applied Water* calculated in CRZWM. Based on review of DWR well logs it was found that the typical agricultural well depth was 150-450 ft below ground surface. Grid cell specific pumping was distributed evenly across layers 2-4, which correspond approximately to these well depths.

4.5 Crop types, crop coefficients, and irrigation efficiencies

Alfalfa, grain and hay, strawberries and pasture are the primary irrigated crops in Butte Valley. As crop coefficient data was calculated using LandSat NDVI data there are not three values for each crop, but rather a gradual change from dormancy to the growing season and after harvest. Plots of the crop coefficient data over time area available in Section 4.4 of Appendix-2E on CRZWM.

4.6 Data Gaps in Model Input Data

As stated in Section 4.4, there is no pumping well data available in the basin which is remedied by estimating groundwater pumping based on the expected applied water for irrigated lands. As the GSP process moves forward, metering agricultural and public supply wells (i.e., all wells except de minimis users) would improve the estimates of current and future groundwater pumping, benefiting the understanding of storage dynamics in the basin. Additionally, the currently available DWR well record completion reports have limited data on total well depth and screened interval which are essential to accurately allocating groundwater pumping to the correct vertical aquifer sections being pumped. Drawdown in the relatively unconfined Alluvial Aquifer will be different from that in the confined Quaternary Volcanics Aquifer. A field campaign using a well borehole camera would be able to measure the screened interval(s) of all active agricultural and public supply wells in the basin if funding is available. Future iterations of the BVIHM will include the Meiss Lake water budget (it was unavailable for inclusion at the time of model development) in the groundwater flow model as it is an artificial wetland that is operated by pumping groundwater to the surface where some water is recharged to the aquifer and some is lost to evapotranspiration. Currently Meiss

Table 3: Expected ranges of hydraulic properties

	Ss min (m^{-1})	Ss max (m^{-1})	K min (m/s)	K max (m/s)	Ss mean (m^{-1})	K mean (m/s)
Sand	10^{-7}	0.00241	1.13×10^{-5}	0.00255	2.88×10^{-5}	1.21×10^{-4}
Fractured igneous and metamorphic rocks	1.28×10^{-8}	3.63×10^{-5}	7.52×10^{-9}	10^{-5}	8.58×10^{-7}	7.93×10^{-8}
Basalt	1.3×10^{-7}	4.7×10^{-6}	0.003	0.019	4.3×10^{-7}	0.00755

Lake is represented as natural lands where the net recharge is calculated from PRMS accounting for precipitation and evapotranspiration and other soil water budget terms. Future iterations of the Meiss Lake region in the BVIHM will account for the applied water demand that exists to maintain saturation of the wetlands.

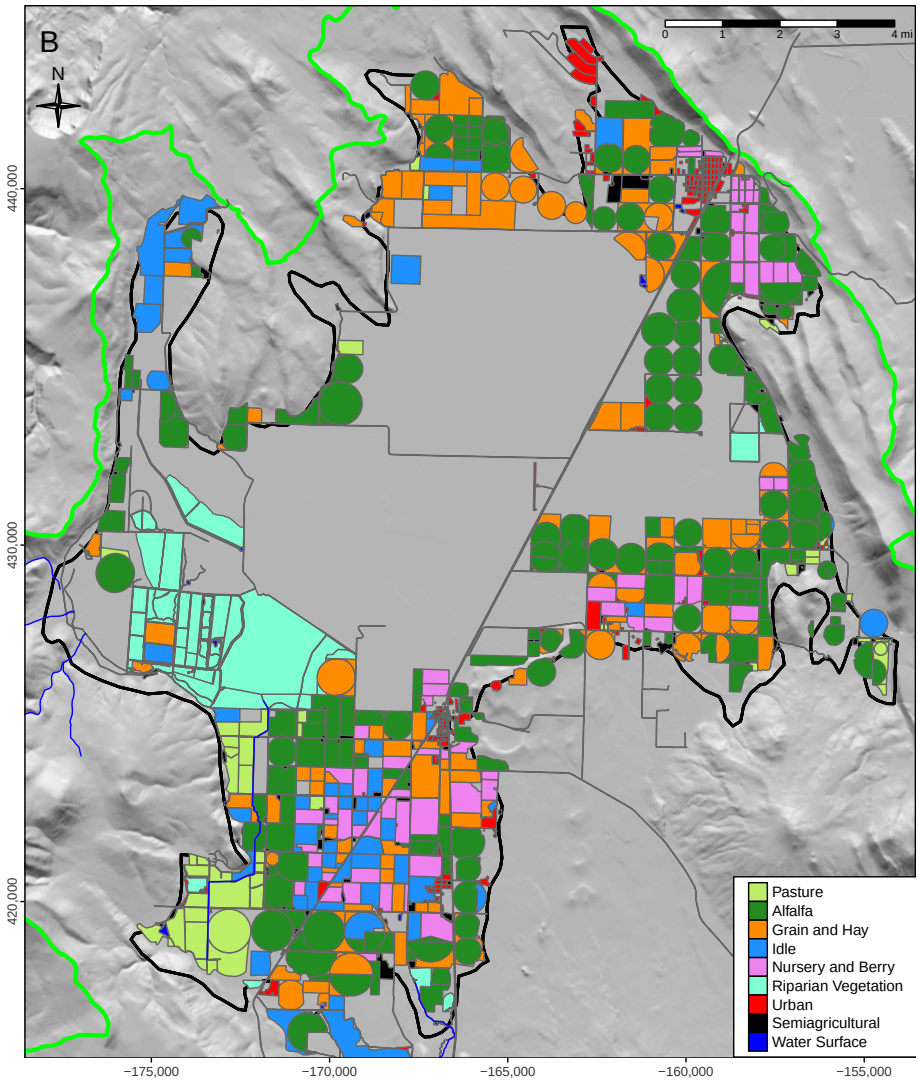


Figure 4: Land use within the Butte Valley groundwater basin (black outline) in the summer of 2014. Grey areas are natural vegetation or outside the Basin boundaries.

5 Calibration Target Data and Objective Functions

The sensitivity analysis and calibration software UCODE2014 was applied to the BVIHM under both steady state and transient groundwater flow conditions. UCODE2014 uses the sum of square weighted residuals as the objective function for determining the models ability to match observations.

5.1 Groundwater Outflow Calibration Targets

Previous groundwater modelling work by Gannett et al. quantified the expected subsurface seepage to the Klamath River which was applied as a low weighted flow observation, with a coefficient of variation of 40% (Gannett, Wagner, and Lite 2012). This observation was largely controlled by the hydraulic conductivity of the (low permeable) Tertiary volcanics that groundwater flow must pass through to reach the Klamath River specified head boundary. The Tertiary volcanics provide a critical barrier that keeps groundwater from flowing into the topographically much lower Klamath River, which is as much as 1000 ft lower than Butte Valley. This outflow target provides a tool to determine appropriate hydraulic conductivity values for this important geologic formation.

5.2 Groundwater Elevation Calibration Targets

The state database of periodic groundwater level measurements was filtered and cleaned for the Butte Valley area and modeled time period to create a database of groundwater observations that were corrected with respect to the model top elevations. In addition to the periodic groundwater level measurements, LWA has collected continuous groundwater level data in stakeholder wells from 2015-present that were included as well on a monthly basis Figure 5. The groundwater level observations were weighted using a variance of 1.0025. Additionally the locations and ground surface locations of creeks and springs throughout the upper watershed of Butte Valley were included as head observations in the spring time, but with a coefficient of variation of 10%.

5.3 Data Gaps in Calibration Data

Currently observation well data are limited to the extent of the Alluvial Aquifer with a few wells located on the boundary with the Quaternary Volcanic Aquifer. The majority of these observation wells do not have total well depth or screened interval data available so it is uncertain whether they are screened in the Alluvial or Quaternary Volcanic aquifer or both. A field campaign using a well borehole camera to measure this missing data would be able to better determine which aquifer the wells are screened in and improve the calibration of specific yield and specific storage that are dependent on well drawdown data. The construction of new monitoring wells in the Quaternary Volcanics and Basalt Aquifers would provide data on the long term and seasonal trends in water levels which would enable the Basalt Aquifer to be calibrated separately from the Quaternary Volcanics aquifer. This would improve understanding of storage coefficients and drawdown in the Basalt Aquifer to improve the estimate of the sustainable yield.

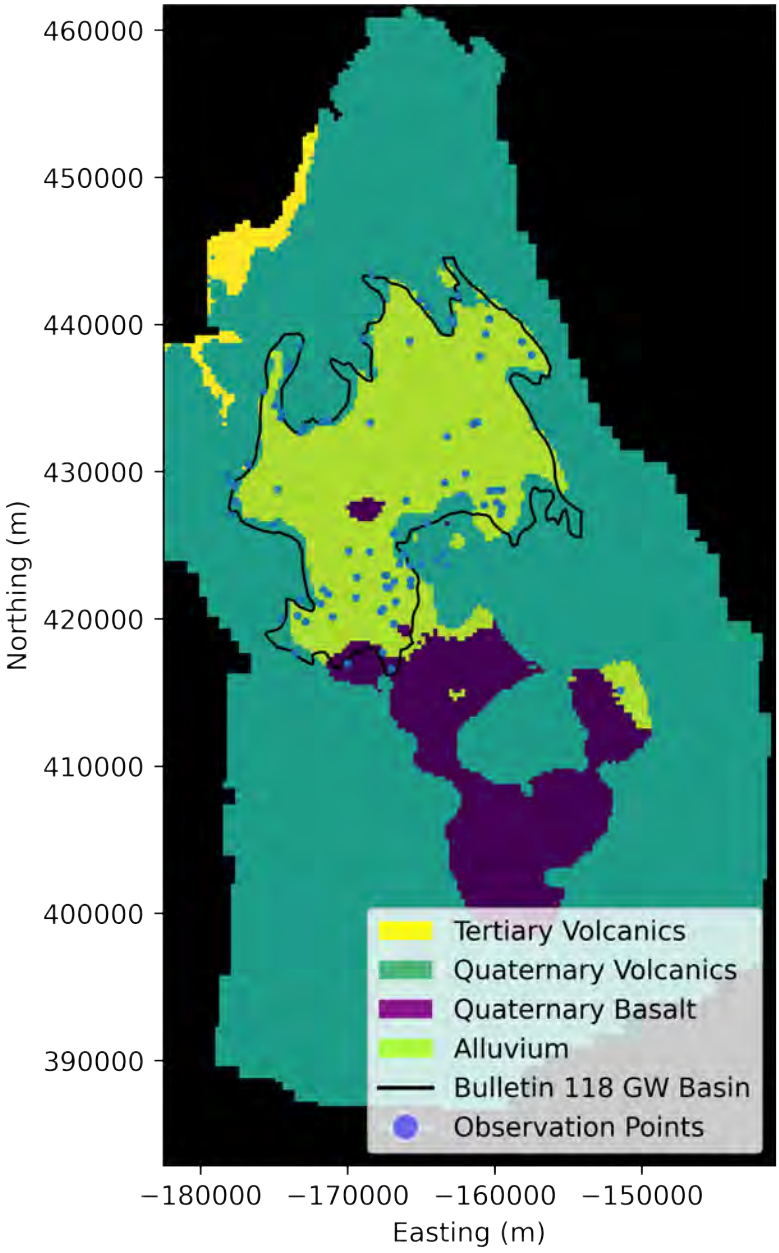


Figure 5: Location of observation wells, creeks and springs for groundwater model calibration

6 Calibration Methodology Summary

The BVIHM steady state model was developed using spatially distributed average recharge and pumping for the first ten years of the model run period,from WY1990-2000. The steady-state model was calibrated using the averaged observations for the same period. Steady state calibration was performed on the three horizontal hydraulic conductivity parameters for the previously identified hydrogeologic units. Due to North-South faulting the horizontal hydraulic conductivity in the north-south direction was assumed to be twice as large as the conductivity in the east-west direction, and the vertical hydraulic conductivity was assumed to be $\frac{1}{30}$ of the horizontal conductivity, which is approximately the logarithmic average between a vertical anisotropy ratio of $\frac{1}{10}$ and $\frac{1}{100}$.

The BVIHM transient model which ran from WY1990-2018 was calibrated against the groundwater elevation and outflow targets described previously. The hydraulic conductivity and storativity were calibrated for the same three hydrogeologic units.

7 Model Calibration Results

7.1 Sensitivity Analyses

Through Sensitivity Analysis the Composite Scaled Sensitivity (CSS) was used to determine that the groundwater pumping and recharge have a very large influence on the simulated groundwater heads as expected. Testing of different initial hydraulic parameters demonstrated that the hydraulic parameters of the alluvium and Quaternary volcanics tended to have the largest CSS. The storage coefficients of the Quaternary Volcanics had a slightly larger CSS after calibration than the storage coefficients of the alluvium, this makes sense as the volcanic aquifer surrounds the alluvium and enforces the heads at the boundary of the alluvium. And as the alluvium has a much larger hydraulic conductivity there is a very mild hydraulic gradient, further increasing the impact of the groundwater heads of the volcanic aquifer on the observations in the alluvium.

Under initial hydraulic parameters the Quaternary and Tertiary volcanics had a large correlation as expected because the Quaternary volcanics limit outflow to the Tertiary volcanics, however, as model calibration further decreased the hydraulic conductivity of the Tertiary volcanics to limit outflow to the Klamath River, given observed groundwater gains in the Klamath River. This lead to dissipation of a significant correlation with the Quaternary volcanics.

7.2 Groundwater Head Calibration Results (MODFLOW)

The hydrographs below present the observed groundwater hydrographs versus the simulated heads (after calibration) for all wells with more than 20 measurements Figure 7. The map below shows the location of each observation well in the model domain using the MODFLOW node as the naming convention for observations. The map of observations demonstrates that the majority of wells with observations are spatially located at locations overlying the alluvial aquifer, except for few wells near the margin of the alluvial aquifer. For the latter it is unknown, whether the well screen would be intersecting with the alluvial units, the volcanic units, or both. The information was not available from well driller reports Figure 8.

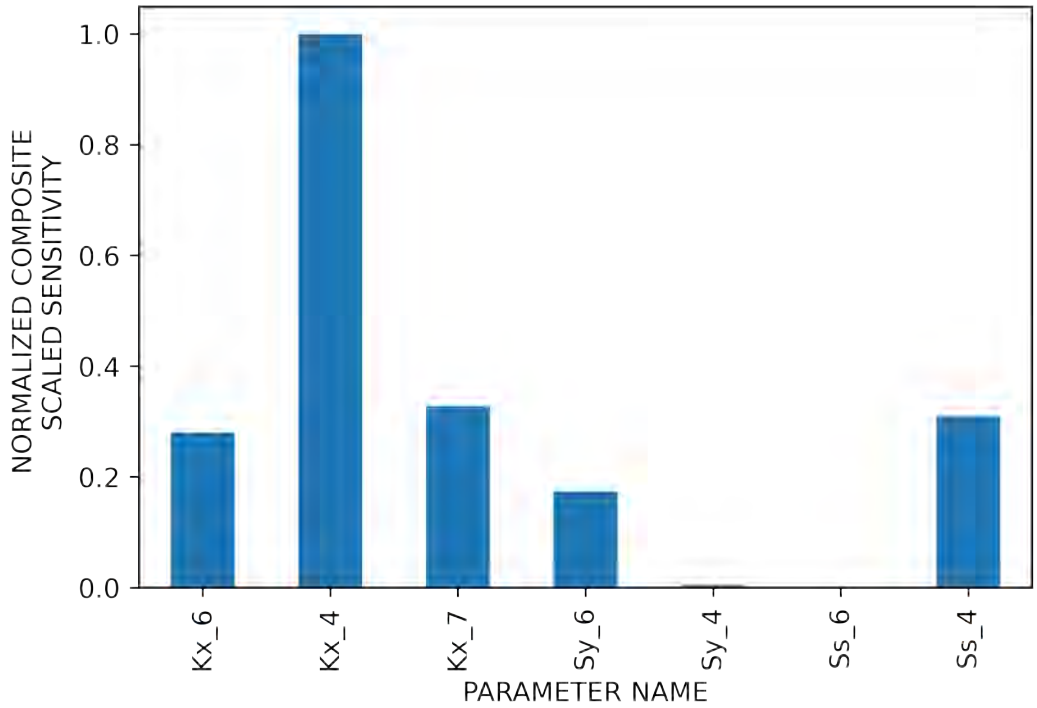


Figure 6: Normalized Composite Scaled Sensitivity of the final parameters used in model calibration.

The hydrographs, on average, show a relatively good fit of the simulated data to the observed data: some wells are matched closely, some well water levels are consistently under-estimated and some water level hydrographs are consistently over-estimated. In general, both the observed seasonal and the observed longterm water level dynamics (longterm decline and rise of water levels) are well captured by the simulated data; the seasonal groundwater pumping amplitudes were very closely matched by some wells and over- or under-estimated by others. Differences between simulated and observed seasonal hydrograph amplitudes may be due to the wells not being screened in aquifer unit that was modeled based on the geologic modeln and well depth. Currently, there is no information on screened interval for many of the wells for which water level data are available (Section 5.3).

7.2.1 Hydraulic Properties by Layer/Zone (MODFLOW)

As stated in section section 6 the steady state calibration was done for the hydraulic conductivity of the alluvium, Tertiary volcanics and Quaternary volcanics. The hydraulic conductivity for the Quaternary basalt was set equal to that of the Quaternary volcanics. The initial values for the calibration were based on a combination of the expected ranges in hydraulic parameters and previous test models that manually matched groundwater levels in the census-designated area of MacDoel and the city of Dorris. Water levels at the northern and eastern boundary of the model are defined with fixed and with general head boundary conditions. Hence, the hydraulic conductivity of the Quaternary volcanics strongly controls water levels in the region near Dorris, at the boundary between the alluvium and the Quaternary volcanics. The very small hydraulic gradient between MacDoel area

and the Dorris area is largely determined by the (high) hydraulic conductivity of the alluvium. The steady state calibration with UCODE2014 showed a significant decrease in the sum of squared weighted residuals (SOSWR) due to calibration of the hydraulic conductivities. Calibrating the hydraulic conductivity in the Quaternary volcanics determines the simulated groundwater levels in the area near Dorris and the entire eastern boundary of the alluvium due to groundwater outflow from the alluvium into the eastern and northern Quaternary volcanics and further through those to the constant and general head boundaries along the eastern and northern model area boundary.

Because of the shallow gradient across the alluvium, the K value for the Quaternary volcanics has a strong influence on water levels across all wells in the alluvial Basin. A single, uniform K value for the Quaternary volcanics could be calibrated to set simulated heads to be in the correct range of observed values. The calibration of the hydraulic conductivity of the alluvium focused on the hydraulic gradient across the (alluvial) Basin itself, where most of the observation wells are. The calibration of the K value for the alluvium sought to best match observed regional groundwater level gradients within the Basin. The calibration of the hydraulic conductivity of the alluvium also adjusted for the observed larger cones of depression from pumping by wells. However, localized cones of depression and water levels in pumping wells were not matched due to the coarser spatial resolution of the model (270 m x 270 m).

Transient calibration was first implemented to calibrate the hydraulic conductivity and storativity (STORAGE COEFFICIENT option in MODFLOW-2005) for all four hydrogeologic units individually. The initial SOSWR is larger for the transient calibration than after the steady state calibration because 20 more years of observation data is now included and it is no longer averaged. Calibration and sensitivity analysis found that the hydraulic conductivity and storativity of the Quaternary basalt and the storativity of the Tertiary volcanics do not have a large impact on model results. It is more difficult to calibrate the storage coefficients of the aquifers because the well observations available often do not have data on their screened interval. The simulated screen location was therefore highly uncertain.

The transient calibration included the hydraulic conductivity previously calibrated and storage coefficients for the Quaternary volcanics and alluvium; the Tertiary volcanics were not calibrated for storage coefficients because there are no groundwater level observations in or near that aquifer to represent the seasonal and interannual head fluctuations. Contrary to initial expectation, the calibration suggested that the alluvium should have a much smaller storage coefficient due to the large seasonal head fluctuations seen in the observations. This result suggests that the alluvial aquifer may be more heterogeneous with potential for partially confining layers. Also, wells that are potentially screened in the volcanic aquifer below the alluvium within which they are simulated.

7.2.2 Boundary Condition Calibration (MODFLOW)

The boundary conditions were not directly calibrated as the outflow to both the Klamath River and the Lower Klamath Lake Basin were controlled by the hydraulic conductivities of the Tertiary vol-

Table 4: Steady state calibration results

Iteration	Alluvium K_x (m/d)	Quaternary Volcanics K_x (m/d)	Tertiary Volcanics K_x (m/d)	Sum of Squared Weighted Residuals
0	316	1.7	0.024	7.61×10^4
9	575	3.1	0.0295	1.04×10^4

Table 5: First Transient Model Calibration Results,

Iteration	Alluvium K_x (m/d)	Quaternary Volcanics K_x (m/d)	Quaternary Basalt K_x (m/d)	Tertiary Volcanics K_x (m/d)	Alluvium S	Quaternary Volcanics S	Quaternary Basalt S	Tertiary Volcanics S	Sum of Squared Weighted Residuals	Total Observations
0	600	2	2	0.5	0.15	0.15	0.15	0.15	9.7×10^5	1636
−9	316.1	1.712	0.033	0.0241	0.05	0.4	0.05	0.39	3.1201×10^4	1636

Table 6: Final Transient Model Calibration Results

Iteration	Alluvium K_x (m/d)	Quaternary Volcanics K_x (m/d)	Tertiary Volcanics K_x (m/d)	Alluvium S_y	Volcanics S_y	Alluvium $S_s(m^{-1})$	Volcanics $S_s(m^{-1})$	Sum of Squared Weighted Residuals	Total Observations
0	364	2.8	0.008	0.12	0.002	5×10^{-8}	7×10^{-5}	7.1393×10^4	1940
10	383.4	2.755	0.00225	0.1138	0.001	1.8×10^{-8}	9.69×10^{-5}	5.4049×10^4	1940

canics and Quaternary volcanics respectively. The general head boundary condition was indirectly calibrated by using the Quaternary volcanics K value for computing the general head conductance term.

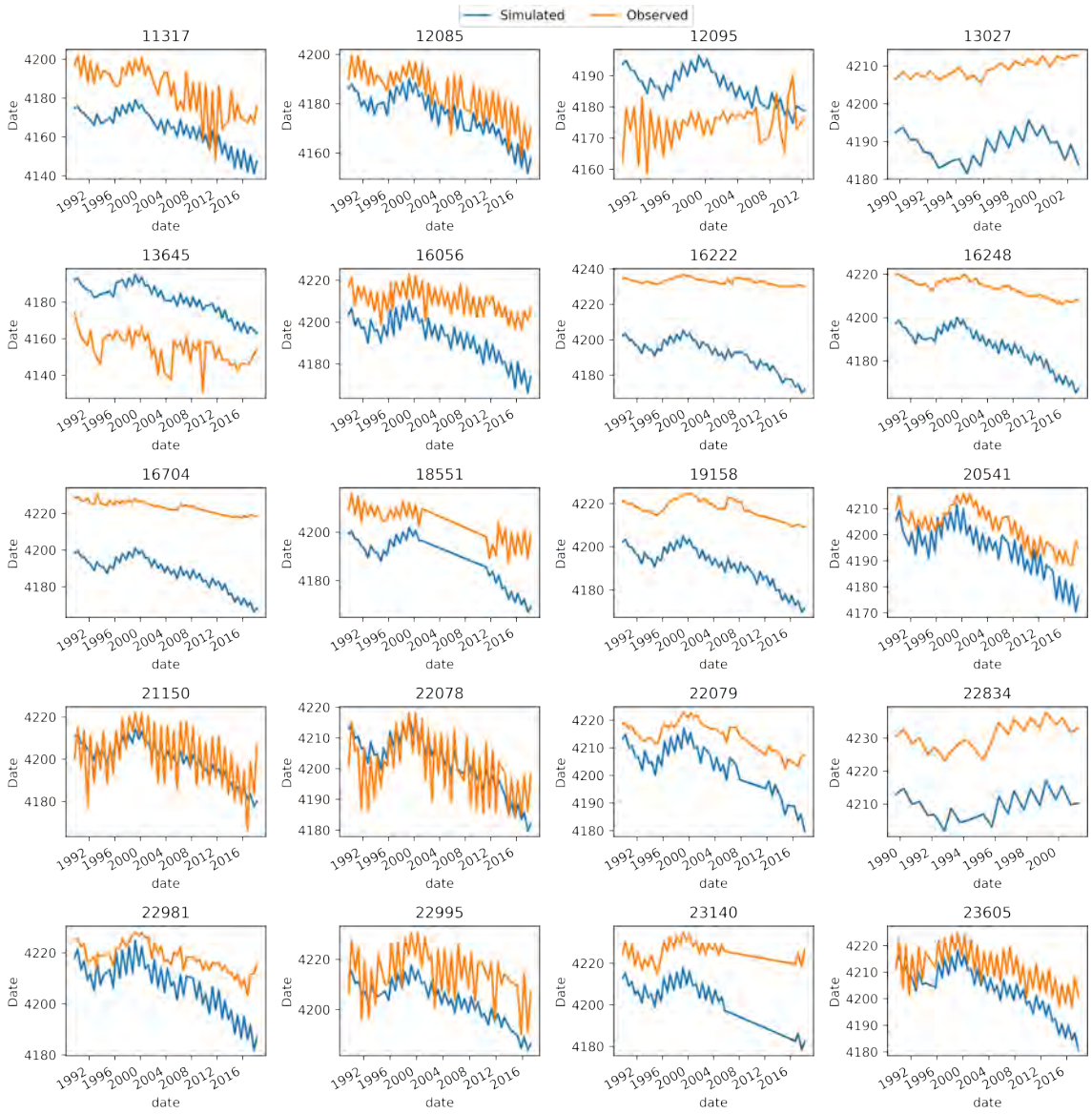


Figure 7: Simulated and observed heads for wells with more than 20 measurements where observed data is in orange and simulated data is in blue

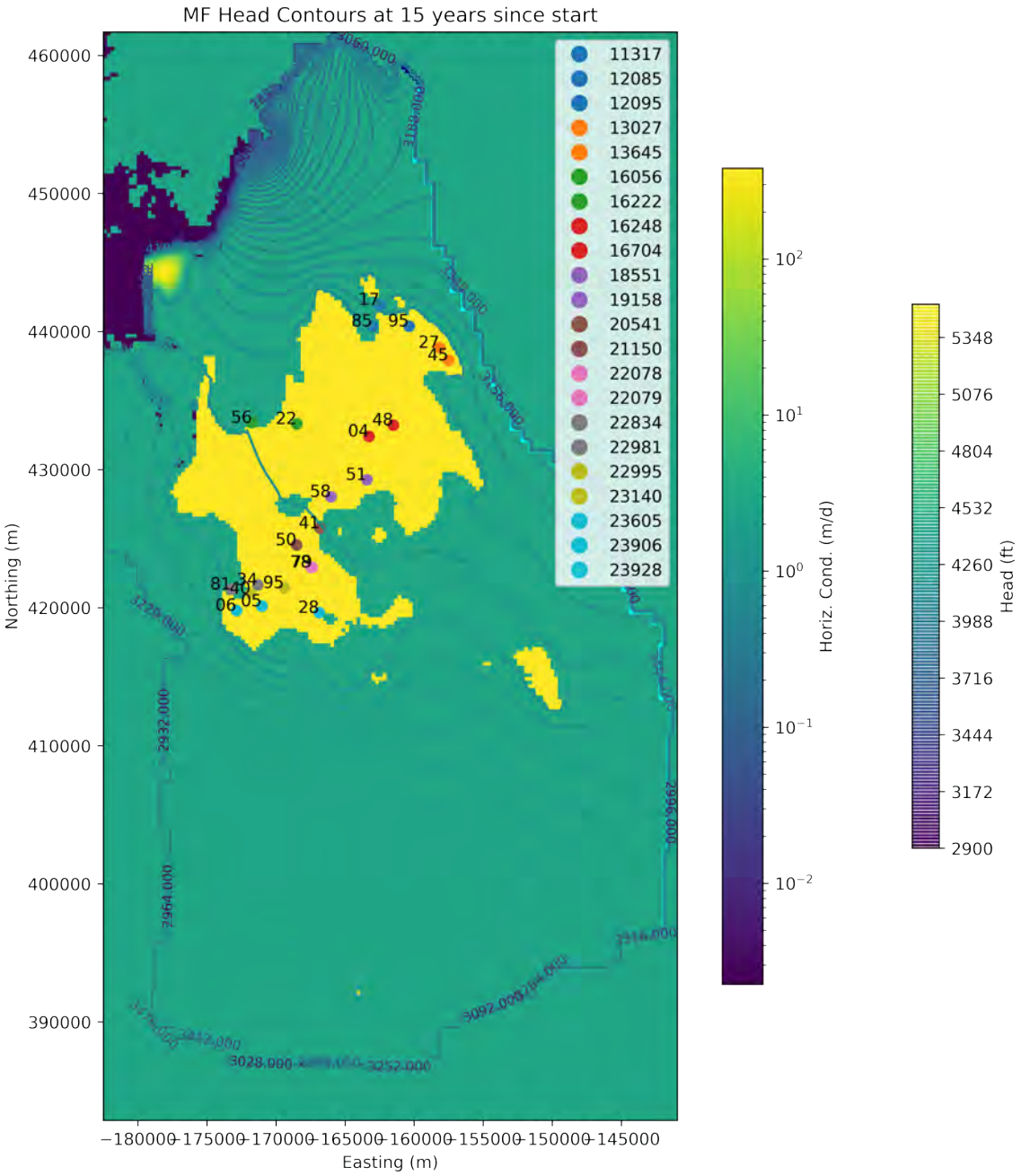


Figure 8: Map of observation wells with more than 20 measurements

8 Results for Calibrated Model

8.1 Groundwater Hydrographs

The simulated groundwater hydrographs obtained from the calibrated model for locations where observations are available demonstrate strong seasonal fluctuations due to summer time groundwater pumping and winter recharge as well as a long term dynamics of lowered groundwater levels due to drought, offset by periods of very wet water years with increased recharge into the aquifer; it is important to point out that the modeled years 2016, 2017 and 2018 did not have output from the PRMS model so we reused PRMS data from other years which resulted in 2017 having a much lower recharge than likely occurred in reality. It is possible that an updated future PRMS model that includes actual data for 2016-2018 would lead to groundwater hydrographs showing similar effects to observed groundwater storage changes in water years 1997-2000 Figure 9.

The observation wells and springs/creeks with more than 20 data points are plotted in Figure 8; the point labels are denoted by the model grid node they are located in. The simulated groundwater hydrographs at these same observation wells are plotted below in Figure 9 to demonstrate the seasonal and long term trends of the groundwater elevations in the basin.

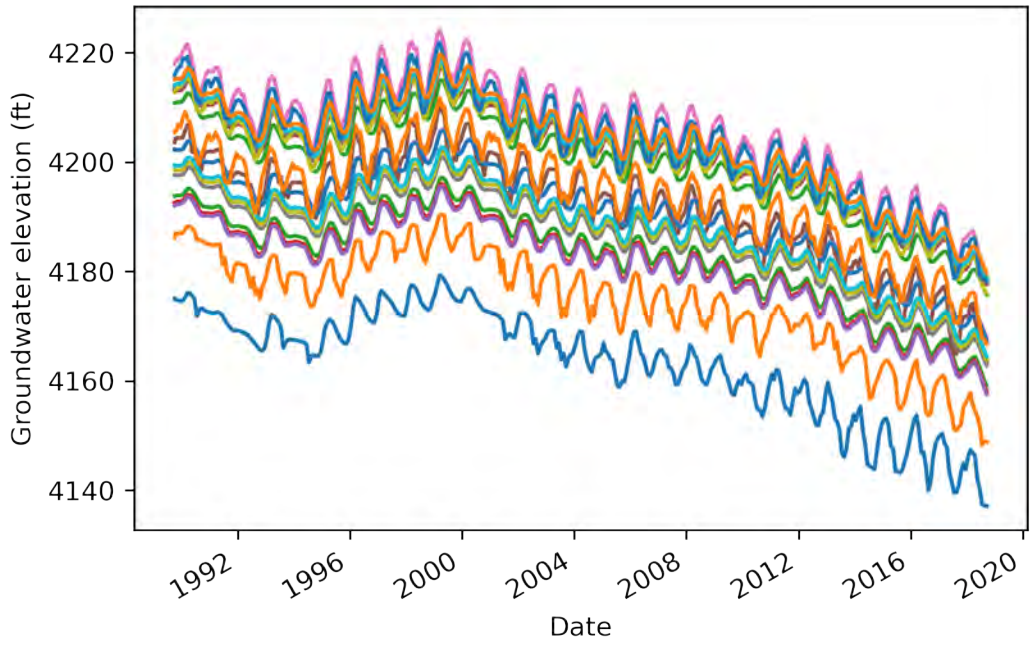


Figure 9: Simulated groundwater hydrographs for wells with more than 20 measurements

The simulated groundwater hydrographs for the same locations of the observation wells demonstrate strong seasonal fluctuations due to summer time groundwater pumping and winter recharge as well as a long term trend of lowered groundwater levels which are offset by periods of very wet water years recharge the aquifer; it is important to point out that the modeled years 2016, 2017 and 2018 did not have output from the PRMS model so we reused PRMS data from other years which resulted in 2017 having a much lower recharge than it did. Most likely with actual PRMS data for 2016-2018 the groundwater hydrograph would show a similar recharge of groundwater storage as in water years 1997-2000 Figure 9.

8.2 Model Area Groundwater Budget

The annual groundwater budget for the model area includes the entire Butte Valley watershed and additional areas to the west, north, and east of the watershed. The model area is bounded to the west and south by groundwater divides along the boundary of the larger Upper Klamath basin, to the north by the Klamath River (an outflow boundary) and to the east by an arbitrary groundwater outflow boundary within the High Cascade volcanics ("Quaternary volcanics" zone), represented as a general head boundary. The black line ("dStorage") represents the annual (but not cumulative) change in groundwater storage. It represents the difference in total inflows (positive bar length) and total outflows (negative bar length).

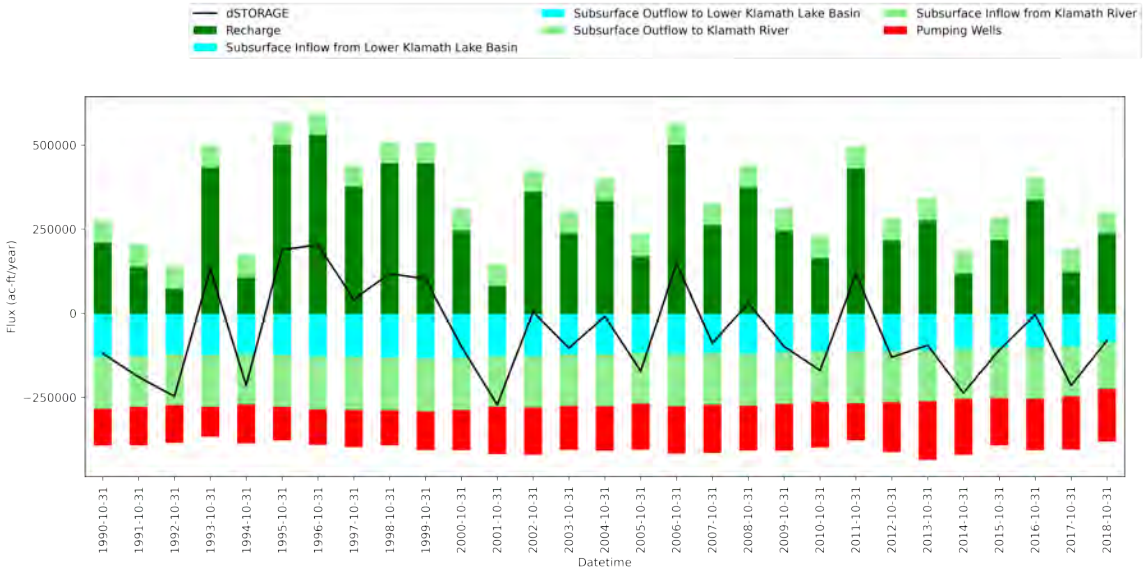


Figure 10: Annual Model Area Groundwater Budget

The model area groundwater budget shows high interannual variability for the amount of net inflow to the model area as a whole, because that inflow is entirely a function of the amount of rainfall in a given year. On the other hand, the net outflow from the basin is nearly constant throughout the simulation period with only long-term changes, as outflow is limited to groundwater discharge out of the model area and groundwater pumping Figure 10. The groundwater pumping is relatively constant because the dominant growing season is summer, which is mostly dry regardless of overall precipitation amounts. Most agricultural land is regularly irrigated. In dry years, irrigation slightly increases due to earlier start of the irrigation season and winter crops not receiving sufficient spring rainfall. Additionally, the combined net outflow from the groundwater subsystem remains near constant because increased groundwater pumping generally leads to a decline in subsurface outflow towards the Lower Klamath Lake Basin and Klamath River. Additional groundwater pumping captures more of the the natural recharge from the upper watershed flowing into the Basin as subflow. Further discussion of this and other water budgets is provided in Chapter 2.2.3 of the Butte Valley Groundwater Sustainability Plan. The following provide bar charts and tables of the two Basin water budgets: the agricultural Land/Soil subsystem, simulated by CRZWM, and the groundwater subsystem.

8.3 Basin Agricultural (CRZWM) Land/Soil Subsystem Water Budget

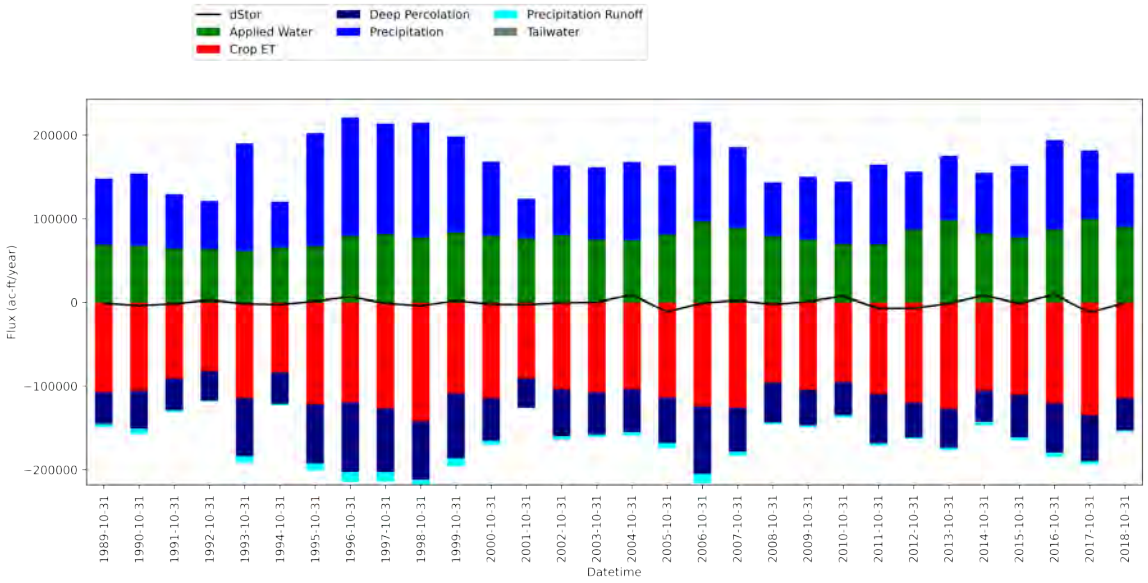


Figure 11: Annual Basin Root Zone Budget Limited to Irrigated Lands

The agricultural water budget is similar to the model area budget because it also has large interannual fluctuations in precipitation and additionally it has large interannual fluctuations of evapotranspiration Figure 11. The agricultural water budget is useful because it demonstrates the interannual variability in deep percolation due to changes in rainfall and evapotranspiration.

8.4 Bulletin 118 Groundwater Budget

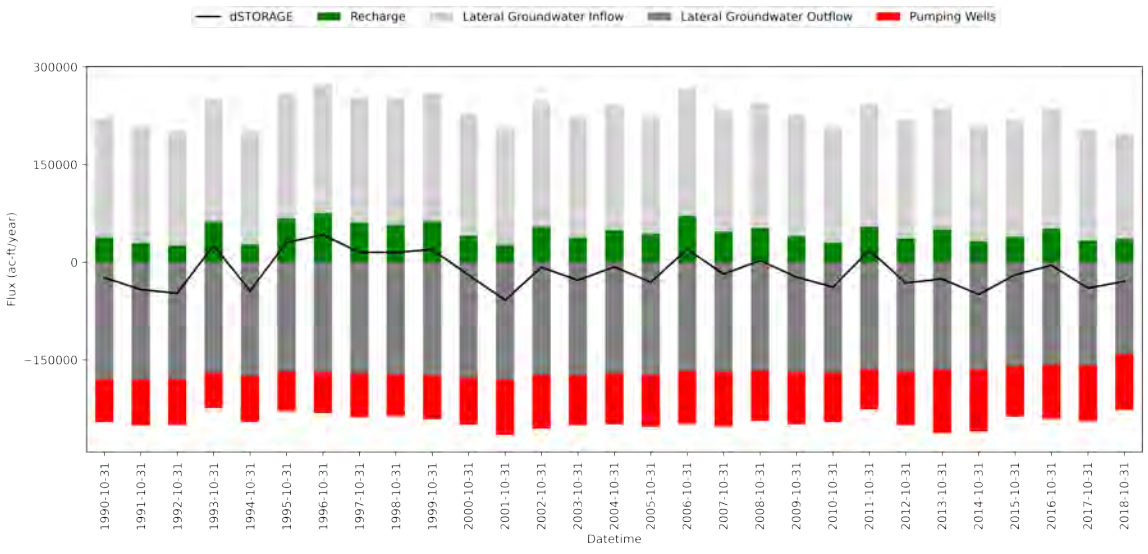


Figure 12: Annual Bulletin 118 Basin Aquifer Water Budget

The Bulletin 118 groundwater budget demonstrates a decrease in interannual variability as the high natural recharge in the watershed slowly travels through the Quaternary Volcanics aquifer providing subsurface inflow, designated asLater Groundwater Inflow Figure 12. Again the groundwater pumping is relatively constant between years as most crops are grown in the summer and require a relatively constant irrigation each year. As a result of this the interannual change in storage for the Bulletin 118 groundwater basin is much less pronounced than the change in storage for the watershed groundwater basin.

8.5 Bulletin 118 Groundwater Budget for Select Water Year Types

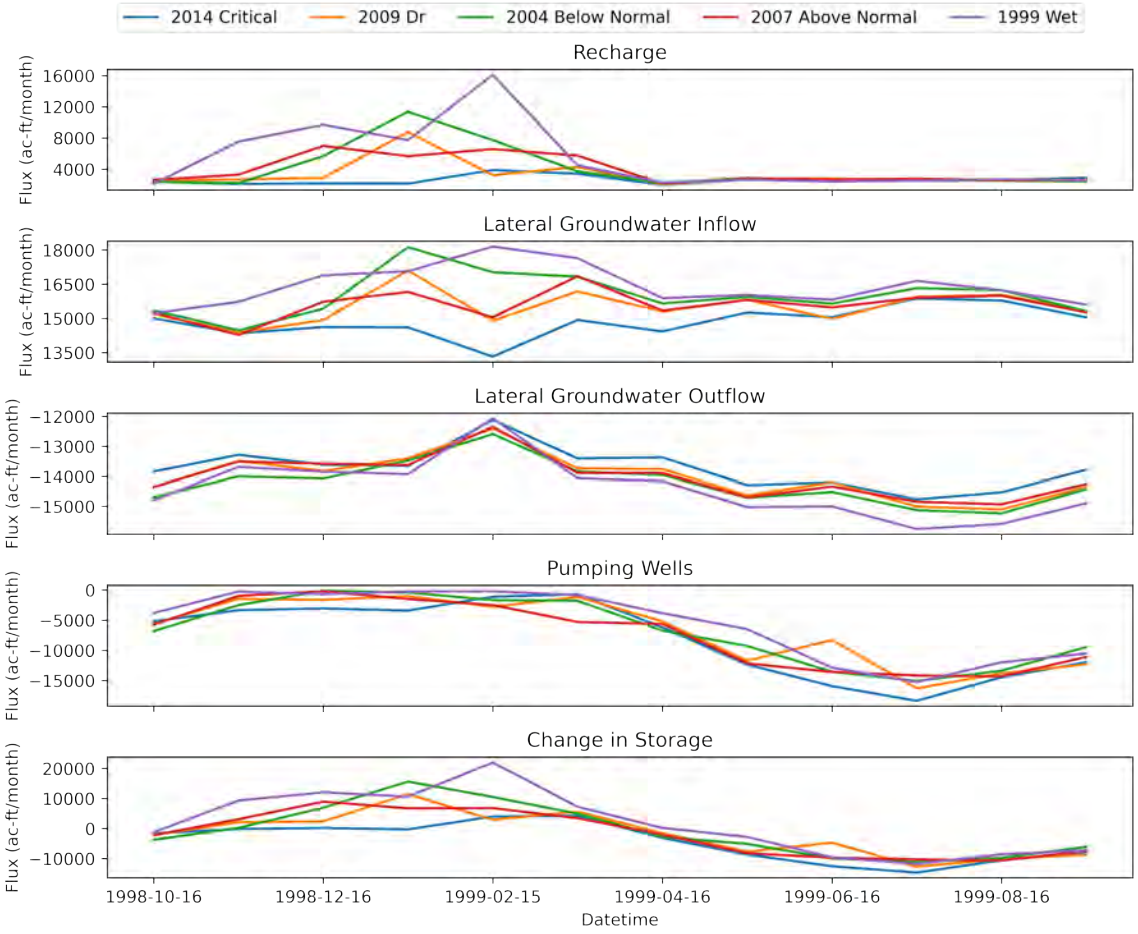


Figure 13: Monthly Bulletin 118 Basin Aquifer Water Budget for selected water year types (i.e. Dry, Average and Wet)

Selected water years were plotted to represent the 5 categories of water years developed by DWR to aid in GSP development (DWR 2021). The major difference between selected water year types is a large peak in recharge in the wet year that is entirely missing in critically dry years and a corresponding relationship in lateral groundwater inflow (driven by recharge in the upgradient watershed area, outside the Basin). Lateral groundwater outflow increases over several months after the recharge and inflow peaks, coinciding with the pumping season. The lateral groundwater outflow and groundwater pumping remain relatively similar between years. Thus there is an increase

in groundwater storage due to the increase in groundwater recharge and inflow during the wet year Figure 13.

8.6 Tables of Annual Sum Water Budgets

Table 7: Table of Annual Model Area Aquifer Water Budget

Date	From Recharge	From GHB	To GHB	To Constant Head	From Constant Head	To Wells
1989	32.58	0.06	-22.22	-26.29	10.92	-14.25
1990	209.17	0.45	-129.18	-153.96	64.78	-109.72
1991	137.57	0.62	-125.49	-152.05	65.70	-114.76
1992	70.88	0.84	-121.49	-150.69	66.77	-112.34
1993	433.00	0.75	-123.44	-154.16	64.50	-88.51
1994	106.18	0.81	-119.75	-150.94	66.27	-115.70
1995	500.94	0.72	-122.39	-155.08	64.17	-100.18
1996	529.43	0.48	-127.70	-157.66	63.30	-104.94
1997	375.49	0.34	-129.36	-157.42	63.03	-110.56
1998	445.53	0.33	-130.39	-157.21	63.13	-104.42
1999	445.49	0.26	-133.00	-158.56	62.38	-114.56
2000	244.94	0.31	-130.90	-155.97	64.13	-119.85
2001	80.38	0.50	-125.46	-151.88	65.75	-140.52
2002	360.39	0.55	-125.02	-154.90	64.18	-139.92
2003	237.63	0.64	-121.02	-153.39	65.05	-131.39
2004	334.56	0.66	-120.71	-154.81	64.69	-132.26
2005	168.43	0.81	-116.55	-151.15	66.21	-137.38
2006	500.17	0.70	-119.57	-156.18	63.62	-140.88
2007	261.39	0.68	-117.11	-154.01	64.81	-143.33
2008	373.78	0.64	-118.74	-155.29	64.43	-133.64
2009	244.32	0.72	-115.59	-153.20	65.19	-138.98
2010	162.65	0.94	-111.55	-151.19	66.16	-136.05
2011	429.81	0.91	-112.75	-154.11	64.66	-110.69
2012	215.36	0.99	-110.67	-152.41	65.99	-149.14
2013	275.40	1.00	-109.50	-151.98	65.79	-173.25
2014	116.32	1.27	-104.22	-149.58	67.04	-166.70
2015	216.52	1.48	-100.99	-150.05	66.83	-141.39
2016	335.95	1.43	-101.43	-151.97	66.20	-153.43
2017	121.15	1.62	-97.59	-148.73	67.54	-157.62
2018	237.10	1.62	-87.23	-137.00	61.31	-156.02

Table 8: Annual Basin Root Zone Budget Limited to Irrigated Lands

Date	Applied Water	Crop ET	Deep Percolation	Precipitation	Precipitation Runoff	Tailwater	dStorage
1989	68.89	-107.06	-38.28	79.02	-3.35	0	-0.80
1990	67.37	-105.69	-45.22	86.56	-6.53	0	-3.54
1991	63.93	-90.80	-38.15	65.33	-1.83	0	-1.55
1992	63.25	-81.97	-35.39	57.88	-0.88	0	2.86
1993	60.90	-114.10	-69.82	129.18	-7.59	0	-1.47
1994	65.24	-83.26	-37.97	55.00	-1.36	0	-2.38
1995	66.67	-121.62	-70.65	135.52	-8.48	0	1.41
1996	79.19	-119.46	-83.31	142.00	-12.03	0	6.36
1997	81.32	-126.63	-76.27	132.30	-11.57	0	-0.89
1998	77.25	-142.01	-69.92	137.49	-6.55	0	-3.78
1999	83.12	-108.89	-77.35	115.10	-9.75	0	2.20
2000	79.44	-114.10	-51.04	88.86	-5.15	0	-2.03
2001	76.11	-90.77	-35.02	47.59	-0.36	0	-2.48
2002	80.18	-103.89	-55.95	83.33	-3.83	0	-0.19
2003	75.11	-107.32	-50.47	86.16	-3.11	0	0.34
2004	73.93	-103.55	-51.43	93.79	-3.98	0	8.73
2005	80.66	-113.68	-54.53	82.79	-6.09	0	-10.86
2006	96.37	-124.02	-80.98	119.38	-11.33	0	-0.61
2007	88.54	-125.89	-52.51	97.07	-4.87	0	2.29
2008	78.91	-95.44	-47.95	64.45	-2.28	0	-2.33
2009	74.75	-104.28	-42.94	75.42	-1.71	0	1.21
2010	69.66	-94.75	-40.02	74.57	-2.44	0	6.98
2011	69.07	-109.48	-59.05	95.47	-2.81	0	-6.84
2012	86.67	-119.78	-41.49	69.62	-1.82	0	-6.82
2013	97.69	-127.34	-46.13	77.54	-2.87	0	-1.15
2014	82.15	-105.33	-37.37	72.69	-4.09	0	8.01
2015	77.27	-110.39	-50.87	86.03	-3.37	0	-1.36
2016	86.84	-120.49	-59.01	107.31	-5.36	0	9.26
2017	99.28	-134.95	-55.05	82.49	-3.64	0	-11.90
2018	89.82	-114.13	-38.95	64.55	-1.37	0	-0.11
2019	2.34	-7.58	-6.25	17.84	-0.68	0	5.66

Table 9: Table of Annual Bulletin 118 Basin Aquifer Water Budget

Date	From Recharge	From Groundwater	To Groundwater	To Wells
1989	6.99	31.35	-29.75	-8.90
1990	38.22	183.61	-179.33	-66.04
1991	29.84	179.39	-180.19	-70.77
1992	26.12	175.90	-179.14	-70.39
1993	62.15	187.91	-169.75	-54.11
1994	27.46	174.10	-174.61	-70.52
1995	67.23	191.84	-167.58	-61.01
1996	75.35	198.88	-167.87	-63.87
1997	61.07	192.06	-170.31	-67.43
1998	58.16	193.49	-171.72	-64.50
1999	63.43	197.22	-173.02	-67.84
2000	41.40	188.44	-177.36	-71.93
2001	26.91	180.02	-179.92	-85.05
2002	55.09	192.94	-172.71	-82.86
2003	37.83	184.73	-173.49	-76.54
2004	49.62	192.20	-170.26	-78.35
2005	43.63	179.27	-172.63	-80.04
2006	71.36	196.80	-167.06	-80.91
2007	47.13	186.77	-168.04	-83.84
2008	52.84	193.42	-166.35	-77.24
2009	40.15	186.02	-168.30	-80.38
2010	30.15	177.25	-169.57	-75.78
2011	54.82	189.56	-163.90	-61.60
2012	36.61	181.89	-167.80	-82.27
2013	50.38	187.00	-164.46	-97.67
2014	32.04	178.12	-164.64	-94.91
2015	39.59	178.32	-159.80	-77.16
2016	52.03	183.95	-157.09	-83.39
2017	33.59	170.90	-158.04	-86.07
2018	35.81	161.70	-140.60	-85.93

9 Climate Projection Scenarios

Under their SGMA climate change guidance, DWR provided a dataset of climate change factors which each GSA can use to convert local historical weather data into 4 different climate change scenarios (DWR 2018). Change factors are geographically and temporally explicit. Geographically, a grid of 1/16-degree resolution cells covers the extent of California; for each of these cells, one change factors applies to each month, 1911-2011. The plots of precipitation and evapotranspiration demonstrate the impact of the change factors on the inputs to the BVIHM both directly and to the PRMS model that calculates recharge as an input to the MODFLOW model (see the Butte Valley Groundwater Sustainability Plan Chapter 2.2.4 for further explanation of the future climate scenario construction).

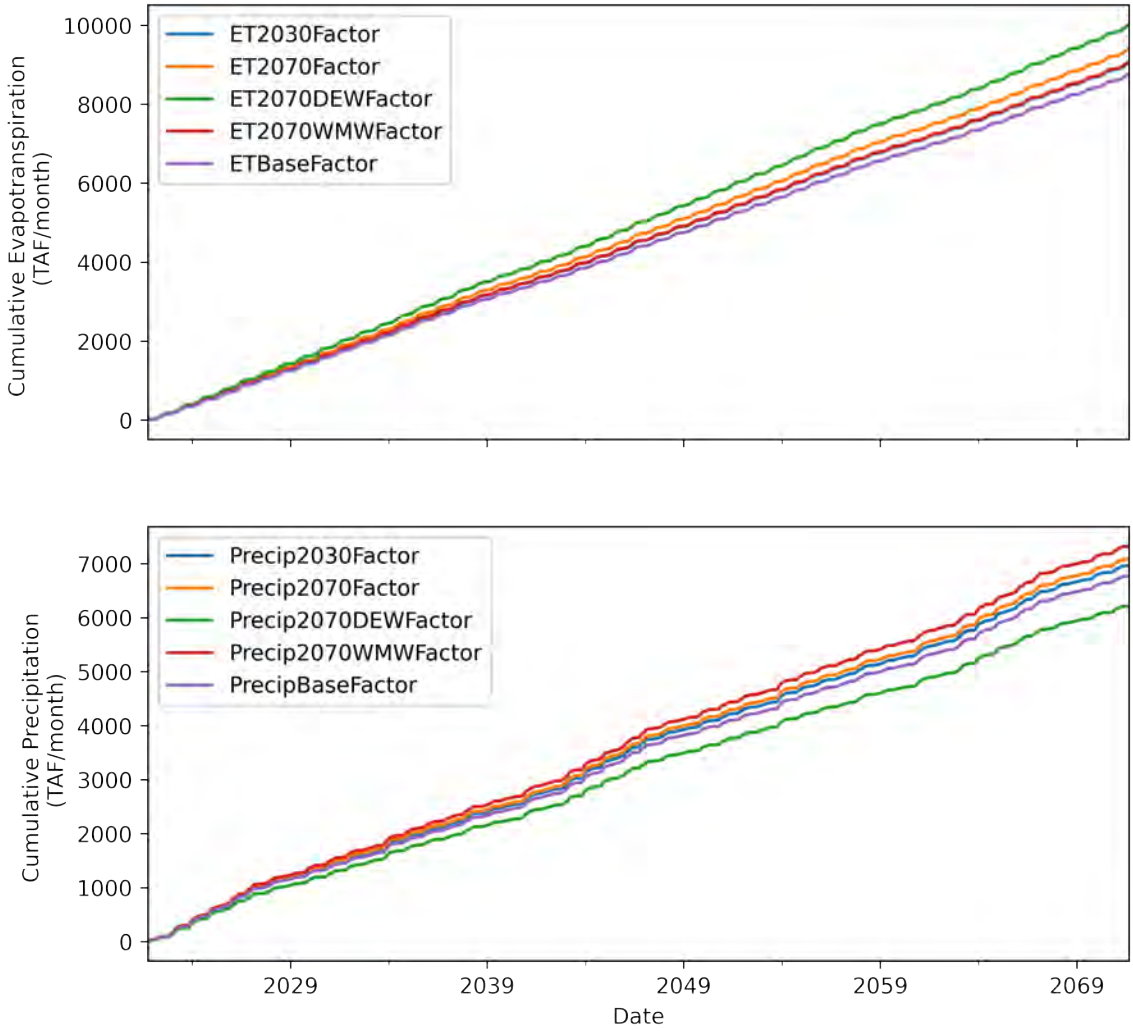


Figure 14: Future Climate Projections of Precipitation and Actual Evapotranspiration for the Butte Valley Watershed

The 2030 (Near) and 2070 central tendency (Far) scenarios predict similar rainfall conditions to the Base case, while the 2070 DEW (Dry) and 2070 WMW (Wet) scenarios show less and more cumulative rain, respectively. Conversely, all scenarios predict higher future ET than the Base case.

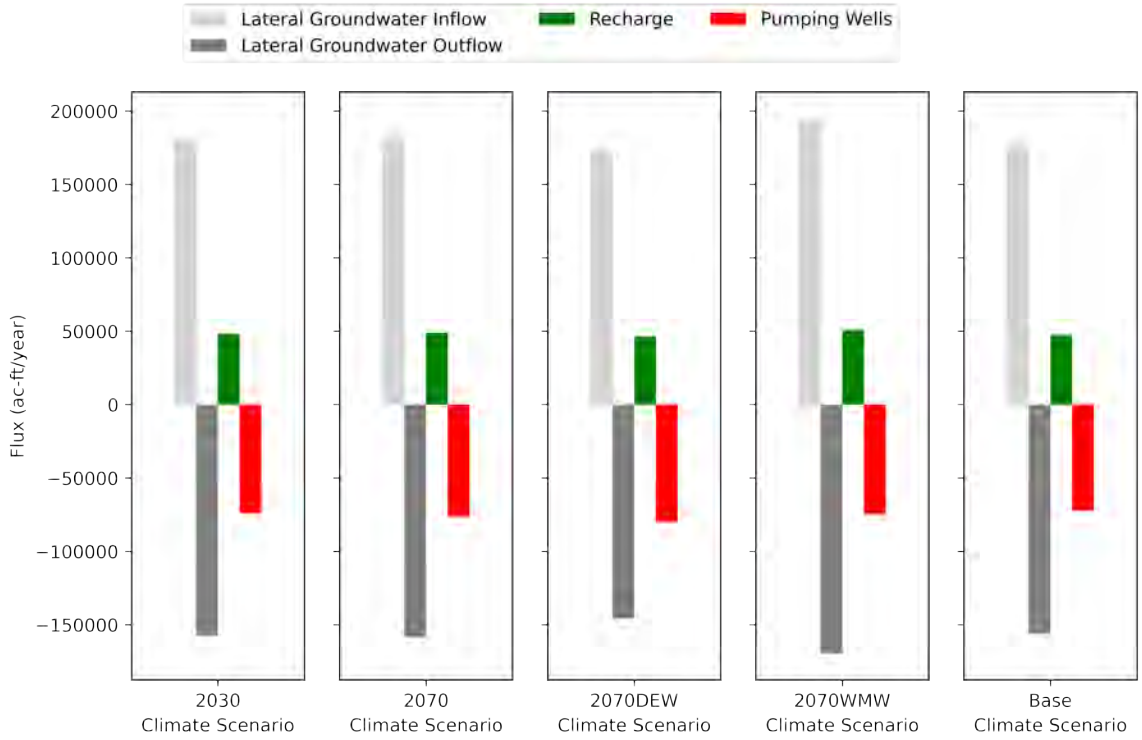


Figure 15: Average Bulletin 118 Basin Water Budget 1990-2070

These climate change scenarios directly impact the monthly groundwater recharge, precipitation dependent, and groundwater pumping, evapotranspiration dependent. All of the climate change scenarios expect the 2070 DEW predict an increase in both precipitation and and evapotranspiration for Butte Valley that lead to an overall increase in groundwater storage over the 50 year future modeled climate scenarios. The 2070 DEW climate scenario depicted losses in groundwater storage in Butte Valley for the recent future until groundwater levels were lowered such that the subsurface outflow to the Lower Klamath Lake Basin was reduced, stabilizing water levels in the Basin itself.

9.1 Future Climate Individual Annual Water Budget Plots

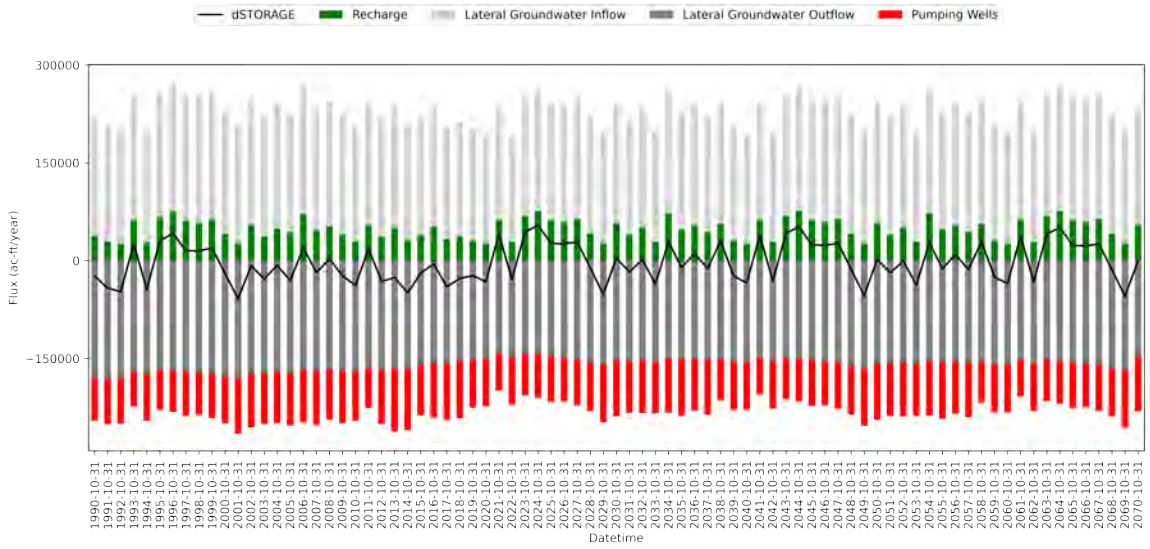


Figure 16: Bulletin 118 Basin Water Budgets from 1990-2070 for 2030 Climate Scenario

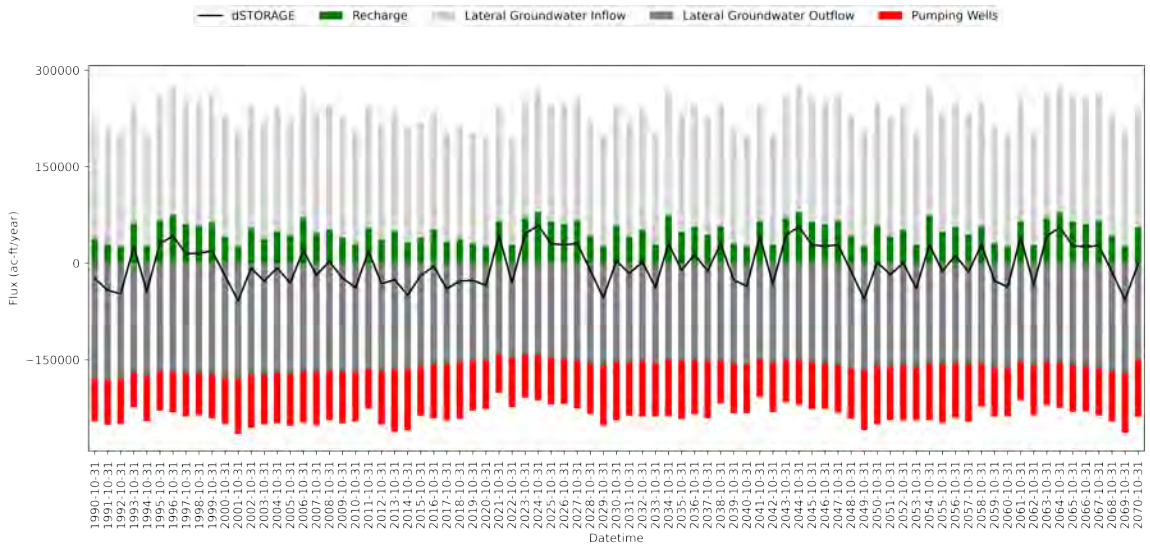


Figure 17: Bulletin 118 Basin Water Budgets from 1990-2070 for 2070 Climate Scenario

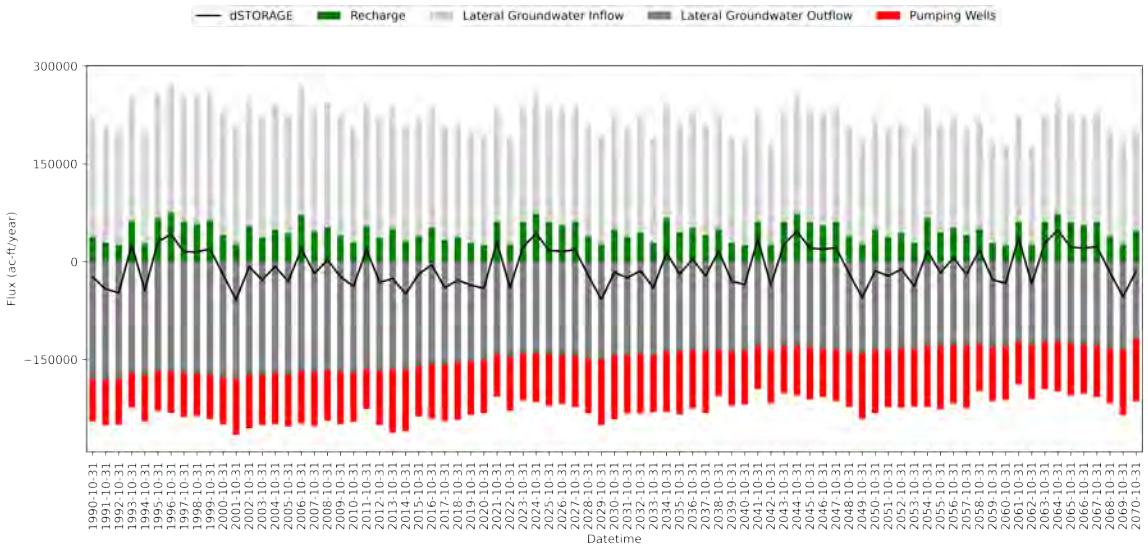


Figure 18: Bulletin 118 Basin Water Budgets from 1990-2070 for 2070DEW Climate Scenario

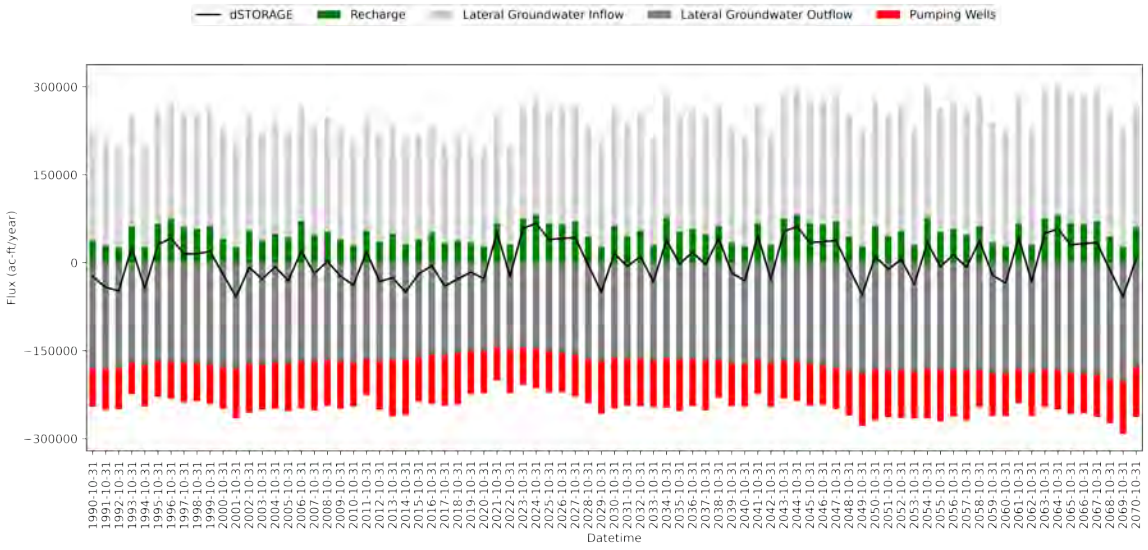


Figure 19: Bulletin 118 Basin Water Budgets from 1990-2070 for 2070WMW Climate Scenario

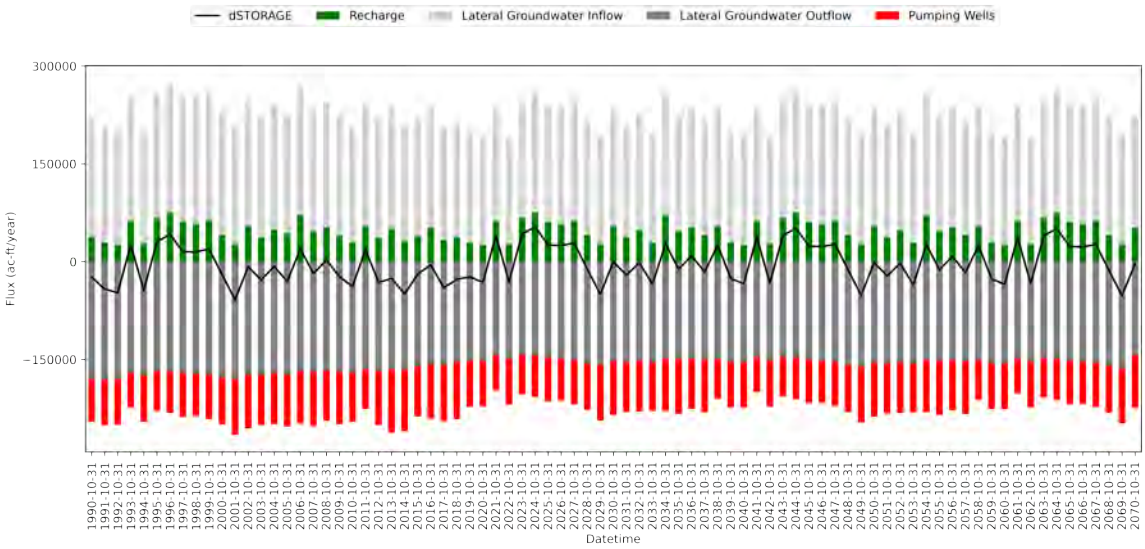


Figure 20: Bulletin 118 Basin Water Budgets from 1990-2070 for base Climate Scenario

9.2 Tables of Future Climate Individual Annual Water Budget Data

Table 10: Table of Annual Bulletin 118 Basin Aquifer Water Budget for 2030 Climate Scenario

Year	From Recharge	From Groundwater	To Groundwater	To Wells
2019	31.11	171.28	-151.30	-73.69
2020	26.39	165.32	-150.71	-72.83
2021	63.19	177.22	-142.49	-56.51
2022	28.94	163.00	-147.44	-73.12
2023	68.78	181.60	-142.10	-63.93
2024	76.34	188.44	-143.45	-66.56
2025	62.19	181.27	-146.39	-70.21
2026	59.16	182.53	-148.56	-67.14
2027	64.19	186.41	-150.74	-70.66
2028	41.96	177.56	-155.65	-74.60
2029	26.91	169.26	-159.14	-88.37
2030	57.86	184.67	-152.36	-86.16
2031	40.28	176.07	-153.81	-79.18
2032	50.88	184.08	-151.73	-81.76
2033	29.37	168.45	-154.96	-78.37
2034	73.08	189.33	-148.98	-84.07
2035	48.15	179.04	-150.58	-87.09
2036	54.56	186.50	-149.60	-80.38
2037	43.86	180.28	-151.66	-84.13
2038	57.06	187.05	-150.09	-63.42
2039	31.11	173.69	-154.66	-73.69
2040	26.39	168.26	-155.51	-72.83
2041	63.19	180.53	-148.09	-56.51
2042	28.95	166.53	-153.40	-73.12

Table 10: Table of Annual Bulletin 118 Basin Aquifer Water Budget for 2030 Climate Scenario *(continued)*

Year	From Recharge	From Groundwater	To Groundwater	To Wells
2043	68.78	185.07	-148.01	-63.93
2044	76.34	191.92	-149.30	-66.56
2045	62.19	184.83	-152.22	-70.21
2046	59.16	186.08	-154.27	-67.14
2047	64.19	189.92	-156.30	-70.66
2048	41.96	181.09	-161.14	-74.60
2049	26.91	172.75	-164.48	-88.37
2050	57.86	188.03	-157.48	-86.16
2051	40.28	179.42	-158.83	-79.18
2052	50.88	187.34	-156.60	-81.76
2053	29.37	171.70	-159.72	-78.37
2054	73.08	192.43	-153.53	-84.07
2055	48.15	182.11	-155.05	-87.09
2056	54.56	189.48	-153.92	-80.38
2057	43.86	183.25	-155.91	-84.13
2058	57.06	189.94	-154.21	-63.42
2059	31.11	176.56	-158.72	-73.69
2060	26.39	171.07	-159.47	-72.83
2061	63.19	183.19	-151.86	-56.51
2062	28.95	169.21	-157.14	-73.12
2063	68.78	187.61	-151.57	-63.93
2064	76.34	194.39	-152.77	-66.56
2065	62.19	187.30	-155.64	-70.21
2066	59.16	188.51	-157.63	-67.14
2067	64.19	192.28	-159.56	-70.66
2068	41.96	183.44	-164.36	-74.60
2069	26.91	175.06	-167.63	-88.37
2070	55.52	175.57	-146.96	-84.39

Table 11: Table of Annual Bulletin 118 Basin Aquifer Water Budget for 2070 Climate Scenario

Year	From Recharge	From Groundwater	To Groundwater	To Wells
2019	30.88	171.52	-151.46	-77.30
2020	26.21	165.79	-150.67	-75.97
2021	65.39	179.62	-141.57	-59.41
2022	29.06	164.27	-146.79	-76.81
2023	70.23	183.92	-141.67	-66.97
2024	79.19	192.71	-142.86	-69.85
2025	64.71	185.38	-146.14	-73.23
2026	61.07	186.32	-148.55	-70.13
2027	65.86	190.26	-151.18	-74.10
2028	43.06	181.02	-155.94	-78.39

Table 11: Table of Annual Bulletin 118 Basin Aquifer Water Budget for 2070 Climate Scenario *(continued)*

Year	From Recharge	From Groundwater	To Groundwater	To Wells
2029	26.91	171.68	-159.59	-92.63
2030	58.92	188.34	-152.73	-90.88
2031	41.50	179.84	-153.93	-83.08
2032	52.08	188.02	-152.09	-85.99
2033	29.41	171.10	-155.64	-82.15
2034	74.47	193.73	-149.65	-87.96
2035	48.77	182.79	-151.17	-91.03
2036	56.73	191.53	-150.12	-84.47
2037	44.42	184.21	-152.43	-88.03
2038	57.58	190.39	-151.10	-66.28
2039	30.88	176.51	-155.83	-77.30
2040	26.21	171.02	-156.76	-75.97
2041	65.39	185.00	-148.54	-59.41
2042	29.07	169.79	-154.21	-76.81
2043	70.23	189.22	-149.01	-66.97
2044	79.19	197.92	-150.15	-69.85
2045	64.71	190.61	-153.43	-73.23
2046	61.07	191.49	-155.74	-70.13
2047	65.86	195.31	-158.20	-74.10
2048	43.06	186.07	-162.91	-78.39
2049	26.91	176.64	-166.41	-92.63
2050	58.92	193.09	-159.28	-90.88
2051	41.50	184.54	-160.38	-83.08
2052	52.08	192.60	-158.36	-85.99
2053	29.41	175.63	-161.80	-82.15
2054	74.47	198.02	-155.55	-87.96
2055	48.77	187.05	-156.98	-91.03
2056	56.73	195.64	-155.74	-84.47
2057	44.42	188.30	-157.97	-88.03
2058	57.58	194.36	-156.49	-66.28
2059	30.88	180.45	-161.15	-77.30
2060	26.21	174.86	-161.96	-75.97
2061	65.39	188.63	-153.49	-59.41
2062	29.07	173.44	-159.14	-76.81
2063	70.23	192.67	-153.71	-66.97
2064	79.19	201.27	-154.72	-69.85
2065	64.71	193.95	-157.95	-73.23
2066	61.07	194.77	-160.17	-70.13
2067	65.86	198.50	-162.51	-74.10
2068	43.06	189.25	-167.18	-78.39
2069	26.91	179.76	-170.60	-92.63
2070	56.58	181.00	-149.53	-89.12

Table 12: Table of Annual Bulletin 118 Basin Aquifer Water Budget for 2070DEW Climate Scenario

Year	From Recharge	From Groundwater	To Groundwater	To Wells
2019	28.71	170.54	-152.07	-83.05
2020	26.11	165.45	-150.00	-81.85
2021	61.48	175.61	-141.28	-65.30
2022	26.73	161.60	-145.85	-82.32
2023	61.13	174.28	-140.29	-71.88
2024	73.86	184.75	-139.60	-75.67
2025	60.44	178.12	-141.39	-79.70
2026	56.16	177.76	-142.76	-74.98
2027	61.15	180.54	-144.11	-79.12
2028	39.25	172.22	-147.74	-84.30
2029	26.91	165.43	-149.39	-100.68
2030	49.82	174.94	-143.33	-97.79
2031	38.10	169.85	-143.20	-89.07
2032	44.46	174.16	-140.90	-91.49
2033	28.80	161.68	-142.73	-87.39
2034	67.11	177.77	-136.90	-93.56
2035	45.55	169.24	-136.77	-96.83
2036	52.06	176.57	-135.14	-89.59
2037	40.85	169.75	-136.45	-95.54
2038	50.07	172.08	-134.44	-71.22
2039	28.71	162.12	-137.34	-83.05
2040	26.11	157.50	-136.80	-81.85
2041	61.48	168.26	-129.37	-65.30
2042	26.73	154.19	-134.31	-82.32
2043	61.13	167.22	-129.42	-71.88
2044	73.86	177.88	-129.14	-75.67
2045	60.44	171.20	-131.07	-79.70
2046	56.16	170.94	-132.71	-74.98
2047	61.15	173.89	-134.36	-79.12
2048	39.25	165.55	-138.11	-84.30
2049	26.91	158.92	-140.04	-100.68
2050	49.82	168.67	-134.32	-97.79
2051	38.10	163.67	-134.38	-89.07
2052	44.46	168.13	-132.32	-91.49
2053	28.80	155.77	-134.37	-87.39
2054	67.11	172.12	-128.89	-93.56
2055	45.55	163.63	-128.87	-96.83
2056	52.06	171.20	-127.56	-89.59
2057	40.85	164.37	-128.93	-95.54
2058	50.07	166.84	-127.13	-71.22
2059	28.71	156.96	-130.19	-83.05
2060	26.11	152.51	-129.87	-81.85
2061	61.48	163.58	-122.80	-65.30
2062	26.73	149.45	-127.74	-82.32
2063	61.13	162.72	-123.14	-71.88

Table 12: Table of Annual Bulletin 118 Basin Aquifer Water Budget for 2070DEW Climate Scenario *(continued)*

Year	From Recharge	From Groundwater	To Groundwater	To Wells
2064	73.86	173.53	-123.06	-75.67
2065	60.44	166.82	-125.02	-79.70
2066	56.16	166.62	-126.76	-74.98
2067	61.15	169.66	-128.55	-79.12
2068	39.25	161.32	-132.33	-84.30
2069	26.91	154.81	-134.43	-100.68
2070	47.48	151.81	-118.21	-95.51

Table 13: Table of Annual Bulletin 118 Basin Aquifer Water Budget for 2070WMW Climate Scenario

Year	From Recharge	From Groundwater	To Groundwater	To Wells
2019	34.23	173.92	-150.53	-73.26
2020	27.86	167.72	-149.81	-72.79
2021	67.92	184.07	-142.26	-58.24
2022	31.15	168.14	-148.02	-74.08
2023	75.28	191.73	-143.55	-64.63
2024	81.67	199.16	-146.28	-67.10
2025	67.93	192.93	-150.51	-70.50
2026	65.95	196.33	-153.48	-67.05
2027	70.22	201.22	-157.14	-71.08
2028	44.79	190.56	-163.31	-75.68
2029	27.35	180.65	-167.86	-89.57
2030	63.37	200.62	-161.31	-86.76
2031	45.14	192.53	-163.76	-79.85
2032	54.83	201.24	-162.86	-82.23
2033	30.49	183.75	-166.83	-79.33
2034	77.57	208.21	-161.65	-85.21
2035	52.28	198.51	-164.12	-88.47
2036	57.96	205.28	-163.92	-80.81
2037	48.05	200.21	-166.67	-84.69
2038	62.67	208.59	-165.95	-63.52
2039	34.23	193.57	-171.42	-73.26
2040	27.86	186.94	-172.62	-72.79
2041	67.92	202.51	-165.39	-58.24
2042	31.15	186.64	-171.69	-74.08
2043	75.28	209.19	-166.39	-64.63
2044	81.67	216.17	-168.75	-67.10
2045	67.93	209.81	-172.81	-70.50
2046	65.95	212.87	-175.38	-67.05
2047	70.22	217.30	-178.49	-71.08
2048	44.79	206.61	-184.55	-75.68

Table 13: Table of Annual Bulletin 118 Basin Aquifer Water Budget for 2070WMW Climate Scenario *(continued)*

Year	From Recharge	From Groundwater	To Groundwater	To Wells
2049	27.35	196.43	-188.72	-89.57
2050	63.37	215.69	-181.35	-86.76
2051	45.14	207.38	-183.47	-79.85
2052	54.83	215.68	-182.08	-82.23
2053	30.49	198.01	-185.75	-79.33
2054	77.57	221.78	-179.77	-85.21
2055	52.28	211.88	-181.94	-88.47
2056	57.96	218.31	-181.31	-80.81
2057	48.05	213.01	-183.73	-84.69
2058	62.67	221.00	-182.52	-63.52
2059	34.23	205.88	-187.80	-73.26
2060	27.86	199.02	-188.69	-72.79
2061	67.92	214.00	-180.77	-58.24
2062	31.15	198.08	-186.93	-74.08
2063	75.28	220.06	-180.98	-64.63
2064	81.67	226.73	-182.95	-67.10
2065	67.93	220.23	-186.78	-70.50
2066	65.95	223.08	-189.05	-67.05
2067	70.22	227.23	-191.81	-71.08
2068	44.79	216.49	-197.75	-75.68
2069	27.35	206.13	-201.65	-89.57
2070	61.03	207.72	-177.35	-85.29

Table 14: Table of Annual Bulletin 118 Basin Aquifer Water Budget for base Climate Scenario

Year	From Recharge	From Groundwater	To Groundwater	To Wells
2019	29.77	169.64	-151.50	-70.77
2020	26.12	164.03	-151.27	-70.39
2021	62.15	175.33	-142.93	-54.11
2022	27.44	160.71	-148.25	-70.52
2023	67.23	178.57	-142.31	-61.01
2024	75.35	185.59	-143.41	-63.87
2025	61.07	178.44	-146.30	-67.43
2026	58.16	179.89	-148.41	-64.50
2027	63.43	183.76	-150.44	-67.84
2028	41.40	174.90	-155.22	-71.93
2029	26.91	166.65	-158.47	-85.05
2030	55.09	179.94	-152.08	-82.86
2031	37.83	171.78	-153.31	-76.54
2032	48.60	179.52	-150.86	-78.65
2033	29.19	165.24	-153.55	-75.30
2034	71.43	184.93	-147.70	-80.91

Table 14: Table of Annual Bulletin 118 Basin Aquifer Water Budget for base Climate Scenario *(continued)*

Year	From Recharge	From Groundwater	To Groundwater	To Wells
2035	47.13	174.91	-149.16	-83.84
2036	52.84	181.83	-148.21	-77.24
2037	41.04	174.49	-150.51	-80.64
2038	54.28	181.18	-148.60	-60.91
2039	29.77	168.64	-152.75	-70.77
2040	26.12	163.97	-153.46	-70.39
2041	62.15	175.88	-145.77	-54.11
2042	27.46	161.58	-151.31	-70.52
2043	67.23	179.55	-145.40	-61.01
2044	75.35	186.68	-146.48	-63.87
2045	61.07	179.65	-149.35	-67.43
2046	58.16	181.16	-151.38	-64.50
2047	63.43	185.05	-153.31	-67.84
2048	41.40	176.24	-158.02	-71.93
2049	26.91	168.00	-161.17	-85.05
2050	55.09	181.26	-154.65	-82.86
2051	37.83	173.12	-155.82	-76.54
2052	48.60	180.84	-153.27	-78.65
2053	29.19	166.58	-155.90	-75.30
2054	71.43	186.21	-149.93	-80.91
2055	47.13	176.20	-151.34	-83.84
2056	52.84	183.08	-150.30	-77.24
2057	41.04	175.75	-152.56	-80.64
2058	54.28	182.41	-150.58	-60.91
2059	29.77	169.88	-154.69	-70.77
2060	26.12	165.19	-155.34	-70.39
2061	62.15	177.04	-147.55	-54.11
2062	27.46	162.75	-153.08	-70.52
2063	67.23	180.66	-147.08	-61.01
2064	75.35	187.76	-148.10	-63.87
2065	61.07	180.74	-150.95	-67.43
2066	58.16	182.23	-152.94	-64.50
2067	63.43	186.09	-154.83	-67.84
2068	41.40	177.28	-159.53	-71.93
2069	26.91	169.03	-162.64	-85.05
2070	52.75	168.09	-142.89	-81.04

10 Model Archiving

The original steady state MODFLOW models for Butte Valley were developed in Groundwater Vistas to perform manual sensitivity analysis on hydraulic conductivity, average groundwater pumping, and recharge. Parameters and key outcomes for these varying steady state trial models are captured in a spreadsheet to understand their general impact on simulated groundwater levels.

Results are available upon request.

Later versions of the steady state and transient models were developed with the USGS developed python package *flopy* which allows a user to write scripts to import data, clean and adjust it, and to write model input files (Bakker et al. 2016). Additional python scripts were developed to run the model and model calibration and to post-process model results using the JupyterNotebooks python development environment Kluyver et al. (2016). One set of python scripts was continuously developed to create the historical BVIHM which had input files written to different directories to create model archives or to note different model set ups such as when more observation data was included. A different set of python scripts were used to alter the historical BVIHM for the 50 year climate projections, each of these models were written to their own model directory.

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Technical Memorandum

To: Larry Walker Associates

From: Davids Engineering

Date: January 23, 2020

Subject: **Butte Valley Evapotranspiration and Applied Water Estimates**

1 Summary

The purpose of this effort is to develop time series estimates of agricultural water use for the Butte Valley Basin from January 1989 through December 2018. The approach builds upon estimates of actual evapotranspiration (ETa) developed using remotely sensed information from the Landsat satellite.

The consumptive use of water (i.e., evapotranspiration) is the primary destination of infiltrated precipitation and applied irrigation water within the Basin. Quantification of consumptive use was achieved by performing daily calculations of evapotranspiration (ET) for individual fields for the study period. ET was separated into its evaporation (E) and transpiration (T) components. Transpiration was quantified using a remote sensing approach where Landsat satellite images acquired from USGS were used to calculate the Normalized Difference Vegetation Index (NDVI), which was subsequently translated to a basal crop coefficient and combined with reference ET (ETo) to calculate transpiration over time.

A spatial coverage of field boundaries was developed for the study area, and individual field polygons were assigned cropping and irrigation method information over time based on available data. Field boundaries were delineated by combining polygon coverages in GIS format from the California Department of Water Resources (DWR).

ET was calculated based on a combination of remote sensing data and simulation of irrigation events in a daily root zone water balance model. Due to the remote sensing approach, ET estimates are relatively insensitive to crop or land use type and irrigation method so detailed, accurate assignment of crop types and irrigation methods to each field is not critical to developing relatively reliable estimates of ET. The amount of green vegetation present over time was estimated for each field polygon based on NDVI, which is calculated using a combination of red and near infrared reflectances as measured using multispectral satellite sensors onboard Landsat satellites. Following the preparation of NDVI imagery spanning the analysis period, all images were quality controlled to remove pixels affected by clouds.

Mean daily NDVI values for each field were converted to basal crop coefficients. Daily precipitation was estimated based on assembly and review of data from the PRISM Climate Group at Oregon State University[1]. Daily reference evapotranspiration (ET_o) was estimated based on information from the California Irrigation Management Information System (CIMIS) and from National Oceanic and

[1] PRISM website: http://prism.oregonstate.edu/

Atmospheric Administration (NOAA) weather stations. Root zone parameters that influence the amount of available soil moisture storage were estimated based on crops and soils present in the study area.

A summary for the analysis period of the annual ET of applied water (ET_{AW}), ET_c (synonymous with ET_a), applied water (AW), deep percolation of applied water (DP_{AW}) and deep percolation of precipitation (DP_{pr}) estimates based on the root zone water balance model is given in the Results section.

Application of remote sensing combined with daily remote sensing-based root zone water balance modeling (RS-RZ model) provides a reliable methodology in the absence of more detailed, ground-based information for estimation of surface interactions with the groundwater system including net groundwater depletion through estimation of ET of applied water and other fluxes.

2 Introduction

The purpose of this effort is to develop time series estimates of agricultural and native vegetation water use for the Butte Valley Basin from 1989 to 2018. Demand has been quantified at the field scale using a remote-sensing based daily root zone water balance model.

3 Methodology

3.1 Daily Root Zone Simulation Model

A conceptual diagram of the various surface layer fluxes of water into and out of the crop root zone is provided in Figure 3.1. The consumptive use of water (i.e., evapotranspiration or ET) is the primary destination of infiltrated precipitation and applied irrigation water within the study area. Quantification of consumptive use was achieved by performing daily calculations of ET for individual fields from January 1989 through December 2018. Evapotranspiration was separated into its evaporation (E) and transpiration (T) components. Additionally, each component was separated into the amount of E or T derived from precipitation or applied water.

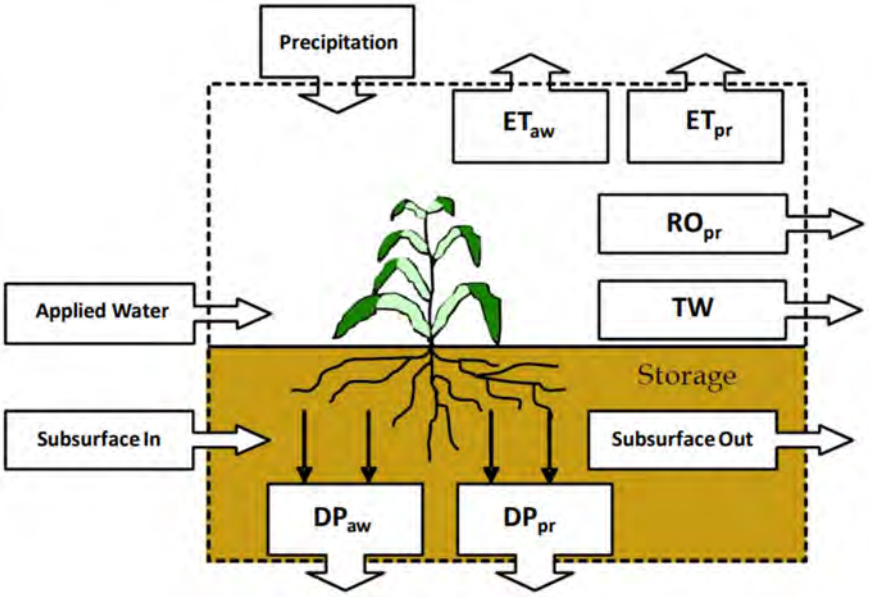


Figure 3.1. Conceptualization of Fluxes of Water Into and Out of the Crop Root Zone

Transpiration was quantified using a remote sensing approach whereby Landsat satellite images acquired from USGS were used to calculate the Normalized Difference Vegetation Index (NDVI), a

measure of the amount of green vegetation present. NDVI values were calculated and interpolated for each field over time. NDVI values were then converted to transpiration coefficients that were used to calculate transpiration over time by multiplying daily NDVI by daily reference evapotranspiration (ET_o). Evaporation was quantified by performing a surface layer water balance for the soil based on the dual crop coefficient approach described in FAO Irrigation and Drainage Paper 56 (Allen et al. 1998). On a daily basis, evaporation was calculated based on the most recent wetting event (precipitation or irrigation) and the evaporative demand for the day (ET_o). This methodology is described in greater detail in Davids Engineering (2013).

3.2 Development of Field Boundaries

A spatial coverage of field boundaries was developed for the study area, and individual field polygons were assigned cropping and irrigation method information. For each polygon, daily water balance calculations were performed, and irrigation events were simulated to estimate the amount of water applied to meet crop irrigation demands. This section describes the development of the field polygon coverage and assignment of cropping and irrigation method attributes.

The Study Area includes areas within and immediately surrounding the Butte Valley and Red Rock Valley Basins, and areas along Butte Creek. This technical memorandum summarizes results for the Butte Valley groundwater basin.

Field boundaries in agricultural areas were delineated by combining polygon coverages from the California Department of Water Resources (DWR) in GIS format. Non-agricultural areas were filled using a grid of approximately 40-acre tracts based on the Public Land Survey System (PLSS).

3.3 Assignment of Cropping and Irrigation Method

As described previously, crop evapotranspiration (ET) was calculated based on a combination of remote sensing data, precipitation data, and simulation of irrigation events in a daily root zone water balance model. A result of the remote sensing approach is that crop transpiration was estimated with little influence from the assigned crop type for each field. Additionally, crop transpiration is the dominant component of ET, meaning that ET estimates are likewise largely independent of the assigned crop type.

Crop evapotranspiration is driven to some extent by the characteristics of the irrigation method and its management, including the area wetted during each irrigation event and the frequency of irrigation. Surface irrigation methods typically wet more of the soil surface than micro-irrigation methods; however, surface irrigated fields are typically irrigated less frequently than their micro-irrigated counterparts. As a result, evaporation rates can be similar among surface and micro-irrigated fields and estimates of evaporation are likewise somewhat independent of the assigned irrigation method. Parameters related to irrigation method were assigned based on the predominant irrigation method for each crop, as described by available DWR land and water use surveys.

A key result of the relative insensitivity of the crop ET estimates to crop type or irrigation method (due to the remote sensing approach), is that detailed, accurate assignment of crop types and irrigation methods to each field is not critical to developing reliable estimates of crop ET at the field scale and, more importantly, at coarser scales due to the cancellation of errors in individual field estimates as they are aggregated (Davids Engineering 2013).

Crop types were assigned to each field based on a combination of data from the 2000, 2010, and 2014 DWR land use surveys for Siskiyou County. In years without available survey data, crop type was assigned based on the nearest year in time for which crop data were available.

3.4 NDVI Analysis

The amount of green vegetation present over time was estimated for each field polygon based on the Normalized Difference Vegetation Index (NDVI), which is calculated using a combination of red and near infrared reflectances, as measured using multispectral satellite sensors onboard Landsat satellites. NDVI can vary from -1 to 1 and typically varies from approximately 0.15 to 0.2 for bare soil to 0.8 for green vegetation with full cover. Negative NDVI values typically represent water surfaces.

3.4.1 Image Selection

Landsat images are preferred due to their relatively high spatial resolution (30-meter pixels, approx. 0.2 acres in size). A total of 428 raw satellite images were selected and converted to NDVI spanning the study period (Table 3.1). Of the images selected, 217 were from the Landsat 5 satellite, 128 were from the Landsat 7 satellite (first available in 2001), and 83 were from the Landsat 8 satellite (first available in 2013). These images were used to process and download surface reflectance (SR) NDVI from the USGS Earth Resources Observation and Science (EROS) Center Science Processing Architecture (ESPA)[2].

The number of days between image dates ranged from 8 to 160, with an average of 25 days. Generally, there was at least one image selected for each month, with less images available during winter months when cloudy conditions are more likely to occur.

3.4.2 Extraction of NDVI Values by Field and Development of Time Series NDVI Results

Following the preparation of NDVI imagery spanning the analysis period, NDVI for water surfaces (such as lakes or some wetlands) was adjusted to a higher value to more accurately estimate ET. All images were then masked using the Quality Assessment Band (BQA) provided by ESPA to remove pixels affected by snow, clouds and cloud shadows. Then, mean NDVI was extracted from the imagery for each field for each image date. These NDVI values were interpolated across the full analysis period from January 1, 1989 to December 31, 2018 to provide a daily time series of mean NDVI values for each field.

3.4.3 Development of Relationship to Estimate Basal Crop Coefficient from NDVI

Basal crop coefficients (K_{cb}) describe the ratio of crop transpiration to reference evapotranspiration (ET_o) as estimated from a ground-based agronomic weather station. By combining K_{cb}, estimated from NDVI, with an evaporation coefficient (K_e), it is possible to calculate a combined crop coefficient ($K_c = K_{cb} + K_e$) over time[3]. By multiplying K_c by ET_o, crop evapotranspiration (ET_c) can be calculated. For this analysis, ET_o, K_{cb}, K_e, and ET_c (synonymous to actual ET, ET_a) were estimated for each field on a daily time step for the full analysis period.

Mean daily NDVI values for each field were converted to basal crop coefficients using a relationship following Er-Raki (2007) and as described in greater detail by Davids Engineering (2013)[4].

[2] USGS ESPA website: https://espa.cr.usgs.gov/

[3] The estimation of Ke is based on a daily 2-stage evaporation model described in FAO Irrigation and Drainage Paper No. 56 (Allen et al. 1998).

[4] This relationship is developed based on comparison of the combined crop coefficient to NDVI for individual fields but represents only the transpiration component of ET. Thus, the relationship developed predicts the basal crop coefficient, Kcb.

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Table 3.1. Landsat Image Selection by Month and Year for Study Period.

Year	Month												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
1989	0	0	1	1	1	2	2	1	2	2	0	2	14
1990	1	1	1	2	1	2	0	1	1	2	0	0	12
1991	0	0	1	2	0	2	0	2	2	2	0	0	11
1992	0	0	1	1	2	1	2	2	2	2	2	1	16
1993	1	1	0	0	2	2	1	1	2	1	1	1	13
1994	2	1	1	2	1	1	2	2	2	1	1	0	16
1995	0	0	0	1	1	2	2	2	2	2	1	1	14
1996	1	1	1	2	2	1	2	2	1	2	1	0	16
1997	1	1	2	2	2	1	1	2	2	2	1	1	18
1998	0	1	2	2	0	2	2	1	2	2	0	2	16
1999	0	0	1	1	1	1	2	1	1	1	1	1	11
2000	0	0	1	0	2	2	1	2	1	1	0	1	11
2001	1	0	1	1	1	1	2	1	1	0	1	0	10
2002	1	1	0	1	1	2	1	1	1	1	1	0	11
2003	1	2	1	0	1	1	1	1	1	1	1	0	11
2004	0	1	1	1	1	1	2	1	1	0	1	1	11
2005	1	0	2	1	2	1	2	1	1	1	1	0	13
2006	0	1	0	1	2	1	2	1	1	1	1	0	11
2007	1	0	2	1	1	2	2	1	1	1	1	0	13
2008	0	0	1	1	1	2	2	2	0	1	1	0	11
2009	1	0	1	2	1	1	2	2	2	0	1	1	14
2010	0	1	1	2	1	1	2	1	2	0	1	0	12
2011	1	0	1	1	1	1	1	1	2	1	0	1	11
2012	1	1	0	1	2	0	1	2	2	0	1	1	12
2013	0	1	0	1	1	2	3	1	2	2	1	0	14
2014	1	0	0	1	1	2	2	1	1	2	0	0	11
2015	3	2	2	2	0	2	2	1	1	2	2	0	19
2016	4	1	4	2	3	2	2	3	3	1	3	2	30
2017	2	2	3	3	3	2	2	2	3	2	1	2	27
2018	1	2	0	1	2	2	2	2	2	2	2	1	19
Total	25	21	32	39	40	45	50	44	47	38	28	19	428

3.5 Precipitation

Daily precipitation was estimated based on assembly and review of data from the PRISM Climate Group at Oregon State University. Specifically, each field was assigned estimated daily precipitation from the 4km PRISM grid cell within which its centroid fell. The study area is represented by 99 individual grid cells.

Annual precipitation totals, averaged over the study area for water years 1990 to 2018, are shown in Figure 3.1. Water year precipitation over the study period varied from 7.9 inches in 2001 to 22.1 inches in 1998, with an annual average of 14.0 inches.

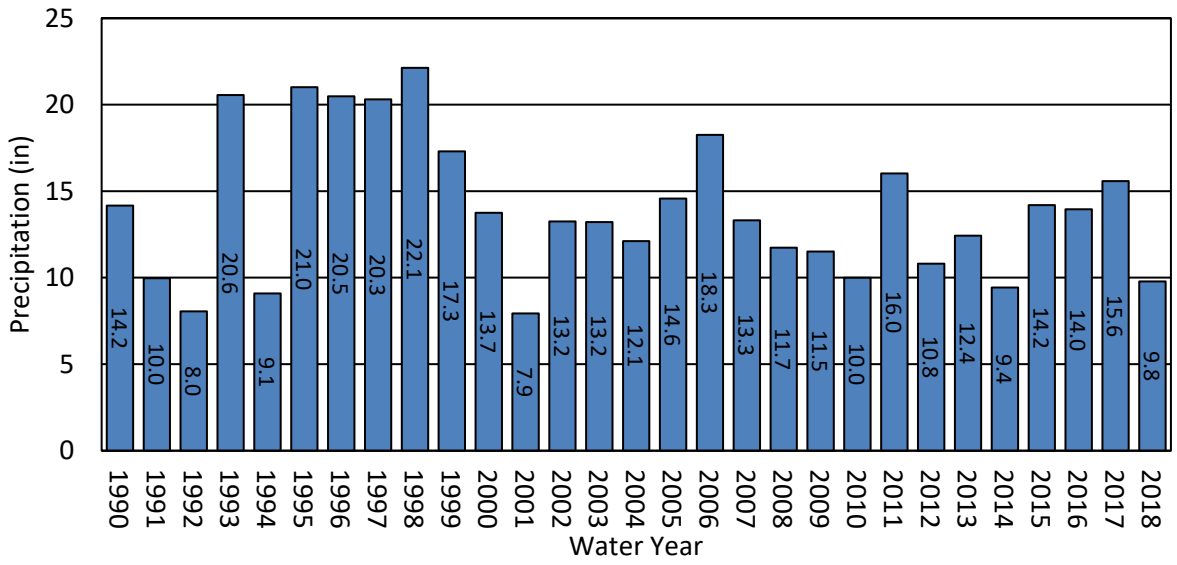


Figure 3.2. Annual Precipitation Totals

3.6 Reference Evapotranspiration

Daily reference evapotranspiration (ET_o) was estimated based on information from the MacDoel II CIMIS weather station (Station No. 236) and air temperature at the Juanita Lake NOAA[5] weather station. ET_o provides a means of estimating actual crop evapotranspiration over time for each field. Based on review of nearby weather stations with data available during the period of analysis, the MacDoel II station was selected based on it being located within the Butte Valley Basin, having relatively good fetch, and having available data during part of the analysis period. Since the MacDoel II station only had data available starting in 2015, estimated ET_o data based on temperature at the Juanita Lake station were used to fill in the remaining time period.

Individual parameters from the available CIMIS data including incoming solar radiation, air temperature, relative humidity, and wind speed were quality-controlled according to the procedures of Allen et al. (2005). The quality-controlled data were then used to calculate daily ET_o for the available period of record. Quality controlled NOAA temperature data were used to estimate daily ET_o using the method of Hargreaves and Samani (1985). The estimated Juanita Lake ET_o data were then correlated to the CIMIS data at MacDoel II during the period of overlap. This resulted in an adjustment factor that was applied to the Juanita Lake ET_o for the period during which MacDoel II data were not available.

[5] https://www.ncdc.noaa.gov/cdo-web/search

ET_o zones were developed to account for the variability in elevation, slope, and aspect (and therefore ET) found in the study area based on long-term average spatialy distributed ETo from Spatial CIMIS[6]. One ET_o zone was created for each PRISM precipitation grid cell, resulting in the creation of 99 ET_o zones. ET values were multiplied by an adjustment factor for each zone to derive an ET time series for each land use and ET zone.

3.7 Root Zone Water Balance Parameters

Root zone parameters that influence the amount of available soil moisture storage were estimated based on crops and soils present in the study area. Crop parameters of interest include root depth, NRCS curve number[7], and management allowable depletion (MAD). Root depth was estimated by crop group based on published values. Curve numbers were estimated based on values published in the NRCS National Engineering Handbook, which provides estimates based on crop type and condition. MAD values by crop were estimated based on values published in FAO Irrigation and Drainage Paper No. 56 (Allen et al., 1998).

Soil hydraulic parameters of interest include field capacity (% by vol.), wilting point (% by vol.), saturated hydraulic conductivity (ft/day), total porosity (% by vol.), and the pore size distribution index (λ, dimensionless). These parameters were estimated by first determining the depth-weighted average soil texture (sand, silt, clay, etc.) based on available NRCS soil surveys. Next, the hydraulic parameters were estimated using hydraulic pedotransfer functions developed by Saxton and Rawls (2006). Then, hydraulic parameters were adjusted within reasonable physical ranges for each soil texture so that the modeled time required for water to drain by gravity from saturation to field capacity agreed with typically accepted agronomic values. Unsaturated hydraulic conductivity (e.g. deep percolation) within the root zone was modeled based on the equation developed by Campbell (1974) for unsaturated flow.

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[6] Spatial CIMIS is a gridded ETo product available from DWR. Long-term average gridded ETo was estimated based on daily ETo grids for the years 2004 to 2018.

[7] The curve number runoff estimation method developed the Natural Resources Conservation Service (NRCS) was used to estimate runoff from precipitation in the model. For additional information, see NRCS NEH Chapter 2 (NRCS, 1993).

4 Results

4.1 Evapotranspiration

Estimated annual crop evapotranspiration volumes for agricultural fields in the Study Area are shown in Figure 4.1. Estimated volumes of ET derived from applied water (ETaw) and precipitation (ETpr) are shown in thousands of acre-feet (taf). Annual ETaw ranged from 28 taf to 61 taf, with an average of 41 taf. Annual ETpr ranged from 12 taf to 32 taf, with an average of 21 taf. Total crop ET ranged from 49 taf to 82 taf, with an average of 62 taf.

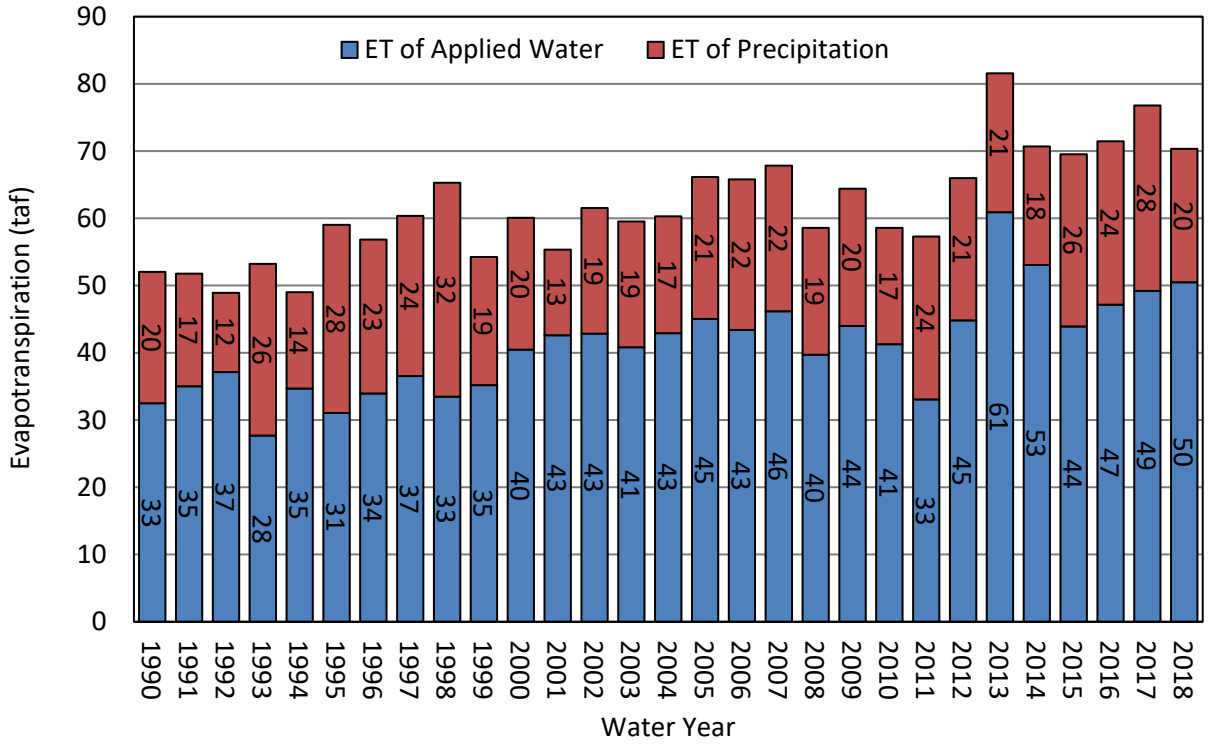


Figure 4.1. Crop ET by Water Year

4.2 Irrigation Demands

Annual estimated irrigation demands for fields in the Study Area are shown in Figure 4.2 in thousands of acre feet. Annual demands ranged from 42 taf to 82 taf, with an average of 59 taf.

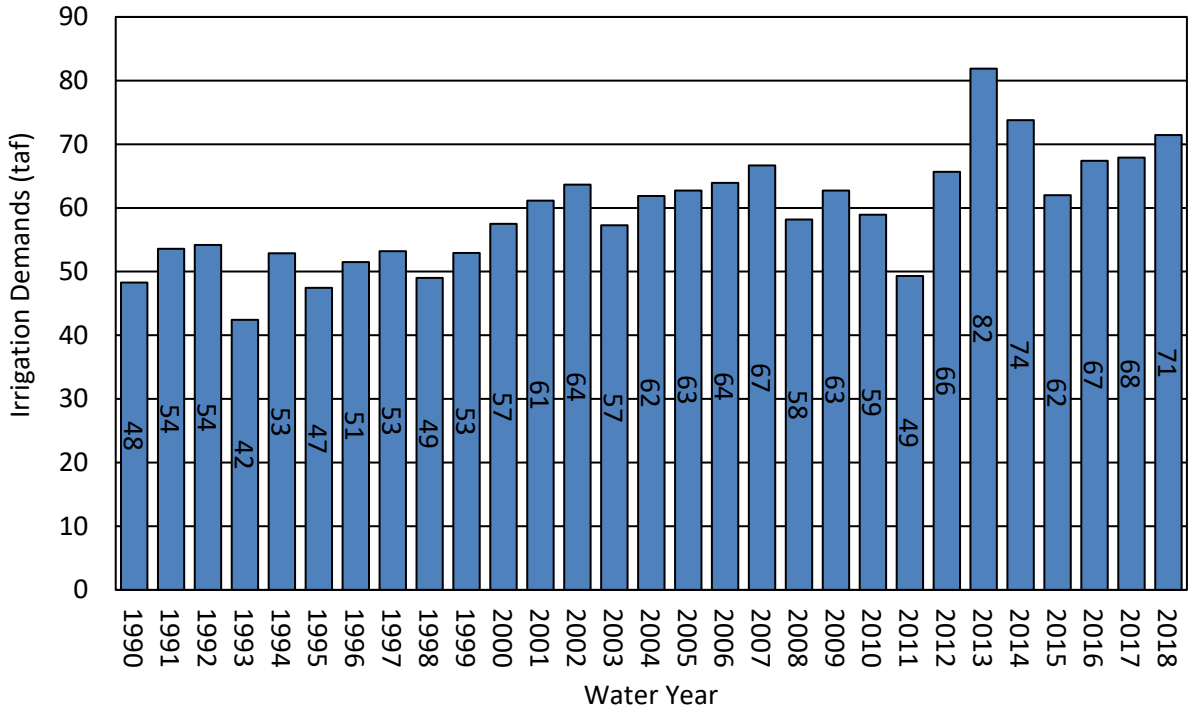


Figure 4.2. Study Area Irrigation Demands by Water Year

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4.3 Deep Percolation

Estimated annual deep percolation volumes for fields in the Study Area are shown in Figure 4.3. Estimated volumes of deep percolation derived from applied water (DPaw) and precipitation (DPpr) are shown in thousands of acre-feet. Annual DPaw ranged from 15 taf to 23 taf, with an average of 18 taf. Annual DPpr ranged from 5 taf to 21 taf, with an average of 12 taf. Total deep percolation ranged from 23 taf to 42 taf, with an average of 30 taf.

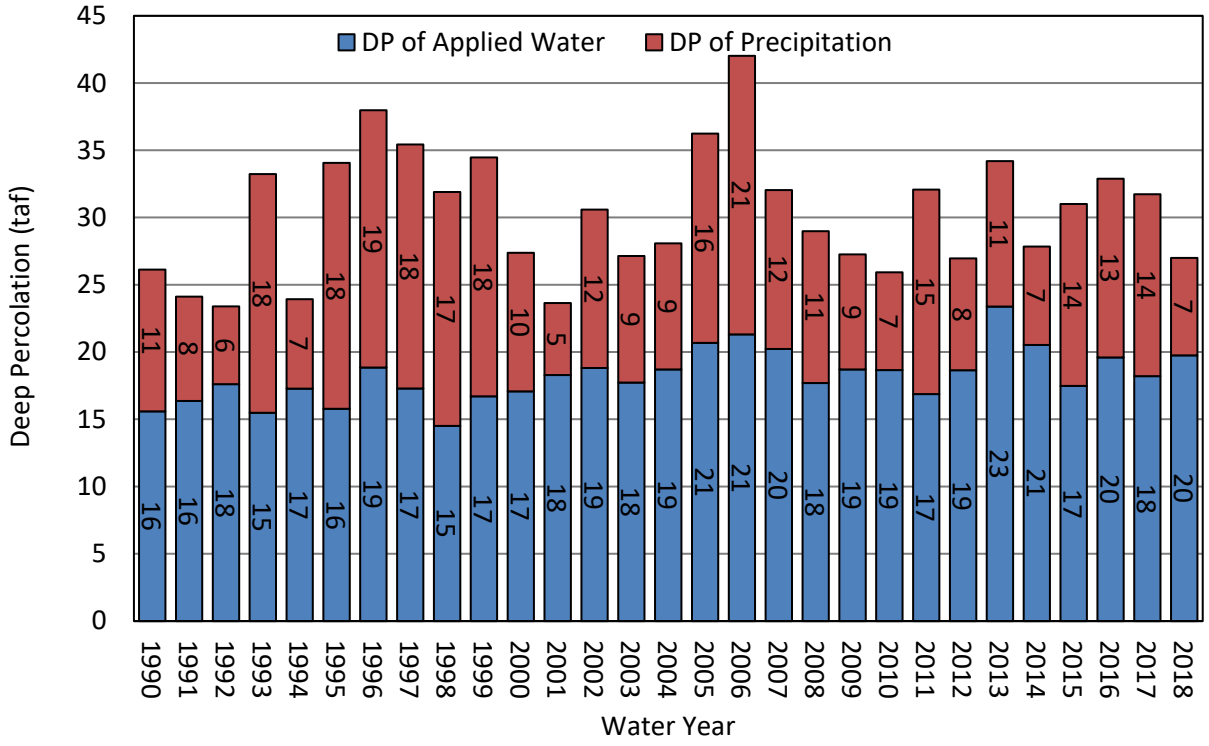


Figure 4.3. Study Area Deep Percolation by Water Year.

4.4 Evapotranspiration by Crop

Average monthly evapotranspiration by crop (ETc) is presented in Figures 4.4 through 4.9 for each year with available DWR land use survey data (2000, 2010, and 2014), along with averages for the three survey years. Additionally, monthly ETo values are shown along with monthly crop coefficients (Kc), calculated as ETc divided by ETo.

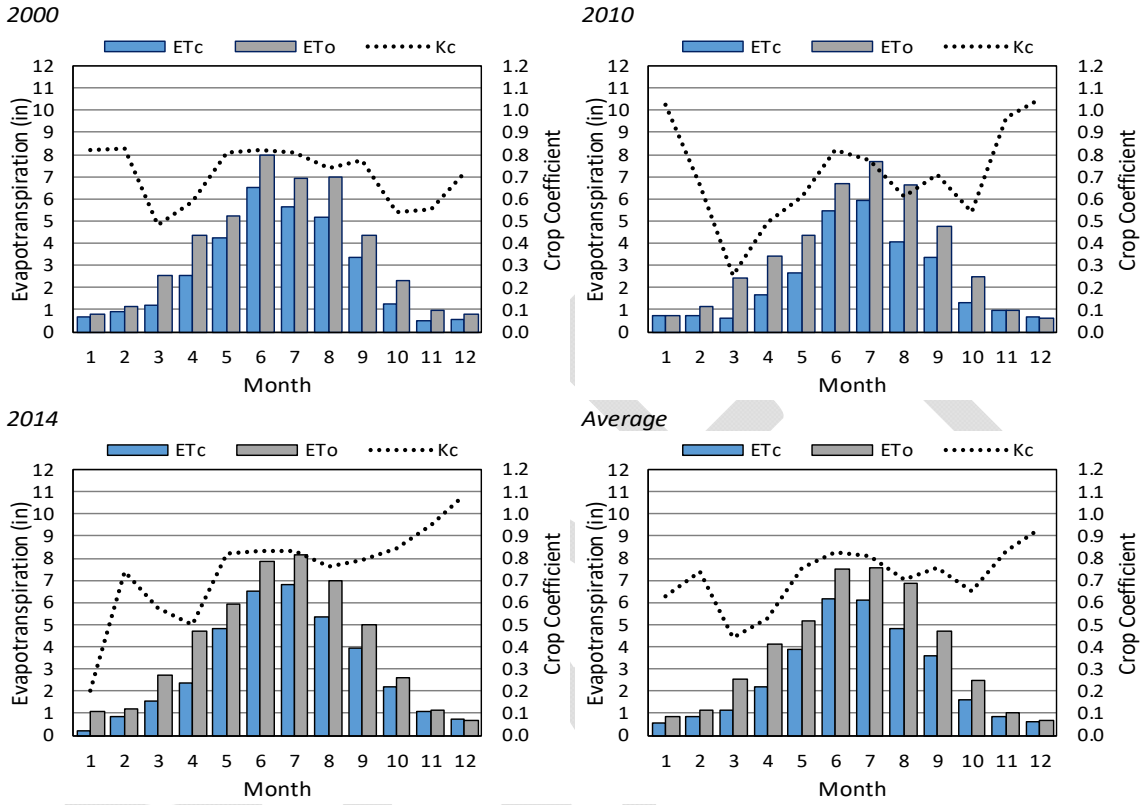


Figure 4.4. Alfalfa Monthly ETc, ETo, and Kc.

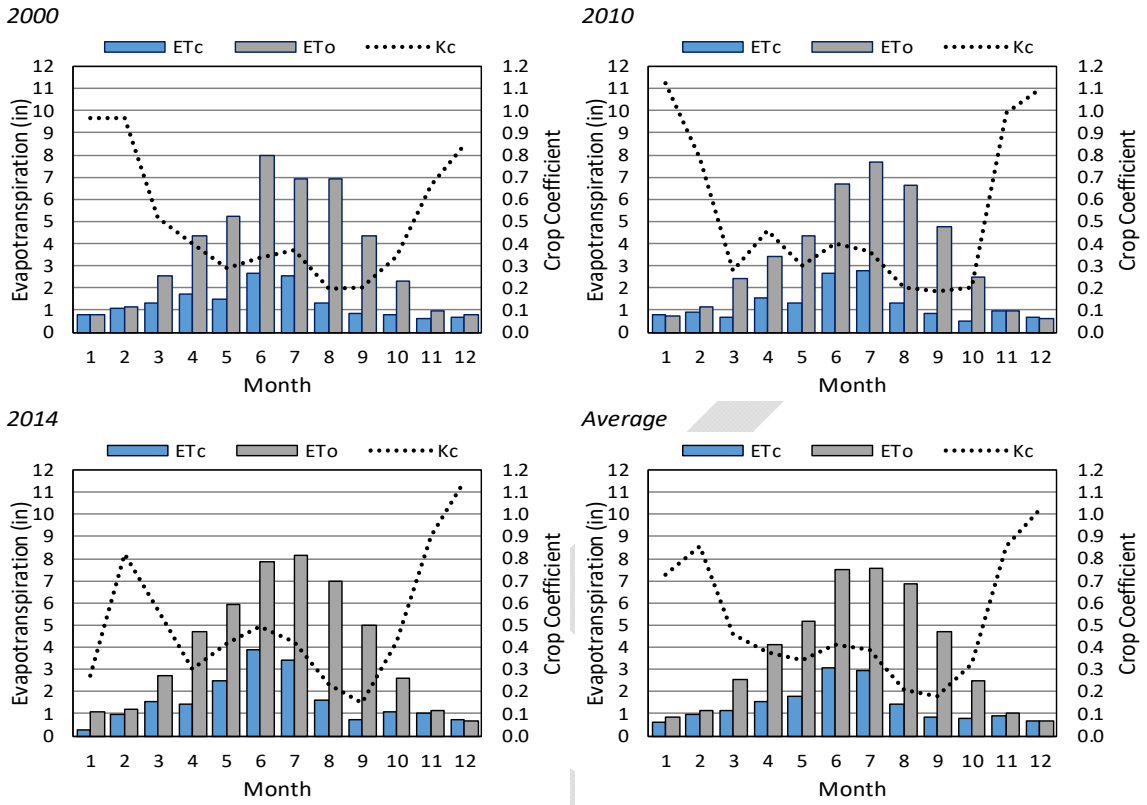


Figure 4.5. Grain and Hay Monthly ETc, ETo, and Kc.

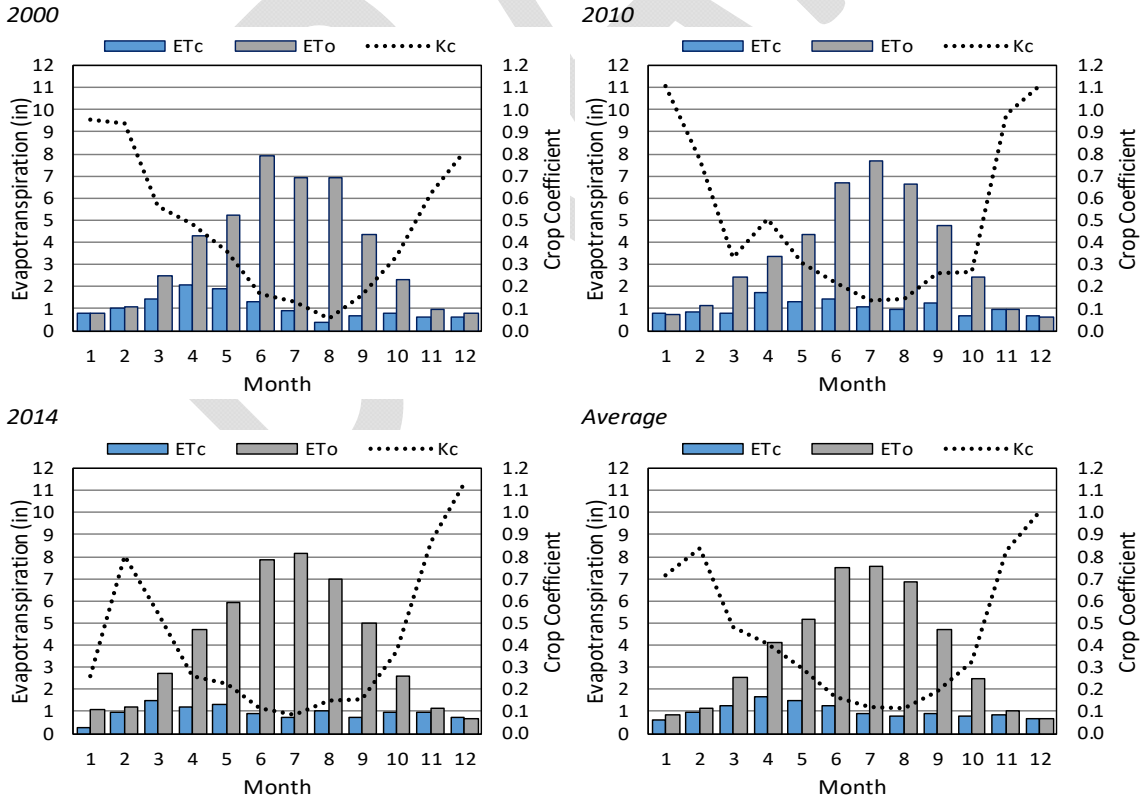


Figure 4.6. Idle Cropland Monthly ETc, ETo, and Kc.

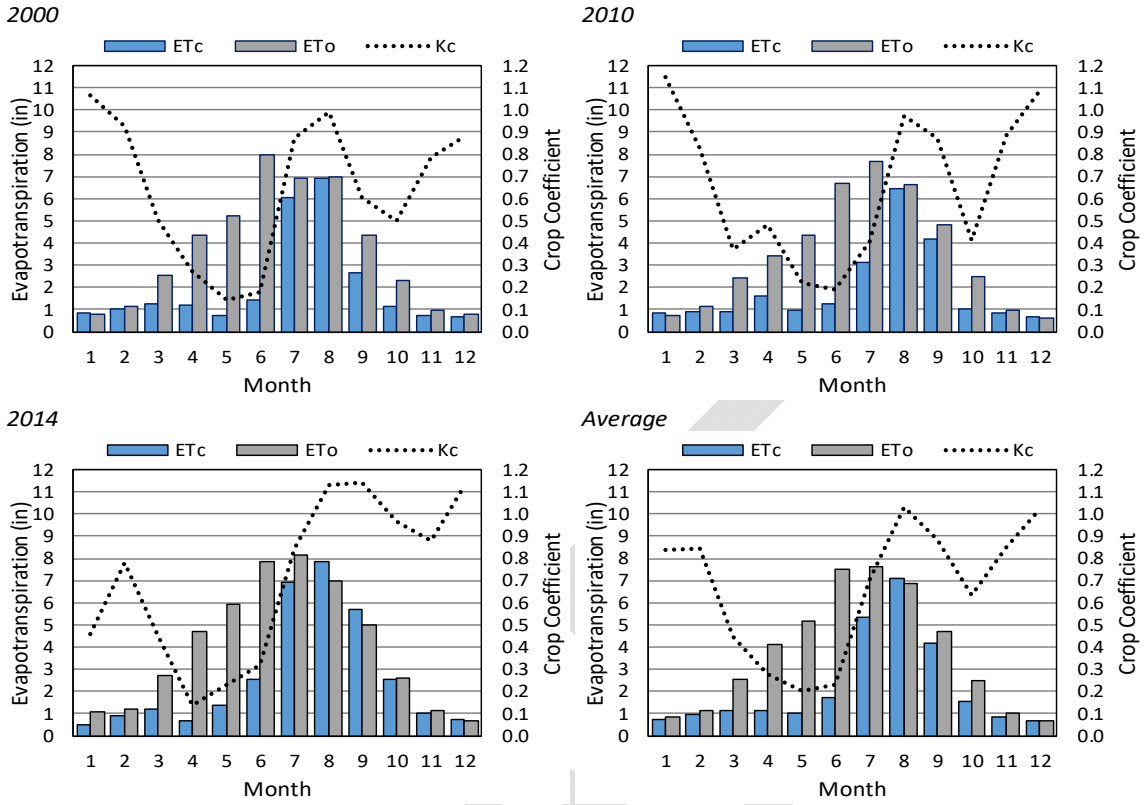


Figure 4.7. Miscellaneous Truck Crop Monthly ETc, ETo, and Kc.

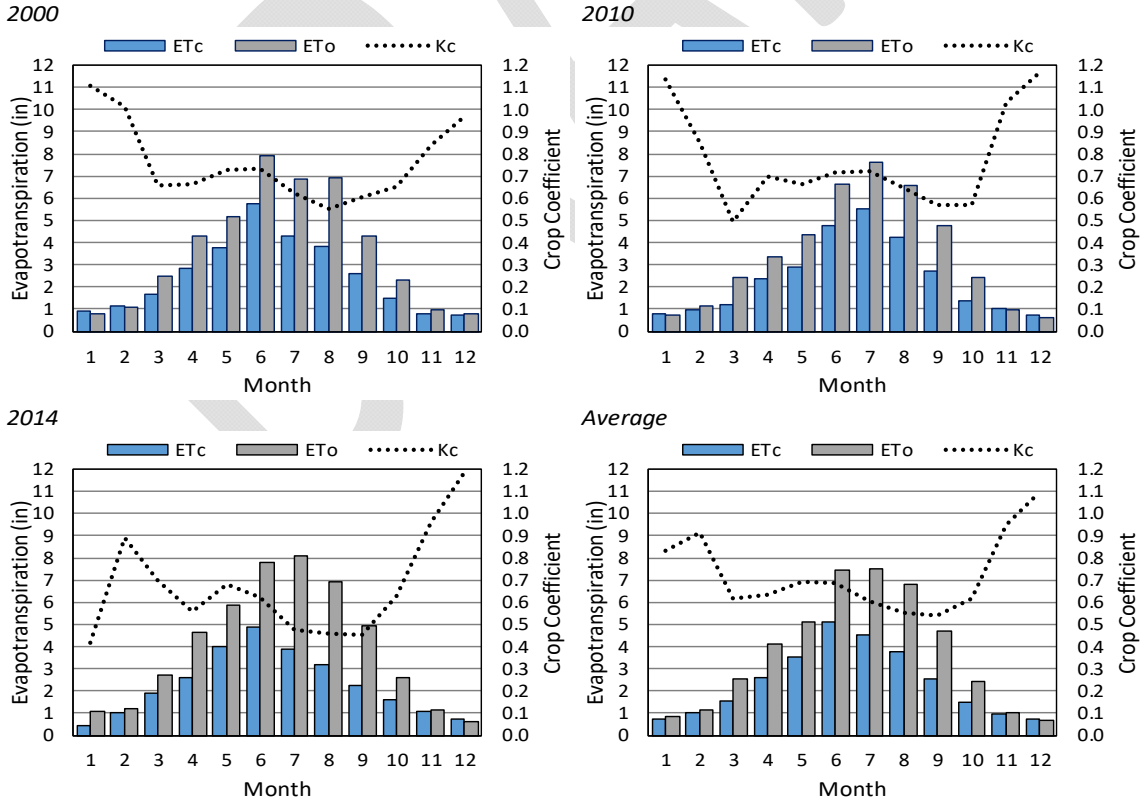


Figure 4.8. Pasture Monthly ETc, ETo, and Kc.

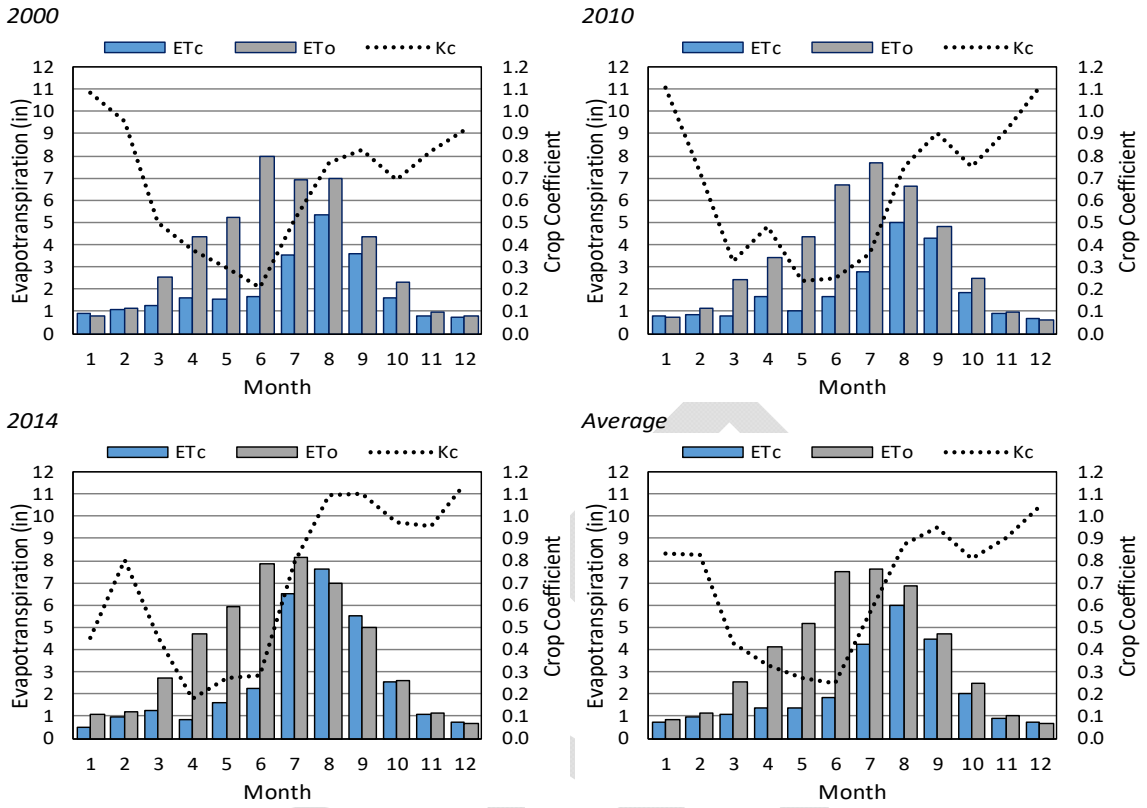


Figure 4.9. Strawberry Monthly ETc, ETo, and Kc.

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Technical Memorandum

To: Interested Parties

From: Davids Engineering

Date: May 2021

Subject: **Water Budget Development for Butte Valley Wildlife Area**

Summary

An estimated water budget was developed for Butte Valley Wildlife Area (BVWA) using a water budget tool developed to estimate applied water demands based on estimated acres for seasonal wetlands, upland vegetation, and cropland based on water management regimes. BVWA is located in northwestern Siskiyou County west of Macdoel and lies west of Meiss Lake, a shallow natural water body.

The water budget results indicate that water sources in a typical year include applied water (2.2 taf[1] or 3 inches annually[2]) and precipitation (11.4 taf or 15 inches annually). Primary outflows include evapotranspiration (12.5 taf or 16 inches annually) and percolation (1.1 taf or 1.5 inches annually). Other outflows estimated include surface runoff of precipitation (0.1 taf or 0.1 inches annually) and return flows from applied water (0.1 taf or 0.1 inches annually). These small runoff amounts are reused within BVWA. Only during extreme flooding do outflows from the BVWA occur, during which water is pumped out of the wildlife area to either the Klamath River or the National Grasslands. The WWBT simulates management for individual cells, rather than routing of flows between cells; under normal conditions these small runoff amounts will be reused within BVWA.

Background and Overview

This technical memorandum describes water budgets developed for wetlands at Butte Valley Wildlife Area (BVWA) as part of an effort for Audubon to prepare water budget information that is consistent with and adequate to satisfy requirements for water budgets developed for Groundwater Sustainability Plans (GSPs) under the Sustainable Groundwater Management Act of 2014 (SGMA) while also supporting other wetlands water management activities. In addition to supporting SGMA implementation, these water budgets and the water budget tool described below could support future decision-making by wetlands managers related to the optimization of available water supplies to maximize habitat value.

[1] Thousand acre-feet.

[2] These estimates, generated by the model represent relatively full water supply conditions and may vary in dry years during which refuge water supply is reduced.

The water budgets were generated using a Microsoft Excel-based Wetlands Water Budget Tool (WWBT) developed as part of this effort (Davids Engineering 2020) to quantify primary inflows to and outflows from managed wetlands based on publicly available information and information received through consultation with BVWA representatives. This tool could also be used in the future to evaluate additional wetlands management scenarios that may be contemplated by wetlands managers.

BVWA Land and Water Management

Managed wetlands at BVWA include approximately 4,300 acres of seasonal wetlands, of which approximately sixteen percent receive applied water for winter flooding. Water management practices, in general, may be summarized as follows:

- Approximately 300 wetlands acres receive applied groundwater in stages in August and September. An additional 300 acres receive applied groundwater during October, and an additional 100 acres receive applied water during the first half of November. Runoff of precipitation from upslope areas through three creeks that flow into BVWA may also provide a source of supply at times in the fall to supplement applied groundwater supplies and help flood wetland areas.
- After mid-November, the wetland ponds then rely on available precipitation to maintain habitat. Flow through the three creeks in the winter and spring are redirected from the wetlands to flow directly into Meiss Lake.
- To the extent supplies are adequate, wetlands ponds are maintained through the spring and drawdown occurs in May and June.
- The wetlands remain dry during the summer until water is applied again in the fall.
- In addition to wetlands receiving applied water, approximately 3,600 acres of additional wetlands habitat exists within BVWA. These lands are managed to capture upslope precipitation runoff, direct precipitation, and water pumped from Meiss Lake[3] on the wetlands cells when available. Historically, in very wet years, a substantial percentage of these acres may have been flooded. However, due to a variety of factors including decreasing creek flows into BVWA and budget constraints, in more recent years, none of this acreage has received water, even during wet years.
- Approximately 600 acres of additional land can be planted and irrigated for grain production. However, due to limited funding, labor, and water supply, the planted and irrigated acreage is typically around 300 acres. These lands are irrigated in July and August. The remaining 300 acres of crop land are typically idle.
- Finally, the BVWA includes approximately 4,400 acres of upland vegetation.

This summary of water management practices was originally developed using the 1996 Management Plan for the BVWA and was refined and revised through coordination and discussion with the BVWA Manager to incorporate recent management practices.

[3] Meiss Lake overtopping and flooding private lands to the east is a concern in Butte Valley. When the lake is nearly full during wet periods, water is pumped from Meiss Lake to these adjacent wetland cells or overland to the Klamath River or National Grasslands.

Water Budget Methodology

Structure

Water budgets were developed using methodologies consistent with existing water budgets from the California Department of Water Resources (DWR) for managed wetlands. These DWR water budgets support the California Water Plan, the CalSim water resources planning model, and the California Central Valley Groundwater-Surface Water Simulation Model (C2VSim). A general schematic depicting the water budget structure is shown in Figure 1.

For a given wetlands complex, estimates of water budget components including inflows, outflows, and change in storage[4] are estimated over time on a monthly time step. Water budgets are estimated for the period 1991 to 2017 to evaluate differences in water requirements over a range of hydrologic conditions. Applied water requirements are estimated through closure of the water budget based on the principle of conservation of mass, as shown in Equation 1, where AW = applied water, ET = evapotranspiration, SR = surface runoff, RF = return flow, Perc = percolation, Precip = precipitation, and dS = change in storage.

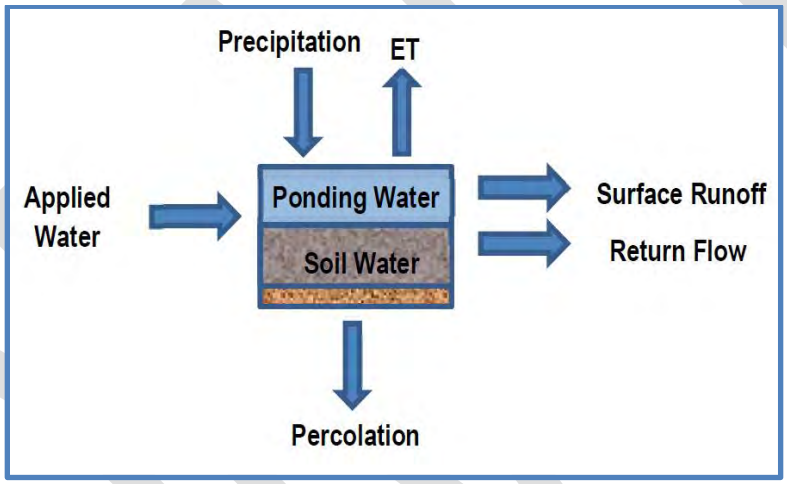


Figure 1. Wetlands Water Budget Structure (DWR 2017).

$$AW = ET + SR + RF + Perc - Precip - dS \quad [1]$$

The methodology used to estimate individual water budget components is described in the following section. Some component methodologies vary based on the operational mode of a given wetland, which varies over time based on habitat and water management objectives. The following modes are considered:

- Floodup – Period during which ponds are filled, typically during late summer/fall;
- Maintenance – Period during which ponds are maintained, and water is applied as needed to maintain desired water levels, typically during fall/winter;
- Hold – Period during which pond drainage is prevented, but additional water is not applied, typically during fall/winter;
- Drawdown – Period during which ponds are drained, typically during late spring;

[4] Change in storage refers to the change in pond storage and stored moisture in the top few feet of the soil.

- Irrigation – Period during which water is applied for irrigation to produce feed (e.g. smartweed, watergrass, timothy, etc.) for migratory waterfowl and shorebirds, typically during late spring/summer;
- Cropped – Period following irrigation when an actively growing crop is present but additional irrigation water is not applied, typically during summer; and
- No Action – Period during which water is not present, typically during summer.

For a given wetlands complex, the timing of water management operations is estimated for unique habitat types, and estimated water budgets for each habitat type are aggregated to develop the water budget for the complex as a whole to estimate total AW. Once total AW requirements are estimated, groundwater demand can be estimated as the difference between the total AW and available surface water supplies.

Components

Evapotranspiration (ET)

ET over time for each habitat type is estimated based on the well accepted reference evapotranspiration (ET_o) – crop coefficient methodology (ASCE, 2016). ET_o is available from DWR through the Spatial CIMIS system (https://cimis.water.ca.gov/SpatialData.aspx) and estimated habitat coefficients (Kh) relating ET_o to actual ET (Allen et al. 1998) according to Equation 2. For this effort, values of actual ET have been estimated based on Landsat satellite imagery and the METRIC energy balance model (Allen et al. 2007), and used to estimate Kh. The METRIC model was applied to the Sacramento National Wildlife Refuge (NWR) in 2017-2018. The actual ET and corresponding Kh resulting from the energy balance inherently accounts for stress during the operational modes when a full water supply is unavailable. Estimated monthly ETo, Kh, and actual ET are shown in Figure 2. As shown, actual ET tends to equal or exceed ETo between December and March when conditions are relatively wet due to precipitation and applied water and falls below ETo during the remainder of the year due to drier conditions as cells dry following spring drawdown. The Kh is typical for seasonal operational modes and can be used with ET_o from the BVWA to estimate actual ET for the BVWA area.

$$\text{Actual ET} = ET_o \times Kh \qquad [2]$$

Surface Runoff (SR)

SR represents runoff occurring due to precipitation[5]. SR is estimated as follows:

- Periods when individual wetlands cells are not ponded: Runoff is calculated using the Natural Resources Conservation Service (NRCS) curve number method, applied on a daily basis as described by Schroeder et al. (1994) and aggregated to monthly SR. Daily precipitation was estimated as described below.
- Periods when cells are ponded: When ponds are maintained at targeted levels by applying water (Maintenance mode) for individual cells, it is assumed that all precipitation runs off. When ponds are held, but water is not applied for individual cells, it is assumed that no precipitation runs off, unless the target water level is exceeded.

[5] Surface runoff is estimated in the WWBT at the cell level. The volume is estimated to leave the specific cell, but not necessarily the wildlife refuge as a whole. It may still be available for recapture and reuse within the wildlife refuge.

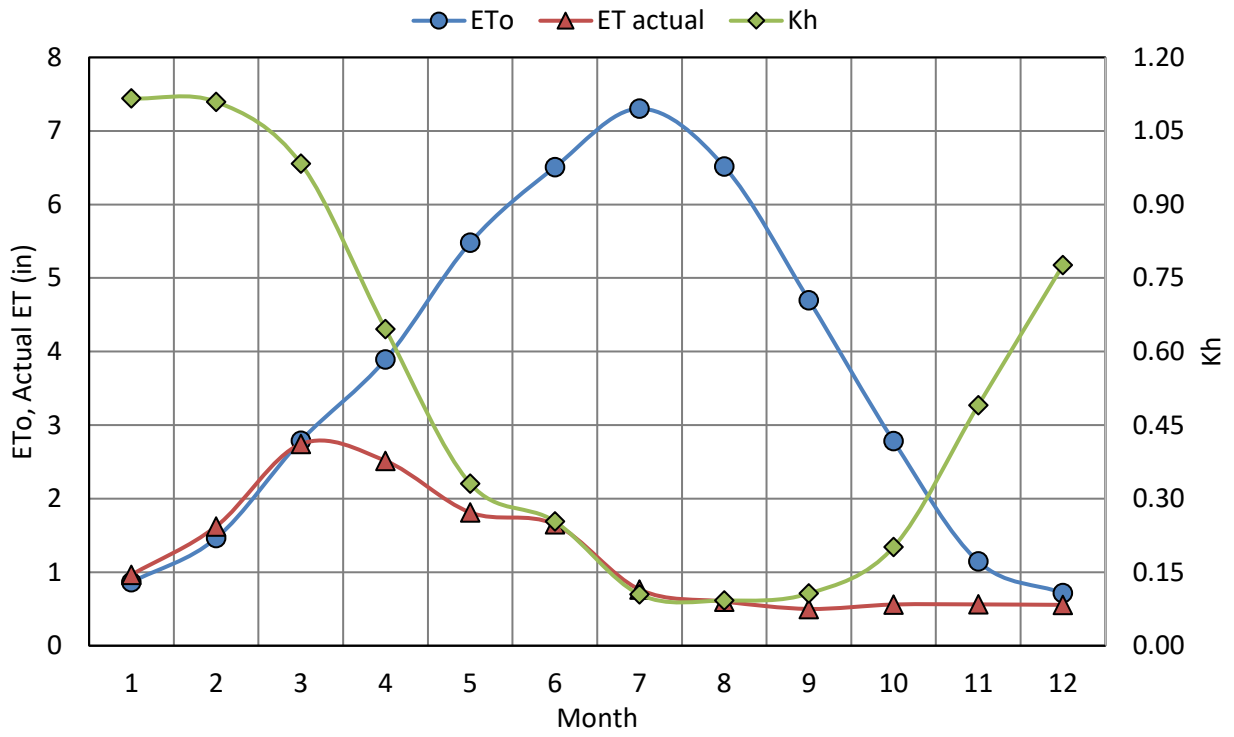


Figure 2. Reference ET (ET_o), Habitat Coefficients (Kh), and Actual ET for 2017-2018 for the Sacramento NWR.

Return Flow (RF)

RF represents runoff occurring due to applied surface water and/or groundwater[6]. RF is estimated as follows:

- Periods when cells are not ponded – For periods when summer irrigation occurs, RF is estimated based on a user-specified percentage of applied water running off of an irrigated cell and ultimately leaving the wetlands complex, if any.
- Periods when cells are ponded – For periods when cells are ponded, RF can occur through three modes:
    - Specified flow-through water from individual cells ultimately leaving wetlands complex,
    - Specified lateral seepage to natural waterways or manmade drains ultimately leaving wetlands complex, and
    - Pond drainage during periods of drawdown.

Percolation (Perc)

Perc represents the rate of percolation of water below the root zone entering the groundwater system and is estimated using the Campbell equation (Campbell 1974) based on estimated soil hydraulic parameters and soil moisture content. For periods when the soil moisture is above field capacity (e.g. ponded periods or periods within the first few days following irrigation), the percolation rate is

[6] Return flow is estimated in the WWBT at the cell level. The volume is estimated to leave the specific cell, but not necessarily the wildlife refuge as a whole. It may still be available for recapture and reuse within the wildlife refuge.

equivalent to the soil's saturated hydraulic conductivity. For periods when the soil moisture is below field capacity, the percolation rate is calculated based on unsaturated flow, as described by the Campbell equation. Soil parameters were estimated based on NRCS soil surveys and then calibrated as part of water budget development.

Precipitation (Precip)

Precipitation is estimated using interpolated local rainfall data from the Parameter Regression for Independent Slopes Model (PRISM) (http://www.prism.oregonstate.edu/) developed at Oregon State University for the centroid of the refuge boundary.

Change in Storage (dS)

During the non-ponded period, changes in storage are estimated based on a daily root zone water balance for each cell tracking AW, Precip, ET, SR, RF, and Perc as described by DWR (2017). During the ponded period, changes in storage are estimated based on daily changes in pond depth resulting from AW, Precip, ET, SR, RF, and Perc. Changes in pond depth are estimated based on estimated target pond depths and days required to flood each cell. Changes in storage over the course of a year are typically near zero, but vary somewhat from year to year.

Applied Water (AW)

As described previously, AW is estimated through closure of the water budget using Equation 1.

Results

Monthly Water Budget

Monthly water budget results for a relatively typical year (Water Year 2016[7]) are presented in Tables 1 and 2 and Figures 3 and 4, respectively. Table 1 and Figure 3 present estimated water budget components volumetrically in acre-feet per month, while Table 2 and Figure 4 express the water budget components as a depth in inches per month.

AW occurs in the late summer and fall between August and November, with the greatest applied water occurring in August and September. It then decreases into October and November as maintenance stops, and water is held through the winter. A positive change in storage (dS) occurs during months in late summer and fall in which water is applied and increases pond storage and soil moisture; positive dS also occurs in the winter months of December and January from precipitation. A negative change in storage in subsequent months reflects decreases in pond storage and reduction in stored soil moisture.

ET generally increases during the spring and decreases in summer due to relatively dry conditions. ET then increases again in fall as water is applied but subsequently decreases in winter due to decreases in evaporative demand (ETo).

SR is small due to precipitation being held to maintain pond storage. RF is also small, due to almost all applied water being consumed as ET or entering the groundwater system through percolation. SR is negligible in most months; it is highest in April when drawdown in the ponds occurs and precipitation collected in the ponds over the winter is drained. RF is negligible in most months, although minimal amounts occur during the months of water application. All of the estimated runoff (SR) or return flow

[7] A water year refers to the period from October to September. For example, the 2016 water year corresponds to the period from October 2015 to September 2016. The 2016 water year was selected as a recent year with near average precipitation based on the period 1991-2017.

(RF) is recaptured and reused before leaving the refuge under normal conditions; however, the WWBT is applied at the individual cell scale, rather than for the refuge as a whole.

Table 1. Water Year 2016 Monthly Water Budget (acre-feet).

Month	Area (ac)	Inflows		Outflows				dS (af)	Check
		Precip (af)	AW (af)	ET (af)	Perc (af)	SR (af)	RF (af)		
10	9,300	698	893	410	136	45	33	966	0
11	9,300	457	221	380	169	3	0	126	0
12	9,300	3,480	0	393	181	9	0	2,897	0
1	9,300	2,100	0	737	181	0	0	1,182	0
2	9,300	698	0	1,577	169	0	0	-1,048	0
3	9,300	1,860	0	2,416	179	0	0	-735	0
4	9,300	612	6	2,797	25	0	0	-2,204	0
5	9,300	558	4	1,352	0	27	0	-818	0
6	9,300	736	0	1,235	0	20	0	-518	0
7	9,300	124	100	608	0	0	20	-404	0
8	9,300	39	467	337	30	0	20	119	0
9	9,300	85	465	221	66	3	16	245	0
Total	**9,300**	**11,447**	**2,155**	**12,465**	**1,136**	**107**	**89**	**-194**	**0**

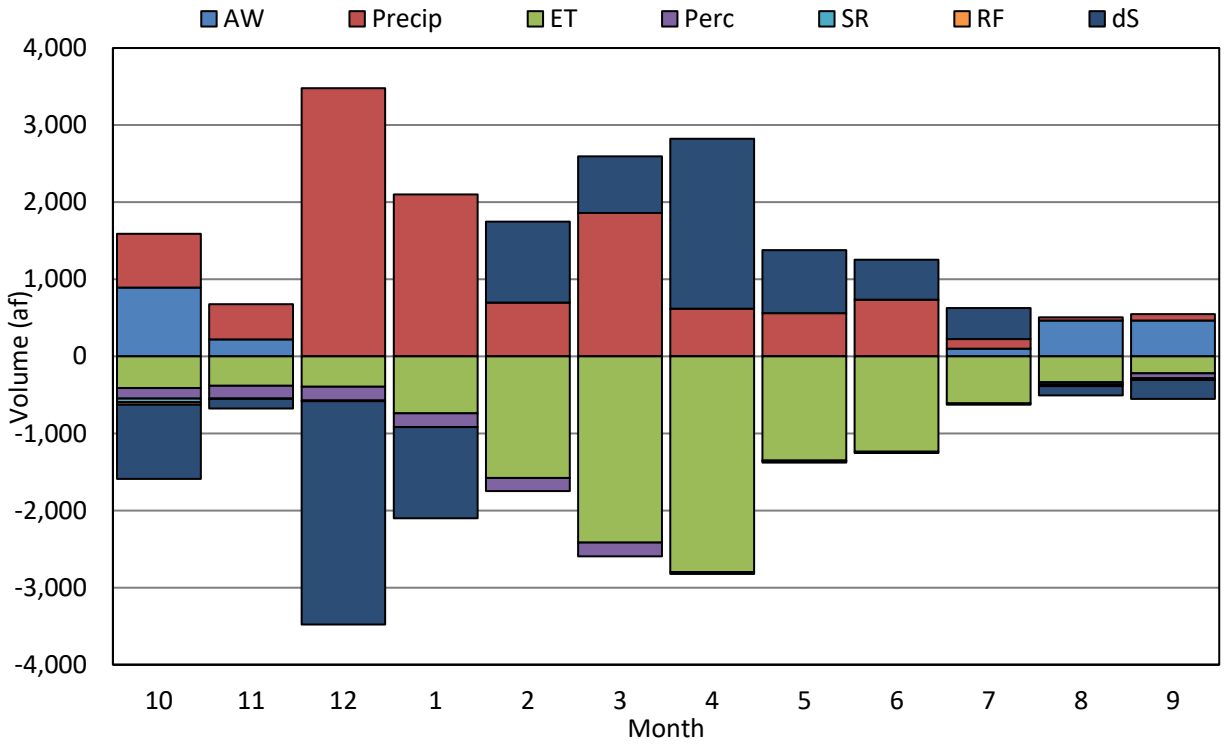


Figure 3. Water Year 2016 Monthly Water Budget (acre-feet).

Table 2. Water Year 2016 Monthly Water Budget (inches).

Month	Area (ac)	Inflows		Outflows				dS (in)	Check
		Precip (in)	AW (in)	ET (in)	Perc (in)	SR (in)	RF (in)		
10	9,300	0.9	1.2	0.5	0.2	0.1	0.0	1.2	0.0
11	9,300	0.6	0.3	0.5	0.2	0.0	0.0	0.2	0.0
12	9,300	4.5	0.0	0.5	0.2	0.0	0.0	3.7	0.0
1	9,300	2.7	0.0	1.0	0.2	0.0	0.0	1.5	0.0
2	9,300	0.9	0.0	2.0	0.2	0.0	0.0	-1.4	0.0
3	9,300	2.4	0.0	3.1	0.2	0.0	0.0	-0.9	0.0
4	9,300	0.8	0.0	3.6	0.0	0.0	0.0	-2.8	0.0
5	9,300	0.7	0.0	1.7	0.0	0.0	0.0	-1.1	0.0
6	9,300	1.0	0.0	1.6	0.0	0.0	0.0	-0.7	0.0
7	9,300	0.2	0.1	0.8	0.0	0.0	0.0	-0.5	0.0
8	9,300	0.1	0.6	0.4	0.0	0.0	0.0	0.2	0.0
9	9,300	0.1	0.6	0.3	0.1	0.0	0.0	0.3	0.0
Total	**9,300**	**14.8**	**2.8**	**16.1**	**1.5**	**0.1**	**0.1**	**-0.3**	**0.0**

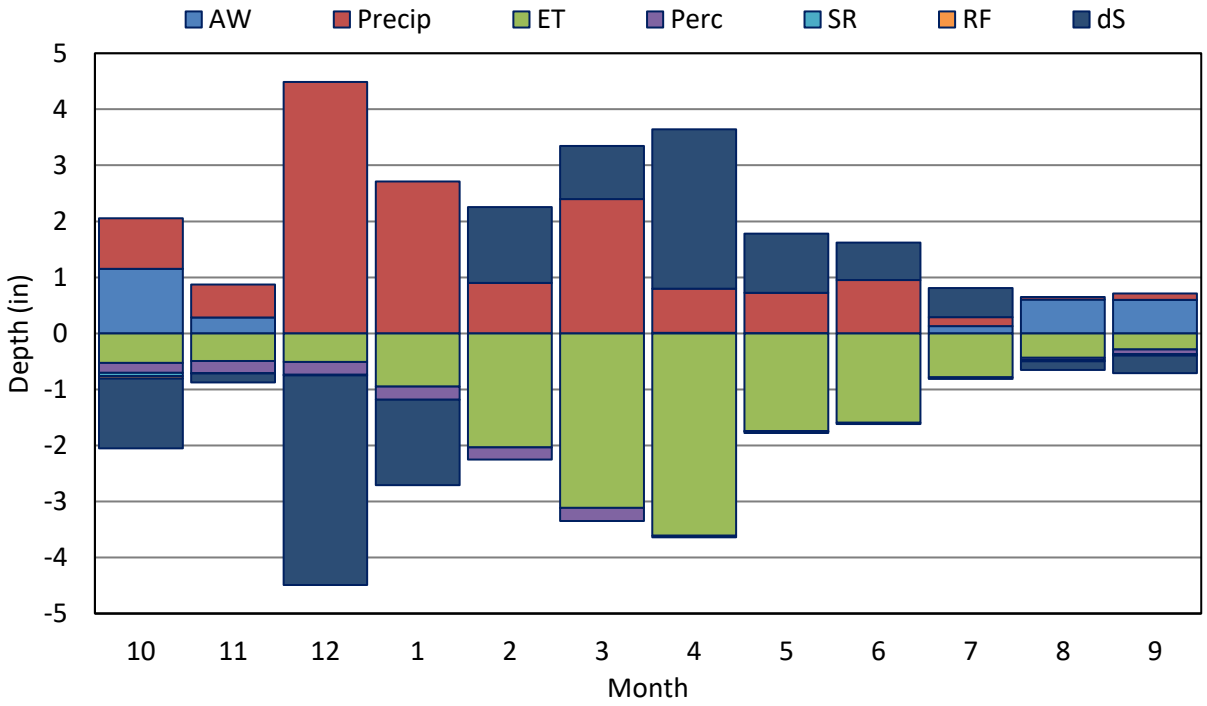


Figure 4. Water Year 2016 Monthly Water Budget (inches).

Annual Water Budget

Annual water budget results for water years 1991 to 2017 are presented in Table 3 and summarized by year type (wet, dry, and average) in Figure 5.

AW is relatively consistent across years and year types; precipitation varies across years and is obviously greatest in wet years and least in dry years. ET varies from year to year and is largely influenced by precipitation; the greater water availability in wet years results in higher ET values, as compared to dry

years. Similarly, Perc and SR are also higher in wet years and lower in dry years, although the overall volumes and changes from year to year are not as great. RF is generally small and is relatively consistent across years and year types. Change in storage (dS) varies from year to year but averages near zero over the period of analysis.

Table 3. Annual Water Budget, 1991 – 2017 (acre-feet).

Water Year	Year Type	Inflows		Outflows				dS (af)	Check
		AW (af)	Precip (af)	ET (af)	Perc (af)	SR (af)	RF (af)		
1991	Dry	2,152	8,122	9,997	906	116	89	-834	0
1992	Dry	2,148	6,030	6,911	991	92	89	94	0
1993	Wet	2,083	15,523	15,606	1,233	191	89	486	0
1994	Dry	2,083	6,991	8,370	917	153	89	-455	0
1995	Wet	2,093	15,655	16,179	1,252	117	89	110	0
1996	Wet	2,102	16,399	16,399	1,574	216	89	223	0
1997	Wet	2,097	16,337	16,258	1,231	324	89	531	0
1998	Wet	2,039	17,081	17,776	1,266	251	89	-262	0
1999	Wet	2,091	13,880	14,659	1,459	255	89	-491	0
2000	Wet	2,148	10,680	11,610	1,054	90	89	-16	0
2001	Dry	2,120	6,239	7,173	880	92	89	124	0
2002	Dry	2,152	10,486	11,927	1,067	82	89	-528	0
2003	Wet	2,155	10,238	10,927	1,072	40	89	264	0
2004	Dry	2,136	8,959	9,911	1,063	74	89	-42	0
2005	Wet	2,097	11,393	12,136	980	255	89	30	0
2006	Wet	2,101	13,842	14,288	1,412	292	89	-138	0
2007	Dry	2,130	10,277	11,027	1,050	63	89	177	0
2008	Dry	2,120	8,672	9,812	1,014	172	89	-296	0
2009	Dry	2,153	8,982	9,830	992	110	89	115	0
2010	Dry	2,121	7,649	8,432	928	84	89	238	0
2011	Wet	2,100	12,788	13,655	1,138	174	89	-169	0
2012	Dry	2,112	8,796	9,929	935	69	89	-115	0
2013	Dry	2,142	9,455	9,148	971	165	89	1,224	0
2014	Dry	2,118	6,921	8,474	882	67	89	-473	0
2015	Dry	2,090	11,579	12,888	1,031	177	89	-516	0
2016	Dry	2,155	11,447	12,465	1,136	107	89	-194	0
2017	Wet	2,063	13,322	13,903	1,146	187	89	59	0
Minimum		2,039	6,030	6,911	880	40	89	-834	-
Maximum		2,155	17,081	17,776	1,574	324	89	1,224	-
Averages	Wet	2,097	13,928	14,450	1,235	199	89	52	0
	Dry	2,129	8,707	9,753	984	108	89	-99	0
	All	2,115	11,027	11,840	1,096	149	89	-32	0

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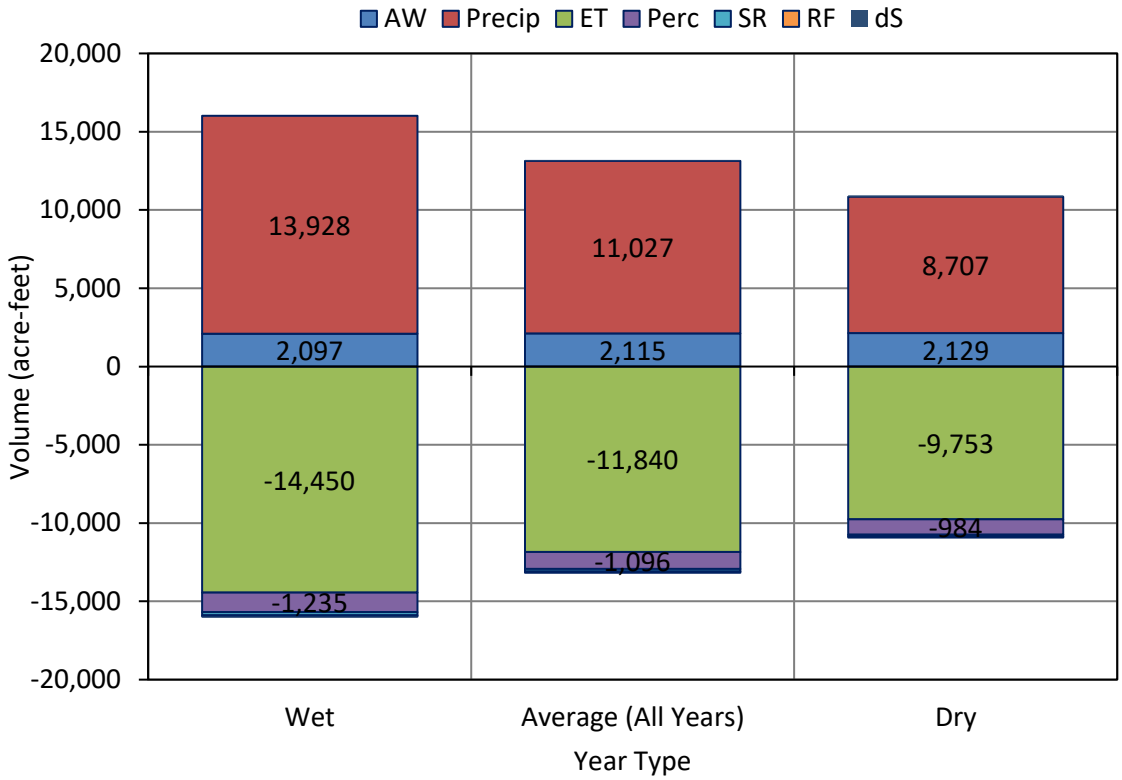


Figure 5. Annual Water Budget Results for Wet and Dry Years, and Overall Average, for 1991 – 2017 Period (acre-feet).

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Appendix 3-A. Data Gap Appendix

Introduction

Multiple datasets were utilized during development of this GSP to characterize current and historical Basin conditions. Monitoring networks were designed to support the evaluation of Basin conditions throughout GSP implementation, particularly with respect to the six sustainability indicators. The representative monitoring points (RMPs) in these monitoring networks are sites at which quantitative values for minimum or maximum thresholds, measurable objectives, and interim milestones are defined. New RMPs will be considered for the 5-years update based on the suggested expanded monitoring network. Data gaps that were identified throughout the GSP development process can be categorized into:

I. Data gaps in information used to characterize current and historical basin conditions.
II. Data gaps in monitoring networks developed to evaluate future Basin conditions which will be used in reporting and tracking Basin sustainability.
III. Additional data or information valuable for measuring progress towards the Basin's sustainability goal. This information has been identified as information that may be useful but has not been confirmed as a data gap.

These data gaps were identified based on spatial coverage of data, the period for which data are available, frequency of data collection, and representativeness of Basin conditions. An overview of data gaps in the first category is provided in Chapter 2, as part of the characterization of past and current Basin conditions, and the data gaps in the second and third categories are in Chapter 3 as part of descriptions of the monitoring networks. This appendix details the identification of data gaps and uncertainties in each of the categories and the associated strategies for addressing them. The process of data gap identification, and development of strategies to fill data gaps is illustrated in Figure 1 below, sourced from the Monitoring Networks and Identification of Data Gaps Best Management Practice (BMP), provided by DWR (2016).

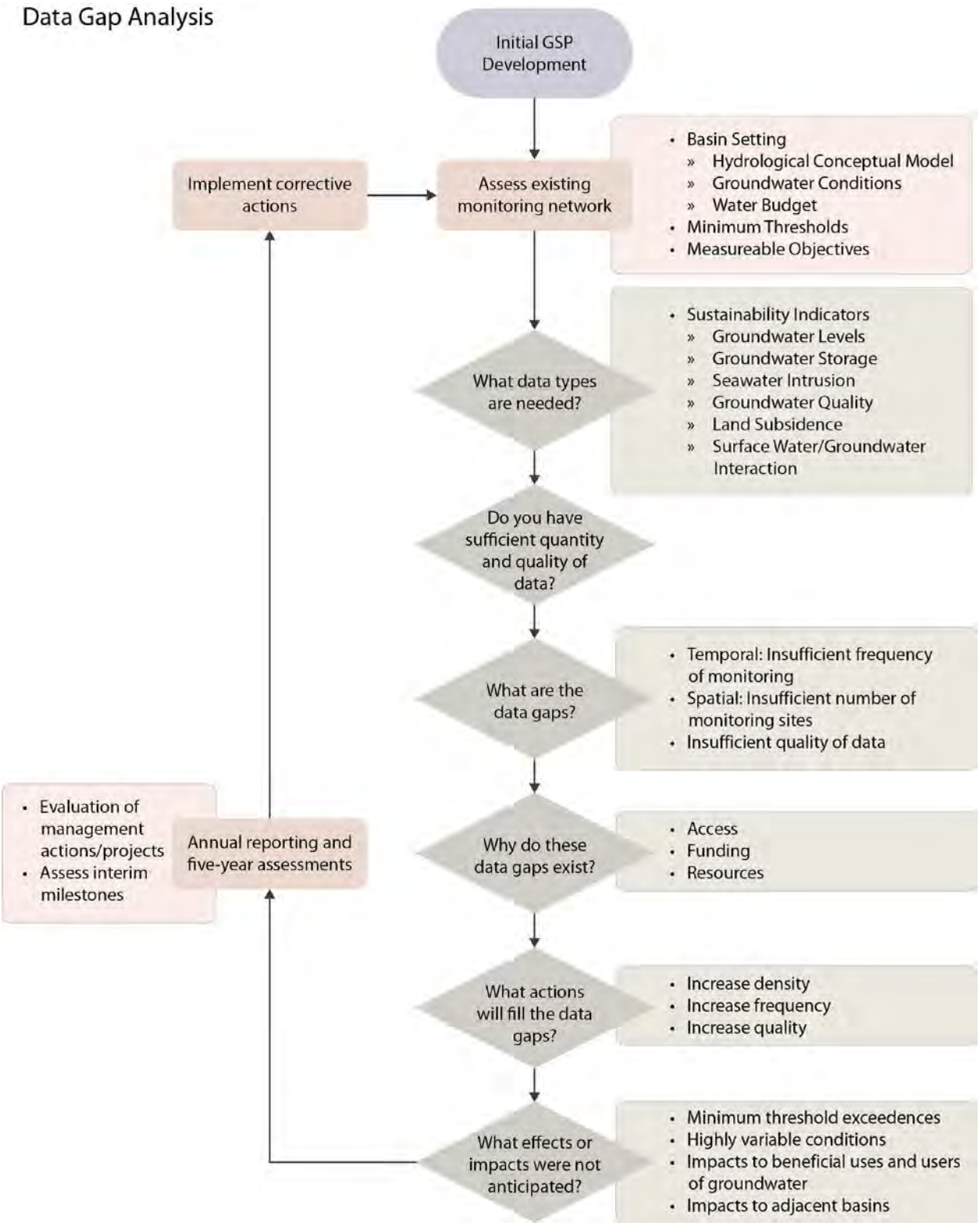


Figure 1: Data Gap Analysis Flowchart (DWR 2016).

I. Data Gaps in Existing Information Used for Basin Characterization

Definition of the hydrogeological conceptual model (HCM) is a key requirement for understanding the Basin setting and characterizing existing and historical Basin conditions. An accurate assessment of the physical setting and processes that control groundwater occurrence in the Basin is foundational to development of the sustainable management criteria and monitoring networks in Chapter 3 and identification of projects and management actions in Chapter 4.

Identification of data gaps and uncertainty within the HCM is a requirement per 23 CCR 354.14 (b)(5) and is important to choosing locations and types of additional monitoring that reduce these gaps and uncertainties.

Identification of Data Gaps

The HCM is detailed in Chapter 2 of this GSP. Data gaps and uncertainties were identified throughout development of the HCM and are briefly discussed in Chapter 2 under applicable subsections. A discussion of the components of the HCM for which key datasets were used, associated data gaps, and uncertainties is provided below.

Climate

Long-term records are available from National Oceanic and Atmospheric Administration (NOAA) weather stations in and around Butte Valley. A list of the applicable NOAA weather stations used in development of the climate component of the HCM can be found in Section 2.2.1.2. Data from these stations were used to evaluate historical and current precipitation and evaluate spatial and temporal (seasonal and long-term) trends in precipitation. Maximum and minimum air temperatures from 1942 to 2020 were obtained from the Mount Hebron Ranger weather station (USC00045941), and reference evapotranspiration (ET) from 2015 to 2020 is calculated at CIMIS Station 236, near Macdoel. Temperature and ET data was used to evaluate short and long-term trends in the Basin. Snow measurement data is not available in the Butte Valley watershed and is a data gap.

Current and historical climate data is readily available for the Butte Valley watershed (Watershed) and has insufficient spatial coverage, but adequate frequency of measurement and length of record to evaluate current and historical conditions and identify trends. Based on an initial assessment of the data, a rainfall gradient is suspected but not confirmed in the Watershed. The presence of a rainfall gradient is an uncertainty in this section of the HCM.

Geology

The primary sources of information used in development of the geology section of the HCM are the California Geologic Survey digitized geologic map (Charles W. Jennings, with modifications by Carlos Gutierrez, William Bryant and Wills 2010), and the foundational geologic report (Wood 1960).

Data gaps related to the total depth of alluvial deposits within the basin and the lateral extent of major buried features such as the Butte Valley Basalt were identified in development of this section of the HCM.

Soils

A 1985 soil survey of Butte Valley-Tule Lake Area (USDA 1994) was the primary source used for development of this component of the HCM. Additionally, soil properties as they relate to groundwater recharge were characterized through the Soil Agricultural Banking Index (SAGBI) ratings for the soil series in the Butte Valley area can be viewed on a web application (app), developed by the California Soil Resource Lab at the University of California at Davis and University of California Agriculture and Natural Resources (UC Davis Soil Resource Lab and University of California Agriculture and Natural Resources 2019).

No data gaps were identified in the development of this section.

Hydrology and Identification of Interconnected Surface Water Systems

The hydrology and natural flow regime in Butte Valley have previously been of limited study due to the limited number of surface water features. There are no stream gauges within the Butte Valley basin boundary. Historical surface water flows were recorded within the watershed along Butte Creek and Antelope Creek at USGS stations 11490500, 11489500, and 114900000, with no recent data. Reporting on Antelope Creek near Tenant from 1952 to 1979, on Antelope Creek nearer Macdoel from 1921 to 1922, and along Butte Creek during two periods, from 1921 to 1922 and from 1952 to 1960.

Data gaps were identified in historical and current information for this component of the HCM. Streamflow records contain significant data gaps any recent data since 1980. In addition, Ikes, Prather, Muskgrave, and Harris creeks also drain into Butte Valley but have no records. Data gaps were identified in the development of this section.

Identification of Groundwater Dependent Ecosystems

Data from the National Wetlands Inventory, The Nature Conservancy, and other sources (as detailed in Section 2.2.2.7) was used to identify groundwater dependent ecosystems (GDEs) in the Basin. While the results of the initial GDE inventory were evaluated by the Technical Advisory Committee, physical verification has not been completed. Uncertainty exists regarding habitat maps and presence of certain species in the Basin. Additionally, groundwater levels near the GDEs are poorly constrained and the groundwater level monitoring network must be expanded appropriately. There is therefore some uncertainty between riparian and non-riparian GDEs that were mapped and the existence and extent of these GDEs on the ground.

A GDE PMA addresses filling data gaps (see Chapter 4). Local habitat and potential GDEs must be groundtruthed using local knowledge, from ranchers to environmentalists. For example, local ranchers can review mapped GDE and habitat polygons on their property and mark the irrigation canals and natural stands of willow. The Butte Valley Wildlife Area (BVWA) manages its vegetation through irrigation (flooding) using both surface water and groundwater. Irrigation of natural

vegetation and wetlands with groundwater does not establish these ecosystems as groundwater-dependent in the same way as natural, non-irrigated GDEs. The latter depend on specific water level depth, while the former depend on access of wells to groundwater. BVWA will work with the GSA to review mapped GDE and habitat polygons to provide feedback on which potential GDEs within their borders are irrigated versus natural habitat.

Current and Historical Groundwater Conditions

Groundwater Elevation Data

A total of 85 wells with groundwater elevation data are available in the Basin. Groundwater elevation data is sourced primarily from the California Statewide Groundwater Elevation Monitoring Program (CASGEM). Well data is available dating back to the 1950s and wells have reasonable spatial coverage of the Basin, measurement frequency and period of record. CASGEM wells are measured at a frequency of twice per year, however many wells have missed observations. These frequencies are reasonable to enable determination of seasonal, short-term, and long-term trends in most parts of the valley. A summary of the wells with groundwater elevation data, and additional available information is shown in Table 1. Some spatial and temporal data gaps are discussed in Chapter 3 and below.

Table 1: Wells with groundwater elevation data in the Butte Valley Basin. Recent is here used to refer to data from the past ten years.

Wells	Groundwater Basin
Wells with coordinates (including data from WCRs referenced to nearest PLSS section)	295
Wells with screen depth information	62
Wells with coordinates and recent1 water level data	74
Wells with pumping data	None

Estimate of Groundwater Storage

Partial groundwater storage data is available from the foundational geological report (Wood 1960) and overall specific yield and storativity were estimated using the Butte Valley Integrated Hydrologic Model (BVIHM). Data gaps include the depth and width of the High Cascades Volcanic unit (see Section 2.2.2.2).

Groundwater Extraction Data

No pumping monitoring program currently exists in the Basin and this data is not available for any of the wells with groundwater elevation data. This has been identified as a data gap.

Groundwater Quality

Groundwater quality data was obtained from several sources including the California Groundwater Ambient Monitoring and Assessment (GAMA) Program Database, the USEP Storage and Retrieval Data Warehouse (STORET), and GeoTracker GAMA. As detailed in Appendix 2-B, available water quality data were compared to regulatory standards and mapped. Constituents of concern were identified through visual analysis of recent data (within the past 30 years) of the generated maps and timeseries for each constituent (available in Appendix 2-B). As seen on these maps, and noted in Section 2.2.2.3, there are multiple data gaps in the groundwater quality information used to develop the HCM. Spatially, groundwater quality data is frequently concentrated near Dorris and Mount Hebron and coverage in other areas of the Basin is missing for multiple constituents. Additionally, most of the groundwater quality data used in the assessment did not have a long record with consistent measurements, or measurements with a frequency that would be sufficient for determination of historical trends in groundwater quality. Further data gap discussion and the strategy for filling these data gaps is discussed under the groundwater quality monitoring network associated with Chapter 3, below.

Land Subsidence Conditions

Land subsidence data is entirely sourced from the TRE Altamira Interferometric Synthetic Aperture Radar (InSAR) dataset which provides estimates of vertical displacement from June 2015 to September 2019. No data gaps were noted in this section due to the lack of subsidence in the InSAR data and historical observations.

Water Budget

The water budget is dependent on monitoring data inputs. For data gaps in the water budget see previous sections on climate and hydrology (i.e., tributary) data gaps.

II. Data Gaps Monitoring Networks

Requirements

Multiple data gap requirements are relevant to the definition of monitoring networks for sustainability indicators. Per 23 CCR 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:

   i. The location and reason for data gaps in the monitoring network
   ii. Local issues and circumstances that prevent monitoring

(d) Each Agency shall describe steps that will be taken to fill the data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

The following discussion summarizes the identified data gaps, description, and strategy to fill the identified data gaps.

Groundwater Level and Storage Monitoring Network

Data gaps in the groundwater level monitoring network are discussed in Section 3.3:

- Near surface water bodies (Meiss Lake and streams, particularly Butte Creek and Prather Creek)
- Potential groundwater dependent ecosystems
- Potential interconnected surface water
- Sam's Neck
- Butte Valley National Grassland
- Butte Valley Wildlife Area
- Wells within the Watershed in areas of interest, such as the Butte Creek diversion

The above spatial data gaps limit the scope of comprehensive groundwater dependent ecosystem (GDE) analyses, analysis of interconnected surface waters, and limits the analysis of Basin inflows and outflows for the Butte Valley Integrated Hydrogeologic Model (BVIHM). The GSA is seeking funding to install new monitoring wells.

Additionally, continuous groundwater level measurements would enable better monitoring of SMC compliance so PMAs can be initiated effectively in a timely manner. The GSA has begun the process of filling data gaps though voluntary continuous groundwater level metering (shown in Chapter 3). Additional metering is needed.

Groundwater Quality Monitoring Network

Requirements

Requirements for the monitoring network for the degraded water quality sustainability indicator are outlined in 23 CCR 354.34 (c)(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.

Data Gaps

Data gaps in the groundwater quality monitoring network were identified due to inadequate spatial coverage, monitoring frequency, and/or lack of representativeness of Basin conditions and activities. The one site with existing and ongoing groundwater quality monitoring are public supply wells and is therefore concentrated near population, or seasonal population, centers near Dorris, leaving much of the Basin without representative monitoring data. The location of these data gaps is shown on the map of the existing groundwater quality monitoring locations (see Figure 2 in Chapter 3). The entire remaining basin has insufficient monitoring to interpret historical trends or are entirely outside the current monitoring network. These data gaps are due to the limited number of wells that conduct current and ongoing monitoring for the identified constituents of concern. The wells in the existing groundwater quality network also have a temporal data gap with a frequency of measurement annually or greater, corresponding to the public water supply system sampling frequency. A higher frequency of sampling, at minimum biannually, is necessary to enable determination of trends in groundwater quality on an intra-annual scale. No local issues or circumstances are expected to prevent monitoring. As discussed in Section 3.3.3, the groundwater quality monitoring network will be expanded with a minimum addition of five wells within the first five years of plan implementation to address this data gap. Candidate wells have been identified for inclusion in this expansion including wells in the monitoring network for groundwater levels.

Depletions of Interconnected Surface Water Monitoring Network

Requirements

The requirements for the depletion of interconnected surface water (ISW) monitoring network, as part of § 354.34. Monitoring Network, are detailed below:

(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.
(E) Changes in gradient between river and groundwater system.

Data Gaps

Due to the lack of sufficient data on potential ISWs in the Basin, sustainability management criteria (SMC) cannot be set until data gaps are addressed. Critical data gaps include sufficient coverage of the groundwater level monitoring network near potential ISWs and stream gages. One new stream flow station is under development on Butte Creek near the Butte Creek diversion to improve the understanding of surface water flow into Butte Valley. Under sufficient funding conditions, additional stream flow gauging stations will significantly reduce uncertainty caused by this data gap. The GSA will address these data gaps and revisit potential ISW SMCs in the 5-year GSP update.

III. Additional Data or Information Valuable for Measuring Progress Towards the Basin Sustainability Goal

Additional data has been identified that may be valuable to evaluations of progress towards the Basin's sustainability goal. This is primarily additional monitoring information that may be useful to identify adverse impacts on biological uses of surface water, in addition to existing biological monitoring in the Basin.

These include evaluation of streamflow depletion impacts on juvenile salmonids and use of satellite imagery for monitoring riparian and non-riparian vegetation. The GSA may consult other entities or specialists, as feasible, to determine the value of this data.

IV. Data Gap Prioritization

The identified data gaps are prioritized for actions to be taken to resolve them. Data gaps are categorized into "high," "medium," and "low" prioritization statuses based on the value to understanding basin setting or in comparison to the defined SMCs to evaluate Basin sustainability. Filling data gaps can be achieved through increasing monitoring frequency, addition of monitoring sites to increase spatial distribution and density of the monitoring network or adding or developing new monitoring programs or tools. Summaries of the data gaps discussed in this appendix, associated prioritizations, and strategies to fill the data gap are shown in Table 2.

Table 2: Data gap prioritization

Priority	Data Gap Summary	Strategy to Fill Data Gap
High	Increase frequency of water quality sampling to develop a record of future seasonal and annual fluctuations in water quality	Develop and fund an annual sampling plan based on RMP groundwater elevation collection points
High	Expand the groundwater level network to cover current data gaps, particularly near surface waters (potential ISWs) and potential groundwater dependent ecosystems. The utmost priority is filling data gaps near Butte Creek and Butte Valley Wildlife Area (BVWA).	The GSA will seek local volunteers with historical groundwater level data and seek funding for installation of additional monitoring wells.
High	Expand groundwater sampling in RMP points to include continuous logging to improve the quality of observations during major pumping and recharge periods	Where possible, instrument RMP wells with continuous loggers and telemetry
Medium	Install surface water gauges on Butte, Ikes, Prather, Muskgrave, and Harris Creek to develop a record and surface water budget flowing into Butte valley	Establish stream gauges at strategic locations along creeks where existing infrastructure permits inexpensive observations, install data loggers and telemetry, and fund future work
Medium	Develop improved evapotranspiration estimates in Butte Valley to reduce uncertainty in the water budget	Install and maintain multi-season eddy covariance and energy balance towers on critical crops (alfalfa, hay, strawberry) and native vegetation in (sagebrush, willow).
Medium	Develop better estimates of snow water equivalent and weather station data from higher in the Butte watershed by building specialty stations	Develop weather stations in the western and south western watershed to collect snow water equivalent data and general atmospheric information

Table 2: Data gap prioritization *(continued)*

Priority	Data Gap Summary	Strategy to Fill Data Gap
Low	Improve the spatial coverage of irrigation management systems	Install an additional CIMIS station in Butte Valley

References

California Department of Water Resources (2016). BMP 2: Best Management Practices for the Sustainable Management of Groundwater Monitoring Networks and Identification of Data Gaps, December 2016. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-2-Monitoring-Networks-and-Identification-of-Data-Gaps_ay_19.pdf

Wood, P. R. 1960. "Geology and Groundwater Features of the Butte Valley Region, Siskiyou County California," no. 1491: 1–155.

Appendix 3-B. Monitoring Protocols

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Monitoring Protocols

This Appendix provides the monitoring protocols for the monitoring networks described in Chapter 3.

Groundwater Levels

Groundwater level data collection may be conducted remotely via telemetry equipment or with an in-person field crew. The following section provides the monitoring protocols for groundwater level data collection. Establishment of these protocols will ensure that data collected for groundwater levels are accurate, representative, reproducible, and contain all required information. All groundwater level data collection in support of this GSP is required to follow these established protocols for consistency throughout the Basin and over time. These monitoring protocols will be updated as necessary and will be re-evaluated every five years. The reference for the following text is the groundwater level monitoring protocols in the Santa Cruz Mid-County Sustainability Plan (MGA 2020), with modifications.

All groundwater elevation measurements are referenced to a consistent elevation datum, known as the Reference Point (RP), surveyed to the National Geodetic Vertical Datum of 1988 (NGVD 88). For monitoring wells, the RP consists of a mark on the top of the well casing while most production wells have the RP at the top of the well's concrete pedestal. State requirements for surveying the RP is a measurement within 0.1 ft (3 cm) horizontally and 0.01 ft (0.3 cm) vertically. Groundwater level measurements are taken to the nearest 0.01 ft (0.3 cm) relative to the RP.

Groundwater elevation is measured by subtracting the depth to water from the reference point:

GWE = RPE - DTW,

where:

- GWE = groundwater elevation
- RPE = reference point elevation
- DTW = depth to water

Sample Collection:

- Equipment must be operated and maintained in accordance with manufacturer's instructions.
- Water level measurements must use units of feet, tenths of feet, and hundredths of feet.
- Measurements must include a record of the date, well name/identifier, time (in 24-hour military format), RPE, DTW, and GWE.
- Comments must be included regarding factors which may influence the recorded measurement such as nearby production wells pumping, weather, flooding, or well condition (including oil and other foreign bodies floating on the water surface).

Manual Groundwater Level Measurement

Groundwater level data collected by an in-person field crew will follow the following general protocols:

- Prior to sample collection, all sampling equipment and the sampling port must be cleaned.
- Manual groundwater level measurements are made with electronic sounders or steel tape. Electronic sounders consist of a long, graduated wire equipped with a weighted electric sensor. When the sensor is lowered into water, a circuit is completed and an audible beep is produced, at which point the sampler will record the depth to water. Some production wells may have lubricating oil floating on the top of the water column, in which case electric sounders will be ineffective. In this circumstance, steel tape may be used. Steel tape instruments consist of simple graduated lines where the end of the line is chalked to indicate depth to water without interference from floating oil.
- All equipment is used following manufacturer specifications for procedure and maintenance.
- Measurements must be taken in wells that have not been subject to recent pumping. At least two hours of recovery must be allowed before a hand sounding is taken.
- For each well, multiple measurements are collected to ensure the well has reached equilibrium such that no significant changes in groundwater level are observed.
- Equipment is sanitized between well locations to prevent contamination and maintain the accuracy of concurrent groundwater quality sampling.

Data Logger Groundwater Level Measurement

Telemetry equipment and data loggers can be installed at individual wells to record continuous water level data, which is then remotely collected via satellite to a central database and accessed on the Water Level Portal in a web browser.

Installation and use of data loggers must abide by the following protocols:

- Prior to installation the sampler uses an electronic sounder or steel tape to measure and calculate the current groundwater level in order to properly install and calibrate the transducer. This is done following the protocols listed above.
- All data logger installations must follow manufacturer specifications for installation, calibration, data logging intervals, battery life, and anticipated life expectancy.
- Data loggers are set to record only measured groundwater level to conserve data capacity; groundwater elevation is calculated after data are downloaded.
- In any log or recorded datasheet, the well ID, transducer ID, transducer range, transducer accuracy, and cable serial number are recorded.
- The sampler notes whether the pressure transducer uses a vented or non-vented cable for barometric compensation. If non-vented units are used, data are properly corrected for natural barometric pressure changes.
- All data logger cables are secured to the well head with a well dock or another reliable method. This cable is marked at the elevation of the reference point to allow estimates of future cable slippage.
- Data logger data are periodically checked against hand-measured groundwater levels to monitor electronic drift, highlight cable movement, and ensure the data logger is operating correctly. This check occurs at least annually, typically during routine site visits.

For wells not connected to a supervisory control and data acquisition (SCADA) system, transducer data are downloaded as necessary to ensure no data are overwritten or lost. Data are entered into the data management system as soon as possible after download. After the transducer data are

successfully downloaded and stored, the data are deleted or overwritten to ensure adequate data logger memory.

Groundwater Quality

Sample collection will follow the USGS National Field Manual for the Collection of Water Quality Data (Wilde 2008; USGS 2015) and Standard Methods for the Examination of Water and Wastewater (Rice, Bridgewater, and Association 2012), as applicable, in addition to the general sampling protocols listed below.

The following section provides a brief summary of monitoring protocols for sample collection and testing for groundwater quality. Establishment of these protocols will ensure that data collected for groundwater quality are accurate, representative, reproducible, and contain all required information. All sample collection and testing for water quality in support of this GSP are required to follow the established protocols for consistency throughout the Basin and over time. All testing of groundwater quality samples will be conducted by laboratories with certification under the California Environmental Laboratory Accreditation Program (ELAP). These monitoring protocols will be updated as necessary and will be re-evaluated every five years.

Wells used for sampling are required to have a distinct identifier, which must be located on the well housing or casing. This identifier will be included on the sample label to ensure traceability.

Event Preparation:

- Before the sampling event, coordination with any laboratory that will be used to test the samples is required. Coordination must include scheduling laboratory time for sample testing and reviewing the applicable sample holding times and preservation requirements that must be conducted before the sampling event.
- Sample labels must include the sample ID, well ID, sample date and time, personnel responsible for sample collection, any preservative, analyte, and analytical method. Sample containers may be labelled before or during the sampling event.

Sample Collection and Analysis:

- Collection of a raw sample must occur at, or close to, the wellhead for wells with dedicated pumps and may not be collected after any treatment, from tanks, or after the water has travelled through long pipes. Prior to sample collection, all sampling equipment and the sampling port must be cleaned. The sample equipment must also be cleaned between use at each new sample location or well.
- Sample collection in wells with low-flow or passive sampling equipment must follow protocols outlined in EPA's Low-flow (minimal drawdown) ground-water sampling procedures (Puls, Barcelona, and Agency 1996) and USGS Fact Sheet 088-00 (USGS 2000), respectively. Prior to sample collection in wells without low-flow or passive sampling equipment, at least three well casing volumes should be purged prior to sample collection to make sure ambient water is tested. The sample collector should use best professional judgement to ensure that the sample is representative of ambient groundwater. If a well goes dry, this should be noted, and the well should be allowed to return to at least 90% of the original level before a sample is collected.

- Sample collection should be completed under laminar flow conditions, which is defined as follows: the pump rate during sampling should produce a smooth, constant (laminar) flow rate, and should not produce turbulence during the filling of bottles.
- Samples must be collected in accordance with appropriate guidance and standards and should meet specifications for the specific constituent analyzed and associated data quality objectives.
- In addition to sample collection for the target analytes, field parameters, including temperature, pH and specific conductivity, must be collected at every site during well purging. Field parameters should stabilize before being recorded and before samples are collected. Field instruments must be calibrated daily and checked for drift throughout the day.
- Samples should be chilled and maintained at a temperature of 4 C degrees and maintained at this temperature during transport to the laboratory responsible for analysis.
- Chain of custody forms are required for all sample collection and must be delivered to the laboratory responsible for analysis of the samples to ensure that samples are tested within applicable holding limits.
- Laboratories must use reporting limits that are equivalent to, or less than, applicable data quality objectives.
- Quality control samples will be taken to confirm accuracy, replication, confidence, and robustness of the testing protocols procedures. Quality control samples will be collected during each monitoring event based on a schedule dependent on monitoring frequency. Quality control samples may include field blanks, field duplicates, lab duplicates or matrix spike/matrix spike duplicates. Field-generated quality control samples (field duplicates and field blanks) will be submitted “blind” to the laboratory, with an identifier different from the sampled sites. Issues with quality control samples that are flagged either by the laboratory or GSP QA/QC Officer will be used to correct any issues with the monitoring or lab testing protocol.

Subsidence

The subsidence monitoring network currently depends on data provided by DWR through the TRE ALTAMIRA InSAR Subsidence Dataset. The following describes the data collection and monitoring completed by DWR contractors to develop the dataset. The GSA will monitor all subsidence data annually. If any additional data become available, they will be evaluated and incorporated into the GSP implementation. If the annual subsidence rate is greater than minimum threshold, further study will be needed.

The statewide InSAR subsidence dataset was acquired by DWR to provide important SGMA relevant data to GSAs for GSP development and implementation. TRE ALTAMIRA processed InSAR data collected by the European Space Agency (ESA) Sentinel-1A satellite. Statewide data was collected between January 1, 2015 and September 19, 2019 and calibrated to data from 232 stations in the regional network of Continuous Global Positioning System (CGPS) stations. TRE ALTAMIRA compiled time series data of vertical displacement values for point locations on a grid with 100 m spacing, with values representing averages of vertical displacement measurements within the immediate 100 by 100 m square areas of each point. Gaps in the spatial coverage of the point data are areas with insufficient data quality. TRE ALTAMIRA also created two sets of GIS rasters: annual vertical displacement and total vertical displacement relative to the common start date of June 13, 2015, both in monthly time steps. An inverse distance weighted (IDW) method with a maximum search radius of 500 meter was used to interpolate the rasters from the point data.

Under contract with DWR, Towill Inc. conducted an independent study to ground truth and verify the accuracy of the InSAR dataset. In the study, variation in vertical displacement of California's ground surface over time, as measured from interferometric synthetic aperture radar (InSAR) satellites, was statistically compared to available ground-based continuous global positioning systems (CGPS) data. The study compared the InSAR-based vertical displacement point time series data to data from 160 CGPS stations that were not used for calibrating the InSAR data, as well as 21 CGPS stations that were used for calibrating InSAR data in Northern California. For the statewide dataset, the study provides statistical evidence that InSAR data accurately measured vertical displacement in California's ground surface to within 16 mm for the period January 1, 2015 through September 19, 2019. The statement of accuracy may vary for regional or localized area subsets (CDWR 2020).

References

United States Geological Survey. (2015). National Field Manual for the Collection of Water Quality Data. U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9.

CDWR. 2020. "TRE Altamira Subsidence Data." https://data.cnra.ca.gov/dataset/tre-altamira-insar-subsidence.

MGA. 2020. "Santa Cruz Mid-County Groundwater Basin Groundwater Sustainability Plan."

Puls, R. W., M. J. Barcelona, and Environmental Protection Agency. 1996. "Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures." *EPA Ground Water Issue*.

Rice, E. W., L. Bridgewater, and American Public Health Association. 2012. "Standard methods for the examination of water and wastewater."

USGS. 2000. "Use of Passive Diffusion Samplers for Monitoring Volatile Organic Compounds in Groundwater."

USGS. 2015. "National Field Manual for the Collection of Water Quality Data." *U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9*.

Wilde, F. D. 2008. "General Information and Guidelines: U.S. Geological Survey Techniques of Water-Resources Investigations."

Appendix 3-C. Water Level Sustainability Management Criteria

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Groundwater Level Sustainability Measurable Criteria

This Appendix provides further background information for Section 3.4.1 Sustainable Management Criteria - Groundwater Elevation. The following provides additional figures and discussion to supplement the main text:

- The hydrographs used to set the minimum thresholds and measurable objectives.
- The process and figures of the well failure analysis.

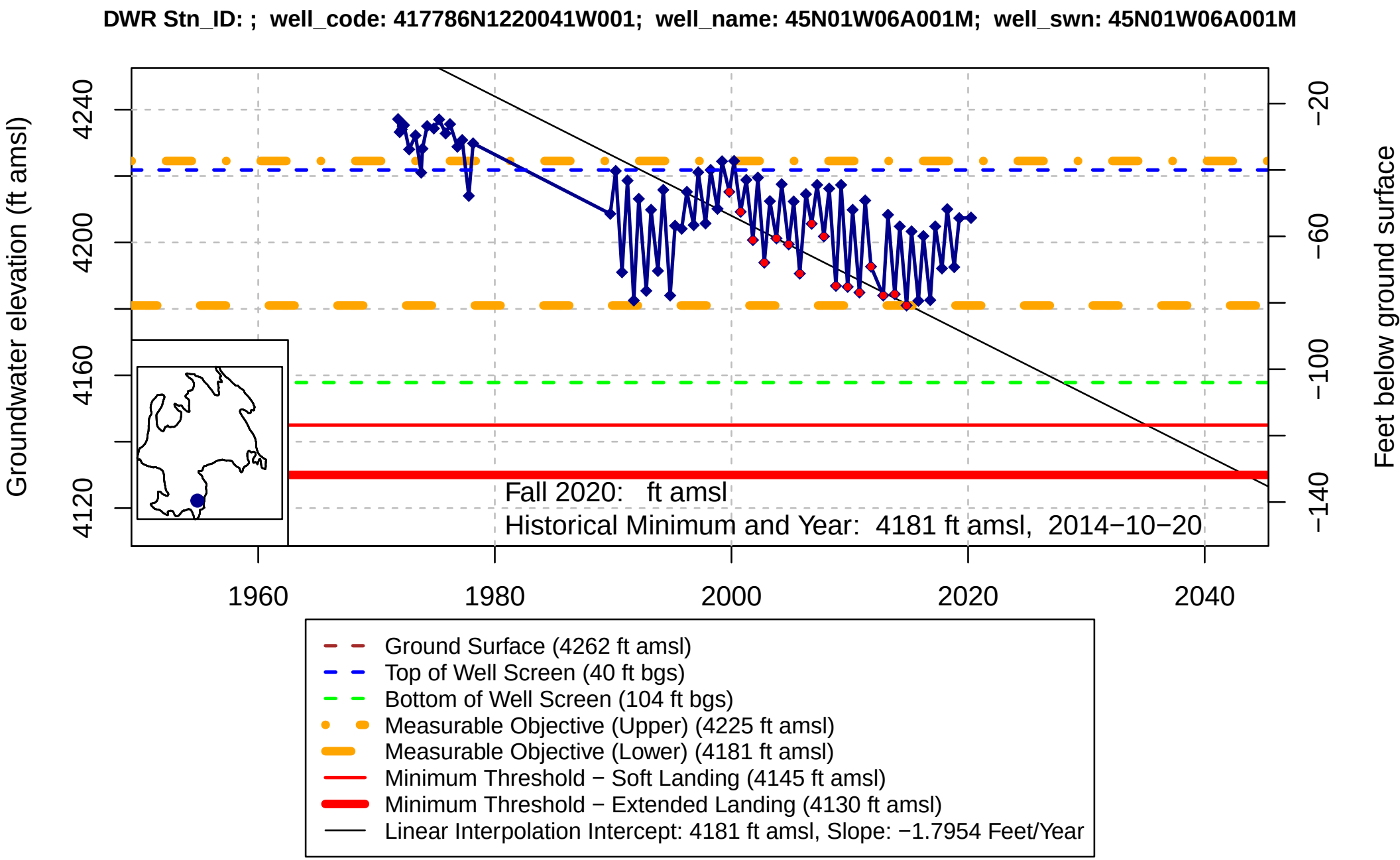
Hydrographs

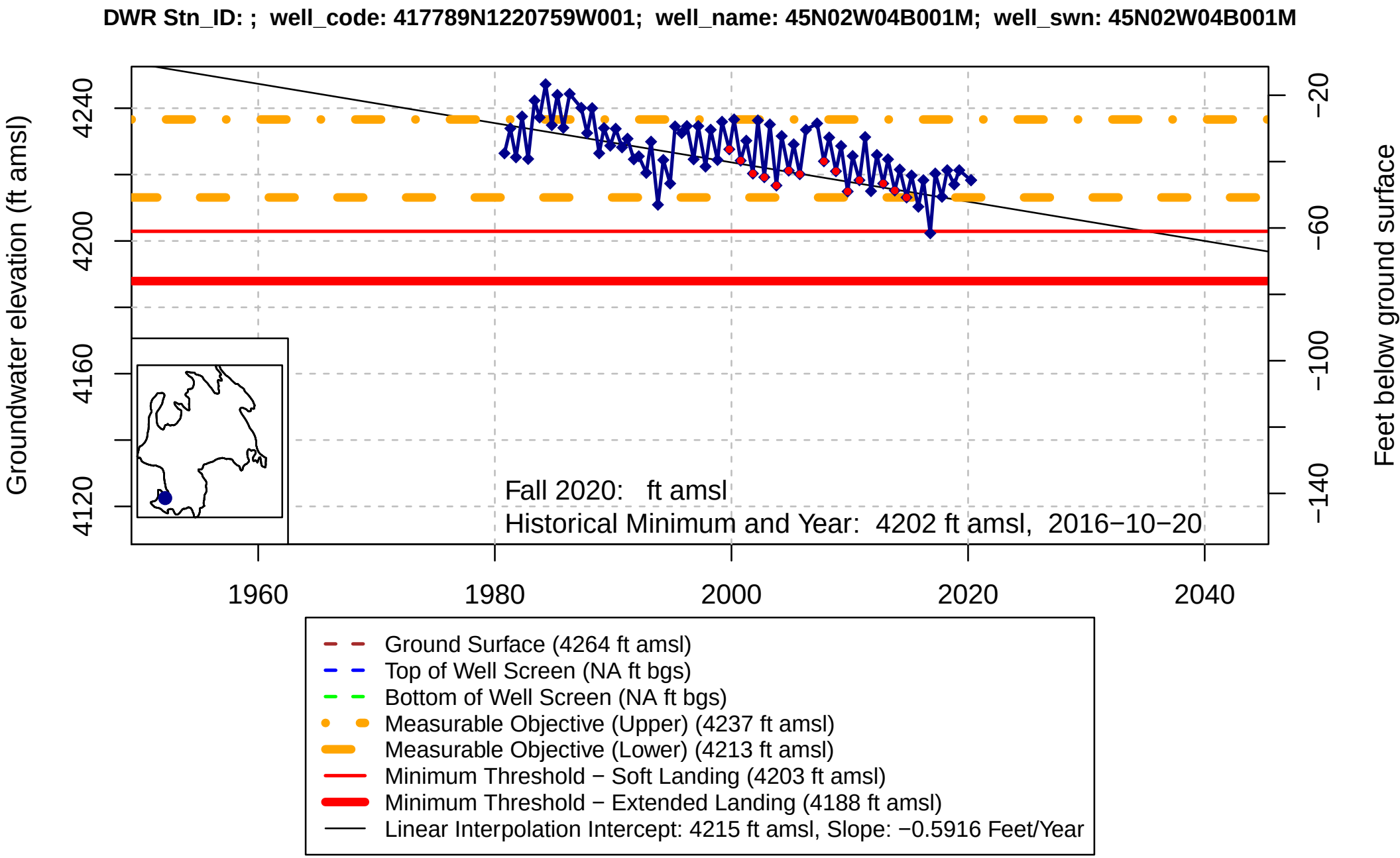
The hydrographs used to set the minimum thresholds and measurable objectives for each representative monitoring point are shown in the following figures. The groundwater level data used in the regression to calculate minimum thresholds have gone through a quality assurance and quality control (QAQC) process that removes data from the analysis for the following reasons:

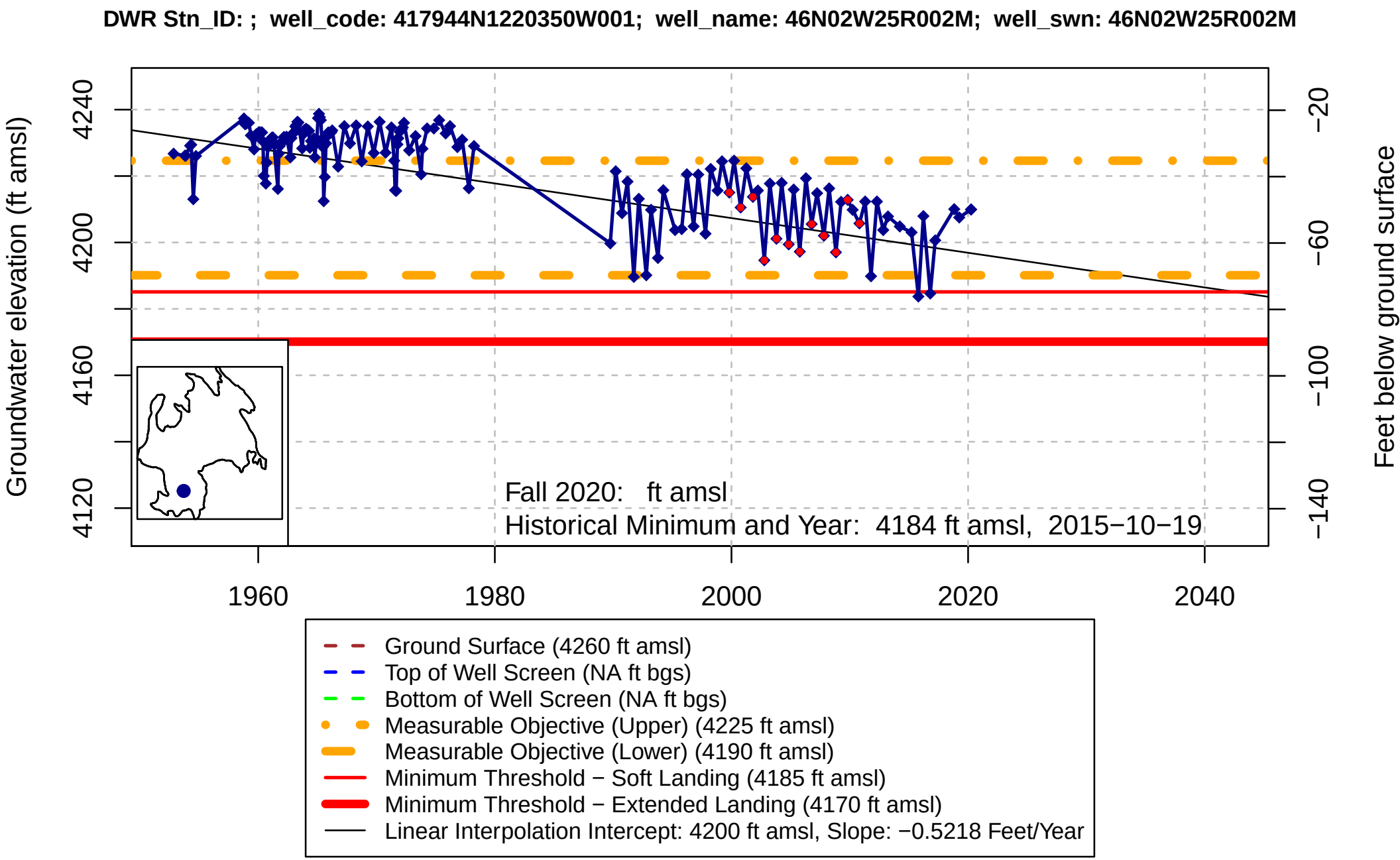
- Oil or other foreign substances were floating at the groundwater surface inside the well and the data had high uncertainty as a result.
- The well was pumped recently.
- During the minimum threshold process and generation of a regression equation, a data point was deemed an outlier, which may result from the interference of drawdown from nearby wells.

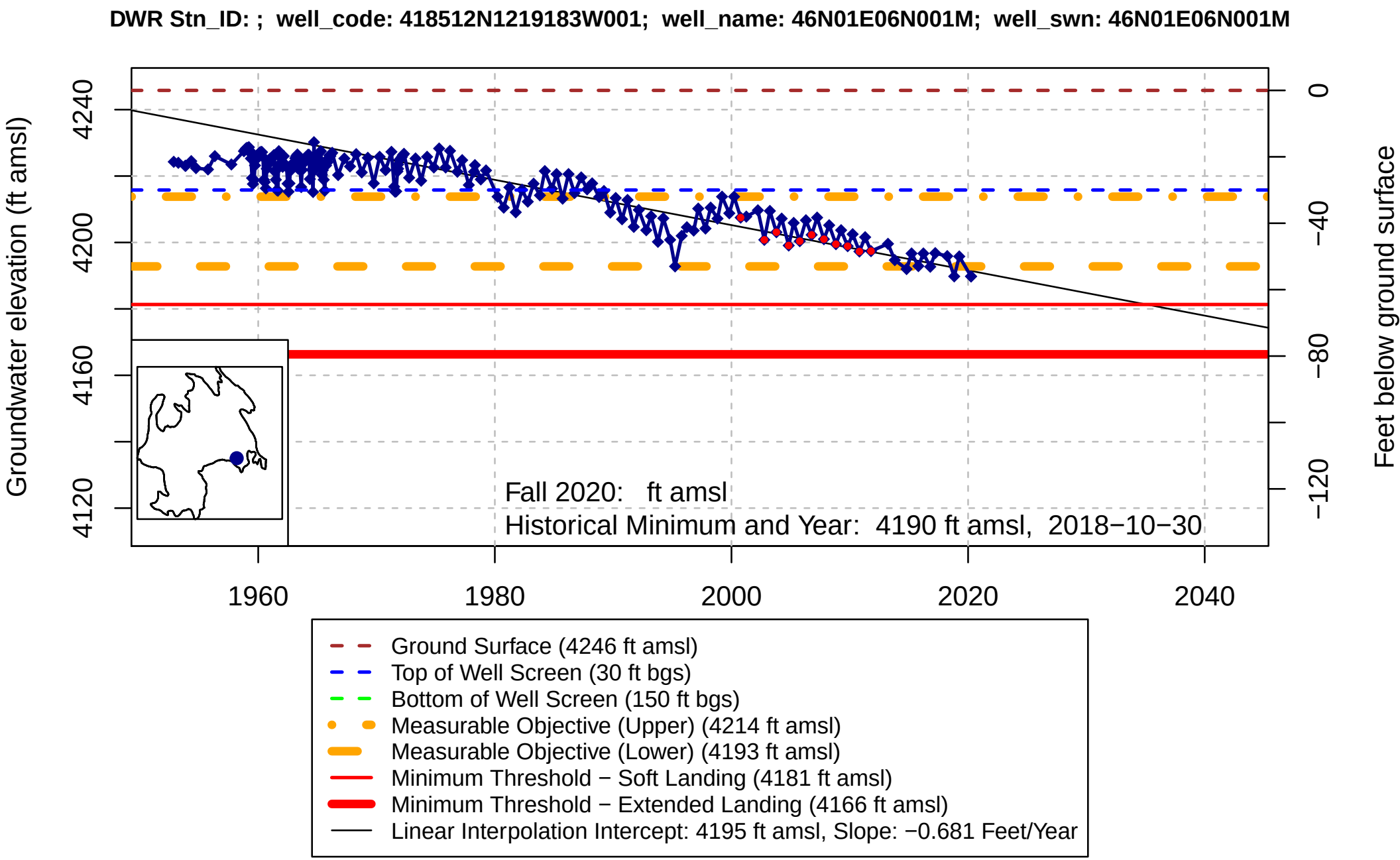
Table 1: Removed groundwater level (WL) data from the regression analysis. The water level is in units of feet above mean sea level (ft amsl).

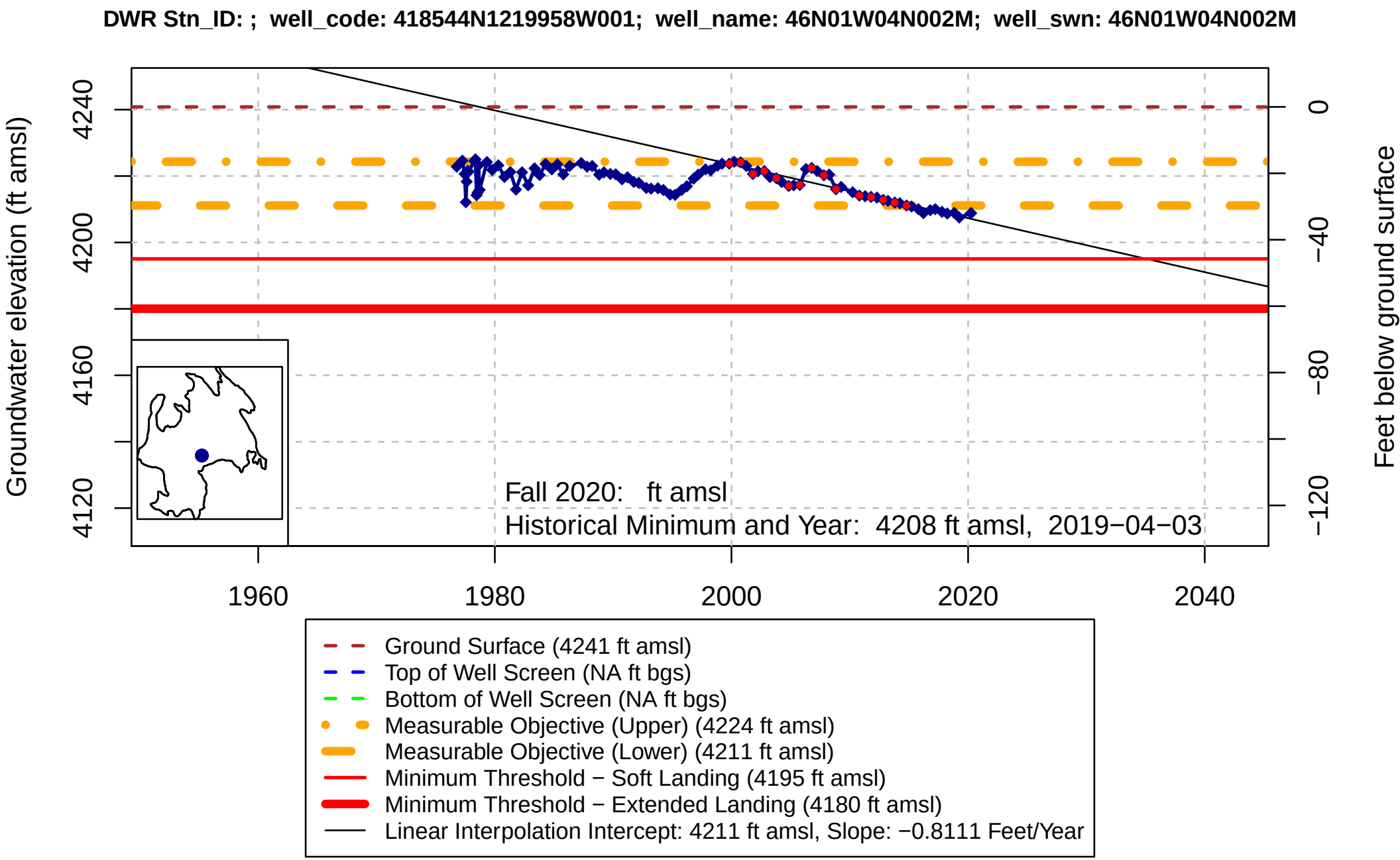
Well Name	Date	Removed WL	Reason
419451N1218967W001	2000-10-10	4157.23	Oil or foreign substance in casing
417944N1220350W001	2012-10-29	4203.73	Oil or foreign substance in casing
418512N1219183W001	1999-10-26	4208.79	Oil or foreign substance in casing
419451N1218967W001	1999-10-26	4159.73	Oil or foreign substance in casing
418512N1219183W001	2013-10-21	4194.69	Oil or foreign substance in casing
417944N1220350W001	2011-10-18	4189.83	Pumped recently
419755N1219785W001	2014-10-20	4172.7	Oil or foreign substance in casing
419451N1218967W001	2002-10-11	4138.73	Oil or foreign substance in casing
418661N1219587W001	1999-10-26	4204.5	Oil or foreign substance in casing
417789N1220759W001	2011-10-18	4215.01	Oil or foreign substance in casing
418948N1220832W001	2013-10-21	4197.37	Oil or foreign substance in casing
418948N1220832W001	2011-10-18	4197.57	Oil or foreign substance in casing
418948N1220832W001	2009-10-27	4202.07	Oil or foreign substance in casing
418948N1220832W001	1999-10-27	4204.27	Oil or foreign substance in casing
419451N1218967W001	2005-10-10	4153.73	Oil or foreign substance in casing
418661N1219587W001	2013-10-21	4193.7	Oil or foreign substance in casing
418512N1219183W001	2014-10-20	4191.99	Oil or foreign substance in casing
419451N1218967W001	2003-10-20	4139.63	Oil or foreign substance in casing
418948N1220832W001	2007-10-25	4205.57	Oil or foreign substance in casing
418948N1220832W001	2010-10-25	4199.97	Oil or foreign substance in casing
418948N1220832W001	2008-10-30	4205.07	Oil or foreign substance in casing
418948N1220832W001	2006-10-12	4204.87	Oil or foreign substance in casing
418948N1220832W001	2000-10-10	4201.67	Pumping
418948N1220832W001	2012-10-29	4197.97	Oil or foreign substance in casing
418948N1220832W001	2005-10-10	4200.07	Oil or foreign substance in casing
419451N1218967W001	2006-10-12	4149.93	Oil or foreign substance in casing
418948N1220832W001	2002-10-11	4202.37	Oil or foreign substance in casing
418948N1220832W001	2003-10-20	4203.07	Oil or foreign substance in casing
419451N1218967W001	2004-11-02	4136.23	Oil or foreign substance in casing
418948N1220832W001	2004-11-03	4204.37	Oil or foreign substance in casing
418512N1219183W001	2001-10-23	4182.69	Outlier
417789N1220759W001	2006-10-12	4204.81	Outlier

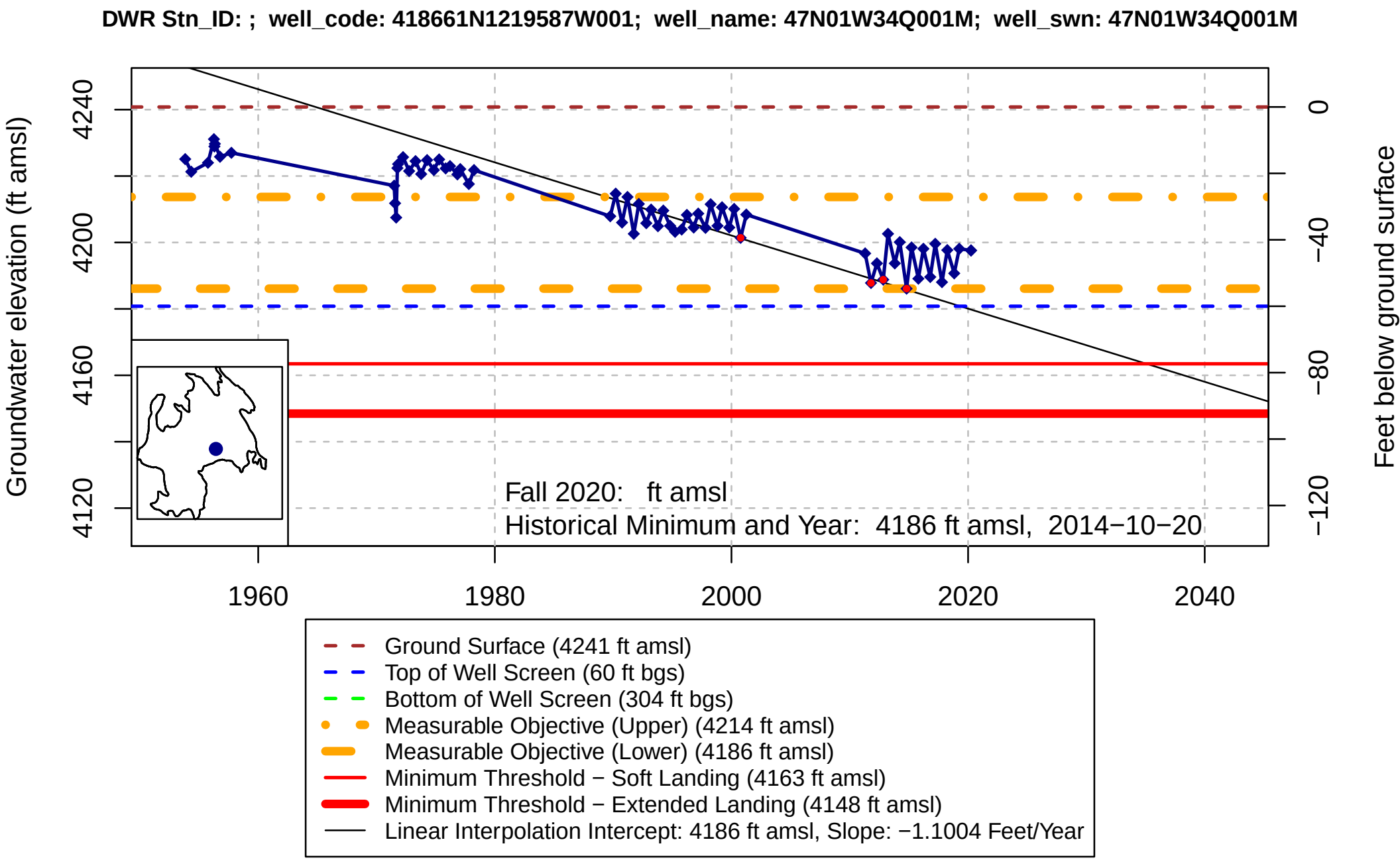

DWR Stn_ID: ; well_code: 417786N1220041W001; well_name: 45N01W06A001M; well_swn: 45N01W06A001M
Groundwater elevation (ft amsl)
Feet below ground surface
4240
4200
4160
4120
−20
−60
−100
−140
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4181 ft amsl, 2014−10−20
Ground Surface (4262 ft amsl)
Top of Well Screen (40 ft bgs)
Bottom of Well Screen (104 ft bgs)
Measurable Objective (Upper) (4225 ft amsl)
Measurable Objective (Lower) (4181 ft amsl)
Minimum Threshold − Soft Landing (4145 ft amsl)
Minimum Threshold − Extended Landing (4130 ft amsl)
Linear Interpolation Intercept: 4181 ft amsl, Slope: −1.7954 Feet/Year

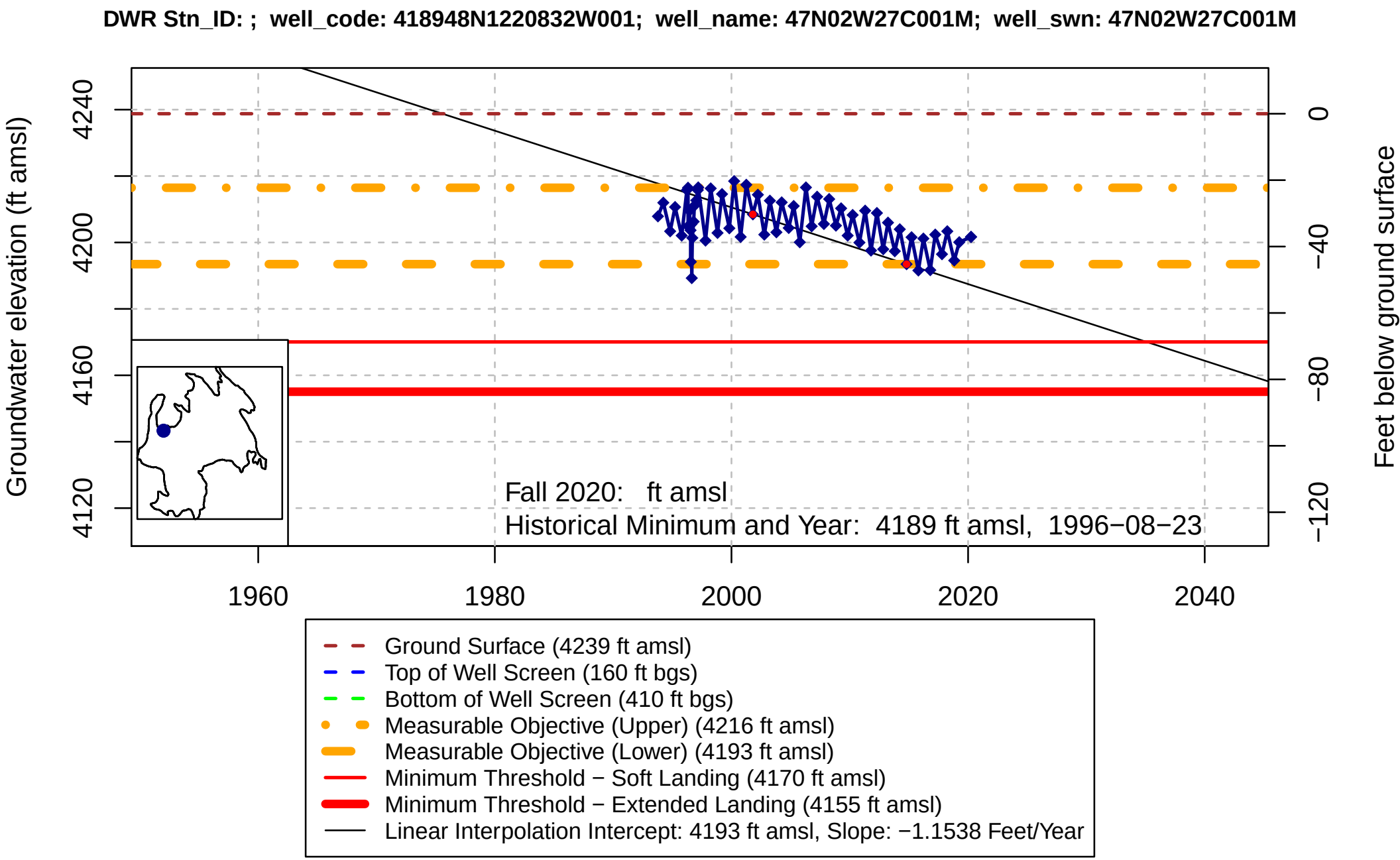

DWR Stn_ID: ; well_code: 417789N1220759W001; well_name: 45N02W04B001M; well_swn: 45N02W04B001M
Groundwater elevation (ft amsl)
4240
4200
4160
4120
−20
−60
−100
−140
Feet below ground surface
Fall 2020: ft amsl
Historical Minimum and Year: 4202 ft amsl, 2016−10−20
1960
1980
2000
2020
2040
Ground Surface (4264 ft amsl)
Top of Well Screen (NA ft bgs)
Bottom of Well Screen (NA ft bgs)
Measurable Objective (Upper) (4237 ft amsl)
Measurable Objective (Lower) (4213 ft amsl)
Minimum Threshold − Soft Landing (4203 ft amsl)
Minimum Threshold − Extended Landing (4188 ft amsl)
Linear Interpolation Intercept: 4215 ft amsl, Slope: −0.5916 Feet/Year

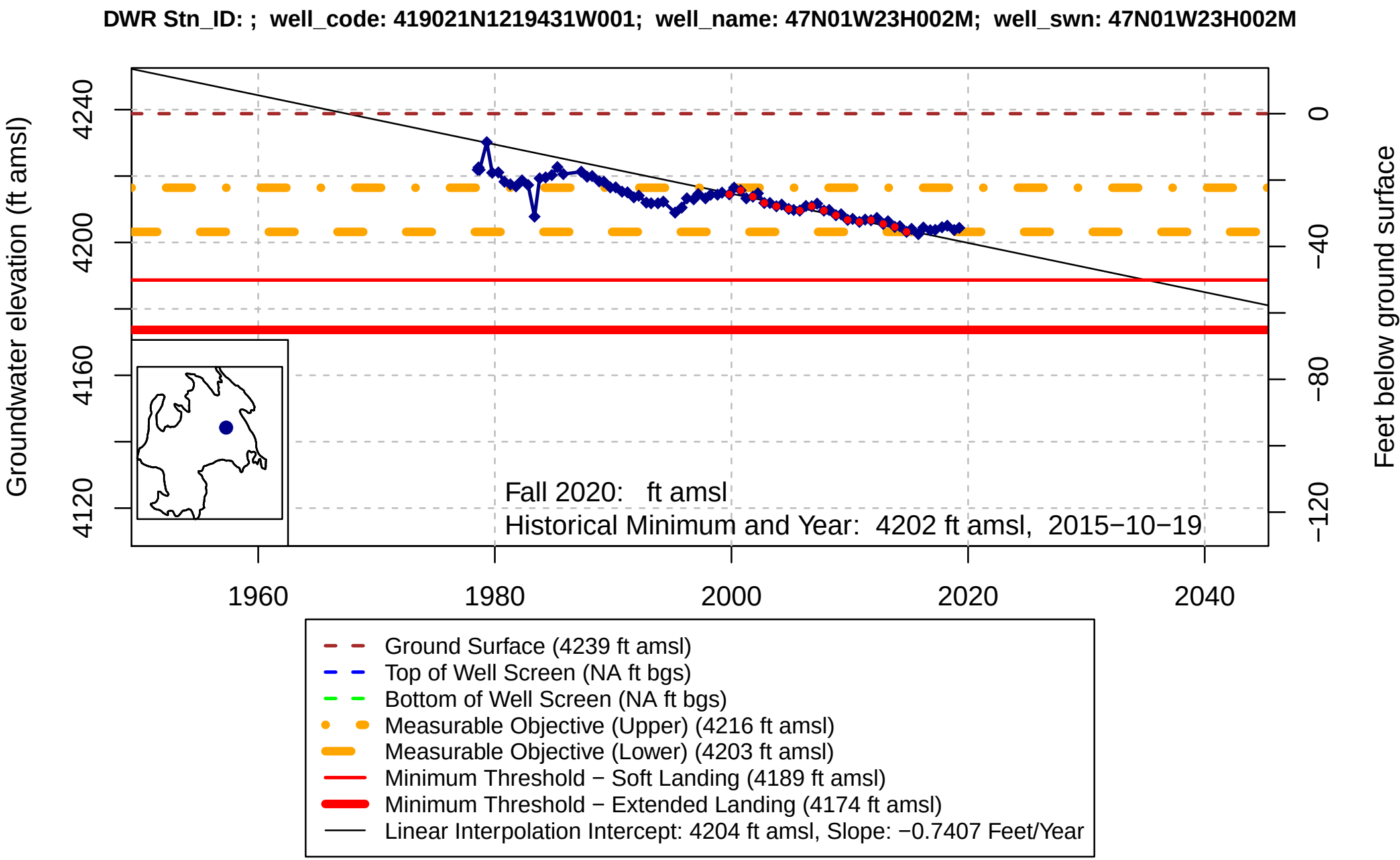

DWR Stn_ID: ; well_code: 417944N1220350W001; well_name: 46N02W25R002M; well_swn: 46N02W25R002M
Groundwater elevation (ft amsl)
4240
4200
4160
4120
Feet below ground surface
−20
−60
−100
−140
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4184 ft amsl, 2015−10−19
Ground Surface (4260 ft amsl)
Top of Well Screen (NA ft bgs)
Bottom of Well Screen (NA ft bgs)
Measurable Objective (Upper) (4225 ft amsl)
Measurable Objective (Lower) (4190 ft amsl)
Minimum Threshold − Soft Landing (4185 ft amsl)
Minimum Threshold − Extended Landing (4170 ft amsl)
Linear Interpolation Intercept: 4200 ft amsl, Slope: −0.5218 Feet/Year

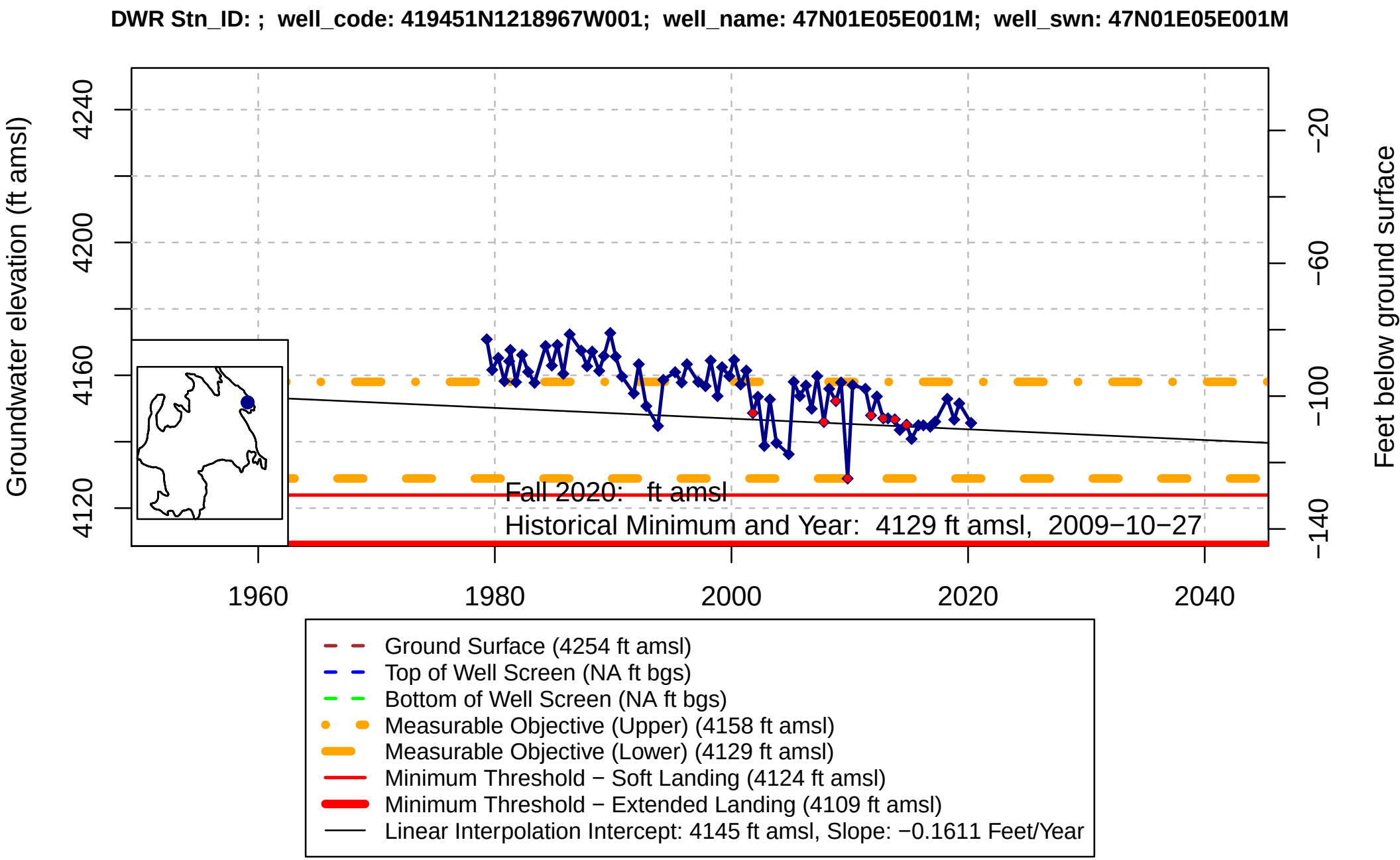

DWR Stn_ID: ; well_code: 418512N1219183W001; well_name: 46N01E06N001M; well_swn: 46N01E06N001M
Groundwater elevation (ft amsl)
Feet below ground surface
4240
4200
4160
4120
0
−40
−80
−120
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4190 ft amsl, 2018−10−30
Ground Surface (4246 ft amsl)
Top of Well Screen (30 ft bgs)
Bottom of Well Screen (150 ft bgs)
Measurable Objective (Upper) (4214 ft amsl)
Measurable Objective (Lower) (4193 ft amsl)
Minimum Threshold − Soft Landing (4181 ft amsl)
Minimum Threshold − Extended Landing (4166 ft amsl)
Linear Interpolation Intercept: 4195 ft amsl, Slope: −0.681 Feet/Year

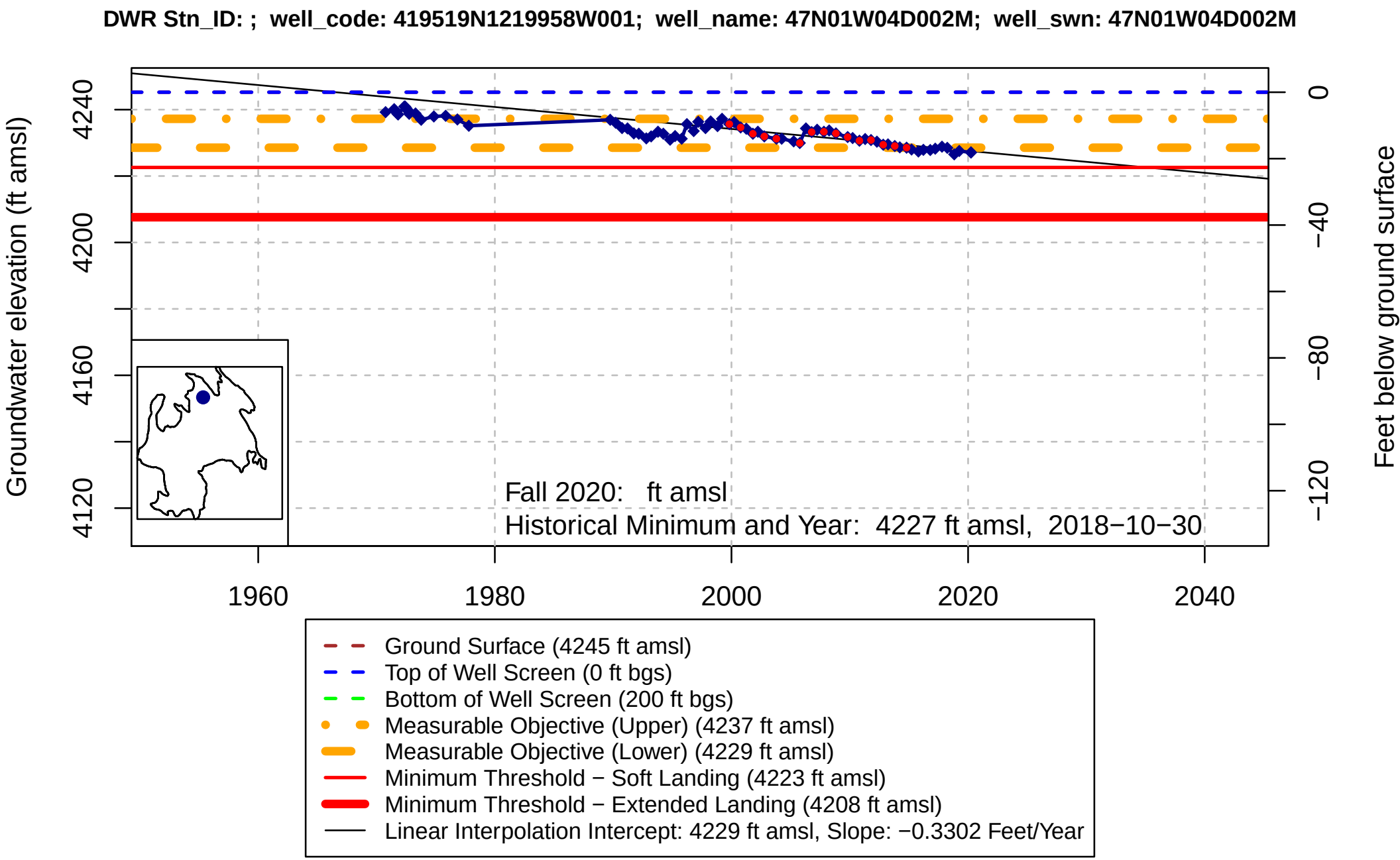

DWR Stn_ID: ; well_code: 418544N1219958W001; well_name: 46N01W04N002M; well_swn: 46N01W04N002M
Groundwater elevation (ft amsl)
4240
4200
4160
4120
0
−40
−80
−120
Feet below ground surface
1960
1980
2000
2020
2040
Fall 2020:   ft amsl
Historical Minimum and Year: 4208 ft amsl, 2019−04−03
Ground Surface (4241 ft amsl)
Top of Well Screen (NA ft bgs)
Bottom of Well Screen (NA ft bgs)
Measurable Objective (Upper) (4224 ft amsl)
Measurable Objective (Lower) (4211 ft amsl)
Minimum Threshold − Soft Landing (4195 ft amsl)
Minimum Threshold − Extended Landing (4180 ft amsl)
Linear Interpolation Intercept: 4211 ft amsl, Slope: −0.8111 Feet/Year

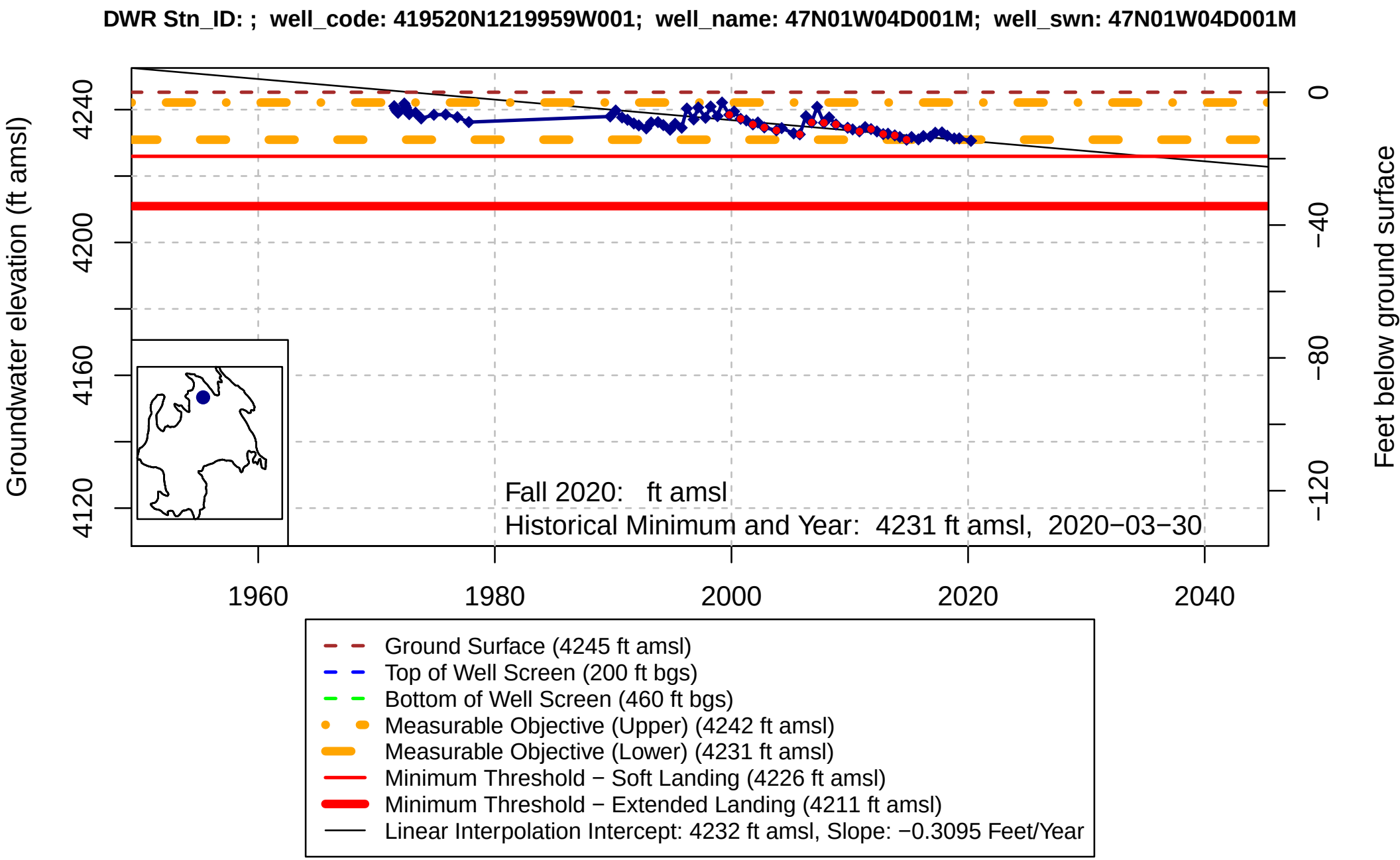

DWR Stn_ID: ; well_code: 418661N1219587W001; well_name: 47N01W34Q001M; well_swn: 47N01W34Q001M
Groundwater elevation (ft amsl)
Feet below ground surface
4240
4200
4160
4120
0
−40
−80
−120
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4186 ft amsl, 2014−10−20
Ground Surface (4241 ft amsl)
Top of Well Screen (60 ft bgs)
Bottom of Well Screen (304 ft bgs)
Measurable Objective (Upper) (4214 ft amsl)
Measurable Objective (Lower) (4186 ft amsl)
Minimum Threshold − Soft Landing (4163 ft amsl)
Minimum Threshold − Extended Landing (4148 ft amsl)
Linear Interpolation Intercept: 4186 ft amsl, Slope: −1.1004 Feet/Year

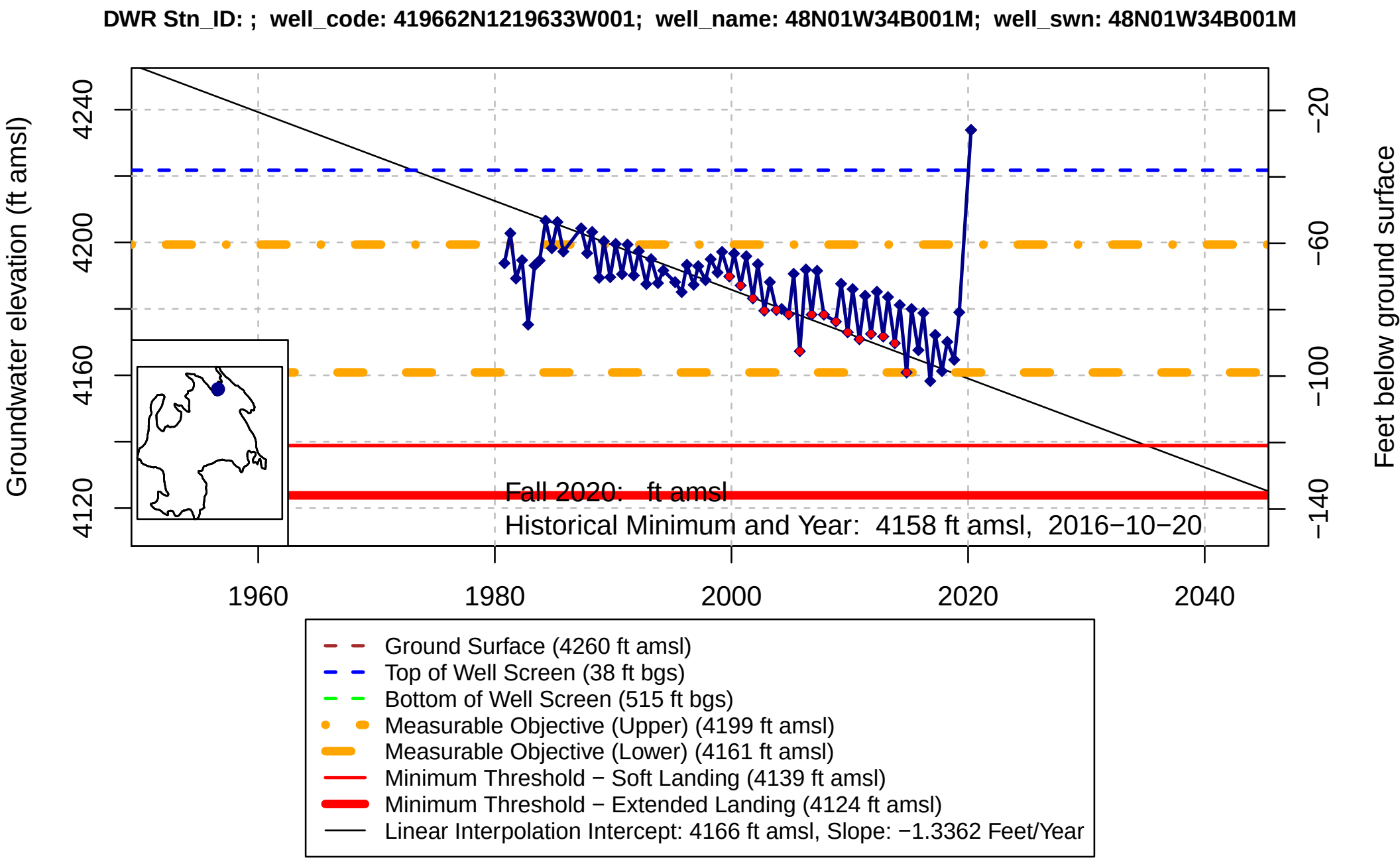

DWR Stn_ID: ; well_code: 418948N1220832W001; well_name: 47N02W27C001M; well_swn: 47N02W27C001M
Groundwater elevation (ft amsl)
Feet below ground surface
4240
4200
4160
4120
0
−40
−80
−120
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4189 ft amsl, 1996−08−23
Ground Surface (4239 ft amsl)
Top of Well Screen (160 ft bgs)
Bottom of Well Screen (410 ft bgs)
Measurable Objective (Upper) (4216 ft amsl)
Measurable Objective (Lower) (4193 ft amsl)
Minimum Threshold − Soft Landing (4170 ft amsl)
Minimum Threshold − Extended Landing (4155 ft amsl)
Linear Interpolation Intercept: 4193 ft amsl, Slope: −1.1538 Feet/Year

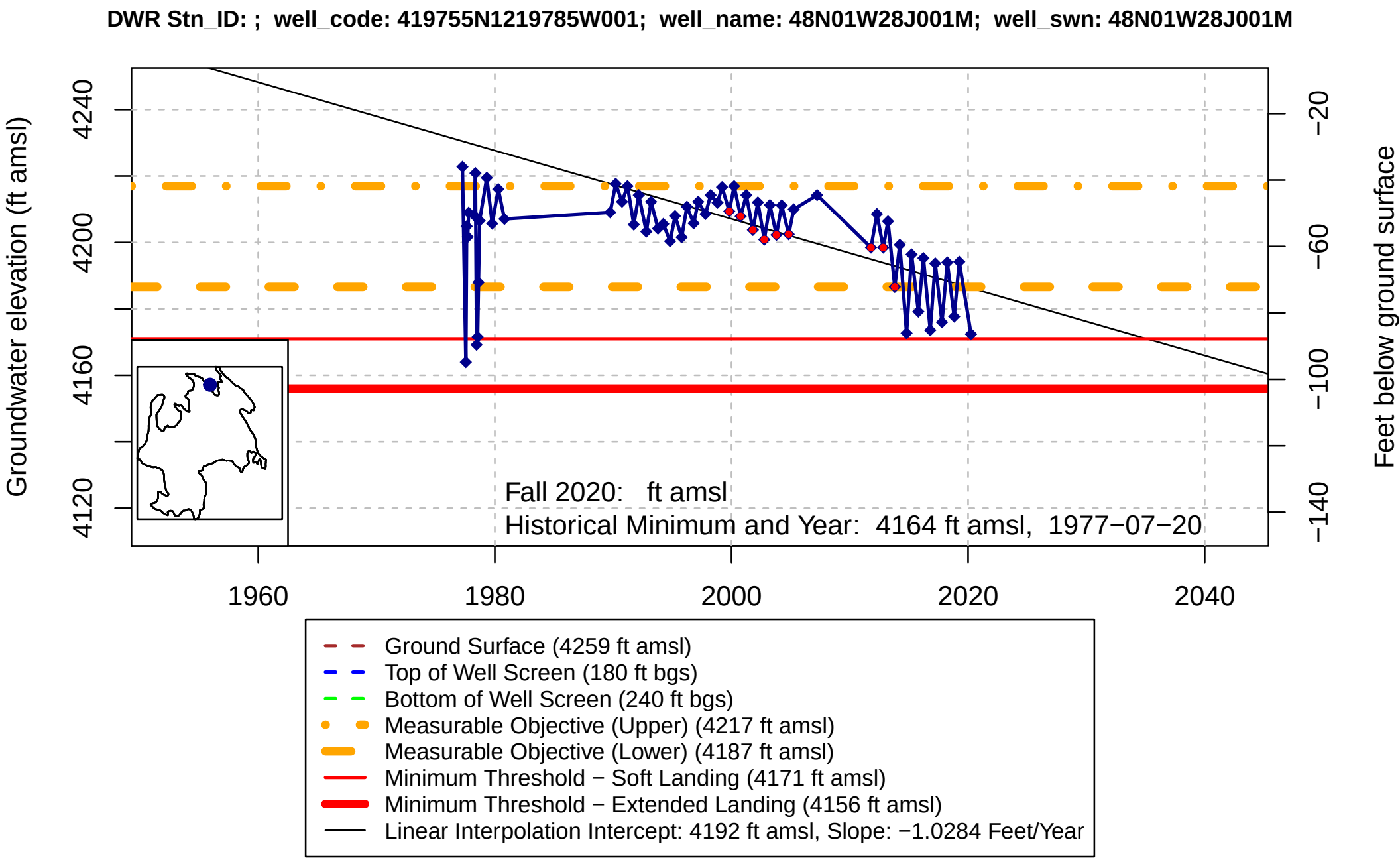

DWR Stn_ID: ; well_code: 419021N1219431W001; well_name: 47N01W23H002M; well_swn: 47N01W23H002M
Groundwater elevation (ft amsl)
Feet below ground surface
4240
4200
4160
4120
0
−40
−80
−120
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4202 ft amsl, 2015−10−19
Ground Surface (4239 ft amsl)
Top of Well Screen (NA ft bgs)
Bottom of Well Screen (NA ft bgs)
Measurable Objective (Upper) (4216 ft amsl)
Measurable Objective (Lower) (4203 ft amsl)
Minimum Threshold − Soft Landing (4189 ft amsl)
Minimum Threshold − Extended Landing (4174 ft amsl)
Linear Interpolation Intercept: 4204 ft amsl, Slope: −0.7407 Feet/Year


DWR Stn_ID: ; well_code: 419451N1218967W001; well_name: 47N01E05E001M; well_swn: 47N01E05E001M
Groundwater elevation (ft amsl)
Feet below ground surface
4240
4200
4160
4120
−20
−60
−100
−140
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4129 ft amsl, 2009−10−27
Ground Surface (4254 ft amsl)
Top of Well Screen (NA ft bgs)
Bottom of Well Screen (NA ft bgs)
Measurable Objective (Upper) (4158 ft amsl)
Measurable Objective (Lower) (4129 ft amsl)
Minimum Threshold − Soft Landing (4124 ft amsl)
Minimum Threshold − Extended Landing (4109 ft amsl)
Linear Interpolation Intercept: 4145 ft amsl, Slope: −0.1611 Feet/Year


DWR Stn_ID: ; well_code: 419519N1219958W001; well_name: 47N01W04D002M; well_swn: 47N01W04D002M
Groundwater elevation (ft amsl)
4240
4200
4160
4120
Feet below ground surface
0
−40
−80
−120
1960
1980
2000
2020
2040
Fall 2020:   ft amsl
Historical Minimum and Year: 4227 ft amsl, 2018−10−30
Ground Surface (4245 ft amsl)
Top of Well Screen (0 ft bgs)
Bottom of Well Screen (200 ft bgs)
Measurable Objective (Upper) (4237 ft amsl)
Measurable Objective (Lower) (4229 ft amsl)
Minimum Threshold − Soft Landing (4223 ft amsl)
Minimum Threshold − Extended Landing (4208 ft amsl)
Linear Interpolation Intercept: 4229 ft amsl, Slope: −0.3302 Feet/Year


DWR Stn_ID: ; well_code: 419520N1219959W001; well_name: 47N01W04D001M; well_swn: 47N01W04D001M
Groundwater elevation (ft amsl)
Feet below ground surface
4240
4200
4160
4120
0
−40
−80
−120
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4231 ft amsl, 2020−03−30
Ground Surface (4245 ft amsl)
Top of Well Screen (200 ft bgs)
Bottom of Well Screen (460 ft bgs)
Measurable Objective (Upper) (4242 ft amsl)
Measurable Objective (Lower) (4231 ft amsl)
Minimum Threshold − Soft Landing (4226 ft amsl)
Minimum Threshold − Extended Landing (4211 ft amsl)
Linear Interpolation Intercept: 4232 ft amsl, Slope: −0.3095 Feet/Year


DWR Stn_ID: ; well_code: 419662N1219633W001; well_name: 48N01W34B001M; well_swn: 48N01W34B001M
Groundwater elevation (ft amsl)
Feet below ground surface
4240
4200
4160
4120
−20
−60
−100
−140
1960
1980
2000
2020
2040
Fall 2020: ft amsl
Historical Minimum and Year: 4158 ft amsl, 2016−10−20
Ground Surface (4260 ft amsl)
Top of Well Screen (38 ft bgs)
Bottom of Well Screen (515 ft bgs)
Measurable Objective (Upper) (4199 ft amsl)
Measurable Objective (Lower) (4161 ft amsl)
Minimum Threshold − Soft Landing (4139 ft amsl)
Minimum Threshold − Extended Landing (4124 ft amsl)
Linear Interpolation Intercept: 4166 ft amsl, Slope: −1.3362 Feet/Year


DWR Stn_ID: ; well_code: 419755N1219785W001; well_name: 48N01W28J001M; well_swn: 48N01W28J001M
Groundwater elevation (ft amsl)
4240
4200
4160
4120
Feet below ground surface
−20
−60
−100
−140
1960
1980
2000
2020
2040
Fall 2020:   ft amsl
Historical Minimum and Year: 4164 ft amsl, 1977−07−20
Ground Surface (4259 ft amsl)
Top of Well Screen (180 ft bgs)
Bottom of Well Screen (240 ft bgs)
Measurable Objective (Upper) (4217 ft amsl)
Measurable Objective (Lower) (4187 ft amsl)
Minimum Threshold − Soft Landing (4171 ft amsl)
Minimum Threshold − Extended Landing (4156 ft amsl)
Linear Interpolation Intercept: 4192 ft amsl, Slope: −1.0284 Feet/Year

Well Failure Analysis

Butte Valley Well Failure Discussion

Bill Rice
Dr. Thomas Harter
Larry Walker Associates & UC Davis

11/30/2021

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Introduction

This analysis seeks to determine the number of wells that may be dewatered due to declining groundwater levels. In the Butte Valley, groundwater elevations are highly seasonal. The highest risk of dewatering occurs in the late summer and early fall, when water levels are at their seasonal low.

A thorough assessment would involve a comparison of historic and current water levels against well construction details across all or a representative subset of wells in Butte Valley. However, two key data limitations inhibit a comparison of well construction details with water levels where they have been measured in wells:

- Well depth and perforated intervals, on one hand, and water level observations on the other have been collected by multiple organizations/agencies.

- For most wells associated with water level measurements, the corresponding well construction information is not readily available, making a direct comparison of water levels and depth to top of perforation (or well depth) impossible without significant further reconnaissance.

Consequently, rather than comparing groundwater elevations with depth to top of perforations, this analysis focuses on interpolated groundwater elevation data to assess the aggregated risk of wells not being able to pump water due to low water levels ("well outages"). The risk analysis necessarily utilizes basic information that is readily available and is therefore limited in its specificity. Future analysis may provide a more refined risk assessment.

Methods

Butte Well Data Statistics

A total of 461 well logs were analyzed in the Butte Valley Bulletin 118 basin boundary. These wells were classified by the dominant geologic formation identified at the bottom of the perforated interval during geologic model development. Formations are described in greater detail in the Basin Setting section of the GSP. Major formations and the number of wells identified are the Ql - Lake deposits, QTb - Older volcanic rocks of the "High Cascades", Qal - Alluvium, and Qb - Butte Valley basalt, with 94, 36, 22, and 16, wells each respectively. Formations with fewer than 10 wells or where the formation was unknown were not considered for this analysis due to the sparsity of data. In total, 168 well logs out of 461, or 36 percent of the available wells, belong to one of the major formations and have sufficient data to describe perforation construction. Well locations are shown in Figure 1.

Paired top of well perforation and water level measurements were not available in most wells. Table 1 shows wells in the California Statewide Groundwater Elevation Monitoring Program (CASGEM) dataset with associated top of perforation data. This data is not sufficiently spatially distributed or representative of well type, depth, and construction to be used alone in establishing well failure risk. Similarly, Table 2 shows the number of wells in each major formation.

Table 1: Available information for Butte Valley wells.

Depth, Obs., Perf. Available?	Well Info Source	No. of Wells
None (location only)	LWA GWO	82
Total Depth Only	LWA GWO	7
Observations Only	Volunteer Monitoring	24
Observations Only	DWR	9
Observations Only	LWA GWO	10
Perforation Only	–	0
Observations and Depth	DWR	17
Observations and Depth	LWA GWO	23
Depth, Obs. and Perf.	DWR	23
Depth, Obs. and Perf.	LWA GWO	26
Depth, Obs. and Perf.	–	0

Table 2: Wells used in Butte Valley Well Outage Analysis

Bottom Formation	Top of Perforation (Depth in Feet)
Qal - Alluvium	22
Qb - Butte Valley basalt	16
Ql - Lake deposits	94
QTb - Older volcanic rocks of the ”High Cascades”	36

Well Outage Risk Analysis

Estimating the elevation datum for each well is based on the USGS reported elevation at the location of the well reported by the respective program agency (mostly DWR). The accuracy of the elevation is estimated to be within 3% of one-half mile, i.e., 80 feet, where 3% represents a general maximum landscape slope within the Butte groundwater basin and one-half mile represents the maximum distance of the actual well location from the reported well location. Some areas within the Butte Valley basin have steeper slopes. There, estimated well elevations may be even less accurate. For comparison of estimated water level elevation with well construction information, not being able to determine elevation of a well at its approximate location with an accuracy much better than 10 feet is potentially very problematic.

Unfortunately, a direct comparison of water levels to screened interval or well depth is not currently possible for the overwhelming majority of Butte Valley wells. A future effort to match water level data with well construction information will help connect some of the wells (from Well Completion Reports) with wells that have recent water level observations. This will provide an aggregated analysis of well outage risk within the network of wells with known water levels.

Instead, the analysis here focuses a) on a review of overall well construction information in Butte Valley and b) a preliminary, highly approximative estimate of the depth of water above the top of well perforations below the water table and its statistical distribution.

This second step relies on comparing the interpolated water level at the reported well location, obtained by mapping measured water levels in Butte Valley, against the elevation of the top of perforations at each well for which construction information is available, at the reported location. The estimate of the elevation of the top of perforations is obtained from the estimated elevation of the well at the reported location and well construction information (depth to top of perforations). The difference between estimated water level elevation and estimated elevation of the top of perforations is herein referred to as the “wet depth to top of perforations”:

```
[reported depth to top of perforations] - [interpolated depth to groundwater
at reported location] = [wet depth to top of perforations]
```

Note: By using the USGS reported elevation at the reported well location as the reference elevation for both terms on the left-hand-side, the wet depth to top of perforations can also be expressed as:

```
[interpolated water table elevation at reported location] - [reported elevation
of top of perforations] = [wet depth to top of perforations]
```

For the interpolated depth to water table two maps were constructed from measured depth to groundwater: in the fall of 2015 (dry year) and in the fall of 2017 (wet year). Water level maps were constructed using spline interpolation. The maps of depth to water table were used to digitally determine the interpolated depth to water table at the reported location of each well considered.

Results and Discussion

Well Construction Information

Well types show different depths to the bottom of the well below ground surface as shown in figure Figure 2. Domestic wells are relatively shallow and vary similarly across various formations. Depths range from less than 100 ft to more than 400 ft. Agricultural wells have a similar depth range to domestic wells (less than 100 ft to over 400 ft), but with most wells deeper within that range than domestic wells. Across formations, agricultural wells follow a similar depth distribution except in the older volcanic rocks of the High Cascades (QTb). In the QTb, the agricultural well depth ranges from about 200 ft to about 1400 ft.

The distribution of depth to the top of the perforated interval follows a similar pattern as well depth: shallow-most top of screens are found in domestic wells, across all formation. A wide range to top of screen is found for agricultural wells in the Older Volcanic Rocks of the High Cascades formation Figure 3. Figure 4 shows the resulting perforation length. Significant differences are observed in the length of agricultural well screens between formations. Agricultural wells in the Older Volcanic Rocks of the High Cascades (QTb) have the broadest range of perforation lengths (50 ft to 1000 ft) and agricultural wells in the Butte Valley Basalt (Qb) have the most narrow range (less than 10 ft to 40 ft). Domestic well screens in alluvium (Qal) and in Butte Valley basalt (Qb) are generally 40 ft or less, and up to 150 ft in lake deposits (Ql) and in older volcanics (QTb)

Few pumping test data provided on Well Completion Reports submitted to the Department of Water Resources show that both domestic wells and public supply wells have low well yields, by design. Agricultural wells tested are generally high production wells with 1000 to 5000 gpm (Figure 5). Agricultural wells have casing diameters of typically 12 to 18 inches. Domestic wells are mostly of smaller (2 to 8 inch) diameter with 10 inch diameter domestic wells in the Butte Valley Basalt (Qb), perhaps owing to miss-classification (Figure 6). During pump testing the Older volcanic rocks of the Older Volcanic Rocks of the High Cascades (QTb) show a narrow range of drawdown between 30 and 60 feet which is deeper than wells completed in the Butte Valley Basalt (Qb). Wells completed in the Lake Deposits (Ql) show a wide range of values between almost no observed drawdown to over 100 feet. Figure 7 summarizes the results of drawdown testing.

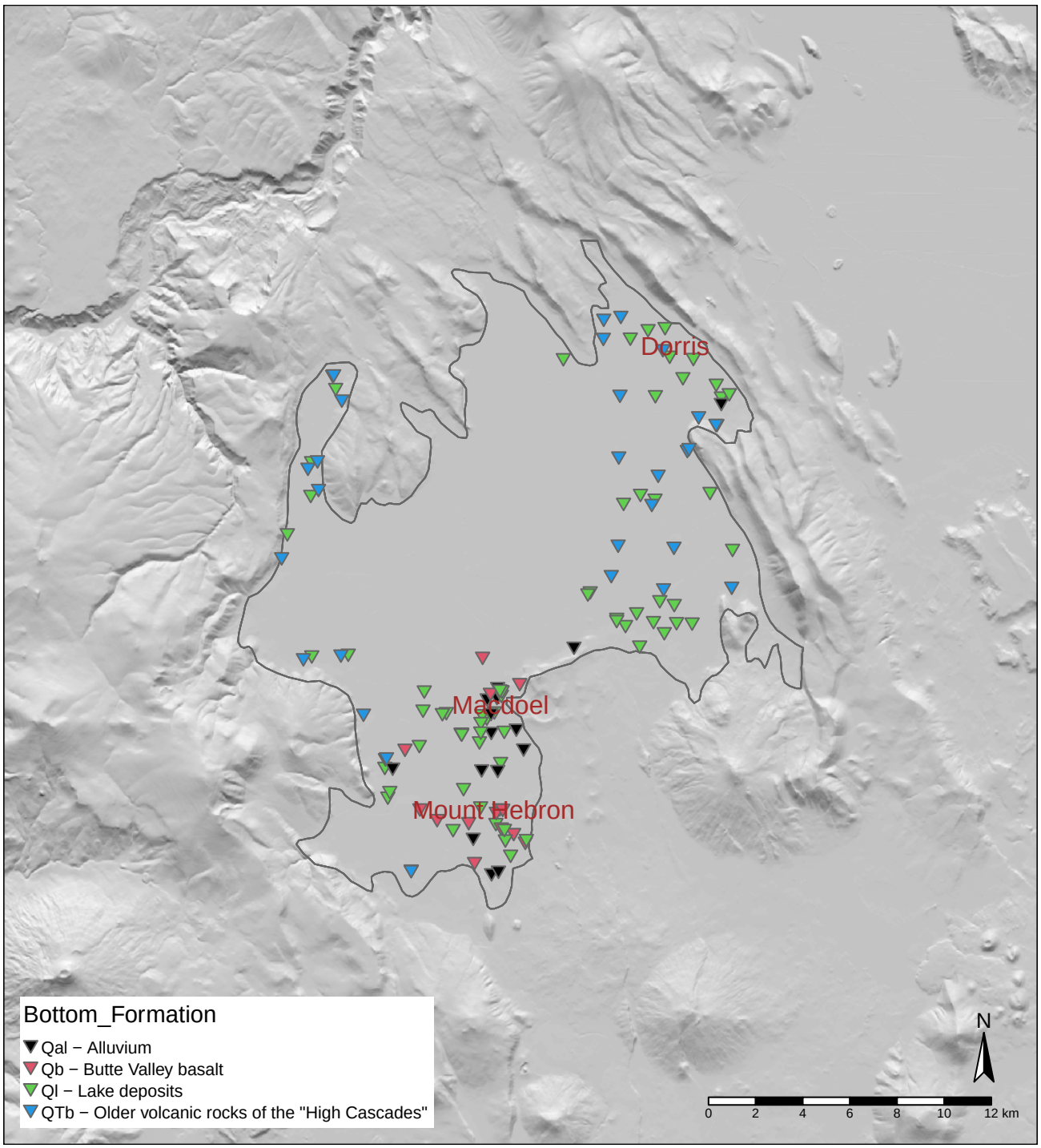


Figure 1: Butte Valley well map of domestic, public supply, and agricultural wells colored by major formation with locations of water wells are given as colored triangles.

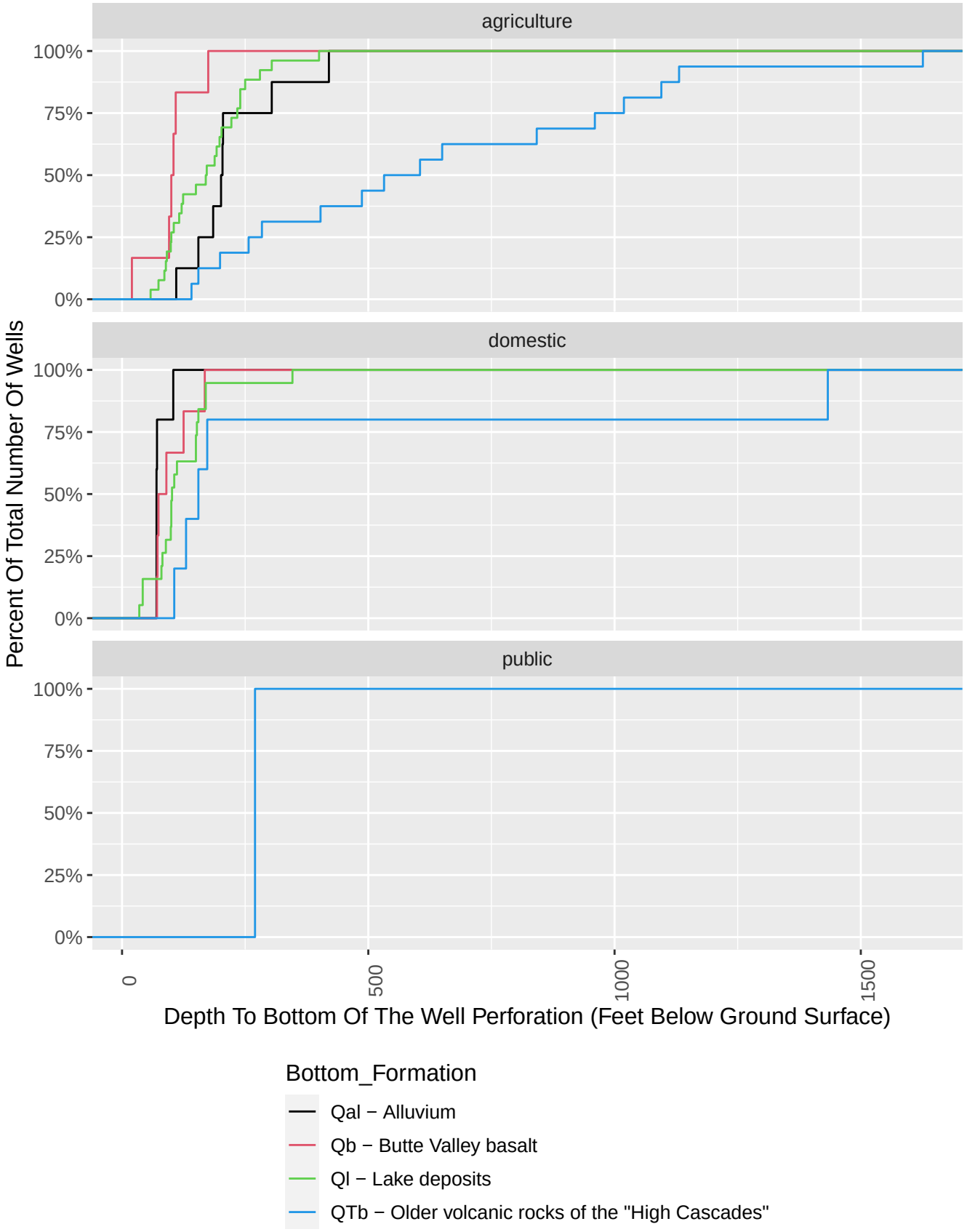


Figure 2: Butte Valley well perforation bottom. Sub-graphs show cumulative distribution graphs by well type and each graph shows major formations.

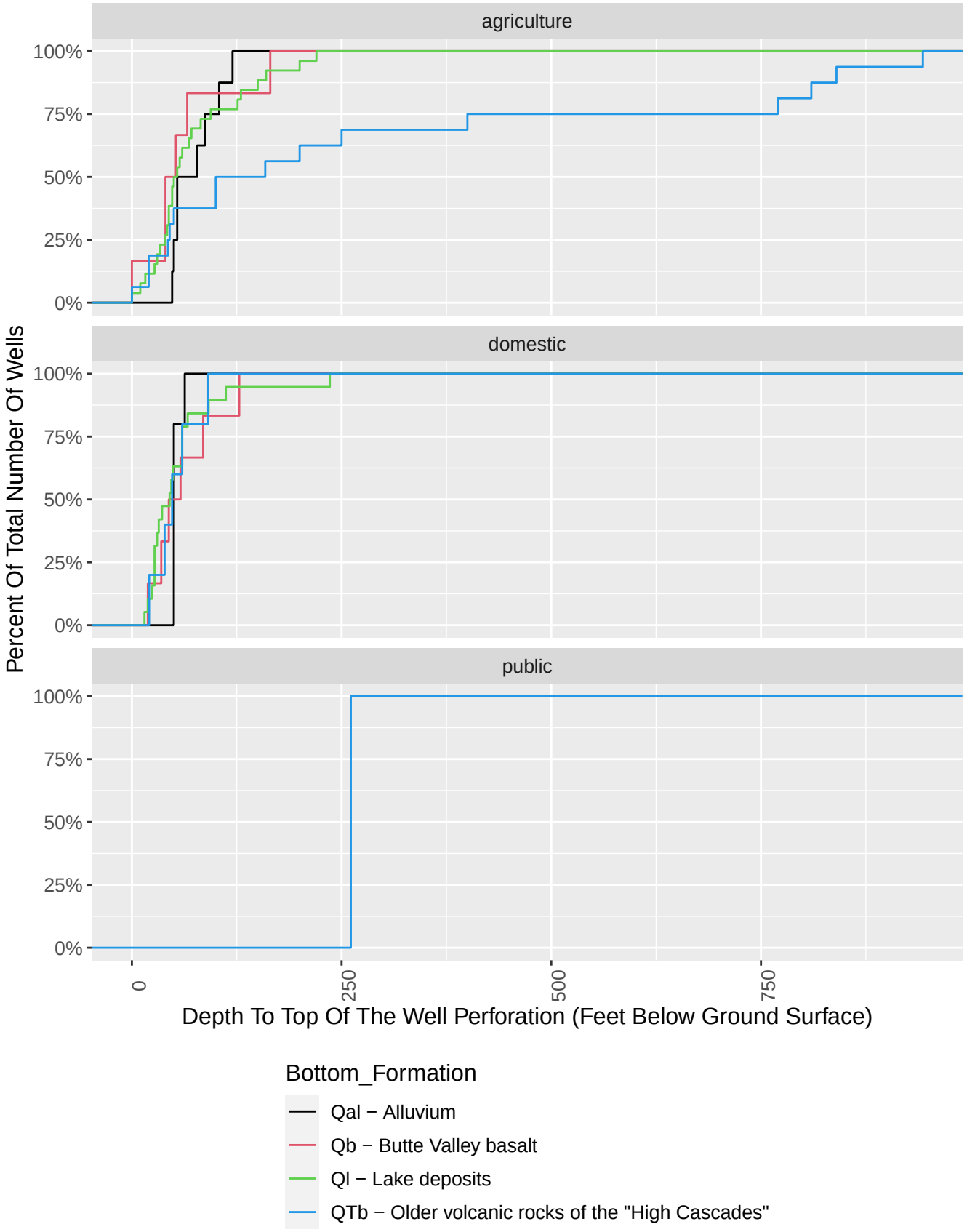


Figure 3: Butte Valley well perforation top. Sub-graphs show cumulative distribution graphs by well type and each graph shows major formations.

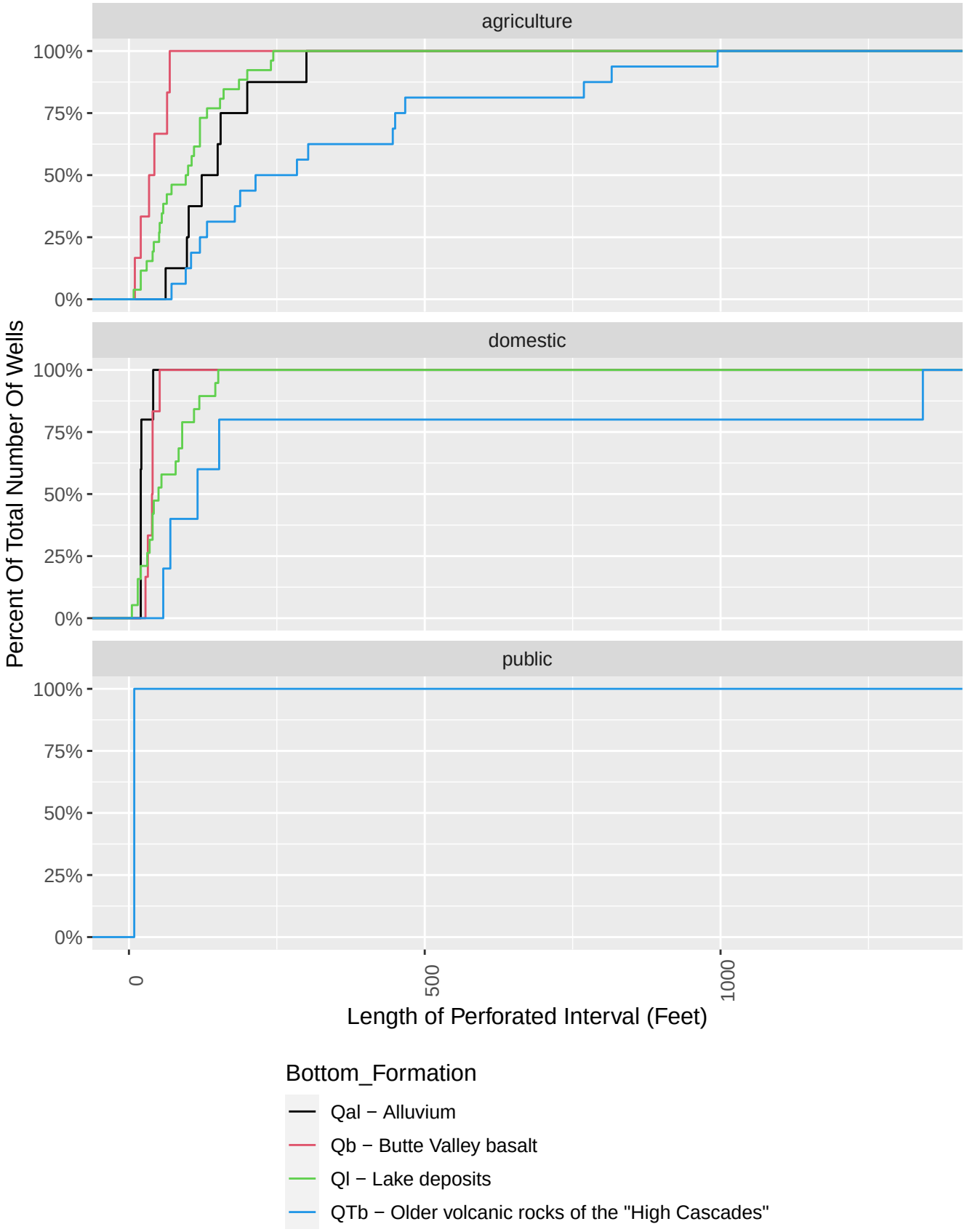


Figure 4: Butte Valley well perforation length. Sub-graphs show cumulative distribution graphs by well type and each graph shows major formations.

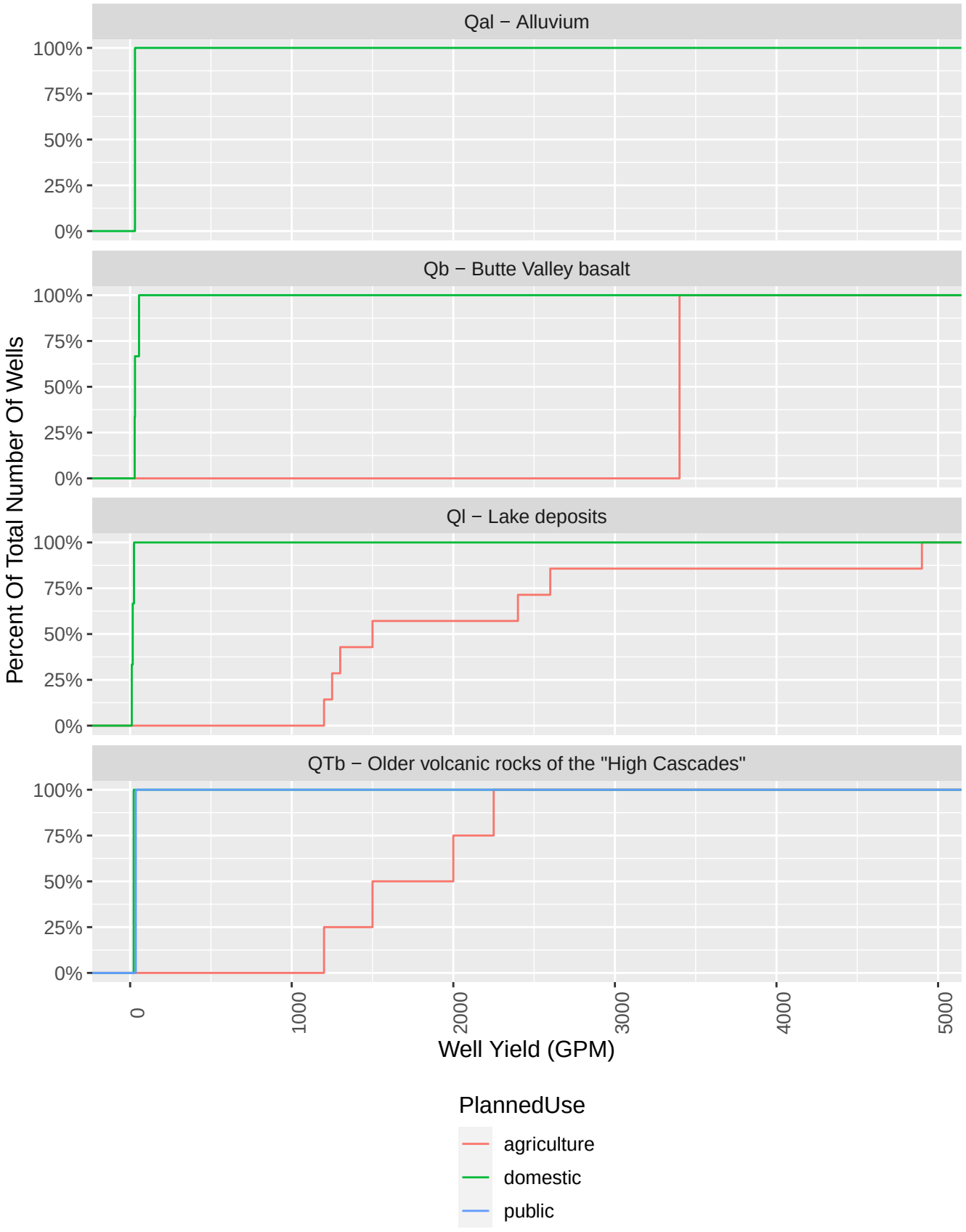


Figure 5: Butte Valley well yield by formation at the bottom of the well comparing major well types

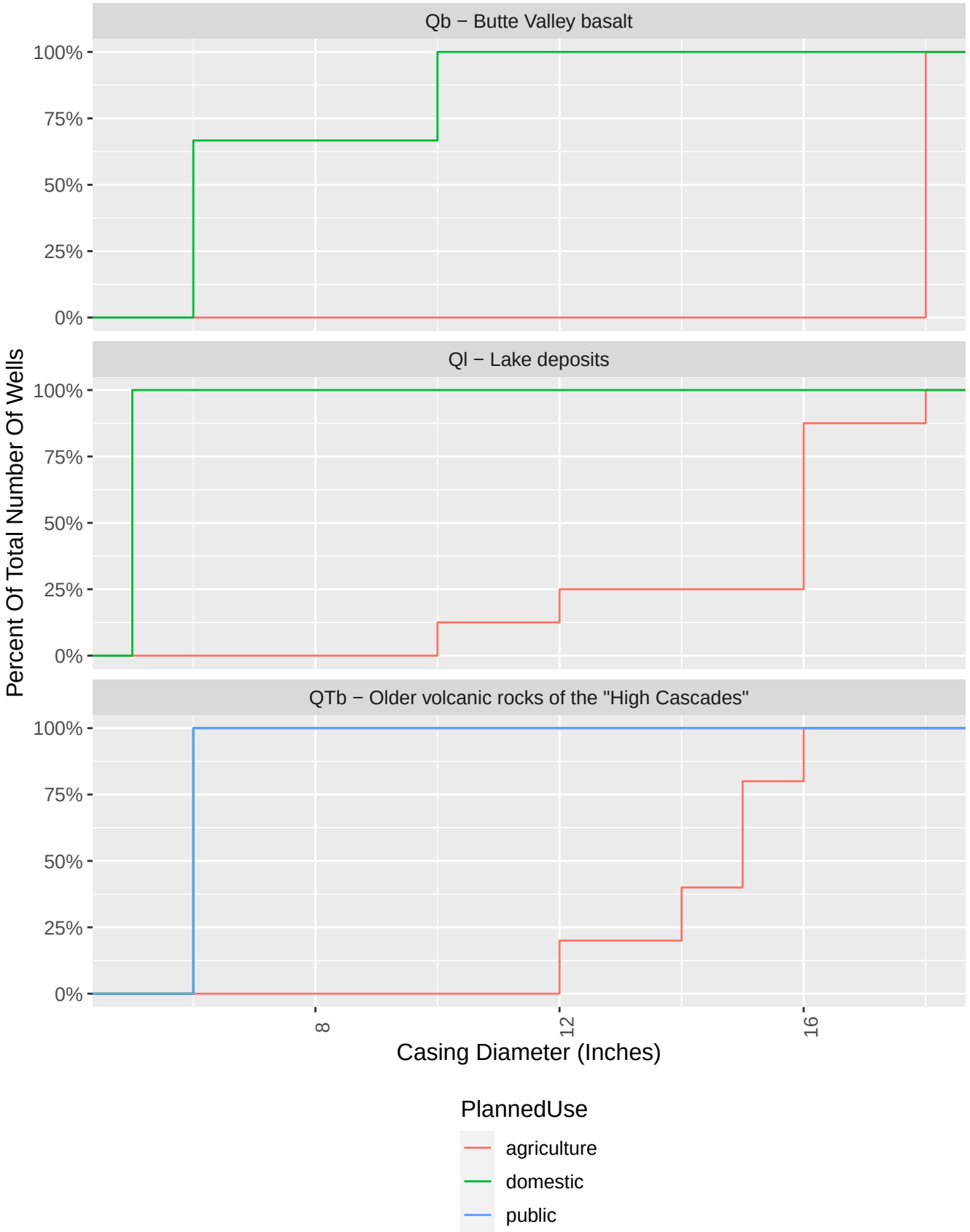


Figure 6: Butte Valley well casing diameter by formation at the bottom of the well comparing major well types

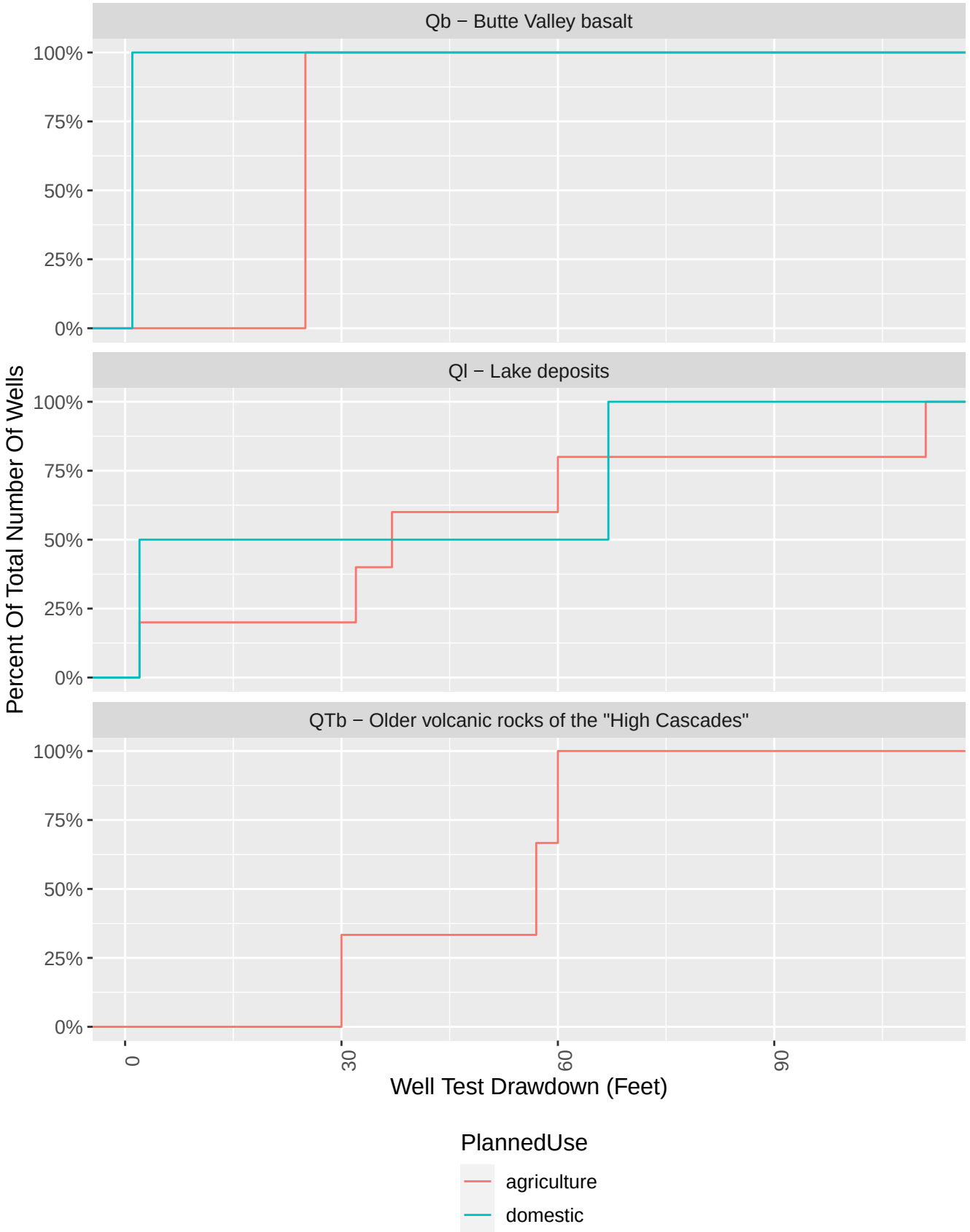


Figure 7: Butte Valley well test drawdown by formation at the bottom of the well comparing major well types

Estimated Wet Depth to Top of Perforations

The interpolated, contoured water table depth in fall of 2015 is shown in Figure 8, together with the location of those wells with water level measurements that are used for the water table depth interpolation. Estimates of water table depths are most accurate near the locations of the measured wells. The accuracy of estimates deteriorates with distance from a measured well (also see Chapter 2 in the Butte Valley Groundwater Sustainability Plan).

The estimated wet depth to top of perforations is shown in the following map (Figure 9). If the interpolated water level elevation was below the top of perforations, the difference shown is a negative number. These wells are color-coded orange and yellow in Figures 9 and 10. In 2015 (dry year) more than one-half of wells have an estimated wet depth to top of perforations that is negative. About one-third of wells are estimated to have a wet depth to top of perforations of less than 200 feet (but not negative). Few wells have a wet depth to top of perforations of more than 200 feet. The wells most vulnerable to well outage are those with the least (or negative) wet depth to top of perforations. Approximately 98 percent of wells have between negative 100 and positive 200 feet of water predicted above the well perforations.

A negative wet depth to top of perforations may be the result of a real event, e.g., the well is old and has been dry for some time, or the well is pumping from below the top of perforations. A negative wet depth to top of perforations may also be the result of estimation errors:

1) the interpolated water table depth used to estimate wet depth to top of perforations can be associated with significant error, from few feet to few tens of feet, due to limitations of the interpolation algorithm. The algorithm cannot account for localized changes in water table depth, especially in hilly terrains, where depth to water table may change rapidly as a function of terrain and well location.

2) depth to top of perforations is inaccurately reported.

The absolute value of the wet depth to top of perforations is therefore thought to be of poor accuracy. However, its cumulative distribution is indicative of the relative distribution of wet depth to top of perforations across wells in Butte Valley. The cumulative distribution of the wet depth to top of perforations is shown in Figure 11 for both years, 2015 and 2017. A zoomed-in version of this Figure, focused on wet depth to top of perforations from 0 feet to 200 feet is shown in Figure 12. Wet depth to top of perforations are shown for fall 2015, following a dry winter and fall 2017, following a wet winter, for comparison purposes. The cumulative distribution of wet depth to top of perforations indicates that fall 2017 water level conditions actually had less wet depth to top of perforation across many wells in Butte Valley than 2015 (in other words, the brown curve is above - shallower than - the green curve). This is consistent with the observation that water levels in 2015 were higher in many wells than in 2017. The difference between the two years is least where (estimated) wet depth to top of perforations is very shallow or negative. From -20 feet to 80 feet wet depth to top of perforations, the difference between fall of 2015 and fall of 2017 is about 10 - 20 feet (most of wells).

The absolute value of the wet depth to top of perforations is, as indicated, highly uncertain. However, the slopes of the cumulative distributions shown are relatively uniform at either end of the distribution and are therefore much less sensitive to the above listed uncertainties. Figure 12 indicates that the slope of the CD is approximately 3% to 8% (in x-axis direction) per 10 feet (in y-axis direction), for the 5th to 35th percentile of shallowest wells. Hence, this slope is representative for

the approximately one-third of Butte Valley wells that have the least estimated wet depth to top of perforations and would be most susceptible to well outages. Given the range over which the slope applies, the slope value is much less sensitive to the specific estimated wet depth to top of perforations at a well. Rather, it applies to all wells with shallow (or negative) values. If we further assume that the minimum wet depth to top of perforations needed for proper pumping is similar for most domestic wells (or most agricultural wells), then the slope can be interpreted as the risk for well outage with additional water level decline below historically low values: the slope indicates that 3% to 8% of Butte Valley wells are likely to experience well outage for every 10 feet of water level decline below the historically lowest measured water levels. Figures 13, 14, 15, and 16 show the cumulative distribution of “wet depth to top of perforations” separately for wells completed in the Lake Deposits, High Cascade Volcanics, the alluvium, and the Butte Valley Basalt, respectively.

Importantly, this approach to estimating well outage risk does not require knowledge of specific well information about pumping bowl elevation relative to the screen location, or about a minimum wet water level depth needed to pump properly. It only assumes that some well outages occur if water levels fall below historic lows and, hence, the selected slope is representative of the one-third of wells at most risk to well outage.

This allows for an estimate of the undesirable result that would occur if water levels declined to the minimum threshold. The average depth difference between the minimum measurable objective (MO, which corresponds to the lowest observed water level between 1991 and 2014) and the soft landing trigger (Chapter 3, Table 1.5) is 15 ft. The approximate number of wells that are at risk of well outage, if water levels across all of the basin fell to the soft landing trigger level is therefore 45 to 120 wells: 3% to 8% of approximately one thousand wells in the Basin fall dry for every ten feet lowering below the minimum MO. That is equivalent to 4.5% to 12% for every 15 feet lowering below the minimum MO. If water levels were to fall to the extended minimum threshold in the basin, which is an additional 15 feet lower at each RMP than the soft landing trigger, the number of well outages would likely double to between 90 and 240 wells.

The well outage risk may be unevenly distributed across Butte Valley (Figures 13, 14, 15, and 16): the slopes indicate a lower risk for wells in the Older Volcanic Rocks of the High Cascade Volcanics, but possibly higher risks elsewhere. However, for individual geologic formations, too few data points exist to make reliable well outage risk estimates.

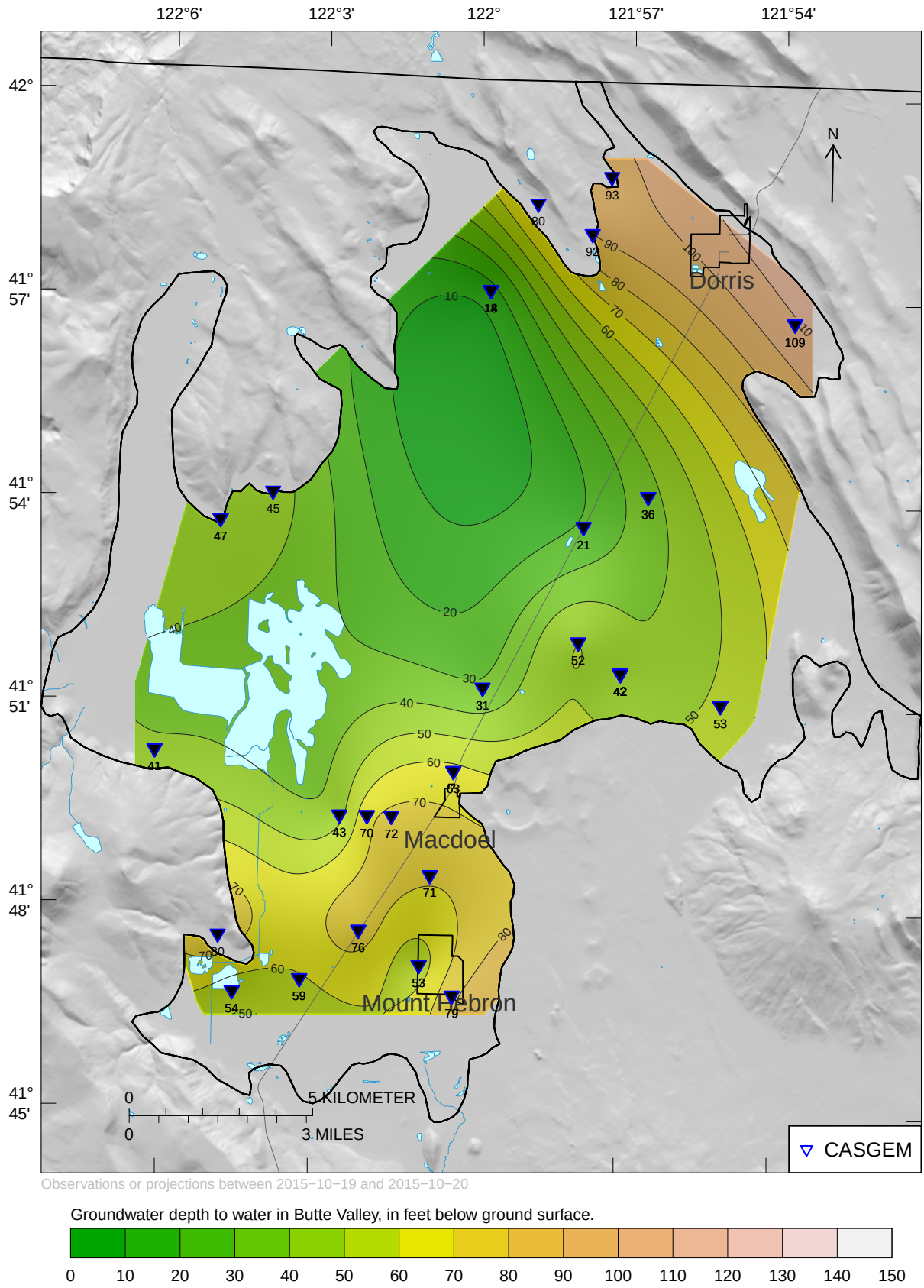


Figure 8: Butte Valley groundwater elevations reported as approximate depth to groundwater, fall 2015 and well failure estimates based on recent water level observations. Approximate basin-scale groundwater depths are shown.

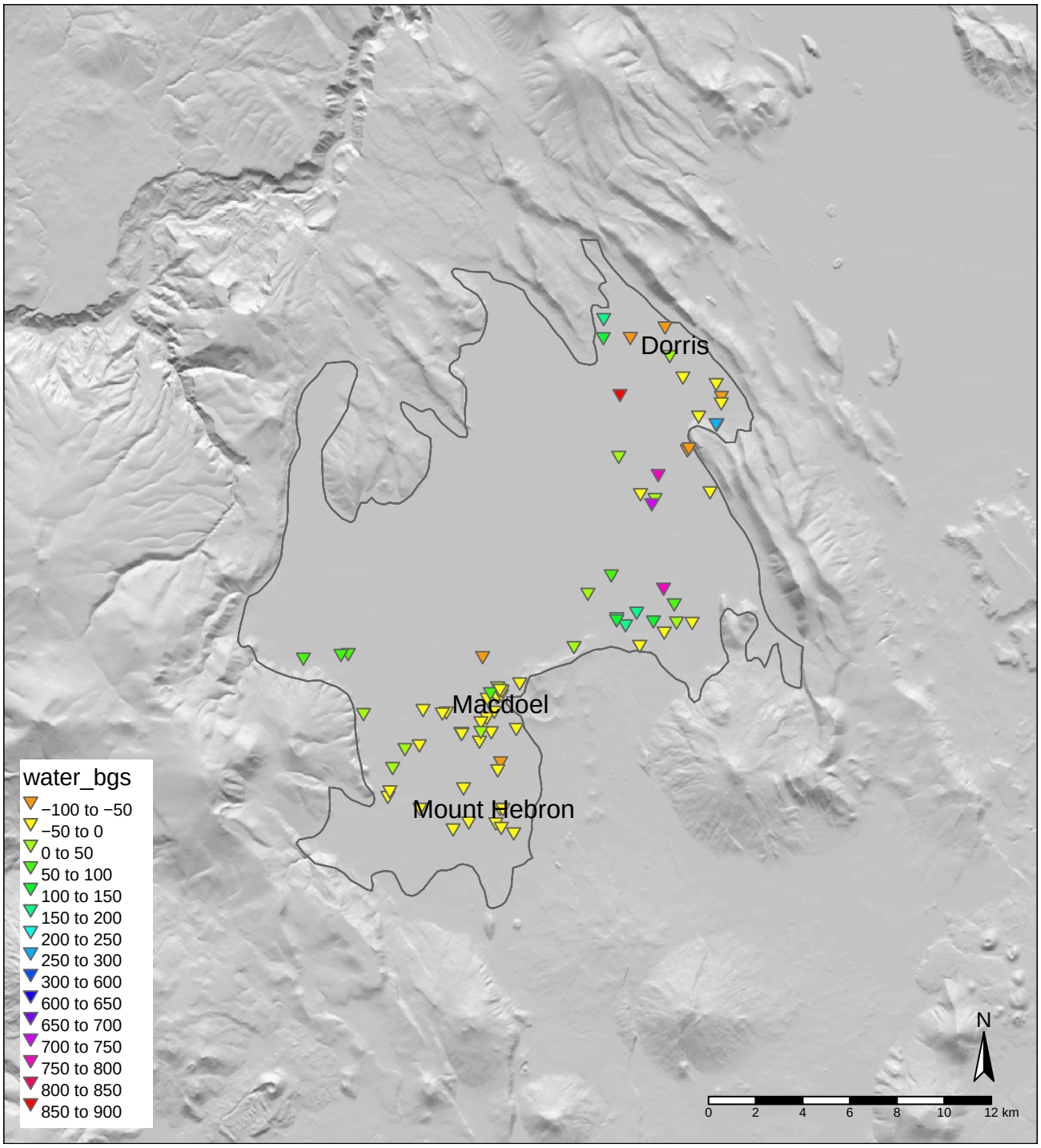


Figure 9: Butte Valley wet depth to top of perforations based on contoured groundwater elevations, October 2015.

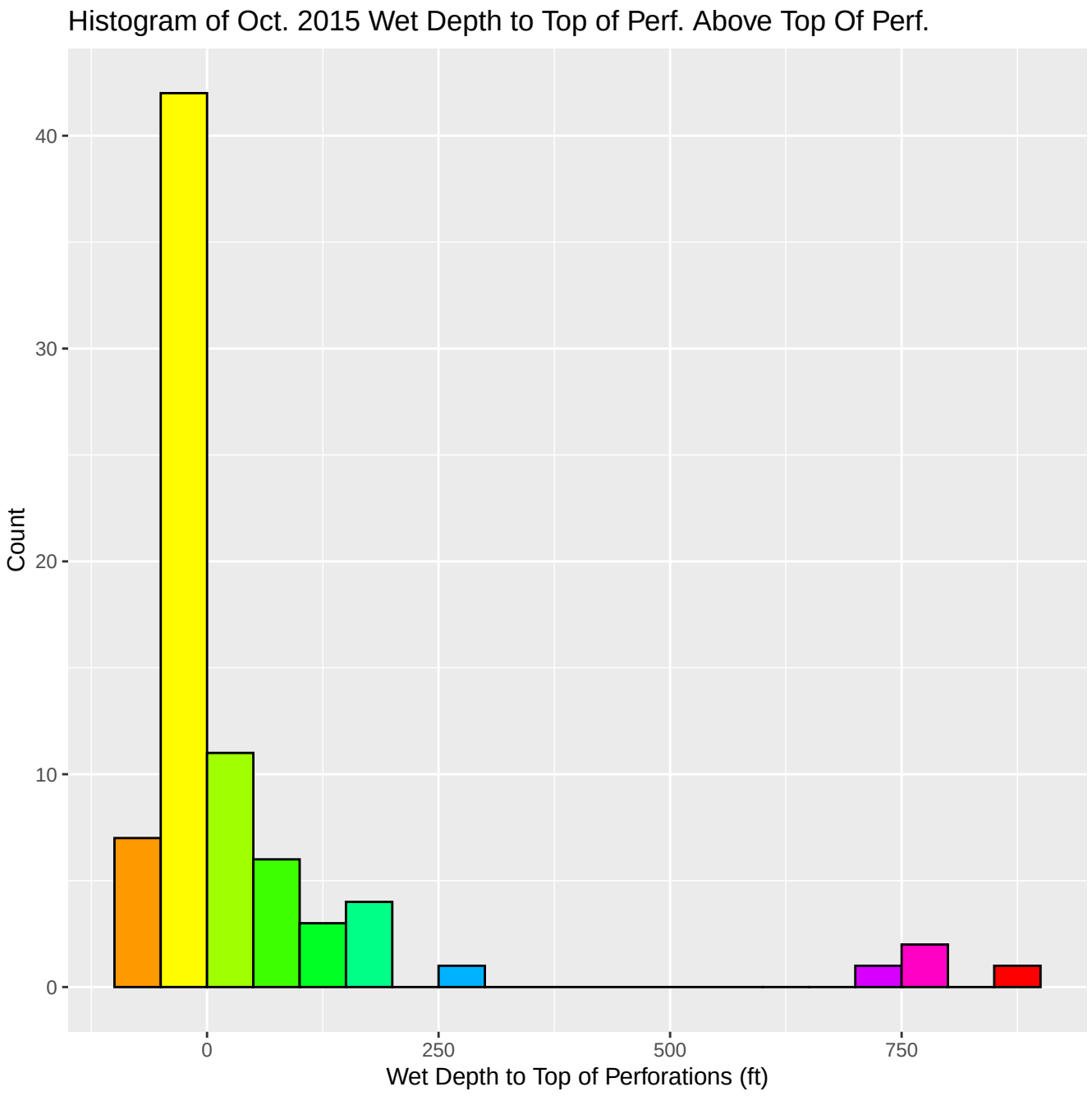


Figure 10: Histogram of wet depth to top of perforations based on contoured groundwater elevations, October 2015.

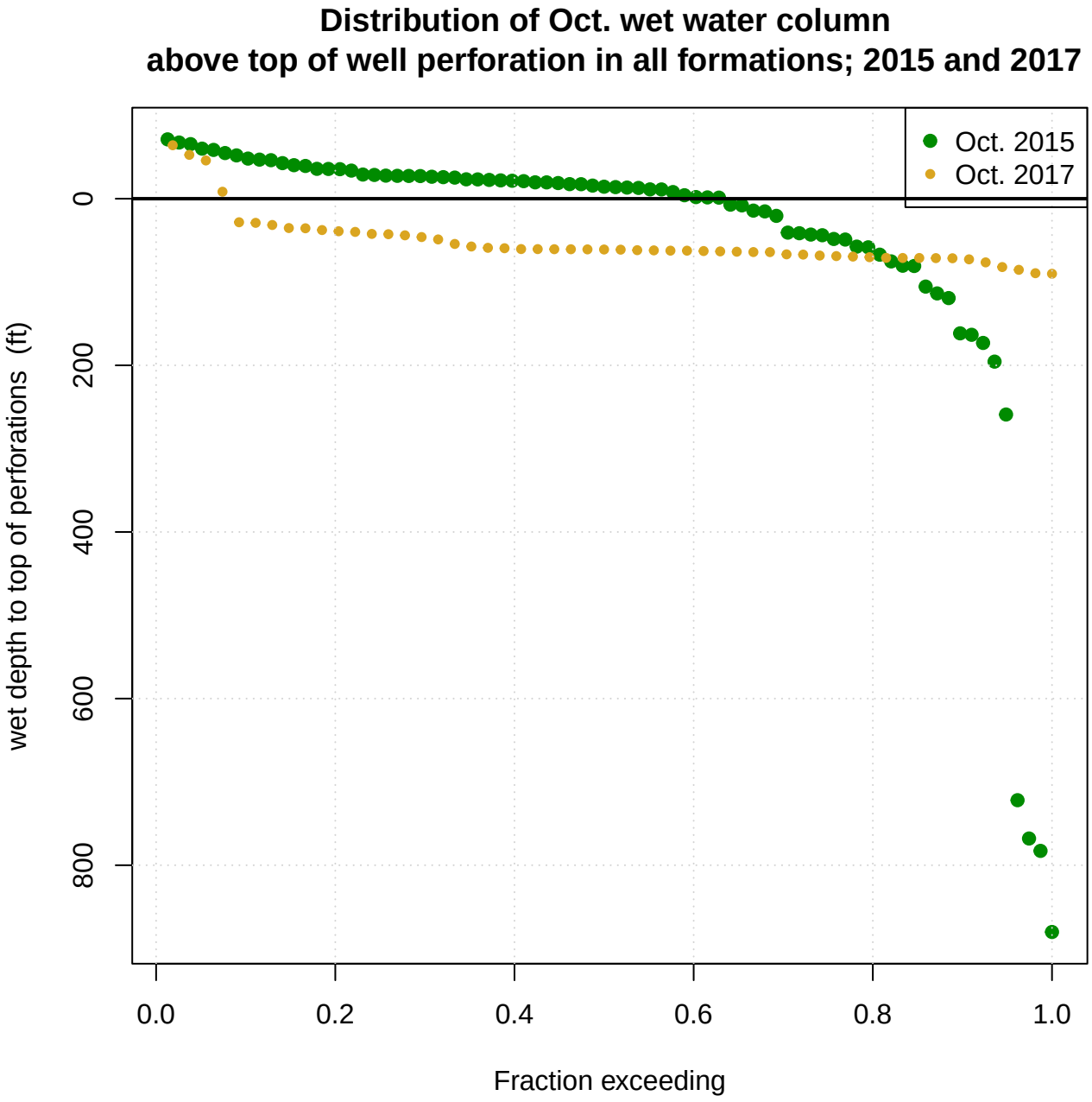


Figure 11: Cumulative distribution function of all well wet depth to top of perforations based on contoured groundwater elevations, Octobers of 2015 and 2017.

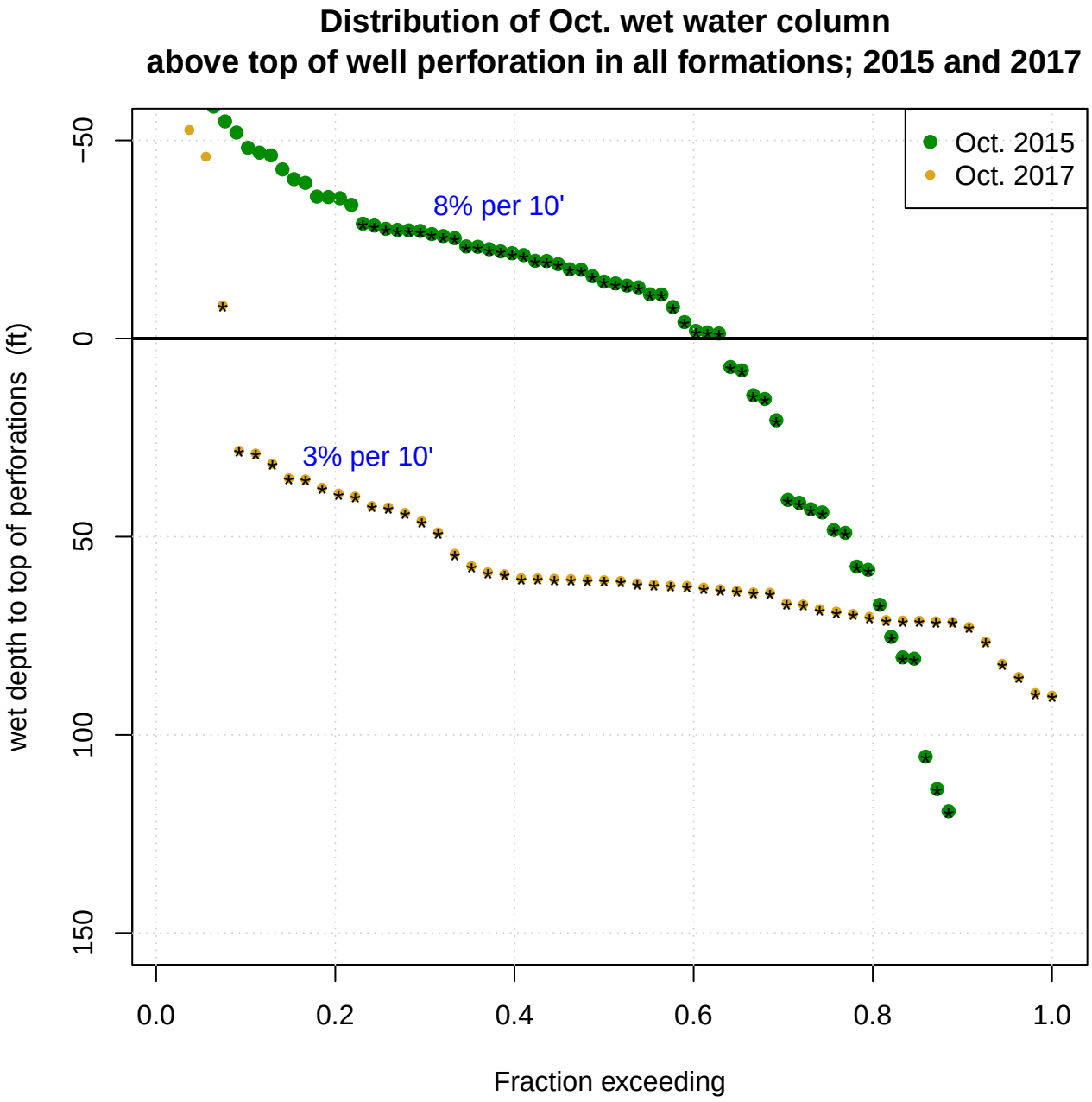


Figure 12: Focused graph of cumulative distribution function of all well wet depth to top of perforations feet based on contoured groundwater elevations, Octobers of 2015 and 2017, -50 to 150 feet. Black dots indicate the wells with water columns betwen -30 and 30 feet used for interpolating the well failure slope. Interpolation computed as a best fit linear slope to the data between the 5th and 35th percentile (LINEST function in Excel: 10* LINEST (fraction range, feet range).

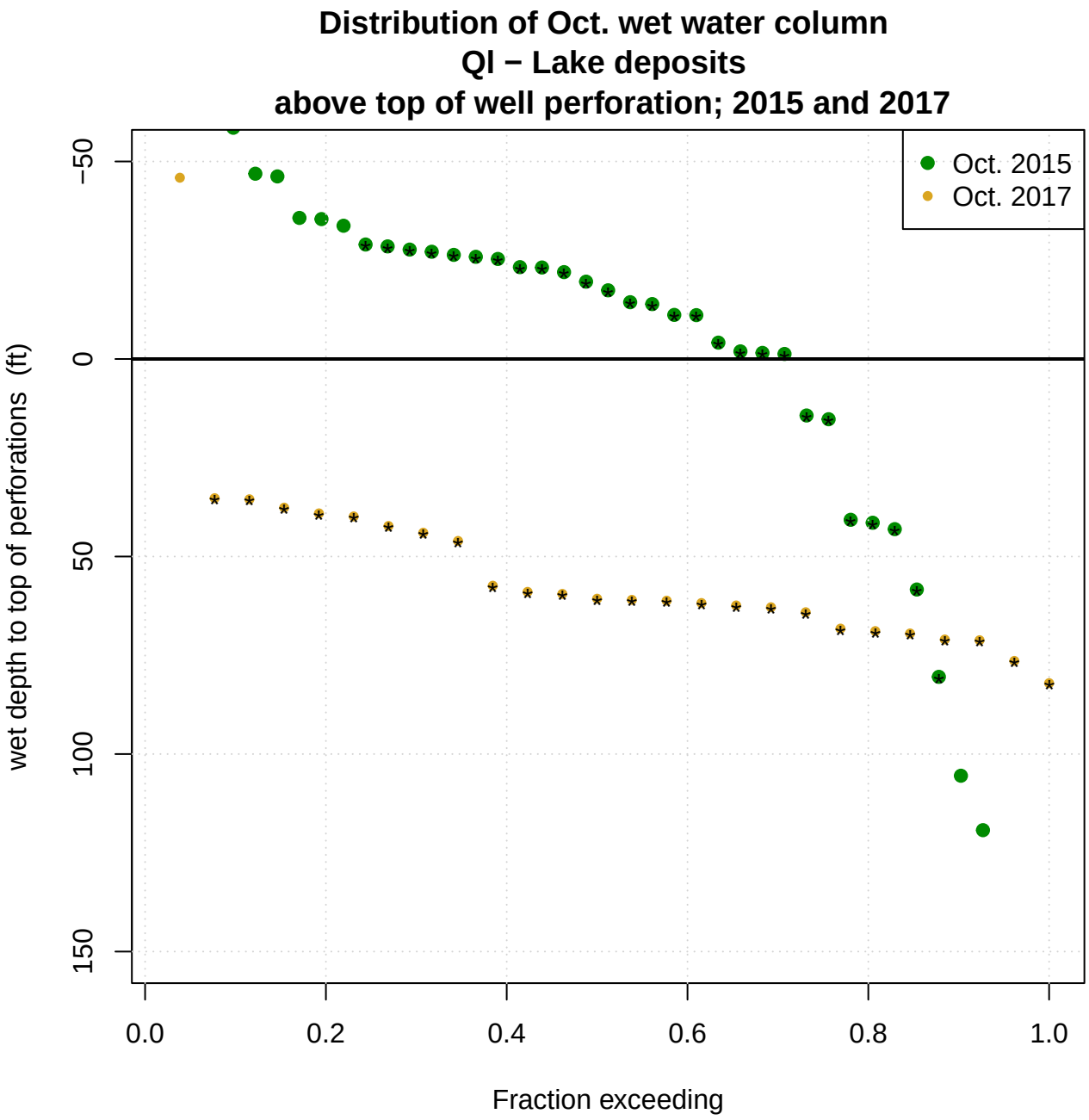


Figure 13: Focused graph of cumulative distribution function of all well wet depth to top of perforations feet based on contoured groundwater elevations, Octobers of 2015 and 2017, -50 to 150 feet. Black dots indicate the wells with water columns betwen -30 and 100 feet used for interpolating the well failure slope. Interpolation computed as a best fit linear slope to the data between the 5th and 35th percentile (LINEST function in Excel: 10* LINEST (fraction range, feet range).

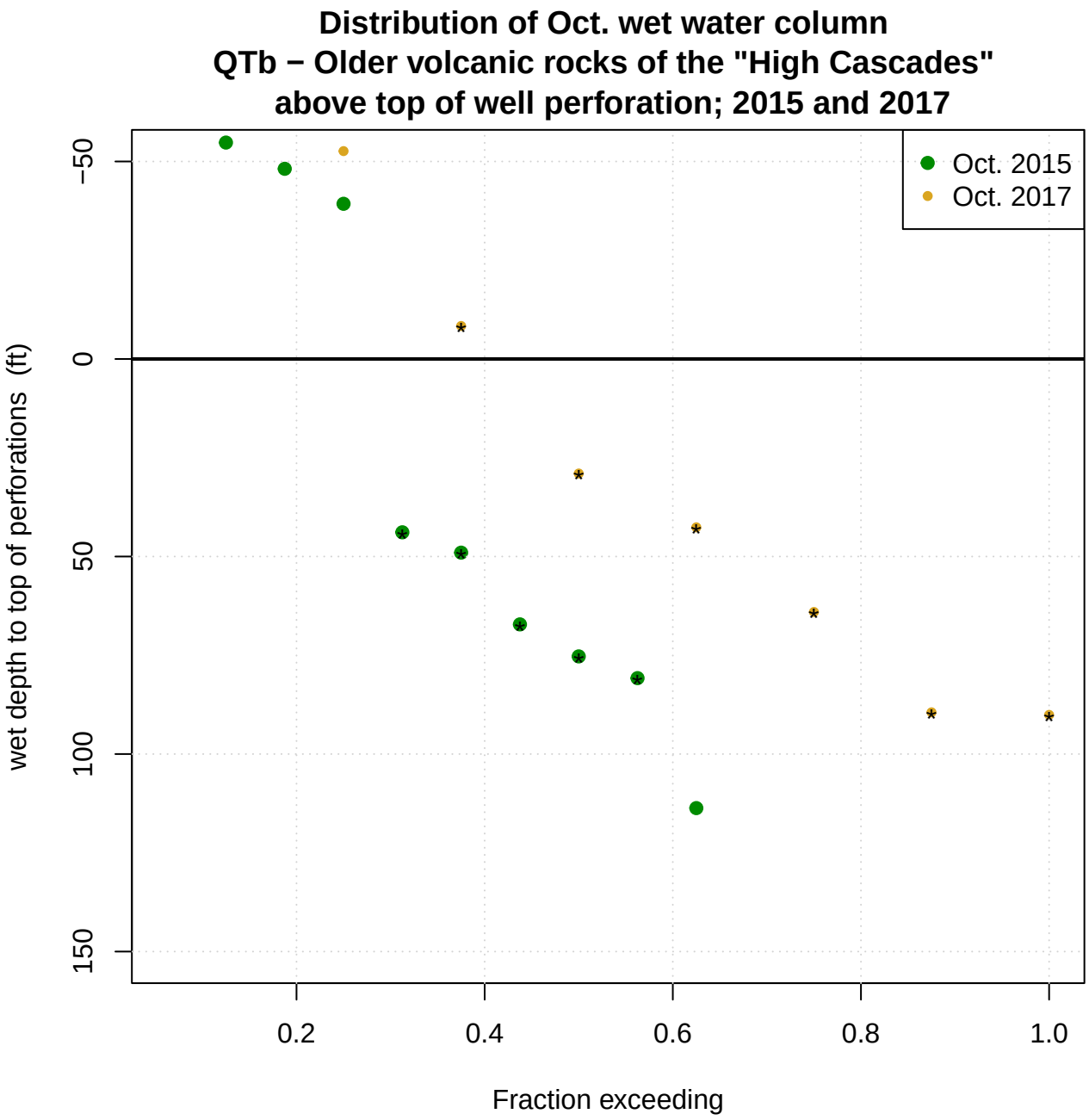


Figure 14: Focused graph of cumulative distribution function of all well wet depth to top of perforations feet based on contoured groundwater elevations, Octobers of 2015 and 2017, -50 to 150 feet. Black dots indicate the wells with water columns betwen -30 and 100 feet used for interpolating the well failure slope. Interpolation computed as a best fit linear slope to the data between the 5th and 35th percentile (LINEST function in Excel: 10* LINEST (fraction range, feet range).

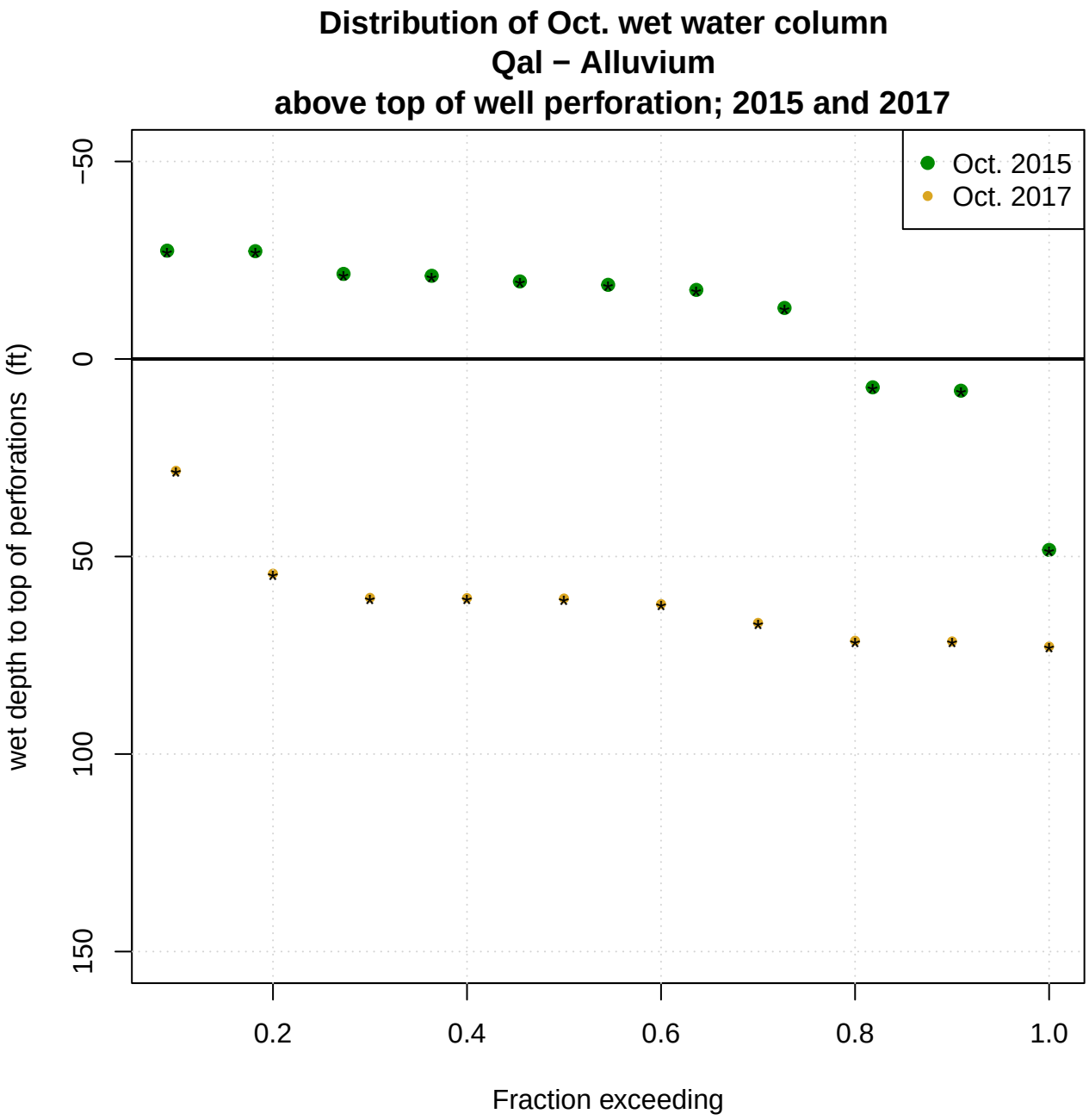


Figure 15: Focused graph of cumulative distribution function of all well wet depth to top of perforations feet based on contoured groundwater elevations, Octobers of 2015 and 2017, -50 to 150 feet. Black dots indicate the wells with water columns betwen -30 and 100 feet used for interpolating the well failure slope. Interpolation computed as a best fit linear slope to the data between the 5th and 35th percentile (LINEST function in Excel: 10* LINEST (fraction range, feet range).

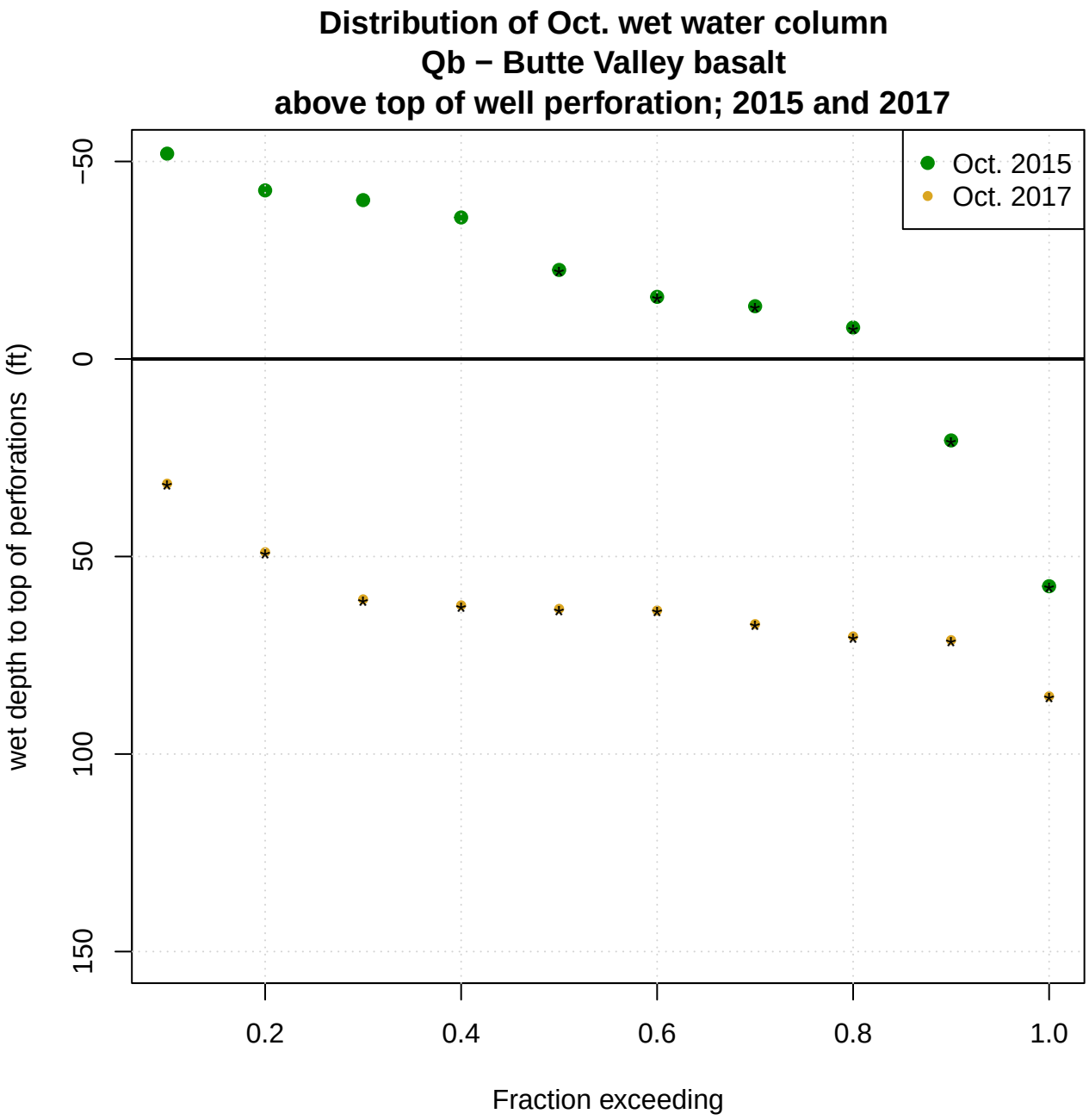


Figure 16: Focused graph of cumulative distribution function of all well wet depth to top of perforations feet based on contoured groundwater elevations, Octobers of 2015 and 2017, -50 to 150 feet. Black dots indicate the wells with water columns betwen -30 and 30 feet used for interpolating the well failure slope. Interpolation computed as a best fit linear slope to the data between the 5th and 35th percentile (LINEST function in Excel: 10* LINEST (fraction range, feet range).

Conclusion

We identified three key findings with respect to well outages:

Majority of wells unlikely to be affected by dewatering. Most wells in Butte Valley have well depths of 50 feet or more below the interpolated groundwater elevations depths of 2015 (at least 65%).

Uncertainty affects analysis quality. The analysis is relatively uncertain due to the lack of wells with both water level measurements and known well construction. Hence, we relied on interpolated water level data, which may be several feet or even tens of feet incorrect in some areas. This may be the case regarding the one third of wells with top of perforations above the interpolated water level depth (Figure 12) in 2015 (dry year) and 2017 (wet year) however many of those wells are also in the south east portion of the basin near Macdoel and Mount Hebron where some of the greatest water level declines since the 1980s has occurred. These wells may simply be operating at degraded capacity or are already out of operation seasonally.

In wells for which the wet depth to top of perforations is negative or exceedingly shallow, either:

1) the well goes dry in the fall, regardless of water year type, or,
2) the well pumps from below the top of perforations, or
3) the depth to water table interpolation is erroneous (most likely in hilly areas), or
4) well depth is inaccurately reported.

Due to the uncertainties arising from (3) and (4), we relied instead on the slope of the cumulative distribution of estimated wet water column depth, which is a more stable indicator of how many additional wells fall dry per 10 foot decline in water levels below historically low water levels. We find that:

The number of wells affected by groundwater elevations at the Minimum Threshold is insignificant. A well replacement PMA will further address well outage issues that occur below the first trigger level and above the extended minimum threshold. The soft landing trigger is, on average, 15 feet below the lowest measured water level during the 1991 to 2014 period. Based on Figure 12, an estimated 45 to 120 wells out of approximately 1,000 wells (4.5% to 12%) in the Basin may be at risk for well outage if water levels across the basin fall to the soft landing trigger. If water levels across the basin fell to the extended minimum threshold (an additional 15 feet water level decline), twice as many wells, from 9% to 24% of all wells, may be at risk of well outage.

Appendix 5-A PMA Prioritization and Scoring System

Preliminary criteria, and an associated scoring system, were developed to assist in the evaluation and prioritization of the PMA options identified in Chapter 4. This prioritization system is intended to facilitate strategic implementation of PMAs based on factors including effectiveness, cost, and stakeholder support. The criteria and descriptions for each scoring category are shown in Table 1. A template, with the PMAs identified in Chapter 4 for near-term and for future implementation (Tiers II and III), is included as Table 2. Categories and scoring may be modified throughout GSP implementation to reflect the principal objectives for PMAs.

Table 1: PMA prioritization criteria and score descriptions.

		Score		
Category		**1**	**2**	**3**
Effectiveness	**Anticipated Benefit**	Some physical benefit anticipated	Medium level of benefit anticipated (relative to other PMAs identified).	High level of benefit anticipated (i.e., streamflow depletion reversal is expected to be significant).
	Frequency	One-time benefit expected	PMA expected to provide benefit on more than one occurrence.	Benefits expected to occur repeatedly.
	Duration	Only short-term benefits expected (1-2 years)	Benefits expected over 2-5 years.	Benefits expected to occur over the long term (>5 years)
Completeness		No planning or studies have been completed, required permitting and funding sources have not been identified.	Some planning or studies have been completed, required permitting and funding sources may be identified and/ or secured.	Plans or studies have been completed, permitting has been secured, project is funded.
Complexity		Requires little planning and design, labor or materials to implement	Requires some planning, design and/or some labor or materials to implement.	Requires significant planning, design and/or significant labor or material to implement
Cost		Low cost or funding has been secured.	Mid-range cost and/or potential funding sources identified.	High cost and / or funding sources have been identified.

Uncertainty		Unproven technology or mechanism, legal authority unclear or no legal authority, anticipated difficulty obtaining required permits for project implementation.	Proven technology may be unproven in Basin setting or conditions), and/ or modelled results show an expected benefit, legal authority exists, and permits are anticipated to be attainable.	Proven technology and/or modelled results show an expected benefit, clear legal authority and required permitting is attainable.
Acceptability		Low or no support from stakeholders.	Medium support or desirability from stakeholders.	Strong support from stakeholders.

Table 1: Shasta Valley GSP PMA prioritization table template

Shasta Valley GSP Proposed List of Projects and Management Actions																			
										Evaluation Criteria and Score									
Tier	Project Name	Lead Agency	Relevant Sustainability Indicators Affected				Status	Timetable / Circumstances for Initiation	Physical Benefit (i.e., stream depletion reversal)	Effectiveness			Completeness	Complexity	Cost	Uncertainties	Acceptability/ Support	Total/ Ranking
			Groundwater Levels and Storage	Groundwater Quality	Land Subsidence	SW & GW Interconnection				Anticipated Benefits	Frequency	Duration						
Tier II Projects (PMAs Planned for Near Term Implementation 2022-2027)																			
II	Avoiding Significant Increase of Total Net Groundwater Use from the Basin	GSA, County of Siskiyou,	•			•	Conceptual only	TBD											

II	Conservation Easements	TBD	•			•	Conceptual Only	TBD										
II	Voluntary Managed Land Repurposing	TBD	•			•	Planning phase	Anticipated 2022-2027										
II	Upslope Water Yield Projects	TBD	•			•	Planning phase	TBD										
II	Habitat Improvement in Shasta Watershed	GSA, TBD	•			•												
II	Irrigation Efficiency Improvements	GSA, UCCE	•			•	Planning phase	TBD	up to 12% stream depletion reversal									
II	Instream Flow Leases	GSA, TBD	•			•												
II	Irrigation Efficiency Improvements	GSA, UCCE	•			•												
II	Juniper Removal	GSA, USFS, TBD	•			•												
II	Aquifer Characterization Analysis	GSA, TBD	•															

II	Reporting of Pump Volumes	GSA, TBD	•			•												
Tier III Projects (PMAs with potential implementation in 2027-2042)																		
III	MAR & ILR	GSA	•			•	Conceptual Only	TBD										
III	Alternative, Lower ET Crops	GSA, UCCE, TBD	•			•	Conceptual Only	TBD										
III	Reservoirs	TBD	•				Conceptual only	TBD										
III	Strategic Groundwater Pumping Curtailment	GSA	•			•	Conceptual only	TBD										
III	Expanded Watermaster Program	Scott Valley and Shasta Valley Watermaster District	•			•	Conceptual only	TBD										

Appendix 5-B Annual Reporting Template

This appendix presents an example template for annual reporting. Use of this appendix is intended as an example only and is not intended to be specific to the Basin. Modification will be required based on specifics outlined in the Basin's Groundwater Sustainability Plan.

SMC Tracker: A web dashboard to support GSP annual reporting with centralized monitoring, modeling, and data access

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Overview page 1
Groundwater level page 3
Other pages 4
Data access 4
Additional features 4
Mobile display 4
Near-real time monitoring 5
Password protection and data privacy 5
Conclusion 5

Introduction

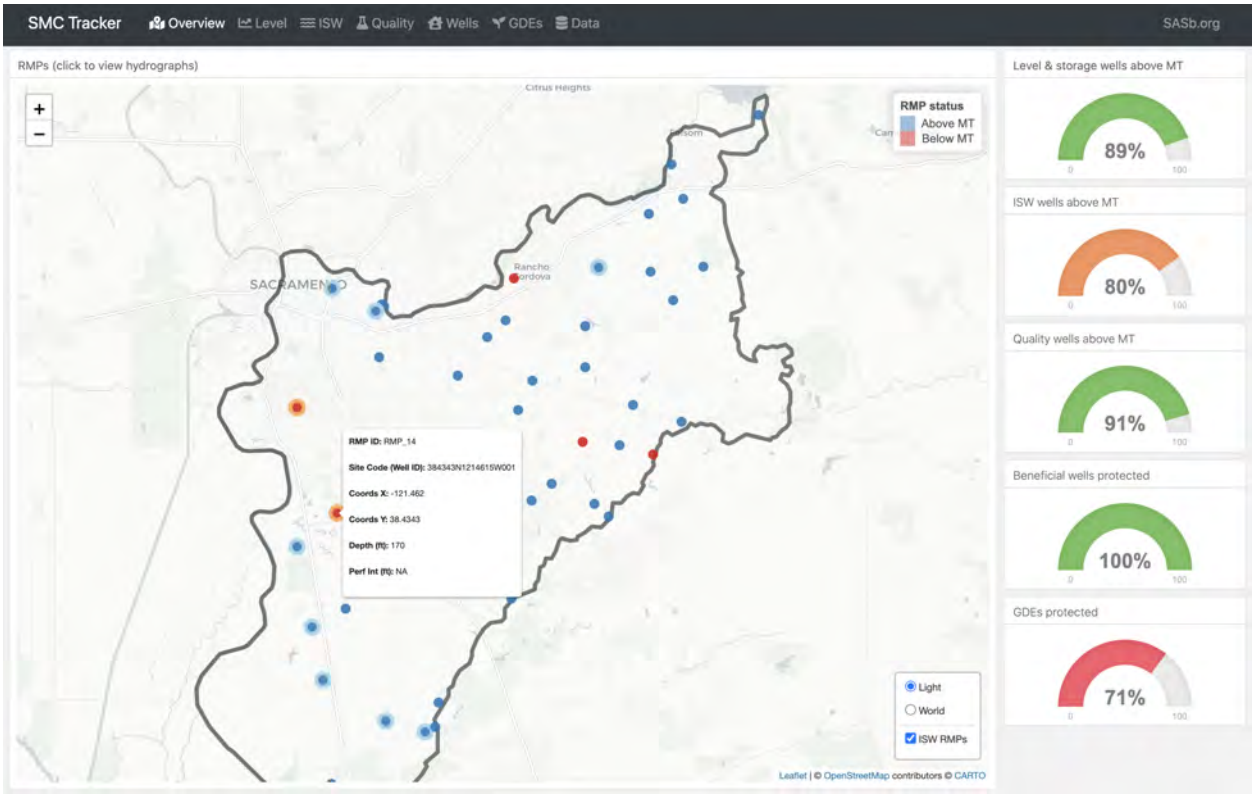
Annual reporting for SGMA requires monitoring at representative monitoring points (RMPs), analysis of potential impacts to beneficial users, evaluation of physical conditions in the basin to sustainable management criteria (SMC), and submission of data to the State. Data is collected different ways and at different sampling frequencies–often by multiple agencies and consulting firms–and the analysis, storage, reporting, and sharing of this information introduces friction into annual reporting, compliance assessment, and decision making. The need for streamlined annual reporting solutions is especially acute during severe drought where rapid access to information to guide critical decision making is paramount.

We propose a solution called **SMC Tracker**: a web-based data reporting and SMC tracking dashboard that integrates RMP monitoring data with assessments to beneficial users in automated interactive visualizations. This dashboard will summarize groundwater conditions in the basin, integrate data and models used in the annual report, and provide a central hub for tracking SMC in near-real time. Users will be able to visualize all RMPs at a glance, drill down into monitoring data collected at each RMP, and use summary panels to rapidly assess "basin vitals" that show if the basin has identified significant and unreasonable results for a given sustainability indicator and/or beneficial users of groundwater. And finally, users will be able to export data for analysis and in forms that directly comply with DWR submission criteria for a painless, drag-and-drop solution.

Overview page

The SMC Tracker main page provides an overview of basin sustainability at a glance. All RMPs for groundwater level and storage are shown. Users can:

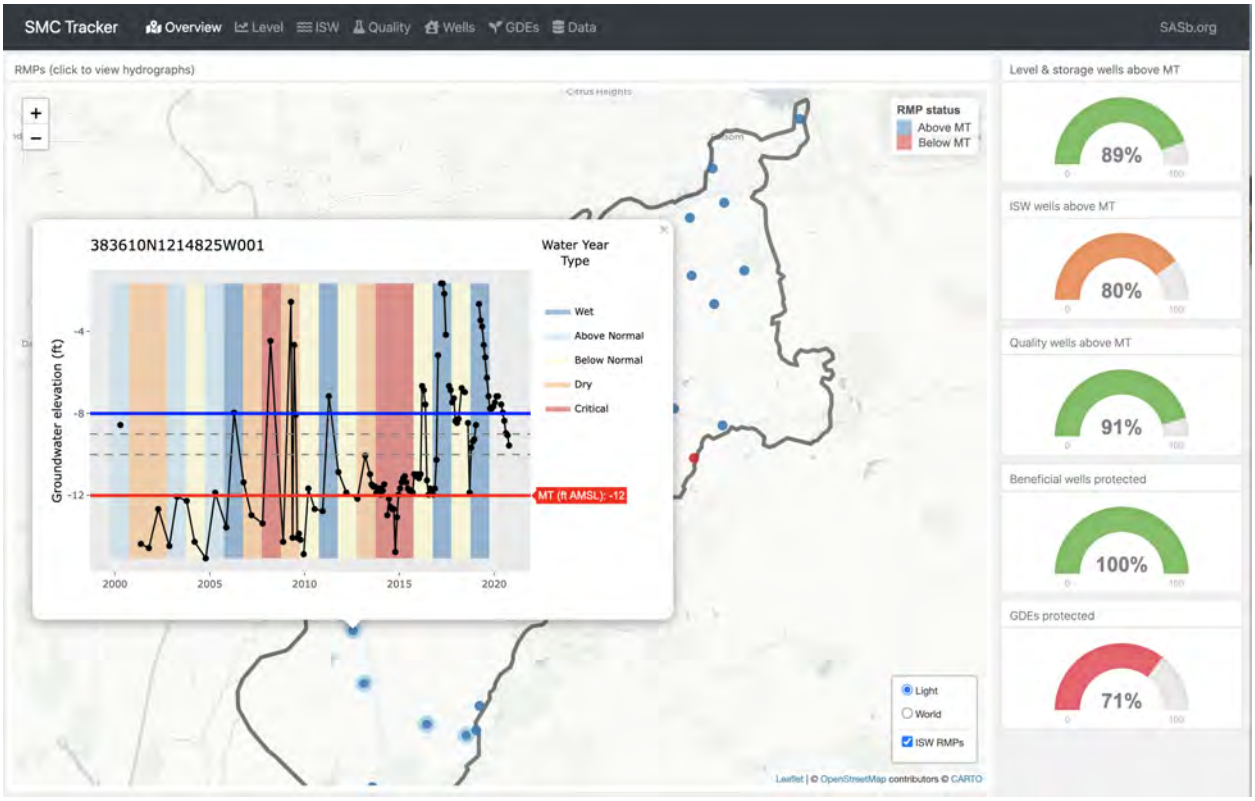
- hover over points to view site metadata
- use the legend to quickly identify RMPs that are above or below their MT
- use the legend to toggle between groundwater level, storage, and ISW monitoring points
- toggle basemaps to view satellite imagery
- click points to expand interactive timeseries plots that allow the user to zoom, pan, and export plots. Plots show:
  - water year type
  - historical data through the present day
  - SMC (minimum thresholds, measurable objectives, and interim milestones)



The lefthand sidebar shows "odometer" gauges which represent critical sustainability criteria, including:

- percentage of groundwater level and storage RMPs above the MT
- percentage of ISW RMPs above the MT
- percentage of water quality wells above the MT
- percentage of shallow wells protected at current groundwater levels
- percentage of GDEs protected

Colors of the gauges can be configured such that when the basin dips into “trigger” or “undesirable result” territory, the gauges show this.



Groundwater level page

The “Groundwater level” pageis one example of many other pages where users can drill down into aggreagted data for a particular sustainability indicator. Whereas in the “Overview” page, users interact with RMPs spatially and click on individual RMPs to view groundwater levels, on the “Groundwater level” page, all groundwater levels are shown in a single interactive visualization.

This page will be configured to automatically incorporate data as is it collected in a standard form by agencies and consultants. In the event that data is collected via telemetry, this page can be configured to auto-update at a regular time interval (e.g., daily) so that users can always view the most up-to-date data. Features include:

- a right hand legend that can be clicked to toggle individual points on and off or highlight one timeseries line
- interactive zoom and pan to inspect small details in the timeseries data
- two tabs that render the data in terms of water surface elevation (ft AMSL) and depth to groundwater (ft below land surface)
- groundwater level data on hover including the site ID, the date, and the groundwater level
- a button to export the current state of the plot to a .png file which can be included in a presentation or a report



Other pages

Just as the "Groundwater level" page allows the user to drill down into groundwater level data, users needs information on other Sustainability indicators that may include interconnected surface water (ISW), groundwater quality, land subsidence, and/or seawater intrusion. Moreover, key beneficial users may include shallow wells and GDEs, and the user may need information on impacts to these users suggested by the latest monitoring data and modeling. "Other" pages accomplish this, and are listed in the header from left to right. Here we include examples for ISW, groundwater quality, wells, and GDEs. Content on these pages will be developed to address basin-specific needs.

Data access

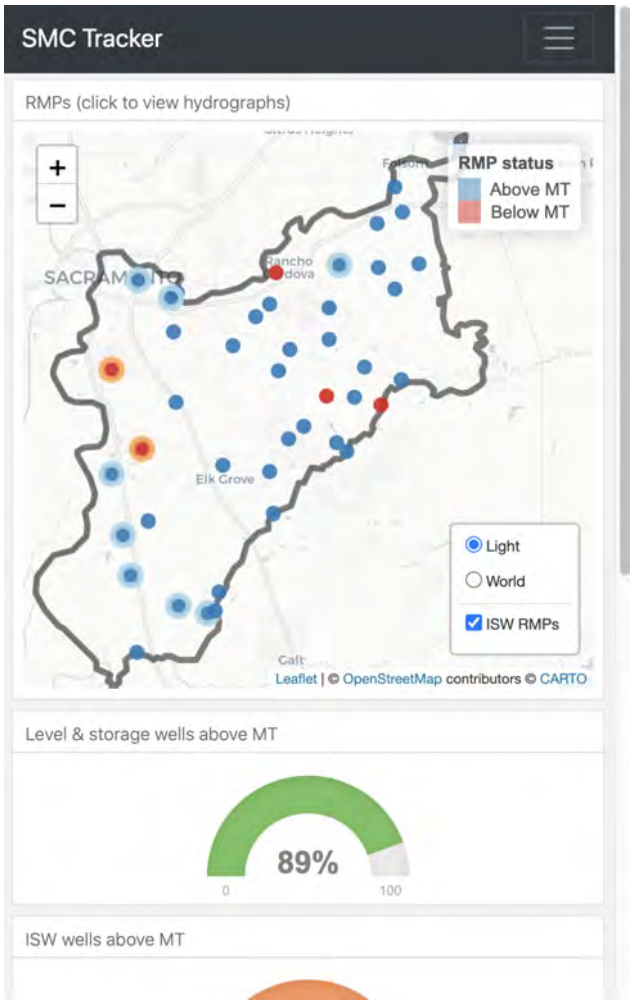
Agencies and consultants may require data from time to time, and as new data is made available, it must be centralized and distributed. SMC Tracker accomplishes this centralization and distribution on a "Data" page with links to the most up-to-date data. Also on this page are download links to data in DWR annual reporting templates for fast, painless, drag-and-drop solutions to annual reporting requirements.

Additional features

Dashboards are highly customizable and additional features may be added on an ad-hoc basis.

Mobile display

SMC Tracker is built with modern software optimized for mobile display. It looks great on smartphones and tablets.



Near-real time monitoring

Custom data extraction for any continuous monitoring sites can be integrated into SMC Tracker so that GSAs can track groundwater levels and other sustainability indicators in near-real-time (e.g., following a recharge project, or during a severe drought). Receiving automated information quickly and in a visual format can help focus priorities for working groups, and allow consultant teams access to standardized data as soon as it is available so data-driven management actions can be rapidly planned and executed.

Password protection and data privacy

Depending on GSA needs, dashboards can be made public or private. If dashboards are made private, they will sit behind password-protected walls for authorized users.

All data will be stored and protected on private servers configured by LWA.

Conclusion

Once developed, SMC defined in GSPs must be monitored for the identification of significant and unreasonable results. Monitoring at RMPs occurs throughout the year and is reported to DWR annually. Data

collection, analysis, reporting, and sharing all present friction in the annual reporting and compliance process. These challenges are obviated by centralizing all monitoring data in one place to visualize near-real-time groundwater conditions in the basin and how they measure up to SMC. The SMC Tracker tool will aid agencies and consultants by providing access to monitoring data, SMC tables, and standardized excel data export sheets that can be dragged and dropped into DWR's online reporting system.

Appendix 5-C Financial Analysis for GSP Implementation

SISKIYOU COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT GROUNDWATER SUSTAINABILITY AGENCY

BUTTE VALLEY, SCOTT VALLEY, AND SHASTA VALLEY BASINS

FUNDING OPTIONS TECHNICAL MEMORANDUM

JULY 2021

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INTRODUCTION AND EXECUTIVE SUMMARY

INTRODUCTION AND GOALS

The Siskiyou County Flood Control and Water Conservation District (District) was enacted in 1957 to provide for the control and conservation of flood and storm waters and the protection of watercourses, watersheds, public highways, life and property damage or destruction from such waters; to provide for the acquisition, retention, and reclaiming of drainage, storm, flood, and other waters; to save, conserve, and distribute such waters for beneficial use within the District boundaries, and to replenish and augment the supply of water in natural underground reservoirs. The boundaries of the District coincide with the County, and the Siskiyou County Board of Supervisors serve as the Board of Directors (Board) of the Flood and Water Conservation District; however, the District is a separate legal entity from the County, with independent rights and limited powers set forth in its originating act.

The Board passed a resolution on April 4th, 2017 to serve as the Groundwater Sustainability Agency (GSA or Agency) for the Butte Valley, Scott Valley, and Shasta Valley Basins (basins) as required by the Sustainable Groundwater Management (SGMA) Act of 2014.

In the Winter of 2018, the Agency engaged a consultant team led by Larry Walker Associates (LWA Team) to develop the Groundwater Sustainability Plan in compliance with the SGMA for the three basins.

A Groundwater Sustainability Plan (GSP) for each of the three basins includes goals and recommendations, as well as the associated costs required for its implementation. Accordingly, the purpose of this technical memorandum is to describe a path forward to fund the GSP's implementation. It should be noted that SGMA and its associated requirements and goals are quite new, and there is not a clear, well-tested path forward to fund GSP implementations. Rather, the funding efforts for GSP implementation in the three basins need to be carefully crafted for local conditions, preferences, and politics – as well as being flexible, creative, and reactive.

The GSA has been initially funded by existing general funds and grants. The general direction from the GSA Board of Directors in regard to funding the GSP implementation can be summarized as:

- GSA expenses should be well-controlled
- Funding strategy needs to be locally viable and right-sized
- Metering of wells is not desired

EXECUTIVE SUMMARY

Following is a brief summary of the findings and recommendations contained within this Technical Memo, including a summary of the GSP implementation costs, potential funding mechanisms, and recommendations for funding of the implementation.

REVENUE NEEDED FOR GROUNDWATER SUSTAINABILITY PLAN IMPLEMENTATION

The GSP makes numerous implementation recommendations, including annual operations and maintenance as well as capital projects. The associated costs for these tasks, including the low range and high range, are summarized in Tables 1, 2, and 3 below. The total estimated annual costs for all three basins combined ranges from $438,750 to $747,500.

TABLE 1 – SUMMARY OF TOTAL ESTIMATED ANNUAL COSTS FOR BUTTE VALLEY BASIN

Summary

	Annual Budget	
	Low Range	**High Range**
Operations and Maintenance	$120,000	$210,000
Grant Writing	$15,000	$20,000
Capital Projects	TBD	TBD
Total	**$135,000**	**$230,000**

TABLE 2 – SUMMARY OF TOTAL ESTIMATED ANNUAL COSTS FOR SCOTT VALLEY BASIN

Summary

	Annual Budget	
	Low Range	**High Range**
Operations and Maintenance	$120,000	$210,000
Grant Writing	$15,000	$20,000
Capital Projects	TBD	TBD
Total	**$135,000**	**$230,000**

TABLE 3 – SUMMARY OF TOTAL ESTIMATED ANNUAL COSTS FOR SHASTA VALLEY BASIN

Summary

	Annual Budget	
	Low Range	**High Range**
Operations and Maintenance	$150,000	$262,500
Grant Writing	$18,750	$25,000
Capital Projects	TBD	TBD
Total	**$168,750**	**$287,500**

It is anticipated that capital projects will be primarily grant-funded. More detail is provided in Section II., below.

FUNDING APPROACHES AND OPTIONS FOR GSP IMPLEMENTATION

There are a variety of funding approaches, each with pros and cons, and most likely a portfolio of various approaches will prove optimal. The likely most optimal funding mechanisms are listed below:

Best Options

- Existing Revenue Sources
- Grants and Loans
- Regulatory Fees

If additional revenue is needed:

- Property Related Fees – non-Balloted (*allocated to well owners*)
- Special Taxes – Balloted (allocated to all property owners within the basins or County)

Less optimal

- Property Related Fees – Balloted
- Benefit Assessments

Each funding mechanism and approach has key attributes - each of which should be considered to select the optimal funding portfolio, including:

  - Flexibility of Methodology (per acre, per acre-feet pumped, per well, etc.)
  - Costs of Implementation
  - Revenue Potential
  - Political Viability / Community Acceptance
  - Legal Rigor
  - Administration

ALLOCATING IMPLEMENTATION COSTS TO WELL OWNERS VERSUS PROPERTY OWNERS

If funding beyond use of existing sources, grants and regulatory fees is needed, then one of the most important considerations for the GSP's is the allocation of the GSP implementation cost between the well owners and the larger group of all property owners within the three basins, or even County-wide. Conventional wisdom suggests that the costs of the implementation of groundwater mitigation policies should be directly borne by the immediate users of the groundwater – the well owners. However, there are clear benefits to all properties and residents within a well-managed groundwater basin that provides additional, lower cost water resources. It can be argued that a community-wide funding mechanism in which all properties and/or residents pay their fair share is a more optimal approach. Both types of approaches are discussed in Section II of this technical memo.

ROADMAP FORWARD AND RECOMMENDATIONS

A summary of this Technical Memo's major recommendations for implementation includes a step sequential roadmap as summarized below:

1. Conduct community outreach regarding the GSP and its implementation
2. Pursue use of existing revenue sources, grants, and regulatory fees to fund implementation

If additional revenue is needed:

3. Conduct a public opinion survey and focused community outreach
4. Implement a property related fee or special tax

The process of establishing long-term, sustainable, comprehensive funding for GSP implementation will likely take at least 18 months to complete. More detail is provided in Section III., below.

I. DETAILED REVENUE NEEDS

ANNUAL OPERATIONS AND MAINTENANCE COSTS

The GSP includes numerous recommendations for annual operations and maintenance in support of the long-term sustainability of the three basins. The costs of these recommendations have been developed and bracketed with a low range of $120,000 per year and a high range of $210,000 for Butte Valley and Scott Valley Basins, and a low range of $150,000 per year and a high range of $262,500 for Shasta Valley Basin. These figures are detailed in Tables 4, 5, and 6 below:

Table 4 – Detailed Summary of Estimated Maintenance and Operations Costs for Butte Valley Basin

Operations and Maintenance

	Annual Budget	
	Low Range	**High Range**
General GSA Operations	$10,000	$25,000
Annual Reporting	$15,000	$25,000
Model Maintenance	$40,000	$80,000
Monitoring	$45,000	$60,000
Future Stakeholder Engagement	$10,000	$20,000
Mediation Fund	TBD	TBD
Total	**$120,000**	**$210,000**

Table 5 – Detailed Summary of Estimated Maintenance and Operations Costs for Scott Valley Basin

Operations and Maintenance

	Annual Budget	
	Low Range	**High Range**
General GSA Operations	$10,000	$25,000
Annual Reporting	$15,000	$25,000
Model Maintenance	$40,000	$80,000
Monitoring	$45,000	$60,000
Future Stakeholder Engagement	$10,000	$20,000
Mediation Fund	TBD	TBD
Total	**$120,000**	**$210,000**

Table 6 – Detailed Summary of Estimated Maintenance and Operations Costs for Shasta Valley Basin

Operations and Maintenance

	Annual Budget	
	Low Range	**High Range**
General GSA Operations	$12,500	$31,250
Annual Reporting	$18,750	$31,250
Model Maintenance	$50,000	$100,000
Monitoring	$56,250	$75,000
Future Stakeholder Engagement	$12,500	$25,000
Mediation Fund	TBD	TBD
Total	**$150,000**	**$262,500**

Where:

General GSA Operations includes costs to operate the GSA including supporting and facilitating Board and committee meetings, disseminating information, satisfying existing grant administrative requirements, managing contracts for tasks listed below, maintaining the website, etc.

Annual Reporting: includes costs to draft and submit all required annual reports.

Model Maintenance: includes the annual installment costs to use the models every year to test scenarios of Projects and Management Actions and to recalibrate and update the model every 5 years.

Monitoring – Interconnected Surface Water: costs are different in Shasta and Scott Valley, and they do not apply to Butte Valley. In Shasta Valley, cost includes the periodic (likely semi-annual) inspection and maintenance at 3 transects sites already fully installed and equipped - approximately 6 visits per year. For both Shasta and Scott, cost of monitoring of the wells located near the river and already equipped with continuous data is already included in the Water Level Monitoring. Further data collections for SW/GW in both Shasta and Scott will be coordinated with other partners and included in the GSP as management action.

Monitoring - Water Level: includes the periodic (likely semi-annual) inspection of water level monitoring equipment at CASGEM and DWR well sites and 10-15 additional well sites with continuous monitoring – approximately 6 visits per year and, as needed, hardware replacement.

Monitoring - Water Quality: includes the periodic sampling of water quality – approximately 10-15 samples per year.

Mediation Fund: is a placeholder for funds in support of mediation. For example, a grant program could be established for local well-owners to access capital to address compliance issues.

Future Stakeholder Engagement: Costs for future stakeholder engagement have not been included in these budgets but may be incurred.

ANNUAL CAPITAL COSTS

The GSPs include numerous recommendations for capital improvements in support of the long-term sustainability of the Basins. Most likely, these capital improvements will be implemented if and only if significant grant funding is available. However, there are often associated costs with grants including grants writing and grants administration.

The costs of these recommendations have been developed and bracketed with a low range of $10,000 per year and a high range of $40,000, and are detailed in Tables 7, 8, and 9 below:

TABLE 7 – DETAILED SUMMARY OF ESTIMATED MAINTENANCE AND OPERATIONS COSTS FOR BUTTE VALLEY BASIN

Capital Projects

	Annual Budget	
	Low Range	**High Range**
Grant Writing	$15,000	$20,000
Annual Grant Administration	TBD	TBD
Capital Projects Costs	TBD	TBD
Total	**$15,000**	**$20,000**

TABLE 8 – DETAILED SUMMARY OF ESTIMATED MAINTENANCE AND OPERATIONS COSTS FOR SCOTT VALLEY BASIN

Capital Projects

	Annual Budget	
	Low Range	**High Range**
Grant Writing	$15,000	$20,000
Annual Grant Administration	TBD	TBD
Capital Projects Costs	TBD	TBD
Total	**$15,000**	**$20,000**

TABLE 9 – DETAILED SUMMARY OF ESTIMATED MAINTENANCE AND OPERATIONS COSTS FOR SHASTA VALLEY BASIN

Capital Projects

	Annual Budget	
	Low Range	**High Range**
Grant Writing	$18,750	$25,000
Annual Grant Administration	TBD	TBD
Capital Projects Costs	TBD	TBD
Total	**$18,750**	**$25,000**

Where:

Grant Writing: includes periodic grant writing primarily for capital projects.

Annual Grant Administration: includes costs satisfying annual grant administrative requirements including reporting and budget management.

TOTAL ANNUAL IMPLEMENTATION COSTS

The total costs of these recommendations have been developed and bracketed with a low range of $90,000 per year and a high range of $182,500, and are detailed in Tables 10, 11, and 12 below:

TABLE 10 – SUMMARY OF TOTAL ESTIMATED COSTS FOR BUTTE VALLEY BASIN

Summary

	Annual Budget	
	Low Range	**High Range**
Operations and Maintenance	$120,000	$210,000
Grant Writing	$15,000	$20,000
Capital Projects	TBD	TBD
Total	**$135,000**	**$230,000**

TABLE 11 – SUMMARY OF TOTAL ESTIMATED COSTS FOR SCOTT VALLEY BASIN

Summary

	Annual Budget	
	Low Range	**High Range**
Operations and Maintenance	$120,000	$210,000
Grant Writing	$15,000	$20,000
Capital Projects	TBD	TBD
Total	**$135,000**	**$230,000**

TABLE 12 – SUMMARY OF TOTAL ESTIMATED COSTS FOR SHASTA VALLEY BASIN

Summary

	Annual Budget	
	Low Range	**High Range**
Operations and Maintenance	$150,000	$262,500
Grant Writing	$18,750	$25,000
Capital Projects	TBD	TBD
Total	**$168,750**	**$287,500**

Shasta Valley Basin costs: Total estimated costs for the Shasta Valley Basin are generally estimated to be 25% higher than for Butte Valley and Scott Valley.

II. EVALUATION OF POTENTIAL FUNDING MECHANISMS

INTRODUCTION TO AVAILABLE POTENTIAL FUNDING MECHANISMS OPTIONS IN CALIFORNIA

Existing California law provides a relatively finite number of mechanisms for local public agencies to reliably generate revenue to provide services. In many cases, a portfolio approach of several of these mechanisms will be optimal. Also, it is crucial to work closely with legal counsel on the implementation of all funding mechanisms to ensure legal compliance. This section provides a discussion of the mechanisms best suited to provide funding for groundwater management services recommended in the Agency GSP, including, but not limited to, the following:

Best Options

- Existing Revenue Sources
- Grants and Loans
- Regulatory Fees

If Additional Revenue is Needed

- Property Related Fees – non-Balloted (*allocated to well owners*)
- Special Taxes – Balloted (allocated to all property owners within the basin)

Less Optimal

- Property Related Fees – Balloted
- Benefit Assessments

Existing Revenue Sources and Grants Are Likely the Preferred Approach

Of course, it is recommended that the Agency rigorously explore all opportunities to fund the recommended groundwater management services through existing revenue sources and grants, eliminating the need for an additional allocation for well owners or all basin property owners. However, there are likely not sufficient available existing revenue sources to support GSP implementation, especially over the long term. See the discussion "Grants and Loans" below.

Regulatory Fee Should Be Imposed

Regulatory fees are an excellent source of reimbursement of actual costs for inspections, plan checks, etc., and should be imposed.

However, If Additional Revenue is Needed

If additional revenue is need beyond the amount that can be generated by existing revenue sources, there are two primary approaches:

Revenue Generated from	Optimal Revenue Mechanism
Well Owners	Property Related Fee (non-balloted)
All Property Owners	Special Tax (balloting is required)

Additional Funding from Well Owners or Community Property Owners

One unique challenge, and opportunity, associated with implementation of a funding mechanism for groundwater sustainability management is the decision regarding how costs will be allocated between well owners and the overall community of property owners. Generally speaking, the development of the Sustainable Groundwater Management Act was based upon the assumption that the allocation of costs would be primarily, perhaps exclusively, assigned to well owners, with some consideration of *de minimis* ground water users. However, there are clear benefits to all properties and residents within a basin, or even the entire county, with well managed groundwater resources. It can be argued that a community-wide funding mechanism in which all properties and/or residents pay their fair share is a more optimal approach.

Local political forces, often concentrated with well owners, may dictate a preference for allocating the GSP implementation costs more broadly to all property owners within the basins or county, but it should be noted that California law requires that special taxes, which would be the mechanism required for an allocation on all basins or county property owners, requires a balloting. Balloted revenue mechanisms are arguably more legally rigorous, and legal challenges to voter-approved fees have rarely been successful. However, the balloting requirement significantly limits the total revenue that may be generated, as it is limited by the political "willingness to pay" of the local voters or property owners. Ballotings are also expensive and politically risky. For that reason, non-balloted approaches are typically preferable, and do not have the same apparent political limitation on the amount of revenue that can be generated, but political realities and influences are still significant.

As the Agency determines its funding strategy, it should take an in-depth look at many attributes, including flexibility of methodology (per acres, per water quantity, per well, per parcel, etc.), costs of implementation, revenue generation potential, political viability, legal rigor, administrative burden, etc., as described below.

EXISTING REVENUE SOURCES

If the Agency can fund the groundwater management services with existing revenue sources, that is certainly optimal. However, even if this is possible in the short term, it is likely not possible very far into the future.

GRANTS AND LOANS

Grant funding is highly desirable, as it eliminates/lessens the need to generate revenue directly from well owners and/or the broader community of property owners. Grant funding is typically available for capital projects but can be available for other programmatic activities, including maintenance and operations. It is worth noting that grants often come with other funding requirements such as matching funds or requirements for post-project maintenance. For these reasons, an underlying revenue stream is very important to have access to leverage these opportunities.

California has a limited number of State grants and programs which provide funding opportunities for groundwater sustainability. The primary grants in support of SGMA are described below (*from https://water.ca.gov/Work-With-Us/Grants-And-Loans/Sustainable-Groundwater*):

"The SGMA Grant Program is funded by Proposition 68 and Proposition 1. To date, the California Department of Water resources (DWR) has awarded $139.5 million in three rounds of planning grants for development of Groundwater Sustainability Plans (GSPs) and related projects. All Proposition 1 funds have been awarded, with about $103 million now remaining to be awarded using Proposition 68 funds. Additional information can be found below.

PROPOSITION 1, CHAPTER 10: GROUNDWATER SUSTAINABILITY

On November 4, 2014, California voters approved Proposition 1, which authorized $100 million be made available for competitive grants for projects that develop and implement groundwater plans and projects in accordance with groundwater planning requirements established under Division 6, commencing with §10000, Water Code §79775. DWR completed two grant solicitations for planning grants.

PROPOSITION 68, CHAPTER 11.6: REGIONAL SUSTAINABILITY FOR DROUGHT AND GROUNDWATER, AND WATER RECYCLING

On June 5, 2018, California voters approved Proposition 68, which amended the Water Code to add, among other articles, §80146, authorizing the Legislature to appropriate funds for competitive grants for proposals that:

- Develop and implement groundwater plans and projects in accordance with groundwater planning requirements.
- Address drought and groundwater investments to achieve regional sustainability for investments in groundwater recharge with surface water, stormwater, recycled water, and other conjunctive use projects, and projects to prevent or cleanup contamination of groundwater that serves as a source of drinking water."

The Agency should plan to submit an application for the next round of Proposition 68 funding.

FUTURE STATE GRANT OPPORTUNITIES

Since all of Proposition 1 funding has been awarded and the remaining portion of Proposition 68 funding (just over $100 million) will be awarded over the next several years, there will likely be a shortfall of grant funding for GSP implementation in the near future. Unfortunately, there are not any large statewide bond measures (with grant opportunities) on the political horizon, but the Agency should continue to track such efforts. Also, future bond measures will likely emphasize funding for multi-benefit projects and programs that cross traditional organizational structures, and the Agency should also consider coordinating with other affected local agencies to put forth larger and potentially more competitive grant applications.

Proposition 68

The final Proposition 68 Implementation Proposal contains $103 million in available funding. DWR has released Round 1 draft funding recommendations, allocating $26 million to high priority basins.[1] Of the remaining $77 million, $15 million will be reserved for Underrepresented Communities, leaving $62 million available for general awards in Round 2 Implementation.[2]

Round 2 Grant Solicitation will open in spring of 2022, with final awards disbursed in fall of that year. Awards will be allocated to medium and high priority basins that have adopted a GSP that has been deemed complete by DWR. Grant amounts must be between $2 million and $5 million, with a 25% locally matched cost share requirement. A cost share waiver is available for eligible projects proportionate to the degree that they serve Underrepresented Communities. Any local cost share cannot have contributed to other grant awarded projects. Project expenses must be incurred after January 31, 2022, the due date for medium and high priority basin GSPs. The state encourages applicants to work with the stakeholders and other non-member agencies in their basin that have potential activities and tasks that are complimentary to the overall project. Eligible projects are defined by Proposition 68 Chapter 11.6 and include sustainability measures such as groundwater recharge and contamination prevention.

OTHER TYPES OF GRANTS

The Agency should work to identify applicable Federal grants, if any, and compete, in coordination with other affected local agencies for funding. Also, the Agency should consider working with local elected officials to pursue provisions that direct approved funds to be spent on specific projects, often called earmarks.

Grants from non-profits, foundations, high-net-worth individuals, and other stakeholders should be considered, especially with an emphasis on environmental sustainability.

REQUIRED DOCUMENTS FOR GRANTS

- Grant applications meeting specific requirements.

FLEXIBILITY OF METHODOLOGY

Use of grant funding is well-specific in the specific grant.

REVENUE GENERATION POTENTIAL

Amount of grant funding is well-specific in the specific grant.

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1 Proposition 68 SGM Grant Program's Implementation – Round 1 Draft Award List (ca.gov)

2 https://www.grants.ca.gov/grants/sustainable-groundwater-management-sgm-grant-programs-proposition-68-implementation-round-2/

ADVANTAGES

- Does not require cost to be allocated to local well owners or property owners.
- Revenue generation can be sufficient to offset significant costs of certain key activities.
- Legally rigorous as long as grants are expended on eligible activities.

CHALLENGES

- Provides funding for a limited time period only – difficult for long term planning solution.
- Awarded through a highly competitive process.
- Often requires matching local funds, tends to be focused on capital expenses, and are often narrowly focused in terms of scope and services.

REGULATORY FEES

Public agencies throughout California often reimburse themselves for the costs of site inspections, permits, plan checks, plan reviews, and associated administrative and enforcement activities using regulatory fees. These fees are often approved and published as part of a "Master Fee Schedule," and are often collected as part of review for approval process. This approach can assist in significantly reducing the GSA's financial burden.

Proposition 26, approved by California voters in 2010, tightened the definition of regulatory fees. It defined a special tax to be *"any levy, charge, or exaction of any kind imposed by a local government"* with certain exceptions. Pursuant to law, all special taxes must be approved by a two-thirds vote of the electorate.

Regulatory fees are thus defined through the cited exceptions. The pertinent exception is, "a charge imposed for the reasonable regulatory costs to a local government for issuing licenses and permits, performing investigations, inspections, and audits, enforcing agricultural marketing orders, and the administrative enforcement and adjudication thereof." The other pertinent exception is, "assessments and property-related fees imposed in accordance with the provisions of Article XIIID."

The Proposition goes on to state that, "the local government bears the burden of proving by a preponderance of the evidence that a levy, charge, or other exaction is not a tax, that the amount is no more than necessary to cover the reasonable costs of the governmental activity, and that the manner in which those costs are allocated to a payor bear a fair or reasonable relationship to the payor's burdens on, or benefits received from, the governmental activity."

Proposition 26 provides the primary guidance for the funding of the Agency's plan review and inspection fees as regulatory fees. Moreover, Section 10730 of the California Water Code, (which corresponds well with Proposition 26 guidance) stipulates that these fees can be used "to fund the costs of a groundwater sustainability program, including, but not limited to, preparation, adoption, and amendment of a groundwater sustainability plan, and investigations, inspections, compliance assistance, enforcement, and program

administration, including a prudent reserve." Hence, it seems that the intent of this section is that the development of the plan can be financed through regulatory fees (and this has been widely agreed upon) as well as some, but not all, GSP implementation activities. In any case, Water Code Section 10730 includes several unique requirements that should be carefully followed when implementing regulatory fees for GSP implementation.

REGULATORY FEE IMPLEMENTATION PROCESS

Regulatory fees are relatively easy and straightforward to implement. Neither a public noticing nor a balloting is required. Typically, a public agency will engage a specialized consultant to conduct a Fee Study. This Study will present findings to meet the procedural requirements of Proposition 26, which require analysis and support that:

1. The levy, charge, or other exaction is not a tax; and
2. The amount is not more than necessary to cover the reasonable cost of the governmental activity; and
3. The way those costs are allocated to a payor bears a fair or reasonable relationship to the payor's burden on, or benefits received from, the governmental activity.

Additionally, case law has provided further clarification of these substantive requirements, that:

1. The costs need not be "finely calibrated to the precise benefit each individual fee payor might derive."
2. The payor's burden or benefit from the program is not measured on an individual basis. Rather, it is measured collectively, considering all fee payors.
3. That the amount collected is no more than is necessary to cover the reasonable costs of the program is satisfied by estimating the approximate cost of the activity and demonstrating that this cost is equal to or greater than the fee revenue to be received. Reasonable costs associated with the creation of the regulatory program may be recovered by the regulatory fee.

REQUIRED DOCUMENTS FOR REGULATORY FEES

- A Fee Study, reviewed by legal counsel and adopted by the governing authority.

FLEXIBILITY OF METHODOLOGY

Legal requirements and industry practice limit these fees to recovery of costs associated with eligible activities (e.g., inspections, permits, etc.) The Agency is advised to work closely with legal counsel and review Proposition 26 and Water Code Section 10730 requirements.

REVENUE GENERATION POTENTIAL

Full recovery of costs associated with eligible activities (e.g., inspections, permits, etc.)

ADVANTAGES

- Quick and inexpensive to implement. No noticing nor balloting is required.

- Revenue generation is sufficient to offset significant costs of certain key activities.
- Legally rigorous as long as fees are for eligible activities.
- Efficient administration.

CHALLENGES

- Very limited revenue generation potential
- Potential for "push back" from affected well owners against fees.
- Potential legal scrutiny if fee covers non-eligible activities.
- Do not typically apply to infrastructure operations and capital costs.

IF ADDITIONAL REVENUE IS NEEDED

To be clear, this technical memorandum is recommending that (if the costs of GSP implementation necessitate it) the Agency consider either a Non-balloted Property Related Fee on Well Owner parcels or a Special Tax on all property owners in the basin, but likely not both, unless the financial need is very significant.

PROPERTY-RELATED FEE – (NON- BALLOTED) ON WELL OWNERS

Property-related fees were first described in 1996's Proposition 218, (which is manifested as Section 6 of Article XIII D of the California Constitution) and are commonly used today to fund water, sewer, solid waste and even storm drainage. They are most commonly referred to as a "water charge or a "sewer charge," etc., but are technically a property-related fee.

Proposition 218 imposes certain procedural requirements for imposing or increasing property related fees. There are two distinct steps: 1.) a mailed noticing of all affected property owners (well owners in this case) and 2.) a mailed balloting on all affected property owners requiring a 50% approval for adoption.

A REALLY IMPORTANT EXEMPTION ELIMINATES THE BALLOTING REQUIREMENT

Proposition 218 goes on to exempt fees for water, sewer and refuse collection from the second step – the balloting. Hence, a property-related fee imposed on well owners' properties would be exempt from the balloting requirement. This is very significant because it reduces costs and political risk and lessens willingness-to-pay limitations.

California Water Code Provides Additional Clarity in 10730.2
California Water Code, Division 6., Part 2.74., Chapter 8. Financial Authority [10730 - 10731] provides considerable direction and authority to local governments tasked with groundwater sustainability regarding property-related fees.

In particular, Section 10730.2 (c) in the water code states:

"Fees imposed pursuant to this section shall be adopted in accordance with subdivisions (a) and (b) of Section 6 of Article XIII D of the California Constitution."

Section 6 of Article XIII of the California Constitution describes the specific requirements of the implementation of a property related fee, and most importantly, refers to subdivision (a) as the noticing requirement, (b) as the limitations on fees and services, and subdivision (c) as the balloting requirement. Hence, by omission of (c) in Section 10730.2, balloting is not required for property related fees for groundwater sustainability.

PROPERTY RELATED FEE IMPLEMENTATION PROCESS

As described above, only the first step of the two-step process applies to property related fees in this context. That step is the noticed public hearing. Once the Agency has determined the fees they wish to impose, they must mail a written notice to each affected property owner at least 45 days prior to the public hearing. During that time, and up until the conclusion of the hearing, any affected property owner may file a written protest opposing the proposed fees. If the owners of a majority of the affected parcels file a written protest, the agency cannot impose the fee (known as a "majority protest"). If a majority protest is not formed, the agency may impose the fees.

Also, Section 10730.2 of the California Water Code includes several unique requirements that should be carefully followed when implementing property related fees for GSP implementation.

REQUIRED DOCUMENTS FOR A PROPERTY RELATED FEE

- Mailed Notices of Rate Proposal/Opportunity to Protest/Public Hearing.
- Fee Report and Presentation for Public Hearing.
- Report to Governing Board (assumes < 50% protest).
- Ordinance or Resolution Adopting Fees (assumes >50% support).

FLEXIBILITY OF METHODOLOGY

Long standing use of property related fees for water charges support relatively flexible use of this approach to fund a wide range of GSP implementation activities.

Section 10730.2 of the California Water Code lists potential uses as:

(1) Administration, operation, and maintenance, including a prudent reserve.
(2) Acquisition of lands or other property, facilities, and services.
(3) Supply, production, treatment, or distribution of water.
(4) Other activities necessary or convenient to implement the plan.

This section also specifies that "fees imposed pursuant to this section may include fixed fees and fees charged on a volumetric basis, including, but not limited to, fees that increase based on the quantity of groundwater produced annually, the year in which the production of groundwater commenced from a groundwater extraction facility, and impacts to the basin."

Other ideas to consider include:

- Parcel-based Administration Fee,
- Remediation Fee for over-pumping.

- Augmentation Fee on over users to pay to import water.

REVENUE GENERATION POTENTIAL

Two potential revenue methodologies are modelled below based upon the use of a property related fee. Tables 13, 14, and 15 model rates and revenue generated using a hypothetical "flat" annual rate for each type of well. Most notably, this approach relies on "estimated usage" based upon attributes such as land use, affected acreage, etc., and does not rely on use of metered extraction amount. (Number and types of wells is approximate):

TABLE 13 – MODEL OF ESTIMATED USAGE RATE AND REVENUE FOR PROPERTY RELATED FEE ON WELLS IN BUTTE VALLEY BASIN

Basin Wells

	Approx. Number	Low Range		High Range	
		Rate	Revenue	Rate	Revenue
Agricultural	34	$3,000.00	$102,000	$5,300.00	$180,200
Industrial	0	$3,000.00	$0	$5,300.00	$0
Municipal	7	$3,000.00	$21,000	$5,300.00	$37,100
Domestic	73	$125.00	$9,125	$150.00	$10,950
Other (Monitoring, injection, etc.)	24	$125.00	$3,000	$150.00	$3,600
Total	**138**		**$135,125**		**$231,850**
	Revenue Goals:		$135,000		$230,000

TABLE 14 –MODEL OF ESTIMATED USAGE RATE AND REVENUE FOR PROPERTY RELATED FEE ON WELLS IN SCOTT VALLEY BASIN

Basin Wells

	Approx. Number	Low Range		High Range	
		Rate	Revenue	Rate	Revenue
Agricultural	88	$1,100.00	$96,800	$2,000.00	$176,000
Industrial	0	$1,100.00	$0	$2,000.00	$0
Municipal	7	$1,100.00	$7,700	$2,000.00	$14,000
Domestic	336	$75.00	$25,200	$100.00	$33,600
Other (Monitoring, injection,etc.)	86	$75.00	$6,450	$100.00	$8,600
Total	**517**		**$136,150**		**$232,200**
	Revenue Goals:		$135,000		$230,000

TABLE 15 –MODEL OF ESTIMATED USAGE RATE AND REVENUE FOR PROPERTY RELATED FEE ON WELLS IN SHASTA VALLEY BASIN

Basin Wells

	Approx. Number	Low Range		High Range	
		Rate	Revenue	Rate	Revenue
Agricultural	139	$850.00	$118,150	$1,500.00	$208,500
Industrial	8	$850.00	$6,800	$1,500.00	$12,000
Municipal	10	$850.00	$8,500	$1,500.00	$15,000
Domestic	885	$30.00	$26,550	$50.00	$44,250
Other (Monitoring, injection, etc.)	206	$30.00	$6,180	$50.00	$10,300
Total	**1,248**		**$166,180**		**$290,050**
	Revenue Goals:		$168,750		$287,500

Also, a property related fee could be established based upon water drawn out of the basin (which would require of metered measuring of extraction amount), as modelled in Tables 16, 17 and 18, below:

TABLE 16 – MODEL OF METERED USAGE RATE AND REVENUE FOR PROPERTY RELATED FEE ON ACRE-FEET IN BUTTE VALLEY BASIN

Basin Wells

	Approx. Acre Feet	Low Range		High Range	
		Rate	Revenue	Rate	Revenue
All Wells	85,000	$1.60	$136,000	$2.75	$233,750
Total	**85,000**		**$136,000**		**$233,750**
	Revenue Goals:		$135,000		$230,000

TABLE 17 – MODEL OF METERED USAGE RATE AND REVENUE FOR PROPERTY RELATED FEE ON ACRE-FEET IN SCOTT VALLEY BASIN

Basin Wells

	Approx. Acre Feet	Low Range		High Range	
		Rate	Revenue	Rate	Revenue
All Wells	40,000	$3.25	$130,000	$5.75	$230,000
Total	**40,000**		**$130,000**		**$230,000**
	Revenue Goals:		$135,000		$230,000

TABLE 18 – MODEL OF METERED USAGE RATE AND REVENUE FOR PROPERTY RELATED FEE ON ACRE-FEET IN SHASTA VALLEY BASIN

Basin Wells

	Approx. Acre Feet	Low Range		High Range	
		Rate	Revenue	Rate	Revenue
All Wells	44,000	$3.75	$165,000	$6.50	$286,000
Total	**44,000**		**$165,000**		**$286,000**
	Revenue Goals:		$150,000		$262,500

It should be noted that while a "metered usage" rate fee will fluctuate each year with the amount of water drawn, and a fixed "estimated usage" rate fee would be relatively uniform each year. Costs are likely to be relatively uniform and do not fluctuate with amount of water drawn out of the basins.

ADVANTAGES

- Revenue generation is likely sufficient to fund all GSP implementation costs.
- Legally rigorous. Property related fees are the described in the Water Code for funding groundwater sustainability.
- Process is exempt from a balloting, and the likelihood of a 50% protest (out of +-1,900) well owners is unprecedented.
- Cost of implementation is relatively low and includes a fee study, a mailing and additional outreach.
- Efficient administration.

CHALLENGES

- Politically challenging. Many well owners within the basins have made it clear that they prefer the costs be allocated to all properties within the basin and/or county

and not just the well owners. Well owners exert significant political influence within the basins. Although a balloting is not required, well owners may be able to stop the process legislatively or possibly could attain a 50% protest, which would force a balloting.

- Unfamiliar Process. One potential criticism of the property-related fee is that property owners are generally unfamiliar with the process, and opponents can exploit this. However, with the recent dramatic increase in voting by mail in California, this is less of a major issue. Nonetheless, political opponents can exploit this unfamiliarity and focus the public's attention on the Proposition 218 process, and away from the proposed groundwater sustainability goals and messaging.

SPECIAL TAX ON ALL PROPERTY OWNERS IN THE BASINS OR COUNTY-WIDE

Special taxes are decided by registered voters and almost always require a two-thirds majority for approval. Traditionally, special taxes have been decided at polling places, or more recently by mail, corresponding with general and special elections. Special taxes are well known to Californians but are not as common as property related fees for funding of water-related services and infrastructure activities.

As a reminder, this technical memorandum is recommending that (only if the costs of GSP implementation requires it) the Agency consider either a Non-balloted Property Related Fee on Well Owner parcels or a Special Tax (described below) on all property owners in the basin, but likely not both, unless the financial need is very significant.

PARCEL BASED TAXES

Many special taxes are conducted on a parcel basis with a uniform "flat" rate across all parcels, or varied rates based upon property attributes such as use and/or size. Parcel taxes based upon the assessed value of a property are not allowed. Parcel based taxes (as opposed to sales taxes, etc.) are the most viable type of special tax for funding water-related activities. As such, most discussion of special taxes in this report will focus on parcel taxes.

LIMITATIONS OF TAXING AUTHORITY – FLOOD CONTROL DISTRICT VERSUS COUNTY

State law requires that only a local government agency, with specific taxing authority, may propose and potentially impose a tax on its underlying parcels. (SGMA does not grant GSAs with specific taxing authority.) The Flood Control District, Siskiyou County and the potentially affected incorporated cities of (Etan, Dorris, Fort Jones, Montague, Yreka and Weed within the basins as well as Dunsmuir, Mount Shasta and Tule Lake if the effort was county-wide) do have taxing authority. Neither the Flood Control District, nor Siskiyou County can tax within the incorporated cities without specific permission.

The Flood Control District is likely the optimal agency to propose the tax, either county-wide or in specific basin areas. The Siskiyou County Flood Control District has the authority, granted by its establishing Act, to establish zones within its boundaries for the purpose of levying taxes. For the GSA to levy a special tax in specific basin areas these areas would need to be established as the zones of benefit for the purposes of the GSA and the

implementation of the GSP. The governing board (Siskiyou County Board of Supervisors) is granted the authority to levy taxes upon the taxable property in the benefitting zones to carry out the purposes of its establishing Act, and "to pay the costs and expenses of maintaining, operating, extending and repairing any work or improvement of such zones for the ensuing fiscal year" (Cal Uncod. Water Deer, Act 1240 § 33). The Act stipulates that the Board shall have the power to control and order the expenditures of all tax revenue, with a limitation $0.05 per one hundred dollars of the assessed valuation of property within each zone, and that all taxes levied shall be apportioned in accordance with the established zones.

Other requirements and limitations are included in the Siskiyou County Flood Control District Act that may additionally hamper the District's ability to efficiently and effectively propose a well-designed tax. Modification of the Act, albeit requiring legislative State-level consideration and approval, should be considered.

COUNTY-WIDE VERSUS BASIN SPECIFIC SPECIAL TAX

Both a county-wide and basin area special tax should be considered. A county-wide tax would result in a lower and more voter-palatable proposed tax rate as the needed revenue would be spread over a large number of parcels. However, voters who do not reside within the basin areas may be significantly less likely to vote in favor of a prosed tax as they would be less likely to perceive a direct benefit. Also, special consideration would need to be made for the Tule Lake area which has a different GSA. See Table 26 for a county-wide model of the tax rates that would be need.

Because the tax rates are relatively low for all tax models (<<$15.00 per year) (Tables 23-26), the political advantage of a county-wide tax is muted.

SPECIAL TAX IMPLEMENTATION PROCESS

Public agencies typically work with special consultants familiar with the administrative and political aspects of proposing a special tax to a community. Special tax elections held at polling places are conducted on the statutorily designated dates (typically in November for the general election and either March or June for the primary).

If the Agency ultimately decides to pursue a special tax, it is highly recommended that a special all-mail election be considered. Special all-mail ballot elections are often less expensive and allow for more optimization of the election date, as well as having the advantage of presenting a single issue to the voters.

REQUIRED DOCUMENTS FOR A PARCEL BASED SPECIAL TAX

- Ordinance or Resolution stating: tax type, tax rates, collection method, election date and services provided
- Notice to the Registrar of Voters of measure submitted to voters
- Measure Text including:
    - Ballot question (75 words or less)
    - Full ballot text (300 words or less) including rate structure
    - Arguments in favor or against and independent analysis

- Tax Report

FLEXIBILITY OF METHODOLOGY

There is considerable flexibility in tax methodology. The Agency could propose a flat tax rate in which all parcels are charged the same or a "tiered approach" where, for example larger, and/or commercial parcels may be taxed more than vacant lots. If a tiered approach is considered, the Agency should consider using existing Community Facilities District ("CFD") law and practice which better defends the use of a tiered structure.

REVENUE GENERATION POTENTIAL

A detail breakdown of the parcel attributes including number of parcels, number of residential units (for multi-family parcels) and acres for agricultural parcels in the three basins is shown in Tables 19, 20, and 21 below:

TABLE 19 – PARCEL ATTRIBUTES WITHIN BUTTE VALLEY BASIN

	Residential		
	Parcels	**Units**	**Acres**
Single Family	410	434	1,318
Multi: 2 - 4 units	68	136	117
Mobile Home	117	117	4,821
Commercial/Industrial	79	NA	114
Office	12	NA	6
Vacant	540	NA	2,198
Parking & Storage	11	0	16
Agricultural	442	NA	51,904
Timber & Pasture	119	NA	40,372
Not Assessable	55	NA	168
Totals	**1,853**	**687**	**101,035**

TABLE 20 – PARCEL ATTRIBUTES WITHIN SCOTT VALLEY BASIN

	Residential		
	Parcels	**Units**	**Acres**
Single Family	1,375	1,401	10,684
Multi: 2 - 4 units	140	280	599
Mobile Home	191	191	3,926
Commercial/Industrial	150	NA	376
Office	16	NA	17
Vacant	659	NA	8,271
Institutional & Gov't	9	0	54
Multi: 5+ units	13	NA	80
Cemetaries	2	NA	34
Agricultural	972	NA	66,763
Timber & Pasture	77		13,981
Not Assessable	167		617
Totals	**3,527**	**1,872**	**90,803**

TABLE 21 – PARCEL ATTRIBUTES WITHIN SHASTA VALLEY BASIN

	Residential		
	Parcels	**Units**	**Acres**
Single Family	4,671	4,868	19,828
Multi: 2 - 4 units	441	882	1,526
Condo	21	21	19
Mobile Home	465	465	8,921
Commercial/Industrial	384	NA	1,099
Office	89	NA	32
Vacant	5,303	0	27,291
Parking & Storage	11	NA	19
Multi: 5+ units	28	NA	10
Cemeteries	344	NA	2,405
Agricultural	1,238	NA	167,985
Timber & Pasture	136	NA	31,400
Unassessable	363	NA	1,822
Totals	**13,494**	**6,236**	**262,355**

Next, we have modelled hypothetical rates to generate the revenue goals in the three basins Tables 22, 23, and 24. Table 25 models Shasta Valley is the boundaries are enlarged to

include all parcels with the Shasta Valley Watershed. Table 26 models a special tax for all of Siskiyou County (including the Tule Lake GSA area).

TABLE 22 – MODEL OF TAX RATE AND REVENUES FOR SPECIAL TAX IN BUTTE VALLEY BASIN

	Residential Parcels	Residential Units	Acres	Low Range		High Range		Units
Single Family	410	434	1,318	$4.50	$1,953	$10.50	$4,557	*per residential unit*
Multi: 2 - 4 units	68	136	117	$4.50	$612	$10.50	$1,428	*per residential unit*
Mobile Home	117	117	4,821	$4.50	$527	$10.50	$1,229	*per residential unit*
Commercial/Industrial	79	NA	114	$4.50	$356	$10.50	$830	*per parcel*
Office	12	NA	6	$4.50	$54	$10.50	$126	*per parcel*
Vacant	540	NA	2,198	$4.50	$2,430	$10.50	$5,670	*per parcel*
Parking & Storage	11	0	16	$4.50	$0	$10.50	$116	*per parcel*
Agricultural	442	NA	51,904	$1.40	$72,666	$2.35	$121,975	*per acre*
Timber & Pasture	119	NA	40,372	$1.40	$56,521	$2.35	$94,875	*per acre*
Not Assessable	55	NA	168	$0.00	$0	$0.00	$0	*per parcel*
Totals	**1,853**	**687**	**101,035**		**$135,118**		**$230,805**	
				Revenue Goals:	**$135,000**		**$230,000**	

TABLE 23 – MODEL OF TAX RATE AND REVENUES FOR SPECIAL TAX IN SCOTT VALLEY BASIN

	Residential Parcels	Residential Units	Acres	Low Range		High Range		Units
Single Family	1,375	1,401	10,684	$6.50	$9,107	$13.00	$18,213	*per residential unit*
Multi: 2 - 4 units	140	280	599	$6.50	$1,820	$13.00	$3,640	*per residential unit*
Mobile Home	191	191	3,926	$6.50	$1,242	$13.00	$2,483	*per residential unit*
Commercial/Industrial	150	NA	376	$6.50	$975	$13.00	$1,950	*per parcel*
Office	16	NA	17	$6.50	$104	$13.00	$208	*per parcel*
Vacant	659	NA	8,271	$6.50	$4,284	$13.00	$8,567	*per parcel*
Institutional & Gov't	9	0	54	$6.50	$0	$13.00	$117	*per parcel*
Multi: 5+ units	13	NA	80	$1.75	$140	$3.00	$240	*per acre*
Cemetaries	2	NA	34	$1.75	$59	$3.00	$101	*per acre*
Agricultural	972	NA	66,763	$1.75	$116,835	$3.00	$200,289	*per acre*
Timber & Pasture	77		13,981	$1.75	$24,466	$2.75	$38,447	*per acre*
Not Assessable	167		617	$0.00	$0	$0.00	$0	*per parcel*
Totals	**3,527**	**1,872**	**90,803**		**$134,565**		**$235,808**	
				Revenue Goals:	**$135,000**		**$230,000**	

TABLE 24 – MODEL OF TAX RATE AND REVENUES FOR SPECIAL TAX IN SHASTA VALLEY BASIN

	Parcels	Residential Units	Acres	Low Range		High Range		Units
Single Family	4,671	4,868	19,828	$3.00	$14,604	$7.00	$34,076	*per residential unit*
Multi: 2 - 4 units	441	882	1,526	$3.00	$2,646	$7.00	$6,174	*per residential unit*
Condo	21	21	19	$3.00	$63	$7.00	$147	*per residential unit*
Mobile Home	465	465	8,921	$3.00	$1,395	$7.00	$3,255	*per parcel*
Commercial/Industrial	384	NA	1,099	$3.00	$1,152	$7.00	$2,688	*per parcel*
Office	89	NA	32	$3.00	$267	$7.00	$623	*per parcel*
Vacant	5,303	0	27,291	$3.00	$0	$7.00	$37,121	*per parcel*
Parking & Storage	11	NA	19	$0.75	$14	$1.00	$19	*per acre*
Multi: 5+ units	28	NA	10	$0.75	$8	$1.00	$10	*per acre*
Cemeteries	344	NA	2,405	$0.75	$1,804	$1.00	$2,405	*per acre*
Agricultural	1,238	NA	167,985	$0.75	$125,989	$1.00	$167,985	*per acre*
Timber & Pasture	136	NA	31,400	$0.75	$23,550	$1.00	$31,400	*per acre*
Unassessable	363	NA	1,822	$0.00	$0	$0.00	$0	*per parcel*
Totals	**13,494**	**6,236**	**262,355**		**$171,491**		**$285,903**	
			Revenue Goals:		**$168,750**		**$287,500**	

Alternatively, a model of tax rate and revenues might be considered for the Shasta watershed as a whole, given the amount of interconnected surface water above the Basin. This model is shown in table 25 below:

TABLE 25 – MODEL OF TAX RATE AND REVENUES FOR SPECIAL TAX IN THE ENTIRE SHASTA VALLEY WATERSHED

	Parcels	Residential Units	Acres	Low Range		High Range		Units
Single Family	6,556	5,033	25,487	$2.50	$12,583	$4.50	$22,649	*per residential unit*
Multi: 2 - 4 units	552	882	552	$2.50	$2,205	$4.50	$3,969	*per residential unit*
Mobile Home	671	483	9,880	$2.50	$1,208	$4.50	$2,174	*per residential unit*
Commercial/Industrial	563	N/A	1,856	$2.50	$1,408	$4.50	$2,534	*per parcel*
Office	105	N/A	38	$2.50	$263	$4.50	$473	*per parcel*
Vacant	6,653	N/A	49,196	$2.50	$16,633	$4.50	$29,939	*per parcel*
Parking & Storage	11	N/A	19	$2.50	$28	$4.50	$50	*per parcel*
Agricultural	1,397	N/A	196,618	$0.50	$98,309	$0.85	$167,125	*per acre*
Timber & Pasture	266	N/A	76,341	$0.50	$38,170	$0.85	$64,890	*per acre*
Not Assessable	393	N/A	1,872	$0.00	$0	$0.00	$0	*per parcel*
Totals	**17,167**	**6,398**	**361,857**		**$170,804**		**$293,800**	
			Revenue Goals:		**$168,750**		**$287,500**	

Another consideration for a special tax is implementing a county-wide model. This would help to spread costs out among all landowners in the county, lessening the financial burden for well owners. This may be perceived as unfair to those who do not reside above the basins, but it can be asserted that the GSP implementation is beneficial to all county residents. A county-wide special tax is modelled below in Table 26:

TABLE 26 – MODEL OF TAX RATE AND REVENUES FOR SPECIAL TAX IN ENTIRE SISKIYOU COUNTY

	Parcels	Residential Units	Acres	Low Range		High Range		Units
Single Family	14,863	7,725	69,376	$2.75	$21,244	$5.25	$40,556	*per residential unit*
Multi: 2 - 4 units	2,185	1,323	5,993	$2.75	$3,638	$5.25	$6,946	*per residential unit*
Mobile Home	2,914	921	32,626	$2.75	$2,533	$5.25	$4,835	*per residential unit*
Commercial/Industrial	1,415	N/A	6,067	$2.75	$3,891	$5.25	$7,429	*per parcel*
Office	186	N/A	66	$2.75	$512	$5.25	$977	*per parcel*
Vacant	16,833	N/A	169,920	$2.75	$46,291	$5.25	$88,373	*per parcel*
Parking & Storage	46	N/A	135	$2.75	$127	$5.25	$242	*per parcel*
Agricultural	4,078	N/A	548,372	$0.30	$164,512	$0.50	$274,186	*per acre*
Timber & Pasture	2,078	N/A	660,295	$0.30	$198,088	$0.50	$330,147	*per acre*
Not Assessable	988	N/A	21,473	$0.00	$0	$0.00	$0	*per parcel*
Totals	**45,586**	**9,969**	**1,514,323**		**$440,835**		**$753,691**	
			Revenue Goals:		$438,750		$747,500	

ADVANTAGES

- Revenue generation is likely sufficient to fund all GSP implementation costs if voter approved.
- Legally rigorous. Special taxes, if approved by two-thirds of the registered voters within a community, are very reliable and very rarely legally challenged successfully. Special tax revenue has not been subject to state level "take-aways" like ERAF.
- Well known. Most property owners are aware and comfortable with (but not necessarily supportive of) the special taxes and the special tax process.
- Very low tax rates (<<$15.00) per year are often reasonably well-supported by voters
- Efficient administration

CHALLENGES

- Political support at required rate and revenue may be difficult. Generally speaking, the two-thirds majority threshold for approval is very politically challenging. Special taxes are subject to significant outside influence from media and opposition groups during voting and are more vulnerable to other measures and candidates that share the ballot. (However, a recent California Supreme Court decision called the “Upland Case” allows for voter initiatives to be approved with a more easily achievable 50% threshed. The Agency should evaluate the pros and cons of the effectiveness of an voter initiative.)

GENERAL OBLIGATION BONDS SUPPORTED BY A SPECIAL TAX

In California, special taxes can be linked directly to the sale of general obligation bonds to finance the construction of infrastructure. In 2004, the City of Los Angeles successfully passed "Measure O" which provided funding for a variety of capital improvements related to water quality. Arguably, voters are more likely to support general obligation bond special taxes than parcel-based taxes at equivalent rates.

However, since special taxes for general obligations bonds can only be used for the financing of capital improvements, this mechanism could only be used to fund the CIP portion of the needs – not the operating costs of the groundwater management infrastructure.

In other words, the passage of a G.O. Bond would not satisfy the Agency's overall groundwater management funding goals, because this source could not fund ongoing operations and maintenance. However, it is possible that community priorities and a revised funding strategy could dictate that pursuit of a G.O. bond measure is optimal to fund any significant groundwater management capital projects. Results of the public opinion survey should help guide this decision.

OTHER APPROACHES – LESS OPTIMAL

BALLOTED PROPERTY-RELATED FEE OR BENEFIT ASSESSMENTS ON ALL PROPERTY OWNERS IN THE BASIN

If the Agency decides to pursue a revenue mechanism applied to well owners, a non-balloted property related fee is optimal, and if the Agency decides to pursue a revenue mechanism applied to all property owners in the basin, a special tax is most likely the best choice. However, there are two other approaches described in Proposition 218 worthy of discussion, especially if voter support is marginal: 1.) a balloted property related fee or 2.) a benefit assessment. Both of these are more expensive to implement and administer and are considerably less legally rigorous (especially with no current precedent) than a special tax. Nonetheless, both require only a 50% approval for implementation. Further research and evaluation would need to be pursued.

OTHER CONSIDERATIONS

CONDUCT A SURVEY IF CONSIDERING A PROPERTY-RELATED FEE OR SPECIAL TAX

See a full discussion in the next section.

IMPLEMENT RIGOROUS COMMUNITY OUTREACH IF CONSIDERING A PROPERTY-RELATED FEE OR SPECIAL TAX

See a full discussion in the next section.

TIMING AND SCHEDULE

The selection of the balloting date is one of the most important factors affecting the success of any measure. Potential competition with other measures, income and property tax due dates, seasons, and holidays, etc. should all be evaluated when choosing a balloting date.

A COST ESCALATOR IS RECOMMENDED FOR BALLOTED MECHANISMS

Non-balloted funding mechanisms can be updated periodically using the noticed public hearing procedure described above. This is the typical method of keeping revenues aligned with costs through the years as in the case for retail water and sewer fees. Accordingly, the rates can be kept updated for inflationary forces and other cost increases on a five-year recurrence cycle.

However, for balloted mechanisms, any increase or change in rate structures requires a re-balloting unless the original balloting included a pre-determined formula for escalation – such as the Consumer Price Index (CPI). Infrastructure-intensive utilities are driven by many different forces than those that drive the CPI, including the need for capital investment programs, regulatory programs, and the economics of sustainability, conservation, and commodity constraints. Due, in part, to these other drivers, rates for utilities have not traditionally been tied to a straightforward CPI, but rather have been expressed as a specific rate amount for a given year based on actual projected costs. Nonetheless, costs do increase over time and a cost escalator is recommended to reimburse the Agency for this increase. The simplest to explain to property owners and to administer annually is a CPI, based upon a readily available index such as the U.S. Department of Labor, which would allow for annual rate increases without annual balloting. A CPI escalator is legally defensible with property related fees, regulatory fees, and special taxes.

However, a CPI approach may make it difficult to accommodate infrastructure-driven cost increases in coming years. An alternative approach would be to include a rate adjustment schedule that would include specific increases in future years that meet the UVBGAS's needs. (This approach, commonly used by water and sewer providers, often communicates to the property owner in table form with the proposed rate corresponding to each year for the next four or five years.)

At this point in the process, it is difficult to make a concise recommendation for the escalator mechanism. It would depend on the escalating costs and how they affect the proposed rates in the foreseeable future. It would also depend in part on the proposed rate structure itself, as some structures may be based on variables that intrinsically accommodate increasing groundwater management needs. Finally, it would depend on the political considerations that come with any ballot measure. Historically, the majority of survey data supports the fact that a CPI escalator introduces minimal decay in overall support.

A SUNSET PROVISION IS NOT RECOMMENDED, BUT SHOULD BE CONSIDERED

A "Sunset Provision" is a mechanism used to increase political support by setting an expiration date for a measure, and can be used with a property related fee, regulatory fee, or tax. Sunset provisions typically range from five years to as much as 20 years in some rare cases. However, the political advantage may be slight and does not outweigh the negative aspect of the increased costs and political risk of having to re-ballot at the termination of the sunset period.

One variation is the "sundown" clause. This is the name given to a tax or fee that would reduce after a specific date – leaving a portion of the tax or fee to continue indefinitely. This tactic is useful for programs that have a one-time capital need and then would reduce to fund only operations and maintenance beyond that. If the one-time capital need is debt financed, the "sundown" period would need to be at least as long as the debt repayment period.

A "DISCOUNT MECHANISM" SHOULD BE CONSIDERED, BUT MAY NOT BE COST-EFFECTIVE

Consistent with the efforts of obtaining higher quality groundwater, a discount or "rate reduction" program should be considered which rewards well owners implementing groundwater sustainability management measures on their properties with a lower fee, based on the reduced cost of providing groundwater service. Any such program would need to be coordinated with whatever rate structure the Agency decides on to ensure that it fits with the rationale and is compliant with Proposition 218.

The advantages of such a program include improved water quality, improved engagement by the community, as well as a rate more tailored to individual usage. Also, discount programs tend to be well received by the electorate, although most people do not participate. The downside of such a program is that the benefit may not justify the cost of administering this program, because the inspection of property-specific improvements is expensive and time consuming. Nonetheless, a couple of public agencies including the cities of Portland, Oregon, South Lake Tahoe, and Palo Alto have successfully implemented discount programs on their storm drainage fees. The community's interest level for a discount mechanism will be evaluated as part of the mail survey opinion research.

III. RECOMMENDATIONS FOR IMPLEMENTATION OF FUNDING MECHANISMS

Following is a "Game Plan" outline of the recommended steps for implementation of funding for the GSA's GSP implementation. Most of the steps have been discussed above – a discussion of community public opinion surveying and community outreach is included below.

GAME PLAN

1. Conduct community outreach regarding the Plan and its implementation.
2. Pursue use of existing revenue sources to fund implementation.
3. Pursue Grants and Loan Opportunities to fund implementation.
4. Implement Regulatory Fees to offset eligible implementation costs.

If additional revenue is needed:

5. Conduct a survey and stakeholder outreach to better evaluate:
    a. Community priorities and associated messaging.
    b. Optimal rate.
    c. Preference of non-balloted property related fee versus special tax.
6. Use results of surveys, stakeholder input and other analyses to develop a community outreach plan.
7. Implement the community outreach.
8. Implement a property related fee or special tax balloting:
    a. Include a cost escalator schedule or mechanism.
    b. Include the use of rate zones or other distinguishing factors.
    c. Do not include a rate expiration date (also known as a "Sunset Clause").
    d. Include a Discount Program to encourage better groundwater management by well owners.

CONSIDER A PUBLIC OPINION SURVEY

The primary purpose of the public opinion survey is to produce an unbiased, statistically reliable evaluation of voters' and property owners' interest in supporting a local revenue measure. Should the Agency decide to move forward with a revenue measure (property-related fee or special tax), the survey data provides guidance as to how to structure the measure so that it is consistent with the community's priorities and expressed needs. Agencies typically engage specialized survey firms to conduct surveys.

Specifically, the survey should:

- Gauge current, baseline support for a local revenue measure associated with specific dollar amounts. (How much are well owners/property owners willing to pay?)
- Identify the types of services and projects that voters and property owners are most interested in funding.
- Identify the issues voters and property owners are most responsive to (e.g., preventing subsidence, maintaining water availability, reducing pumping costs, protecting water quality, etc.).

- Expose respondents to arguments in favor of—and against—the proposed revenue measure to gauge how information affects support for the measure.
- Identify whether local residents prefer the measure as a property related fee or a special tax.

As the nation struggles with the COVID-19 pandemic, it is more important than ever to measure a community's position on all of these elements. What community leaders thought they knew about public opinion may no longer be accurate in a post-COVID world. And while a survey can provide the Agency with valuable information, it will also be an opportunity to begin getting the groundwater "brand" out into the community – a valuable early step in this process.

COMMUNITY SUPPORT AND ENGAGEMENT

Clear, concise, and appropriate community outreach is one of the most important elements for successful implementation of a funding mechanism. The basic message components need to be simple, clear, and transparent, and need to be well supported with detailed and substantive information. Credibility is the most important factor in this outreach.

Agencies often, but not always, will engage specialized consultants to assist with community outreach in support of implementation of funding mechanisms. A community outreach plan should be developed and implemented. Three major steps are described blow.

Develop Communication Infrastructure

The GSA should carefully evaluate and develop potential communication infrastructure, ultimately coordinating with existing communication infrastructure, including stakeholder contacts, print media, website, social media, print publications, neighborhood groups, and newsletters, etc. Use of e-mail contacts (with HOA, neighborhood and stakeholder groups and leaders, and web-based platforms like nextdoor.com is encouraged). Develop a schedule of community stakeholder meetings, due dates for local group newsletters, etc.

In most cases, the most effective communication mechanisms for this type of infrastructure are small, local, and neighborhood-based, with personal communication or face-to-face (as appropriate in COVID-19 environment). This approach is not expensive, but it is a significant amount of work and is very effective when well-executed.

Develop Communication Messaging

The development of the messaging and supporting information is an iterative process with staff, consultant, and community members. (If a community survey is conducted, it can be extremely helpful in developing the most effective messaging.) Throughout this process, the Agency and consultant will analyze and refine messaging associated with groundwater sustainability management benefits. In this task, the Agency should develop draft communications of various types, including Frequently Asked Questions documents, social media content, mailers and brochures, PowerPoint presentations, and e-mails, scripts, and other adaptable messages.

Communications Rollout and Implementation

Once the outreach plan is well-vetted, reviewed, and refined, the Agency should coordinate the plan's rollout and implementation.

Appendix 5-D Siskiyou County Agricultural Economics Analysis Considering Groundwater Regulation

University of California, Merced

Siskiyou County Agricultural Economics Analysis Considering Groundwater Regulation

Supplementary Information for the Groundwater Sustainability Plan

Spencer A. Cole & Josué MedellÍn-Azuara
9-2-2021

1. Introduction

1.1. Background

This economic analysis estimates potential impacts in gross revenues from changing cropping patterns in Siskiyou County's three agricultural valleys namely Butte Valley (Butte), Scott River Valley (Scott), and Shasta Valley (Shasta). This analysis provides insight on economic costs of benefits of land and water use decisions, while identifying areas that may benefit from intervention and stakeholder processes.

Below, we outline the structure and basis for an agricultural production and water use economic model whose purpose is to estimate impacts of land and water use policies on agricultural value in Siskiyou County. Model coverage includes most of the agriculture by irrigated area within the county, with the notable exception of the greater Tulelake area located in the northeast corner of the county (Figure 1) which contains some valuable commodities such potatoes. The Butte, Scott River, and Shasta Valleys were the most distinct agricultural regions within the county and showing significant differences in production factors such as access to groundwater and crop mix. The agricultural model is calibrated using 2018 as a baseline water year because it represents a relatively recent water year with most crop demands fulfilled in comparison to the drier 2014 and 2016 water years (Department of Water Resources, 2021), which are also available at the Department of Water Resources streamflow indices (Department of Water Resources, 2020).

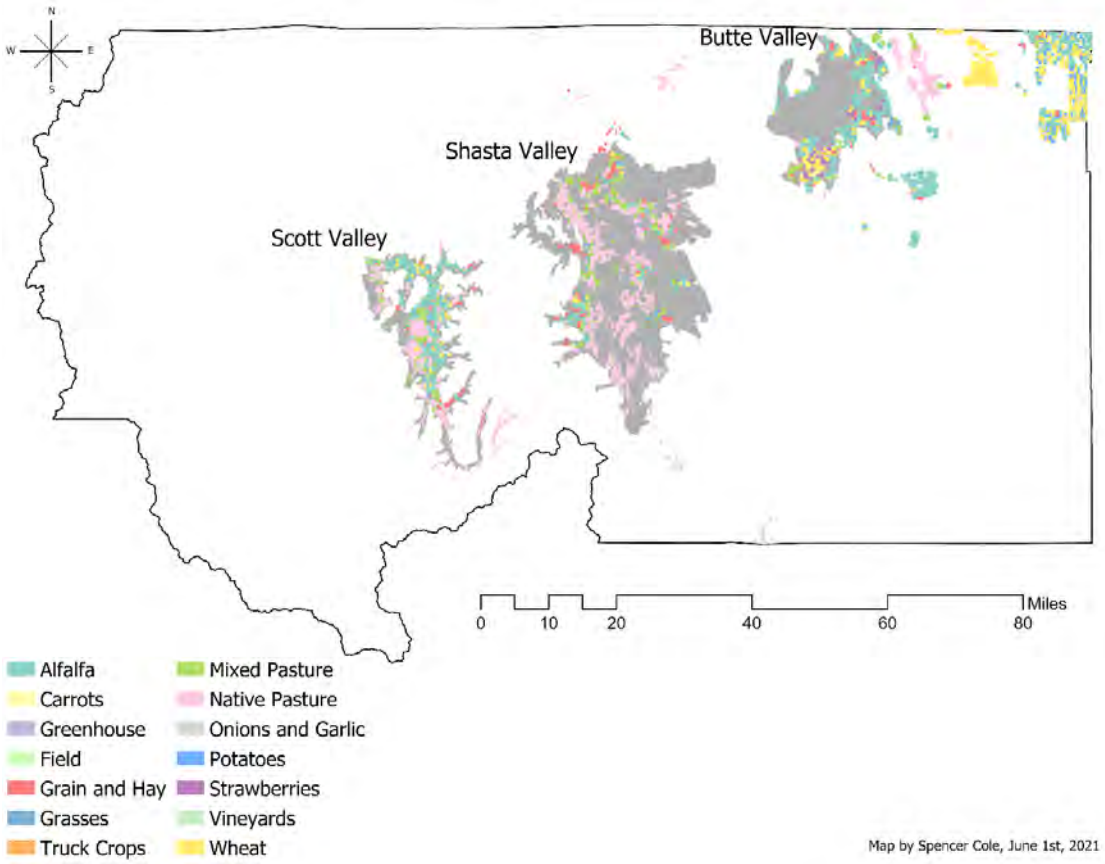


Figure 1: Region delineations and crop coverage represented in the agricultural model. Parcels located outside grey valley boundaries are not included in the model. ***Source: 2018 LandIQ land use survey (Department of Water Resources, 2021).***

1.2. Data sources

Information employed for defining the base case for production in the three valleys is summarized in Table 1. Land use calibration is based on 2018 data for land use and crop production economics where available. Recent cost information for crop commodities is prioritized when available and relevant to the production in Siskiyou County. Applied water requirements for crops are based on specific estimates at the valley scale for use in the integrated valley models. Whereas the model is calibrated using land use information from the LandIQ 2018 land use survey deployed through the California Land Use Viewer (Department of Water Resources, 2021), crop mix across the county and in individual valleys were cross-checked with parcel scale Department of Water Resources surveys for 2000 and 2010, the LandIQ 2016 survey, and the total agricultural footprint represented in the Siskiyou County Agricultural Commissioner's Report to ensure capture of key crops in the region.

Table 1: Summary of data sources for modeling of Siskiyou agricultural production.

Data type	Source	Spatial resolution	Temporal resolution
Valley boundaries	Department of Water Resources[1]	Polygon layer	N/A
Agricultural land use	LandIQ[2]	Parcel	Annual
Crop prices	Siskiyou County Agricultural Commissioner Reports[3]	County	Annual
Crop yields	Siskiyou County Agricultural Commissioner Reports[3]	County	Annual
Crop production costs	UC Davis Cost and Return Studies[4]	Regional	Varies
Applied water	Scott Valley Integrated Hydrologic Model[5], Butte Valley Integrated Hydrologic Model[1], Shasta Valley Integrated Hydrologic Model[6]	Valley	Annual

[1] Provided by Bill Rice.

[2] https://gis.water.ca.gov/app/CADWRLandUseViewer/.

[3] https://www.co.siskiyou.ca.us/agriculture/page/crop-report.

[4] https://coststudies.ucdavis.edu/en/.

[5] Provided by Claire Kouba.

[6] Provided by Cab Esposita.

1.3. Baseline conditions

Tables 2 to 4, below summarize the 2018 base conditions across each of the valleys in the model in terms of land and water use as well as crop revenues. Data is taken directly from the data sources described in section 1.2. above, apart from minor additions and adjustments when necessary to support the model function or to reflect farmer feedback during the workshop stakeholder meetings in June 2021. For example, in Butte Valley, 400 acres of onions and garlic were added to the model because the 2018 land use dataset did not identify any of these crops within the valley boundaries; farmers provided feedback noting that there was cultivation in areas within the valley. Currently, production cost information and crop water demand for nursery berries (raspberries and strawberries) is unavailable and is estimated based on the assumption that returns yield a 15% profit margin over total costs. Cost information available for carrot production is outdated and represents only fresh market cultivation, which does not represent the seed production in Siskiyou County; thus, costs for carrots are scaled to account for these differences. It is assumed that average profit margins for most crops range between

zero and five percent of the crop gross revenues, thus some minor adjustments in selected crop prices were implemented in case negative profits from using the cost and return studies data were identified.

Table 2: Butte Valley base conditions. *Source:* Author calculations using data listed in Table 1.

Crop	Land (ac)	Applied water (AF/ac)	Price ($/ton)	Yield (ton/ac)	Labor cost ($/ac)	Supply cost ($/ac)	Land cost ($/ac)	Gross revenue ($ million)
Alfalfa	14,015	2.22	193	6.4	187	437	482	17.42 (10.6%)
Barley	1,460	1.51	286	2.3	122	285	204	0.97 (0.6%)
Carrots	313	2.09	56	66.7	976	2,278	248	1.16 (0.7%)
Onions and garlic	400	2.09	166	25.0	792	1,849	1,193	1.66 (1.0%)
Other hay	529	2.22	260	4.5	187	437	482	0.62 (0.4%)
Pasture	1,215	2.70	200	3.5	109	254	255	0.85 (0.5%)
Raspberries[†]	140	3.32	14	4,286	31,945	15,734	1,500	8.10 (4.9%)
Strawberries[†]	2,537	3.32	0.14	37,0000	28,495	14,035	1,500	131.39 (79.6%)
Wheat	4,502	1.51	203	3.2	122	285	204	2.90 (1.8%)
Total	**25,112**	-	-	-	-	-	-	**165.06 (100%)**

[†] Units in terms of plants rather than tons.

Table 3: Scott River Valley base conditions. *Source:* Author calculations using data listed in Table 1.

Crop	Land (ac)	Applied water (AF/ac)	Price ($/ton)	Yield (ton/ac)	Labor cost ($/ac)	Supply cost ($/ac)	Land cost ($/ac)	Gross revenue ($ million)
Alfalfa	12,267	1.97	193	6.4	187	437	482	15.25 (54.9%)
Barley	1,415	1.08	284	2.3	122	285	204	0.92 (3.3%)
Other hay	546	1.97	260	4.5	187	437	482	0.64 (2.3%)
Pasture	13,948	2.30	200	3.5	109	254	255	9.76 (35.1%)
Wheat	1,883	1.08	203	3.2	122	285	204	1.21 (4.4%)
Total	**30,060**	-	-	-	-	-	-	**27.79 (100%)**

Table 4: Shasta Valley base conditions. *Source:* Author calculations using data listed in Table 1.

Crop	Land (ac)	Applied water (AF/ac)	Price ($/ton)	Yield (ton/ac)	Labor cost ($/ac)	Supply cost ($/ac)	Land cost ($/ac)	Gross revenue ($ million)
Alfalfa	4,584	2.22	193	6.4	187	437	482	5.70 (14.7%)
Barley	3,780	1.51	286	2.3	122	285	204	2.49 (6.4%)
Other hay	1,660	2.22	260	4.5	187	437	482	1.95 (5.0%)
Pasture	30,642	2.70	200	3.5	109	254	255	21.45 (55.2%)
Strawberries[†]	125	3.32	0.14	370,000	28,495	14,035	1,500	6.49 (16.7%)
Wheat	1,273	1.51	203	3.2	122	285	204	0.83 (2.1%)
Total	**42,063**	-	-	-	-	-	-	**38.89 (100%)**

[†] Units in terms of plants rather than tons.

Table 5 summarizes overall land use, gross revenue, and water use summed across the three valleys. Following the modifications outlined above. The baseline dataset suggests the gross economic value within the three valleys totals $231.8 million, with $164.8 million, $27.6 million, and $38.4 million allocated to Butte, Scott River, and Shasta Valleys, respectively. Total agricultural land use in the study area is estimated to be about 97,000 acres, with 25,000 acres, 30,000 acres, and 42,000 acres in Butte, Scott River, and Shasta Valleys, respectively. Water use from irrigation is estimated at 220,000 acre-feet

per year, of which 55,000 acre-feet, 61,000 acre-feet, and 104,000 acre-feet are used in Butte, Scott River, and Shasta Valleys, respectively on an annual basis. Agricultural value in Butte Valley is dominated by the small but extremely valuable berry plant transplant industry, which contributes $139.5 million of the region's $164.8 million gross revenue on only 11% of land (Siskiyou County Agricultural Commissioner, 2018). Both agricultural land and value in Scott River Valley consist of roughly 85% alfalfa and pasture in combination, with nearly equal area of each crop and small acres of other miscellaneous crops. About 75% of agricultural land and 50% of value in Shasta Valley is composed of pasture, with only about 125 acres of nursery strawberries making up a significant portion of remaining value.

Table 5: Baseline conditions across all three valleys. *Source:* Author calculations using data listed in Table 1.

Crop	Land (ac)	Water use (AF)	Gross revenue ($ million)
Alfalfa	30,866 (31.7%)	65,511 (29.7%)	38.4 (16.6%)
Barley	6,655 (6.8%)	9,424 (4.3%)	4.4 (1.9%)
Carrots	313 (0.3%)	653 (0.3%)	1.2 (0.5%)
Onions and garlic	400 (0.4%)	834 (0.4%)	1.7 (0.7%)
Other hay	2,734 (2.8%)	5,942 (2.7%)	3.2 (1.4%)
Pasture	45,805 (47.1%)	118,017 (53.5%)	32.0 (13.8%)
Raspberries	139 (0.1%)	465 (0.2%)	8.1 (3.5%)
Strawberries	2,661 (2.7%)	8,837 (4.0%)	137.9 (59.5%)
Wheat	7,657 (7.9%)	10,735 (4.9%)	4.9 (2.1%)
Total	**97,236 (100%)**	**217,121 (100%)**	**231.8 (100%)**

2. Model calibration and assumptions

Calibration of the model is based on the concept of Positive Mathematical Programming (PMP; Howitt, 1995), a self-calibrating technique to economically represent agricultural production and water use based on profit maximization theory and capturing non-linearities in production. PMP modeling avoids overspecialization in land allocation decisions which is common in linear programming. Thus, highly profitable crops which are produced in limited amounts do not expand at the expense of low-value crops in a way that is inconsistent with observations. The PMP calibration method consists of three steps as described in Howitt et al. (2012): (1) constrained linear optimization to derive shadow values of crop land; (2) parametrization of a constant elasticity of substitution (CES) production function and non-linear cost function; and (3) specification of the model objective function and check for calibration quality. Once the model is fully calibrated, constraint and objective function modifications can be used to examine scenarios of interest. Each of the three regions in the model (Butte, Scott River, Shasta) are calibrated and run independently from one another with an annual decision period. The calibrated model employs the equations listed below which include a CES production function and a non-linear exponential cost function (Howitt et al. 2012).

Box 1: Specification of calibrated model.

$$max\ \{x_{i,land}\} \prod = \sum_i \left(p_i \tau_i \left(\sum_j \beta_{i,j}\, x_{i,j}^{\rho_i} \right)^{\frac{1}{\rho_i}} - \delta_i e^{\gamma_i x_{i,land}} - \sum_{labor,supplies,water} \alpha_{i,j} \omega_{i,j} x_{i,land} \right)$$

$$s.t.$$

$$\sum_i x_{i,land} \leq \sum_i \tilde{x}_{i,land}$$

$$\sum_i x_{i,land} \tilde{x}_{i,water} \leq \sum_i \tilde{x}_{i,land} \tilde{x}_{i,water}$$

$$\frac{x_{i,water}}{x_{i,land}} \leq 0.99\tilde{x}_{i,water}$$

$$\forall\, i \in \begin{bmatrix} alfalfa, barley, carrots, onions\ and\ garlic, other\ hay, pasture, raspebrries, \\ strawberries, wheat \end{bmatrix}$$

$$\forall\, j \in [land, labor, supplies, water]$$

The first equation is the profit maximization objective function, which is followed by the land and water availability constraint sets, and an irrigation stress constraint to avoid deficit irrigation of crops. Parameters in the three constraint sets above can be modified, including the limit of land and/or water available for crops and use of deficit irrigation as a potential adaptation to drought or water rationing policies.

2.4. Model assumptions

Interpretation of model function and output is contingent on several assumptions employed in the model framework. Agriculture is represented in the model as a "snapshot" of cropping patterns and economics observed across one or more years and pertains only to annual decision-making processes. In many cases, agriculture follows rotation cycles which are not captured explicitly in the model; land use data employed in model calibration is assumed to represent an pseudo-equilibrium state for rotating crops which is representative of a typical annual crop mix, with some portion of cropland in each cycle of their rotation. Farm-scale decisions for plantings oftentimes depend on multi-year investments and production conditions which are not captured in the annual structure of the model. As such, the model's purpose is not to suggest planting decisions for individual parcels, but rather to present possible impacts on agriculture at the aggregate scale. To predict annual cropping patterns at the regional scale, the model assumes that some degree of water trading occurs within each region to retain more profitable crops when resource shortages are in place.

3. Scenarios Overview

The calibrated model was applied in seven scenarios which are designed to establish preliminary measure for the effects of land management policies on agricultural value across the three valleys. Table 6 below, summarizes the context and implementation of the scenarios in the model.

Table 6: Summary of model scenarios.

Scenario number / name	Description
Scenario 1a: 15% fallowing of pasture and alfalfa	All alfalfa and pasture are fallowed by 15%, with no ability to re-operationalize land and water use reductions with other crops.
Scenario 1b: 30% fallowing of pasture and alfalfa	All alfalfa and pasture are fallowed by 30%, with no ability to re-operationalize land and water use reductions with other crops.
Scenario 1c: 60% fallowing of pasture and alfalfa	All alfalfa and pasture are fallowed by 60%, with no ability to re-operationalize land and water use reductions with other crops.
Scenario 2: forego third alfalfa cutting	Simulate ceasing half of irrigation for alfalfa by July 1st, represented in the model as 33% deficit irrigation for alfalfa and a corresponding reduction

	in yield of 33%. Water use reductions from deficit irrigating alfalfa are retained.
Scenario 3: 15% fallowing (adaptive)	Total agricultural land undergoes 15% fallowing, and model given flexibility to optimize distribution of cutbacks across individual crops.
Scenario 4: 15% fallowing ("worst case")	Total agricultural land undergoes 15% fallowing, distributed evenly across all crops (area of all crop reduced by 15%).
Scenario 5: 15% water shortage (adaptive)	Total agricultural water use cutback by 15%, and model given flexibility to optimize distribution of cutbacks across individual crops.
Scenario 6: exploring economic tradeoffs between alfalfa and strawberries in Butte Valley	Comparison of marginal value and unit water use for alfalfa and berry plant transplant strawberries conducted to assess viability of converting between the two crops.
Scenario 7: exploring lower water use alternatives to alfalfa and pasture	Crop portfolio is assessed to locate water saving opportunities through crop conversion, with high retention or expansion of crop value.

4. Scenario Model Outcomes

4.1. Direct agricultural impacts (model results)

4.1.1. Scenario 1a: 15% fallowing of pasture and alfalfa

In this scenario, we simulate prescribed fallowing of pasture and alfalfa by 15% of baseline conditions within each region. Land and water previously devoted to these crops are treated as savings and thus are not allowed to be utilized in the model for the expansion of other crops. Under this land management policy, a total of 11,502 acres are fallowed (11.8%), of which 4,630 acres are alfalfa and 6,871 acres are pasture. Greatest cutbacks in land use occur in Shasta due to the exceptionally high baseline acreage of pasture, resulting in fallowing of 4,596 acres of pasture, nearly half of the total fallowed land. Slack water in lieu of irrigating the fallowed land total 27,530 acre-feet per year across the three valleys (12.5%). Gross revenue losses across all valleys together total $10.56 million (4.6%), concentrated in Scott ($3.75 million; 13.5%) and Shasta ($4.07 million; 10.5%). Economic losses in Butte – 1.7% as a percentage of baseline revenues – are weathered because of the high contribution of other crops such as nursery strawberries to overall agricultural value in the valley. Figure 2 and Table 7 below provide more detailed model outcomes of the cropping patterns, water use reductions, and value associated with this scenario.

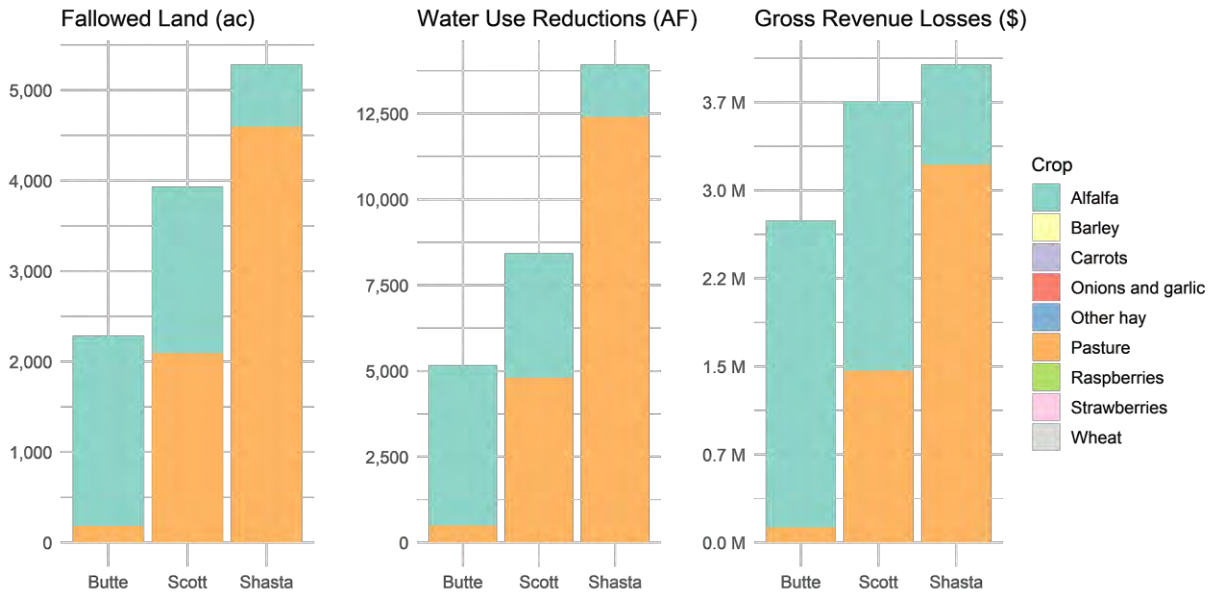


Figure 2: Results of land allocations, water use, and gross revenue differences from base for scenario 1a, 15% fallowing of pasture and alfalfa.

Table 7: Tabulated results of land allocations, water use, and gross revenues for scenario 1a, 15% fallowing of pasture and alfalfa.

Region	Crop	Land (ac)	Water use (AF)	Gross revenue ($ million)
Butte	Alfalfa	11,913	26,495	14.81
	Barley	1,460	2,199	0.96
	Carrots	313	654	1.16
	Onions and garlic	400	834	1.66
	Other hay	529	1,177	0.62
	Pasture	1,033	2,789	0.72
	Raspberries	140	465	8.10
	Strawberries	2,537	8,421	131.39
	Wheat	4,502	6,780	2.90
	Subtotal	**22,828** (-9.1%)	**49,813** (-9.4%)	**162.32** (-1.7%)
Scott	Alfalfa	10,427	20,525	12.96
	Barley	1,415	1,532	0.92
	Other hay	546	1,076	0.64
	Pasture	11,856	27,229	8.30
	Wheat	1,883	2,039	1.21
	Subtotal	**26,128** (-13.1%)	**52,400** (-13.9%)	**24.04** (-13.5%)
Shasta	Alfalfa	3,896	8,665	4.84
	Barley	3,780	5,693	2.49
	Other hay	1,660	3,691	1.95
	Pasture	26,046	70,298	18.23
	Strawberries	125	416	6.49
	Wheat	1,273	1,917	0.82
	Subtotal	**36,780** (-12.6%)	**90,679** (-13.3%)	**34.82** (-10.5%)
Three valleys	**Total**	**85,735** (-11.8%)	**192,892** (-12.5%)	**221.18** (-4.6%)

4.1.2. Scenario 1b: 30% fallowing of pasture and alfalfa

Scenario 1b is an upscaled version of scenario 1a, wherein the model prescribes a more severe fallowing of 30% of all pasture and alfalfa. As expected, the results follow the same trends as in scenario 1a but with more significant reductions in all categories. A total of 23,002 acres are fallowed (23.7%), of which 4,569 acres are in Butte, 7,865 acres are in Scott, and the remaining 10,568 acres are in Shasta. Cutbacks in land use represent about one-quarter of all land in Scott and Shasta as individual regions, and about one-fifth of total land in Butte. Water use reductions total 55,060 acre-feet across the three valleys (25.0%). Compared with scenario 1a gross revenue losses are doubled, valuing $21.13 million in total (9.1%) and distributed similarly to each valley (3.3%, 27.7%, and 20.9% loss for Butte, Scott, and Shasta, respectively). Figure 3 and Table 8 below provide more detailed predictions of the cropping patterns, water use reductions, and value associated with this scenario.

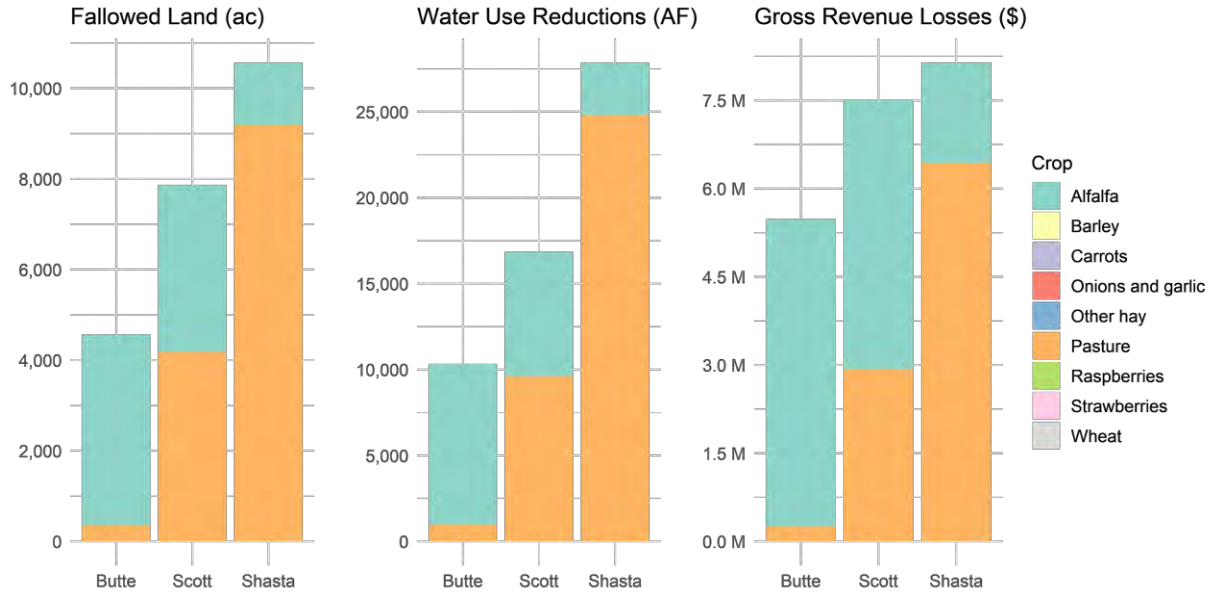


Figure 3: Results of land allocations, water use, and gross revenue differences from base for scenario 1b, 30% fallowing of pasture and alfalfa.

Table 8: Tabulated results of land allocations, water use, and gross revenues for scenario 1b, 30% fallowing of pasture and alfalfa.

Region	Crop	Land (ac)	Water use (AF)	Gross revenue ($ million)
Butte	Alfalfa	9,811	21,819	12.20
	Barley	1,460	2,199	0.96
	Carrots	313	654	1.16
	Onions and garlic	400	834	1.66
	Other hay	529	1,177	0.62
	Pasture	851	2,296	0.59
	Raspberries	140	465	8.10
	Strawberries	2,537	8,421	131.39
	Wheat	4,502	6,780	2.90
	Subtotal	**20,543** (-18.2%)	**43,973** (-18.8%)	**159.58** (-3.3%)
Scott	Alfalfa	8,587	16,903	10.68
	Barley	1,415	1,532	0.92

	Other hay	546	1,076	0.64
	Pasture	9,764	22,424	6.83
	Wheat	1,883	2,039	1.21
	Subtotal	**22,196 (-26.2%)**	**43,973 (-27.7%)**	**20.29 (-27.7%)**
Shasta	Alfalfa	3,209	7,136	3.99
	Barley	3,780	5,693	2.49
	Other hay	1,660	3,691	1.95
	Pasture	21,449	57,892	15.01
	Strawberries	125	416	6.49
	Wheat	1,273	1,917	0.82
	Subtotal	**31,496 (-25.1%)**	**76,745 (-26.6%)**	**30.75 (-20.9%)**
Three valleys	**Total**	**74,234 (-23.7%)**	**165,363 (-25.0%)**	**210.63 (-9.1%)**

4.1.3. Scenario 1c: 60% fallowing of pasture and alfalfa

Scenario 1c further extends the fallowing cutbacks from the previous two scenarios and simulates a 60% fallowing of pasture and alfalfa. Total fallowing totals 46,003 acres (47.3%) with 9,139 acres, 15,729, and 21,136 acres occurring in Butte, Scott, and Shasta, respectively. Reductions in land represent over half of the agricultural acreage in Scott and Shasta but roughly one-third of Butte land use. Water use reductions in the three valleys total 110,117 acre-feet or about 50% of total estimated baseline irrigation demands. Gross revenue losses total $42.26 million (18.2%); Butte experiences the least value loss at $10.97 million (6.6%), followed by Scott at $15.01 million (54.0%), and lastly Shasta with $16.29 million (41.9%). Figure 4 and Table 9 below provide more detailed predictions of the cropping patterns changes, water use reductions, and value associated with this scenario.

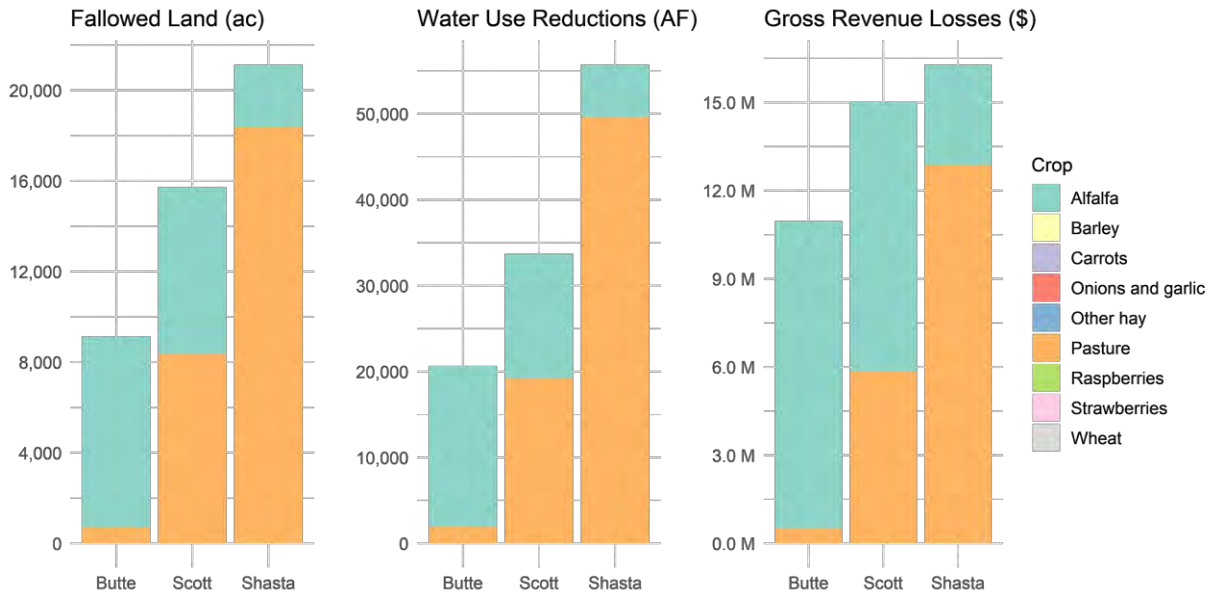


Figure 4: Results of land allocations, water use, and gross revenue differences from base for scenario 1c, 60% fallowing of pasture and alfalfa.

Table 9: Tabulated results of land allocations, water use, and gross revenues for scenario 1c, 60% fallowing of pasture and alfalfa.

Region	Crop	Land (ac)	Water use (AF)	Gross revenue ($ million)
Butte	Alfalfa	5,006	12,468	6.97
	Barley	1,460	2,199	0.96
	Carrots	313	654	1.16
	Onions and garlic	400	834	1.66
	Other hay	529	1,177	0.62
	Pasture	486	1,177	0.34
	Raspberries	140	465	8.10
	Strawberries	2,537	8,421	131.39
	Wheat	4,502	6,780	2.90
	Subtotal	**15,974** (-36.4%)	**34,310** (-37.6%)	**154.10** (-6.6%)
Scott	Alfalfa	4,907	9,659	6.10
	Barley	1,415	1,532	0.92
	Other hay	546	1,076	0.64
	Pasture	5,579	12,814	3.91
	Wheat	1,883	2,039	1.21
	Subtotal	**14,331** (-52.3%)	**27,118** (-55.4%)	**12.78** (-54.0%)
Shasta	Alfalfa	1,834	4,078	2.28
	Barley	3,780	5,693	2.49
	Other hay	1,660	3,691	1.95
	Pasture	12,257	33,081	8.58
	Strawberries	125	416	6.49
	Wheat	1,273	1,917	0.82
	Subtotal	**20,928** (-50.2%)	**48,875** (-53.3%)	**22.60** (-41.9%)
Three valleys	**Total**	**51,233** (-47.3%)	**110,304** (-50.0%)	**189.49** (-18.2%)

4.1.4. Scenario 2: forego third alfalfa cutting

Scenario 2 presents results of a less constrained case as compared with scenario 1. The model simulates deficit irrigation of alfalfa during the summer and consequentially a reduction in the number of cuttings harvested from the crop. Total annual irrigation for alfalfa is reduced by one-third (33%) to reflect these conditions, and crop yield is assumed to respond linearly to deficit irrigation. Changes in yield are accounted for in the profitability of alfalfa when land allocations are made by the model and are also applied to the final assessment of gross crop revenues. To reflect changes in harvesting and cultural costs, all costs are also scaled linearly with yield reductions. Reductions in water use connected to deficit irrigation are assumed to be retained in the model, meaning that the water cannot be reallocated to the expansion of other crops beyond what is otherwise used.

This scenario results in minor fallowing of alfalfa land (2.9% of baseline alfalfa) due to the steep decrease in marginal value making it less attractive to grow in comparison with other options, a factor that also lowers the returns of the allocated alfalfa land. Some compensation occurs to account for profitability shifts, leading to minor expansions of some select crops (Figure 5). Fallowing totals 117 acres across the three valleys (0.1%) after considering alfalfa losses and expansion in other crops. Water use reductions total 21,620 acre-feet (9.8%) of which most occur in Butte and Scott where alfalfa is plentiful. Total net gross revenue losses after accounting for combined cropping pattern shifts come to $12.8 million (5.5%), distributed as $5.7 million, $5.1 million, and $1.9 million in Butte, Scott, and Shasta,

respectively. As compared with scenario 1a, both gross revenue losses and water use reductions are similar, but total changes in agricultural land use are much lower. Figure 5 and Table 10 below provide more detailed results of the cropping patterns, water use reductions, and value associated with this scenario.

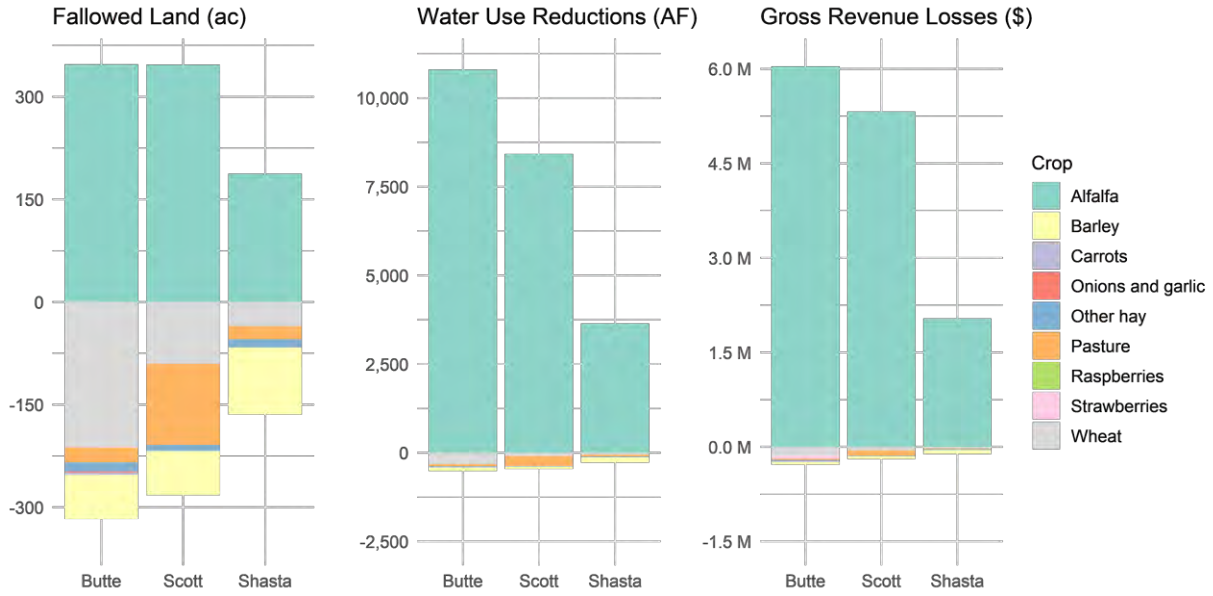


Figure 5: Results of land allocations, water use, and gross revenue differences from base for scenario 2, foregoing third cutting of alfalfa.

Table 10: Tabulated results of land allocations, water use, and gross revenues for scenario 2, foregoing third cutting of alfalfa.

Region	Crop	Land (ac)	Water use (AF)	Gross revenue ($ million)
Butte	Alfalfa	13,668	20,367	11.39
	Barley	1,525	2,296	1.00
	Carrots	317	662	1.17
	Onions and garlic	401	837	1.67
	Other hay	542	1,206	0.64
	Pasture	1,237	3,339	0.87
	Raspberries	140	465	8.10
	Strawberries	2,537	8,424	131.46
	Wheat	4,714	7,099	3.03
	Subtotal	**25,083** (-0.1%)	**44,695** (-18.7%)	**159.32** (-3.5%)
Scott	Alfalfa	11,921	15,721	9.93
	Barley	1,480	1,602	0.97
	Other hay	555	1,092	0.65
	Pasture	14,067	32,307	9.85
	Wheat	1,974	2,136	1.27
	Subtotal	**29,996** (-0.2%)	**52,859** (-13.1%)	**22.66** (-18.5%)
Shasta	Alfalfa	4,396	6,551	3.66
	Barley	3,879	5,841	2.55
	Other hay	1,671	3,717	1.96
	Pasture	30,661	82,754	21.46
	Strawberries	125	416	6.50

	Wheat	1,308	1,970	0.84
	Subtotal	**42,041 (-0.1%)**	**101,250 (-3.2%)**	**36.97 (-4.9%)**
Three valleys	**Total**	**97,120 (-0.1%)**	**198,803 (-9.8%)**	**218.94 (-5.5%)**

4.1.5. Scenario 3: 15% fallowing (adaptive)

Scenario 3 examines the expected impacts under a 15% land fallowing policy wherein cropping patterns can adapt to reduce the economic impacts. This scenario constrains the total land available to be allocated but does not prescribe fallowing in any given crop, meaning that the model is able to cut back in crops in such a way that minimizes farmer profit losses. Adaptive fallowing in this way assumes that there is some form of water trading which allows valuable crops to resist cutbacks because of some willingness to pay for scarce resources such as water.

Land fallowing totals 14,585 acres (15%) of which a large percentage (6,031 acres, 41.3%) consists of pasture reduction mostly in Shasta or Scott; remaining losses come in the form of alfalfa (4,101 acres, 28.1%), wheat (2,201 acres, 15.1%), barley (1,795 acres, 12.3%), and other crops (457 acres, 3.1%). Reductions in water use are slightly lower than land reductions by percentage, totaling 30,850 acre-feet (14.0%) across the three valleys. Gross revenue losses are in the order of $12.9 million (5.6%), distributed approximately equally across each of the valleys. Alfalfa receives the largest revenue loss of any crop ($5.1 million) followed by pasture ($4.2 million), and other minor crop losses representing the remaining economic impacts. Figure 6 and Table 11 below provide more detailed results of the cropping patterns, water use reductions, and value associated with this scenario.

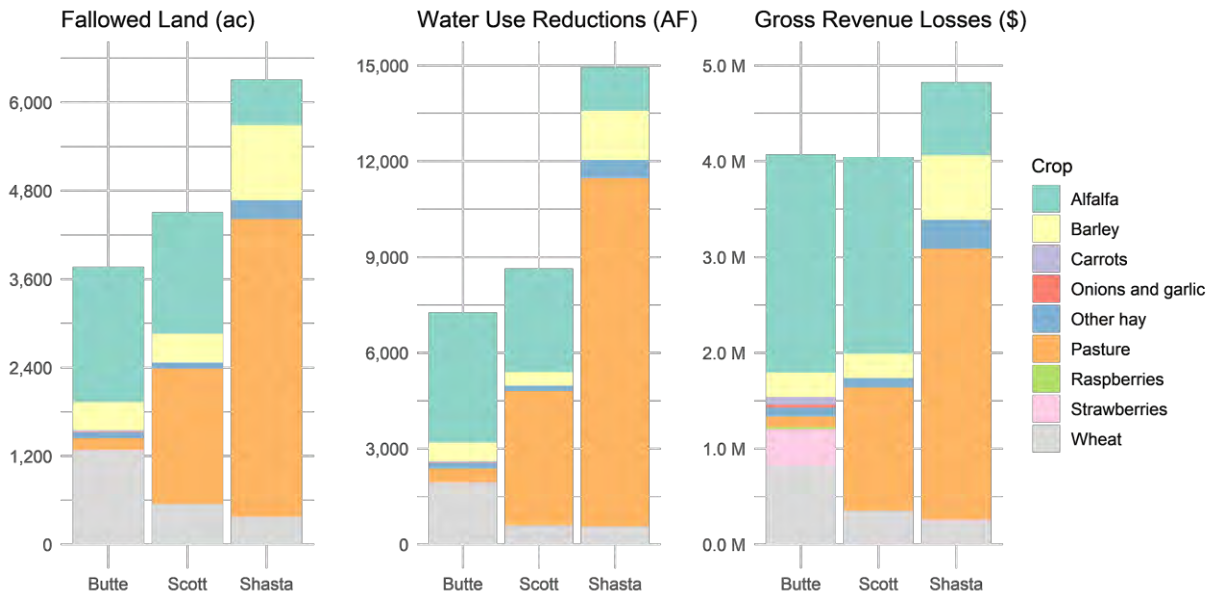


Figure 6: Results of land allocations, water use, and gross revenue differences from base for scenario 3, 15% fallowing of all cropland with adaptive management.

Table 11: Tabulated results of land allocations, water use, and gross revenues for scenario 3, 15% fallowing of all cropland with adaptive management.

Region	Crop	Land (ac)	Water use (AF)	Gross revenue ($ million)
Butte	Alfalfa	12,181	27,091	15.14

	Barley	1,078	1,623	0.71
	Carrots	291	607	1.08
	Onions and garlic	393	819	1.63
	Other hay	449	1,000	0.53
	Pasture	1,060	2,861	0.74
	Raspberries	140	463	8.08
	Strawberries	2,529	8,421	131.01
	Wheat	3,224	4,856	2.08
	Subtotal	**21,345** (-15.0%)	**47,717** (-13.2%)	**160.99** (-2.5%)
Scott	Alfalfa	10,617	20,899	13.20
	Barley	1,025	1,109	0.67
	Other hay	462	909	0.54
	Pasture	12,114	27,822	8.48
	Wheat	1,333	1,443	0.86
	Subtotal	**25,551** (-15.0%)	**52,182** (-14.2%)	**23.75** (-14.5%)
Shasta	Alfalfa	3,967	8,823	4.93
	Barley	2,758	4,154	1.81
	Other hay	1,403	3,120	1.64
	Pasture	26,601	71,796	18.62
	Strawberries	125	415	6.47
	Wheat	900	1,355	0.58
	Subtotal	**35,754** (-15.0%)	**89,663** (-14.3%)	**34.07** (-12.4%)
Three valleys	**Total**	**82,651** (-15.0%)	**189,562** (-14.0%)	**218.81** (-5.6%)

4.1.6. Scenario 4: 15% fallowing ("worst case")

Scenario 4 examines a similar land policy to that of scenario 3 (15% fallowing of all cropland) but restricts the model's ability to minimize losses. In this case all crop types are equally cut back by 15% without an implicit water trading potential. Removing the potential to shift cutbacks between crops leads to much more drastic economic losses compared to the previous scenario.

As a result of the restrictions imposed on the model, cutbacks across all categories (land, water use, and gross revenues) are all equal to the total fallowing percentage (15%) and do not change based on crop or region. Total fallow land remains at 14,585 acres as in scenario 3, distributed as 3,767 acres, 4,509 acres, and 6,310 acres lost in Butte, Scott, and Shasta, respectively. Water use reductions are slightly higher than the previous scenario, at 33,063 acre-feet. Agricultural revenue losses, however, are nearly three times higher than the adaptive scenario, totaling $34.8 million. Most revenue loss is attributed to reductions in strawberries and raspberries which value $21.9 million (62.9%) in combination; alfalfa and pasture make up most remaining value loss. Figure 7 and Table 12 below provide more detailed results of the cropping patterns, water use reductions, and value associated with this scenario.

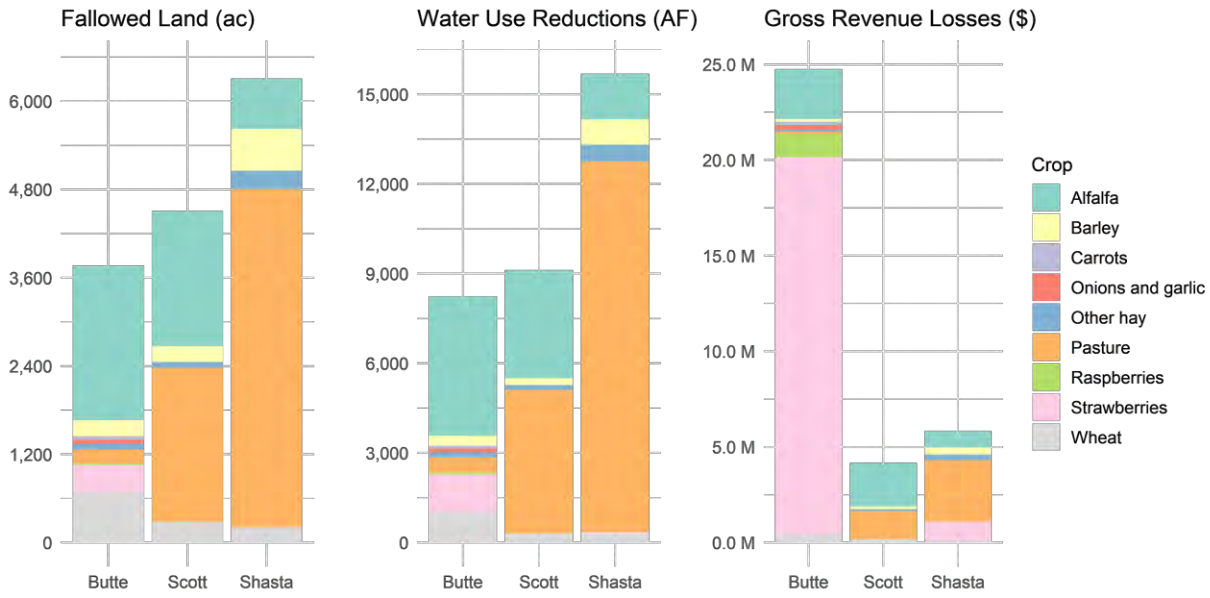


Figure 7: Results of land allocations, water use, and gross revenue differences from base for scenario 4, 15% fallowing of all cropland without adaptive management.

Table 12: Tabulated results of land allocations, water use, and gross revenues for scenario 4, 15% fallowing of all cropland without adaptive management.

Region	Crop	Land (ac)	Water use (AF)	Gross revenue ($ million)
Butte	Alfalfa	11,913	26,495	14.81
	Barley	1,241	1,869	0.82
	Carrots	266	556	0.99
	Onions and garlic	340	709	1.41
	Other hay	450	1,000	0.53
	Pasture	1,033	2,789	0.72
	Raspberries	119	395	6.88
	Strawberries	2,156	7,158	111.68
	Wheat	3,827	5,763	2.46
	Subtotal	**21,345 (-15.0%)**	**46,734 (-15.0%)**	**140.30 (-15.0%)**
Scott	Alfalfa	10,427	20,525	12.96
	Barley	1,203	1,302	0.79
	Other hay	464	914	0.54
	Pasture	11,856	27,229	8.30
	Wheat	1,601	1,733	1.03
	Subtotal	**25,551 (-15.0%)**	**51,703 (-15.0%)**	**23.62 (-15.0%)**
Shasta	Alfalfa	3,896	8,665	4.84
	Barley	3,213	4,839	2.11
	Other hay	1,411	3,137	1.65
	Pasture	26,046	70,298	18.23
	Strawberries	107	354	5.52
	Wheat	1,082	1,629	0.70
	Subtotal	**35,754 (-15.0%)**	**88,922 (-15.0%)**	**33.06 (-15.0%)**
Three valleys	**Total**	**82,651 (-15.0%)**	**187,358 (-15.0%)**	**196.99 (-15.0%)**

4.1.7. Scenario 5: 15% water shortage (adaptive)

Scenario 5 follows a similar concept and realization to that of scenario 3, however, restrictions are made more broadly to water as opposed to land availability. Under this scenario the model is again allowed flexibility in allocating land to crops and minimizing economic losses. Trends in overall resource use remain roughly the same as they were in the results of scenario 3 with minor differences in land allocation due to variability in unit water demand across crop types.

Fallowed land totals 13,848 acres across the three valleys and is composed primarily of alfalfa and pasture, with less severe cutbacks in barley and wheat owing to the lower unit water demands of these crops. In summary, total land fallowing is reduced compared with scenario 3, but targets towards higher water use crops. Water use reductions total of 32,760 acre-feet (15%). Changes in gross revenue losses are minimal compared with the land-limited scenario, and total $13.0 million. Both scenario 3 and 5 see much more evenly distributed economic impacts as compared to scenario 4, which experiences almost all effects in Butte Valley because of losses in berry plant transplant crops.

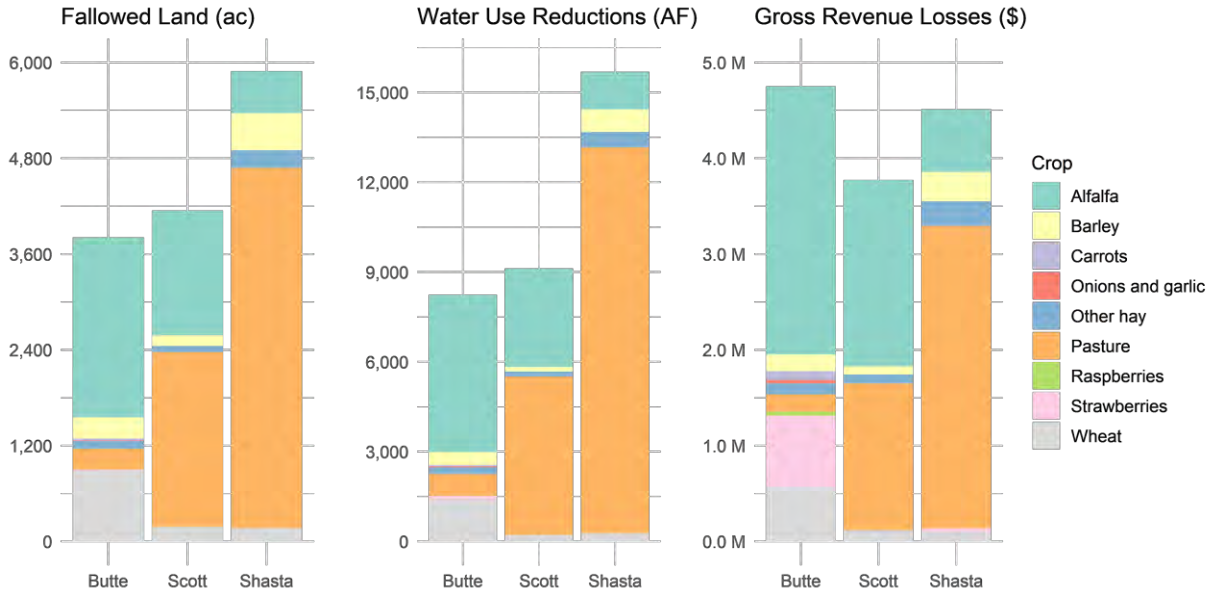


Figure 8: Results of land allocations, water use, and gross revenue differences from base for scenario 5, 15% total water shortage with adaptive management.

Table 13: Tabulated results of land allocations, water use, and gross revenues for scenario 5, 15% total water shortage with adaptive management.

Region	Crop	Land (ac)	Water use (AF)	Gross revenue ($ million)
Butte	Alfalfa	11,765	25,903	14.63
	Barley	1,193	1,779	0.78
	Carrots	288	595	1.07
	Onions and garlic	392	809	1.63
	Other hay	431	949	0.51
	Pasture	959	2,563	0.67
	Raspberries	139	458	8.06
	Strawberries	2,522	8,290	130.65
	Wheat	3,614	5,388	2.33

	Subtotal	**21,303 (-15.2%)**	**46,734 (-15.0%)**	**160.31 (-2.9%)**
Scott	Alfalfa	10,702	20,854	13.31
	Barley	1,284	1,376	0.84
	Other hay	466	909	0.55
	Pasture	11,761	26,742	8.23
	Wheat	1,700	1,822	1.09
	Subtotal	**25,914 (-13.8%)**	**51,703 (-15.0%)**	**24.02 (-13.6%)**
Shasta	Alfalfa	4,057	8,933	5.04
	Barley	3,316	4,943	2.18
	Other hay	1,441	3,172	1.69
	Pasture	26,129	69,817	18.29
	Strawberries	125	410	6.47
	Wheat	1,104	1,647	0.71
	Subtotal	**36,172 (-14.0%)**	**88,922 (-15.0%)**	**34.38 (-11.6%)**
Three valleys	**Total**	**83,389 (-14.2%)**	**187,358 (-15.0%)**	**218.71 (-5.6%)**

4.1.8. Scenario 6: exploring economic tradeoffs between alfalfa and strawberries in Butte Valley

Strawberry plants for transplant are a particularly unique specialty crop grown in Butte Valley due to their high value and importance in supporting downstream berry production on the Central Coast. As such, these crops pose an opportunity for generating great economic value with less land and water resource use – suggesting that conversion of other crops to strawberries may have benefits for managing water use while maintaining agricultural value. Given that alfalfa is the dominant crop by area in the valley (55.8%) and is relatively low value compared to nursery berries, this scenario explores tradeoffs in converting between these two crops.

In this analysis, the marginal revenue of an acre of transplant strawberry plants is estimated to be about $51,800 and the crop is estimated to operate with a 15% profit margin after costs are considered. Irrigation needs for strawberries are estimated at 3.32 AF/ac per year. Alfalfa is estimated to have a marginal revenue of $1,240/ac with a 5% profit margin and irrigation needs of 2.22 AF/ac per year in Butte Valley. Assuming constant returns to scale within both crop groups, about 42 acres of alfalfa produce the same gross revenue as 1 acre of nursery strawberries but use significantly more water in the aggregate.

Tables 14 and 15, below, outline possible options for retiring alfalfa in favor of transplant strawberries. The first strategy focuses on maintaining or expanding value while maximizing resource reductions (1:40 ratio of strawberries to alfalfa). The second strategy replaces alfalfa with strawberries at a higher rate (5:40 ratio of strawberries to alfalfa) in favor of economic expansion. These scenarios recognize the rotations exercised in growing transplant strawberry plants, which are understood to typically operate in 3-year rotations of strawberry-grain-fallow with roughly equivalent acreages of each at any given time. Based on this production model, for each acre of transplant strawberries planted, 1 acre of grain is planted, and 1 acre is set aside as fallow for the rotation with land, water use, and revenue impacts reflecting these conditions.

Table 14: Conservative strategy for converting alfalfa to strawberries (1:40 ratio of strawberries to alfalfa) focused on water use reductions.

Alfalfa fallowed (ac)	Strawberries planted (ac)	Grain planted (ac)	Fallow reserved (ac)	Land reductions (ac)	Water reductions (AF)	Revenue impact ($)
200	5	5	5	185	421	+13,570
400	10	10	10	222	505	+16,284
600	15	15	15	259	589	+18,998
800	20	20	20	296	673	+21,712
1000	25	25	25	333	757	+24,426

Table 15: Progressive strategy for converting alfalfa to strawberries (5:40 ratio of strawberries to alfalfa) focused on economic expansion.

Alfalfa fallowed (ac)	Strawberries planted (ac)	Grain planted (ac)	Fallow reserved (ac)	Land reductions (ac)	Water reductions (AF)	Revenue impact ($)
200	25	25	25	125	324	+1,062,443
400	50	50	50	150	389	+1,274,931
600	75	75	75	175	454	+1,487,420
800	100	100	100	200	519	+1,699,909
1000	125	125	125	225	583	+1,912,397

One consideration to make when examining conversion of alfalfa to higher value crops such as strawberries is the limit on strawberry expansion; consistent with PMP modeling which limits crop specialization, it is typically assumed that valuable crops that are observed to be grown in relatively low amounts are constrained by production conditions and upfront costs aside from profitability. For example, soils used in pasture are often less suitable to grow more sensitive crops such as vegetables because of nutrient deficiencies or soil composition. However, because transplant strawberries in Butte Valley are grown in nursery conditions, this may lend itself to better control of production conditions that might otherwise prevent expansion under natural cultivation practices. Expansion of nursery strawberry production is limited by several additional factors including labor availability and high upfront investment in technical knowledge and infrastructure. Many of the farmers currently involved in this sector have accumulated generational knowledge pertaining to management and business practice which are seen for other crops in the county but require fewer capital investments. These scenarios propose minor expansion of transplant berries by area in recognition of the challenges noted by farmers in this sector that currently prevent significant expansion from occurring.

4.1.9. Scenario 7: exploring lower water use alternatives to alfalfa and pasture

Among the crops cultivated in the three valleys examined for this study of Siskiyou County agriculture, pasture and alfalfa are the largest drivers of water demand, both at the aggregated and unit production scales. There is an interest in exploring the role that these crops play in the context of water use as well as economic value. This scenario examines potential for land use tradeoffs involving these crops with the goal of reducing water use while maintaining gross returns. It is worthwhile noticing alfalfa and pasture support downstream agricultural sectors such as the dairy and beef cattle industry, which may be impacted by higher feed crop costs resulting from a reduction in the local supply of irrigated pasture

and alfalfa. Intermountain alfalfa is also known for its higher quality and is used as feed in more specialized animal operations beyond dairies and beef cattle.

Under baseline conditions, alfalfa covers roughly 32% of agricultural land across the three valleys while pasture makes up an additional 47% of crop cover. Alfalfa is mostly concentrated in Butte and Scott and pasture composes a majority of land use in Shasta. Unit water use for alfalfa is estimated at 2.22 acre-feet/acre in Butte and Shasta and 1.97 acre-feet/acre in Scott. Pasture is estimated to require 2.70 acre-feet/acre in Butte and Shasta and 2.30 acre-feet/acre in Scott. In the aggregate, these two crops contribute 83% of total water demand for the three valleys, of which 30% is attributed to alfalfa and 53% to irrigated pasture. Siskiyou does not have as stark of contrasts in unit water use between crops as other regions in California, where it is common to see grains with sub- 2 acre-feet/acre irrigation needs grown alongside alfalfa or almonds requiring over 4.5 acre-feet/acre in annual irrigation. However, there is still significant differences in unit demands which suggest opportunities for improving economic efficiency in applied water.

Table 16 below provides a baseline for comparison between water use and value for crops grown within each of the three valleys. This table serves to highlight opportunities for conversion between crop types in the interest of water management benefits. For example, wheat and barley offer some tradeoff from pasture and alfalfa for lowering total water demand at the expense of reduced agricultural revenue. Alfalfa demands roughly 1.5 times the irrigation of wheat or barley (per acre) but has nearly double the marginal value of these crops. In the Scott River Valley, where irrigation demands tend to be lower, each of these crops has comparable value per unit of applied water ($/acre-feet), however, in Butte and Shasta the economic return of water for grain crops is about 25% lower than that of alfalfa. Pasture, on the other hand, has both the highest unit water demands of any crop in the three valleys as well as the lowest value per unit of applied water. Marginal values for pasture are comparable to grain crops. Crops such as carrots and onions are suitable to be grown in Butte and have higher marginal value both per unit of land and water as compared with alfalfa or pasture. However, these crops are observed to be grown in only small amounts (approximately 400 acres at most), suggesting that other production factors may constrain their expansion despite higher value than alternatives. Likewise, transplant berries have higher water demands than alfalfa, carrots, or onions, but are vastly more valuable than other crops grown within the valley.

Table 16: Unit water use, marginal value, and economic efficiency of applied water for crops in Butte Valley.

Crop	Region	Unit water use (AF/ac)	Marginal value ($/ac)	Marginal value / unit water ($/AF)
Alfalfa	Butte/Shasta	2.22	1,243	559
Alfalfa	Scott	1.97	1,243	632
Barley	Butte/Shasta	1.51	658	437
Barley	Scott	1.08	653	603
Carrots	Butte	2.09	3,699	1,773
Onions and garlic	Butte	2.09	4,150	1,989
Other hay	Butte/Shasta	2.22	1,172	527
Other hay	Scott	1.97	1,172	596
Pasture	Butte/Shasta	2.70	700	259
Pasture	Scott	2.30	700	305
Raspberries	Butte	3.32	57,857	17,427
Strawberries	Butte/Shasta	3.32	51,800	15,602

Wheat	Butte	1.51	644	427
Wheat	Scott	1.08	644	595

4.2. Spillover effects of land and water use decisions

Table 17 lists spillover effects related to changes in the agricultural sector revenues within the County's economy based on the scenarios outlined above. We employed IMPLAN (https://www.implan.com/), an input-output model which allows estimation of broader impacts on employment, gross revenues and after sector-specific economic events, such as land fallowing or crop shifting. IMPLAN estimates direct, indirect, and induced effects. The direct effects correspond to the changes in revenues with respect to baseline (2018) conditions in crop farming. As various crops see reductions or changes in acreage, such changes indirectly affect production inputs including farm labor, agrochemicals, farm services and others. These are known as indirect effects. As agriculture and agriculture-related sectors face some impacts in gross revenues, households and government also face income impacts in what is known as an induced or second round effect. Altogether, direct, indirect, and induced impacts constitute the total or multiplier effect which is reported in this section for gross revenues (or output), value added (close to gross domestic product), and employment (full and part time jobs).

Scenario 1c shows the highest losses in all economic categories, resulting in $56 million in direct, indirect, and induced revenue losses, nearly $43 million in value added losses, and 393 fewer jobs in agriculture and all other sectors. Scenarios such as 3 or 4 are likely more realistic because they do not prescribe responses in specific crop categories, with scenario 3 assuming water trading allows retentions of higher value crops at the cost of deeper cutbacks in low value crops, and scenario 4 assuming all crops receive equal cutbacks. Management practices under water shortages would likely fall somewhere between these cases, representing slightly less aggressive water trading. Scenario 3 suggests total output losses of $17 million, $13 million in value added losses, and 120 fewer jobs. Meanwhile, scenario 4 falls closer to the extreme of scenario 1c with $46 million total revenue losses, $35 million in value added losses, and 323 fewer jobs. Other scenarios tend to fall within a similar range of economic impacts as those suggested by scenario 3.

Table 17: Combined direct and indirect regional economic impacts (IMPLAN results) for all scenarios.

Scenario	**Region**	**Lost output ($ million)**		**Lost value added ($ million)**		**Lost jobs (#)**	
		Direct	**Total**	**Direct**	**Total**	**Direct**	**Total**
Scenario 1a	Three valleys	10.57	14.05	5.82	10.68	71	98
	Butte	2.74	3.65	1.51	2.77	18	25
	Scott	3.75	4.99	2.07	3.79	25	35
	Shasta	4.07	5.42	2.24	4.12	27	38
Scenario 1b	Three valleys	21.13	28.11	11.65	21.36	142	197
	Butte	5.48	7.29	3.02	5.54	37	51
	Scott	7.50	9.98	4.14	7.59	51	70
	Shasta	8.14	10.83	4.49	8.23	55	76
Scenario 1c	Three valleys	42.26	56.21	23.30	42.72	285	393
	Butte	10.97	14.58	6.04	11.08	74	102
	Scott	15.01	19.96	8.27	15.17	101	140
	Shasta	16.29	21.66	8.98	16.46	110	151
Scenario 2	Three valleys	12.79	17.01	7.05	12.93	86	119
	Butte	5.74	7.63	3.16	5.80	39	53

	Scott	5.13	6.82	2.83	5.18	35	48
	Shasta	1.92	2.55	1.06	1.94	13	18
Scenario 3	Three valleys	12.94	17.21	7.13	13.08	87	120
	Butte	4.07	5.42	2.24	4.12	27	38
	Scott	4.04	5.38	2.23	4.09	27	38
	Shasta	4.83	6.42	2.66	4.88	33	45
Scenario 4	Three valleys	34.76	46.23	19.16	35.14	234	323
	Butte	24.76	32.93	13.65	25.03	167	230
	Scott	4.17	5.54	2.30	4.21	28	39
	Shasta	5.83	7.76	3.22	5.90	39	54
Scenario 5	Three valleys	13.04	17.34	7.19	13.18	88	121
	Butte	4.75	6.32	2.62	4.80	32	44
	Scott	3.77	5.02	2.08	3.82	25	35
	Shasta	4.51	6.00	2.49	4.56	30	42

Figure 9 summarizes the economic losses considering spillover effects in the regional economy for each scenario along with the average value lost per unit of water reductions. Scenario 1c, prescribing a large cutback (60%) in alfalfa and pasture cultivation, shows the greatest total economic output reduction at $56 million. Following closely in total output reduction is scenario 4 with $46 million, in which all crops receive an equal cutback of 15%. Scenarios 1a, 2, 3, and 5 are all found to have similar output impacts in the order of about $15-20 million. Average output losses per unit of reduced water is consistent across most scenarios at approximately $500/acre-foot. Scenario 2 has slightly higher value losses per unit of water because of the additional value lost from reduced alfalfa yield. Scenario 4 exhibits almost triple the average value lost per unit of water compared with other scenarios ($1,400/acre-foot) because of the higher marginal value of transplant berries.

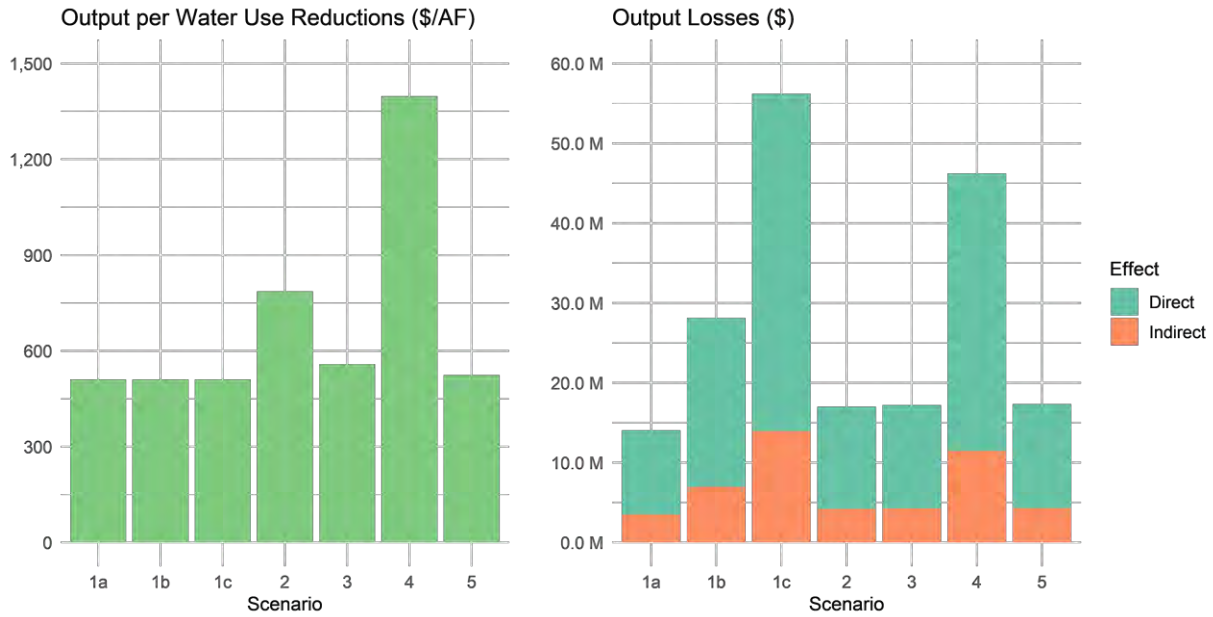


Figure 9: IMPLAN combined spillover effects and average value per unit of water reductions by scenario.

4.3. Economic value of instream flows in the Klamath Basin

Various studies and research reports exist for estimating value of water instream flows in the Klamath River Basin. Kruse and Scholz (2006) estimate a range of net costs for the removal of 4 dams in the Klamath Basin and benefits from temporary employment in the removal and non-use water value with many other costs and benefits unknown. The authors provide an estimate of $172 million in benefits from dam deconstructions, and increased tourism and visitors, and a cost of $2 million for the loss of jobs from the hydropower project. In addition, it is estimated a $104 million benefit from non-use value per year. Considering a flow mean annual flow of 13 million acre-feet in the Klamath River, the estimate in use value is in the order of $8 per acre-foot. This figure does not include the benefits of groundwater dependent ecosystems, fisheries, tourism, tribal, water supply increased reliability and other beneficial uses included in the $172 million above that do not have a direct association to the instream flow gains or change in patterns from dam removal. Yet the study demonstrates values exist for environmental flows and should be weighed against costs of water diversions.

4.4. Limitations of analysis

As with most models, the scenario results shown in this report merit recognition of some limitations. First, data availability on crop production represents average production conditions which rarely occur in specific commodities. Size distribution of farms influences activities and productivity and crop attributes that might also have an influence on crop prices and yields in specific market niches. This also influences the profits from farming. Nevertheless, a representation of the aggregate of production at the county level can still provide useful insights for planning and policy analysis. Second, a profit maximizing behavior and costless water exchanges within each of the valleys are assumed to occur. Thus, results may represent a reasonable lower bound for economic costs of water reductions. Lastly, crops in Siskiyou County have an influence that extends beyond the county boundaries as these are exported or serve as inputs to other sectors including animal operations and food processing. Estimates of these impacts is not estimated in this study yet for most of the scenarios modeled decreases in feed crops will result in higher costs to local ranchers in the dairies and beef cattle sectors which may intermittently or permanently reduce herd sizes to cope with higher production costs and maintain profitability. Animal operations represent roughly 20% of both crops and animal agricultural value in Siskiyou County, thus reductions in their total output due to higher costs should not be ignored. Something similar occurs for transplant berries, which provide inputs to other areas that grow specific commodities into end-products for wholesale or retail. Yet due to their value and profit margins, water shortage price increases from traded water or more expensive water could be absorbed easier than in other sectors. With these limitations in mind, this report may provide insights for discussion of paths forward in water management for Siskiyou County.

5. Conclusions

This report provides costs of agricultural land and water use decisions in selected cropping regions within Siskiyou County and contributes to an improved quantitative understanding of tradeoffs associated with such decisions. Some conclusions arise from this work.

1) Agriculture in Siskiyou County within the Butte, Scott River and Shasta Valleys in our baseline year accounts for 97,000 acres, using roughly 220,000 acre-feet of water per year and generating $231 million in direct gross revenues.

2) The agricultural crop mosaic in these three valleys differ substantially both in the selection of crops and access to water resources. Butte Valley holds the smallest agricultural footprint by area with about 25,000 acres but contributes the greatest value of the three regions owing to the production of berry plants for transplant. Scott River Valley contains about 30,000 acres of cropland consisting primarily of alfalfa and pasture. Shasta Valley has about 42,000 acres of cropland and is mostly pasture. Across the three valleys together, alfalfa and pasture account for 32% and 47%, respectively, of total cropland.
3) A range of scenarios for land and water management was analyzed. Scenarios 1a (15% fallowing alfalfa and pasture), 2 (forego third alfalfa cutting), 3 (15% fallowing, adaptive), and 5 (15% water shortage, adaptive) are expected to result in comparable revenues losses in the order of $10-13 million before considering spillover effects or $15-20 million in related sectors. Scenario 4 (15% fallowing, "worst case") results in the most extreme economic impact with an estimated $35 million in losses stemming in large part from transplant berry reductions. Scenarios 1b and 1c form an intermediate between other scenarios but concentrate impacts on alfalfa and pasture.
4) A 15% reduction in water across the board for all crops can potentially result in direct costs of $35 million for Butte, Scott River, and Shasta Valleys, and 234 jobs lost. When the multiplier effects are accounted for, sector output losses total $46 million and 323 jobs. The cost of applied water reductions in this scenario is about $1,400 per acre-foot when considering direct and indirect sectors.
5) Allowing trading within the valleys for up to 15% applied water reductions substantially decreases economic costs of water use reductions down to $13 million in sector output, and when spillover effects are accounted for such impacts can be as high as $17 million for sector output and 120 jobs. This highlights the potential gains from trading water across commodities to lower economic impacts.
6) Scenarios focusing on resource use reductions in alfalfa and pasture tend to concentrate economic impacts on Shasta Valley, followed by Scott River Valley and finally Butte Valley which generates much of its value from berries for transplant. However, when assessing alfalfa centric scenarios such as foregoing a third cutting (scenario 2), this trend reverses and Butte and Scott River Valleys experience much of the losses. Scenarios which prescribe general reductions in land or water use and allow for adaptive fallowing (scenarios 3 and 5) have nearly equal impacts across each of the regions. When water trading is prohibited and crops experience equal reductions (scenario 4), aggregate impacts become highly concentrated in Butte Valley owing to the exceptional value of berry plants for propagation.
7) Effects from crop production changes into downstream sectors such as dairies and beef cattle and the food processing industry can be sizeable for large enough reductions in crop production and depending on the downstream sector's response to local crop commodity shortages these estimates may merit further investigation.

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