JANUARY 2022

SISKIYOU COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT

Shasta Valley Groundwater Sustainability Plan

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

BOARD

Brandon Criss, County of Siskiyou
Ed Valenzuela, County of Siskiyou
Michael Kobseff, County of Siskiyou
Nancy Ogren, County of Siskiyou
Ray A. Haupt, County of Siskiyou

STAFF

Matt Parker, Natural Resources Specialist, County of Siskiyou

TECHNICAL TEAM

Laura Foglia, LWA
Thomas Harter, UC Davis

Andrew Calderwood, UC Davis
Brad Gooch, UC Davis
Cab Esposito, LWA
Katrina Arredondo, LWA
Kelsey McNeil, LWA
Claire Kouba, UC Davis
Bill Rice, UC Davis

ADVISORY COMMITTEE

John Tannaci, Chair, Residential
Blair Hart, Private Pumper
Gregg Werner, Environmental/Conservation
Justin Holmes, Edson Foulke Ditch Company
Pete Scala, Private Pumper
Grant Johnson, Tribal Representative
Tristan Allen, Montague Water Conservation District
Steve Mains, Grenada Irrigation District
Robert Moser, Municipal/City
Lisa Faris, Big Springs Irrigation District
Justin Sandahl, Shasta River Water Users Association

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

December 8, 2021

LARRY WALKER ASSOCIATES

UC DAVIS
UNIVERSITY OF CALIFORNIA

Shasta 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 University of California Davis under the supervision of the Engineer(s) and/or Geologist(s) whose seal(s) and signature(s) appear hereon. 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. No warranty is expressed or implied.

REGISTERED PROFESSIONAL ENGINEER
THOMAS R. GROVHOUG
C 27901
EXP. 03/31/22
CIVIL
STATE OF CALIFORNIA

Contents

List of Figures

List of Tables

List of Appendices

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
AT	Action Trigger
bgs	Below ground surface
BLM	United States Department of the Interior Bureau of Land Management
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
DTW	Depth to Water
DWR	California Department of Water Resources

(continued)

Abbreviation	Explanation
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
MT	Minimum Threshold
MTBE	Methyl tert-butyl ether

(continued)

Abbreviation	Explanation
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
SWGM	Shasta Watershed Groundwater Model
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
UCCE	University of California Cooperative Extension

(continued)

Abbreviation	Explanation
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.
Basin Setting	The physical setting, characteristics, and conditions of the basin.
CASGEM	The California Statewide Groundwater Elevation Monitoring Program
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.
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	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	A 20-year plan to ensure groundwater is managed sustainability within a groundwater basin.
Hydrogeological Conceptual Model	A description of the geologic and hydrologic setting that determines groundwater occurrence, movement, and general conditions in a basin or subbasin.
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.

(continued)

Term	Explanation
Measurable Objective	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.
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).
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.
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.
SGMA	Sustainable Groundwater Management Act, a three-bill package signed into California state law in 2014.
Sustainability Goal	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.
Undesirable Result	Conditions, defined under SGMA as: ”â€¦ 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 horizonâ€¦. 2. Significant and unreasonable reduction of groundwater storage. 3. Significant and unreasonable seawater intrusion.

(continued)

Term	Explanation
	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).)
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.

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., Shasta Valley). 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.

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 GSPs, 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 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.
- 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-F.

Purpose of the Groundwater Sustainability Plan

The Shasta Valley GSP outlines a 20-year plan to direct sustainable groundwater management activities that considers the needs of all users in the Shasta Valley groundwater basin (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 (SMC) and define projects and management actions (PMA), 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 Shasta Valley Basin area. This includes descriptions of plan area, relevant agencies and programs, groundwater conditions, water quality, interconnected surface waters (ISW), 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 SMCs (Chapter 3) and 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 bounded by Mount Shasta to the South, the Klamath Mountains to the west and the Cascade Range to the east and the Klamath River to the north. The Basin is drained by Shasta River, a tributary to the Klamath River. The primary communities in Shasta Valley are the Cities of Yreka, Weed, and Montague and the census-designated places of Grenada, Carrick, Gazelle, and Edgewood. As reflected in the 2012 to 2016 disadvantaged community (DAC) Mapping Tool, Gazelle, Granada, Weed, and Yreka all qualify as severely disadvantaged communities (SDACs) and Montague qualifies as a DAC based on annual median household income. Land ownership in the Basin is predominantly private, with two large conservation properties, California Department of Fish and Wildlife's Shasta Valley and Big Springs Ranch Wildlife Areas. Agriculture is a significant land use in the Basin with pasture, alfalfa, grain and hay as the primary crops.

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 Shasta 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 2.1.4, including the County of Siskiyou General Plan, City of Weed General Plan and Yreka 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 2.2.1.5).

Current and Historical Groundwater Conditions (Section 2.2.2)

Groundwater Elevation (2.2.2.1)

Groundwater data for the Basin are entirely within the DWR CASGEM Records. The majority of groundwater level data available for the Basin date back to at least the early 1990s, some data available earlier and some data available only post-2010. Generally, groundwater level data indicated levels are stable over the full period of the record as shown in a subset of five wells in Figure 1. Groundwater levels are generally shallow in the central to west-central areas of the Basin (<20-40 feet below ground surface) and typically do not show seasonal or longer variations. In contrast, the deeper groundwater table northwest of Gazelle shows some variation with drought conditions. In the volcanic aquifers, groundwater levels have generally remained stable but with increases in pumping and drought conditions (after 2019), increased lowering is noted, particularly in the Pluto's Cave basalt aquifer area.

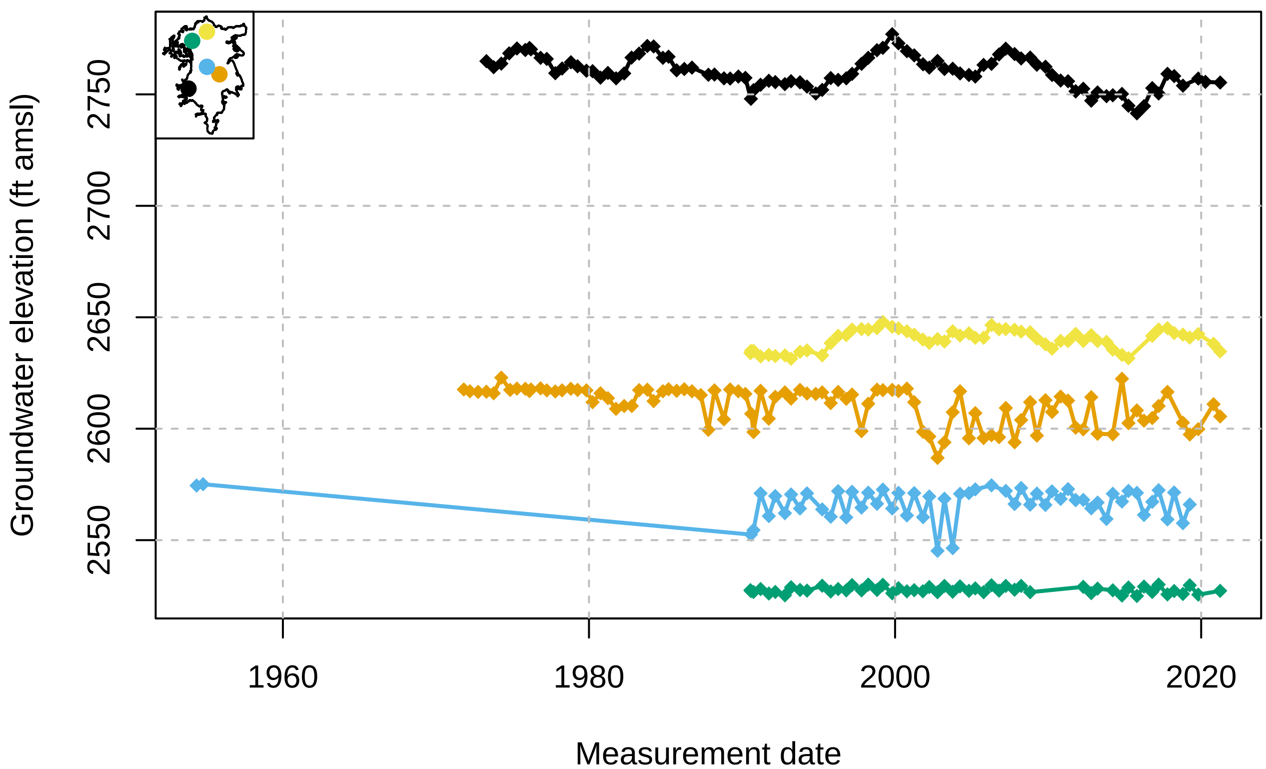


Figure 1: Groundwater level measurements over time in five wells, one located in each hydrogeologic zone.

Estimate of Groundwater Storage (2.2.2.2)

Groundwater storage is estimated based on the model, the Shasta Watershed Groundwater Model (SWGM).

Groundwater Quality (Section 2.2.2.3)

Based on an evaluation of Basin groundwater quality using available monitoring data (see Appendix 2-C), a list of constituents of interest was generated for the Basin. This list includes arsenic, benzene, boron, iron, manganese, nitrate, pH and specific conductivity. Multiple known contaminated sites exist in the Basin, including a leaking underground storage tank (LUST) site, the Davenport Property, three open cleanup program sites in Yreka, and six California Department of Toxic Substances Control sites.

Seawater Intrusion (Section 2.2.2.4))

The Basin is more than 60 miles east of the Pacific Ocean and water levels are more than 2,000 feet above mean sea level. Seawater intrusion is not an issue in this Basin.

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. Subsidence in Shasta Valley, based on the TRE Altamira InSAR dataset provided by DWR is within the range of -0.1 to 0.1 ft, largely within the margin of error indicating the absence of significant subsidence. The type of geological formations present in the Basin is also suggesting that future subsidence is unlikely.

Identification of Interconnected Surface Water Systems (Section 2.2.2.6)

ISW is 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 surface water.

The Shasta River and its major tributaries are all considered part of the ISW system in the Basin (Figure 2). Their large seasonal flow variations exhibit all five elements of the recently proposed functional flows framework for managing California rivers: fall flush flow, winter storm flow, winter baseflow, spring recess, and summer baseflow. The system is also subject to significant interannual variations in flow and largely affected by the complex springs system that is present throughout the valley as a result of the volcanic origin.

The magnitude and direction of flow exchanged between surface water and groundwater varies both in time and spatially (i.e., the geographic distribution of gaining and losing stream reaches is not constant). When this flux is net positive into the aquifer over the Basin, it is commonly referred to as stream leakage; when it is net positive into the stream it is referred to as groundwater discharge.

In most years, the net direction in the entire watershed of stream-aquifer flux is as aquifer recharge into the river, with the largest net groundwater replenishment from streams occurring in wet years. Seasonally, the magnitude of leakage from the streamflow system to the aquifer is greatest during late winter and early spring, while the net magnitude of groundwater discharge to the stream is greatest in late fall at the end of the dry season (least seasonal recharge). Spatially, the mainstem Shasta River is alternately gaining and losing depending on the season, on the location, and on the year type. In other words, river water weaves in and out of the aquifer on its journey along the valley floor. The upper sections of tributaries tend to be losing stream reaches but conditions depend on precipitation levels during any given water year. Some of the tributaries tend to be dry in the summer months before connecting to the main stem of the Shasta river.

With respect to the functional flows of the Shasta River, depletion of surface water due to groundwater pumping affects the timing of the late spring recess, the amount of summer baseflow, and the onset of fall flush flow.

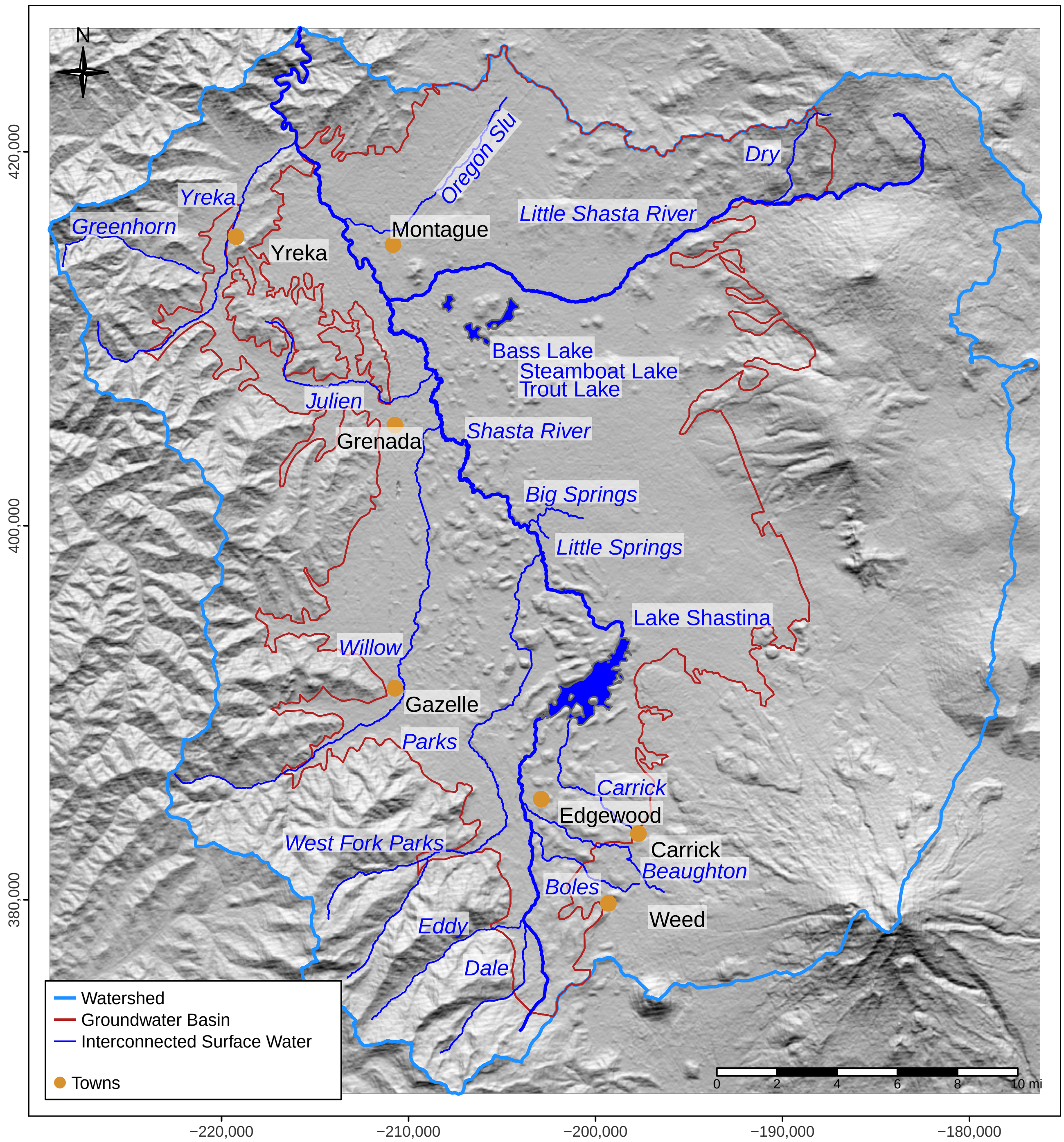


Figure 2: Major ISW in Shasta Valley.

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. Chinook salmon, coho salmon, steelhead trout, pacific lamprey and riparian vegetation are all prioritized for management in the Basin as managing for these species 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 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;
- establishing 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 three categories: riparian GDE, assumed GDE and assumed not a GDE (where the grid-based analysis showed that the area is disconnected from groundwater). Based on this analysis, around 22% of the mapped potential GDE area is likely connected to groundwater and 14% of the mapped potential GDE area is composed of riparian GDEs (shown in Figure 3, below).

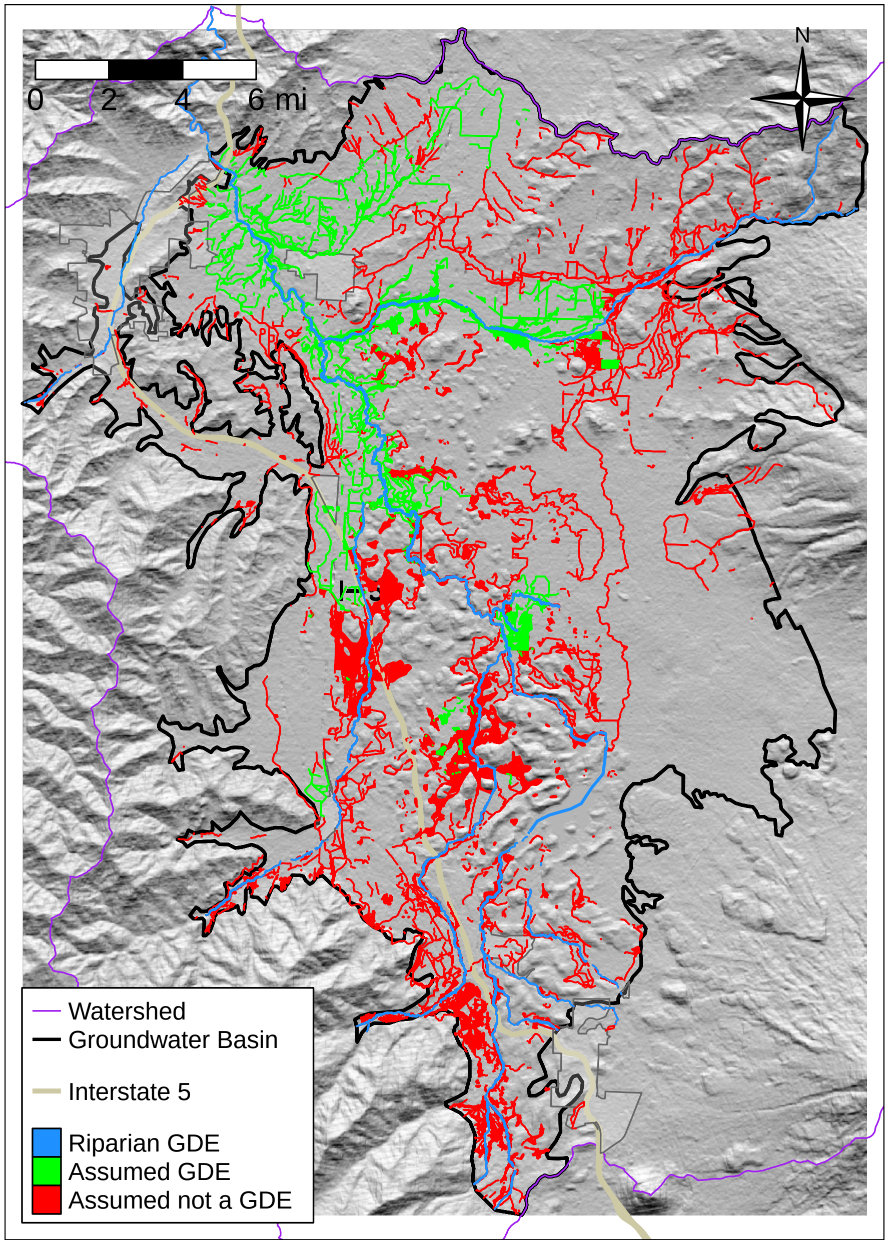


Figure 3: Categorized GDEs within the Basin.

Water Budget (Section 2.2.3)

The historical water budget for the Basin was estimated for the period October 1991 through 2018, using the Shasta Watershed Groundwater Model (SWGM). This 28-year model period includes water years ranging from very dry (e.g., 2001 and 2014) to very wet (e.g., 2006 and 2017). 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 three subsystems of the integrated watershed: the surface water subsystem, the soil zone (land/soil model subsystem) and the groundwater subsystem.

Stream and lake seepage, at 124 TAF per year, accounts for 96% of the contributions from surface water to the groundwater subsystem in the Basin. Fluxes from the groundwater subsystem to surface water is primarily through groundwater leakage into streams with an average value of 219 thousand acre-feet (TAF). Agricultural pumping in the Basin accounts for an average of 43 TAF per year, around one-third of the total land/soil subsystem recharge in the Basin. The difference between total outflows from the groundwater subsystem to land and surface water (312 TAF/ year, on average), and land and surface water inflows to the groundwater subsystem (255 TAF/ year, on average is due to net groundwater inflow from outside the Basin.

Within the integrated model, fluxes from each subsystem to the other two subsystems are simulated as distinct components (e.g. stream leakage, recharge through the soil zone, and applied irrigation water). This section contains a description of each water budget component.

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 Shasta Valley watershed (Watershed).

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 ISW
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 progress made towards 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	Greater than the depletion under which a minimum threshold of 100 CFS +/- 20% average monthly groundwater contributions occurs, for two consecutive years.
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 used to achieve the Shasta Valley sustainability goal.

To achieve the sustainability goals for Shasta Valley by 2042, and to avoid undesirable results over the remainder of a 50-year planning horizon, as required by SGMA regulations, multiple projects and management actions (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:

- Nature Conservancy Leasing Program
- Safe Harbor Group Flow Management
- Bank Stabilization, Streambed Alteration, Floodplain Enhancement, and Riparian Vegetation
- Riparian Fencing and Planting
- Novy Ice Zenkus Fish Passage Improvement Project
- Montague- Grenada Weir Modification Project
- Piezometer Transect Study Project
- City of Yreka Water Demand

- Enforcement of Survival Permits Authorizing Shasta River Template Safe Harbor Agreement
- Site Plans/ Recovery of Sothern Oregon/ Northern California Coast (SONCC) Coho Salmon
- Shasta River Tailwater Reduction Plan
- Upland Management

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

Tier II PMAs include:

- High Priority PMAs - Data Gaps and Data Collection
  - Shasta Watershed Groundwater Model (SWGM) 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)
- Aquifer Characterization Analysis
- Avoiding Significant Increase of Total Net Groundwater Use from the Basin
- Upslope Water Yield Projects
- Habitat Improvement in Shasta Watershed
- Instream Flow Leases
- Irrigation Efficiency Improvements
- Juniper Removal
- Reporting of Pump Volumes
- Voluntary Managed Land Repurposing
- Shasta Recharge Pilot Project

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

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

- Alternative, lower ET Crops
- MAR and ILR
- Strategic Groundwater Pumping Curtailment
- Reservoirs

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 SWGM model updates, SMC tracking, and other technical analysis.
4. Reporting, including preparation of annual reports and 5-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 $168,750 and $287,500. 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 (GSPs), 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 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 Shasta Valley 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 Shasta 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 GSA developed a Shasta 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 Shasta 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 the 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. Shasta 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.
- Recreational users.
- Tribal Governments.
- Disadvantaged Communities (DAC) and Severely Disadvantaged Communities (SDAC; 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.
- **Public Workshops**: Public workshops and open houses were held as information sessions and provided the opportunity to have conversations with the public, answer questions, and gather feedback. A list of the public workshops and open houses that were held during GSP development are included in Appendix 1-B.
- **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. Draft chapters were discussed, along with a summary of comments received and proposed revisions, at Advisory Committee meetings following public review of draft GSP chapters. These meetings provided the opportunity for discussion on the main comments received and proposed revisions in response to this feedback. Comments received through this process, and the responses provided are included in Appendix 1-C and 1-D.

1.4.4. Coordination

GSA and Siskiyou County staff, and, as needed, the 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 as needed 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 issue's related to groundwater management.
- **North Coast Regional Water Quality Control Board (NCRWQCB)**
  - Recently, GSA staff and the technical team has met with NCRWQCB staff regarding efforts to gather groundwater samples, and to also discuss the relationship of Total Maximum Daily Loads (TMDL) waivers in Scott and Shasta Valleys and how those will be impacted or partnered with projects and managements actions in the GSP.
  - GSA staff and technical team participated in a Scott and Shasta flow working group, led by Regional Board staff, where several topics were discussed, including: immediate project needs, actions as they will relate to GSP actions and projects, and development of interconnected surface water (ISW) sustainable management criteria (SMCs). Members of the working group provided comments and asked questions that were answered by the technical team.
- **Quartz Valley Tribe**
- **Yurok Tribe**
- **Karuk Tribe**
  - The GSA developed a Memorandum of Understanding (MOU) with the Karuk Tribe regarding improving coordination and communication efforts related to GSP development, which provided a bridge of opportunity to discuss and deliberate on GSP development for the Scott and Shasta groundwater basins. This took multiple meetings, with valuable assistance from DWR provided Facilitation Support Services. The MOU (in Appendix 1-E) was signed and approved by the District Board on March 17, 2020.
- **State Water Resources Control Board (SWRCB)**
  - Only for the Shasta Valley Basin, GSA staff and the technical team regularly met with SWRCB staff regarding developing groundwater and surface water models for the Shasta River. Both parties regularly shared information, data and input for their respective parties modeling needs. More information regarding SWRCB's modeling efforts in the Shasta can be found in Chapter 2.
  - In 2018, on November 14th and 15th, GSA and County staff, District Board members, met with SWRCB staff and toured agricultural operations in the Scott and Shasta Valleys to discuss water issues and observe on-ground projects being planned or implemented that in various ways will help improve both groundwater and surface water sources.
- **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 both being implemented and in initial design phases, including managed aquifer recharge, storage development and improving upland lake management. These projects are further described in Chapter 4.

- **Scott and Shasta Valley Watermaster District**
  - GSA staff and the technical team have had multiple meetings with Watermaster District staff affirming that the GSP's will not conflict with the Watermaster duties of upholding the Scott and Shasta Valley decrees. The meetings have also been beneficial to understanding current data related to flow and determining data gaps that will both aid in the accuracy and reliability of both groundwater basins respective numerical models.

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 MOs 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-F, 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

Jurisdictional Areas and Land Use

The boundaries of the Shasta Valley groundwater basin (Basin) and Shasta River drainage basin (Watershed) are shown in Figure 2.1. The population of the Basin was estimated at 13,070 during the 2010 Census (DWR 2019b), including the populations of the incorporated cities of Yreka (7,765), Weed (2,967), and Montague (1,443). The Basin also is home to the census-designated places (CDP) of Grenada (367), Carrick (131), Gazelle (70), and Edgewood (43). Communities with an annual median household income (MHI) of less than 80% of the average annual median household income (MHI) in California are classified as Disadvantaged Communities (DACs), while communities with annual MHIs of less than 60% of California's average annual MHI are considered Severely Disadvantaged Communities (SDACs). Communities in the Basin categorized as either disadvantaged or severely disadvantaged include: Gazelle, Grenada, Montague, Weed, and Yreka (Figure 2.2). Based on the 2012 to 2016 DAC Mapping Tool, the statewide average annual MHI is $63,783 and Gazelle, Grenada, Weed, and Yreka all qualify as SDACs with annual MHIs of $31,389, $29,773, $29,427, and $30,202, respectively (DWR 2016). Montague has an annual MHI of $41,923, which qualifies it as a DAC. Carrick and Edgewood are not listed in the government database as either a DAC or SDAC as no MHI data is provided for either CDP (DWR 2016).The DAC and SDAC communities depend on groundwater as a source of drinking water.

The majority of the land within the Basin is under private ownership with the remaining area managed by the California Department of Fish and Wildlife (CDFW), United States Bureau of Land Management (BLM), and the United States Forest Service (USFS). Much of the Watershed surrounding the Basin is a mixture of private (mostly forest) and USFS land. Two large conservation properties (CDFW's Shasta Valley and Big Springs Ranch Wildlife Areas) cover the northern and central portions of the Basin (Figure 2.3). The dominant land use in the Basin is agriculture with pasture, alfalfa, and grain and hay comprising the primary crops (Figure 2.4). The original Bulletin 118 Basin boundary (DWR 2004) consisted of 52,589 acres and was classified as medium priority. The Agency successfully modified the Basin through the California Department of Water Resources (DWR) 2018 Basin Boundary Modification Process. The modified Basin was finalized by DWR in February of 2019 and increased to 217,980 total acres. The updated boundary accounts for much more of the groundwater pumping in the Basin allowing for more comprehensive management moving forward. This modification substantially increased the area designated under the Sustainable Groundwater Management Act (SGMA), and also expanded the extent of the Basin to include various complex geological and hydrological areas of the Watershed requiring significantly more resources to fully develop an understanding of the various hydrological connections in the Basin. Gaining such understanding will require filling numerous data gaps. Portions of the Basin lack sufficient well monitoring sites within the network and some regions completely lack monitoring wells. The absence of a comprehensive well monitoring network is a critical data gap in the analysis of groundwater level trends. Surface water-groundwater interaction is a key sustainability criterion to evaluate within the Basin's groundwater sustainability plan (GSP). Therefore, continuously measured surface water and groundwater levels are necessary to build on the biannual measurements collected under DWR's California Statewide Groundwater Elevation Monitoring (CASGEM) Program when analyzing groundwater-surface water interaction.

Groundwater and surface water are hydraulically connected in the Basin. Beginning in 1992, the State Water Resources Control Board (SWRCB), in conjunction with the North Coast Regional Water Control Board (NCRWQCB), identified WQOs within the Shasta River. The Shasta River is in out of compliance of the Total Maximum Daily Load (TMDL) for temperature and dissolved oxygen. The Shasta River TMDL is explored in greater detail in Section 2.1.2. Under the California Water Action Plan, the Shasta River was named one of five priority stream reaches that the SWRCB, in coordination with CDFW, will "seek to enhance flows to support and improve critical habitat for anadromous fish" (State of California 2014).

In September 2018, the SWRCB released their "Draft Shasta River Watershed Characterization and Model Study Plan" which outlines a proposed groundwater-surface water modeling plan for the Shasta River, distinct from the current integrated model developed for the GSP. The development of such a model will be an integral part of this Basin's GSP implementation process to enable the decision-makers to run different scenarios, create the Basin's water budget, and determine projects that will assist the Basin in attaining groundwater sustainability and improving in-stream flows for anadromous fishery needs in the Shasta River. The County of Siskiyou (County), Basin stakeholders, and SWRCB staff have been collaborating on combining aspects of both modeling projects, including collaborating on data collection. The County and the SWRCB entered into a Memorandum of Understanding (MOU) on October 18, 2019 to coordinate future collaborations. Data gaps should be filled for modeling inputs to enable tracking water movement through the Basin and establishing a water budget. Therefore, strategic continuous groundwater observations and measurements will provide valuable information for model development and installation of soil moisture sensors is crucial in the Basin's efficient water use. Additionally, water users are encouraged to pursue projects that aid in the NCRWQCB TMDL requirements, including minimizing tailwater from entering the Shasta River and associated tributaries by working with NCRWQCB to develop land management plans.

Groundwater is not adjudicated within the Basin. No other groundwater sustainability agency (GSA) is present within the Basin. An Alternative Plan (to a GSP) was not prepared for the Basin.

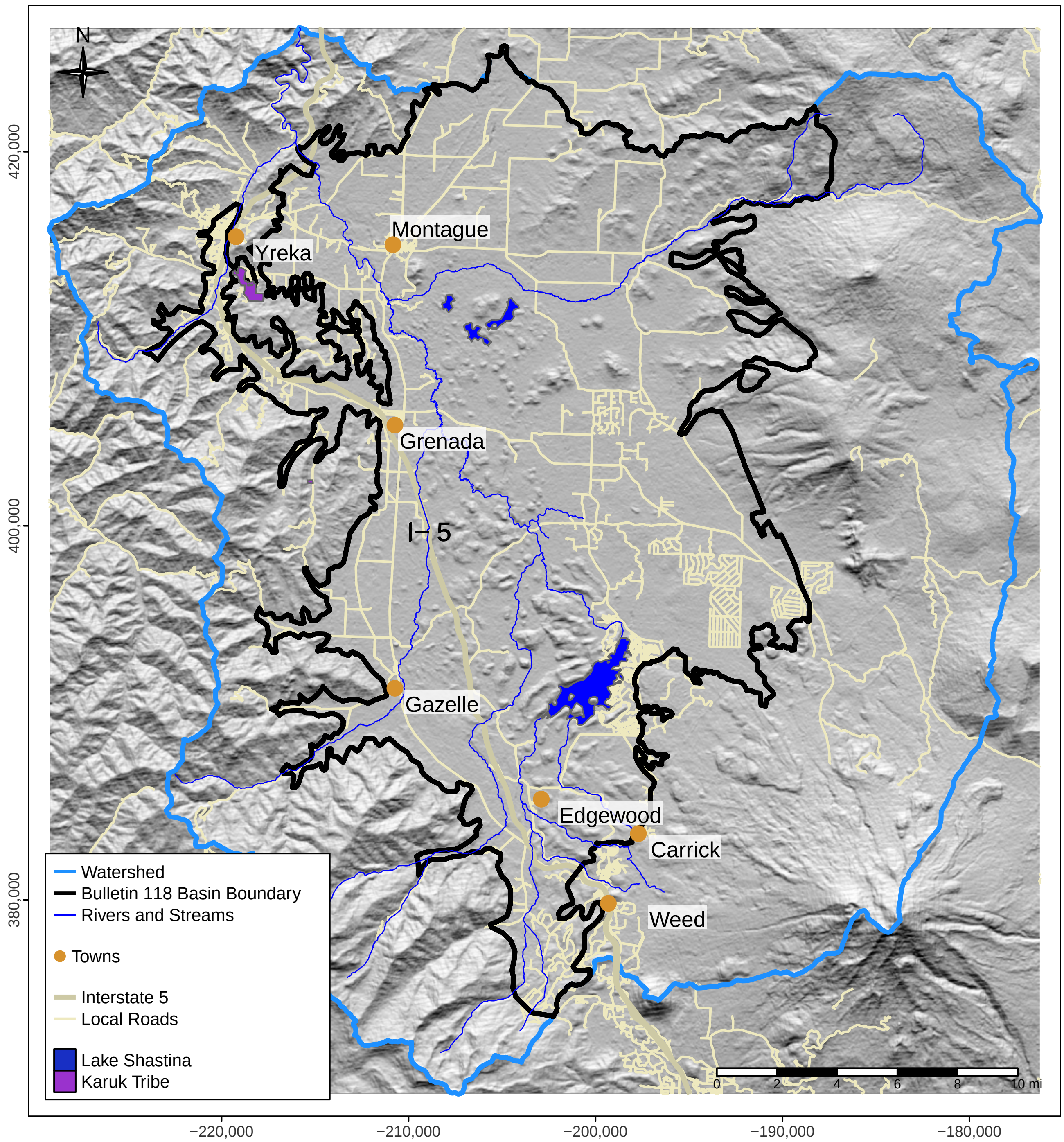


Figure 2.1: Bulletin 118 Basin boundary (black) and Watershed boundary (light blue).

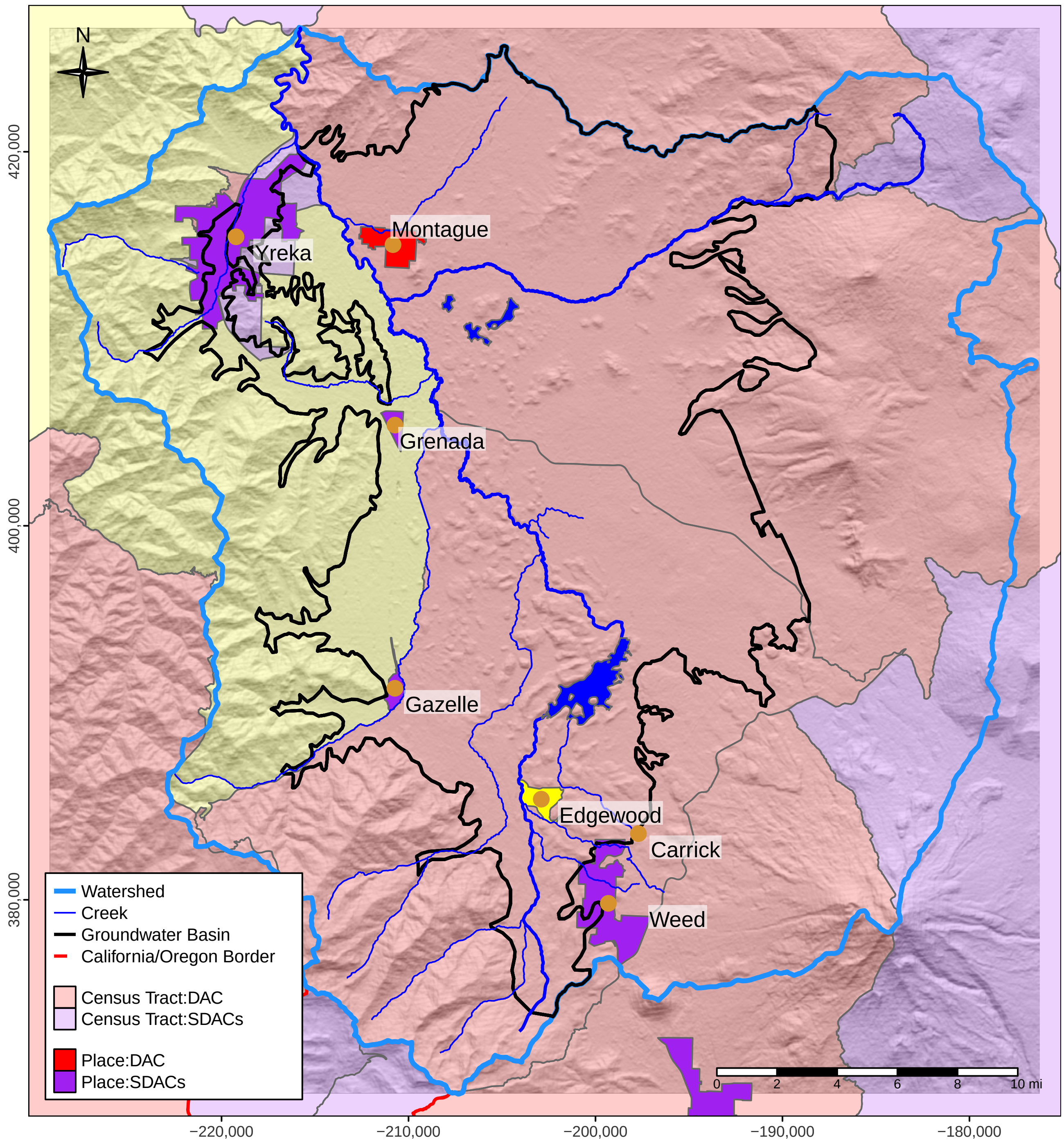


Figure 2.2: Based on the 2016 U.S. Census, place and tract boundaries of DAC and SDAC in the Basin (DWR 2016).

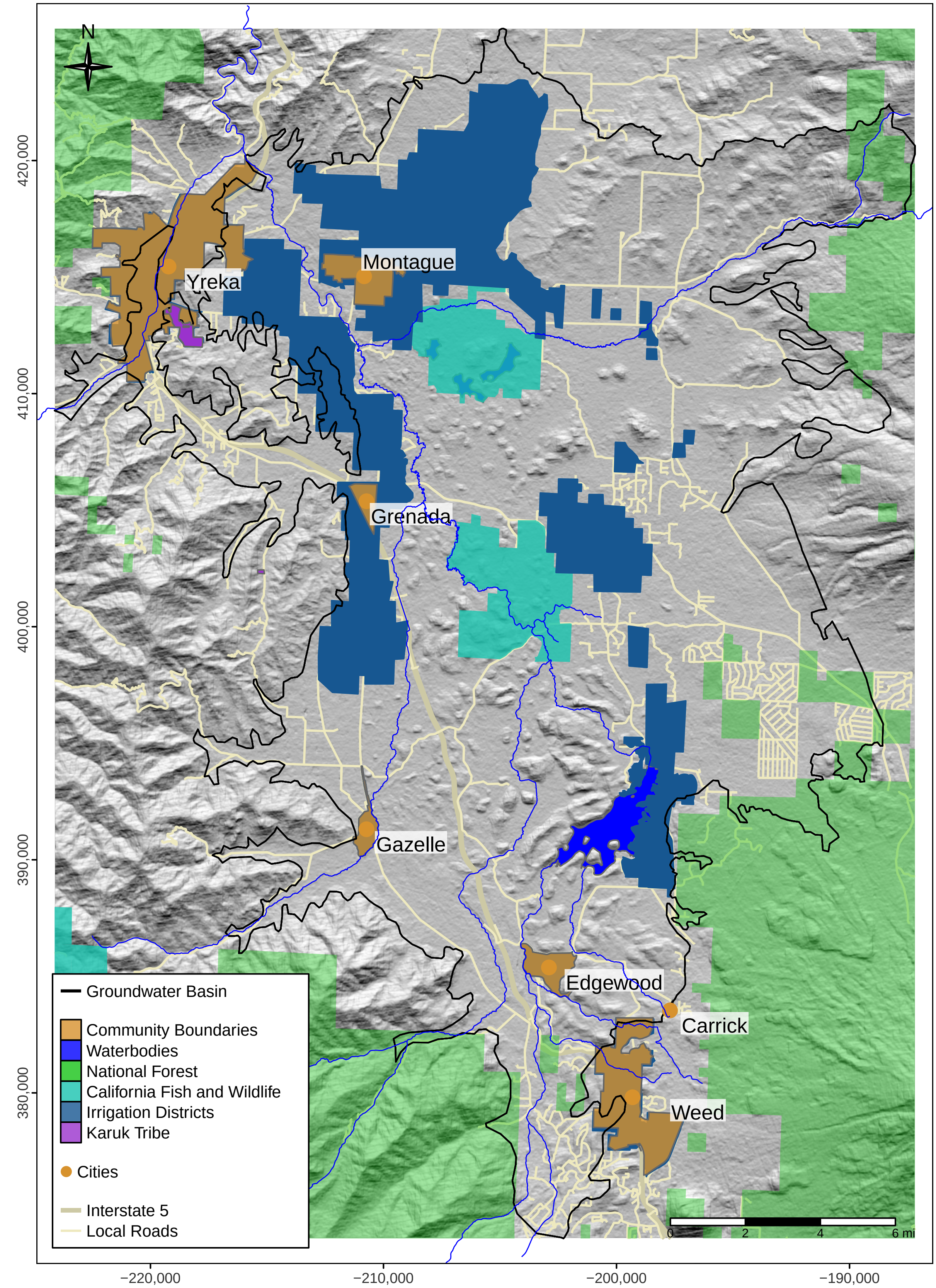


Figure 2.3: Irrigation districts and administrative areas within the Basin

Current Land Use

Acreages associated with various land uses surveyed by the County in 2010 and updated based on stakeholder comments are presented in Table 2.1 (DWR 2010). Land use within the Basin is discussed further in Section 2.1.3.

Table 2.1: Acreage and percent of total Basin area covered by all identified land uses in the updated 2010 County of Siskiyou land use survey. Updates provided by stakeholder comments.

Land Use Description	Area (Acres)	Percent (%)
Alfalfa	7990.16	1.6
Barren	9.03	0
Commerical	1556.44	0.3
Farmsteads	954.73	0.2
Fruit	36.03	0
Grain and Hay	10755.66	2.1
Idle	2286.93	0.4
Native	420905.43	82.8
Native Water	4555.87	0.9
Pasture	41734.78	8.2
Riparian	1954.93	0.4
Semi-Ag	5.89	0
Truck, Nursery, and Berry	180.18	0
Unknown	226.88	0
Urban	15346.09	3
Total	508499.02	100

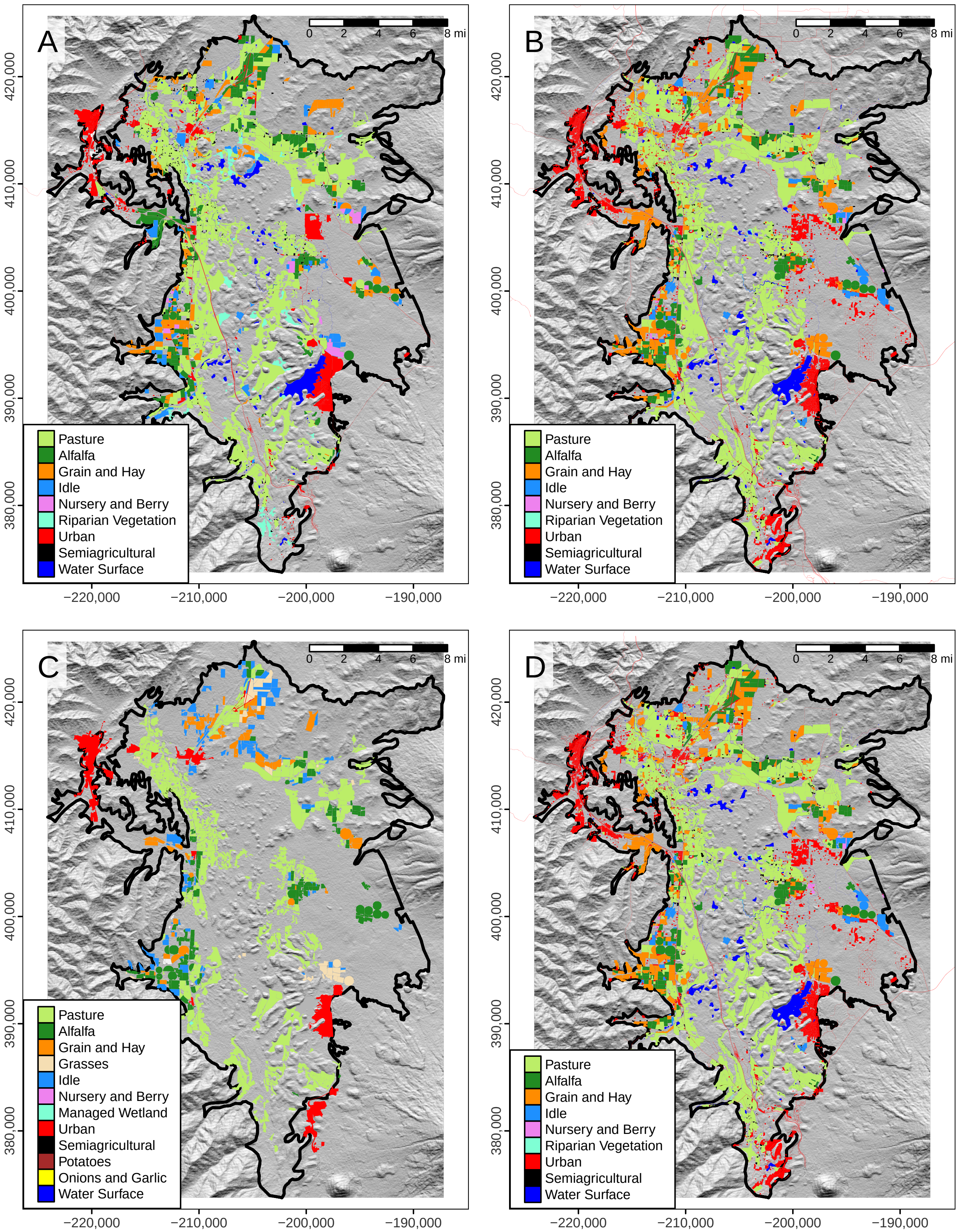


Figure 2.4: Land uses within the Basin boundary taken from the 2000 DWR Siskiyou Land Use Survey (Panel A), the 2010 DWR Siskiyou Land Use Survey (Panel B), the 2014 DWR LandIQ Land Use Survey (Panel C), and the stakeholder updated 2010 DWR Siskiyou Land Use Survey (Panel D).

Well Records

Public data regarding wells is limited in the Basin. 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 2.5). Because OSWCR represents an index of Well Completion Report records dating back many decades, this dataset may include abandoned wells, destroyed wells, or wells with quality control issues such as inaccurate, missing or duplicate records, but is nevertheless a valuable resource for planning efforts.

The primary uses of the wells reviewed were:

- Domestic Wells: 3,264
- Agricultural Production Wells: 388
- Public/Municipal Wells: 35

Currently only CASGEM wells (Section 2.1.2) and future monitoring networks are included as observation wells.[1]

In alignment with urban land use areas, the density of groundwater wells is highest in the south and northwest sections of the Basin, especially near the cities of Montague, Grenada, Weed and Yreka, as shown in Figure 2.5.

[1] {https://water.ca.gov/Programs/Groundwater-Management/Groundwater-Elevation-Monitoring--CASGEM}

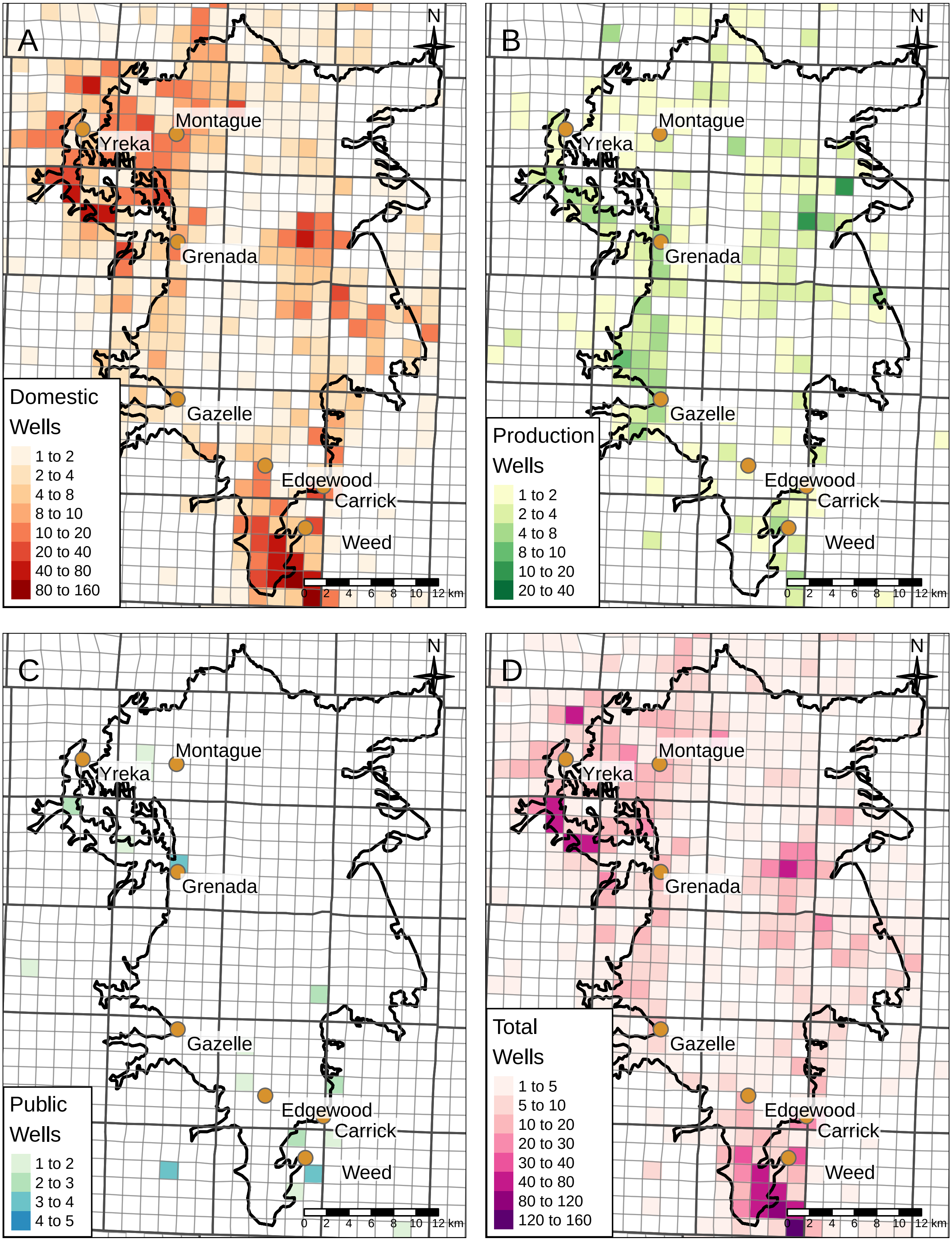


Figure 2.5: Well density maps indicating number of domestic (panel A), agricultural (panel B), and public (panel C) Well Completion Reports present in each Public Land Survey System (PLSS) section, based on data from the DWR Online System for Well Completion Reports (OSWCR). Panel D shows the sum of panels A-C.

2.1.2 Water Resources Monitoring and Management Programs

An array of historical and ongoing efforts have been carried out in the Basin and Watershed related to the management of surface and groundwater resources. The following section describes each monitoring and/or management program, and outlines the current understanding of a) how those programs will be incorporated into GSP implementation and b) how they may limit operational flexibility in GSP implementation.

2.1.2.1 California Department of Water Resources (DWR)

The CASGEM program is managed by DWR. CASGEM collects and centralizes groundwater elevation data across the state and makes them available to the public. The CASGEM Program has tracked seasonal and long-term groundwater elevation trends in groundwater basins statewide. 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.[2] Additionally, the full dataset can be retrieved from the California Natural Resources Agency (CNRA) Open Data website.[3]

As of October 2019, records from the CASGEM well network in the Basin cover much of the Basin with 37 wells of varying temporal coverage spanning the 1950s to present (27 stations were active in 2018 and 2019, 24 were active in 2019, and 10 are no longer active). The majority of these wells within the Basin boundary are designated as “Voluntary” status (DWR 2019c). “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). No limitations to operational flexibility of monitoring groundwater levels in GSP implementation are expected in the Basin due to implementation of the CASGEM Program because continuous monitoring stations can be jointly biannually measured.

In addition to the CASGEM Program, DWR operates two stream gages within the Basin. The stations are located at the Parks Creek diversion near Edgewood (Station ID: MPD; records from 2005 to present) and the Shasta River at the Grenada pumping plant (Station ID: SPU; records from 2013 to present). These and other stream gages are critical for calibration of integrated hydrologic models as well as developing conceptual knowledge models of the hydrologic system in the Basin.

2.1.2.2 California Department of Fish and Wildlife (CDFW)

Big Springs Ranch Wildlife Area (BSRWA)

The Big Springs Ranch area contains the largest groundwater springs (by water flow rate) in the Basin. The Big Springs Complex (including Big and Little Springs) is a critical water source to the Shasta River, often contributing more water than flows derived from the Shasta River upstream of the confluence with Big Springs Creek. The Big Springs Complex supplies approximately 95

[2] {https://water.ca.gov/Programs/Groundwater-Management/Groundwater-Elevation-Monitoring--CASGEM}
[3] {https://data.cnra.ca.gov/}

percent of summer baseflow in the lower Shasta River via Big Springs Creek (Nichols et al. 2010). The Big Springs Complex is one of the most important groundwater dependent ecosystems (GDEs) in the Basin due to its critical aquatic habitat for anadromous fish. CDFW recently acquired the Big Springs Ranch from The Nature Conservancy (TNC) in the middle of 2019. The BSRWA was purchased for the protection and preservation of water rights and anadromous fish habitat. The location of BSRWA and its access to nutrient-rich cold spring water provides critical habitat for Fall Chinook and the endangered and threatened Coho salmon, making protection and restoration of the ranch's waterways essential for these populations. TNC and its partners restored 10 miles of river, planted 6,000 native riparian trees, invested in over 60 scientific research projects and implemented new practices developed to improve salmon habitat by decreasing water temperatures and increasing stream flows, all while running an active cattle ranch. The numerous scientific studies focusing on the surface water and groundwater features of this property were conducted by University of California, Davis (Center for Watershed Sciences, UC Davis), the Shasta Valley Resource Conservation District (SVRCD), and numerous environmental consultants. Future operations will be carried out by the CDFW Fisheries Branch rather than the CDFW Wildlife Area Lands Department. All monitoring and management operations past, present, and future in BSRWA will be incorporated in the development of this GSP.

Shasta Valley Wildlife Area (SVWA)

SVWA was designated as a wildlife area by the Fish and Game Commission in 1991. According to CDFW, it contains approximately 4,700 acres of Great Basin juniper woodland, riparian forest, seasonal wetlands, and crop lands, with Mt. Shasta as a backdrop. Sandhill cranes, waterfowl, raptors, and shorebirds are commonly seen at SVWA. Deer, porcupines, and coyotes are among the mammals that can be seen. There are three deep water reservoirs and numerous seasonal wetlands on the wildlife area.[4] There are three domestic wells and no irrigation wells that CDFW operates on this property. CDFW does not utilize groundwater for managing habit in SVWA, only surface water management via diversion from the Little Shasta River. Operations of surface water management at SVWA will be incorporated in the development of this GSP.

2.1.2.3 California Department of Pesticide Regulation (CDPR)

The CDPR maintains a current well inventory database containing data from wells sampled for pesticides by a variety of agencies, including the California Department of Public Health (prior to CDPR reporting being taken over by SWRCB), CDPR, DWR, United States Geological Survey (USGS), and SWRCB Division of Drinking Water (DDW). These agencies monitor a variety of wells for 35 different pesticides and report measurements to the CDPR. Wells monitored include domestic, large and small water systems, irrigation, and community wells. Exact locations are not known, but based on an estimation of coordinates using county, township, range, and section data, there are 33 wells monitored within the Basin with groundwater quality measurements for pesticides like atrazine, aldrin, and simazine.

[4] {https://wildlife.ca.gov/Lands/Places-to-Visit/Shasta-Valley-WA}

2.1.2.4 California State Water Resources Control Board (SWRCB)

SWRCB manages several programs that are active in the Basin and are described below. In addition to managing a water rights permitting licensing program, the SWRCB Division of Water Rights is also responsible for conducting statutory and court reference adjudications. The SWRCB receives statements of water use and diversion from surface water users in accordance with SB 88 (State of California 2015).

The SWRCB may also issue curtailment orders under drought emergency conditions, similar to those issued between 2014 and 2017. On August 30, 2021, the SWRCB issued a drought emergency order for the Scott and Shasta River watersheds that authorized the Division of Water Rights to issue curtailment orders for a range of users including groundwater pumpers. Certain domestic, public, and stockwater use rights were exempt.

Division of Drinking Water (DDW)

The SWRCB DDW, (formerly under the Department of Health Services) monitors public water system wells per the requirements of Title 22 of the California Code of Regulations relative to levels of organic and inorganic compounds such as metals, microbial compounds and radiological analytes. Data are available for active and inactive drinking water sources, for water systems that serve the public, and wells defined as serving 15 or more connections, or more than 25 people per day. In the Basin, DDW wells were monitored for Title 22 requirements, including pH, alkalinity, bicarbonate, calcium, magnesium, potassium, sulfate, barium, copper, iron, zinc, and nitrate.

Division of Water Rights

The SWRCB's Division of Water Rights have jurisdiction over diversions of water not covered by the Scott Valley and Shasta Valley Watermaster District (SSWD).

Groundwater Ambient Monitoring and Assessment Program (GAMA)

Established in 2000, the Groundwater Ambient Monitoring and Assessment (GAMA) Program monitors groundwater quality throughout the state of California. The GAMA Program created a comprehensive groundwater monitoring program throughout California and increased public availability and access to groundwater quality and contamination information. The GAMA Program receives data from a variety of monitoring entities including DWR, USGS, and the SWRCB. GeoTracker, operated by the SWRCB, is a subset program of the GAMA program. GeoTracker GAMA does not regularly monitor for general groundwater quality constituents. GeoTracker contains records for sites that require cleanup, such as leaking underground storage tank sites, Department of Defense sites, and cleanup program sites. GeoTracker also contains records for various unregulated projects as well as permitted facilities including: the Irrigated Lands Regulatory Program (ILRP), oil and gas production, operating permitted underground storage tanks, and land disposal sites. GeoTracker receives records and data from SWRCB programs and other monitoring agencies.

2.1.2.5 Endangered Species Conservation Laws

Federal Endangered Species Act (ESA)

The Endangered Species Act (ESA) outlines a structure for conserving threatened or endangered 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 Department of the Interior's U.S. Fish and Wildlife Service (FWS), primarily responsible for terrestrial and freshwater species, and the Department of Commerce's National Marine Fisheries Service (NMFS) which primarily handles marine wildlife and anadromous fish. In Shasta Valley, coho salmon are listed as threatened under the ESA, as part of the Southern Oregon and Northern California coasts (SONCC) evolutionary significant unit (ESU).

California Endangered Species Act (CESA)

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 federal ESA, the 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 for "candidate species" exists under CESA that includes species or subspecies that have been formally noticed as under review. Coho salmon are also listed as threatened under CESA. Additional detail on other species in Shasta Valley listed under CESA can be found in Section 2.2.1.7 as part of the discussion on 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, 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.

2.1.2.6 Public Trust Doctrine

The public trust doctrine is a legal doctrine under which the State is a Trustee to protect resources including waters, tidelands, and wildlife resources of the state, which are held in a trust for all people. In 2010, the Environmental Law Foundation (ELF), Pacific Coast Federation of Fisherman's Associates, and the Institute for Fisheries Resources filed against the SWRCB and the County of Siskiyou over permitting of wells near the Scott River, alleging that these wells decreased flows in the Scott River, diminishing suitability for recreational uses of Scott River and harming fish populations. The petitioners argued that the public trust doctrine applies to groundwater that is hydrologically connected to navigable surface water and sought an injunction to stop the County from issuing permits for groundwater wells until it complied with the public trust doctrine. The ruling by the trial court affirmed that the County had a duty to consider the public trust doctrine prior to issuing well permits and that the doctrine "protects navigable waters from harm caused by extraction of groundwater, where the groundwater is so connected to the navigable water that its extraction adversely affects public trust uses." After an appeal, the Third Appellate District published an opinion in 2018 on the *Environmental Law Foundation v. State Water Resources Control Board ("ELF")* which noted that the County has a public trust duty, when issuing well permits, to consider if groundwater extractions impact public trust uses and that SGMA does not supersede, fulfill, or replace the County's public trust duties.

2.1.2.7 University NAVSTAR Consortium (UNAVCO)

In the Watershed, subsidence monitoring is partially performed using continuous global positioning system (GPS) stations monitored by UNAVCO's Plate Boundary Observatory (PBO) program. The UNAVCO PBO network consists of a network of about 1,100 continuous global positioning system (CGPS) and meteorology stations in the western United States to measure deformation resulting from the constant motion of the Pacific and North American tectonic plates in the western United States. Information from this monitoring can support the monitoring of land subsidence resulting from the extraction of groundwater.

There are four CGPS stations (P657, P658, P661, and P663) within the Watershed but not within the Basin (all are on the north slope of Mount Shasta) with records spanning 2007 to the present. There is one borehole strainmeter operated by UNAVCO within the Basin near Gazelle (B039) with data records from 2007 to present. However, this instrument does not record vertical displacement and is not capable of characterizing land subsidence.

2.1.2.8 United States Bureau of Reclamation (USBR)

USBR is granting funds to the Agency to install 10 co-located, continuous groundwater level and soil moisture sensors that will be incorporated into the Basin's GSP development and implementation.

2.1.2.9 United States Geological Survey (USGS)

USGS operates two stream gages within the Watershed (one within the Basin boundary). The stations are located on the Shasta River near Montague (DWR Station ID: SRM [USGS Station ID: 11517000]; records from 1999 to present) and on the Shasta River near Yreka (Station ID: SRY [USGS Station ID: 11517500]; records from 2000 to present).

Although neither of these stream gages provide a comprehensive picture of surface water flows in the Basin, they provide some information about the inflow and outflow of surface water through the Basin.

2.1.2.10 North Coast Regional Water Control Board (NCRWQCB)

Groundwater quality within Shasta Valley is regulated under the NCRWQCB Water Quality Control Plan for the North Coast Region (Basin Plan) (NCRWQCB 2018b):

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 (WQO) for groundwater based on the assigned beneficial uses (NCRWQCB 2018b). 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)

Potential beneficial uses designated for groundwater include: Industrial Process Supply (PRO) and Aquaculture (AQUA; see NCRWQCB 2018b). The MUN beneficial use designation is used to protect sources of human drinking water and has the most stringent WQOs. The MUN beneficial use applies to all groundwater in Shasta Valley.

Section 3.4 and Table 3-1 of the Basin Plan outlines the WQO for all groundwaters in the North Coast Region and those specific to the Shasta Valley Hydrologic Area (NCRWQCB 2018b). 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 2018b; State of California 2019). The Basin Plan WQO and numerical limits are used in Section 2.2.2 of the GSP regarding water quality characterization and issues of concern. They will also guide Section 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 and TMDL components.

Total Maximum Daily Loads (TMDLs)

TMDLs regulating temperature and dissolved oxygen in the Watershed were first promulgated in 2006 (NCRWQCB (California North Coast Regional Water Quality Control Board) 2006). The Shasta River TMDLs for dissolved oxygen and temperature were established in accordance with Section 303(d) of the Clean Water Act. The United States Environmental Protection Agency (USEPA) added the Shasta River to the impaired waters list in 1992 due to low dissolved oxygen. The listing was modified in 1994 to include elevated temperature. In 2006 the NCRWQCB incorporated these TMDLs into the Basin Plan. The plan has undergone multiple updates with the current iteration released in 2018 (NCRWQCB 2018a).

Since 2006 the NCRWQCB has waived the requirement for dischargers (entities or individuals which may discharge pollutants to the Shasta River, or which are responsible for controlling such discharge), if they were not already covered by an existing permit, to file a Report of Waste Discharge (ROWD) and obtain Waste Discharge Requirement permits (WDRs; see NCRWQCB 2018a).

2.1.2.11 United States Forest Service (USFS)

Klamath National Forest

The USFS manages the Klamath National Forest in a manner consistent with the Klamath National Forest Land and and Resource Management Plan (Klamath NF 2010). The Management Plan includes monitoring of aquatic ecosystems, of which water quality monitoring is included. Water temperature and stream flow in Klamath River tributaries are monitored to establish watershed condition and stream health, and to assess the role of tributaries in maintaining water quality in the Klamath River. Water quality data are compared to the standards and criteria of the Clean Water Act to determine if water quality and the health of aquatic systems are being maintained. Water quality monitoring reports are posted to the Klamath National Forest website,[5] and include sediment and water temperature monitoring coordinated with the Regional Water Board. Monitoring of groundwater is not conducted under the Management Plan.

The Klamath National Forest does not manage groundwater wells that report data to the California Department of Public Health (CDPH) or the SWRCB (SWRCB 2019a, 2019b). Due to the minimal amount of Klamath National Forest land in the Basin, it is unlikely the USFS will be a major partner for GSP implementation; however, this may change in the future as monitoring requirements and programs evolve.

Shasta National Forest

USFS manages the Shasta-Trinity National Forest which is managed under the Shasta-Trinity National Forest Land and Resource Management Plan (Shasta-Trinity NF 1995). The Management Plan includes a Monitoring Action Plan that uses monitoring of the following metrics to evaluate best management practices (BMPs) as well as the effectiveness of BMPs for the protection of water quality: water quality parameter monitoring in affected streams, paired watershed studies, monitoring of beneficial uses, site-specific soil erosion monitoring, and slope stability site monitoring. The Shasta-Trinity National Forest also conducts watershed scale analysis to meet the requirements of the Aquatic Conservation Strategy adopted for the President's Plan, Record of Decision for Amendments to USFS and BLM Planning Documents within the Range of the Northern Spotted Owl; Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Related Species (USDA and USDI 1994). Groundwater monitoring is not conducted as part of the Management Plan or the watershed analysis. Watershed Analysis/Assessment Reports, and Monitoring and Evaluation Reports are posted to the Shasta-Trinity National Forest website.

The Shasta-Trinity National Forest does not manage groundwater wells that report data to CDPH or the SWRCB (SWRCB 2019a, 2019b). Due to the minimal amount of Shasta-Trinity National Forest land in the Basin that is managed by the USFS, it is unlikely the USFS will be a major partner for GSP implementation; however, this may change in the future as monitoring requirements and programs evolve.

[5] {https://www.fs.usda.gov/detail/klamath/landmanagement/resourcemanagement/?cid=stelprdb5312713}

2.1.2.12 Karuk Tribe Department of Natural Resources (KTDNR)

The KTDNR operates a field monitoring program in the Basin and posts information to the interactive web portal.[6] The GSA will work with the Karuk Tribe to share information about monitoring programs.

2.1.2.13 Irrigation Districts and Associations

The irrigation season in the Basin generally extends from March 1 or April 1 to October 1. During this time there are four large users of surface water and groundwater:

- Big Springs Irrigation District (BSID)
- Montague Water Conservation District (MWCD)
- Grenada Irrigation District (GID)
- Shasta River Water Association (SRWA)

The first two districts (BSID and MWCD) divert groundwater while the last two districts (GID and SRWA) are adjudicated surface water users outside of SGMA jurisdiction. BSID does not divert surface water. Taken together these four districts maintain water diversions totaling 227 cubic feet per second (cfs), subject to flow availability, during the irrigation season (SVRCD and Trush 2013). The areas served by the four major irrigation districts are shown below (Figure 2.6).

Big Springs Irrigation District (BSID)

BSID does not divert surface water and no longer has water rights to Big Springs Lake (of the original water right, 25 cfs was abandoned in 1987 and the remaining 5 cfs was abandoned in 1996). BSID no longer relies on surface water rights to meet district demands (M. Deas 2006), instead relying on groundwater resources. BSID uses a water delivery system with an upper and lower ditch. The upper ditch tailwater fortifies the lower ditch flows. BSID consists of approximately 1,800 irrigable acres. Operations of surface water management at BSID are incorporated in the GSP in regards to sources of surface water recharge to groundwater.

Montague Water Conservation District (MWCD)

MWCD was formed in 1925 and serves both agricultural and municipal customers. MWCD services the town of Montague and provides water to approximately 14,000 irrigable acres. The water rights of approximately 70 cfs are met through releases from Dwinnell Reservoir (Lake Shastina) that are transported through over 60 miles of canals in the area (Willis et al. 2013). MWCD has flow meters below the reservoir and on Parks Creek diversion and augments supply with groundwater pumping during dry years. Operations of surface water management at MWCD are incorporated in the GSP in regards to sources of surface water recharge to groundwater.

[6] {waterquality.karuk.us}

Grenada Irrigation District (GID)

GID was formed in 1916 and currently serves approximately 1,600 acres of irrigable land; however, GID does not irrigate the entire acreage every year. For example, during the 2018 irrigation season, only 445 acres were irrigated. The GID maintains five miles of open ditch canals, continuous improvements are being made to line the canals with concrete (Grenada Irrigation District 2019). The GID has adjudicated surface water rights via the Shasta River Decree that are not subject to SGMA. Operations of surface water management at GID are incorporated into the Shasta Watershed Groundwater Model (SWGM).

Shasta River Water Association (SRWA)

SRWA serves an area located in the north end of the Basin west of Montague. Current water rights include 42 cfs during the irrigation season (SVRCD and Trush 2013). SRWA has adjudicated surface water rights via the Shasta River Decree that are not subject to SGMA. Operations of surface water management at GID are incorporated into the SWGM.

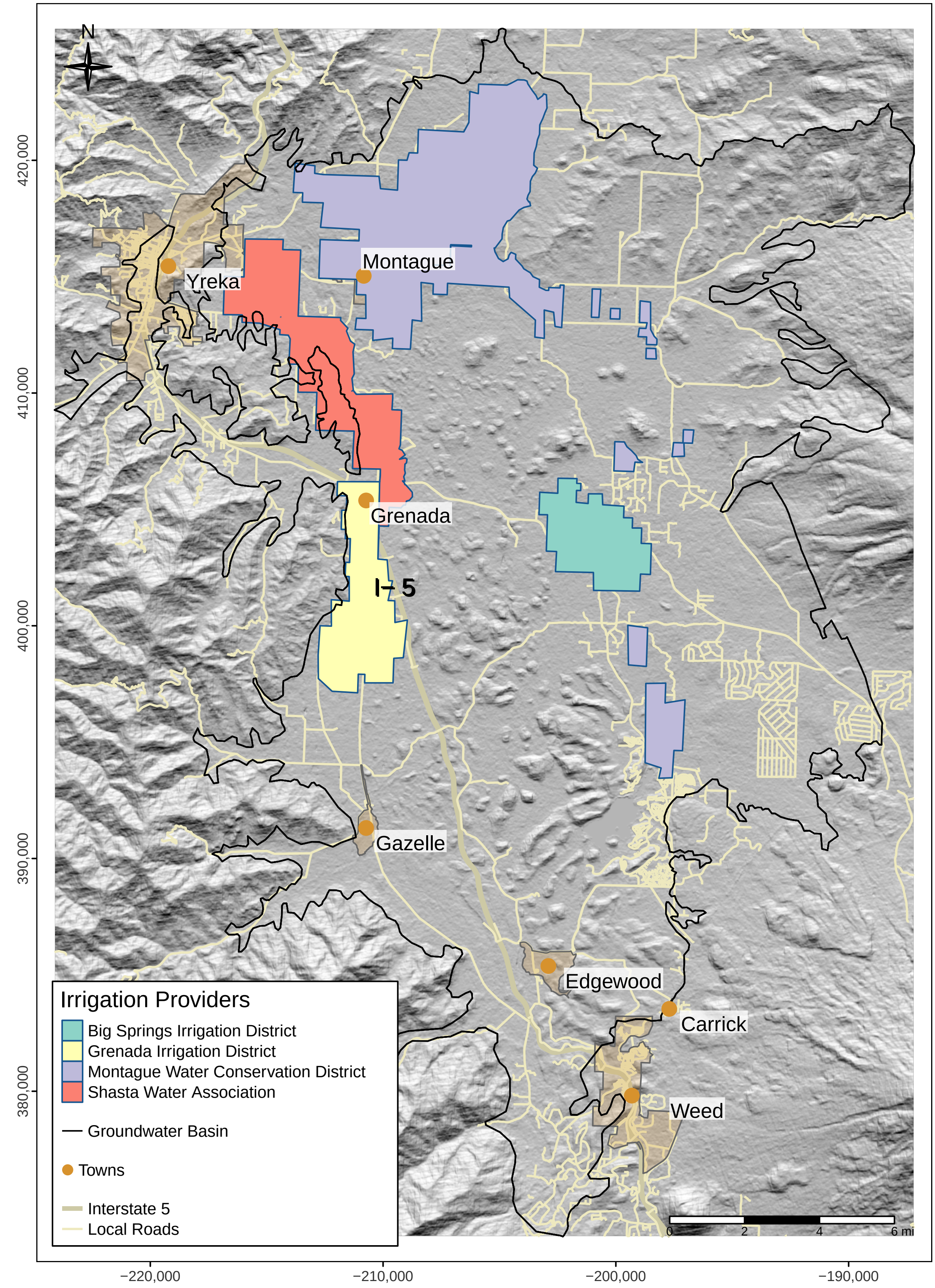


Figure 2.6: Irrigation Districts of the Basin

2.1.2.14 Shasta Valley Resource Conservation District (SVRCD)

The SVRCD is a special district serving central Siskiyou County, California. The SVRCD service area includes the Klamath watershed and all its minor tributaries from the California State line near Keno to below Happy Camp, the entire portion of the Applegate River in California, the lower end of the Scott River, the entire Shasta River drainage basin, and the Siskiyou County portions of the Sacramento River watershed, McCloud watershed and Fall River watersheds.

The SVRCD conducts a variety of surface water and groundwater monitoring efforts through the Watershed for public and private land owners needing assistance with environmental monitoring efforts. The SVRCD is currently installing a DWR-funded monitoring network in the Basin (11 out of a total of 12 continuous monitoring groundwater level stations have been installed). All well owners (public and private) have access to their specific groundwater level data through a secure, private web portal.

The SVRCD performs monitoring for some landowners in the upper Shasta River below Dwinnell Reservoir as part of a Safe Harbor Agreement with local landowners. The data are supplied to the landowner for reporting purposes related to annual use reports.

The SVRCD operates one stream gage within the Watershed (outside of Basin) that is located on Yreka Creek at Anderson Grade Road (Station ID: YCK; records from 2014 to present).

2.1.2.15 County of Siskiyou Flood Control and Water Conservation District (SCFCWCD)

The SCFCWCD is currently installing a DWR- and USBR-funded monitoring network in the Basin for use during GSP implementation. USBR funding has provided 10 co-located groundwater level and soil moisture monitoring stations, two of which are already installed. Soil moisture sensors are expected to help well owners to improve irrigation efficiency. All well owners (public and private) have access to their specific groundwater level data through a secure, private web portal, as well as real-time soil moisture data from their irrigated land. DWR and the SCFCWCD are working towards the installation of new groundwater monitoring wells within the Basin.

2.1.2.16 The Nature Conservancy (TNC)

Big Springs Ranch

TNC formerly owned and managed the Shasta Big Spring Ranch property until mid-2019 when CDFW agreed to purchase the land. TNC conducted a variety of surface water and groundwater monitoring activities on the property in conjunction with UC Davis researchers (see CDFW section for further information on Big Springs Ranch).

Stream Gage

TNC operates one stream gage within the Basin. The station is located on the Little Shasta River near Montague (Station ID: LSR; records from 2010 to present), which was previously operated by DWR.

In-stream Flows

TNC has been conducting additional monitoring of surface flows related to salmonid migration and rearing as part of its in-stream flows program.

2.1.2.17 Scott Valley and Shasta Valley Watermaster District (SSWD; Watermaster)

Surface water diversion rights for the Shasta River and tributaries were set forth in the Shasta River Decree, No. 7035 and adjudicated in 1932. The diversions are located within the Shasta River Watermaster Service Area (Service Area) and controlled by the Scott Valley and Shasta Valley Watermaster (Watermaster). In 1933 the Orders Creating Shasta River Water Master District (aka. Watermaster Service Area) was filed with the Siskiyou County Superior Court. Multiple amendments to the Service Area have been adopted, the largest occurring in 1962 for the creation of the Montague Water District (Decree 3647, 1962) and the exclusion of Cold Creek (Superior Court of Siskiyou County 2018). One supplemental decree was filed with the Siskiyou County Superior Court in 2014. Since February 1, 2012 the service area has been managed by the SSWD per the Petition for Substitution of Watermaster filed with the Siskiyou County Superior Court by Hon. Laura Masunaga, Judge on December 23, 2011. Between February 1, 2012 and June 30, 2018 the appointed Deputy Watermaster was a third party consultant, GEI Consulting, Inc. Beginning July 1, 2018 an SSWD was appointed as the Deputy Watermaster at which time the collection of preliminary diversion data commenced for the purpose of supporting the annual Statement of Use required under Water Code Section 5101. Any data used for reporting prior to July 1, 2018 cannot be verified by the SSWD and is assumed to duplicate other Statements of Use or Supplemental Statements submitted by riparian, permitted, and licensed right holders.

Currently the Watermaster regulates 365 cfs of water rights (primarily through water diversions) during the irrigation season, of which 40 cfs is allocated to the GID, and the Watermaster regulates 58 cfs of water rights during the winter, of which 42 cfs is allocated to the SRWA. The Watermaster also regulates MWCD's annual storage rights of 49,000 acre-feet which are held in Dwinnell Reservoir.

The flow rates indicated above are seldom available for diversion during the irrigation season and, based on the prior appropriation doctrine that determines the adjudicated water users priority system of "first in time, first in right," the lower priority water right holders are typically curtailed early in the irrigation season to meet the needs of higher priority users, as well as to meet in-stream bypass requirements. The Watermaster is evaluating the potential to administer surface flow diversions related to adjudicated and riparian uses within the Watershed, providing data to the landowners for reporting purposes beyond that of the SSWD.

The SSWD has implemented a Voluntary Monitoring Program (VMP) for diversions that require measurement data beyond the scope of work for Court-Ordered Service. The VMP is available to riparian users and diverters having permits or licenses issued by the SWRCB Division of Water Rights and subject to SB88 monitoring requirements.

The SSWD is a regulatory entity that routinely and frequently measures surface diversion volumes from all adjudicated diversions from an entire stream system within service areas to determine current availability of the established priority system, as set forth in the various decrees.

Information can be found on the SSWD website,[7] visit the Services page, click on links to court-ordered watermaster service and the Voluntary Monitoring Program.

BSID had 30 cfs of adjudicated surface water rights but now relies on groundwater to avoid early season curtailment by the Watermaster.

[7] {sswatermaster.org}

2.1.3 Land Use Elements or Topic Categories of Applicable General Plans

2.1.3.1 General Plans

The County of Siskiyou General Plan (General Plan) serves as a directive for land use decisions within the unincorporated areas of Siskiyou 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 (County of Siskiyou 1973) recognizes the importance of water resources in the County and outlines objectives for the conservation and protection of these resources to ensure continued 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: "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 or 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, watershed and groundwater recharge land (County of Siskiyou 1972). 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 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 Siskiyou County Zoning Plan (Zoning Plan) is codified in Title 10 (County of Siskiyou 2019), Chapter 6 of the County Code. The Siskiyou County 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, requirements and stipulations for land use and development.

2.1.3.2 City Plans

Yreka General Plan

The City of Yreka General Plan (YGP; Yreka (2003)) was developed to guide community decisions related to land use and development. The 2003 version of the YGP incorporates a long-term view of planning decisions, extending to the year 2022 and includes the required elements of land use, open space, noise, safety, circulation, housing and conservation. Surface water impacts from the City of Yreka include the release of treated water into percolation ponds near Yreka Creek. The City of Yreka operates under the authority of NCRWQCB Water Quality Control Plan. The City of Yreka Zoning Plan is the controlling land use document within the portion of the Basin that is within the Yreka city limits.

City of Weed General Plan

The City of Weed has a General Plan (WGP; Weed (2017)) that represents the adopted goals and policies of the City of Weed. The WGP provides the framework for development decisions leading up to the year 2040, and includes the elements of land use, circulation, housing, conservation, open space, safety, and noise. The Conservation Element of the WGP discusses natural resources within the City of Weed and aims to minimize negative impacts of development on the natural environment while allowing the City to grow. The Conservation Element addresses federal and state standards of environmental regulation.

The City has adequate water supplies but must continue to explore opportunities for future water supply as this resource may be a limiting factor for growth. As stated in the WGP, the City is using close to the full capacity of its water supply with approximately 2.46 million gallons of water available per day. Water savings from conservation efforts are needed to meet the per capita water consumption goals established in Senate Bill X7-7; additionally, the City does not have an Urban Water Management Plan, which would address current and future water supply. With respect to wastewater, an increase in population would require an expansion of the Weed Wastewater System that serves the northern half of the City, and the Shastina Wastewater System that serves the southern half.

2.1.3.3 Williamson Act

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 square kilometers [sq km]) were enrolled as Prime Land and 324,300 acres (1,312 sq km) were enrolled as Non-Prime Land (DOC 2016).

2.1.4 Additional GSP Elements

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

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 in this chapter.

The County of Siskiyou Environmental Health Department (CSEHD) is the local enforcement 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.

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 to add Article 7. Article 7 finds extracting and discharging groundwater for illegal cultivation of cannabis to be a public nuisance and a waste and/or unreasonable use of groundwater and prohibits 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 the Basin. In the Basin, the illegal cannabis grows of the most substantial concern are primarily found in the Pluto's Cave Basalt flow. In particular, they occur in the Big Springs/Shasta Vista area, a region where two critical springs are located, Big Springs and Little Springs, along with other smaller but important spring complexes.

Illegal cannabis growers rely on groundwater from production and residential well owners within the Basin 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. The Advisory Committee discussed modeled scenarios using the Siskiyou County Sheriff Department's estimate of 2 million illicit cannabis plants and a consumptive use of 4 to 10 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 application of fertilizers and pesticides in a manner inconsistent with best practices that may adversely affect surface and groundwater water quality (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 has 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 historical and future water budgets. The GSA will coordinate with local enforcement agencies to collect information relevant to the water balance within the Basin and will place an emphasis on collecting data to fill relevant gaps in understanding during the five years of plan implementation.

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. 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 to be used in a manner consistent with what is allowed under the 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 "non-community water system," or "small community water system" as defined by the Health and Safety Code, serving residents of the County of Siskiyou.

2.1.4.4 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 the Basin. 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 Monitoring and Management Programs. 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

2.2.1.1. Physical Geography

The Watershed is located in central Siskiyou County in north-central California and is bounded by Mount Shasta to the south, the Klamath Mountains to the west, and the Cascade Range to the east. Within the Watershed, the Basin trends northward and is drained by the Shasta River, a tributary to the Klamath River. The Basin covers approximately 800 square miles (sq mi; about 2,000 square kilometers [sq km]) and consists of a north dipping and topographically rough valley floor surrounded by mountain terrain (Figure 2.7). The topography of the Basin ranges in elevation from just over 2,000 feet (ft; ~610 meters [m]) above mean sea level (amsl) near the confluence with the Klamath River (the hydrologic terminus for the Watershed) to over 14,100 ft (~4,300 m) amsl near the volcanic peak of Mount Shasta. The valley floor transitions sharply to the mountains bordering the valley, all of which are either part of the Klamath or Cascade Mountain Ranges. The Klamath Mountains on the west side of the Basin are less steep and reach lower elevations (4,000 to 9,000 ft, or about 1,200 to 2,700 m, amsl than the Cascades that border the east side of the Basin (6,000 to 8,000 ft, or about 1,800 to 2,500 m, amsl, not including the topography roughly associated with Mount Shasta). The south side of the Basin is headed by the geologically active stratovolcano Mount Shasta, the most voluminous of the active Cascade volcanoes, but sits west of the Cascade Range axis which runs predominantly northwest to southeast. Most of the topography associated with Mount Shasta is above 5,000 ft (~1,500 m) amsl and, as its relief extends west to the Klamath Mountains, it acts as a closure feature to the head of the Watershed. The closure topography to the north is largely a lower-relief saddle region bridging the Cascade and Klamath ranges' extents east to west.

The Basin contains one principle aquifer with various water-bearing geologic formations consisting of a mixture of alluvial and volcanic formations, with the latter consisting of water-laden lava tubes to water-sediment-filled pockets within the cracks and crevices in the volcanic deposits. Much of the complexity and unique juxtaposition of markedly differing water-bearing formations result in a multitude of springs or diffuse wetlands where groundwater more easily discharges to the surface than into less-conductive water-bearing units or where head levels are close to or exceed the ground level. The discharge levels of the springs can vary over many orders of magnitude from one spring to the next and can also significantly vary seasonally at the same spring as well as year-to-year averages. The largest spring complexes, such as the Big Springs complex, contribute a significant quantity of water to the surface water features in the Basin. The overall aquifer is very complex in its nature, including fractures and sediment pore space ranging over many length scales. The complexity and variety of geologic formations in the Watershed are extreme enough that any conceptual or numeric model is at risk of over-simplifying the natural system. However, the effort of this GSP seeks to produce a model that is fit-for-purpose by design and represent the latest approach to characterize the hydrogeologic nature this Watershed.

Vegetation on the mountains to the east, south, and west of the Basin mainly consists of evergreen tree species, with lower flank elevations containing shrub and scrub vegetation (MRLC 2019). The remaining lower-lying areas in the Basin core are vegetated by shrub and scrub, grasslands, wetland, pasture, small forested pockets, and cultivated crops (mainly alfalfa). The Shasta River and its tributaries within the Basin provide key spawning and rearing habitat for native anadromous fish species, including *Oncorhynchus tschawytscha* (Chinook salmon) and the threatened *Oncorhynchus kisutch* (Coho salmon) (NCRWQCB 2006). The Basin's hydrogeology, including its shallow grade, unique mineral deposits/chemical composition, and continual inputs of glacial-fed spring water, make the Shasta River prime salmon habitat that historically boasted a significant majority percentage of salmon returning to spawn in the Klamath River system. Such hydrological conditions are supported by winter snowpack, but as winter snowpack is diminishing under current and projected warming, the hydrological conditions are changing.

2.2.1.2 Climate

The Basin generally has a mixture of warm-summer Mediterranean and high desert environment climates with distinctive seasons of cooler, wetter winters and warm, dry summers. The orographic effect of the mountains to the west and south sides of the Basin creates a rain shadow in eastern areas of the Basin. The higher elevation areas to the west and south of the Basin historically receive greater annual precipitation (30-70 inches [in], or about 76–177 centimeters [cm]) in comparison to annual precipitation on the east side of the Basin (12–15 in) (Figure 2.8; (DWR 2011)). Annual mean precipitation ranges from a low of about 13 to 15 in (33–38 cm) at lower elevations to a high of about 67 in (170 cm) at Mount Shasta (SWRCB 2018) (Figure 2.10). Annual precipitation for the City of Yreka is presented in Figure 2.9, annual precipitation averages range from 19 to 21 inches (48–53 cm) and the summary statistics for the Yreka rainfall gauge are in Figure 2.11 (SWRCB 2018). Annual precipitation ranges from 25 to 29 in (64–74 cm) at higher elevations of the Klamath Mountains to the west, and up to 33 in (84 cm) near China Mountain. To the east, higher elevations of the Cascade Range receive from 19 to 27 in (48–69 cm) of precipitation annually. The rainy season, which generally begins in October and lasts through April, accounts for about 80 percent of total annual rainfall.

There are three California Data Exchange Center (CDEC) snow stations within the Watershed (SWT, PRK, and LSH) and the nearest Mount Shasta station is MSH (Figure 2.12, 2.13, 2.14, 2.15 and 2.16) (DWR 2021a). NOAA weather stations are listed in Table 2.2.

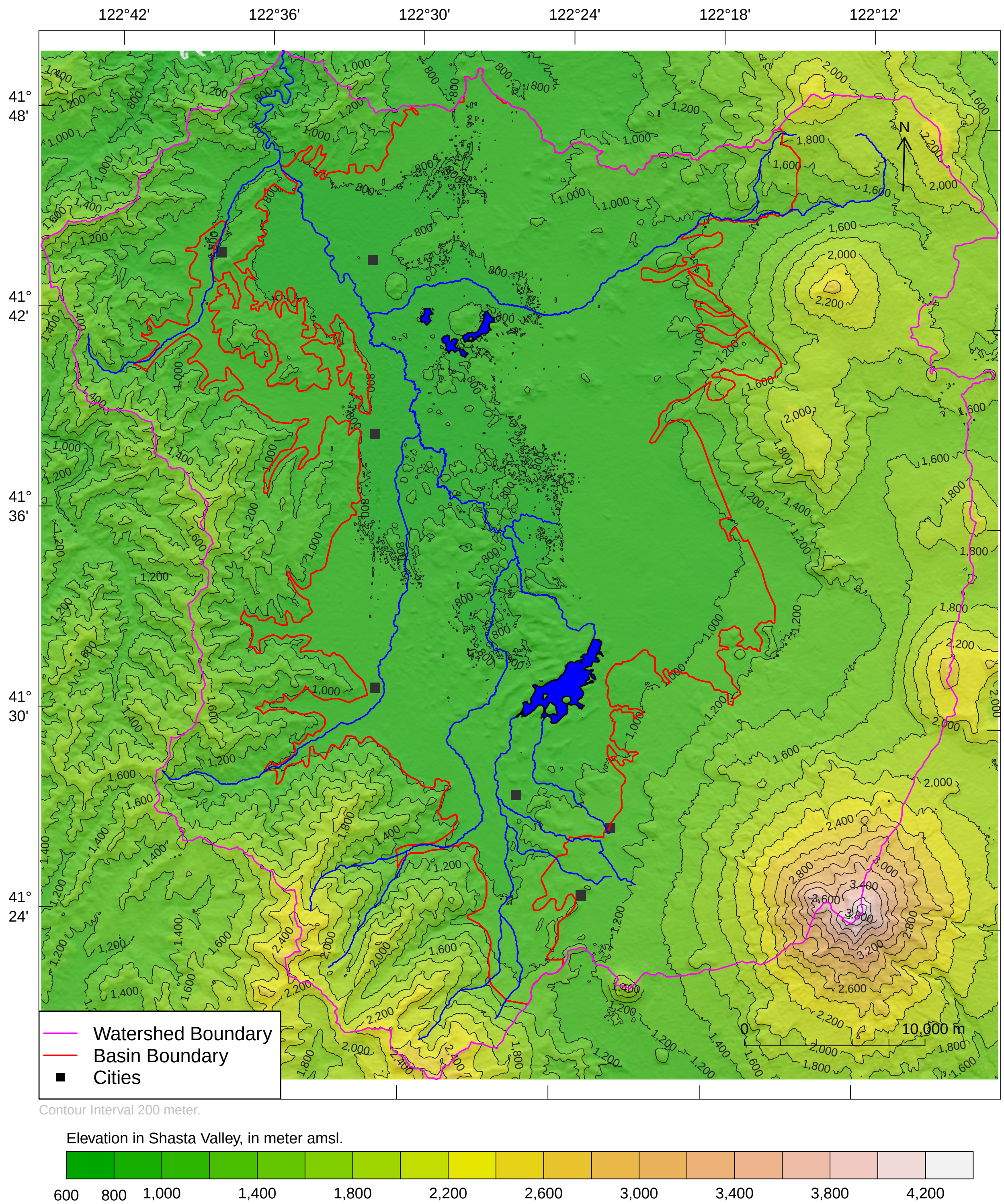


Figure 2.7: Topography of the Basin and surrounding Watershed.

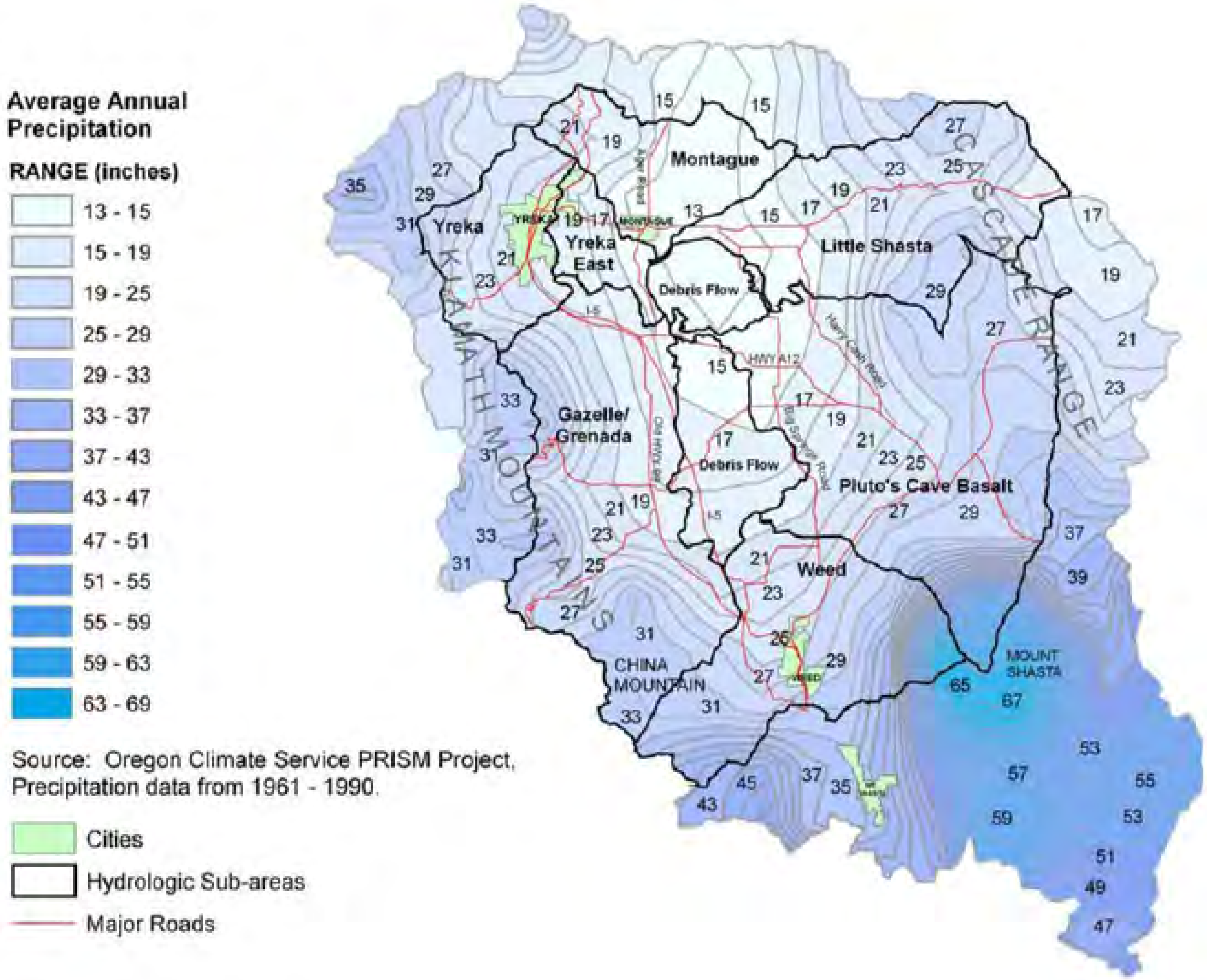


Figure 2.8: Central Siskiyou County area isohyetal (precipitation) contour map covering the greater Watershed. Reprinted from DWR (2011).

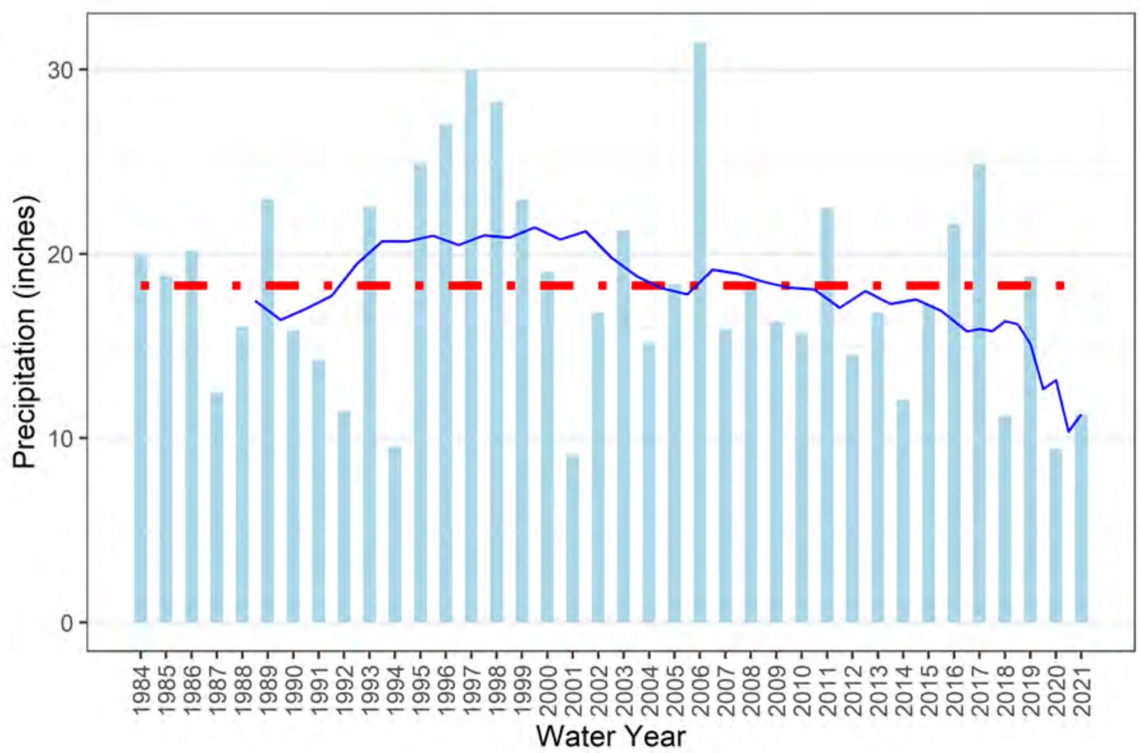


Figure 2.9: Yreka annual precipitation from 1983 to 2021, according to CDEC data. The long term mean (18 in) shown as a red dashed line, and the ten year rolling mean is the blue trendline.

Month	Avg. Rainfall (in./month)	Avg. No. Consecutive Dry Days	Wettest Monthly Rainfall		Driest Monthly Rainfall		1-Day Maximum Rainfall		Avg. No. Rain Days with Rainfall ≥ Indicated Value (inches)			
			(in./month)	Water Year	(in./month)	Water Year	(in./day)	Date	≥0.01	≥0.10	≥0.50	≥1.00
Oct	2.3	21	7.7	2005	0.0	2003	3.8	10/19/2004	7	4	1	1
Nov	4.8	12	14.1	1982	0.4	2014	4.4	11/16/1981	11	7	3	1
Dec	7.5	11	25.9	2003	0.1	1990	4.9	12/14/2002	13	9	4	2
Jan	6.4	10	27.5	1995	0.2	1984	6.0	1/9/1995	13	9	4	2
Feb	6.9	10	21.8	1998	0.4	1988	4.9	2/6/2015	12	8	5	2
Mar	6.1	9	18.9	1995	0.4	1988	3.9	3/9/1989	14	9	4	2
Apr	2.8	11	9.1	2003	0.1	1985	2.1	4/12/2012	11	5	2	1
May	2.1	16	9.3	1990	--	1986	2.3	5/27/1990	8	4	1	0
Jun	1.2	19	3.8	2005	0.0	2008	1.8	6/17/2005	5	3	1	0
Jul	0.5	24	1.7	1985	--	2009	1.1	7/5/2000	3	1	0	0
Aug	0.4	27	1.3	1990	--	1995	1.2	8/20/1997	2	1	0	0
Sep	0.7	27	3.8	1986	--	2012	1.5	9/25/2001	4	2	0	0
Annual	**41.7**	**16**	**75.1**	**1998**	**16.0**	**2014**	**6.0**	**1/9/1995**	**103**	**62**	**25**	**12**

1: Data Source: Global Historical Climatology Network. Period of record: 10/1/1980 – 9/30/2015.
2: Average number of rainfall days with a rainfall total greater than or equal to the depth (inches) shown.
3: Relative Color Gradient: Rainfall depth/distribution and average consecutive dry days. Darker is higher.

Figure 2.10: Mount Shasta rainfall gauge (045983) summary statistics. Note that the station is out of the Watershed but is close to the southern border. Reprinted from SWRCB (2018).

Month	Avg. Rainfall (in./month)	Avg. No. Consecutive Dry Days	Wettest Monthly Rainfall		Driest Monthly Rainfall		1-Day Maximum Rainfall		Avg. No. Rain Days with Rainfall ≥ Indicated Value (inches)			
			(in./month)	Water Year	(in./month)	Water Year	(in./day)	Date	≥0.01	≥0.10	≥0.50	≥1.00
Oct	1.1	23	3.4	2008	0.0	2004	1.8	10/24/2010	5	3	1	0
Nov	2.7	12	8.2	1985	0.4	2001	2.4	11/23/1988	11	6	1	1
Dec	3.9	11	12.2	2006	0.3	2014	3.3	12/31/2005	12	7	2	1
Jan	2.9	12	7.4	1996	--	1985	2.6	1/8/1990	12	6	2	1
Feb	2.0	12	5.9	1999	--	1986	2.1	2/7/2015	9	5	1	0
Mar	1.9	11	5.4	2011	0.2	1994	1.3	3/3/1991	11	5	1	0
Apr	1.1	14	3.4	2000	--	1992	1.3	4/30/2002	8	3	0	0
May	1.3	18	4.1	2009	0.0	1982	2.8	5/3/2009	8	3	0	0
Jun	0.9	20	4.4	1982	--	1987	1.9	6/8/1998	5	2	0	0
Jul	0.5	25	2.1	1995	--	2008	1.3	7/27/2010	3	1	0	0
Aug	0.4	27	1.9	1983	--	1998	1.0	8/20/1997	3	1	0	0
Sep	0.5	27	2.2	1991	--	2012	2.2	9/7/1991	3	1	0	0
Annual	**19.0**	**18**	**33.4**	**1982**	**9.0**	**2001**	**3.3**	**12/31/2005**	**90**	**42**	**10**	**3**

1: Data Source: Global Historical Climatology Network. Period of record: 10/1/1980 – 9/30/2015.
2: Average number of rainfall days with a rainfall total greater than or equal to the depth (inches) shown.
3: Relative Color Gradient: Rainfall depth/distribution and average consecutive dry days. Darker is higher.

Figure 2.11: Yreka rainfall gauge (049866) summary statistics. Reprinted from SWRCB (2018).

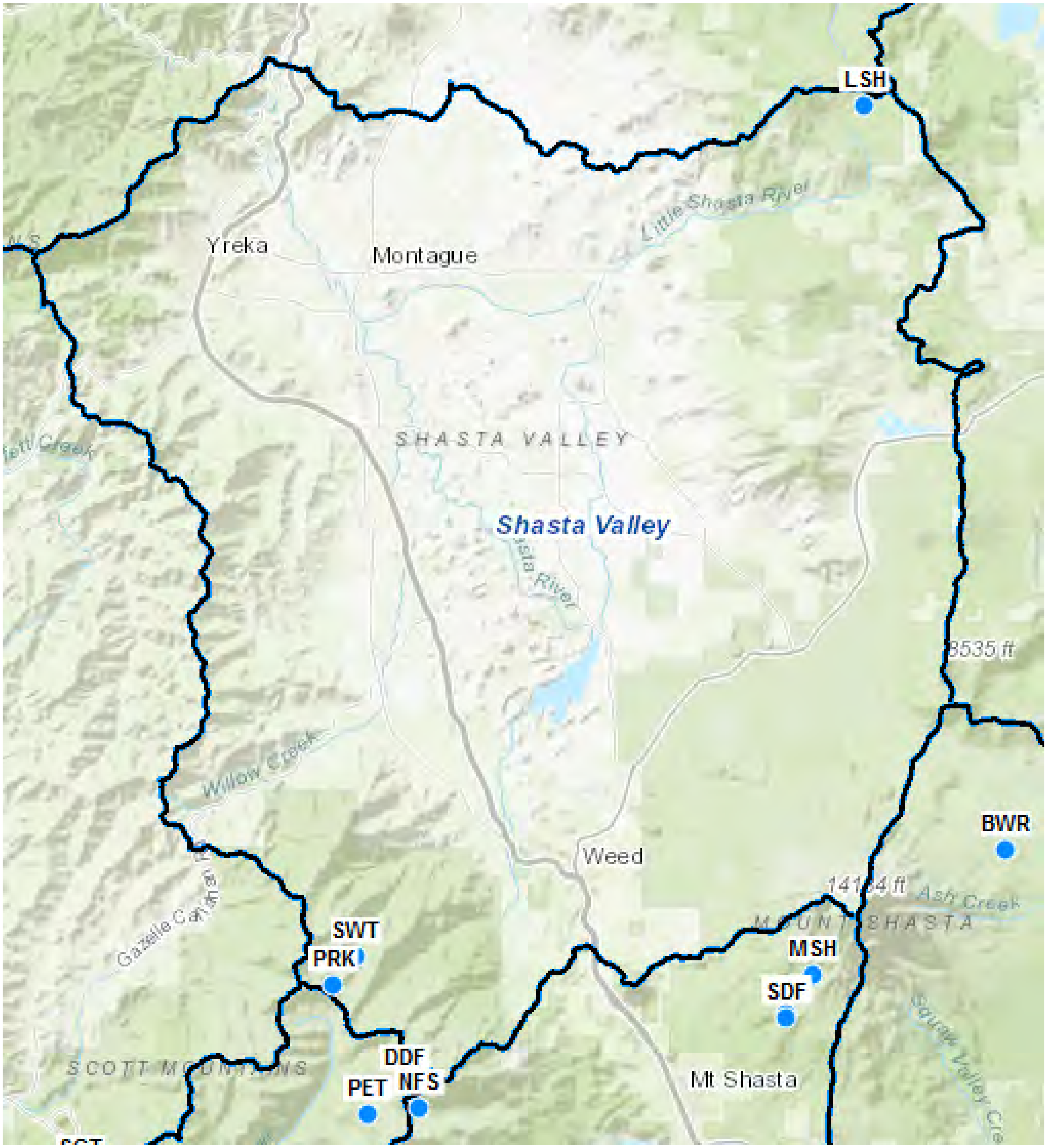


Figure 2.12: CDEC snow stations for the Watershed. Adapted from CDEC (DWR 2021).

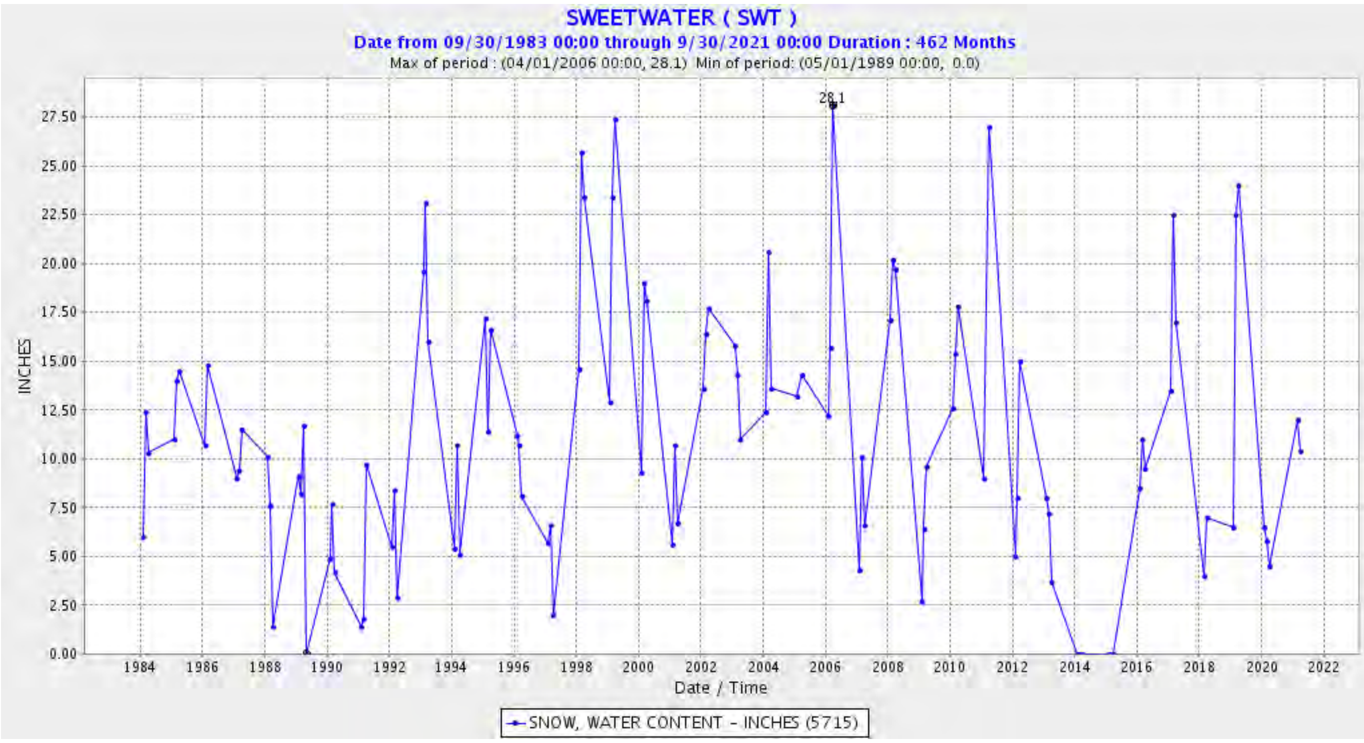


Figure 2.13: Snow water content record for Sweetwater station (SWT) from WY 1984 to WY 2021. Adapted from CDEC (DWR 2021).

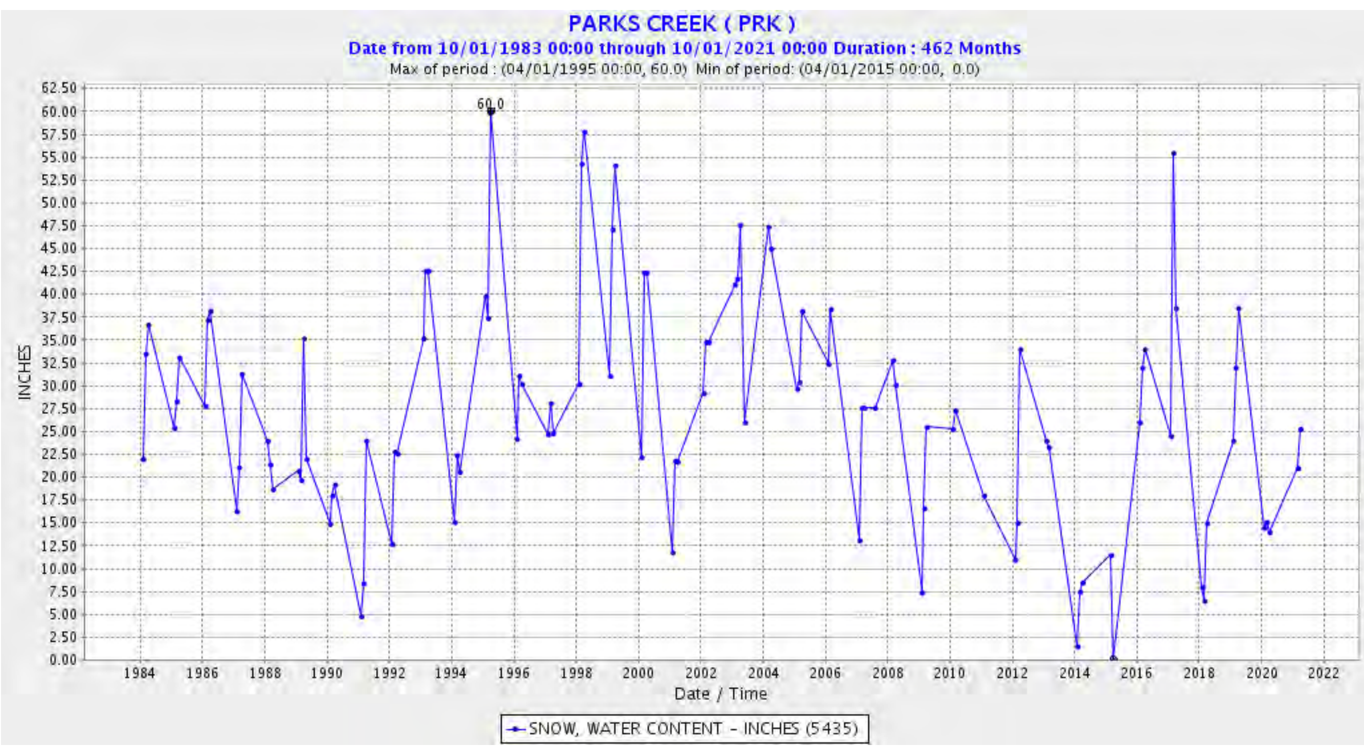


Figure 2.14: Snow water content record for Parks Creek station (PRK). Adapted from CDEC (DWR 2021).

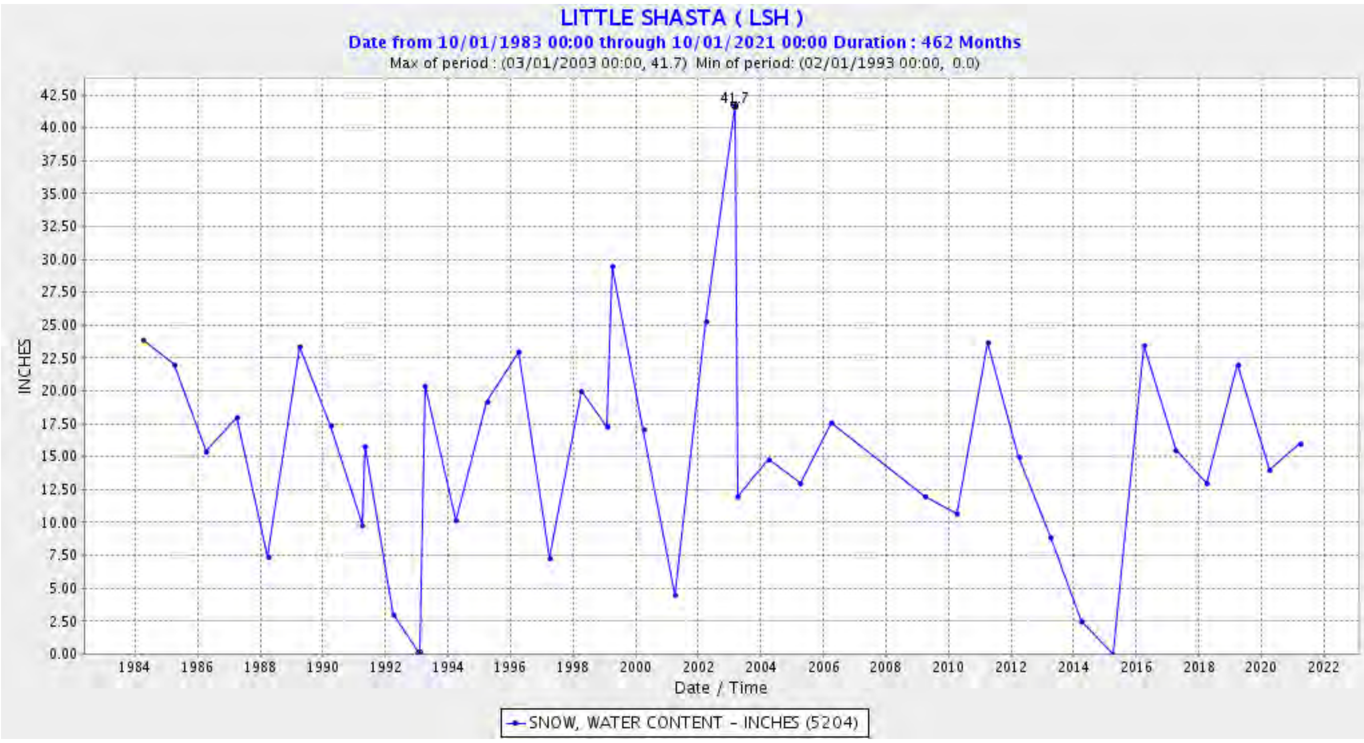


Figure 2.15: Snow water content record for Little Shasta station (LSH). Adapted from CDEC (DWR 2021).

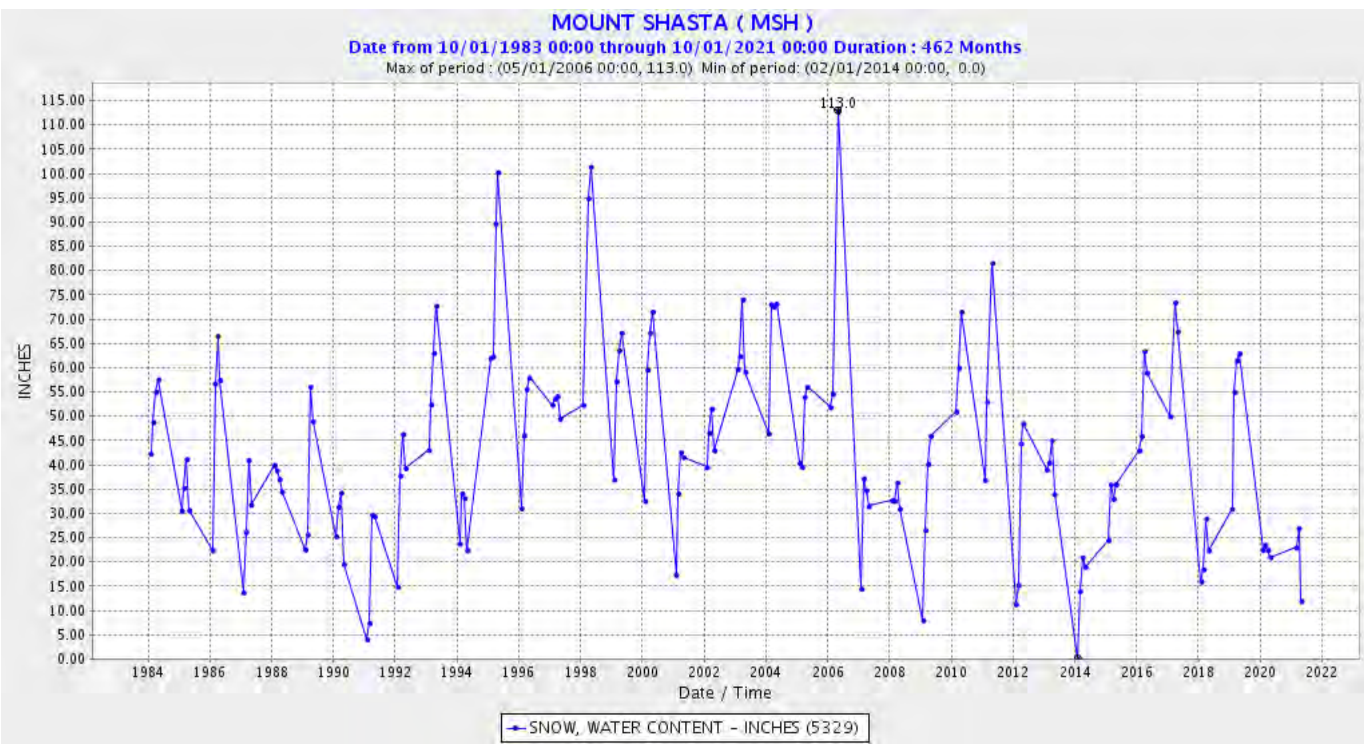


Figure 2.16: Snow water content for Mount Shasta station (MSH). Adapted from CDEC (DWR 2021).

Table 2.2: Station details and record length for NOAA weather stations in the Watershed.

Station ID	Station Name	Elevation (ft amsl)	Start Date	End Date	Record Length (years)	No. Missing Days
US1CASK0002	YREKA 4.5 S, CA US	2937	2008-10-07	2014-11-02	6.1	25
US1CASK0003	WEED 5.4 N, CA US	3064	1998-06-17	2021-06-27	23.0	158
US1CASK0005	YREKA 0.9 WNW, CA US	2692	2008-12-01	2021-06-27	12.6	65
US1CASK0007	MONTAGUE 1.6 ESE, CA US	2556	2010-12-01	2018-11-28	8.0	40
US1CASK0020	GRENADA 0.8 SW, CA US	2650	2018-02-23	2021-06-27	3.3	2
USC00043564	GRASS LAKE HIGHWAY MNTC, CA US	5092	1960-09-01	1967-11-30	7.2	26
USC00049498	WEED FIRE DEPARTMENT, CA US	3514	1943-05-01	1957-02-28	13.8	78
USC00049499	WEED FIRE DEPARTMENT, CA US	3589	1957-04-18	1989-07-31	32.3	35
USC00049866	YREKA, CA US	2709	1893-02-01	2021-06-27	128.4	1691
USR0000CBZE	BRAZIE RANCH CALIFORNIA, CA US	3000	1990-06-28	2021-06-27	31.0	11069
USR0000CWEE	WEED AIRPORT CALIFORNIA, CA US	2930	1990-05-02	2021-06-27	31.2	11234
USW00024214	MONTAGUE YREKA MUNICIPAL AIRPORT, CA US	2519	1948-01-01	1949-12-31	2.0	0
USW00024259	MONTAGUE SISKIYOU AIRPORT, CA US	2651	1948-07-01	2021-06-26	73.0	148

2.2.1.3 Geology

Plate tectonic, volcanic, and erosional (particularly fluvial- and landslide-related erosion) processes have formed and reformed the geomorphology and groundwater aquifer of the Watershed. The geologic and hydrologic characteristics of the Watershed are highly variable and are delineated by the boundaries of the regional geomorphic provinces. The Basin's western boundary, the Klamath Mountain terrane, is the result of subduction of the Pacific Plate beneath the North American Plate. The ocean sediments deposited on the Pacific Plate have been unloaded onto the North American Plate and have undergone episodes of burial, faulting, and folding yielding the rich assortment of many kinds of metamorphic rocks of igneous, sedimentary, and even prior metamorphic origins. The subduction of tectonic plates overlying the Pacific Ocean has also driven multiple events of more recent uplift, giving rise to more faults, fissures, and even eruptions of volcanic materials. Much of the Basin floor is covered with volcanic deposits originating from these eruptive episodes, along with more recent alluvial deposits resulting from the erosion of uplifted mountain ranges. These surficial deposits are underlain by marine deposits of the Hornbrook Formation, which were deposited in a shallow sea after the end of the addition of the Klamath Mountains terrane but before the Cascadian volcanic episode had begun. The volcanic rocks of the Cascade Range form the eastern and northeastern boundaries of the Basin. The collective deposits from these geologic events constitute most of the Basin's usable water-bearing formations and, in particular, the geologically recent Pluto's Cave Basalt and shallow, surficial alluvial fill deposits.

2.2.1.3.1 Geologic Units

A detailed description of the geology of the Watershed is provided below and overview maps of the previously most-recent surface geology (DWR 2011; SVRCD 2018a) and the current modeled surface geology can be viewed in the figures below (Figure 2.17 to 2.19). A more detailed description of geology is provided below and can be viewed in Figure 2.19.

A more detailed description of geology is provided below and whose units are referenced in Figure 2.19.

Klamath Mountains Province (Map unit: Basement group)

The Klamath Mountains Physiographic Province comprises rocks ranging in age from the early Paleozoic to late Mesozoic eras (Mack 1960). The Klamath Mountains trend north-south and consist of four east-dipping belts that are mainly separated by thrust faults (Fuis et al. 1987). Within the Watershed, the Klamath Mountains are composed of marine mafic and ultramafic volcanic rocks (such as basalt produced from underwater volcanism), marine sediments, and their metamorphic equivalents (DWR 2011). Occurrence of the marine rock-bearing portion of the Klamath Mountains and its metamorphosed equivalents range from Yreka in the north to China Mountain in the south. Parent material of the marine deposits range in size from sand to silt and has undergone extensive metamorphism. Heat and pressure recrystallized individual quartz grains, cementing materials within the marine sandstone deposits forming primarily quartzite. Resulting quartzite deposits are highly resistant to weathering and provide poor conditions for the formation of soil. The first metamorphic product of clay-rich sedimentary rocks is slate with continued metamorphism leading to the formation of phyllite and eventually mica schist, which have slightly thicker sediment horizons than quartzite-dominant areas. Mafic and ultramafic materials of the Klamath Mountains represent parent materials basalt, gabbro, and peridotite that have largely undergone metamorphism forming abundant serpentinite in many locations. These areas also contain little sediment cover, but usually a little more than the quartzite-dominated areas. In the Shasta Valley Watershed geologic model, the various Klamath Mountain Province geologic units observed in the Watershed are lumped as a Basement group. A description of each of these units can be found in the Basement group description in Table 2.3. The Basement group is found in all cross sections produced from the model except for *Cross Section H-H'* (Figure 2.25). While the Basement group is almost entirely positioned on the western side of the Watershed, the Yellow Butte fault zone activity has uplifted a portion (known as a horst) of the Basement group material seen in *Cross Sections A-A' and E-E'* (Figure 2.20 and 2.24).

Hornbrook Formation (Map unit: Kh)

Exposed to the north and east of Montague, the Cretaceous-aged Hornbrook Formation was deposited at the end of the tectonic period that created the Klamath Mountains but ended before the volcanic activity that created the Cascade Range. It sporadically outcrops for roughly 50 mi (~80 km) from the Medford Valley in southwestern Oregon to the Basin (Nilsen 1993). Many of the exposures within the Basin lie to the north and east of Montague in the Little Shasta River drainage basin. Rocks comprising the Hornbrook Formation consist of interlayered beds of shallow marine sandstone and deep marine mudstone as well as siltstone, shale, conglomerate, and fossils (Nilsen 1993). The marine rocks of the Hornbrook Formation underlie much of the geologically younger alluvium and volcanic deposits on the Basin floor east of the Klamath Mountain province. This is observed in all of the geologic cross sections of the Shasta Valley Watershed geologic model.

Cascade Range Province (Map units: Pv, Qv, Qvs, & Tv)

The Cascade Range in the Basin consists of two main volcanic rock types: the Western and High Cascade volcanic rock series. The Western Cascade volcanic series were deposited during a period from about the Eocene to the Oligocene, but possibly even into the Miocene (Mack 1960). These are the older volcanic rocks of the east side of the Basin and have been overlain by younger volcanic deposits of the High Cascades, which are Pleistocene to Holocene in age. Over long periods of geologic time after deposition, the Western Cascade units were faulted and tilted to the northeast before being buried by the High Cascade volcanic deposits (Fuis et al. 1987). Pluto's Cave Basalt, which is a highly permeable volcanic deposit found in the Basin (Buck 2013), is a subunit of the High Cascade lava flows (Wagner and Saucedo 1987). Volcanic rock in the Basin is mainly differentiated by the debris avalanche in the central part of the Basin and Pluto's Cave Basalt on the eastern side. The volcanic rocks range in thickness from as little as 20 ft in the northern part of the Basin to over 400 ft in the southern Basin. The most prominent feature of the Cascade Range Province in the Basin is Mount Shasta, a large stratovolcano reaching over 14,000 ft (~4,200 m) amsl that largely forms the southern terminus of the Cascade Range in the Basin. Mount Shasta is composed of at least four main volcanic cones formed in the last 250,000 years with the most recent eruptive activity taking place only 200 years ago (Blodgett, Poeschel, and Thornton 1985).

Table 2.3: Basement Group Unit Descriptions.

Unit ID	General Lithology	Age	Description
Mzd	Basement (group) - Plutonic Dioritic rocks	Jurassic	Mostly diorite, but locally includes gabbro and quartz diorite; also some granite
MzPz s	Basement (group) - Stuart Fork Formation	Mesozoic-Paleozoic	Micaceous quartzite and phyllite (representing bedded chert, shale, and sandstone) and actinolitic schist and phyllonite (representing metavolcanic rocks); contains blueschist-facies metamorphic minerals
MzPz ms	Basement (group) - metasedimentary rocks	Mesozoic-Paleozoic	Includes slate, feldspathic metagraywacke, metachert, quartzite, and chert-argillite breccia
MzPz mv	Basement (group) - metavolcanic rocks	Mesozoic-Paleozoic	Intermediate-composition to felsic, pillowed to massive, predominantly aphyric flows, tuff, and minor intrusive rocks
DSg	Basement (group) - Gazelle Formation	Devonian-Silurian	Shale, mudstone, siltstone, sandstone, limestone, bedded chert, and siliceous mudstone; poorly to well bedded
Smc	Basement (group) - Moffett Creek Formation	Silurian-Ordovician	Tan-weathering shale and mudstone, calcareous siltstone, sandstone, and minor bedded chert, siliceous mudstone, and limestone; mostly massive and disrupted; generally unfossiliferous, but chert contains Ordovician or Silurian radiolarians; common in fault contact with adjacent units, but locally is depositionally overlain by the Gazelle Formation
SOd	Basement (group) - Duzel Formation	Silurian and/or Ordovician	Phyllitic calcareous siltstone and calcareous sandstone
Pza	Basement (group) - Abrams Mica Schist	Devonian(?)-Ordovician(?)	Predominantly metasedimentary rocks, including quartz-mica schist, calc shist, micaceous marble, and minor intercalated amphibolite schist
Oam	Basement (group) - Antelope Mountian Quartzite	Silurian and/or Ordovician	Well-bedded quartz sandstone; locally thin and rhythmically bedded; includes chert beds and lenses adjacent to Duzel Formation
Op	Basement (group) - Trinity peridotite	Ordovician	Dominantly serpentinized tectonitic peridotite and minor dunite; ophiolite sequence

Western Cascades Volcanic Rock Series (Map unit: Tv)

Rocks of the Western Cascades volcanic series form a major portion of the Cascade Mountains and are an assemblage of differing volcanic rock and sediment types of Eocene to Oligocene (possibly Miocene) age including not only lava flows but also dense beds of hardened tuff, airborne pyroclastics, massive volcanic mudflow deposits, and highly variable breccias (DWR 2011). The Western Cascades are a significant component of the hillslopes of the northeastern portion of the Basin. Rocks of this series underlie some of the western portions of the Basin and most of the eastern portion and constitutes the main bedrock material along the eastern margins (Mack 1960). The age of Western Cascade volcanic deposits has provided sufficient time for extensive weathering, fracturing, and subsequent infilling prior to and during the deposition of the High Cascades volcanic rock series. The Western Cascade volcanic deposits are present, to varying levels of abundance, in every geologic cross section.

High Cascades Volcanic Rock Series (Map units: Pv, Qv, & Qvs)

The High Cascades volcanic rock series are Pliocene- to Holocene-aged volcanic rocks that overlie the older rocks of the Western Cascades at the eastern margin of the Basin as well as to the south as the volcanic activity of Mount Shasta is slightly west of the rest of the Cascade Range in the Basin. The High Cascade volcanic rocks consist of highly fractured lava rock deposits and ash deposits originating from a number of geologically young volcanic peaks (e.g., Miller Mountain, Goosenest Mountain, Willow Creek Mountain, Ball Mountain, Deer Mountain, The Whaleback, and Mount Shasta). The volcanic rocks of this series mainly consist of andesite or basalt and compose the uplands, volcanoes, and cones forming the southern and eastern portions of the Watershed (Mack 1960; Hotz 1977; Wagner and Saucedo 1987). The High Cascade volcanic deposits include more recent effuse basaltic flows (e.g., Pluto's Cave Basalt) that cover much of the eastern side of the Basin and the expansive, fine-grained pyroclastic (andesitic and volcaniclastic) sediment deposits. These pyroclastic deposits result from a Late-Pleistocene debris avalanche originating from the northwest flank of a previous version of Mount Shasta (i.e. Ancestral Mount Shasta), creating the unique morphological assortment of conical hillocks, ridges, and depressions that are ubiquitous across the central portion of the Basin floor (Crandell et al. 1984; Crandell 1989).

Pleistocene Debris Avalanche (Map units: Qvs)

A catastrophic, volcanic debris avalanche deposited materials across approximately 260 sq mi (~680 sq km) of the Basin valley floor, covering an area from just northeast of the peak of modern Mount Shasta to the Shasta River Canyon north of Yreka. The debris flow formed the dominant geology and topography of the central portion of the Basin, which consists of hundreds of hummocks, ridges, hills, and flat surfaces. Ancestral Mount Shasta was the origin of the debris avalanche which occurred during the Pleistocene epoch roughly 300,000 to 380,000 years ago (Crandell 1989). The debris avalanche incorporated existing deposits of alluvium, lahars, and pyroclastic flows as it progressed northward scouring the preexisting landscape. The deposits are made up of two primary components: a block facies and a matrix facies. As the name implies, the block facies consists of blocks of volcanic rock that, in many areas, have retained some internal structure from their original deposition. The hummocks, ridges and hills in the region typify the block facies from the debris flow comprising individual andesite blocks (ranging in size from tens to hundreds of feet in maximum dimension) and intact stratigraphic sequences of volcaniclastic materials transported in the same relative positions as the original deposition (Crandell et al. 1984; Crandell 1989). The matrix facies is made up of a fine, sandy ash-rich material with a mudflow, lahar-like character in which the blocks are embedded. Similar in nature to a mudflow, the matrix facies contain an unstratified and poorly sorted mixture of pebbles, cobbles, boulders, and consolidated silty sand (Crandell 1989).

The deposit from the volcanic debris avalanche ranges in thickness from about 650 to 1,000 ft (200-300 m; see *Cross Sections E-E', H-H', and North-South* (Figure 2.24, 2.25, and 2.26)) on the lower slopes of Mount Shasta to about 20 ft along the Shasta River near Montague (DWR 2011). Crandell (1989) notes that the size fraction (relative percentages of differently sized materials such as sand and rock) and types of material within the avalanche deposits changes from south to north. Near Mount Shasta in the south, nearly 100 percent of the deposits consist of volcanic material. In the north near Montague, only about 25 percent of the deposits are volcanic. As the avalanche moved north during its deposition, it scoured the ground surface and incorporated pre-existing rocks into the flows matrix. Embedded within the deposit are clasts of Klamath metamorphic rocks, sandstones of the Hornbrook Formation, and lacustrine clays. The wide range of rock types comprising the debris avalanche deposits attest to the varied nature of the pre-existing landscape. Because of its chaotic mode of deposition, there is no coherent internal structure to the deposits and as a result, well yields from avalanche deposits are highly variable.

Pluto's Cave Basalt (Map unit: Qv (subset))

Pluto's Cave Basalt is a particular portion of interest in the High Cascade volcanic rock series and whose deposition dates to either the Pleistocene epoch somewhere in the range of 190,000 to 160,000 years ago or possibly the Holocene, which would be less than 10,000 years ago (Mack 1960; DWR 2011). This basalt flow covers more than 50 sq mi (~130 sq km) of the eastern portion of the Basin (Williams 1949) and overlies the older Western Cascade volcanic series rocks. The formation is a composite of several dark, porous basalt flows (DWR 2004). Individual flow units are considered to be approximately 10 to 30 ft (3-9 m) thick, while the thickness of the entire basalt flow ranges from about 400 (or more) ft (120+ m) near the flanks of Mount Shasta to 50 ft (15 m) or less at its northern edge near the Little Shasta River (Williams 1949). Mack (1960) reports that Pluto's Cave Basalt appeared to have developed from fissures close to the northeastern base of Mount Shasta. According to DWR (2011), Deer Mountain and Whaleback Mountain are the source of Pluto's Cave Basalt flows. The formation is a composite of several flows each composed of black, vesicular olivine-rich augite basalt (DWR 2004). Pluto's Cave Basalt can primarily be seen in the cross-sectional intersection of the *Cross Sections A-A' and H-H'* from the Shasta Valley Watershed geologic model (Figure 2.20 and 2.25).

Quaternary Alluvium (Map units: Q & Qg)

Alluvial deposits, including the stream and terrace deposits originating mainly from fluvial processes associated with Parks Creek, Willow Creek, Julien Creek, Yreka Creek, Whitney Creek, the Little Shasta River, and the Shasta River, as well as the alluvial fan deposits of the Klamath Mountains, comprise the remainder of the surficial deposits within the Basin. Stream deposits are generally confined to active stream channels, and terrace deposits follow these channels. Alluvial fans are found along the western and northern perimeters of the Basin and form the sedimentary aprons at the base of the mountains. These coarse fan deposits transition into finer floodplain deposits on the Basin valley floor. Significant accumulations of alluvium are present along the Highway A12 corridor south of Big Springs, in the Gazelle-Grenada area and the Little Shasta Valley. Alluvial deposits range from coarse grained sand in higher-gradient locations to silt and clay in low-gradient locations. In addition to the most recent alluvium (Q), glacial alluvium (Qg) from the most recent glacial moraine advance of glaciers originating from the slopes of Mount Shasta are present at the base of Mount Shasta. The unconsolidated glacial deposits (both fluvioglacial and morainal) range from clay- to boulder-sized materials and are poorly sorted. The glacial alluvium (Qg) is mainly present in *Cross Sections E-E' and H-H'* (Figure 2.24 and 2.25). The most recent alluvium (Q) is mainly present in *Cross Sections A-A', E-E', West-East, and North-South* (Figure 2.20, 2.24, 2.27, and 2.26).

Geologic Basin Structures, Surface Processes, and Geomorphology

The dynamic geologic history of the Watershed resulted in many vastly different geologic formations and structures which control the surface and subsurface flow and storage of water in varying ways (such as the nearly impermeable volcanic rock, highly conductive lava tubes and moderately conductive alluvium all exist in the Watershed). Some of these geologic formations and structures led to the formation of the Basin's numerous springs and streams; this occurs when water encounters an impermeable formation or structure where it then seeks a path of least resistance. The varying geologic formations coincide with varying elevations in the Watershed which impacts where precipitation occurs as mostly rain or snow for much of the year year with formations like alluvium tending to exist in lower elevations where rainfall is dominant.

Surface Processes and Channel Geomorphology

Tributaries draining the western and southwestern Basin flow off the eastern slopes of the Klamath Mountains and are underlain by the Paleozoic Eastern Klamath Belt terrane (Hotz 1977; Wagner and Saucedo 1987). Tributaries in the southeastern and eastern Basin drain the western slope of the Cascade Range, which are underlain by the Cenozoic Western Cascade and High Cascade Volcanic subprovinces (Hotz 1977; Wagner and Saucedo 1987). The Shasta River flows through the Basin before entering Shasta River Canyon and eventually joins the Klamath River. The Basin is primarily underlain by various volcanic and volcaniclastic units of the High Cascades subprovince and deposits of Quaternary alluvium in the Montague vicinity. The canyon reach of the Shasta River is incised into the Western Paleozoic and Triassic (Mesozoic) Belt terrane of the Klamath province (Hotz 1977; Wagner and Saucedo 1987).

The Shasta River exhibits distinct longitudinal variability in channel morphology primarily controlled by the underlying geologic regime. Stream channels in headwater areas of the Eastern Klamath Belt terrane are steep and cobble dominated. Upon crossing the lithologic contact with the High Cascade subprovince, the drainage network transitions to predominantly gravel-bedded channels with moderate gradient. Meandering single-thread channel morphology in these reaches is interspersed with short multi-thread channel morphology containing active lateral, mid-channel, and point bars (Nichols 2008). The presence of active gravel bars and trapezoidal channel cross-sectional morphology indicate a hydrologic regime dominated by precipitation (via both rain and snow) driven runoff (Nichols et al. 2010). Analysis of aerial photos and historical maps indicate channel morphology in these reaches has changed little since 1923 (Nichols 2008). Channel gradient steadily decreases downstream of Dwinnell Dam as the Shasta River flows across the Late-Pleistocene debris avalanche described above (Crandell et al. 1984; Crandell 1989). These reaches have gravel- and sand-bedded, single-thread and meandering channel morphology without exposed point bars. Following the closure of Dwinnell Dam in 1928, the Shasta River between Dwinnell Dam (river mi 40.6/river km 65.3) and the confluence of Big Springs Creek (river mi 33.5/river km 53.9) transitioned from a gravel-bedded meandering stream with exposed point bars to its present-day form without exposed point bars (Nichols 2008). Downstream of the Big Springs Creek confluence, the Shasta River takes on a more rectangular channel morphology with greater width-to-depth ratio that has changed little since 1923. A lack of change reflects less dynamic fluvial processes and a muted hydrologic response dominated by stable year-round baseflows controlled by groundwater inputs (Nichols 2008; Nichols et al. 2010). The Shasta River meanders at a near-constant low gradient throughout the central and northern portions of the Basin before steeply descending through the bedrock canyon near Yreka to the Klamath River.

The Eastern Klamath Belt is the eastern-most terrane in the Klamath Mountains geomorphic province, which is interpreted as a structural sequence of east dipping thrust sheets, decreasing in age from east to west, formed by accretion of oceanic and island-arc assemblages (Irwin 1981; Saleeby et al. 1982). Paleozoic rocks of the Eastern Klamath Belt terrane in the Watershed consist of partially-serpentinized peridotite, gabbro, diorite, and marine meta-sedimentary units including sandstone, shale, phyllite, chert, conglomerate, and limestone (Mack 1960; Hotz 1977; Wagner and Saucedo 1987). These lithologic units compose the east face of the Scott Mountains and are dissected by a dendritic drainage pattern of Shasta River tributaries including Dale Creek, Eddy Creek, Parks Creek, Willow Creek, Julien Creek, and Yreka Creek. These stream channels flow roughly perpendicular to the northerly strike of the Eastern Klamath Belt. Hillslope mass wasting and valley bottom fluvial erosion are the dominant geomorphic processes in these tributary basins. Runoff response time is short during rainfall and snowmelt events in these areas of the Klamath Mountain terraces due to steep topography, high relief, shallow and well-drained soils, and less permeable bedrock (McNab and Avers 1994).

Geologic Structure Controlling Hydrology

The Watershed contains a mélange of various, unique, geologic situational components that either directly or indirectly control the hydrologic setting of the Watershed. The surface geology found in the China Mountain area of the Klamath Mountain Range, for example, initiates the headwaters of the Shasta River, Parks Creek, and the South Fork of Willow Creek due to the relatively impermeable surface materials (e.g., serpentinite) and steeper slopes that comprise these mountains. Concentrated overland flow routing depends on the surface restricting water infiltration into the subsurface and channelizing to form the headwaters of these important creeks and rivers (DWR 2011). However, while the majority of the igneous and metamorphic rock initially is almost entirely impermeable, the subsequent tectonic processes produced secondary porosity through jointing and faulting of the rocks, allowing some limited and highly localized water storage and transmission. This high level of variability in the relative spacing, size, and degree of interconnection of these secondary openings adds to the overall complexity in characterizing the hydrology of the Watershed as the western mountain region cannot truly be considered completely impermeable or as a distinct water-bearing formation.

On the east side of the Basin there is a thin region of block faulting, the Yellow Butte Fault Zone, which is where a vertical sliver of geologic units (i.e. a horst block) bounded by faults on either side have effectively moved the entire section out of alignment with the same geologic units on each side of the parallel faults (Figure 2.19). This is the only geologically recent faulting residing within the Basin boundary. This region of block faulting may be a factor in impeding groundwater flow recharged on the east side of the Basin that would likely flow into the Pluto's Cave Basalt; however, it is unclear at this time whether this feature acts as a barrier to groundwater. The block faulting along the Yellow Butte Fault Zone has produced exposures of the Late Cretaceous marine-deposited Hornbrook Formation and the Mesozoic rocks (primarily monzonite) of Yellow Butte and can been seen in a few of the geologic cross sections of the Watershed seen in *Cross Sections A-A' and E-E'* (Figure 2.20 and 2.24). From previous efforts to characterize this feature (Mack 1960; Holliday 1982) and recent geologic modeling undertaken for this Plan (Appendix A-D) shows that a few thousand feet of displacement (~2,000-4,000 ft; 600-1,200 m) has likely taken place as the aforementioned rocks within the fault block underlie much of the Basin as deep-lying basement rock.

The variability of groundwater chemistry across the Watershed is likely heavily dependent on the varying rock types where groundwater is stored, as well as flows through; generally, the longer groundwater is stored in a water-bearing formation, the more its chemistry mirrors the host rock or sediment chemistry. Faults in the Watershed, not only the Yellow Butte Fault Zone but also the ancient faults of the Klamath Mountains, might also contribute in part to the variability in groundwater chemistry by acting as conduits for increased groundwater flow, allowing for water chemistry contributions from greater distance than in-place mixing. This fault mechanism, or even the high variability in surface geologic units that may differ wildly in hydrologic properties, might explain water chemistry observed in specific wells appearing different from other wells located nearby.

Hydrogeologic Units of Shasta River Valley Watershed and Groundwater Basin

The Watershed's long and complex geologic history has resulted in a very heterogeneous hydrogeologic setting, which is illustrated by the juxtaposition of a variety of water-bearing geologic units across the Watershed. The Basin is a geologic mix of alluvial valley deposits, fractured metamorphic with thin sediment veneers, volcanic rock and sediment debris flows, and lava flow deposits of varying geologic ages. Much of the surficial deposits that form the primary water-bearing formations of the Basin are relatively young (less than 400,000 years old). These deposits include the volcanic debris avalanche (most likely deposited a little less than 400,000 years ago), lava flows of the High Cascades, such as Pluto's Cave Basalt (some of which are possibly less than 10,000 years old), and various alluvial deposits, many of which date to less than 10,000 years in age. While not primary water-bearing formations, the remaining geologic units do bear some amounts of water; however, they do not store or transmit enough water to define as usable primary water-bearing formations, but still have localized use for domestic and small stock water applications. This GSP's approach is to describe all the water-bearing units in the Watershed relevant to the Basin and designate the primary water-bearing formations based on public usage statistics, hydrogeologic properties, and water storage and conveyance ability. The hydrogeologic water-bearing formations within the groundwater aquifer are described in detail in the following text: (1) Klamath Mountains Province; (2) Hornbrook Formation; (3) Cascade Range Province, divided into the (3.1) Western Cascades and (3.2) High Cascades, which is further divided into the (3.2.1) Debris Avalanche Deposits and the (3.2.2) Pluto's Cave Basalt[1]; and (4) Quaternary Alluvium[8].

[8]Primary water-bearing formations of the Basin

Klamath Mountains Province (Map unit: Basement (group))

The Paleozoic-aged Klamath Mountain Province composes the western boundary of the Watershed. The province consists of marine sediments and intrusive rocks that experienced varying degrees of structural deformation and metamorphism during major tectonic episodes in the early Paleozoic through the late Cenozoic, resulting in the Klamath Mountains of today. Extensive mineral recrystallization resulting from the process of metamorphism has reduced the primary porosity in these units to confining conditions. Structural deformation from tectonic activity after the metamorphic rock formed resulted in secondary porosity through the formation of fractures, joints, faults, and shear zones. These units are not an important groundwater source due to limited holding capacity and conveyance (DWR 2011). However, many wells are still constructed in the Paleozoic rocks of the Klamath Mountains, where well yields range from one (1) to 12 gallons per minute (gpm) (~0.06-0.75 liters per second [lps]). For the purposes of this GSP, all Klamath geologic units are grouped as one metamorphic formational group as an (effectively) impermeable formation comprising both the western boundary and underlying bedrock for much of the model area.

Hornbrook Formation (Map unit: Kh)

The Hornbrook Formation underlies most of the surface deposits throughout the Basin. The Hornbrook Formation is a thick sequence of Cretaceous-aged marine sedimentary rocks, with total thickness up to several thousand feet (Mack 1960). The increased amount of consolidation and cementation of the formation results in minimal quantities of groundwater storage and low well yields. It is typically only sufficient for domestic and stock uses only. The order of magnitude of typical well yields for wells completed in the Hornbrook Formation is roughly one (1) to 10 gpm (~0.06-0.63 lps), but this not a robust statistic (DWR 2011). It is also likely that much of the formation may also act as a largely impermeable bed for the surficial water-bearing formations in the Basin. This can be seen in all of the geologic cross sections as the Hornbrook Formation effectively operates as the hydrostratigraphic basement deposit for much of the Basin water-bearing formations.

Cascade Range Province (Map units: Pv, Qv, Qvs, & Tv)

A significant body of work has explored the Cascade Range hydrogeology, mainly focused in Oregon (James et al. 2000; Nathenson and Thompson 2003; Tague and Grant 2004; Jefferson et al. 2006; Tague et al. 2007). The Cascade Range is characterized by varying types of volcanic deposits. Volcanic deposits can be highly porous and fractured and potentially store and transmit large volumes of groundwater. However, these deposits can also be quite impermeable, or transmit large volumes of water but store relatively little water volume and vice versa. Numerous groundwater springs are present in these young, permeable volcanic units and contribute significant flow to Shasta River and tributary creeks. Abundant and high discharge groundwater springs demonstrate a well-developed subsurface drainage network that exists in the southern and central extents of the Basin (Mack 1960; Jeffres et al. 2008; Nichols 2008; Nichols et al. 2010). This section characterizes the Western and High Cascades as two distinct hydrogeologic water-bearing formations within the Watershed.

The Western Cascades are Eocene to Oligocene (possibly as late as Miocene) in age and tend to have lower permeability than the geologically younger (Pleistocene to Holocene in age) basalt flows of the High Cascades characterized by spring-fed rivers and water-bearing units with high transmissivities and large portions of precipitation recharging groundwater systems (Mack 1960; Jefferson et al. 2006). The Western Cascades tend to have shallow subsurface flow paths along steep gradients with high horizontal conductivities, while the High Cascades environment reflects a deeper groundwater system (Tague and Grant 2004). Basin geology and geomorphology play a dominant role on flow patterns related to peak timing and magnitude of stream flow (Tague et al. 2007). The timing and shape of stream flow hydrographs and summer monthly stream flow volumes are related to the percentage of High Cascade geology in the contributing area (Tague and Grant 2004). Jefferson et al. (2006) published findings that indicate recharge areas in the Cascades can extend beyond modern topographic boundaries. Well logs from the Cascades Range area in Oregon show that wells drilled in Quaternary lavas recorded static water levels higher than the elevation where water was first encountered during drilling suggests the High Cascades unit behaves as a confined water-bearing formation, at least in some areas (Jefferson et al. 2006).

The younger High Cascade volcanics, which overlay the Western Cascade volcanics, are highly vesicular and fractured rocks that can store and transmit large volumes of groundwater. Many springs discharge from the contact between the Western and High Cascade subprovinces due to the discontinuity in permeability (DWR 2011). The High Cascades volcanics include the Holocene-age Pluto's Cave Basalt, a highly vesicular and fractured unit that critically influences groundwater storage and recharge in the Basin, contributing large volumes of water to wells and springs (DWR 2011). Wells in the Pluto's Cave Basalt yield up to 4,000 gpm (~250 lps), with an average of 1,300 gpm (~80 lps; (Mack 1960; PGS 2001; DWR 2011)). The unit is composed of multiple individual flows providing permeable contact surfaces, and lava tubes (including Pluto's Cave) that facilitate groundwater flow. Recharge to the unit occurs from direct precipitation on the ground surface, streamflows that become subsurface upon reaching the unit (e.g., Whitney Creek), irrigation ditch loss, percolation from applied irrigation water (mainly through flood irrigation), and groundwater flow from snowmelt in the Cascade peaks to the south and east (Mack 1960; DWR 2011).

Western Cascades Volcanic Rock Series (Map unit: Tv)

The diverse Western Cascade volcanics can be highly fractured and weathered, although they tend to have reduced porosity and permeability due to secondary infilling of fine-grained sediments. These units have shallow subsurface flow paths yielding springs and seeps on Basin hillslopes – an indication of impermeable horizons that impede vertical groundwater flow through the water-bearing formation (DWR 2011). Potentially due to the lower permeability of the underlying older Western Cascade rocks, many springs and seeps appear at the contact between the Western Cascade and High Cascade volcanic series, reflecting a contact where more permeable rock abuts much less permeable rock (i.e. Western Cascade series). Considerable portions of the Western Cascades are deeply fractured and weathered, containing a great deal of secondary infilling of clays and fine silt and sands. Springs and seeps observed along steep slopes indicate the locations of impermeable horizons that restrict vertical movement of groundwater. Well yields are likely between five (5) and 400 gpm (~0.3-25 lps) based on limited data analyses (Mack 1960; DWR 2011).

High Cascades Volcanic Rock Series (Map units: Pv, Qv, & Qvs)

High Cascade volcanics overlie older materials of the Western Cascade volcanics and are predominantly composed of highly fractured andesitic and basaltic lava flows. These highly permeable materials likely originated from peaks along the eastern edge of the Basin, including: Goosenest Mountain, Deer Mountain, Whaleback Mountain, and Mount Shasta (DWR 2004). The highly permeable effuse basalt flows of the High Cascade subprovince allow rainfall and snowmelt to quickly infiltrate the porous water-bearing formation, resulting in a poorly-developed, surficial drainage pattern (Mack 1960; Tague and Grant 2004). The High Cascade volcanics act as an important groundwater reservoir and source of springs in the Basin (Mack 1960). Geophysical estimates of unit depths range from hundreds to possibly thousands of feet deep (hundreds of meters; (Fuis et al. 1987; Stanley, Mooney, and Fuis 1990).

The interface between individual lava flows, fractures, and lava tubes provides preferential flowpaths capable of transmitting large quantities of water (DWR 2004). For example, some of the geologic units provide substantial quantities of water to wells with yields averaging 1,300 gpm (~80 lps) and as high as 4,000 gpm (~250 lps) (DWR 2004). The interface between the highly fractured and permeable basalt flow and the low permeability debris flow deposits give rise to numerous springs (DWR 2011). As a result of the heterogeneous nature of fracture flow in the water-bearing formation and systems of both local and regional flows, spring water can travel up to 16 mi (25 km) before it surfaces. Analysis of naturally occurring isotopes from springs range from 14 to 50+ years in age (Trout 2010). These ages and distances indicate that the water in the volcanic formation is connected in both small- and large-scale flow paths. Because of the heterogeneity produced by faults, fractures, and lava tubes, localized pumping may have varying influences on the regional system.

Pleistocene Debris Avalanche (Map unit: Qvs)

During the Pleistocene epoch, a catastrophic debris avalanche, originating at the stratovolcano that formed Ancestral Mount Shasta, caused a debris flow to fill a portion of the Basin (Crandell et al. 1984; Crandell 1989). The avalanche deposits consist primarily of matrix facies embedded with occasional volcanic rocks, boulders, and blocks scattered throughout the region. The deposits are estimated to range from 150 to 200 ft (~46-61 m) thick. The block facies are made up of masses of volcanic rock; some of the internal structure in the facies was derived from the development of the stratovolcano that formed Ancestral Mount Shasta, a taller, antecedent version of Mount Shasta. During the debris avalanche event(s), the block facies were transported and deposited along the avalanche flow path. The blocks came to rest on the Basin valley floor and now overlie the Paleozoic rocks of the Klamath Mountains, the Late Cretaceous marine deposits of the Hornbrook Formation, and the alluvial deposits of local streams that existed at the time of the debris avalanche. The matrix facies, which acted as a mudflow during deposition, flowed beyond the initial avalanche toe and is now part of the alluvium found within many other areas of the Basin. Within the debris flow area, the matrix deposits form the sediments in which the blocks are embedded. The matrix facies likely underlie Pluto's Cave Basalt deposits to the east because the debris avalanche occurred before the eruption of the Pluto's Cave Basalt and acted as western boundary to the basalt flows.

Highly variable rock types within the volcanic debris avalanche, and the chaotic modes of transport and deposition during the event have resulted in a lack of coherent internal structure. Consequently, well yields from within the debris avalanche deposits are highly variable (DWR 2011).

Although groundwater yields are variable, the avalanche deposit exerts control on regulating and redirecting groundwater flow through the valley and to the Shasta River. Both the matrix facies and the block facies are water-bearing units and can more or less supply water for domestic purposes. Compared to the matrix facies, the debris blocks may be more permeable and transmit groundwater from the more permeable Pluto's Cave Basalt deposits to the east. The blocks may also serve to transmit groundwater from deeper, semi-to-fully-confining water-bearing formations below. Although few wells have been constructed in the debris flow, available data show that well yields can range from 6 to 40 gpm (~0.4-2.5 lps) for domestic wells and from 100 to 1,200 gpm (~6.3-76 lps) for irrigation wells. Although both the block and matrix facies are considered water-bearing units, the block facies may be more permeable and transmit groundwater from both deep, confined water-bearing formations, as well as the younger, more permeable basalt flows (DWR 2011).

The greatest significance of the volcanic debris avalanche is the role it plays in regulating and redirecting the natural flow of groundwater to the Shasta River. The avalanche deposits acted as a barrier to the subsequent lava flows and deposition of the Pluto's Cave Basalt. The less permeable avalanche deposits act as a barrier to groundwater flow through the more permeable Pluto's Cave Basalt, resulting in multiple voluminous groundwater springs (including the Big Springs Complex) along the contact between the two formations (Mack 1960; DWR 2011).

Pluto's Cave Basalt (Map unit: Qv (subset))

The southeastern portion of the Basin is covered by High Cascade basalt flows (known as Pluto's Cave Basalt, referencing a notable eponymous lava tube cave within the unit) of Pleistocene (likely 160,000 to 190,000 years ago) or possibly Holocene age (PGS 2001). Pluto's Cave Basalt is one of the primary water-bearing formations units within the Basin as well as the entire Watershed. The entire subarea's shallow subsurface is characterized by many successive series of overlapping lava flow units ranging in thickness from about 10 to 30 ft (~3-9 m; Williams (1949)). The total thickness of the Pluto's Cave Basalt flow ranges from more than 500 ft (>150 m) in the south (i.e. the head of the lava flow) to 50 ft (~15 m) or less in the north (i.e. toe of the lava flow). During these past lava flow events, clinkery surfaces (quickly hardened volcanic rock) formed at the contact between successive lava flows, producing "cinders" (drillers commonly use this term, which is more or less correct). These clinkery surfaces, together with cooling lava tube and fracture structures, act as functional conduits for water and can transmit large volumes of groundwater through these interconnected hollows. Geologic cross sections A-A' and H-H' provide the best vertical sections of the Pluto's Cave Basalt as modeled in the Shasta Valley Watershed geologic model (Appendix 2-A) (Figure 2.20 and 2.25). According to DWR (2011), most wells within this subarea yield between 10 and 100 gpm (0.6 to 6 lps), although several wells reportedly yield over 1,000 gpm (~63 lps).

Recharge to Pluto's Cave Basalt occurs from precipitation, percolation from irrigation and leaky water conveyance ditch losses, and groundwater underflow associated with meltwater from snowfall on the Cascade Range. Mount Shasta, Deer Mountain, and Whaleback Mountain are all likely source areas of groundwater (i.e. recharge) found in Pluto's Cave Basalt. A number of freshwater springs generally arise from the contact between Pluto's Cave Basalt and the debris avalanche deposits, as well as, at least locally, from the contact with the less conductive Western Cascade volcanic series. These contact zone springs include Big Springs, Hole in the Ground Spring, and a multitude of other named and unnamed springs. These springs are the principal source of cold freshwater for the Shasta River. Past investigations suggest that spring water discharged in the area is slightly thermal, meaning that groundwater sampled was at a slightly higher temperature which indicates higher recharge elevation, likely above 8,000 ft (>2,500 m) amsl. Past studies also suggest that this recharged groundwater likely interacts with marine sedimentary rock deposits at depth (likely in the Hornbrook Formation), due to the detection of elevated levels of chloride, nitrate, phosphate, and sulfate (Nathenson and Thompson 2003; Mcclain 2008). Mack (1960) showed that groundwater quality samples from Pluto's Cave Basalt contain the highest average concentration of silica (63 parts per million [ppm], or 1 mg/L) of waters in the Basin, which may partly be due to the pyroclastic debris and glacial outwash deposits that groundwater would recharge through up gradient on the north slopes of Mount Shasta. In contrast, groundwater sampled in the andesitic volcanic rocks of the debris avalanche material has on average a lower silica content (45 ppm).

Quaternary Alluvium (Map units: Q & Qg)

The Basin previously consisted of only the Quaternary-aged unconsolidated alluvium located along the western and northern portions of the Basin, not including the glacial deposits at the base of Mount Shasta (DWR 2004). In 2019, DWR updated this Basin boundary at the Agency's petition to additionally include the glacial deposits (Qg), debris avalanche deposits (Qvs), Pluto's Cave Basalt (Qv subset), and portions of the Western Cascade volcanics (Tv) from the western portions of the Cascade Range adjacent to the previous Basin boundary (Figure 2.19). The previous alluvial water-bearing unit (Q) includes stream and terrace deposits of Parks Creek, Willow Creek, Julien Creek, Yreka Creek, Shasta River, Little Shasta River, and Oregon Slu, as well as alluvial fan deposits forming the sedimentary apron at the base of the Klamath Mountains (DWR 2011).

According to Mack (1960) and DWR (2011), alluvial deposits of the Julien Creek and Willow Creek drainages vary in thickness. To the north in the Julien Creek drainage, the maximum thickness of the alluvial deposits is an estimated 300 ft (~90 m); this alluvium consists primarily of Julien Creek channel and alluvial fan deposits. In the south, channel deposits are estimated at 50 ft (~15 m) thick in the Willow Creek drainage. Well yields in matrix deposits generally range from 20 to 220 gpm (1.3-14 lps), while one well reportedly has a yield of 1,500 gpm (95 lps). In Julien Creek, drainage well yields range from 33 to 166 gpm (2-10.4 lps); in Willow Creek drainage, well yields are slightly less productive ranging from 20 to 100 gpm (1.3-6.3 lps). Most agricultural production in the valley occurs in areas containing alluvial deposits because they provide the soil structure and water holding capacity necessary for plant growth with well yields generally fluctuating from four (4) to 60 gpm (1.3-6.3 lps). The younger and older alluviums of recent and Pleistocene age yield water sufficient for domestic and stock uses. Along the west side of the Basin the younger alluvium produces adequate water for irrigation and supplies the City of Yreka with abundant water for municipal uses.

The Holocene alluvium found in the Basin is primarily silt and clay interbedded with sand and gravel with depths up to 150 ft (46 m) in some locations, and well yields measured at 150 to 1,000 gpm (9.5-63 lps; (Mack 1960)). North of Montague, the Basin is underlain by older Pleistocene alluvium up to 100 ft thick (~30 m) containing gravels derived from the Klamath Mountains. This portion of the Basin contains an iron-cemented hardpan just below the ground surface. Additionally, calcium derived from mafic volcanic rocks in the Little Shasta Valley has cemented the subsoil into hardpan, while the alluvial western valley margin extending south past Gazelle contains no hardpan (Mack 1960). The alluvial water-bearing formation is generally much less productive than the underlying volcanic water-bearing formation. Most large wells in the Basin, including those in locations with

Quaternary alluvium, produce groundwater from the underlying volcanic water-bearing formation. The alluvial water-bearing formation (Q) is mainly present in *Cross Sections A-A', E-E', West-East, and North-South* (Figure 2.20, 2.24, 2.27, and 2.26).

Deposits from the debris avalanche redirected flow paths of the Shasta River, Parks Creek, and Willow Creek within the alluvial system of the Gazelle/Grenada hydrologic region. Shasta River and Parks Creek have migrated back across the avalanche deposits; however, Willow Creek now flows in a northerly direction, adjacent to the topographically higher block facies portion of the debris avalanche deposit. Consequently, Willow Creek channel deposits, which have developed over the last 300,000 years, may convey unconfined groundwater north to the Willow Creek confluence with the Shasta River.

During the Pleistocene epoch, glaciers that descended the northwest slopes of Mount Shasta spread into the Basin to an altitude of about 2,800 ft (~850 m). The record of this glaciation is preserved in the southern part of the valley in the form of morainal hills and ridges, remarkably similar in appearance to the erosional remnants of the volcanic rocks of the western Cascades and in bouldery outwash deposits that extend from the shores of Dwinnel Reservoir (Lake Shastina) southward to Weed. Glaciers still remain on Mount Shasta and continue to supply fluvioglacial debris to the Basin to the present day. Fluvioglacial materials derived from the remaining glaciers (Whitney, Bolam, and Hotlum Glaciers) are still being deposited on the lower northwest flank of Mount Shasta as broad fans which are spreading over the edges of the Pluto's Cave Basalt. The glacial water-bearing unit (Qg) is mainly present in *Cross Sections E-E' and H-H'* (Figure 2.24 and 2.25). The morainal and fluvioglacial deposits generally yield sufficient water for domestic and stock uses. Several irrigation wells tapping glacial materials east of Edgewood yield 600 to 1,500 gpm (38-95 lps).

Vertical Cross Sections

Vertical cross sections of the Watershed originate from the Shasta Valley Watershed geologic model (Appendix 2-A) are shown below, with cross section line locations shown in Figure 2.19. Cross section naming convention followed the names of previous cross sections published (primarily Mack (1960) and DWR (2011)) covering the same vertical cross sectional plane (i.e. along the same line at the ground surface); however, they are not necessarily identical in area and extent. Additionally, cross section names identical in name and not in location to previously published cross sections of the area were avoided to prevent confusion and aide in comparison to published literature of the area (i.e. Cross Sections F-F' and G-G' are not used).

Table 2.4: Hydrostratigraphic Model Unit Descriptions.

Unit ID	General Lithology	Age	Description	Water-Bearing Unit Properties
Q	Alluvium	Holocene-Pleistocene	Alluvium, lake, playa, and terrace deposits; unconsolidated and semi-consolidated	Typically shallow deposits (generally <200 ft thick; <61 m) concentrated on western and northern parts of the Valley along fluvial corridors; highly utilized aquifer in the Valley; well yields range from 10's to 100's of gal/min (0.6-6.3+ liters/sec)
Qg	Glacial deposits	Holocene-Pleistocene	Glacial till and moraines	Heterogeneous glacial aquifer material; shallow deposits are limited spatially across the Valley floor, mostly at the base of Mt. Shasta; few wells completed in this unit; moderate yields of typically 10-100+ gal/min (0.6-6.3+ liters/sec), some east of Edgewood yield 600-1,500 gal/min (38-95 liters/sec)
Qv	Pleistocene Volcanic rocks	Holocene(?)-Pleistocene	Basaltic and andesitic flows and pyroclastic rocks of Cascade Range	Highly heterogeneous volcanic aquifer material; significant recharge material in the Valley; Pluto' Cave basalt subunit is the most important aquifer material in the Valley; thickness increases toward Mt. Shasta (50-500+ ft; 15-150+ m); yields can be low but can easily top 1,000+ gal/min (63+ liters/sec) in permeable zones (usually in lava tubes)
Qvs	Volcanic rocks of Shasta Valley	Pleistocene	Catastrophic volcanic-debris avalanche incorporated existing deposits of andestic volcanic rock, alluvium, lahars, and pyroclastic flows	Highly heterogeneous volcanic/sedimentary debris flow aquifer material; both matrix and block facies are water-bearing units; blocks may be more permeable and transmit groundwater across or under surface deposits; few wells have been completed in this unit; well yields range 6-40 gal/min (0.4-2.5 liters/sec) for domestic wells and 100-1,200 gal/min (6.3-76 liters/sec) for irrigation wells
Pv	Pliocene Volcanic rocks	Pliocene	Basaltic and andesitic flows, breccia, and tuff of Cascade Range	Heterogeneous volcanic aquifer material; surface outcrops are uncommon on Valley floor; generally the least important High Cacade aquifer material in the Valley; few wells completed in this formation leading to a lack of information on yields

Table 2.4: Hydrostratigraphic Model Unit Descriptions. *(continued)*

Unit ID	General Lithology	Age	Description	Water-Bearing Unit Properties
Tv	Western Cascade Volcanics	Miocene(?)-Eocene	Andesitic and basaltic flows, breccia, tuff, minor rhyolitic tuff, and intercalated sedimentary units of Cascade Range	Heterogeneous volcanic aquifer material; generally the least important aquifer material in the Valley; yielding lower supplies for domestic and stock purposes
Kh	Hornbrook Formation	Cretaceous	Shallow- and deep-water marine and nonmarine shale, sandstone, and conglomerate	Functions as a partial hydrogeologic basement for younger basin deposits in some portions of the Valley; Some wells in these units, typically in jointed/faulted rock or in more sandy rock subunits, yielding minimal water supply for domestic and stock uses
Basement	Basement (group)	Mesozoic-Paleozoic	Various Paleozoic metamorphic (metasedimentary and metavolcanic) units and Mesozoic igneous (granite/diorite) units	Hydrogeologic basement for basin deposits; Very few wells in these units, typically in jointed/faulted rock, yielding minimal water supply for domestic and stock uses

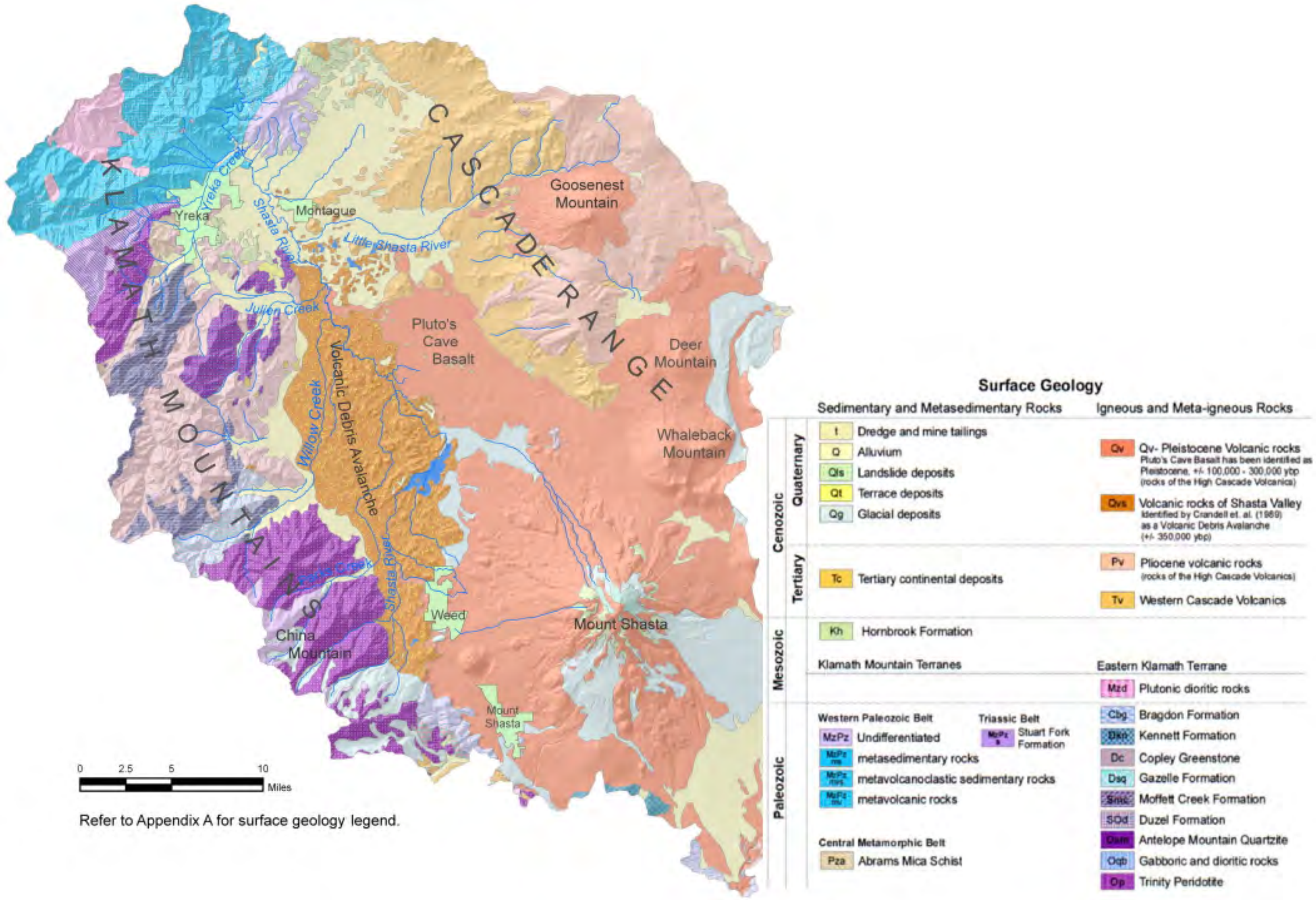


Figure 2.17: The Watershed and extended Mount Shasta area - previous surface geologic map (reprinted and adapted from DWR 2011).

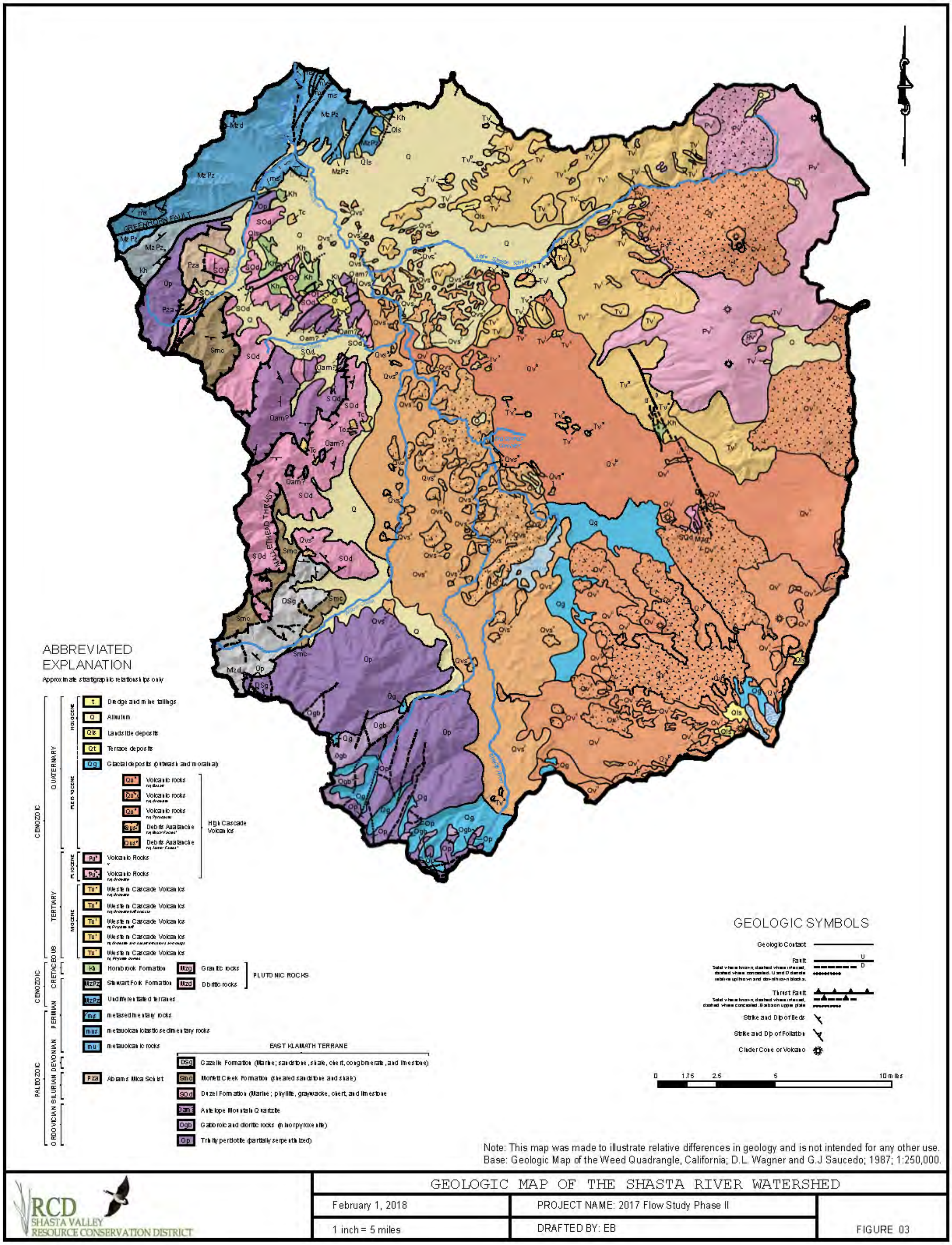


Figure 2.18: The Watershed - previous surface geologic map (reprinted from SVRCD 2018).

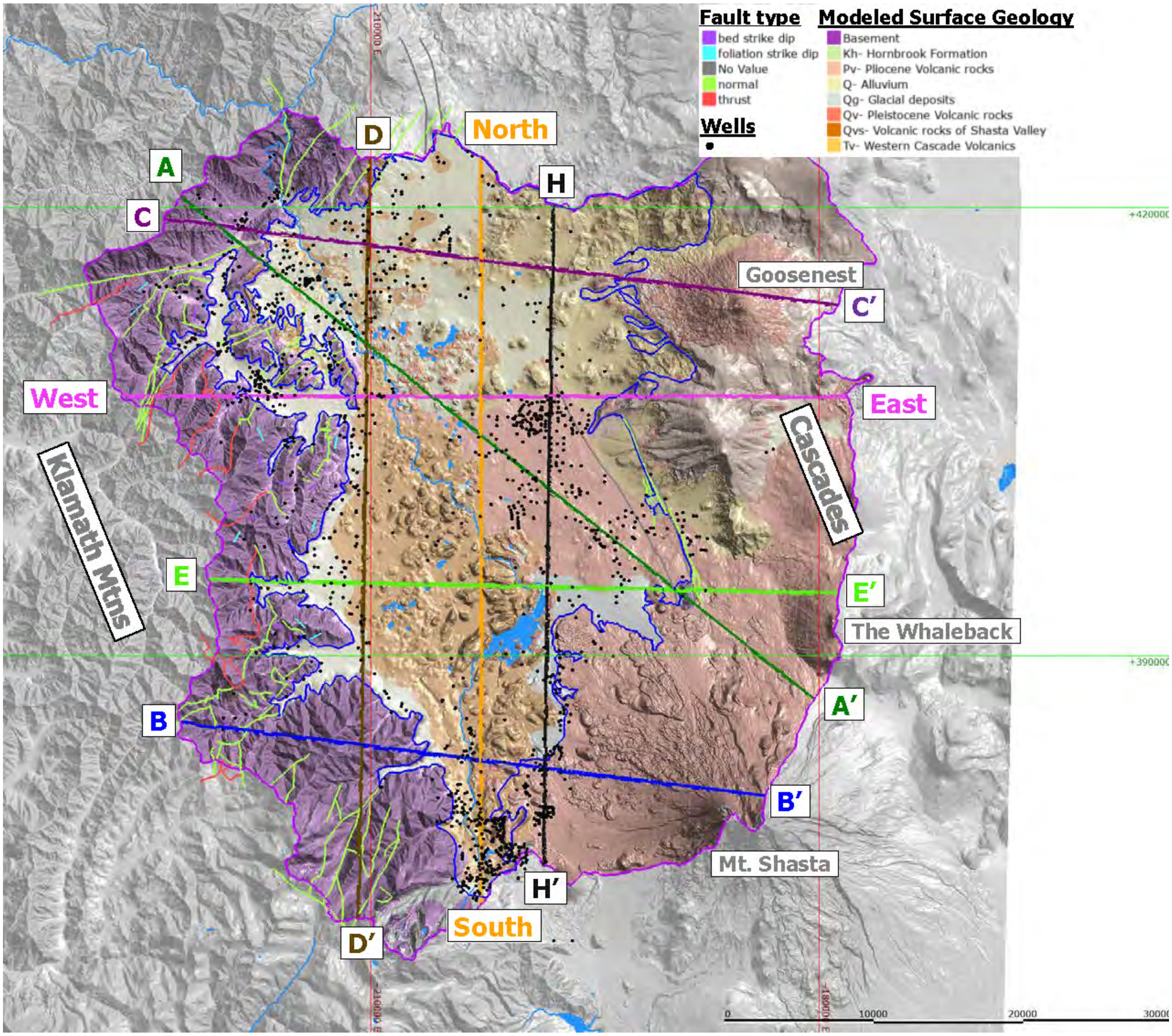


Figure 2.19: The Watershed geologic model overview and cross section map. Wells pictured in the map are the approximate locations noted in the Well Completion Reports used to construct the geologic model. The surface geology utilized in the geologic model is based on DWR 2011 and SVRCD 2018.

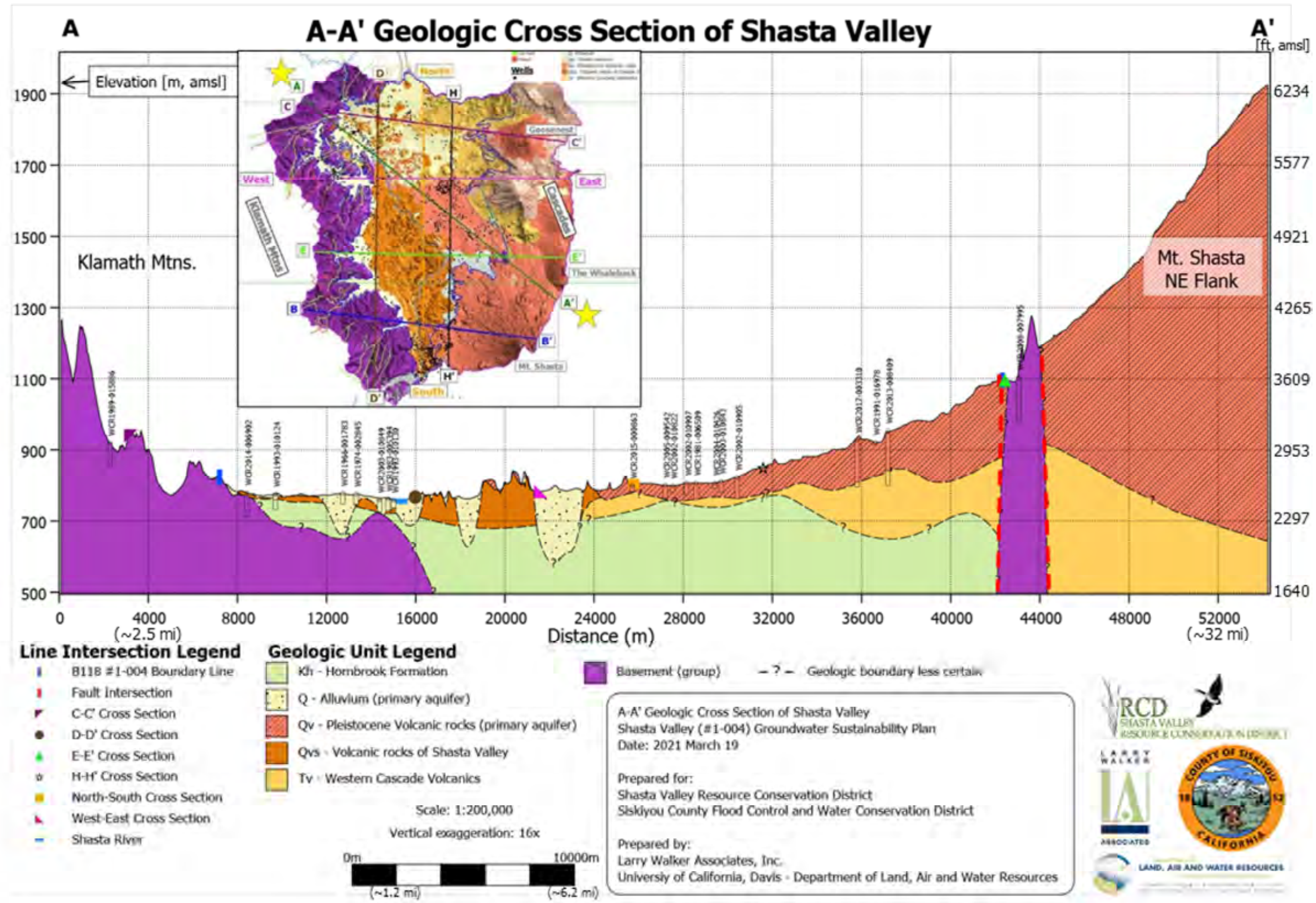


Figure 2.20: Geologic cross section A-A’ from the Shasta Valley Watershed geologic model. Inset includes the surface geologic overview map of the Shasta Valley Watershed geologic model.

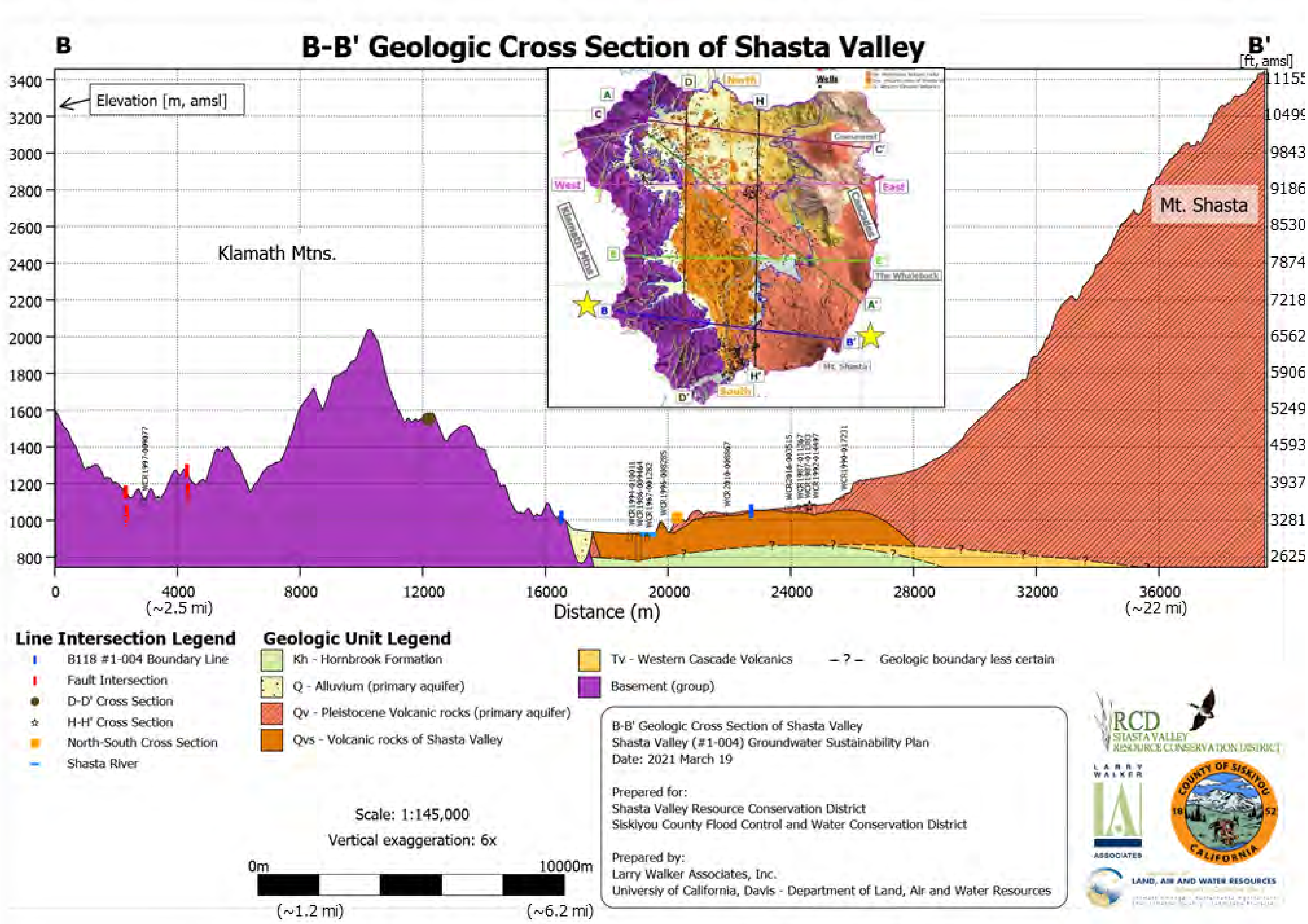


Figure 2.21: Geologic cross section B-B' from the Shasta Valley Watershed geologic model. Inset includes the surface geologic overview map of the Shasta Valley Watershed geologic model.

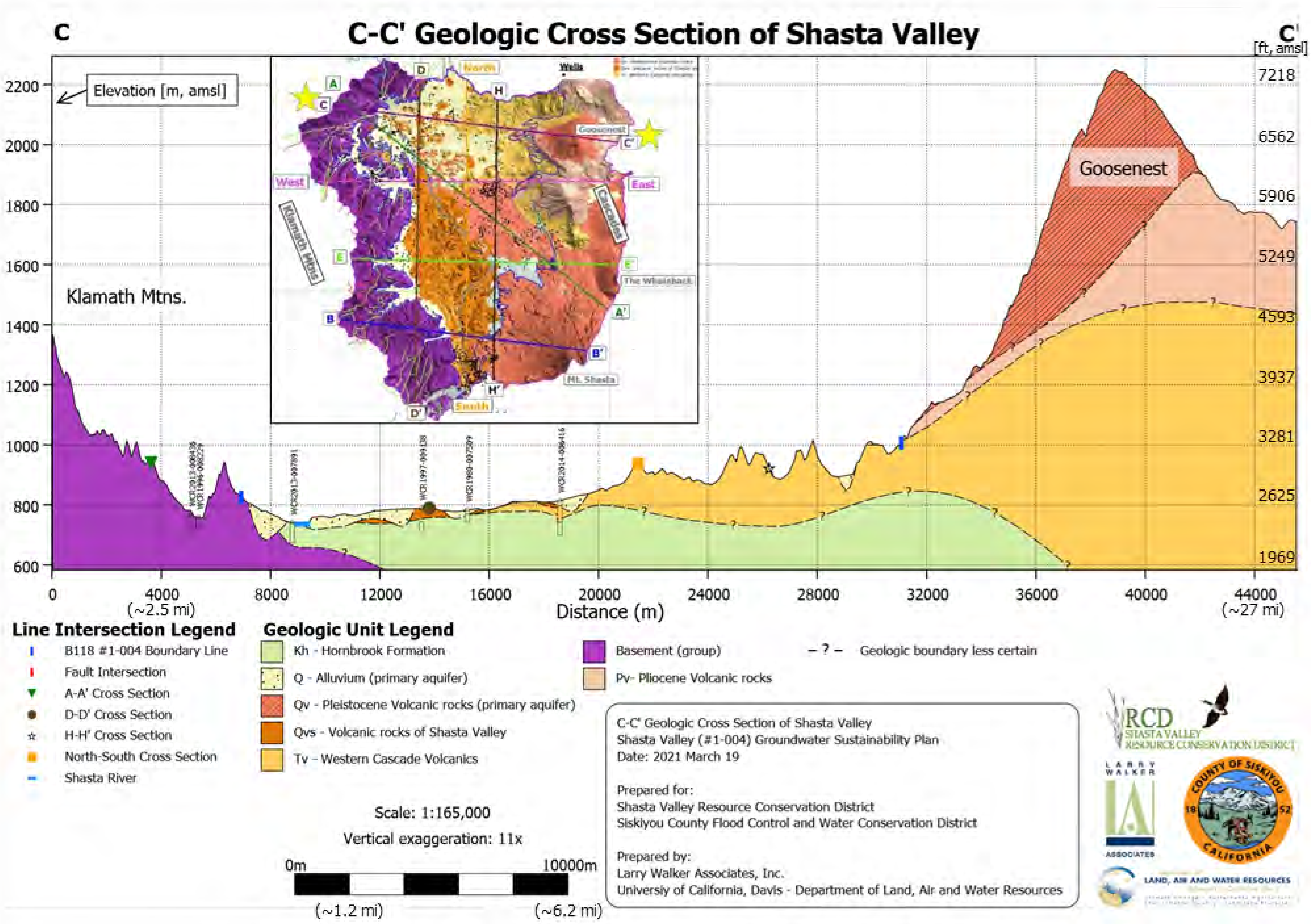


Figure 2.22: Geologic cross section C-C' from the Shasta Valley Watershed geologic model, Inset includes the surface geologic overview map of the Shasta Valley Watershed geologic model.

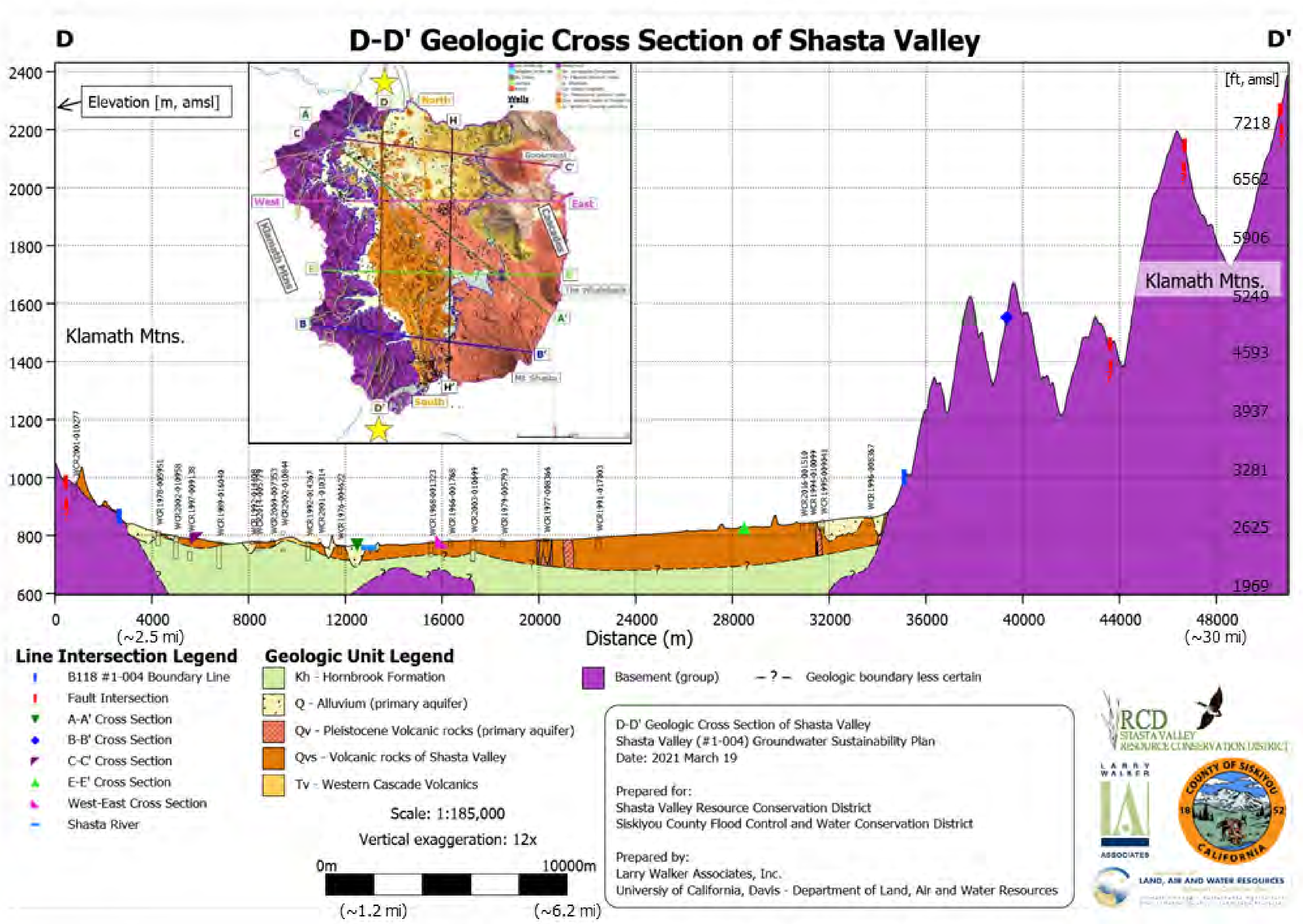


Figure 2.23: Geologic cross section D-D' from the Shasta Valley Watershed geologic model. Inset includes the surface geologic overview map of the Shasta Valley Watershed geologic model.

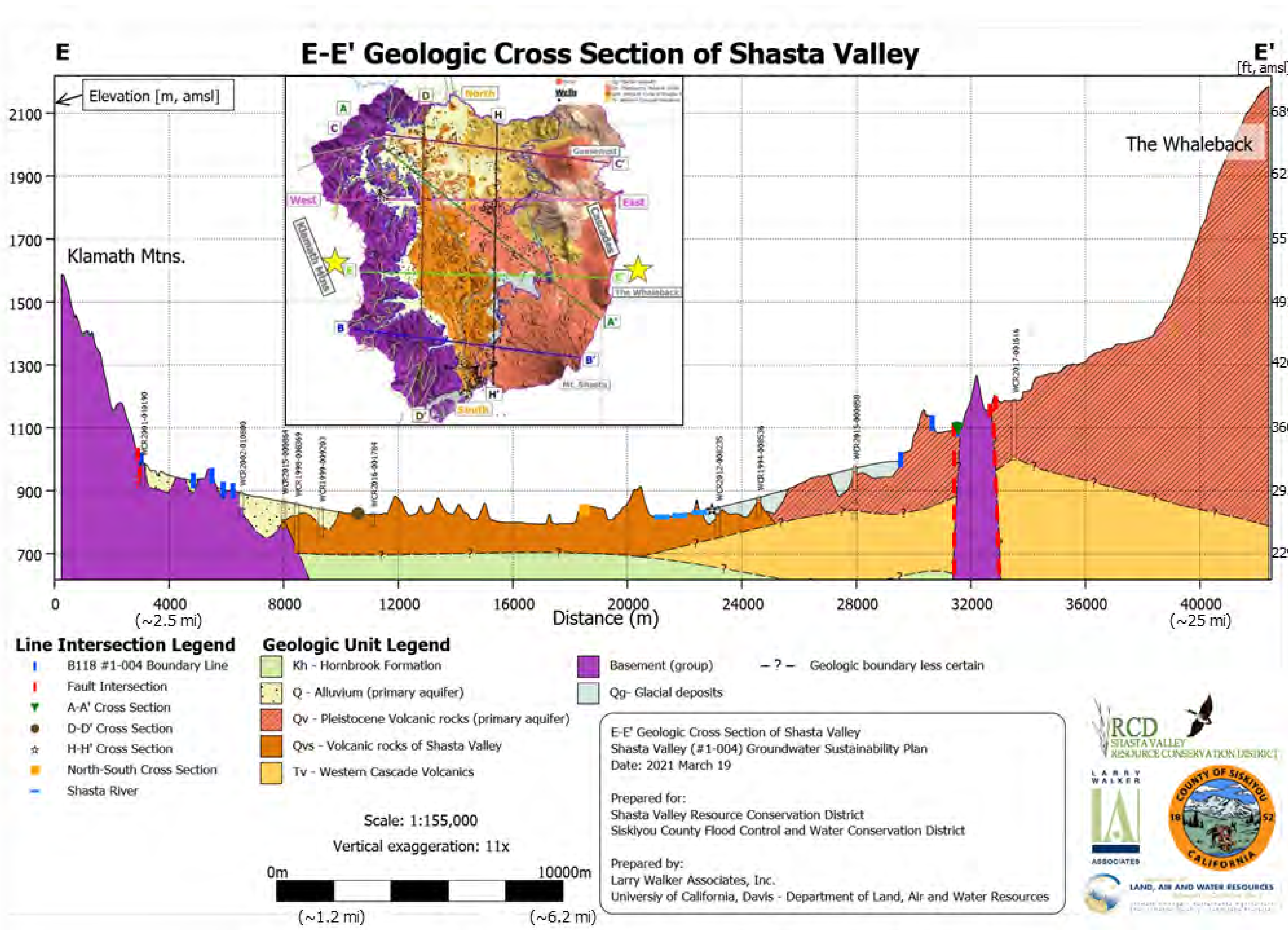


Figure 2.24: Geologic cross section E-E' from the Shasta Valley Watershed geologic model. Inset includes the surface geologic overview map of the Shasta Valley Watershed geologic model.

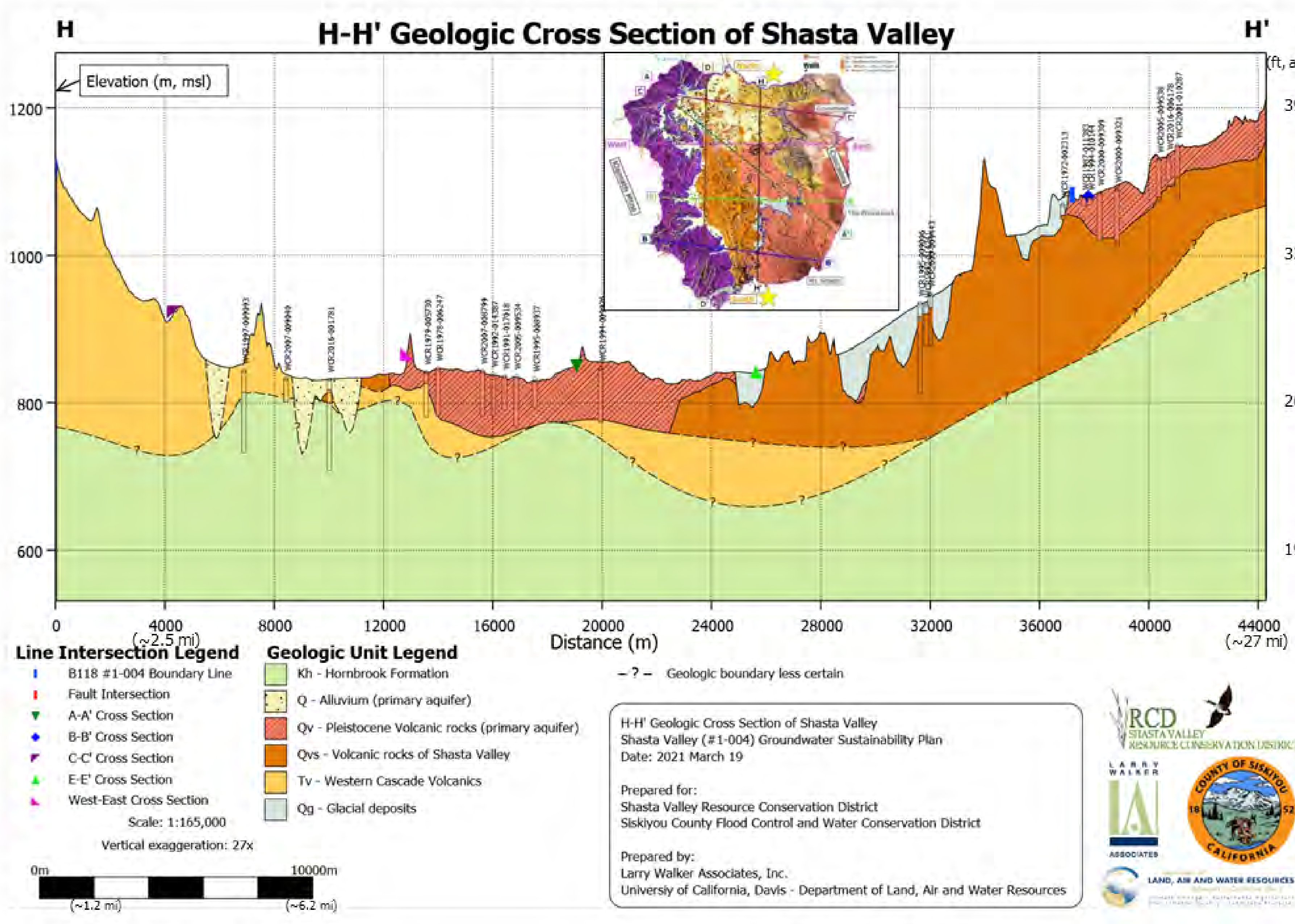


Figure 2.25: Geologic cross section H-H' from the Shasta Valley Watershed geologic model. Inset includes the surface geologic overview map of the Shasta Valley Watershed geologic model.

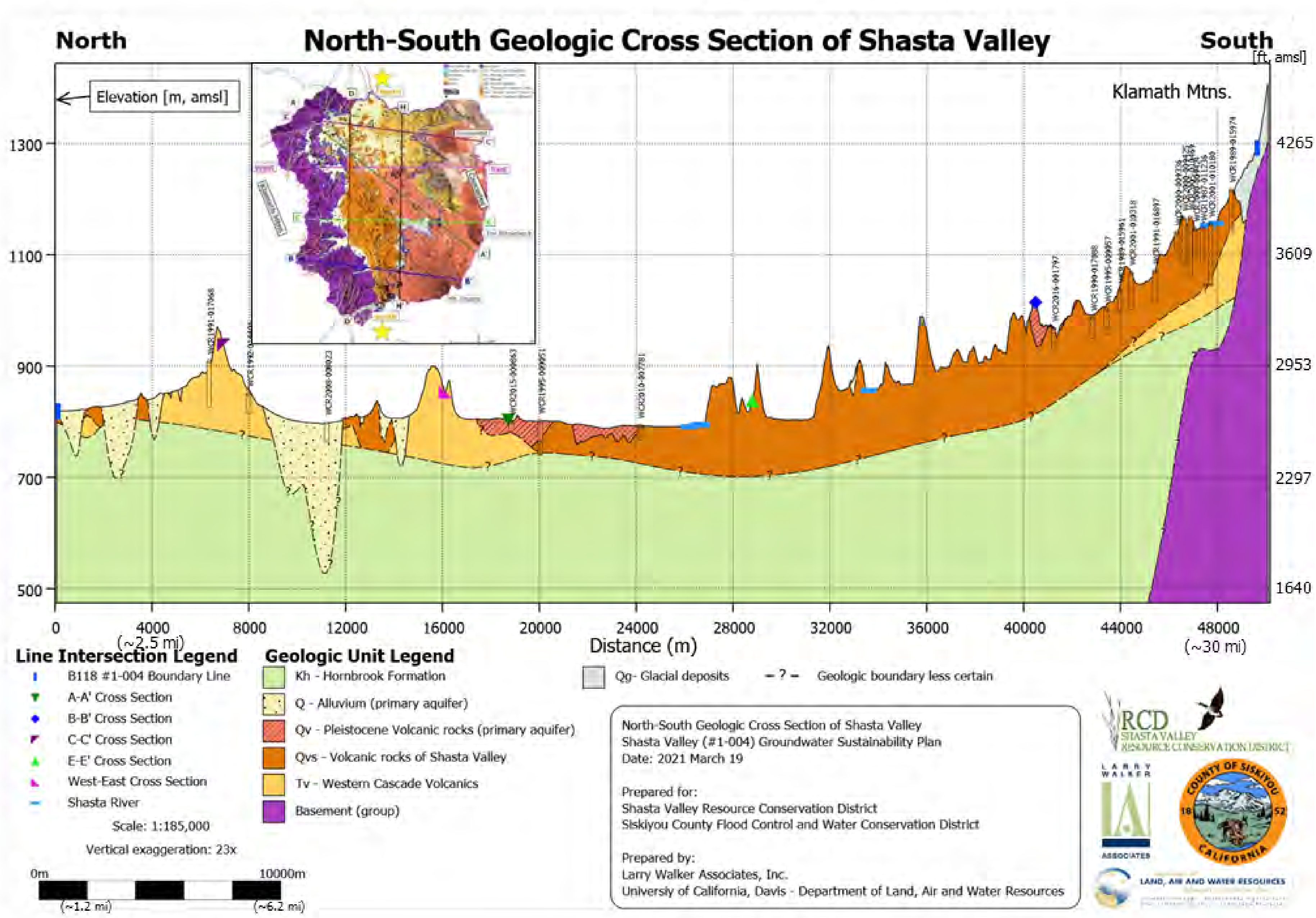


Figure 2.26: Geologic cross section North-South from the Shasta Valley Watershed geologic model. Inset includes the surface geologic overview map of the Shasta Valley Watershed geologic model.

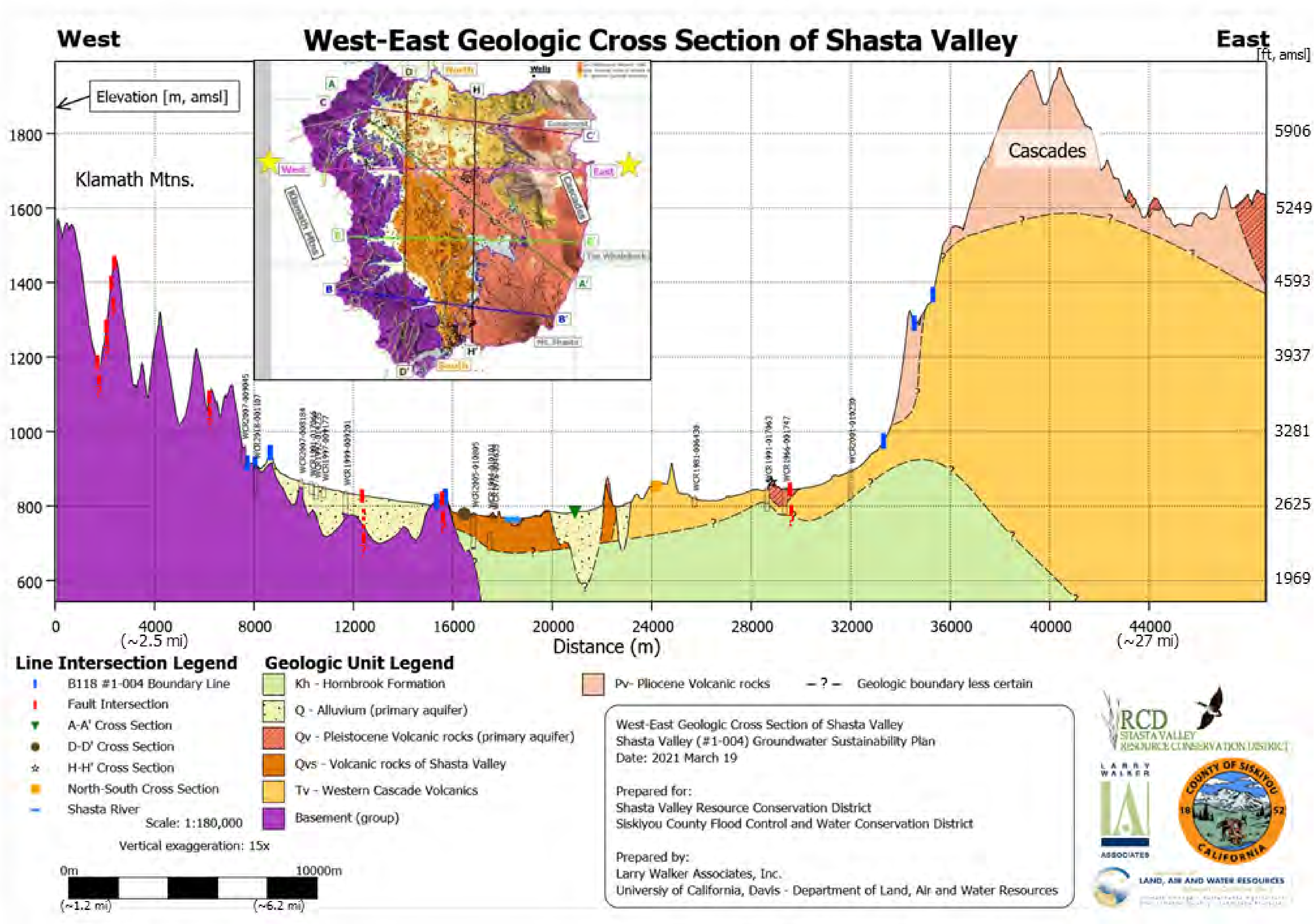


Figure 2.27: Geologic cross section West-East from the Shasta Valley Watershed geologic model. Inset includes the surface geologic overview map of the Shasta Valley Watershed geologic model.

2.2.1.4 Soils

The Natural Resources Conservation Service's (NRCS) State Soil Geographic and Soil Survey Geographic Database (STATSGO/SSURGO) is a soils database that has four main hydrologic soil groups that characterize surface water runoff potential. Group A generally has the lowest runoff potential with the highest infiltration rates and Group D has the highest runoff potential and the lowest infiltration rates. Groups B and C are intermediates between Groups A and D. Group A contains very well-drained sand, loamy sand, or sandy loam. Group B contains silt, silt loam, or loam. Group C contains sandy clay loams that are moderately to poorly drained with low infiltration rates. Group D contains poorly-drained clays, sandy and silty clays, clay loam, and silty clay loam, silt loams, and loams.

A map of soil orders in the Watershed is shown in Figure 2.28 and Figure 2.29 shows the spatial distribution of the STATSGO/SSURGO data for the Watershed's hydrologic soil groups. There is no dominant soil group in the Watershed with Groups A, C, and D comprising almost the entirety of the Watershed's surficial soils. Each of these groups occupy roughly one quarter to one third of the total area of the Watershed. Group B is not widely observed in the Watershed like the other groups.

2.2.1.4.1 Soil Recharge Suitability

The Soil Agricultural Banking Index (SAGBI) identifies the potential for groundwater recharge on areas of land based on five factors: deep percolation, root zone residence time, topography, chemical limitations, and the condition of soil surfaces (O'Geen et al. 2015). The deep percolation factor is derived from the soil horizon with the lowest saturated hydraulic conductivity. Saturated hydraulic conductivity is a measure of soil permeability when soil is saturated. The root zone residence time factor estimates the likelihood of maintaining good drainage within the root zone shortly after water is applied. This rating is based on the harmonic mean of the saturated hydraulic conductivity of all horizons in the soil profile, soil drainage class and shrink-swell properties. The chemical limitations factor is quantified using the electrical conductivity of the soil, which is a measure of soil salinity. Level topography is better suited for holding water on the landscape, thereby allowing for infiltration across large areas, reducing ponding and minimizing erosion by runoff. Ranges in slope percent are used to categorize soils into five slope classes: optimal, good, moderate, challenging, and extremely challenging. Depending on the water quality and depth, standing water can lead to the destruction of aggregates, the formation of physical soil crusts, and compaction, all of which limit infiltration. Two soil properties are used to diagnose surface condition: sodium adsorption ratio is used to identify soils prone to crusting, and the soil erosion factor is used to estimate the potential soil susceptibility to erosion, disaggregation, and physical crust formation.

The unmodified SAGBI does not account for modifications by deep tillage. The modified index is theoretical and assumes that all soils with restrictive surficial layers have been modified by deep tillage. The SAGBI ratings for the soil series in the Watershed area is shown in Figure 2.30 to 2.31 and can also be viewed on a web application developed by the California Soil Resource Lab at University of California Davis and the University of California Agriculture and Natural Resources (O'Geen et al. 2015). The unmodified SAGBI ratings for the Basin largely show that most areas are listed as "Very Poor" or do not have data coverage. Particularly, the index ratings are absent for much of the eastern portion of the Basin along Pluto's Cave Basalt, a recharge area for the Watershed, and in some central portions of the Basin in the debris avalanche area. However, the missing eastern area is covered by the STATSGO/SSURGO Database discussed above, which lists much of this missing area as Group A that generally has the lowest runoff potential with the highest infiltration rates. There is a significant area of "Excellent" ratings in the Gazelle area in the Bonnet soil. Additionally, there is an area assigned "Excellent" and "Good" ratings following the Whitney Creek drainage area north from Mount Shasta (this is the drainage path for Whitney Glacier) in the Delaney soil. The modified SAGBI ratings for the Basin show a very different picture than the unmodified index. The modified index ratings increase much of the "Very Poor" areas by a number of levels, and in some cases, to "Excellent" and "Good" in the central, eastern, and northern areas of the Basin. Although these SAGBI ratings can provide an indication of suitability for recharge projects, groundwater transit times may need to be investigated for prior to implementation of groundwater recharge projects.

Pertinent to the Basin, alfalfa was not considered in the root zone residence time factor. The authors of the SAGBI state that "…alfalfa may be an ideal crop for groundwater banking because it requires little or no nitrogen fertilizer, reducing the risk that groundwater recharge would transport nitrates into aquifers. Alfalfa is sensitive to flooding and saturated conditions; thus, the timing of flooding should coincide with older fields (typically 4 to 5 years old) slated for replanting. Because the financial risk associated with crop damage is lower in alfalfa than in tree and vine crops, the financial incentive needed to drive grower participation in groundwater banking programs likely would be lower as well." (O'Geen et al. 2015). Other limitations to consider when evaluating the SAGBI are a lack of consideration of proximity to surface water sources. This is especially important to groundwater-dependent agriculture operations not connected to surface water supply conveyances, and the particular characteristics of the unsaturated zone and the depth to groundwater.

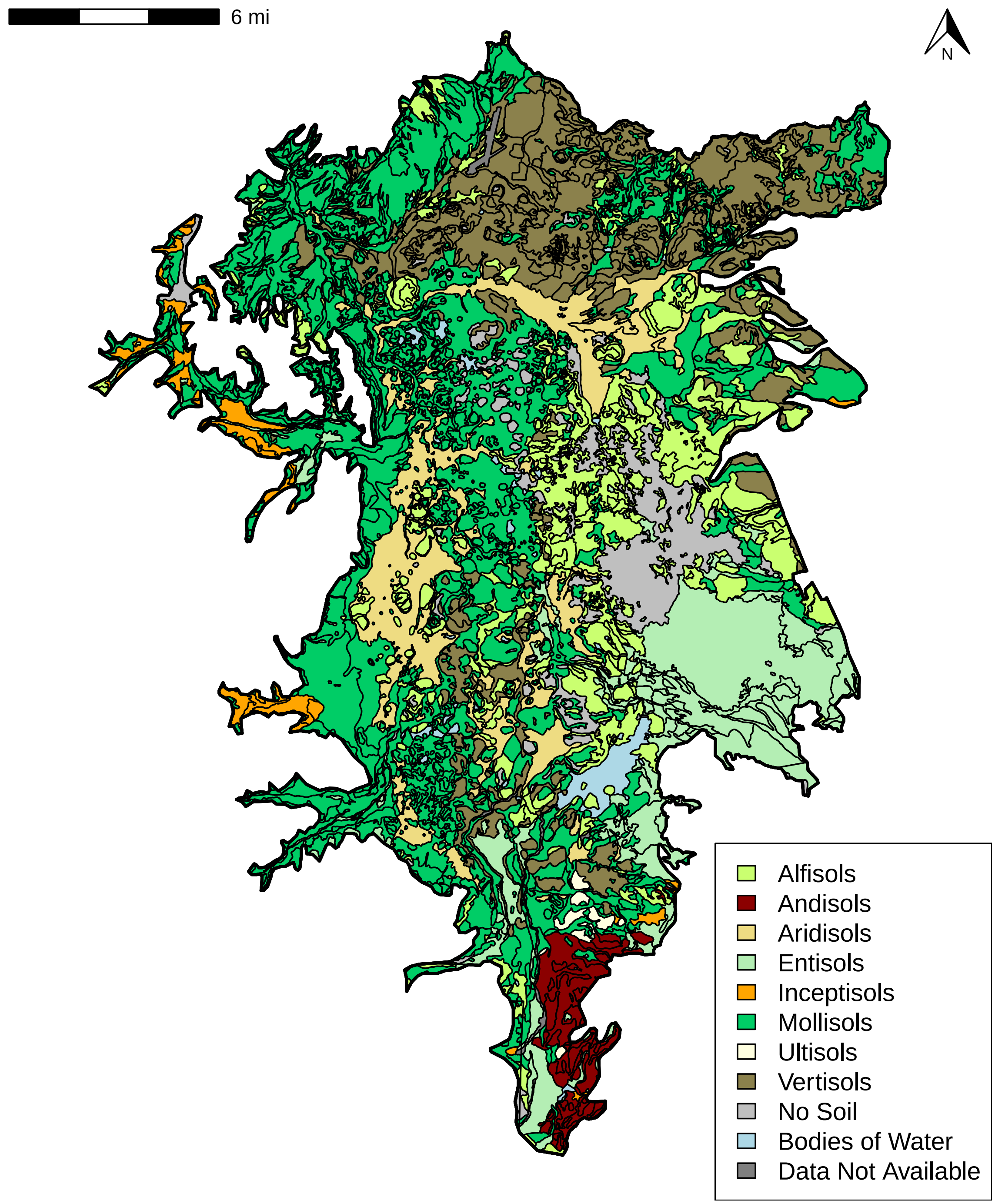


Figure 2.28: Soil classifications in the Basin

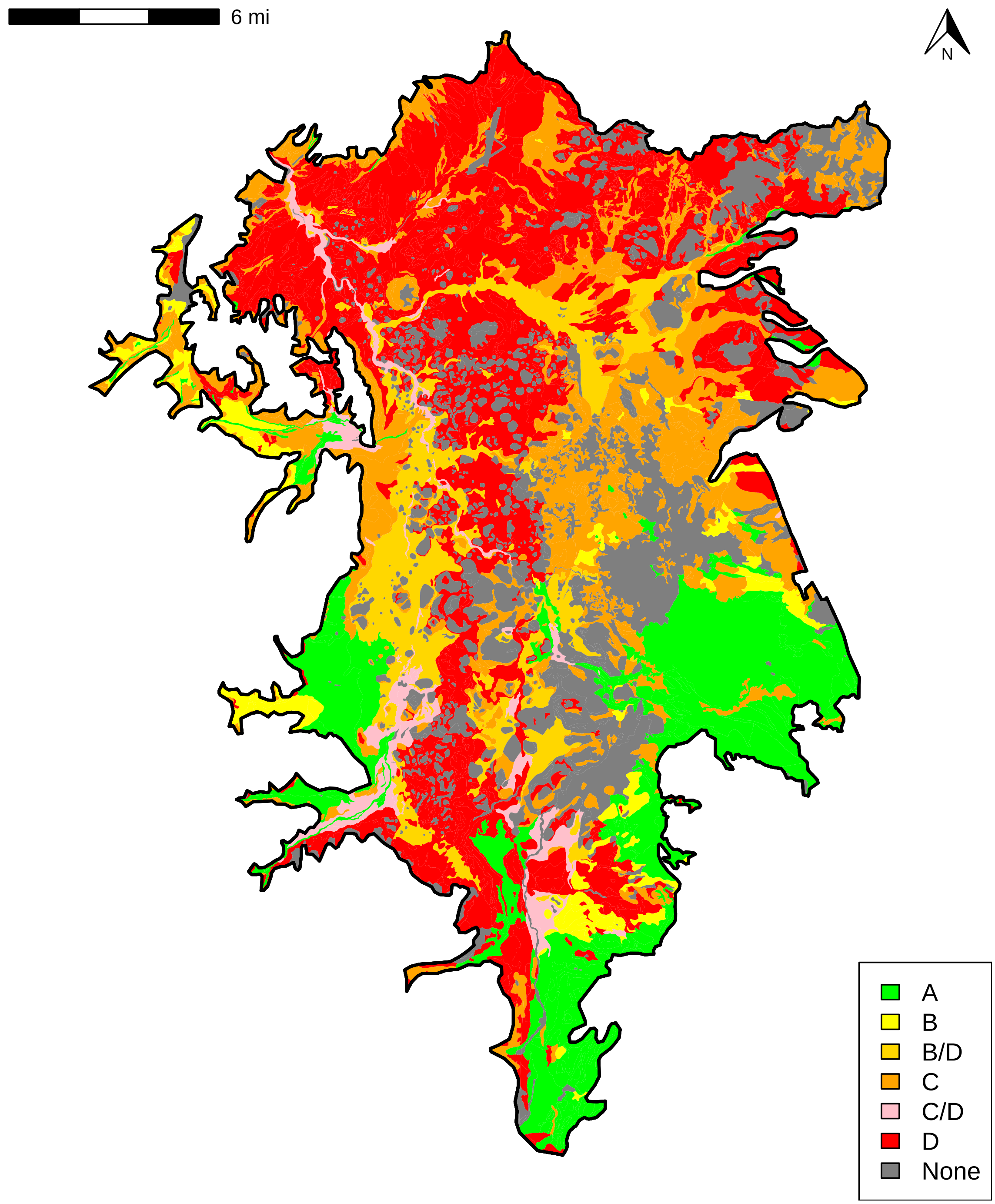


Figure 2.29: Hydrologic soil groups in the Basin, where Group A are soils with a high infiltration rate and low runoff potential to Group D with very slow infiltration and high runoff potential. Soils have two Groups if a portion is artificially drained and the rest undrained.

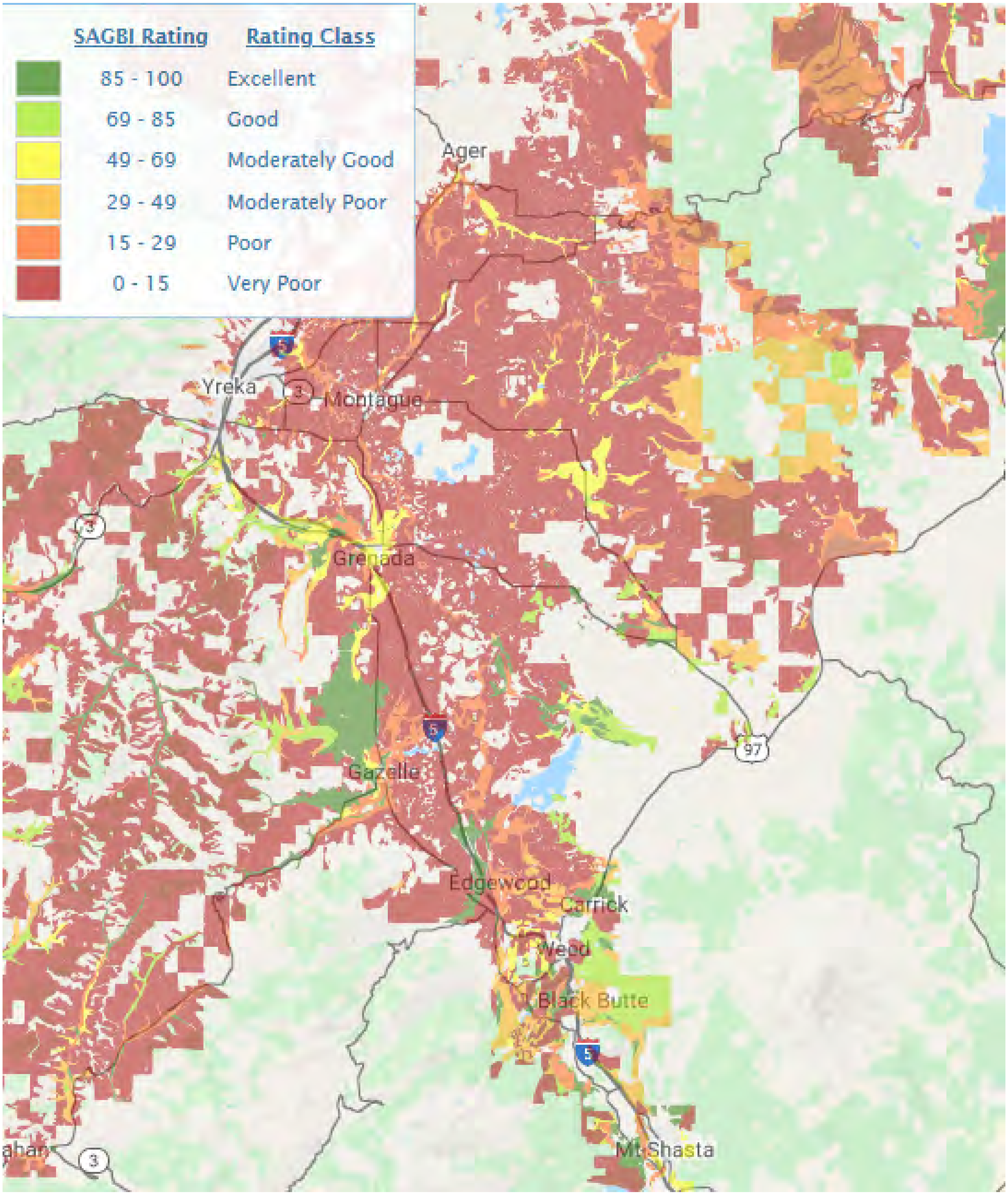


Figure 2.30: Unmodified Soil Agricultural Banking Index (SAGBI) of the greater the Basin area. Unmodified overlay shows SAGBI suitability groups when not accounting for modifications by deep tillage. Adapted from https://casoilresource.lawr.ucdavis.edu/sagbi/.

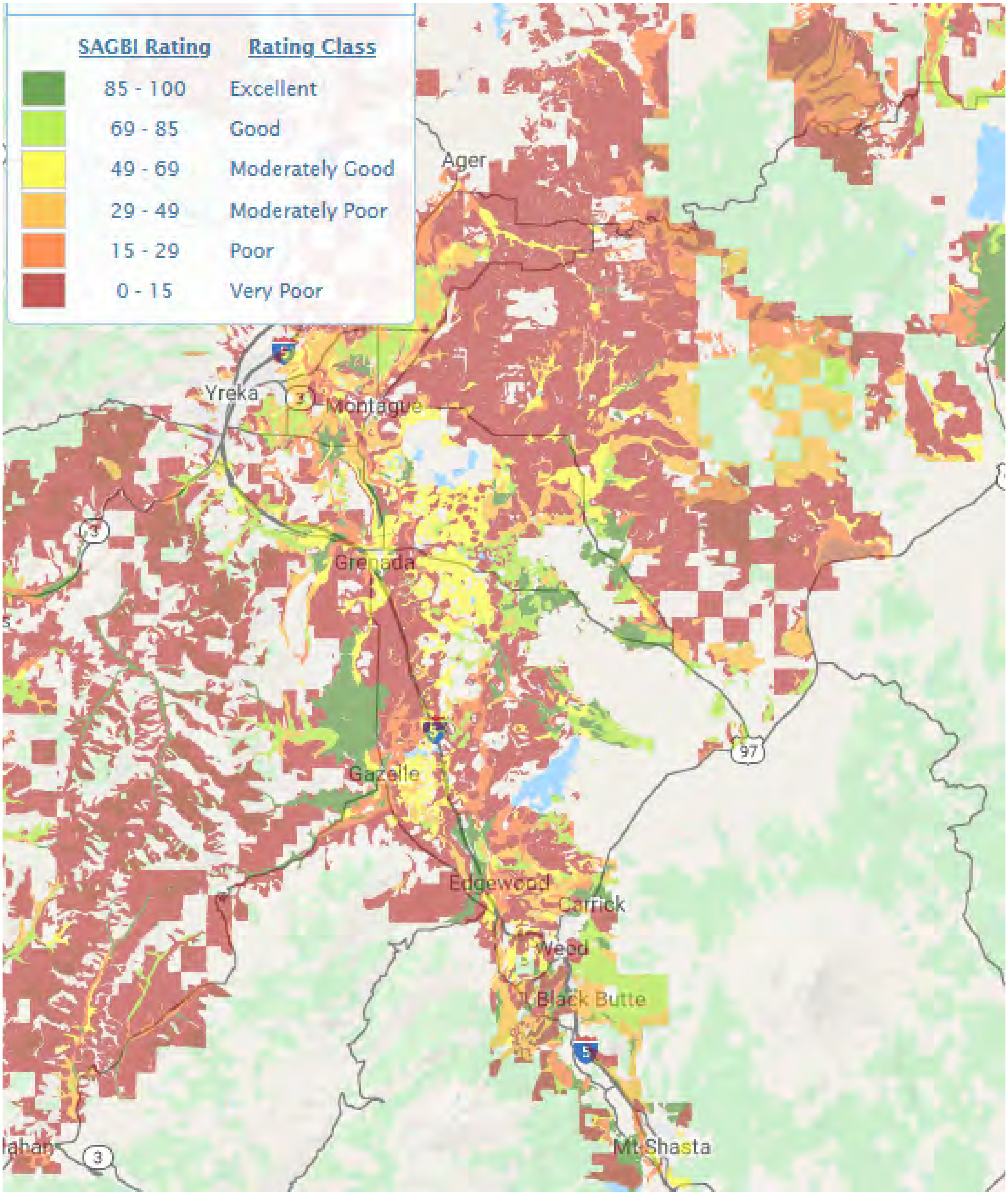


Figure 2.31: Modified Soil Agricultural Banking Index (SAGBI) of the greater Basin area. Modified overlay is theoretical; it shows SAGBI suitability groups when assuming that all soils with restrictive layers have been modified by deep tillage. Adapted from https://casoilresource.lawr.ucdavis.edu/sagbi/.

2.2.1.5 Hydrology

The Watershed covers approximately 800 sq mi (~2,070 sq km) ranging in elevation from just over 2,000 ft (610 m; near the confluence with the Klamath River) to over 14,000 ft (4,300 m; near the peak of Mount Shasta) amsl. The Watershed encompasses several smaller watersheds; the two most notable being the Little Shasta River and Parks Creek. Shasta Valley also includes the Grass Lake area, a high volcanic plateau to the north of Mount Shasta. The area has few streams, none of which connect to the Klamath River, all flow into dry sinks, and none support anadromous fish (NOAA 1981). The Watershed is bounded to the west by the Scott River watershed, to the south by the Sacramento River watershed, to the east by the Butte Valley watershed, and by the Klamath River to the north. The Shasta River is approximately 58 miles (93 km) long stretching from the peak of Mount Eddy at about 9,000 ft (2,750 m) amsl to the confluence with the Klamath River. The Little Shasta River drainage basin within the Watershed is bounded by Goosenest Mountain (8,260 ft; 2520 m amsl) to the south, Ball Mountain (7,792 ft; 2375 m amsl) to the east and Willow Creek Mountain (7,828 ft; 2386 m amsl) to the north. Little Shasta River is predominantly spring fed, sustained by a series of springs emerging from Quaternary and Tertiary High Cascade volcanic materials, discussed further in the following sections.

Mount Shasta, snow-covered year-round, is the most conspicuous feature of the landscape, visible from all parts of the Basin. Several glaciers stretch along its upper slopes which are the primary source of recharge to the Basin. On its north slope, Whitney, Bolam, and Hotlum Glaciers descend to altitudes of about 10,000 ft (3,048 m) amsl. On the south slope, the Koiiwakiton Glacier descends to an altitude of 12,000 ft (3,658 m) amsl, and the Clear Creek and Winton Glaciers to about 11,000 ft (3,353 m) amsl. Regional climate models generally predict the loss of Mount Shasta's glacier volume over the next 50 years and total loss of the glacier by the year 2100, likely resulting in reduced recharge in the Basin (Pelto 2008).

The Shasta River has a complicated seasonal and longitudinal flow regime due to intricate surface water and groundwater interactions, coupled with extensive agricultural diversion and return flows (Vignola and Deas 2005; Nichols et al. 2010). The Watershed includes a small number of small-scale diversion dams and diversions of the Shasta River or major tributaries, with the two main sources of water being the Shasta River and Parks Creek with storage in Dwinnell Reservoir (Lake Shastina). A number of the small-scale diversion dams have been or are in the process of being removed or modified for fish passage. Water rights dictating usage throughout the Shasta Basin are a combination of riparian and appropriative water rights adjudicated as a part of the 1932 Decree (DWR 1932). Buck (2013) constructed a groundwater model for a portion of the Watershed and summarized major balance components for the period 2008–2011.

The upper Shasta River, upstream of Dwinnell Dam, originates on the eastern slope of the Mount Eddy and is characterized by a runoff-driven hydrograph derived from rainfall and snowmelt (Nichols et al. 2010). Inflows to Lake Shastina consist of the upper Shasta River, flows diverted from Parks Creek near Edgewood, and Carrick Creek originating from the northwest flank of Mount Shasta. In 1928, construction of Dwinnell Dam was completed, impounding Lake Shastina to primarily serve as a storage reservoir and diversion for agricultural irrigation water throughout the Basin. Lake Shastina is the largest single water source in the Watershed. Outflow from Lake Shastina to the lower Shasta River, regulated by Dwinnell Dam, has reduced mean annual discharge in the reaches immediately downstream of the reservoir by up to 90 percent (Jeffres et al. 2008; Nichols 2008; Nichols et al. 2010)). Maximum reservoir storage capacity in Lake Shastina is rarely achieved because of the permeable underlying volcaniclastic rocks which allow impounded water to flow into the underlying water-bearing formations (Vignola and Deas

2005). Mack (1960) reported that multiple springs along the base of the ridge forming the western embankment of Lake Shastina increased in flow following construction of the reservoir. Seepage losses from Lake Shastina have been estimated at 6,500 to 42,000 acre-feet (AF) (~8-52 million cubic meters (m^3)) annually, significant relative to the reservoir's 50,000 AF (~62 million m^3) storage capacity, representing a loss of 13 to 84 percent of storage capacity (NCRWQCB 2006).

Flows in the lower Shasta River, downstream of Dwinnell Dam, are composed of minimal releases from Lake Shastina, tributary creeks (e.g., Parks Creek, Willow Creek, Little Shasta River), multiple discrete groundwater springs (e.g., Big Springs, Little Springs, Clear Springs, Kettle Springs, Bridge Field Springs), and additional diffuse groundwater springs. The lower Shasta River is characterized by a spring-dominated hydrograph primarily sourced from Big Springs Creek, supplied by multiple groundwater springs in the Big Springs Complex vicinity (Jeffres et al. 2008; Nichols 2008; Nichols et al. 2010)). Spring-fed baseflows from Big Springs Creek outside the irrigation season (i.e., November to March) are five times those of the lower Shasta River upstream of the Big Springs Creek confluence (including Parks Creek) for the same time period (Jeffres, Dahlgren, et al. 2009). Approximately 95 percent of baseflows during irrigation season (i.e., April to October) in the lower Shasta River originate from the Big Springs Complex. During irrigation season, Big Springs Creek baseflows are approximately 35 percent lower, caused by temporally variable irrigation diversions and unquantified groundwater pumping (Jeffres, Dahlgren, et al. 2009). In-stream flows downstream of Big Springs Creek confluence quickly rebound to spring-fed baseflow conditions following irrigation season (Nichols et al. 2010).

Dwinnell Dam is the largest water storage structure in the Basin, with current capacity of 50,000 AF (~62 million m^3), upgraded from 36,000 AF (~44 million m^3) in 1955 (CDFG 1997). Water is delivered to users in Shasta Basin via canals, diversion facilities, pumps, and storage infrastructure (Willis et al. 2013). Major diversions and smaller dams or weirs are located below Dwinnell Dam, along with numerous diversions on tributaries (CDFG 1997; Lestelle 2012; Fisheries 2014; CDFW 2016). Several diversions and return channels exist largely for agricultural purposes that primarily operate during the irrigation season, including the Grenada Irrigation District Ditch, the SRWA, and Oregon Slough (Jeffres, Nichols, et al. 2009) (Figure 2.32).

The City of Yreka obtains much of its water supply from Fall Creek (Figure 2.33), located outside the Watershed near Iron Gate Reservoir (Pace Engineering 2016). The City's treated wastewater, totaling 966 AF (1.2 million m^3) in 2015, is discharged to percolation fields near Yreka Creek (Pace Engineering 2016). Historical in-stream flow data were collected from the USGS and DWR Water Data Library and CDEC. Two USGS streamflow gages (stations SRM and SRY) are present in the Watershed with observed discharge data spanning water years 1911 to 2021 and 1933 to 2021 respectively. Five additional gauging stations are maintained by DWR and are associated with sporadic data collection in two to three-year periods. Gage locations in the Watershed are shown in Figure 2.33.

Data were analyzed to assess quantity and quality of the observed record. Quantity was measured as percent of days with recorded flow data at each gauge, and quality was assessed as percent of days flagged by USGS as having been "edited or estimated by USGS personnel" (USGS 2018). Figure 2.35 provides a summary of USGS data quantity and quality in the Watershed; a continuous flow record of reliable data (in terms of quantity and quality) is present throughout the Watershed from 1957 to present. In 2005 and 2009, TNC acquired property in the Watershed, and at this time the University of California at Davis Center for Watershed Science, TNC, and Watercourse Engineering began monitoring streamflow in Big Springs Creek, the mainstem Shasta River, and Little Shasta River (Jeffres et al. 2008; Jeffres, Dahlgren, et al. 2009; Jeffres, Nichols, et al. 2009;

Null, Deas, and Lund 2010; Willis et al. 2012, 2013, 2017; Nichols et al. 2016; Nichols, Lusardi, and Willis 2017). Additional sources of flow data include gages placed on the Shasta River and Parks Creek in 2001 and 2002 (Watercourse Engineering 2006); estimates of unimpaired flows (M. L. Deas et al. 2004); a 2016 water balance study (SVRCD 2017); summaries of discrete flow measurements for springs in the Watershed including Little Springs Creek (M. L. Deas et al. 2015) and Big Springs Creek; measurements of springs, creeks, and diversions on the Shasta Springs Ranch (NCRWQCB 2006; Chesney et al. 2009; Davids Engineering, Inc 2011); and a compilation of data for sites in the Little Shasta River drainage basin (CDFW 2016). Streamflow data from all available sources was assessed during hydrologic model development to identify important critical conditions. Data quantity and quality impact both selection of data to be used for calibration and interpretation of model performance during associated time periods. More weight is given to locations and time periods with higher quality data. Data from several USGS stream gages were used in calibration with equal weighting as the data sets had similar quantity and quality of data. As the modeled time period is expanded to recent years, more streamflow data will be included and further assessment of data quantity and quality will be done.

In-stream flows in the Watershed have been significantly affected by water resource management in the Basin. Seasonal low flow and drought conditions naturally occur in the Watershed, but are becoming more common. Studies have been conducted to characterize hydrology and hydrologic habitat in the Watershed and to determine interim and minimum in-stream flow needs in the Watershed (McBain & Trush 2017). The in-stream Flow Needs study documented historical and current sampling above and below Parks Creek confluence, in the center of the Watershed (McBain & Trush 2017). Historical data of unimpaired mean monthly flow in the Upper Shasta River and Parks Creek estimate a maximum of approximately 208 cubic feet per second (cfs; ~6 cubic meters per second [m3/s]) and a minimum of 6 cfs (~0.2 m3/s) during spring and summer months. Baseflows in spring and summer 2010 recorded a maximum of 36 cfs (~1 m3/s) and a minimum of 5.6 cfs (0.16 m3/s; see Figure 2.34). According to these studies, considerable inter-annual streamflow variability exists along with uniformity and predictability of streamflow between June and late October, consistent with other streams in the region.

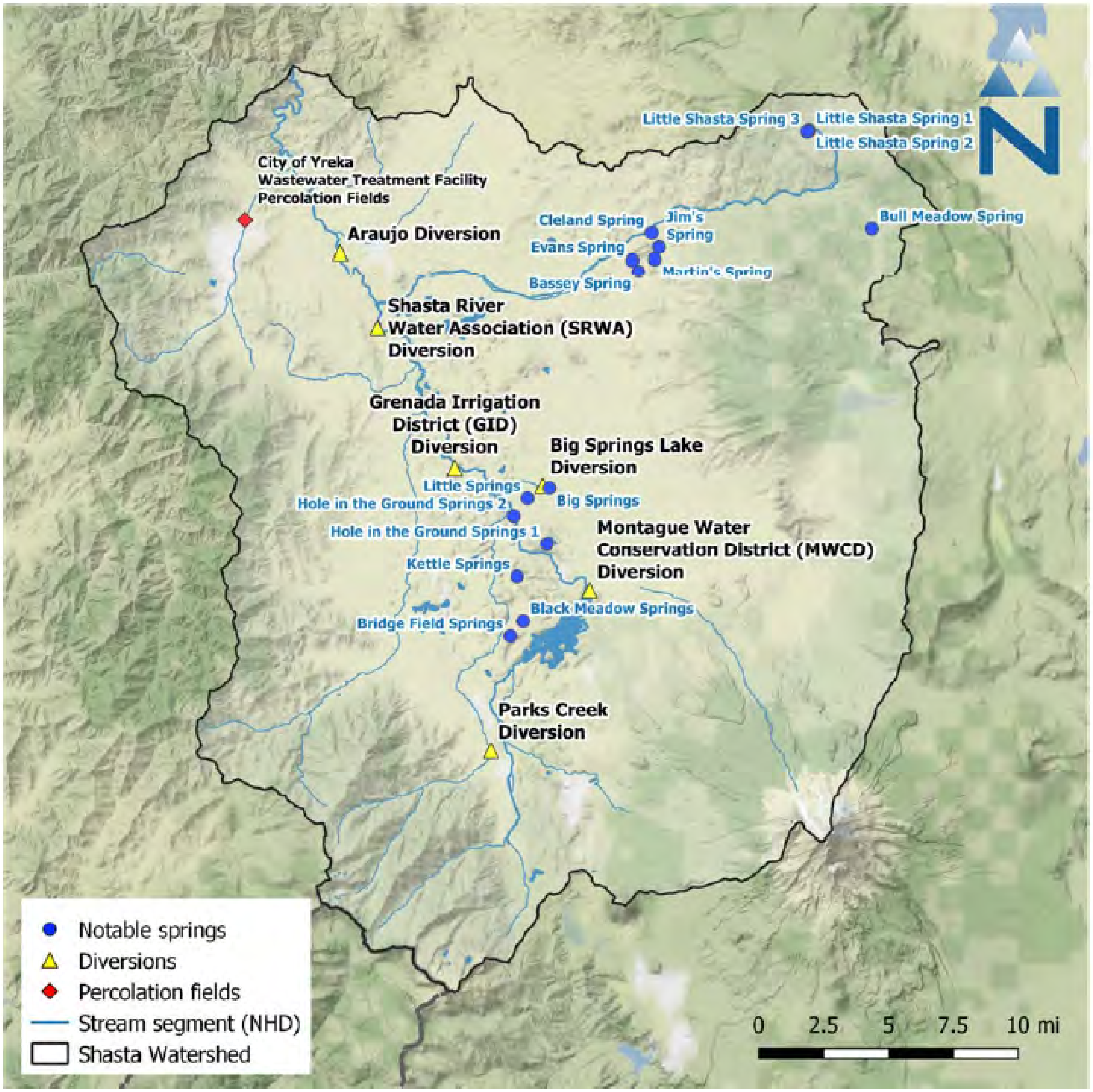


Figure 2.32: Notable hydrologic features of the Watershed. Reprinted from SWRCB (2018).

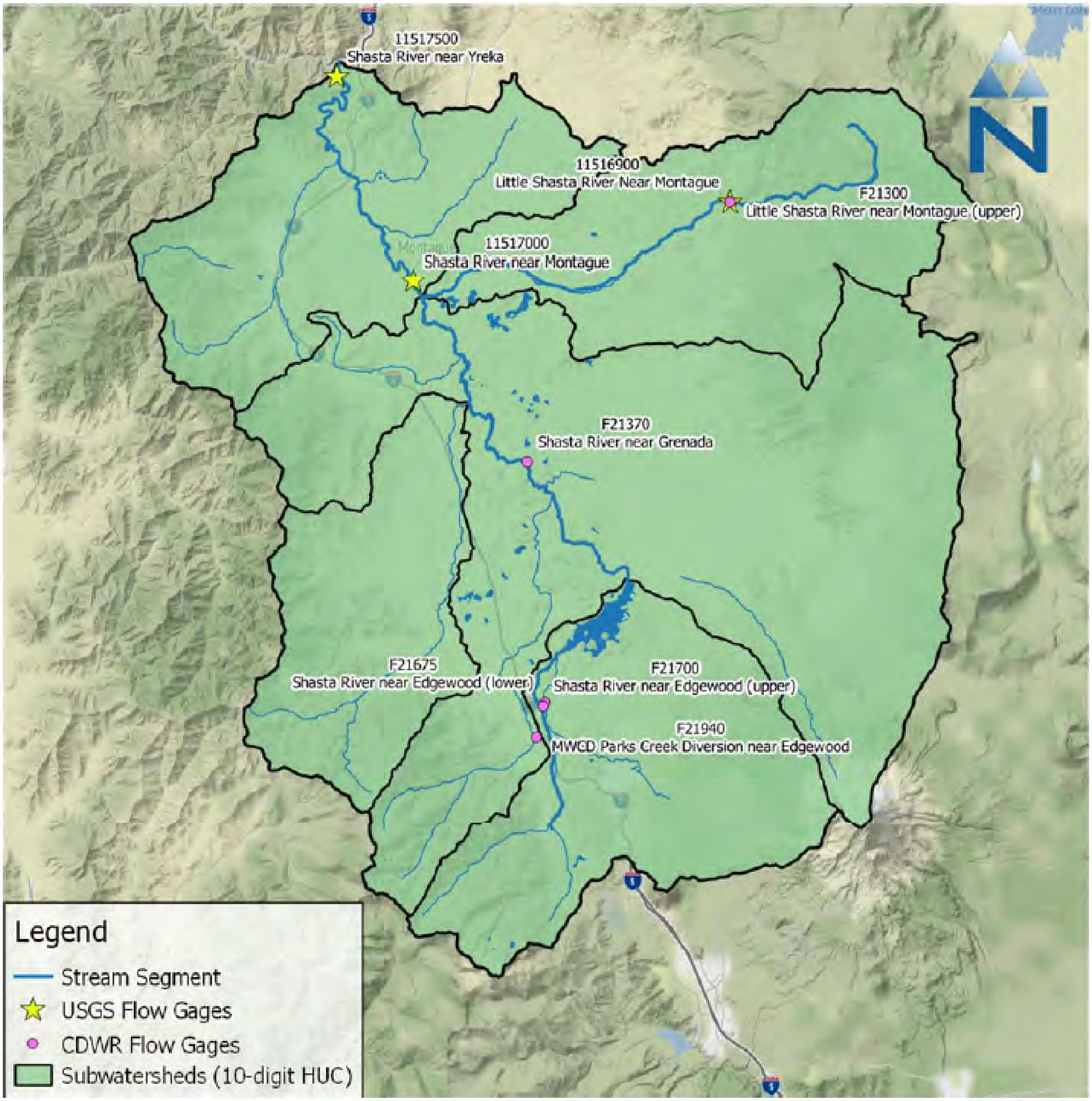


Figure 2.33: Flow gages in the Watershed. Reprinted from SWRCB (2018).

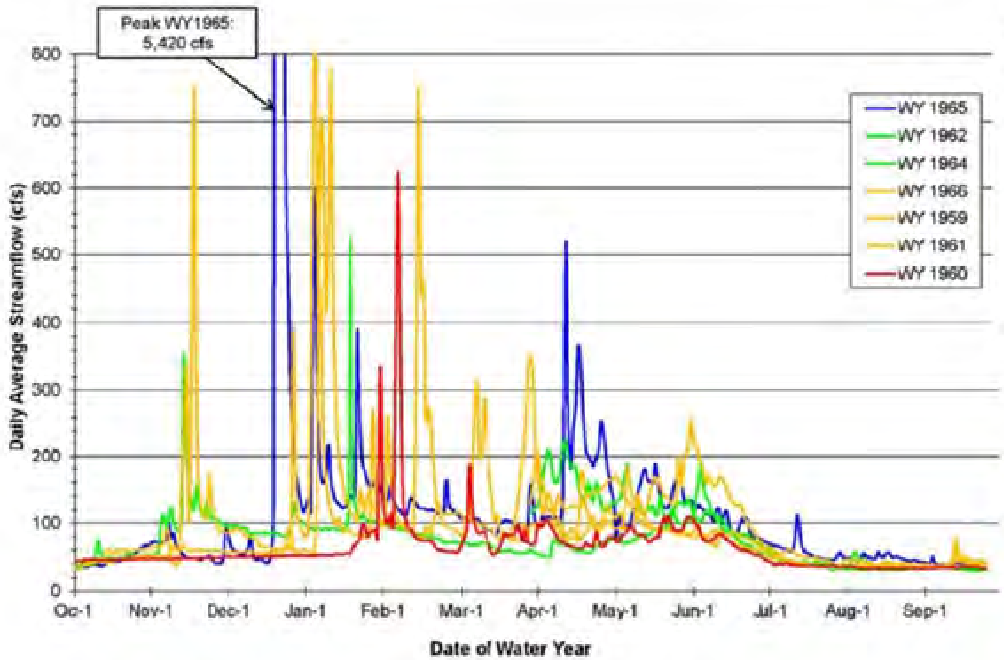


Figure 6. Estimated unimpaired annual hydrographs, for the Shasta River immediately downstrea of the Parks Creek confluence in Reach No.3.

Figure 9. Observed streamflows for April 1 – October 1 2010, in Parks Creek.

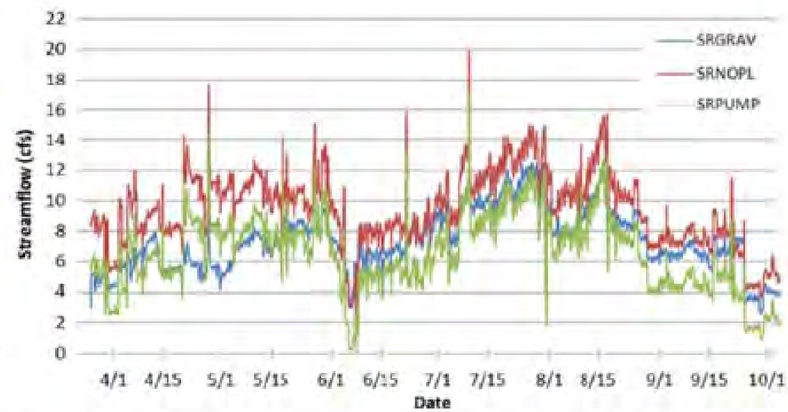


Figure 12. Observed streamflows for April 1 – October 1 2010, in the Shasta River above Parks Creek.

Figure 2.34: Historic stream flows at notable gages along the Shasta River and Parks Creek. Reprinted from SWRCB (2018); adapted from McBain and Trush (2013).

Period	Station ID	Water Years (October 1, 1956 – September 30, 1976)																			
		1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1957-1976	11516900		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	11517000																				
	11517500	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	F21300																				●
	F21370																				
	F21675																				
	F21700					●	●	●	●	●	●	●									
	F21940																				

Period	Station ID	Water Years (October 1, 1976 – September 30, 1996)																			
		1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1977 - 1996	11516900	●	●																		
	11517000																				
	11517500	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	F21300	●	●																		
	F21370																				
	F21675																				
	F21700			●	●	●	●	●	●	●	●	●	●	●	●	●					
	F21940																				

Period	Station ID	Water Years (October 1, 1996 – September 30, 2016)																			
		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1997 - 2016	11516900																				
	11517000						●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	11517500	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	F21300																				
	F21370									●											
	F21675									●											
	F21700																				
	F21940									●	◕							●	●	●	

Legend: Data Quantity (Percent Complete): 0% | 25% | 50% | 75% | 100%

Data Quality (Percent Estimated):

	○	◔	◑	◕	●
No Data	90-100%	65-90%	35-65%	10-35%	0-10%

Figure 2.35: Summary of streamflow data quantity and quality in the Watershed. Reprinted from SWRCB (2018).

2.2.1.6 Geophysical Studies

In September of 2020, a geophysical study was conducted in Shasta Valley to collect data to aide in understanding the geological and hydrological structures of key areas of the Basin that were poorly represented in the hydrogeological conceptual model. The study utilized two electromagnetic survey tools: the towed-TEM (or tTEM) and WalkTEM devices. The tTEM and WalkTEM instruments are time-domain electromagnetic systems specifically designed for hydrogeophysical and environmental investigations. The tTEM system measures continuously while towed on the ground by an ATV or similar vehicle. The WalkTEM instrument is a pair of large electrical coil loops that are manually placed on the ground to record electromagnetic response of the subsurface. The WalkTEM system is essentially identical to the one used in the airborne electromagnetic (AEM) system currently flown in California by DWR that records continuously along pre-planned flight lines.

Additionally, the electromagnetic geophysical surveying work was instrumental in testing the potential data quality for future AEM survey flights to be conducted by DWR in late 2021 (data from the AEM flights will not be available until 2022). This is because the ground-based electromagnetic surveying equipment used in this study is both theoretically and operationally similar to that to be used with the future AEM flights.

The surveying took place in two key areas. One area is the Shasta Big Springs Ranch (Area 1) and the other is a large portion of the headwaters area for the Pluto's Cave Basalt (Area 2). The significance of Area 1 is that it is a hydrogeologically complex area containing sensitive GDEs, particularly the Big and Little Springs Complex areas. These areas that contain many groundwater springs that supply the immediate areas with a constant flow of fresh spring water from the Pluto's Cave Basalt which comes into direct contact with the less permeable debris avalanche deposits, resulting in groundwater flow to the surface rather than continuing flowing laterally through the subsurface. Area 2 is a very arid area of the valley that has little-to-no groundwater level measurements and is situated in the upgradient area of the Pluto's Cave Basalt, opposite of Area 1. Due to the lack of groundwater level information in Area 2 and the dryness of the surface sediments in the area, despite ephemeral glacial streams periodically recharging the area, electromagnetic surveying was employed to study the geological structure of the area and prospect for potential indicators of groundwater level.

The results of the electromagnetic geophysical surveying can be found in Appendix 2-F. The most important resulting data product figures from the geophysical study are shown in the report in Figures 9 through 11, as well as the vertical tTEM sections of A-A' and F-F' containing the co-located, full-length WalkTEM results. The orange, red, and magenta colored electrical resistivity zones shown in the data collected in Area 1 largely represent the debris avalanche materials which are thought to be barriers to groundwater flow and surface recharge. The lateral yellow to green features under the debris avalanche materials are likely sedimentary deposits that were originally paleo-surfaces prior to the collapse of Ancestral Mount Shasta. Where these deposits are darker green to blue in color are likely saturated by groundwater. The darker blue zones nearest the surface streams are likely zones of active recharge and relate to interconnected surface water-groundwater systems. The tTEM system was towed around the edge of the dry Bass Lake to aide in future characterization efforts by the GSA and CDFW to potentially use this site as a managed aquifer recharge area. The survey results show that the outer rim of the lakebed appears to contain potentially decent structure for recharge efforts, such as managed aquifer recharge (MAR). This is shown by the bowl-shaped yellow to green resistivity values, which likely deepen toward the center of the dry lakebed. It is possible that fine-grained sediment deposits nearest the lakebed surface may impede future MAR efforts and are not shown in these surfaces as they would be thought to be thin and could easily be moved to improve MAR efficiency. The deep WalkTEM results from stations W02 along vertical section F-F’ and W03 along vertical section A-A’ show that there might be an effective base to the groundwater aquifer past ~350-400 feet below ground surface. This is shown as the very dark blue sections which are likely fine-grained sediments and sedimentary rocks that may act as basal confining units. This may be where the top of the Hornbrook Formation lies under the surface deposits.

In Area 2, it was hypothesized that if groundwater was within the depth of penetration of the tTEM system (<300 feet), electromagnetic signal returns would be possible. If deeper, it was thought that the thick, dry sediments would present an obstacle to obtaining results. As the tTEM results were not able to be used to estimate electrical resistivity confidently across this whole area, it is likely that the groundwater level in this area is greater than 400-500 feet below ground surface. The WalkTEM results at station W01 are additionally difficult to determine however it appears from the results that there begins to be conductive signal past 600 feet below ground surface, which may represent where the groundwater level is located. This is not surprising as this area at the northern base of Mount Shasta likely contains a thick sequence of sediment deposits from glacial outwash and volcanic lahars (mudflows) and lies at a higher elevation the northern toe of the Pluto’s Cave Basalt deposit.

This work was funded by Prop 68 funding granted to the GSA by DWR.

2.2.2 Current and Historical Groundwater Conditions

2.2.2.1 Groundwater Level Data

The historical groundwater elevation data available for the Basin is entirely based on DWR CASGEM records, with the majority going back to the early 1990s and some into the 1960s and 1970s. However, there are also some stations with only post-2010 data. Generally, the data show that groundwater levels are stable over the full period of record throughout the area historically monitored by the CASGEM program. Full rebound of groundwater levels occurs by the spring of each year. Groundwater level data are shown as surface contours in Figure 2.36 to 2.39 for the spring and fall measurements from 2015 and 2010, as well as select hydrographs in Figure 2.40. Groundwater level contours were created using the interpolation method known as kriging that interpolates an elevation between two or more points using the variance between the measurements and distance to the point as a means of weighting the influence of a measurement on an interpolated point. All available groundwater level data are shown in Appendix 2-C, which include all available CASGEM data and recently collected continuous groundwater level monitoring data. CASGEM data is primarily collected bi-annually in the spring and fall. Continuously monitored wells provide better data for the true seasonal maximum and minimum groundwater levels, as well as their timing.

The groundwater levels in the central to west-central portions of the Basin are largely shallow, typically less than 20-40 ft (6-12 m) below ground surface. These areas are dominantly alluvial or debris avalanche (consisting of mainly alluvial materials in between large andesite blocks) deposits. The groundwater levels in these water-bearing units do not typically show large seasonal (or longer) variations. The area northwest of Gazelle has a deeper groundwater table likely due to shallower alluvium and increased usage of groundwater for irrigation purposes. The groundwater levels in this area are more likely to see changes due to water year type than to seasonal variations. The eastern section of the Basin is dominated by volcanic units whose groundwater levels are deeper (generally >60 ft (18 m) below ground surface) than the more alluvial units to the west. The groundwater levels in the volcanic units have historically been relatively stable. However, recent increased pumping and drought conditions (post-2019) have resulted in increased lowering of groundwater levels, particularly in the Pluto's Cave Basalt. The small area of the Basin where Yreka is located is mainly reliant on surface water and groundwater levels have not been historically monitored there.

Groundwater recharge occurs as stream leakage, and from irrigation ditch leakage, as percolation through the soil zone (including under irrigated agricultural fields), and along the valley margin as mountain front recharge (MFR). Groundwater outflow within the Basin includes groundwater pumping for irrigation, discharge to streams, discharge to springs, and by direct evapotranspiration in areas where the water table is near the land surface. Additionally, groundwater leaves the Basin through deeper underflow in the Hornbrook Formation and the other various deep volcanic water-bearing formations. The availability of water in critical periods, during the end of summer and beginning of fall, is a key concern in Shasta Valley for agricultural uses, domestic well users, and for in-stream flows and cold surface water temperatures (cold groundwater discharges for baseflow and springs discharging to the river) for fish.

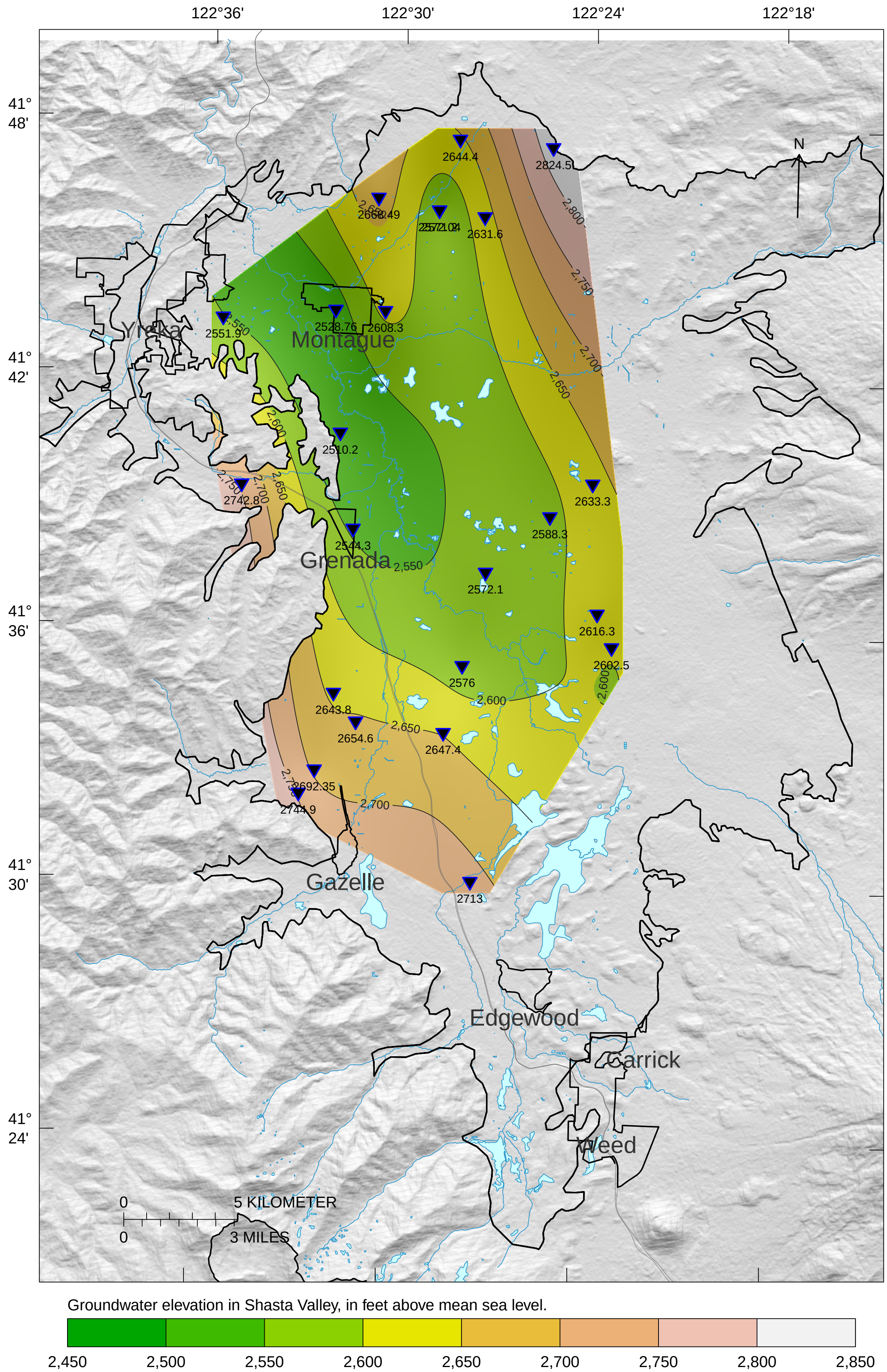


Figure 2.36: Interpolated representation of Shasta Valley Groundwater Elevations, Spring 2015

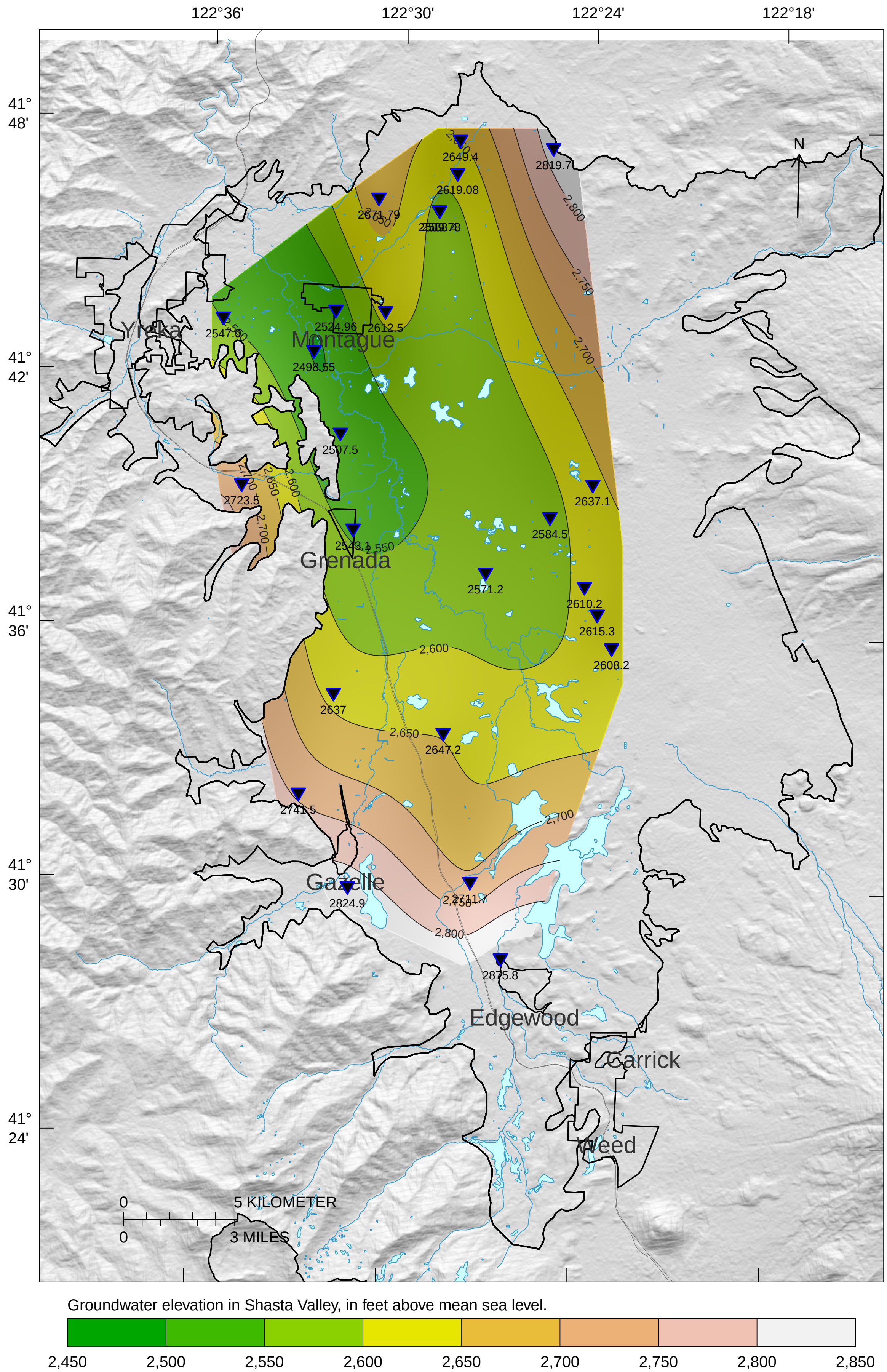


Figure 2.37: Interpolated representation of Shasta Valley Groundwater Elevations, Fall 2015

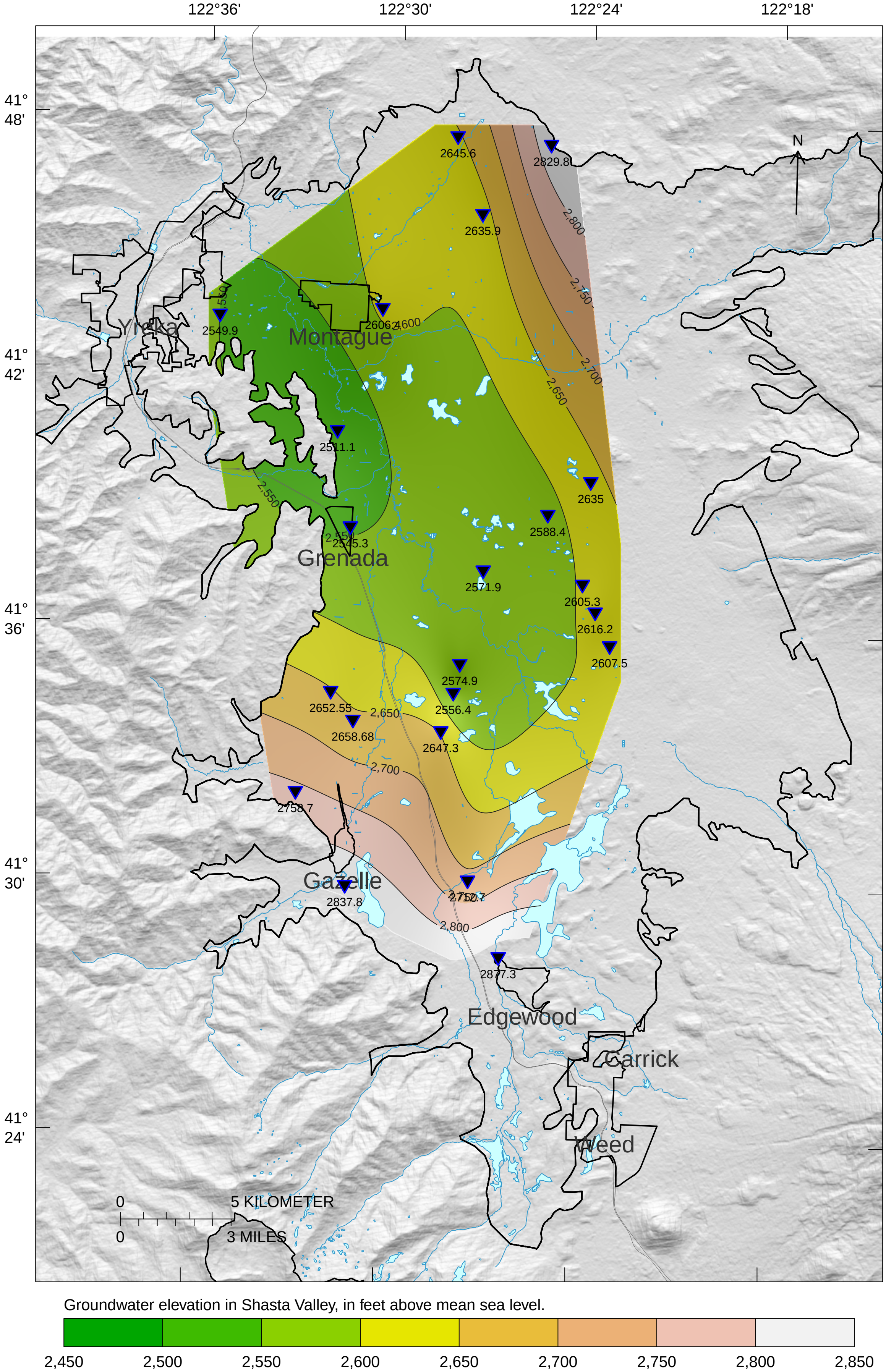


Figure 2.38: Interpolated representation of Shasta Valley Groundwater Elevations, Spring 2010

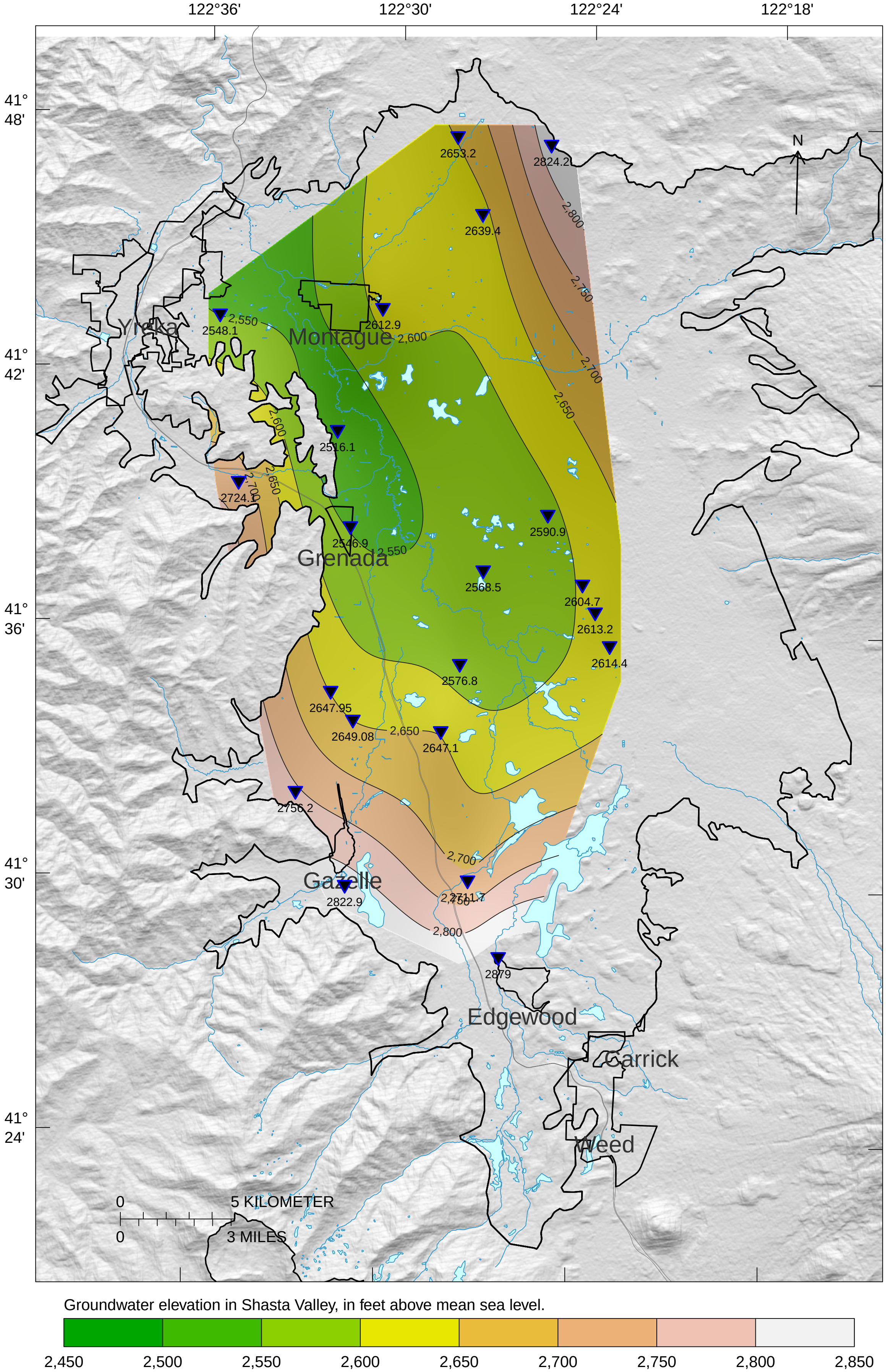


Figure 2.39: Interpolated representation of Shasta Valley Groundwater Elevations, Fall 2010

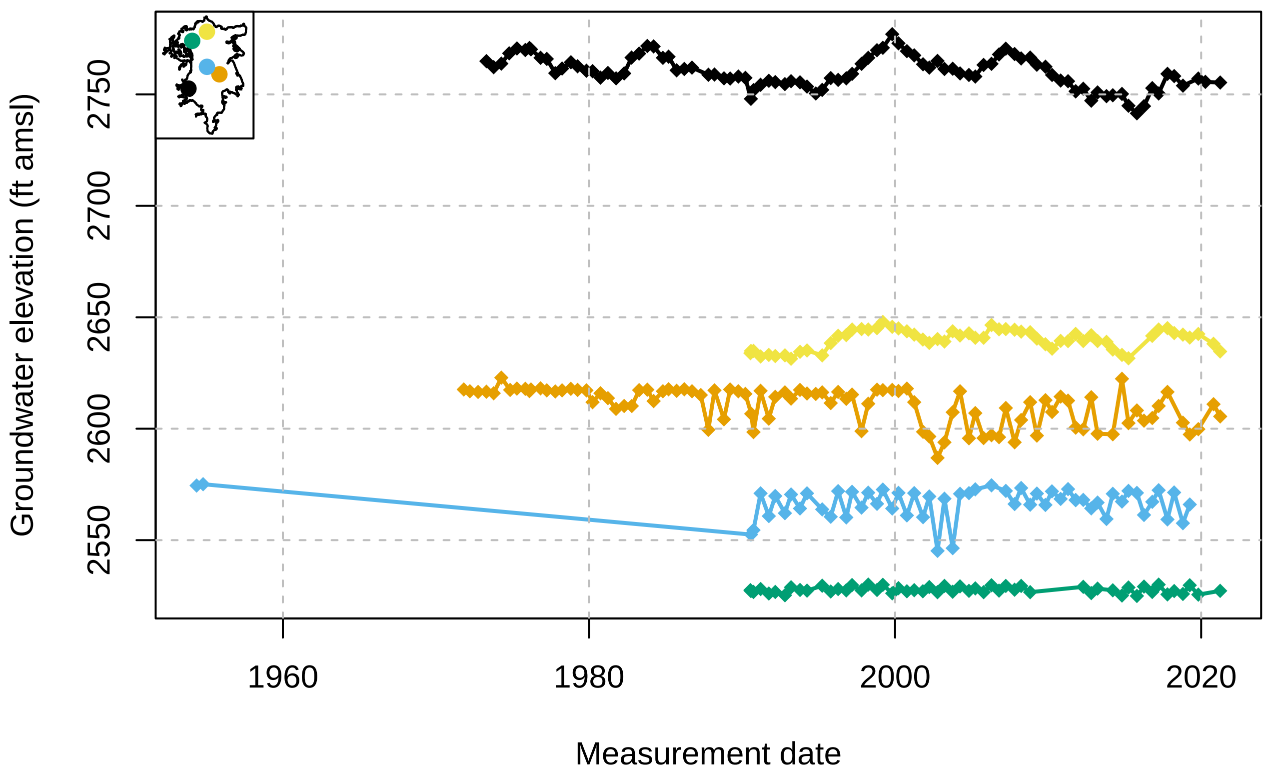


Figure 2.40: Groundwater elevation measurements over time in five wells, one located in each hydrogeologic zone.

2.2.2.2 Estimate of Groundwater Storage

Overall groundwater storage in the Basin has not been previously estimated. Seymour Mack with the USGS attempted to estimate this in 1960, however, the effort was left undone due to the complexity in estimating storage properties of the volcanic water-bearing formations of the Basin (Mack 1960). The only current estimate of storage is based off of the SWGM results described in detail 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 Groundwater Quality Overview

Water quality includes the physical, biological, chemical, and radiological quality of water. Physical water quality includes temperature. Examples of biological water quality constituents include E. coli bacteria, commonly used as an indicator species for fecal waste contamination. Radiological water quality parameters refer to the radioactivity of waters. 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 has a usually low level 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 content 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. Hardness refers to high amounts of calcium and magnesium 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, of contamination from anthropogenic point sources, or originates from diffuse (non-point) sources that are the result of human activity.

Previous work has characterized groundwater in the Basin as calcium magnesium bicarbonate type (DWR 2004). Within the Basin, groundwater quality issues have historically been localized and attributed to natural sources. Elevated constituents have included: boron, calcium, chloride, conductivity, magnesium, iron, fluoride, nitrate, sodium, sulfate and hardness. TDS in the Basin have historically been within the range of 131 mg/L to 1,240 mg/L with locally elevated levels (DWR 2004). Groundwater quality has been noted to be closely connected to local geology, in particular high magnesium has been attributed to serpentine and elevated calcium has been attributed to the presence of limestone (Mack 1960). Identified localized groundwater quality issues include Table Rock Springs with high sodium, chloride and boron, areas near Willow Creek and Julian Creek with elevated boron, dissolved solids and sodium, near Montague, Grenada and Big Springs and near Oregon Slough and Little Shasta River (Gwynne 1993; DWR 2004).

Groundwater in the Basin is generally of good quality and meets local needs for municipal, domestic, and agricultural uses. Ongoing monitoring programs show that some constituents, including arsenic, boron, iron, manganese, and benzene, in addition to pH and specific conductivity, 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.

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 – Water Quality Assessment.

2.2.2.3.2 Existing Water Quality Monitoring Networks

Water quality data of 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, but some are or 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 GAMA database, which includes water quality information collected by DWR, SWRCB, DDW, Lawrence Livermore National Laboratory (LLNL) special studies; and the USGS. 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 1949. Figures in Appendix 2-B show the Basin boundary, as well as the locations and density of all wells with available water quality data. Within the Basin, a total of 266 wells were identified and used to characterize 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 are 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 WQOs for the constituents evaluated and are consistent with state and NCRWQCB assessment of beneficial use protection in groundwater. The standards are compared against groundwater quality data to determine if a constituent's 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 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° 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. Secondary MCLs (2° MCL) 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. The Basin is regulated under the NCRWQCB and relevant WQOs and beneficial uses are contained in the Basin Plan. 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 the Basin. 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 WQO; for this GSP, a prioritization system was used to select the appropriate numeric threshold: The strictest value among the state and federal drinking water standards and state WQOs specified in the Basin Plan was used 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 identified 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 1949 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 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 three 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: benzene, 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 provides 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 Basin

Constituent	Regulatory Basis	Water Quality Threshold
Arsenic (μg/L)	Title 22	10
Benzene (μg/L)	Title 22	1
Boron (mg/L)	Basin Plan 90% Upper Limit	1
Boron (mg/L)	Basin Plan 50% Upper Limit	0.3
Iron (μg/L)	Title 22	300
Manganese (μg/L)	Title 22	50
Nitrate (mg/L as N)	Title 22	10
pH	Basin Plan	7.0-8.5
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.

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 ppb 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 micrograms per liter (μg/L).

Arsenic data, collected in the past 30 years (1990 to 2020) from municipal and monitoring wells, are distributed throughout the Basin, with numerous measurements along the western Basin boundary and more limited data in the northeast section of the Basin (Appendix 2-B). The majority of measurements are below half of the 1° MCL. Values above the 1° MCL are located near Grenada, Edgewood and Carrick. These findings are 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 the municipal wells near Edgewood as having “high” arsenic levels (greater than 10 ug/L) based on measurements between 1995 to 2014 (Jurgens et al. 2020). Based on the timeseries in Appendix 2-B, wells with arsenic levels below the 1° MCL have fairly stable concentrations over time. Wells with values that exceed the 1° MCL show more variation in measured arsenic levels, with no general identifiable trend.

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 DHHS, 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 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 µg/L, as defined in Title 22.

Recent benzene data (1990 to 2020) are from municipal and monitoring wells and are concentrated along the western and southeastern Basin boundary with limited measurements in the northern and northeastern parts of the Basin (Appendix 2-B). The majority of the measurements are non-detected values and measurements that exceed the 1° MCL are located in the south of the Basin near Carrick and near Yreka. Benzene levels in wells with multiple monitoring events from 1990 to 2020 are generally stable or decreasing over time.

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 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 specifies a 50% upper limit for boron of 0.3 mg/L and a 90% upper limit for Boron of 1.0 mg/L.

As shown in Appendix 2-B, boron measurements over the past 30 years (1990 to 2020) are distributed throughout the Basin. While the majority of measurements do not exceed the 50% or 90% upper limits, values that do exceed these limits are also distributed throughout the Basin. Timeseries of boron levels in wells with multiple monitoring events from the past 30 years show boron levels to be generally stable or decreasing over time.

IRON AND MANGANESE

Iron and manganese in groundwater are primarily from natural sources. As abundant metal elements in rocks and sediments, iron and manganese can be mobilized under favorable geochemical conditions. Iron and manganese occur in the dissolved phase under oxygen-limited conditions. Anthropogenic sources of iron and manganese can include waste from human activities including industrial effluent, mine waste, sewage, and landfills. As essential nutrients for human health, iron and manganese are only toxic at very high concentrations. Concerns with iron and manganese in groundwater are commonly related to the aesthetics of water and the potential to form deposits in pipes and equipment. The Title 22 SMCLs, for iron and manganese are 300 µg/L and 50 µg/L, respectively.

Iron measurements in the Basin, collected in the past 30 years (1990 to 2020) are distributed throughout the Basin (Appendix 2-B). The majority of the measurements are either not detected or below half of the 2° MCL; values that exceed the MCL are located along the southern boundary of the Basin and in wells throughout the central region of the Basin. Timeseries of wells with multiple iron measurements over the past 30 years (1990-2020) indicate that wells with iron levels consistently below the 2^o MCL are relatively stable over time while wells with values that exceed the 2^o MCL have more variation in measured concentrations and do not show a general Basin-wide increasing or decreasing trend.

Recent monitoring for manganese levels (from 1990 to 2020) is distributed throughout the Basin (Appendix 2-B). Measurements range from non-detected values to values above the 2^o MCL. Manganese levels are variable within the Basin, with multiple localized exceedances throughout the Basin. Timeseries constructed for wells with multiple monitoring events over this same time period show variability between and within wells, with stable, increasing and decreasing values over time.

pH

The pH of groundwater is determined by a number of factors including the composition of rocks and sediments through which water travels in addition to pollution caused by human activities. Variations in pH can affect the solubility and mobility of constituents. Acidic or basic conditions can be more conducive for certain chemical reactions to occur; arsenic is generally more likely to mobilize under a higher pH, while iron and manganese are more likely to mobilize under more acidic conditions. High or low pH can have other detrimental effects on pipes and appliances, including formation of deposits at a higher pH and corrosion at a lower pH, along with alterations in the taste of the water. The Basin Plan specifies a pH range of 7.0 to 8.5 as a water quality objective for groundwater in the Shasta Valley hydrologic area.

Measurements for pH, conducted over the past 30 years (1990 to 2020) are located primarily along the western and southwestern Basin boundaries, with several measurements in the central area near Grenada. Data are limited in the north and northeastern portions of the Basin. Most of the measured levels are outside of the pH range specified in the Basin Plan. Trends in pH values over time are not able to be evaluated with current data due to a lack of wells with multiple measurements over time.

SPECIFIC CONDUCTIVITY

Specific conductivity, also referred to as electrical conductivity, 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. The Basin Plan specifies a 50% upper limit (UL) of 500 micromhos per centimeter (μmhos/cm) and a 90% UL of 800 μmhos/cm for specific conductivity.

Specific conductivity measurements over the past 30 years (1990 to 2020) are located throughout the Basin but are mostly concentrated along the western and southeastern Basin boundaries, with limited data in the northeast part of the Basin (Appendix 2-B). Multiple values exceed the 50% and 90% ULs specified in the Basin Plan. Wells with specific conductivity measurements that exceed these limits are distributed throughout the Basin. In wells with multiple monitoring events over the past 30 years, wells with specific conductivity values consistently below the Basin Plan 50%

UL are relatively stable over time while wells with specific conductivity measurements above the Basin Plan 90% UL have greater variability in measured values over time.

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 six 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° MCL for nitrate is 10 milligrams per liter (mg/L) as N.

Recent (1990 to 2020) nitrate data in the Basin are concentrated in the south and west, with more limited data in the eastern and central portions of the Basin. Wells with exceedances of the 1° MCL are located near Montague, Grenada, and Carrick (Appendix 2-B). Measurements range from non-detected values to above the 1° MCL. Nitrate concentrations in wells with multiple measurements between 1990 and 2020, can be increasing, decreasing or stable.

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. 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. 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 including methyl tertiary butyl ether (MTBE) and benzene, toluene, ethylbenzene and xylenes (BTEX), as well as lead scavengers including ethylene dibromide (EDB) and 1,2-dichlororethane.

A brief overview of notable information 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 2.41.

The Davenport Property, located in Yreka, is the sole open LUST site in the Basin. The case at this site was opened in 2017, after an authorized release was reported following removal of a heating oil UST. Remediation efforts have included soil excavation and monitoring activities have included groundwater and soil vapor sampling. Though WQOs in groundwater have been reported to be below, or close to WQOs, a review summary report from February of 2019 concludes that the site does not meet all criteria for closure due to lack of definition of the benzene plume (SWRCB 2019c).

Three open cleanup program sites fall within the Basin boundary, all located in Yreka. Two of the sites are associated with an oil and gas plant. All three cleanup sites have a cleanup status of open and inactive as of 2011. At this time, no cleanup actions have been completed at any of these sites.

There are six California Department of Toxic Substances Control (DTSC) sites within the Basin. Three of these sites have a cleanup status as no further action, meaning that a Phase I Environmental Assessment at the site has concluded no action is required. One site has been referred to the NCRWQCB as of 1989. The remaining two sites are classified as inactive, one with action required as suggested by a preliminary investigation at the site; the other site requires evaluation.

In addition to contaminated sites located within the Basin boundary, several sites are in close proximity to the Basin boundary (all within 5 miles or 8 km). These include a LUST site, multiple cleanup program sites, a military cleanup site and DTSC sites, including a Federal Superfund Site. The J.H. Baxter Superfund site, located in northern Weed was previously used as a wood-treatment facility dating back to the late 1930s. Contaminants of concern include: polynuclear aromatic hydrocarbons (PAHs), pentachlorophenol (PCP), dioxin and metals including arsenic, chromium III, chromium VI, copper, lead and zinc in the soil, groundwater and surface water surrounding the site. Investigation into contamination at the site began in 1982 under the DTSC and NCRWQCB and the site was officially added to the USEPA's National Priorities List in 1989. The cleanup status has been listed as "Certified Operation & Maintenance" since 2007, meaning that certified cleanup activities have been implemented but ongoing operation and maintenance is required.

While current data are 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 evaluation of 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.

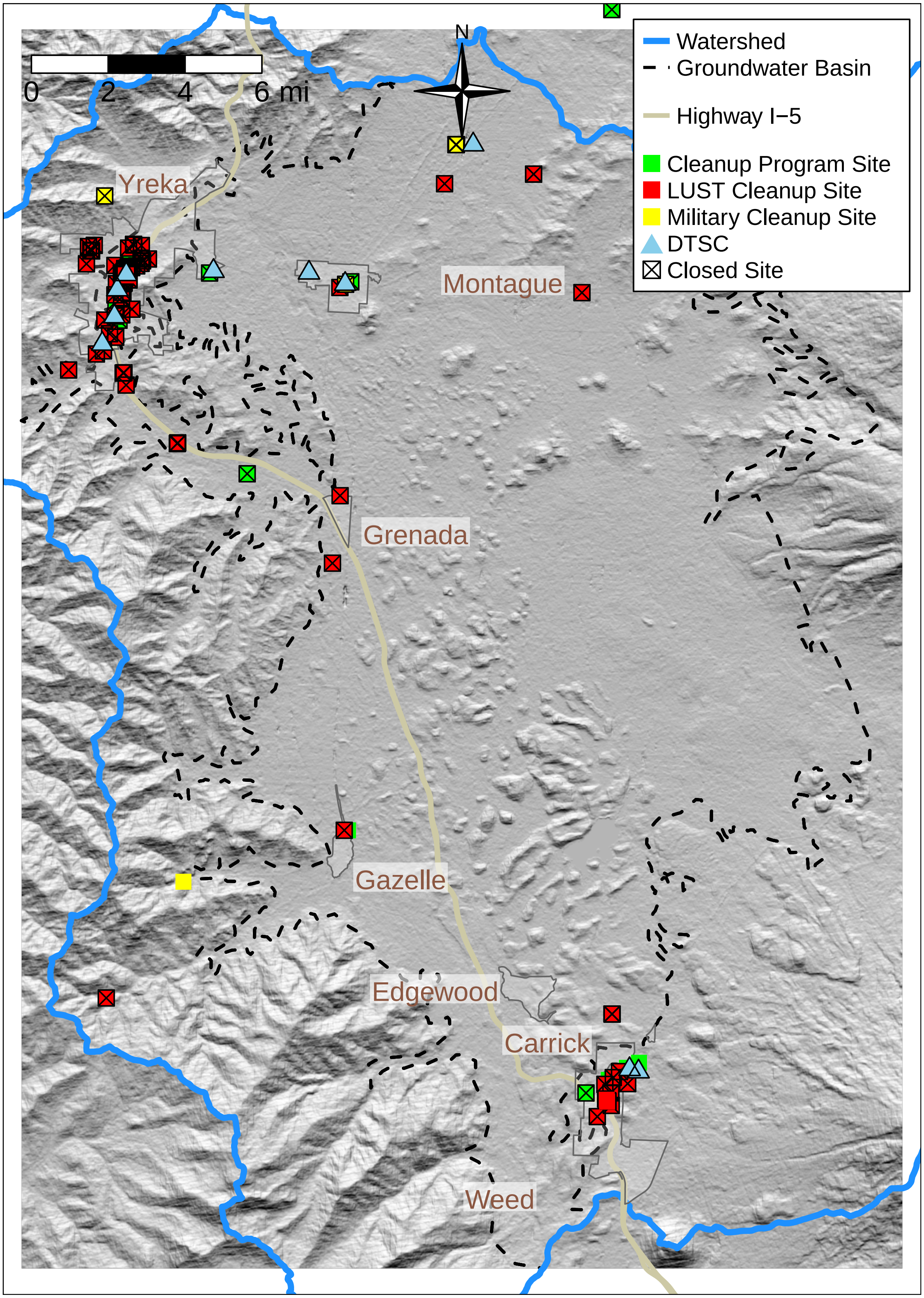


Figure 2.41: Contaminated Sites

2.2.2.4 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. Land subsidence, particularly inelastic subsidence, is not known to be historically or currently significant in the Basin. The lithology that may cause subsidence, particularly thick clay units that typically define the confining layers of aquifers found in the Central Valley of California, are not present in the Basin. The geologically recent, shallow alluvial and volcanic rock water-bearing formations of the Basin are largely insusceptible to inelastic subsidence.

Data Sources

There are no known Basin-wide survey data available for estimating subsidence in the Basin. The single borehole strainmeter in the Basin (UNAVCO station #B039), while recording four horizontal displacement directions, does not record vertical displacement and cannot accurately record evidence of inelastic subsidence (Figure 2.42). The strainmeter is also on the very edge of the Basin boundary on a foundation of andesite and serpentinite rock with minimal sediment overburden, also effectively invalidating this station as a monitoring location for groundwater basin subsidence monitoring. There is one other UNAVCO strainmeter station (B040) just north of the Basin in the Willow Creek watershed, but it also does not record vertical displacement, only horizontal.

There are no known CGPS stations located within the Basin boundary. While there are a number of CGPS stations adjacent to the Basin boundary (Figure 2.42), they are all either located on basement rock or are too far from the Basin to be relevant for subsidence monitoring.

DWR has made Interferometric Synthetic Aperture Radar (InSAR) satellite data available on their SGMA Data Viewer web map (DWR 2019d) as well as downloadable raster datasets to estimate subsidence (DWR contracted TRE Altamira to make this data available). These are the only data used for estimating subsidence in this GSP as they are the only known subsidence-related data available for this Basin.

The TRE Altamira InSAR dataset provides estimates of total vertical displacement from June 2015 to September 2019 and is shown in Figure 2.42 using raster data from the TRE Altamira report (DWR 2019d). It is important to note that the provided 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 (Brezing 2020):

1. The error between InSAR data and continuous GPS data is 0.052 ft (0.016 m) 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 ft (0.015 m) with 95% confidence level.

The addition of the both of these errors results in the combined error is 0.1 ft (0.03 m). 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 (0.03 m) is within the noise of the data and is likely not indicative of groundwater-related subsidence in the Basin. DWR contracted Towill, Inc. to complete a data accuracy report, which found similar results to the error presented above. The full report is included in Appendix 2-D.

Data Analysis

Using the TRE Altamira InSAR Dataset provided by DWR, it is observed that the majority of the vertical displacement values in the Basin are essentially near-zero, within the range of 0.1 ft (0.03 m; uplift) to -0.1 ft (-0.03 m; Figure 2.42). These values are generally within the same order of magnitude of the method error (combined data and raster conversion error), suggesting the observed vertical displacement is essentially noise or from non-groundwater related activity. Any 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 ft (1.1 m) of subsidence.

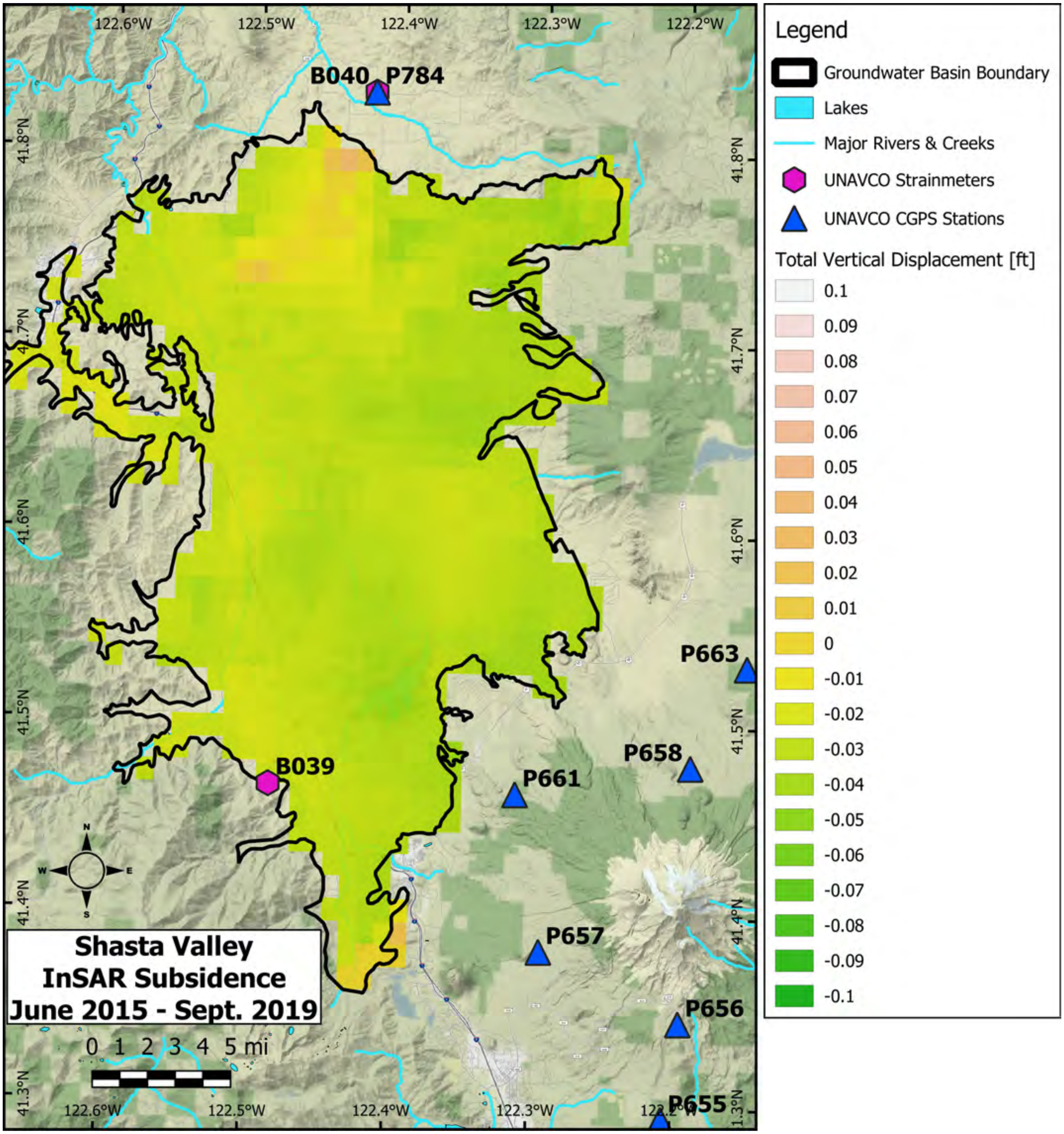


Figure 2.42: InSAR Total Subsidence (in feet) between 6.2015 and 9.2019

2.2.2.5 Seawater Intrusion

Due to the distance between the Basin and the Pacific Ocean, seawater intrusion is not evident nor of concern and therefore, is not a sustainability indicator applicable to the Basin.

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."

ISW is 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 within the watershed of the Shasta River, a major tributary to the Klamath River that eventually flows to the Pacific Ocean. The Shasta River is fed by its tributaries and springs originating from Mount Shasta and other Cascade volcanic mountains. Its major tributaries are the Little Shasta River, Parks Creek, Big Springs Creek, and Yreka creek. Minor tributaries include Oregon Slough and Carrick, Julian, Willow, and Eddy Creeks. The upper quarter of the Shasta River is marked by Lake Shastina (Dwinnel Reservoir) and Dwinnell Dam on the north lake side. Prior to Lake Shastina the river has high slopes, while below the dam the river becomes slow and meandering (SVRCD 2018b).

Springs

Springs feed surface waters on the east side of the Watershed due to the volcanic geology (Figure 2.43). The Pluto's Cave Basalt transmits the majority of Shasta River base flows, discharged as springs in the southeast, and is responsible for nearly all the unimpaired summer base flow of >100 cfs in the Shasta River (SVRCD 2018a; SVRCD 2018b). This base flow sustains summer flows in the river despite low precipitation in the valley and is dependent on snowmelt from annual snowfall and glaciers in the surrounding mountains (SVRCD 2018b).

Springs fed by the Pluto's Cave Basalt include the Big Springs Complex (SVRCD 2018a). The Big Springs Complex encompasses Big Springs Lake, Big Springs Creek, and Little Springs Creek (Figure 2.52). The extent of the springs complex is a data gap but contributions of Big Springs Creek to the Shasta River is estimated to be 60 cfs, and historically (pre-diversion) contributed 100 to 125 cfs (M. Deas 2006).

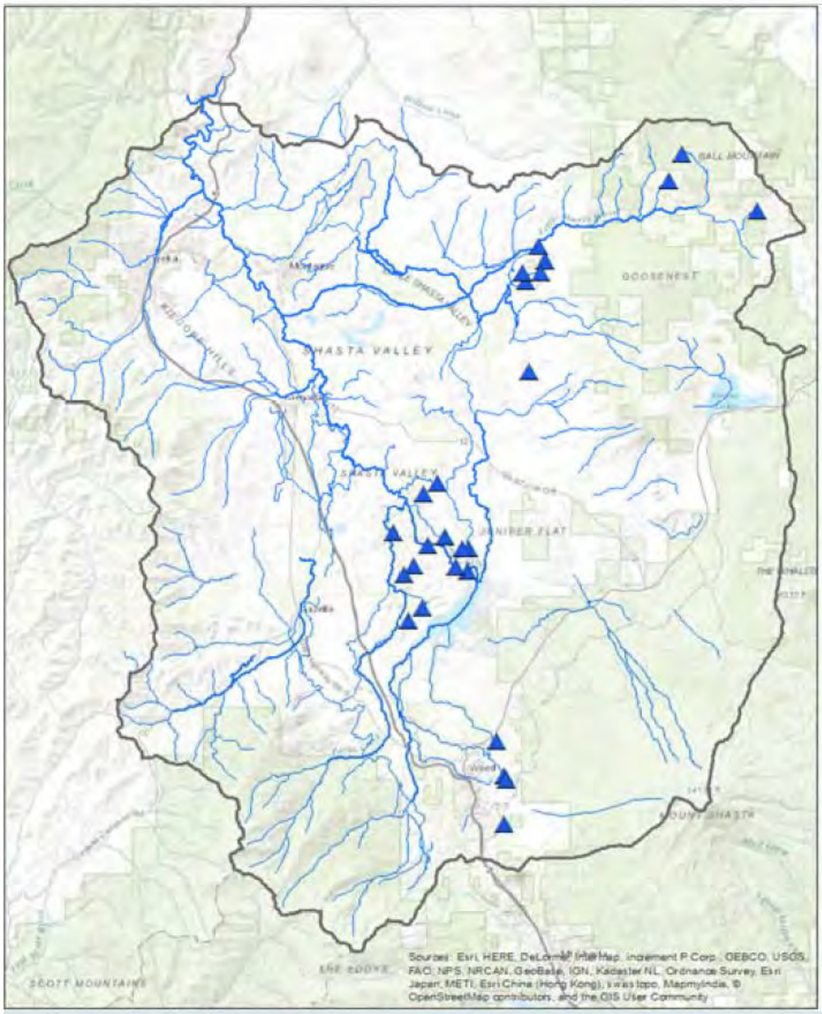


Figure 2.43: Major springs in the Watershed.

Transect Study

The GSA is working with SVRCD to conduct transect studies for the Little Shasta River and Shasta River to determine the direction of flow exchange. Historically, the Little Shasta River rarely has surface water during the irrigation season due to adjudicated water rights (SVRCD 2018a). During that period, the Little Shasta River is known to disappear and reappear at locations upstream of the confluence with the Shasta River (SVRCD 2018a). Preliminary results indicate that, between May to October 2020, the Little Shasta River was losing at its transect location in the Little Shasta Valley. Upstream and downstream of the Little Shasta River confluence, the Shasta River was gaining in both transect locations (Davids Engineering 2020). For additional information, see Appendix 2-H. This study will continue as long as funding is available, with current funding allowing the study to last until December 2021. Expansion of the transect study to other locations in the Basin will depend on funding.

Shallow piezometers were installed in three transects across the Basin in late April 2020: two transects along different reaches of the Shasta River and one along the Little Shasta River. One of the transects on the Shasta River was upstream of the confluence with the Little Shasta River (SRU), and the other was downstream of the confluence with the Little Shasta River (SRD) (Figure 2.44).

The transect along the Little Shasta River (LSR) lay within the alluvial portion of the Little Shasta Valley. These piezometers, along with the rivers, were instrumented to continuously monitor water surface elevations and temperatures in and adjacent to surface water features.

Each transect includes six pressure transducers: one measuring atmospheric pressure, one installed in a temporary stilling well in the river to measure surface water levels, and four installed in piezometers (two on each bank of the river) to measure shallow groundwater levels. The individual location in each transect is marked as follows: LB Left bank, looking D/S; RB Right bank, looking D/S; N Near, Closer to stream/river; F Far, Further to stream/river; SWE Surface Water Elevation; ATC Atmospheric Compensation (Table 2.6).

Table 2.6: The SiteID, site name, and location of each site (Davids Engineering 2020).

SiteID	Site Description	ATC SiteID
SRU-LBN	Shasta River upstream of the Little Shasta River confluence, Left Bank near River	SRU-ATC
SRU-LBF	Shasta River upstream of the Little Shasta River confluence, Left Bank further from River	SRU-ATC
SRU-RBN	Shasta River upstream of the Little Shasta River confluence, Right Bank near River	SRU-ATC
SRU-RBF	Shasta River upstream of the Little Shasta River confluence, Right Bank further from River	SRU-ATC
SRU-SWE	Shasta River upstream of the Little Shasta River confluence, Surface Water Elevation	SRU-ATC
SRU-ATC	Shasta River upstream of the Little Shasta River confluence, Atmospheric Pressure Compensation	SRU-ATC
SRD-LBN	Shasta River downstream of the Little Shasta River confluence, Left Bank near River	SRD-ATC
SRD-LBF	Shasta River downstream of the Little Shasta River confluence, Left Bank further from River	SRD-ATC
SRD-RBN	Shasta River downstream of the Little Shasta River confluence, Right Bank near River	SRD-ATC
SRD-RBF	Shasta River downstream of the Little Shasta River confluence, Right Bank further from River	SRD-ATC
SRD-SWE	Shasta River downstream of the Little Shasta River confluence, Surface Water Elevation	SRD-ATC
SRD-ATC	Shasta River downstream of the Little Shasta River confluence, Atmospheric Pressure Compensation	SRD-ATC
LSR-LBN	Little Shasta River in Little Shasta Valley, Left Bank near River	LSR-ATC
LSR-LBF	Little Shasta River in Little Shasta Valley, Left Bank further from River	LSR-ATC
LSR-RBN	Little Shasta River in Little Shasta Valley, Right Bank near River	LSR-ATC
LSR-RBF	Little Shasta River in Little Shasta Valley, Right Bank further from River	LSR-ATC
LSR-SWE	Little Shasta River in Little Shasta Valley, Surface Water Elevation	LSR-ATC
LSR-ATC	Little Shasta River in Little Shasta Valley, Atmospheric Pressure Compensation	LSR-ATC

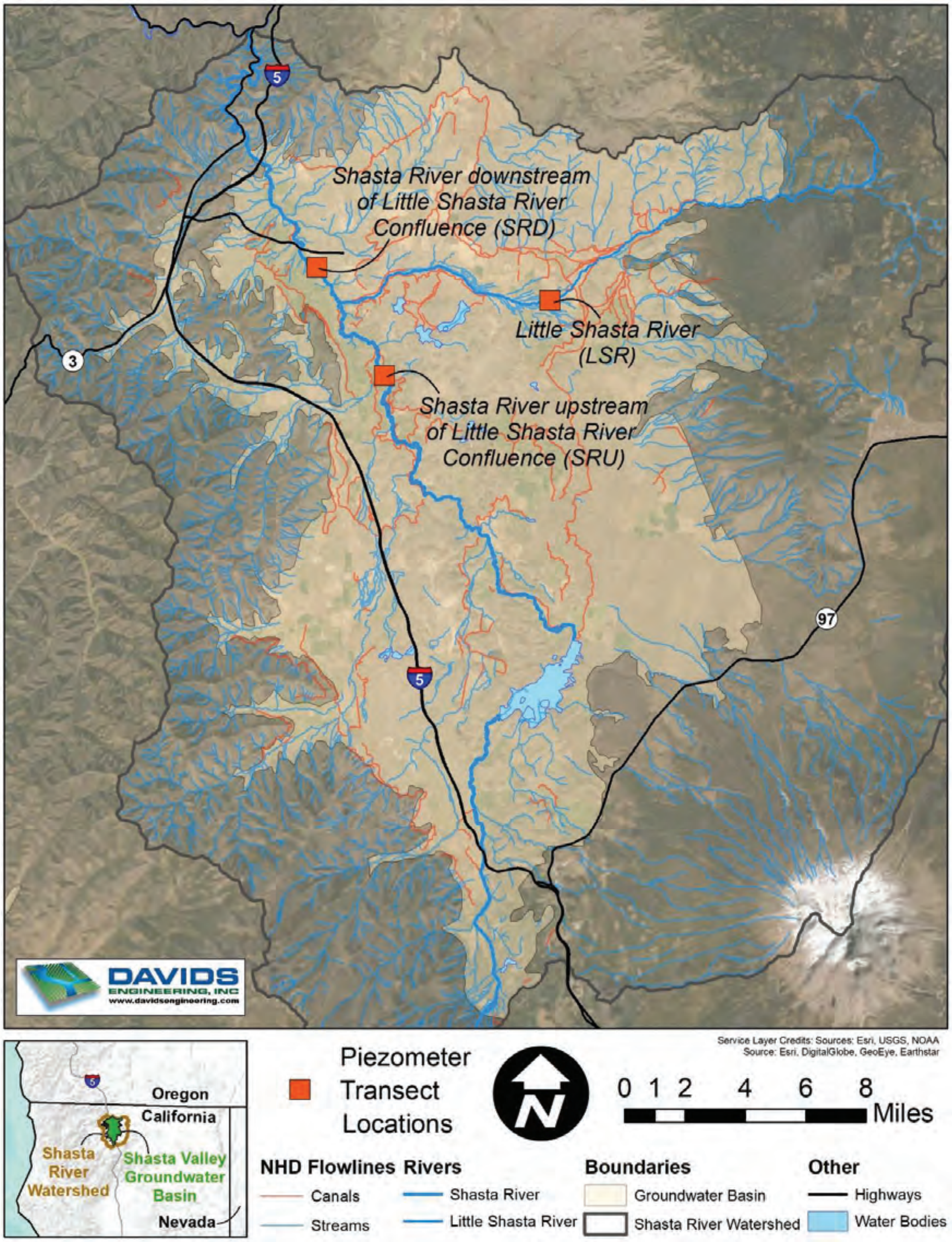


Figure 2.44: Approximate Location of Piezometer Transects within the Basin (Davids Engineering 2020).

Temperatures can be measured and monitored in the aquifer and stream to provide additional insight into stream-aquifer interactions. Surface water is exposed to four heat-transfer mechanisms, most notably radiative heat input from the sun and convective heat transfer as water flows downstream and mixes. In a losing reach, the temperature in the shallow aquifer adjacent to the stream will more closely mirror surface water temperatures in the stream as surface water flows from the stream into the adjacent groundwater system. Conversely, in a gaining reach, the temperature in the shallow aquifer adjacent to the stream will remain more constant, not following surface water temperature trends as closely, as groundwater flows from the aquifer into the stream (Figure 2.45) (Davids Engineering 2020).

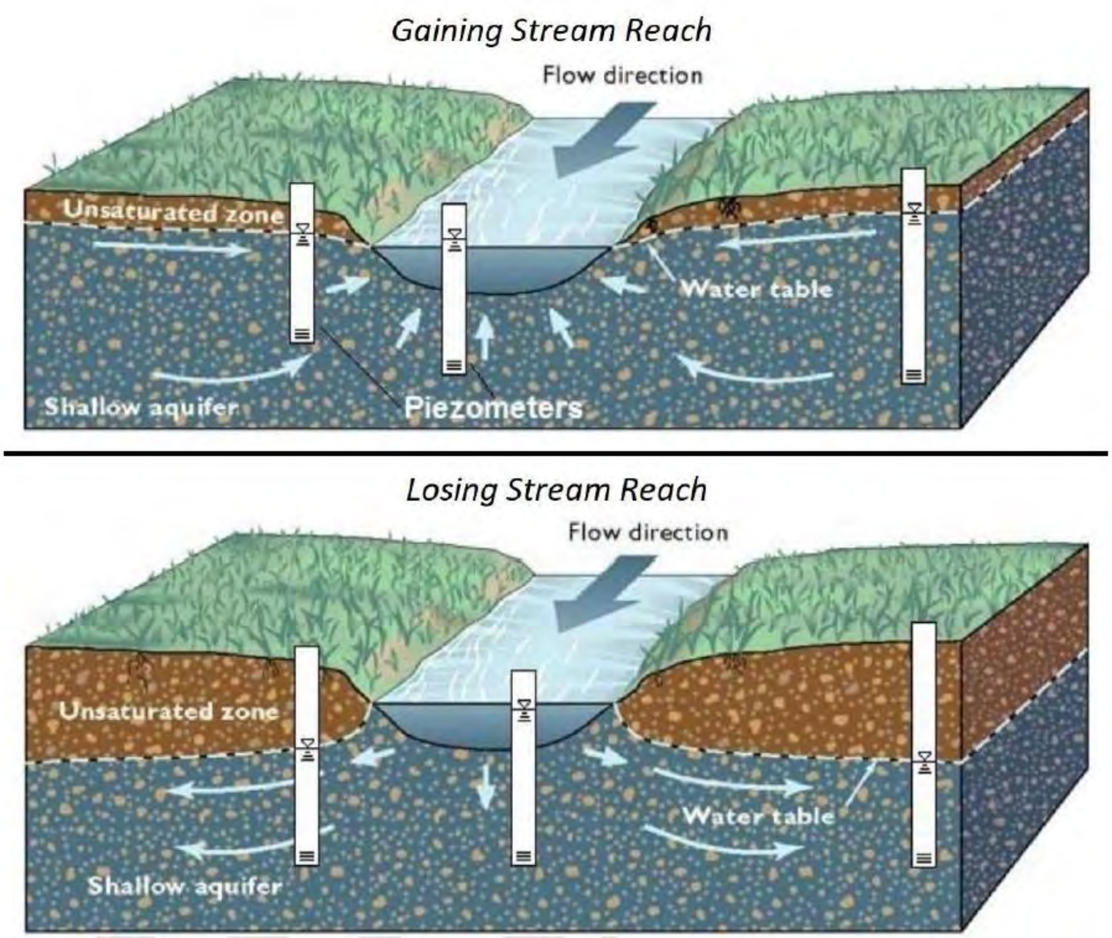


Figure 2. Conceptual Diagram of Piezometers in Gaining and Losing Stream Reaches (Modified from Winter et al., 1999).

Figure 2.45: Conceptual Diagram of Piezometers in Gaining and Losing Stream Reaches (Modified from Winter et al., 1999) (Davids Engineering 2020).

Shasta River Upstream of Little Shasta River Confluence (SRU)

The Shasta River had continuous flow past the transect location throughout the study period from May 2020 through October 2020. The river stage remained steady during this period, with fluctuations in stage of less than one foot. There was an increase in stage in late September and early October, potentially coinciding with the end of the irrigation season and cessation of upstream diversions. Groundwater elevations in the piezometers on both sides of the river tended to be higher than the surface water elevation in the river, with elevations increasing with distance from the river. The lands on either side of the river in this transect location were irrigated, and these periodic pulses of water observed in piezometers were likely reflective of irrigation events (Davids Engineering 2020).

With the exception of the SRU-RBN piezometer in late July and early August, all piezometers showed higher water surface elevations during the study period (Figure 2.47). Groundwater temperatures also tended to be lower than surface water temperatures for a majority of the study period, and did not show strong responses to surface water temperature fluctuations. These results indicate that the Shasta River was gaining in the transect location over the study period (Davids Engineering 2020).

Shasta River Downstream of Little Shasta River Confluence (SRD)

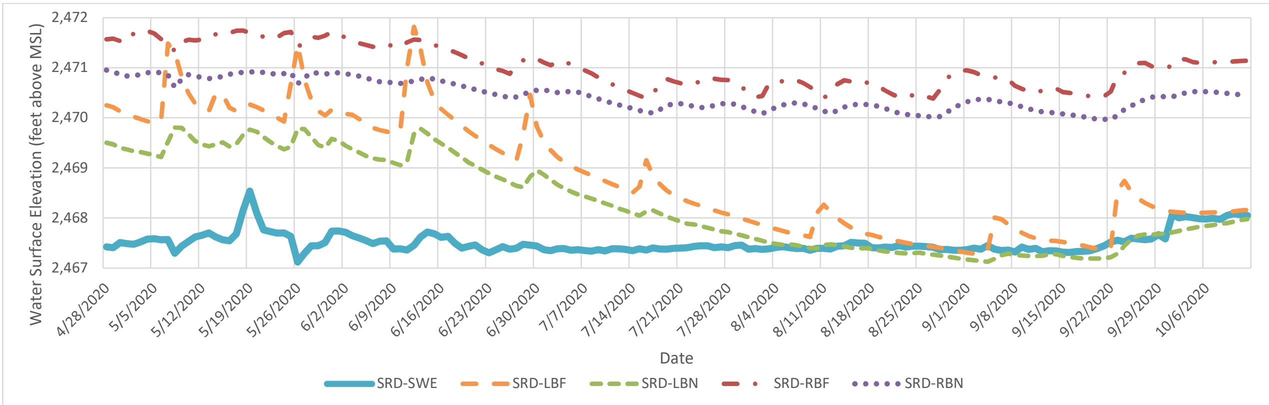
The river stage remained steady during the study period, excluding fluctuations in May. There was also an increase in stage in late September and early October, potentially coinciding with the end of the irrigation season and cessation of upstream diversions. Groundwater elevations in the piezometers on both sides of the river tended to be higher than the surface water elevation through most of the study period, with elevations increasing with distance from the river. The lands on either side of the river in this transect location were irrigated; increases in groundwater levels observed in piezometers were likely reflective of irrigation events (Davids Engineering 2020).

With the exception of the LBN piezometer from mid-August to mid-September, piezometers tended to show higher water surface elevations during the study period (Figure 2.46). Groundwater temperatures also tended to be lower than surface water temperatures for a majority of the study period, and did not show strong responses to surface water temperature fluctuations, although the LBF temperature appeared to be influenced by something distinct from the other sites. These results indicate that the Shasta River was generally gaining in the transect location over the study period, with some potential losses to the aquifer adjacent to the left bank in the late summer (Davids Engineering 2020).

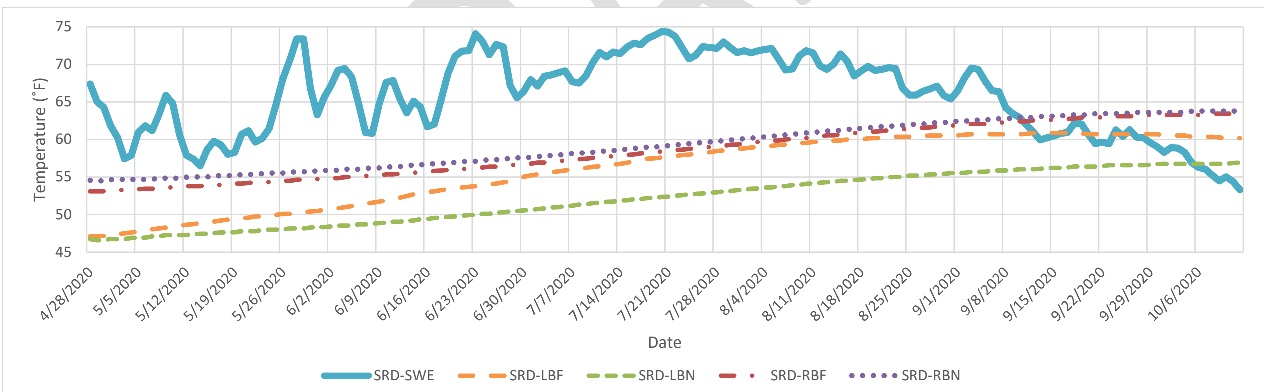
Little Shasta River in Little Shasta Valley (LSR)

The river stage at the transect remained relatively steady until late June to early July, where water levels declined until the river stretch completely dried out by August. Generally speaking, groundwater levels were declining during the study period. Due to underlying geological conditions (primarily the presence of large cobbles) the piezometer boreholes were not able to be drilled as deeply in this transect as the other two transects and groundwater levels in three of the four piezometers dropped below the level that could be measured (Davids Engineering 2020).

Piezometers tended to have lower water surface elevations than the surface water site during the study period, and temperatures were typically within 10˚F between groundwater and surface water (Figure 2.48). These results indicate that the Little Shasta River was losing in the transect location over the study period (Davids Engineering 2020).



Daily Average Water Surface Elevations at Shasta River Downstream of Little Shasta River Confluence (SRD) Transect.

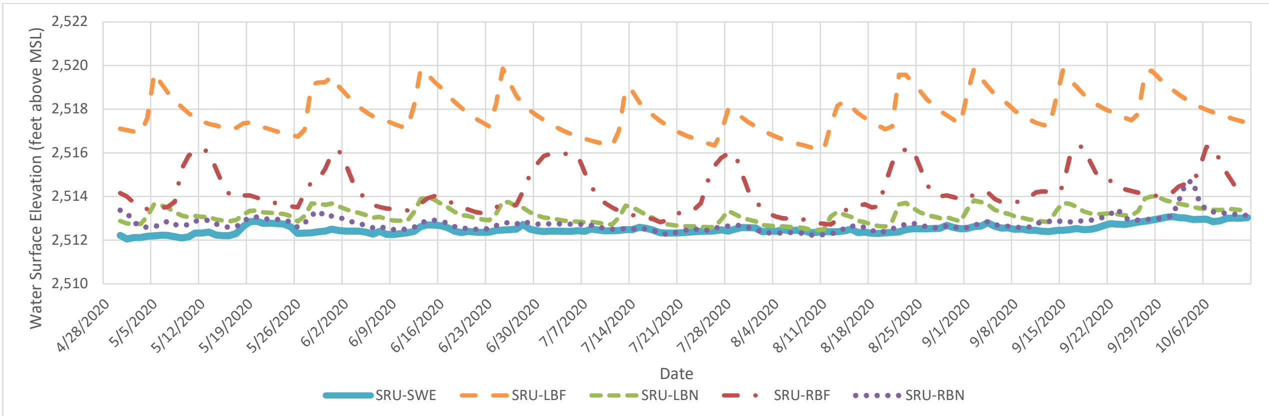


Daily Average Temperatures at Shasta River Downstream of Little Shasta River Confluence (SRD) Transect.

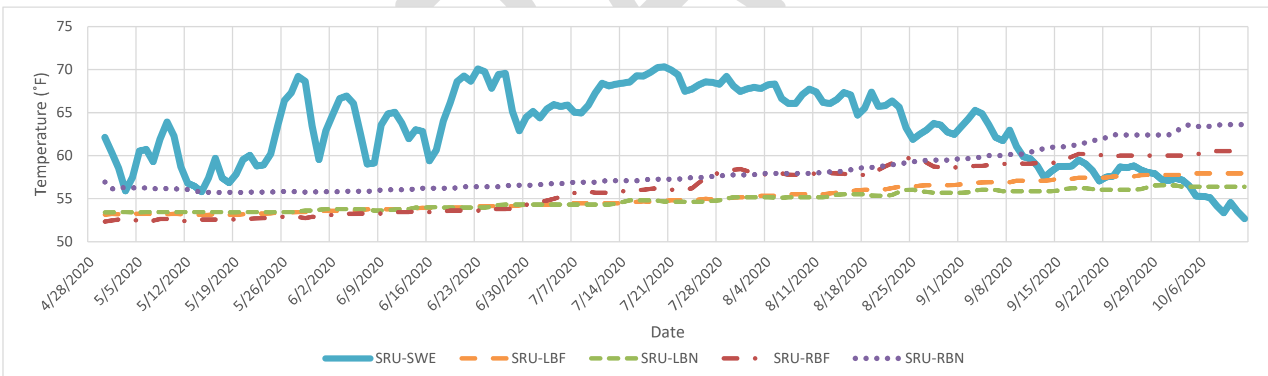
Davids Engineering

Shallow Piezometer
Transect Study

Figure 2.46: Study data from the Downstream Shasta River transect (Davids Engineering 2020).



Daily Average Water Surface Elevations at Shasta River Upstream of Little Shasta River Confluence (SRU) Transect.

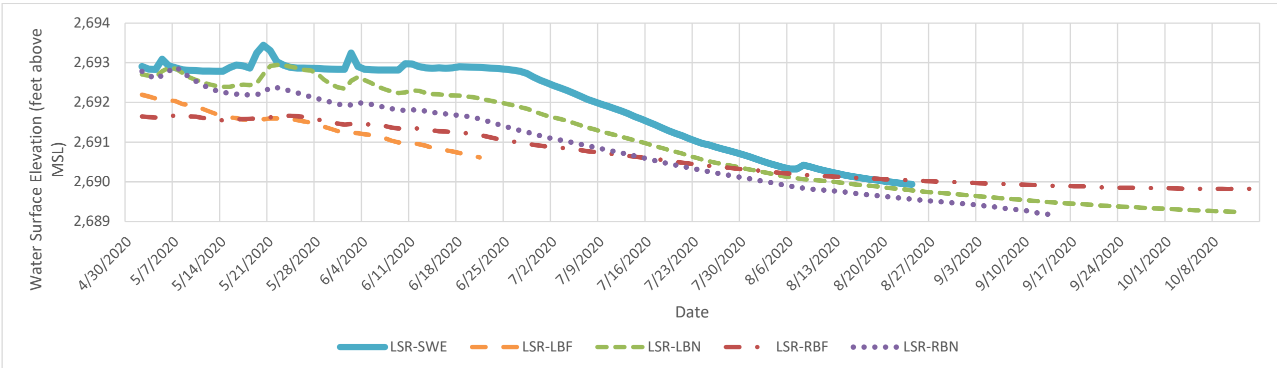


Daily Average Temperatures at Shasta River Upstream of Little Shasta River Confluence (SRU) Transect.

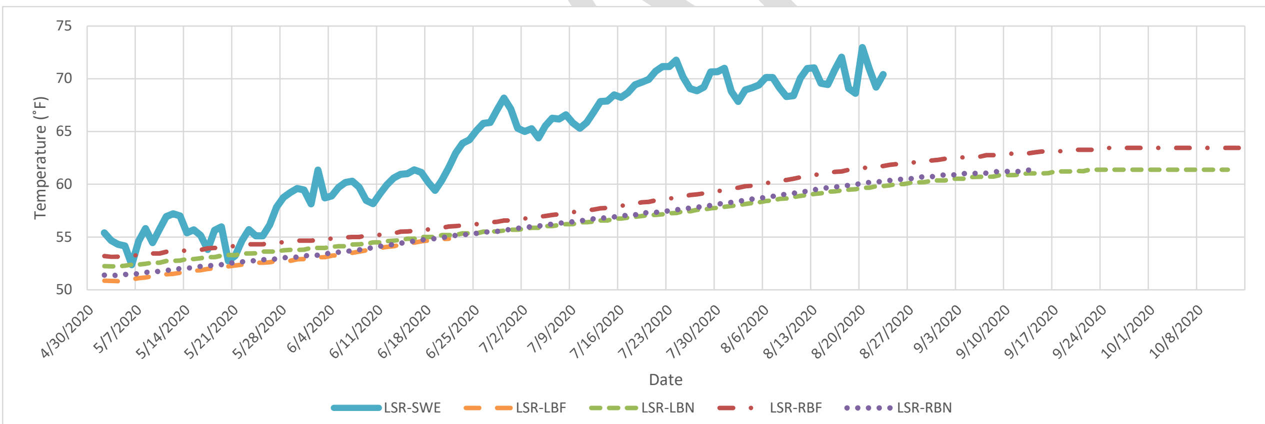
Davids Engineering

Shallow Piezometer Transect Study

Figure 2.47: Study data from the Upstream Shasta River transect (Davids Engineering 2020).



Daily Average Water Surface Elevations at Little Shasta River (LSR) Transect.



Daily Average Temperatures at Little Shasta River (LSR) Transect.

Davids Engineering

Shallow Piezometer Transect Study

Figure 2.48: Study data from the Little Shasta River in Little Shasta Valley transect (Davids Engineering 2020).

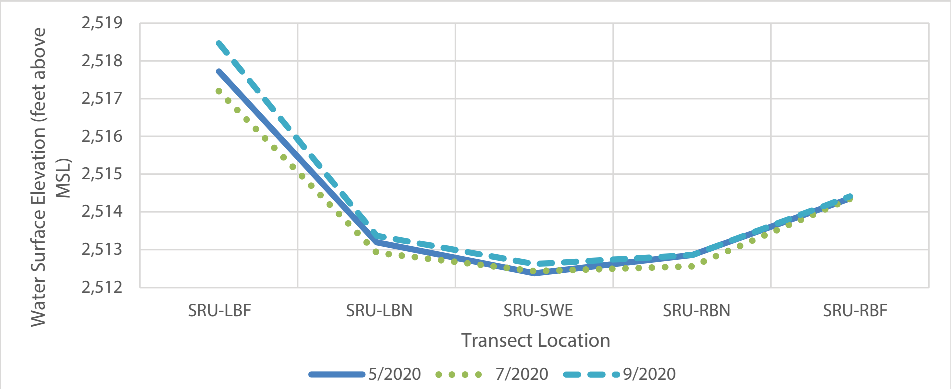
Average Monthly Water Elevations During May, July, and September 2020

Each transect had differing trends in water surface elevation (Figure 2.49). For the SRU transect, conditions remained relatively stable over the study period, and the hydraulic gradient towards the river from the left bank was substantially greater than from the right bank. For the SRD transect, decreasing water surface elevations were seen at all sites over the study period, but to varying degrees. The highest hydraulic gradient towards the river occurred from the right bank; water elevations in the RBN and RBF piezometers declined from May to July but remain steady from July to September. In contrast, along the left bank, the water surface elevations continually decreased from May through September. For the LSR transect, decreasing water surface elevations were seen at all sites over the study period. The smallest decrease was observed in the RBF piezometer in this transect (Davids Engineering 2020).

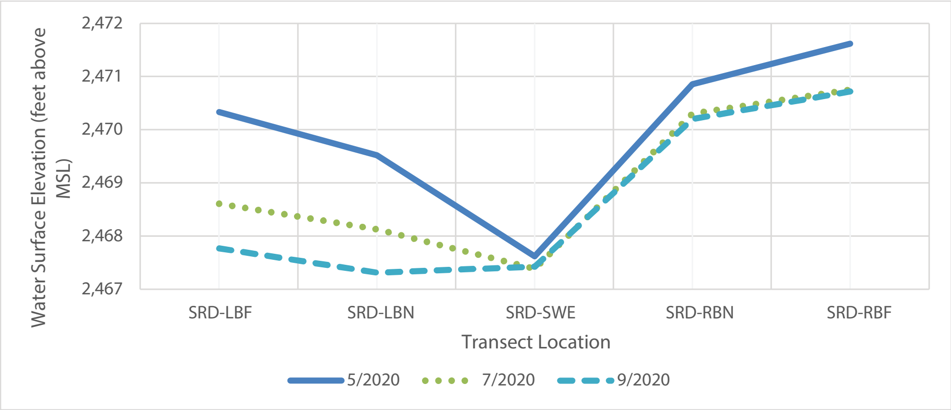
Summary

Both transects along the Shasta River (SRU and SRD) had higher shallower groundwater water surface elevations in the piezometers than surface water elevations throughout the study period. Overall, shallow groundwater levels relative to surface water showed relatively consistent trends during the study period. The shallow groundwater levels in the two transects along the Shasta River tended to be higher in elevation and have a hydraulic gradient towards the river, while in the Little Shasta River they tend to be lower in elevation and have a hydraulic gradient away from the river. While these trends were influenced by a variety of factors, one that may contribute to differences is the irrigation of lands on either side of the river, as the lands along the Shasta River in the vicinity of the transect were irrigated while lands along the Little Shasta River were unirrigated.

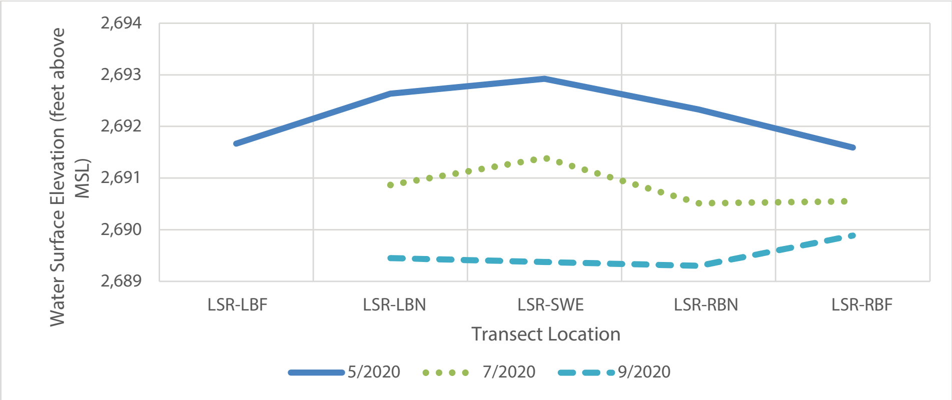
Temperature differences varied between the transects, but overall showed the same general trends. The shallow groundwater was lower in temperature at the start of the study in May 2020 (e.g. negative values), and the differences increased into the summer as surface water temperatures increased more rapidly than groundwater temperatures. However, in late summer and early fall, as groundwater temperatures continued to slowly rise and surface water temperatures began falling, the trend reversed. The differences decreased and then became positive, reflective of surface water temperatures decreasing below shallow groundwater temperatures. The temperature difference was the smallest for the LSR transect and greatest for the SRD transect. The temperature difference may have been greater at the SRD transect than the SRU transect because of surface warming in the Shasta River as it flowed downstream. The temperature difference comparison at all transects reflected the slower changes in shallow groundwater temperatures relative to surface water temperatures (Davids Engineering 2020).



Monthly Average Water Surface Elevations at Shasta River Upstream of Little Shasta River Confluence (SRU) Transect (Perspective Looking Downstream).



Monthly Average Water Surface Elevations at Shasta River Downstream of Little Shasta River Confluence (SRD) Transect (Perspective Looking Downstream).



Monthly Average Water Surface Elevations at Little Shasta River (LSR) Transect (Perspective Looking Downstream)

Figure 2.49: Cross-sectional view of water elevations at each piezometer transect, looking downstream. The horizontal axis is equally spaced and not representative of true distances between piezometers (Davids Engineering 2020).

Spring Discharge Monitoring Results

Discharge measurements are scheduled to be taken at a monthly interval at select springs in the Basin to evaluate seasonal variability and trends in spring discharge in different locations (Figure 2.50 and Figure 2.51). Data included below should be considered preliminary.

Observations (SVRCD 2021):

- Big Springs Creek, Little Springs Creek and Hole in the Ground springs show relatively large changes in spring discharge.
- The fluctuations in Big Springs Creek align with the irrigation season, and are likely reflective of groundwater pumping (i.e. BSID groundwater pumps) resulting in decreased spring discharge during the spring and summer months.
- The trend in Hole in the Ground Springs generally follows the same pattern as Big Springs Creek in the data thus far, so it may be influenced by similar factors, although seems to have more delayed increases/decreases compared to Big Springs Creek.
- Little Springs Creek shows decreased flow in September 2020, which may be an anomaly. A construction project in the vicinity of the measurement location had recently been completed, and the channel may have been dewatered. It also shows decreased flow in April and May 2021, which may potentially be indicative of an upstream diversion between the spring source and the measurement location, or may be caused by another factor.
- Evans Spring, Kettle Spring, and Clear Spring appear to be more stable, not showing the same fluctuations in flow seen at the sites listed above. They also have lower flows.
- Kettle Spring Creek in the discharge measurement location has a soft channel bottom, making measurement of channel depth with a wading rod and placement of the velocity sensor at the correct depth in water column more difficult. Although the measurements can be considered representative, this adds uncertainty to these measurements that are not present at measurement sites with a firm channel bottom. Additionally, total discharge is calculated as sum of the transect measurement in Kettle Spring Creek and the measured diverted flows from Kettle Spring, which also adds uncertainty to the total flow.
- Both Evans Spring and Clear Spring show increasing flow in the past few months.

These conditions may change course during drought conditions.

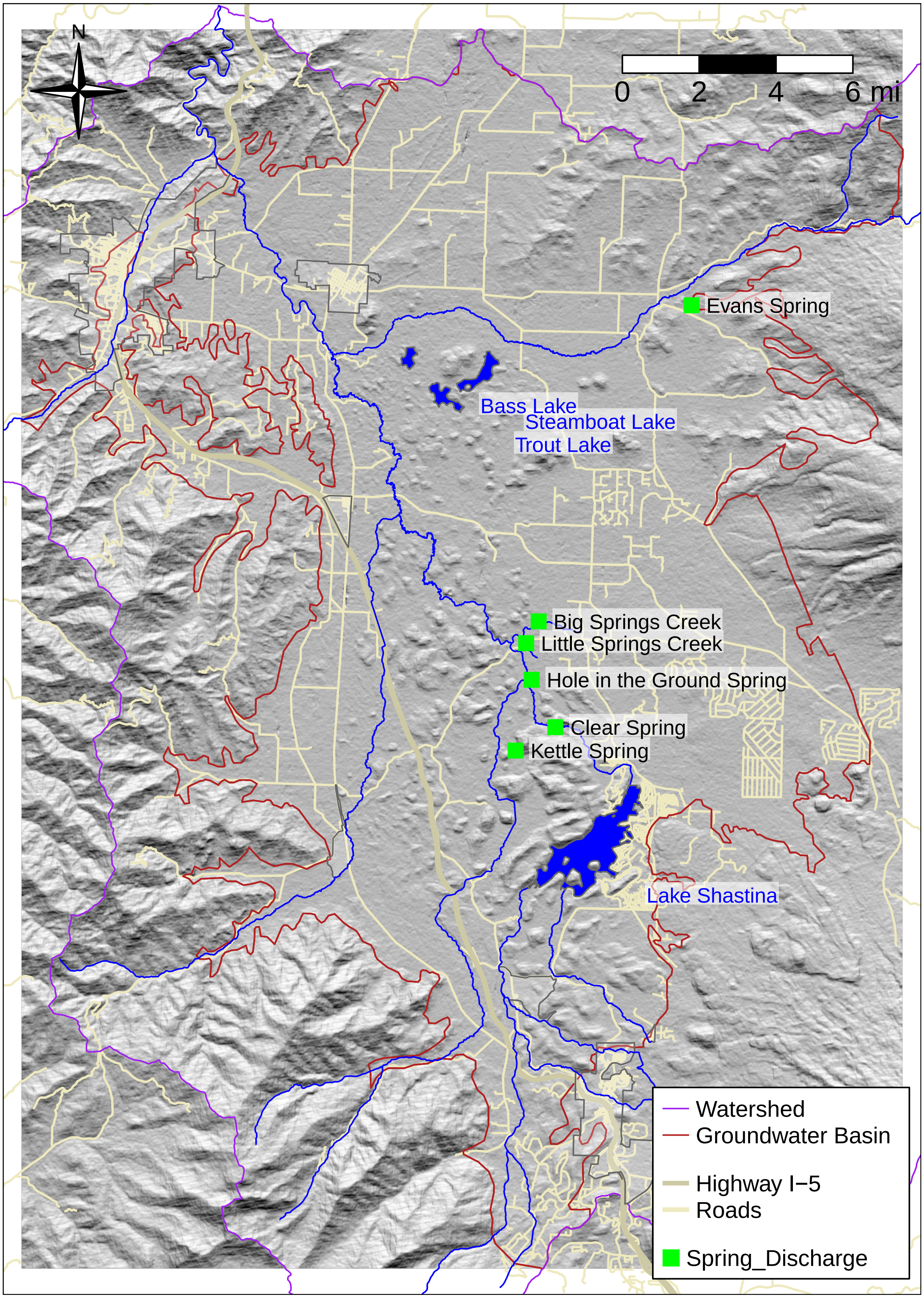


Figure 2.50: Monthly Spring Monitoring Networks.

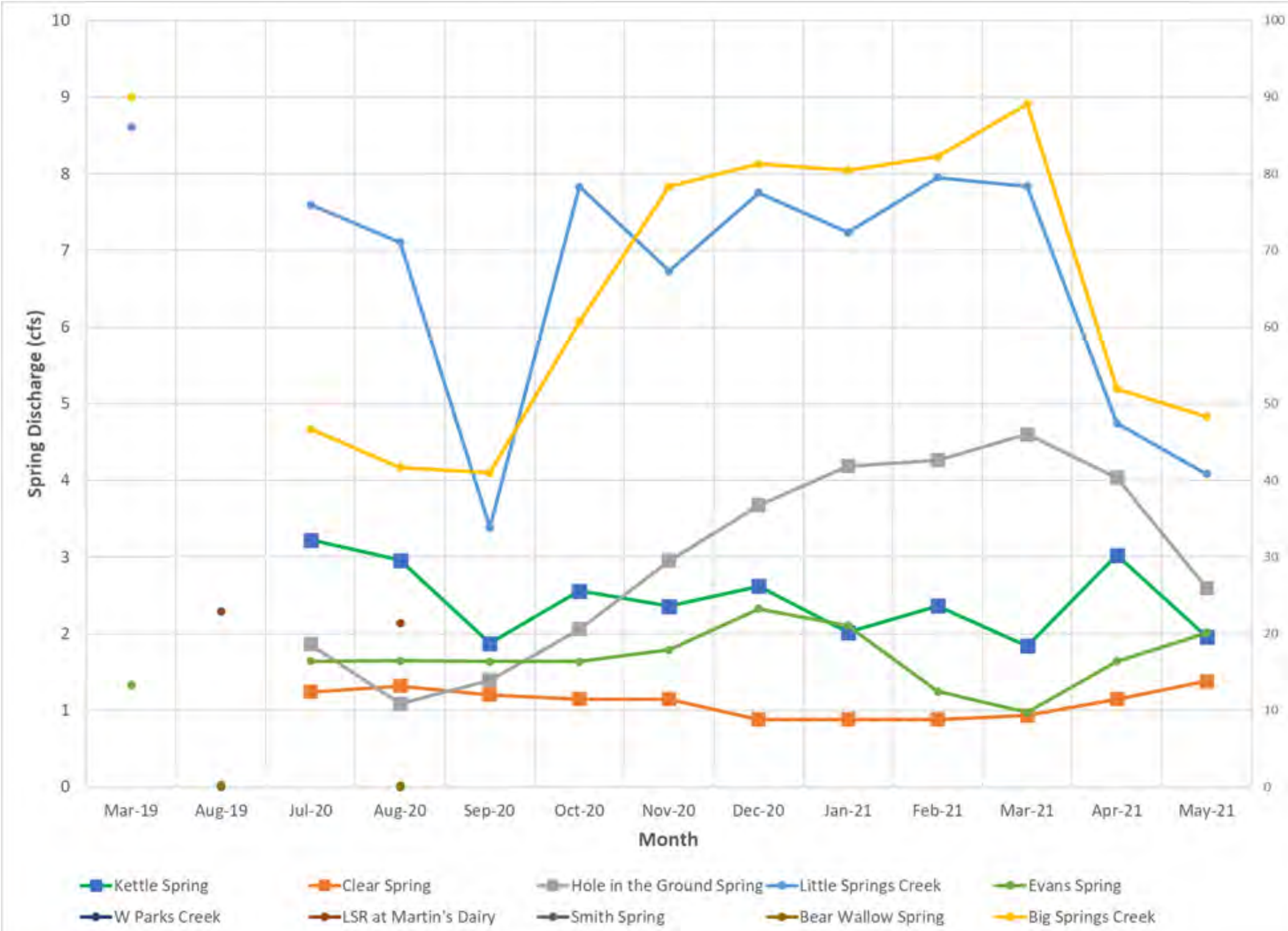


Figure 2.51: Monthly spring discharge measurement results. Please note that only Big Springs Creek discharge corresponds to the secondary vertical axis values. Please also note that the horizontal axis is not at regular intervals (SVRCD 2021).

Identified Interconnected Surface Waters

Assumed ISW within the Basin, reflecting the current understanding of groundwater-surface water interactions are presented in a manner consistent with requirements outlined in SGMA in Figure 2.52. These ISWs are presented with representations of depth to groundwater for the spring and fall of 2015 in Figure 2.53 and Figure 2.54, respectively.

The link between surface and groundwater is based on historic reports (Mack 1960) as well as continued summer baseflow within the Shasta River. Because the water table in many parts of the Basin can be relatively shallow, the Shasta River surface water network contains many miles of stream channel that are connected to groundwater. The Shasta River and its major tributaries are all considered part of the ISW system in the Basin. Their large seasonal flow variations exhibit all five elements of the recently proposed functional flows framework for managing California rivers: fall flush flow, winter storm flow, winter baseflow, spring recess, and summer baseflow. The system is also subject to significant interannual variations in flow and largely affected by the complex springs system that is present throughout the valley as a result of the volcanic origin.

The magnitude and direction of flow exchanged between surface water and groundwater varies both in time and spatially (i.e., the geographic distribution of gaining and losing stream reaches is not constant). When this flux is net positive into the aquifer over the Basin, it is commonly referred to as stream leakage; when it is net positive into the stream it is referred to as groundwater discharge.

In most years, the net direction in the entire Watershed of stream-aquifer flux is as groundwater discharge into the river, with the largest net groundwater replenishment from streams occurs in wet years. Seasonally, the magnitude of stream leakage from the streamflow system to the aquifer is greatest during late winter and early spring, while the net magnitude of groundwater discharge to the stream is greatest in late fall at the end of the dry season (least seasonal recharge). The mainstem Shasta River is alternately gaining and losing depending on the season, on the location, and on the year type. In other words, river water weaves in and out of the aquifer on its journey south to north along the valley floor. When considered as a whole, the mainstem of the Shasta River is a gaining reach. The upper sections of tributaries tend to be losing stream reaches but conditions depend on precipitation levels during any given water year and some of the tributaries tends to be dry in the summer months before connecting to the main stem of the Shasta River.

With respect to the functional flows of the Shasta River, depletion of surface water due to groundwater pumping affects the timing of the late spring recess, the amount of summer baseflow, and the onset of fall flush flow.

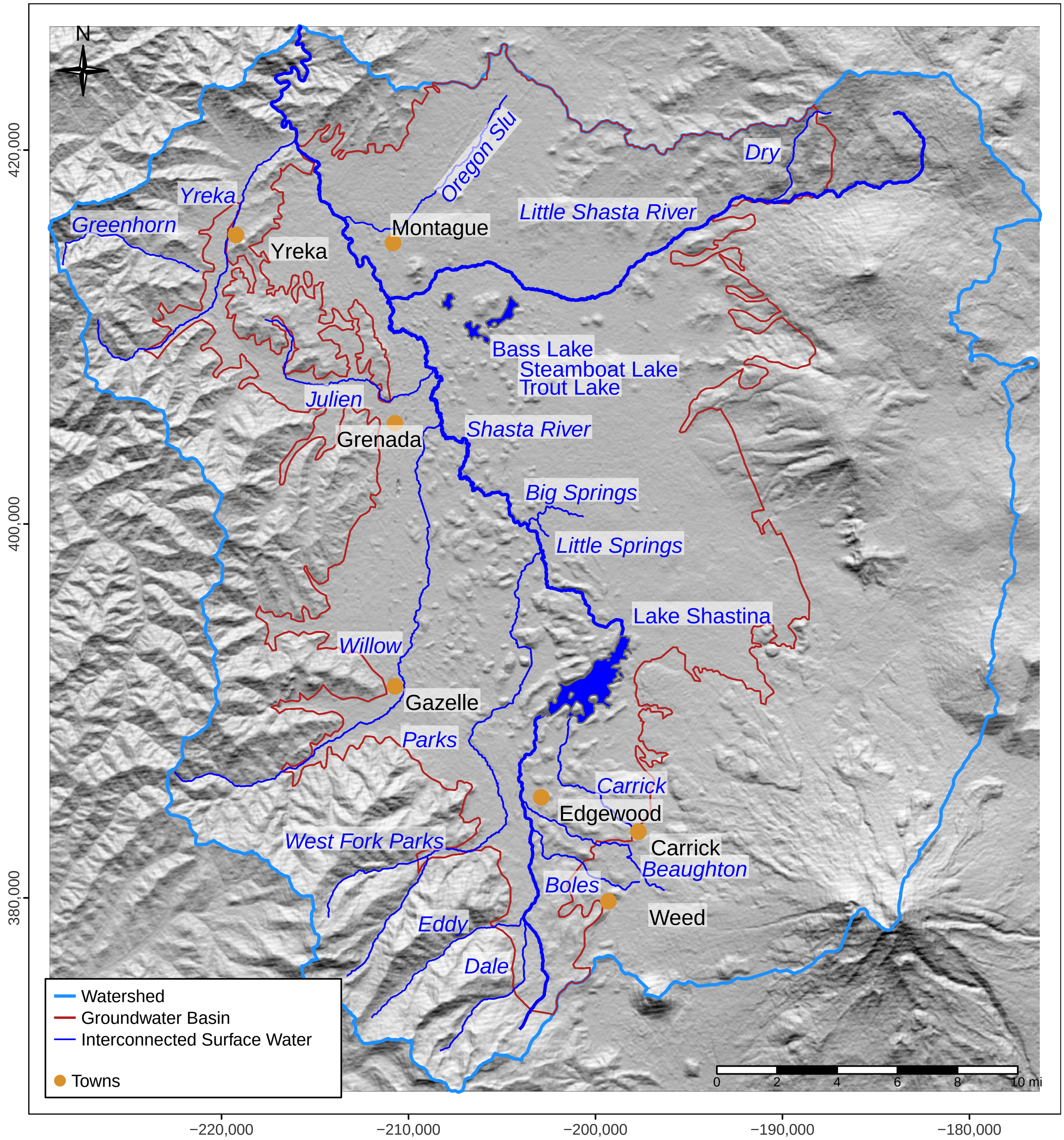


Figure 2.52: Major ISW in the Basin includes the Shasta River tributaries and Lake Shastina and Big Springs Lake. All surface water is considered a potential ISW.

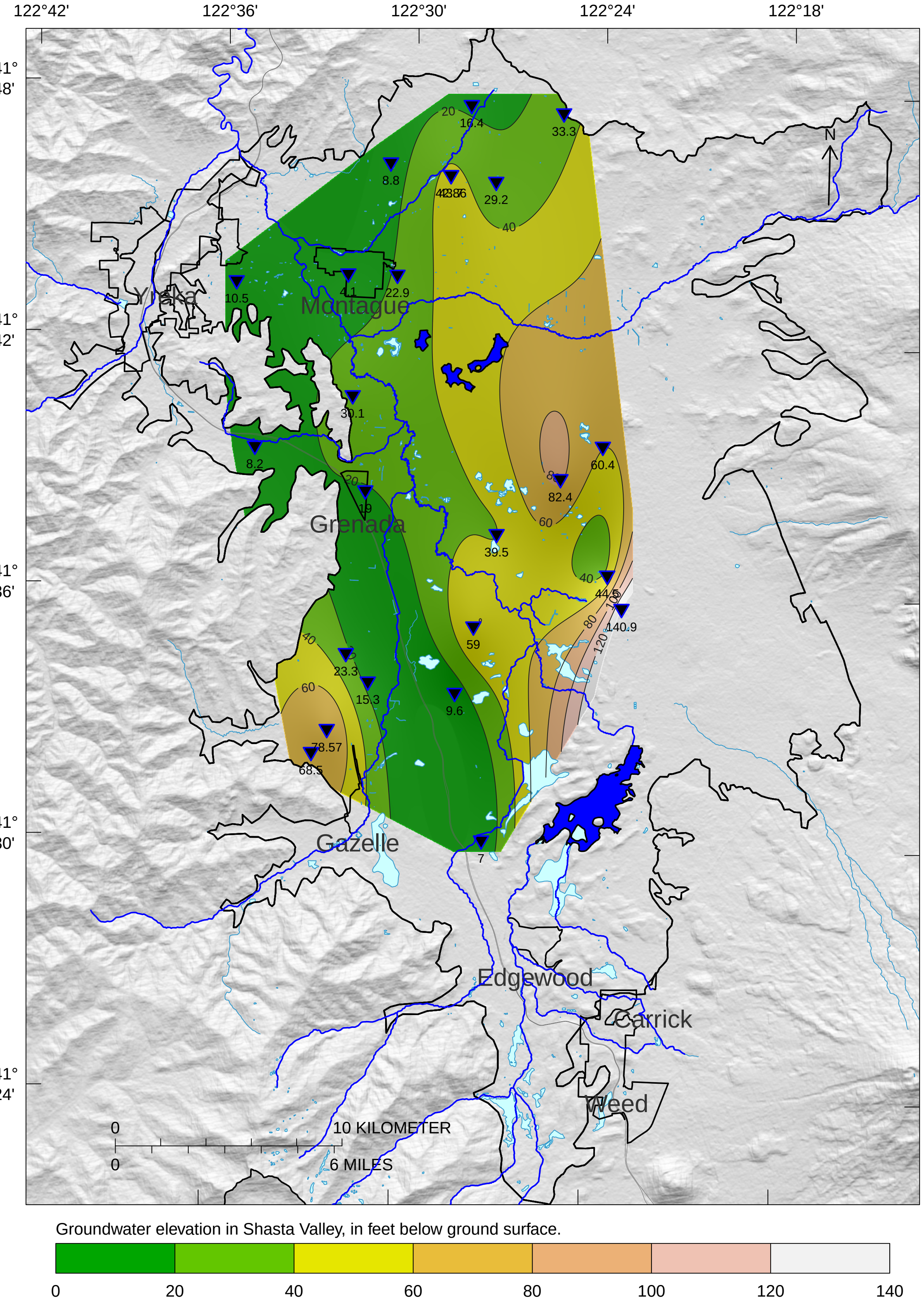


Figure 2.53: Major ISW in the Basin, with groundwater contours in terms of depth below ground surface in Sping 2015.

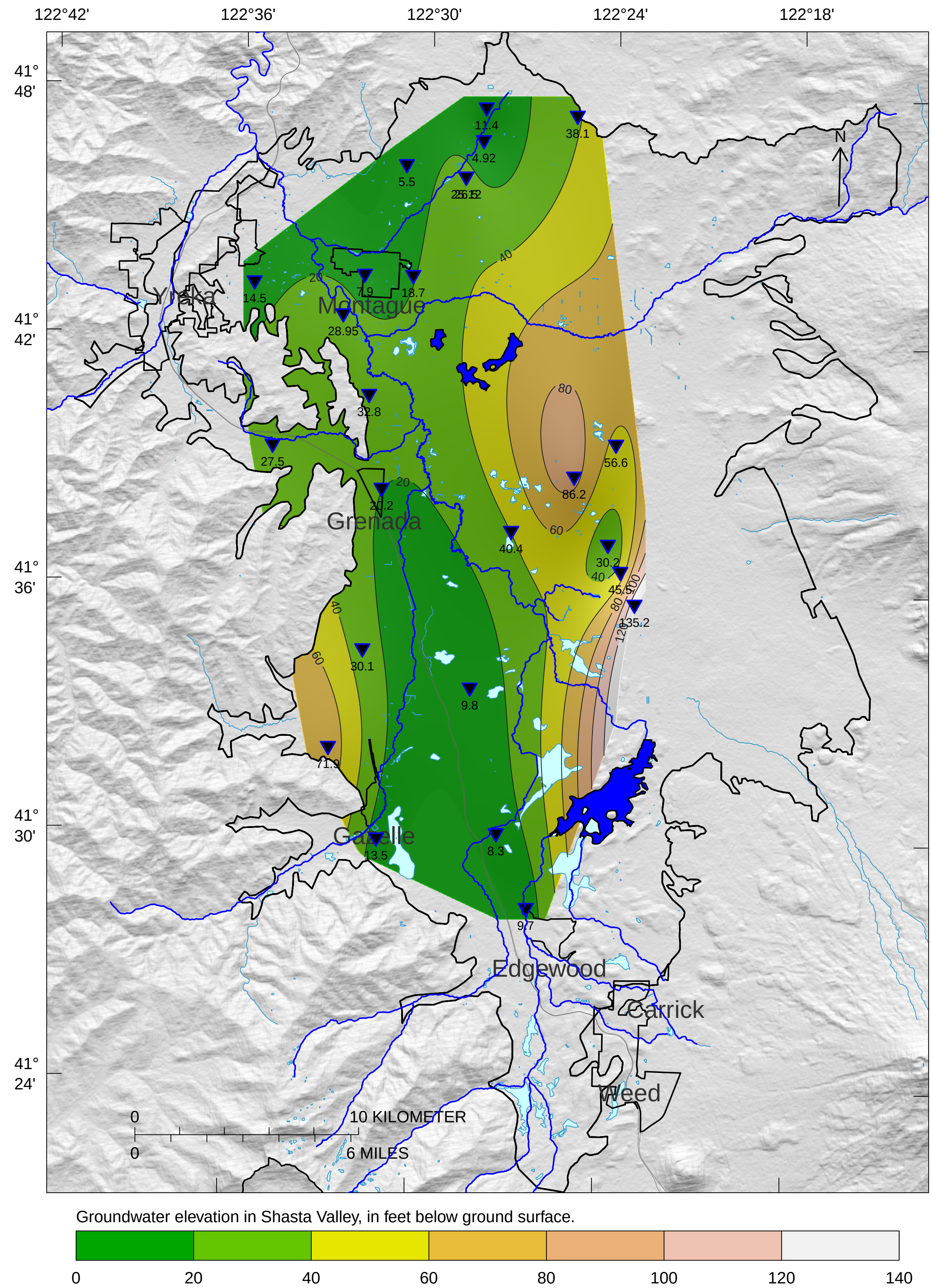


Figure 2.54: Major ISW in the Basin, with groundwater contours in terms of depth below ground surface in Fall 2015.

2.2.2.7 Identification of Groundwater Dependent Ecosystems

Section 354.16(g) of SGMA requires identification of 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.

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 ISW, 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 (SMCs), improve the monitoring network, and define projects and management actions 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.

Environmental Beneficial Water Uses and Users within the Basin

To establish SMCs for groundwater levels and for the depletion of ISWs, 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 three USEPA Level III Ecoregions of California (Griffith et al. 2016) (Figure 2.55):

- Cascade (Ecoregion 4), which covers approximately 32% of the Watershed, 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 accounts for 46% of the Watershed. 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.
- Klamath Mountain/California High North Cascade Range (Ecoregion 78), covers approximately 22% of the Watershed area. The mild Mediterranean climate of the ecoregion is characterized by hot, dry summers and wet winters. The region's mix of granitic, sedimentary, metamorphic, and extrusive rocks contrasts with the predominantly younger volcanic rocks of the Cascades Ecoregion 4 to the east. It includes ultramafic substrates, such as serpentinite and mafic lithologies that directly affect vegetation. The region's diverse flora, a mosaic of both northern Californian and Pacific Northwestern conifers and hardwoods, is rich in endemic and relic species.

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. An overview of jurisdictional areas and land uses can be found in Section 2.1.1.

Endangered, Threatened, or Species of Special Concern

The CDFW Biogeographic Information and Observation System (BIOS) Viewer was used to identify threatened and endangered species that may be present within the Watershed. A total of six species are listed as endangered at the federal level with 17 listed as endangered by the State of California. An additional nine species are listed as threatened at the federal level with ten receiving the same designation at the State level. An additional subset of species are listed as either being a candidate for endangered species status or rare at the federal level, proposed endangered at the State level, or species of special concern. Two species of special concern not present in the BIOS viewer summary were added to the list at the request of CDFW staff. These species were the Western pond turtle and the Pacific lamprey. A summary of endangered, threatened, or species of special concern for the Watershed is presented in Table 2.7.

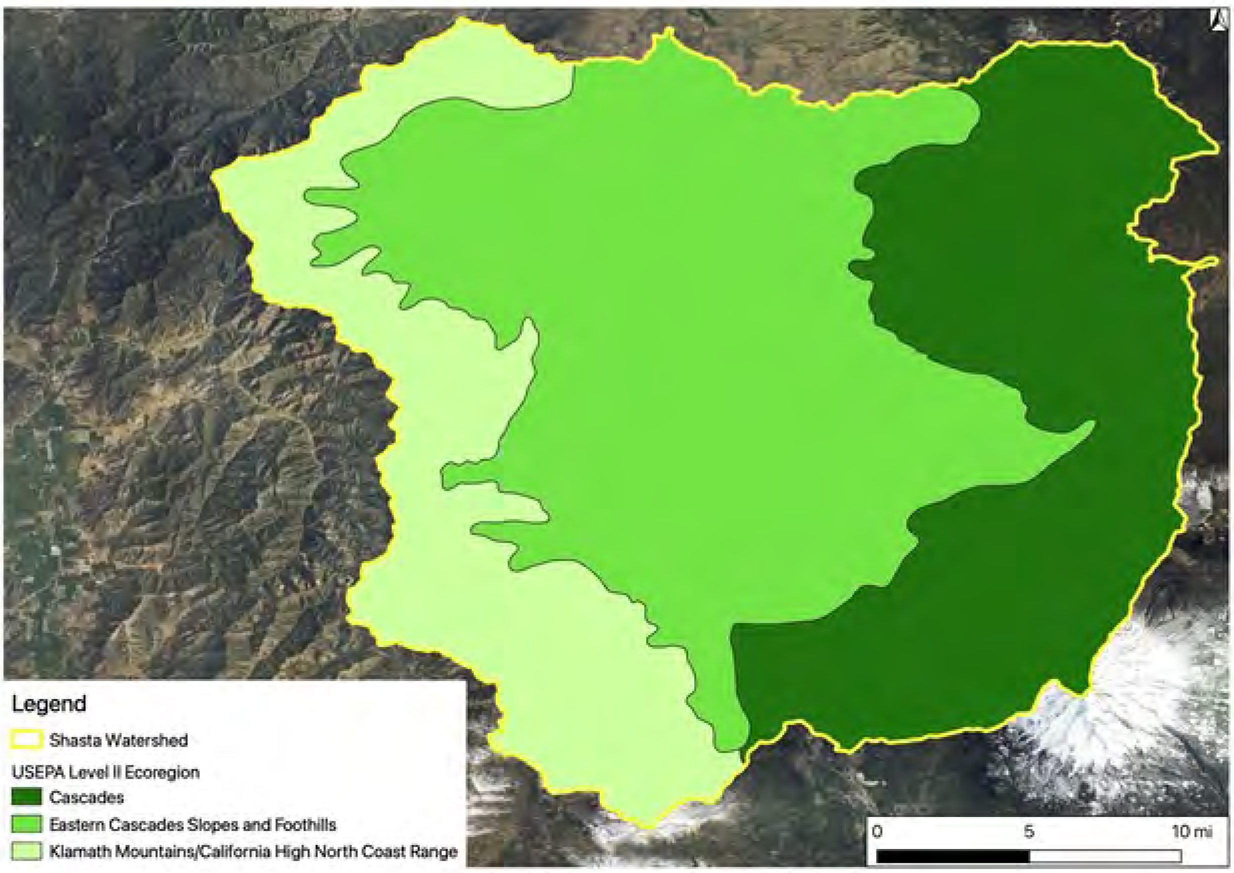


Figure 2.55: Ecoregions in the Watershed

Table 2.7: Threatened and Endangered Species Within Siskiyou County Identified in the CDFW BIOS Viewer.

Species Common Name	Scientific Name	Group	State Status	Federal Status
Scott Bar salamander	Plethodon asupak	Animals - Amphibians	Threatened	None
Siskiyou Mountains salamander	Plethodon stormi	Animals - Amphibians	Threatened	None
Foothill yellow-legged frog	Rana boylii	Animals - Amphibians	Endangered	None
Cascades frog	Rana cascadae	Animals - Amphibians	Candidate Endangered	None
Oregon spotted frog	Rana pretiosa	Animals - Amphibians	None	Threatened
Western pond turtle	Actinemys marmorata	Animals - Amphibians	Species of Special Concern	Species of Concern
Swainson's hawk	Buteo swainsoni	Animals - Birds	Threatened	None
Bald eagle	Haliaeetus leucocephalus	Animals - Birds	Endangered	Delisted
Western snowy plover	Charadrius nivosus nivosus	Animals - Birds	None	Threatened
Western yellow-billed cuckoo	Coccyzus americanus occidentalis	Animals - Birds	Endangered	Threatened
Greater sandhill crane	Antigone canadensis tabida	Animals - Birds	Threatened	None
Bank swallow	Riparia riparia	Animals - Birds	Threatened	None
Tricolored blackbird	Agelaius tricolor	Animals - Birds	Threatened	None
Great gray owl	Strix nebulosa	Animals - Birds	Endangered	None
Northern spotted owl	Strix occidentalis caurina	Animals - Birds	Threatened	Threatened
Willow flycatcher	Empidonax traillii	Animals - Birds	Endangered	None
Little willow flycatcher	Empidonax traillii brewsteri	Animals - Birds	Endangered	None
Green sturgeon	Acipenser medirostris	Animals - Fish	None	Threatened
Shortnose sucker	Chasmistes brevirostris	Animals - Fish	Endangered	Endangered
Lost River sucker	Deltistes luxatus	Animals - Fish	Endangered	Endangered
Coho salmon - southern Oregon / northern California ESU	Oncorhynchus kisutch pop. 2	Animals - Fish	Threatened	Threatened
Steelhead - northern California DPS	Oncorhynchus mykiss irideus pop. 16	Animals - Fish	None	Threatened
Summer-run steelhead trout	Oncorhynchus mykiss irideus pop. 36	Animals - Fish	Candidate Endangered	None
Chinook salmon - upper Klamath and Trinity Rivers ESU	Oncorhynchus tshawytscha pop. 30	Animals - Fish	Candidate Endangered	Candidate
Bull trout	Salvelinus confluentus	Animals - Fish	Endangered	Threatened
Pacific Lamprey	Entosphenus tridentatus	Animals - Fish	Species of Special Concern	Species of Concern

Table 2.7: Threatened and Endangered Species Within Siskiyou County Identified in the CDFW BIOS Viewer. *(continued)*

Species Common Name	Scientific Name	Group	State Status	Federal Status
Crotch bumble bee	Bombus crotchii	Animals - Insects	Candidate Endangered	None
Franklin's bumble bee	Bombus franklini	Animals - Insects	Candidate Endangered	Proposed Endangered
Western bumble bee	Bombus occidentalis	Animals - Insects	Candidate Endangered	None
Suckley's cuckoo bumble bee	Bombus suckleyi	Animals - Insects	Candidate Endangered	None
Gray wolf	Canis lupus	Animals - Mammals	Endangered	Endangered
Sierra Nevada red fox	Vulpes vulpes necator	Animals - Mammals	Threatened	Proposed Endangered
California wolverine	Gulo gulo	Animals - Mammals	Threatened	Proposed Threatened
Humboldt marten	Martes caurina humboldtensis	Animals - Mammals	Endangered	Proposed Threatened
Ashland thistle	Cirsium ciliolatum	Plants - Vascular	Endangered	None
McDonald's rockcress	Arabis mcdonaldiana	Plants - Vascular	Endangered	Endangered
Siskiyou mariposa-lily	Calochortus persistens	Plants - Vascular	Rare	None
Gentner's fritillary	Fritillaria gentneri	Plants - Vascular	None	Endangered
Boggs Lake hedge-hyssop	Gratiola heterosepala	Plants - Vascular	Endangered	None
Leafy reed grass	Calamagrostis foliosa	Plants - Vascular	Rare	None
Slender Orcutt grass	Orcuttia tenuis	Plants - Vascular	Endangered	Threatened
Yreka phlox	Phlox hirsuta	Plants - Vascular	Endangered	Endangered
Trinity buckwheat	Eriogonum alpinum	Plants - Vascular	Endangered	None
Scott Bar salamander	Plethodon asupak	Animals - Amphibians	Threatened	None

Table 2.8: GDE species prioritization for management. 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
Chinook salmon	Bank Swallow
Coho Salmon	Western Pond Turtle
Steelhead trout	Foothill Yellow-legged Frog
Pacific Lamprey	Greater Sandhill Crane
Unprotected species that depend on groundwater dependence ecosystem	Willow Flycatcher

CDFW's 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. BIOS also presents the extent of suitable habitat for a subset of the species presented in Table 2.7. Representation of the extent of habitat for species where such information is made available in the BIOS viewer are presented in Appendix 2-G.

Management Approach

Groundwater dependent species were prioritized for management, primarily focusing on anadromous fish species (Chinook Salmon, Coho Salmon, Steelhead Trout, and Pacific Lamprey) and GDEs located along the Shasta River, tributaries, and riparian corridors. 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, foothill yellow-legged frog, greater sandhill crane, willow flycatcher, and other bird species that use riverine habitats during their various life stages. 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 2.8, are considered throughout this GSP. Other species listed in Table 2.7 and Table 2.8 are protected by federal or state agencies. As needed, the GSA will partner with environmental agencies to protect non-threatened, threatened, and endangered species within the Basin.

GDE Analysis Approach

The GDE analysis for the Watershed was comprised of a two-part analysis first identifying riparian GDEs relying on in-stream flows addressed in the ISW analysis presented in Section 2.2.2.6 and then vegetative GDEs likely relying on groundwater in areas that are not in close proximity to surface water features or riparian corridors. The following sections discuss the process of mapping potential GDEs based on available resources and categorizing mapped potential GDEs into riparian GDE or vegetative GDE categories.

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. 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 2.56 and Figure 2.57, respectively.

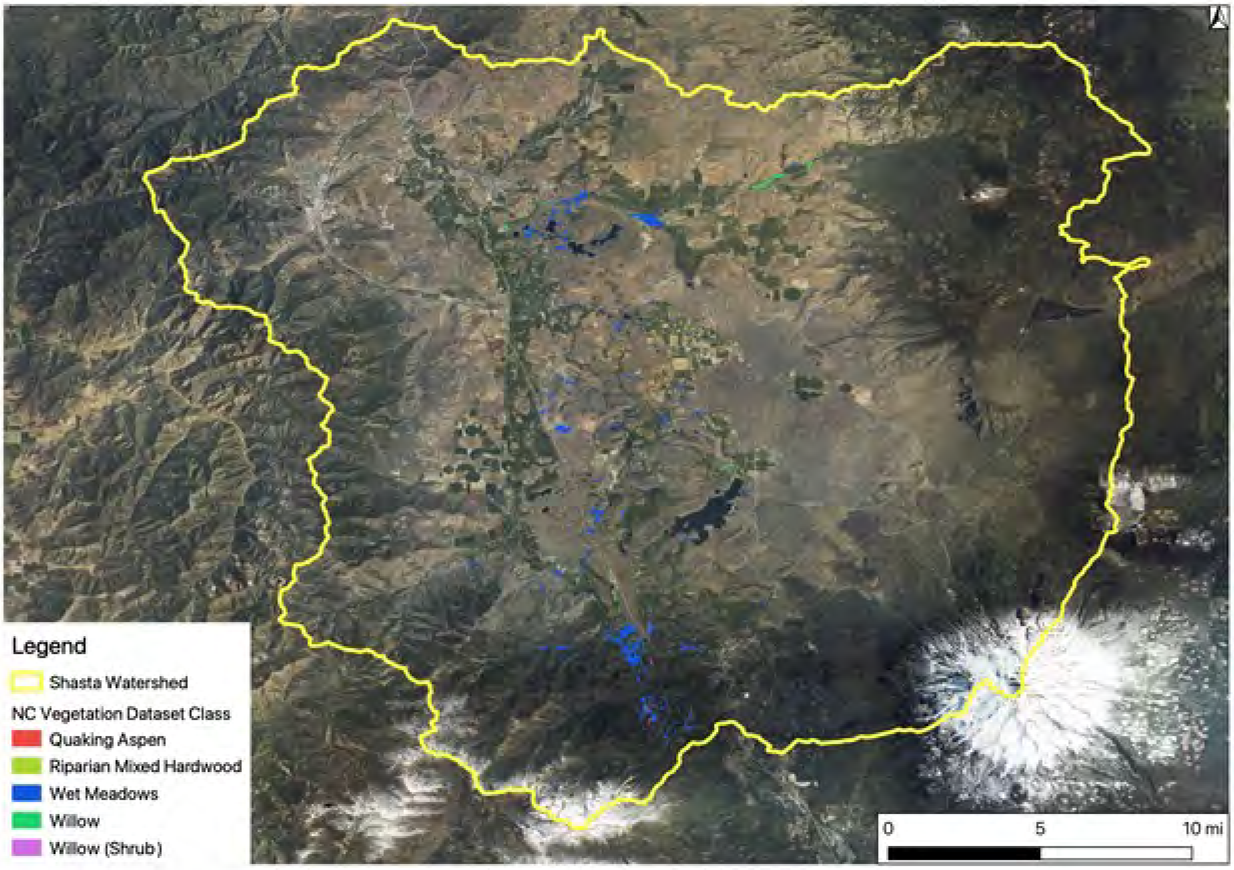


Figure 2.56: Classes Within NCCAG Vegetation Dataset for the Watershed.

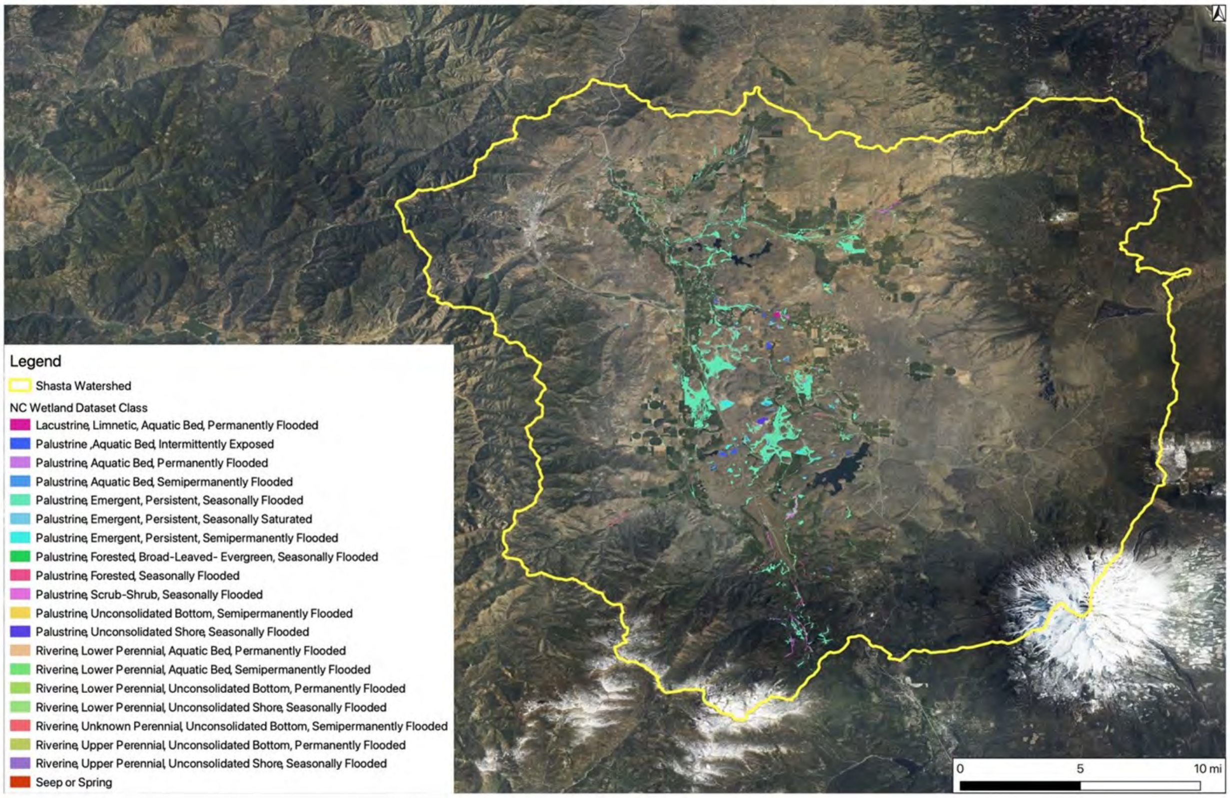


Figure 2.57: Classes Within NCCAG Wetland Dataset for the Watershed.

An initial review of NCCAG mapped potential wetland and vegetation 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, initially developed in 2010 by DWR and adapted based on stakeholder input in 2016, 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-G. Areas identified as agricultural areas, urban areas, and irrigated areas were removed from consideration as GDEs.

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. This combined or unioned NCCAG dataset was intersected with the adapted 2016 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 2.9 based on best professional judgment. Additional tables used in this process are presented in Appendix 2-G.

Table 2.9: 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.

As an example, if the NCCCAG Wetland dataset identified an area as class "PEM1C" corresponding to a "Palustrine, Emergent, Persistent, Seasonally Flooded" mapped potential wetland GDE and the 2016 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. As a second example, if neither the NCCAG Wetland or Vegetation datasets identified an area as a mapped GDE, but the 2016 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. For 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.

Riparian GDE Identification and Classification

Mapped potential GDEs in close proximity to surface water features were assumed to be riparian GDEs and reliant on the presence of in-stream flows. Mapped river channels within the Watershed were isolated and buffered to a distance of 100 ft on either side of the surface water feature centerline reflecting a conservative representation of the hyporheic zone supporting riparian vegetation. This representation of the assumed extent of riparian vegetation was overlaid or intersected with the mapped potential GDE presented in Figure 2.58 yielding potential mapped GDEs within the assumed riparian extent. The 1,700 acres assumed to represent riparian GDEs, accounting for 11.1% of mapped potential GDEs are presented in Figure 2.59.

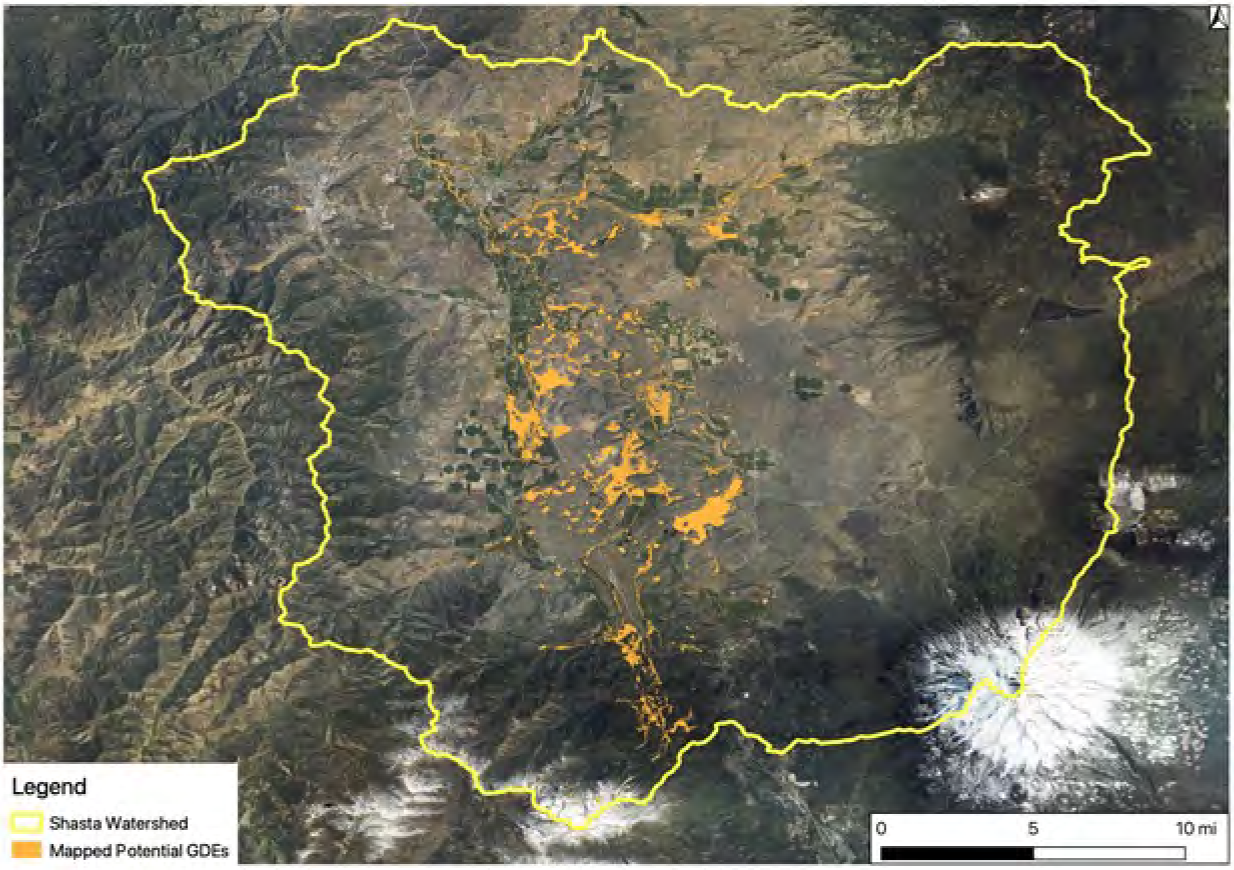


Figure 2.58: Mapped potential GDEs for the Watershed.

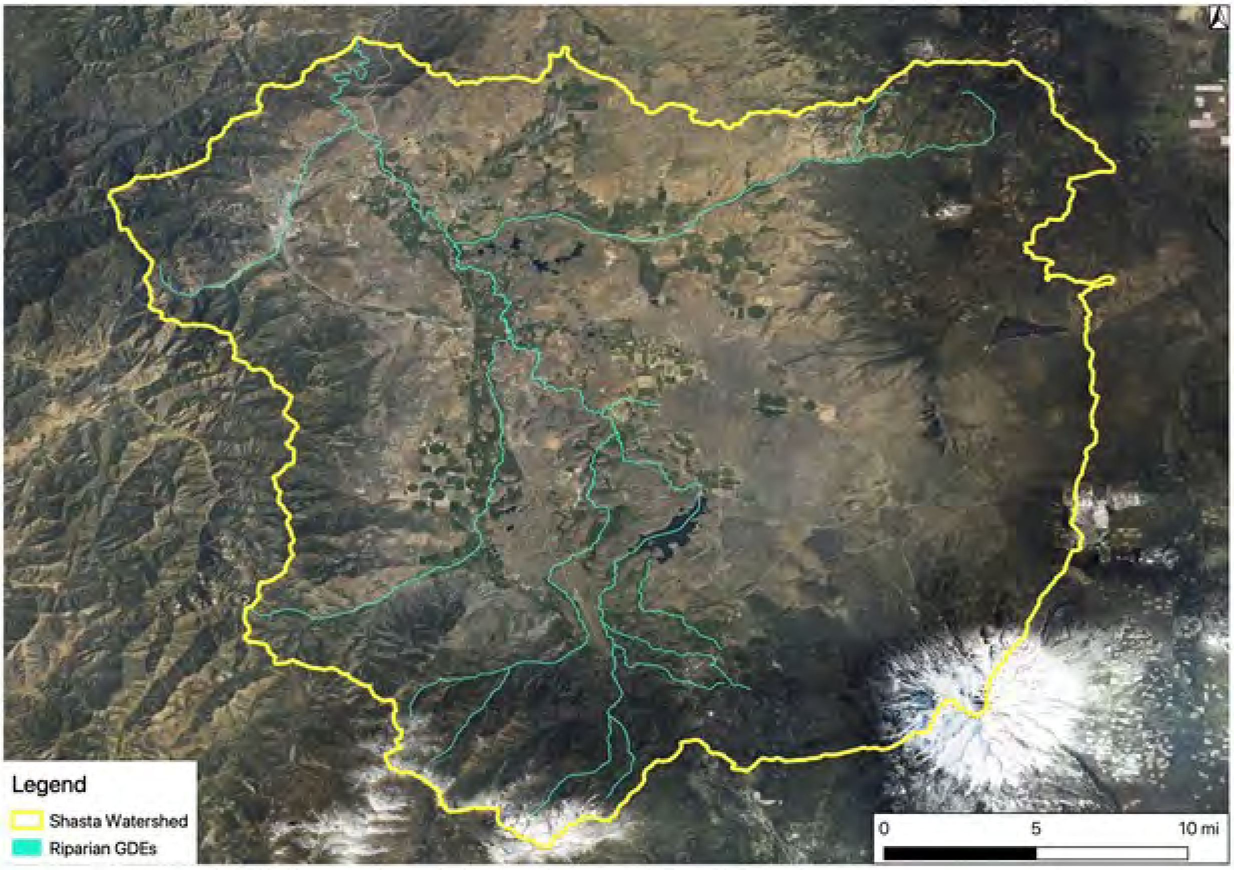


Figure 2.59: Assumed riparian GDEs in the Watershed

Vegetative GDE Identification and Classification

The following section discusses the process of identifying potential vegetative GDEs, effectively mapped potential GDEs that weren't classified as riparian 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 vegetative GDEs based on available resources;
- Assigning rooting depths based on predominant assumed vegetation type; and
- Establishing representations of depth to groundwater.

The following subsections discuss the process of assembling these three building blocks and the subsequent vegetative GDE categorization based on the relationship between them.

Assumed Rooting Zone Depths

Rooting zone depths were assigned to all combined or concatenated values for the NCCAG vegetation, NCCAG wetland, and 2016 Siskiyou County LU/LC 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 vegetation GDE dataset. Classifications from the NCCAG vegetation dataset were used to assign rooting zone depths based on a presumably higher level of mapping accuracy and more descriptive classes with values such as "wet meadow" or "willow shrub" present within the Watershed. 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 2016 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 vegetative GDEs. Vegetation classifications were grouped into four broad categories based on best professional judgment. The relationship between mapped vegetation categories and assumed predominant or representative vegetation is presented in Table 2.10, Table 2.11, and Table 2.12 for the NCCAG vegetation, NCCAG wetland, and 2016 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 ft (Niswonger1and and Fogg 2008) indicating that this assumed depth of 13.1 ft is relatively conservative while additional resources suggest that rooting zone depths of 13.1 ft are consistent with mean values for deciduous broadleaf trees which would have deeper rooting depths than willows (Fan et al. 2017). A rooting depth of 9.51 ft was assumed for Quaking Aspen (Canadell et al. 1996).

Other vegetation classes such as those included in the NCCAG wetland dataset 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). The mean of mean literature values for grasses, forbs, sedges, and rushes was assumed be 4.8 ft with the maximum of mean literature values assumed to be 9.6 ft. 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 2.10: Assumed Rooting Zone Depth and Representative Vegetation for Classes Within the NCCAG Vegetation Dataset.

Vegetation Class	**Assumed Rooting Zone Depth (ft.)**	**Assumed Representative Vegetation**
Quaking Aspen	9.51	Quaking Aspen
Riparian Mixed Hardwood	13.10	Willow
Wet Meadows	4.80	Grasses, Forbs, Sedges, and Rushes Mean of Mean Rooting Depths
Willow	13.10	Willow
Willow (Shrub)	13.10	Willow

Table 2.11: 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
Lacustrine, Limnetic, Aquatic Bed, Permanently Flooded	9.6	Grasses, Forbs, Sedges, and Rushes Max of Mean Rooting Depth
Palustrine, Aquatic Bed, Semipermanently Flooded	13.1	Willow
Palustrine, Aquatic Bed, Intermittently Exposed	13.1	Willows
Palustrine, Aquatic Bed, Permanently Flooded	13.1	Willows
Palustrine, Emergent, Persistent, Seasonally Saturated	4.8	Grasses, Forbs, Sedges, and Rushes Mean of Mean Rooting Depths
Palustrine, Emergent, Persistent, Seasonally Flooded	4.8	Grasses, Forbs, Sedges, and Rushes Mean of Mean Rooting Depths
Palustrine, Emergent, Persistent, Semipermanently Flooded	4.8	Grasses, Forbs, Sedges, and Rushes Mean of Mean Rooting Depths
Palustrine, Forested, Broad-Leaved- Evergreen, Seasonally Flooded	13.1	Willows
Palustrine, Forested, Seasonally Flooded	13.1	Willows
Palustrine, Scrub-Shrub, Seasonally Flooded	13.1	Willows
Palustrine, Unconsolidated Bottom, Semipermanently Flooded	13.1	Willows
Palustrine, Unconsolidated Shore, Seasonally Flooded	13.1	Willows
Riverine, Lower Perennial, Aquatic Bed, Semipermanently Flooded	4.8	Grasses, Forbs, Sedges, and Rushes Mean of Mean Rooting Depths
Riverine, Lower Perennial, Aquatic Bed, Permanently Flooded	4.8	Grasses, Forbs, Sedges, and Rushes Mean of Mean Rooting Depths
Riverine, Lower Perennial, Unconsolidated Bottom, Permanently Flooded	4.8	Grasses, Forbs, Sedges, and Rushes Mean of Mean Rooting Depths
Riverine, Lower Perennial, Unconsolidated Shore, Seasonally Flooded	13.1	Willows

Table 2.11: 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**
Riverine, Upper Perennial, Unconsolidated Bottom, Permanently Flooded	4.8	Grasses, Forbs, Sedges, and Rushes Mean of Mean Rooting Depths
Riverine, Upper Perennial, Unconsolidated Shore, Seasonally Flooded	13.1	Willows
Riverine, Unknown Perennial, Unconsolidated Bottom, Semipermanently Flooded	4.8	Grasses, Forbs, Sedges, and Rushes Mean of Mean Rooting Depths
Seep or Spring	9.6	Grasses, Forbs, Sedges, and Rushes Max of Mean Rooting Depths

Table 2.12: 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. Interpolation was carried out using ordinary kriging (Wackernagel 1995), and observed groundwater elevations were obtained from the Periodic Groundwater Level Database (DWR 2021b). Altogether, depth to groundwater conditions were developed for 16 three-year periods (e.g. spring 2012 through 2014 would involve spring representations for 2012, 2013, and 2014) between spring of 2011 and the fall of 2020, as sufficient groundwater level data is available during this timeframe. These periods represent water level data every 6 months from spring 2011 to fall 2020, with equal amounts of fall and spring periods. These depths to groundwater provide the best available representation of relatively modern depths to groundwater, pending estimates from the groundwater flow model in development. Mapped representations of depth to groundwater, the difference between surface elevations and groundwater elevation above mean sea level, were developed for 16 rolling three-year periods (e.g. spring 2012 through 2014 would involve spring representations for 2012, 2013, and 2014) between spring of 2011 and the fall of 2020. These grid or raster geospatial datasets were developed by interpolating between statistical representations of observed groundwater elevations for each three-year rolling period using data obtained from the CASGEM Program using the well-established kriging method.

An example representation of depth to groundwater for the Shasta Basin is presented in Figure 2.60. Representations of depth to groundwater for each of the 16 representation of three-year rolling depth to groundwater are presented in Appendix 2-G.

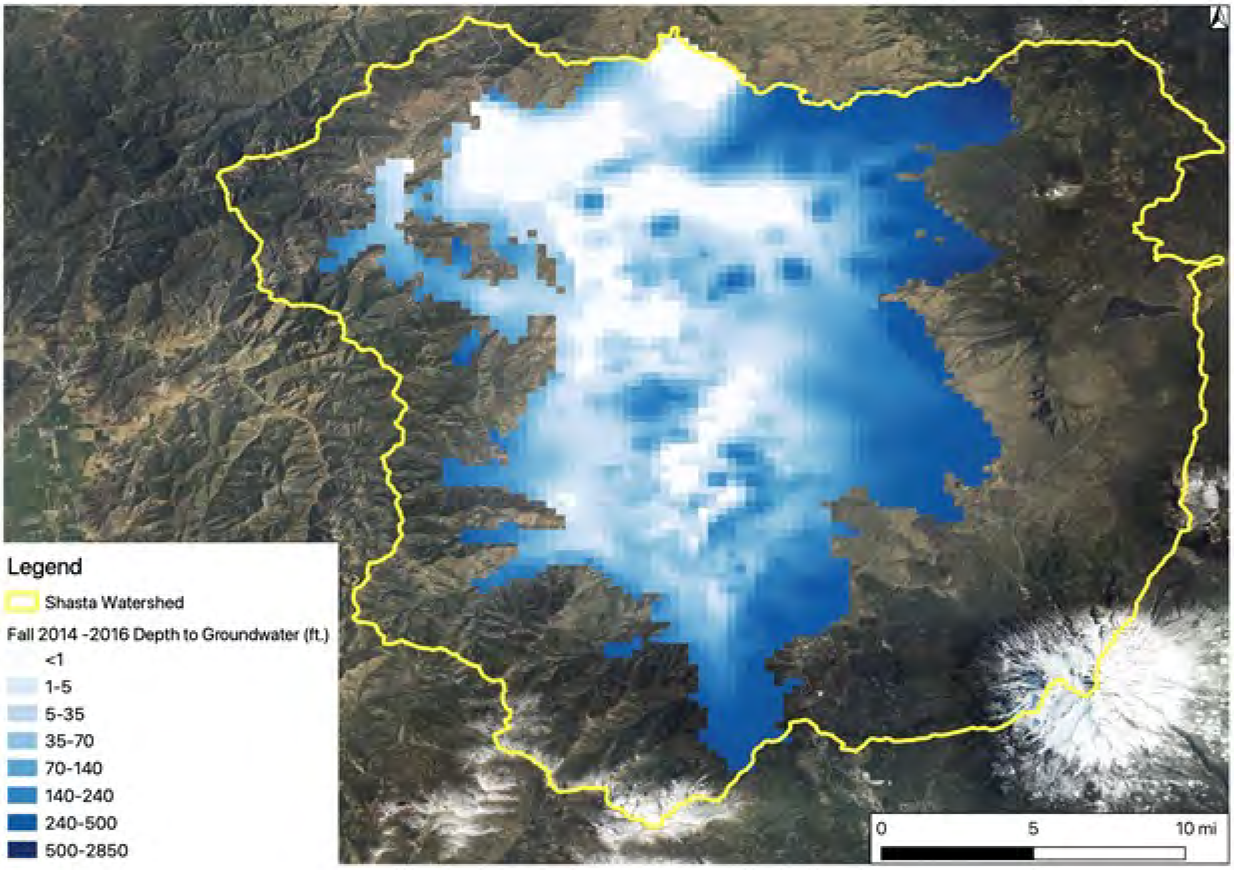


Figure 2.60: Depth to Groundwater for the Three-Year Rolling Period Between Fall 2014 and Fall 2016.

Relationship Between Rooting Zone Depths and Depth to Groundwater

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

Grid-Based Vegetative GDE Analysis

The grid-based analysis relied on the grid or raster-based representations of depth to groundwater similar to what is presented in Figure 2.60 in the previous subsection. 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 vegetative GDE area using the zonal statistics function in available many GIS programs. This zonal statistics function identifies what cells of the depth to groundwater grid or raster dataset fall within the bounds of each mapped potential vegetative GDE polygon and then computes an area-weighted average for that area. This zonal statistics analysis was carried out for each of the 16 three-year rolling average representations of depth to groundwater between spring 2011 and fall 2020 yielding 16 columns summarizing the average depth to groundwater for each mapped potential vegetative GDE area. The 16 periods used in the analysis represent water levels every 6 months from spring 2011 to fall 2020.

The second step involved simply subtracting the calculated depth to groundwater for each mapped potential vegetative 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 16 representations of depth to groundwater and was added as a new field for each representation of depth to groundwater.

The third step of the grid-based geospatial processing effort involved identifying which mapped potential vegetative GDE areas can reasonably be assumed to have access to groundwater for each period. Where the difference between assumed rooting zone depth and computed depth to groundwater is positive or above zero, then the rooting zone depth is greater than the depth to groundwater. In that case, mapped potential vegetative GDEs are assumed to be connected to groundwater for that season and year representation. Conversely, mapped potential vegetative GDEs where the difference between assumed rooting zone depths and computed depth to water is negative or below zero suggests that roots do not have access to groundwater. These areas are 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 16 periods is presented in Appendix 2-G. 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 is only available every 6 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 than 50% of periods indicates a multi-year lack of groundwater in the rooting zone.

Mapped Potential Vegetative GDE Classification

A tabular summary of the grid-based GDE classifications for each mapped potential vegetative GDE area was developed. Potential mapped vegetative 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" ("Assumed GDE"). Similarly, areas that were shown to be disconnected from groundwater were considered a "Potentially not a GDE" ("Assumed not a GDE"). Riparian and vegetative GDEs analyses were integrated to produce a comprehensive representation of assumed GDEs for the Watershed and are presented in Table 2.13 and Figure 2.61.

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

Table 2.13: Distribution of Mapped Potential GDEs into Vegetative and Riparian GDE Categories.

GDE Categorization	Grid Classification	Area (Acres)	% of Mapped Potential GDE Area
Riparian GDE	Likely connected to groundwater	1639	13.81%
Potential GDE	Likely connected to groundwater	2589	21.82%
Potentially not a GDE	Likely disconnected from groundwater	9008	75.92%

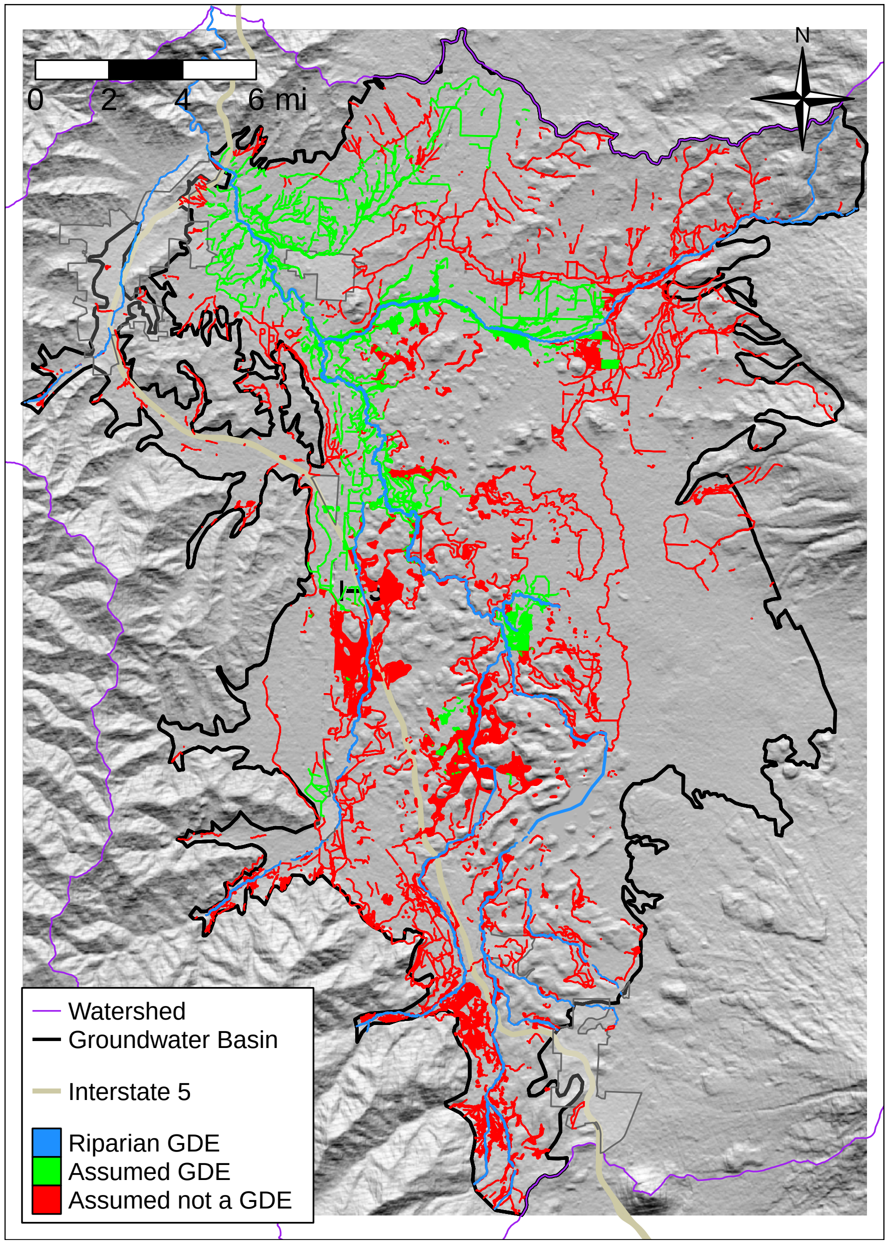


Figure 2.61: Categorized Riparian and Vegetative GDEs Within the Shasta Basin.

Assumptions and Uncertainty

The approach developed and carried out to identify and evaluate GDEs within the Shasta 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 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. Uncertainty and data gaps in the groundwater level data is discussed in Section 2.2.2.1.

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 a 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 Basin.

2.2.3 Historic Water Budget Information

This water budget section provides summary results for water years 1991 to 2018 period analyzed for developing the GSP baseline. It also describes future climate change projections. Details of the water budget with water year type analysis and month-by-month output is summarized in Appendix 2-E on model development. the water budgets are the best current representation of the Shasta Valley groundwater system and will be improved by the five year update with further model calibration with the ongoing collection of continuous groundwater elevation data.

The historical water budget for the Basin was estimated for the period October 1990 through September 2018, using the Shasta Watershed Groundwater Model (SWGM) presented and discussed in Section 2.2.3.1 Summary of Model Development. This 28-year model period includes water years ranging from very dry (e.g., 2001 and 2014) to very wet (e.g., 2006 and 2017). 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 2.62 and Figure 2.63 for the Bulletin 118 Basin boundary and Watershed, respectively. Annual summaries of these budgets are presented in Appendix 2-E. The following two sections provide an overview of the SWGM, which is used to determine the water budget for the three hydrologic subsystems of the Basin: the surface water subsystem, the land/soil subsystem, and the groundwater subsystem. The budget also includes the total water budget of the Basin. 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 presents critical rationale that is later used in this GSP for the design of monitoring networks, development of sustainable management criteria, and identification of projects or management actions (Chapters 3 and 4).

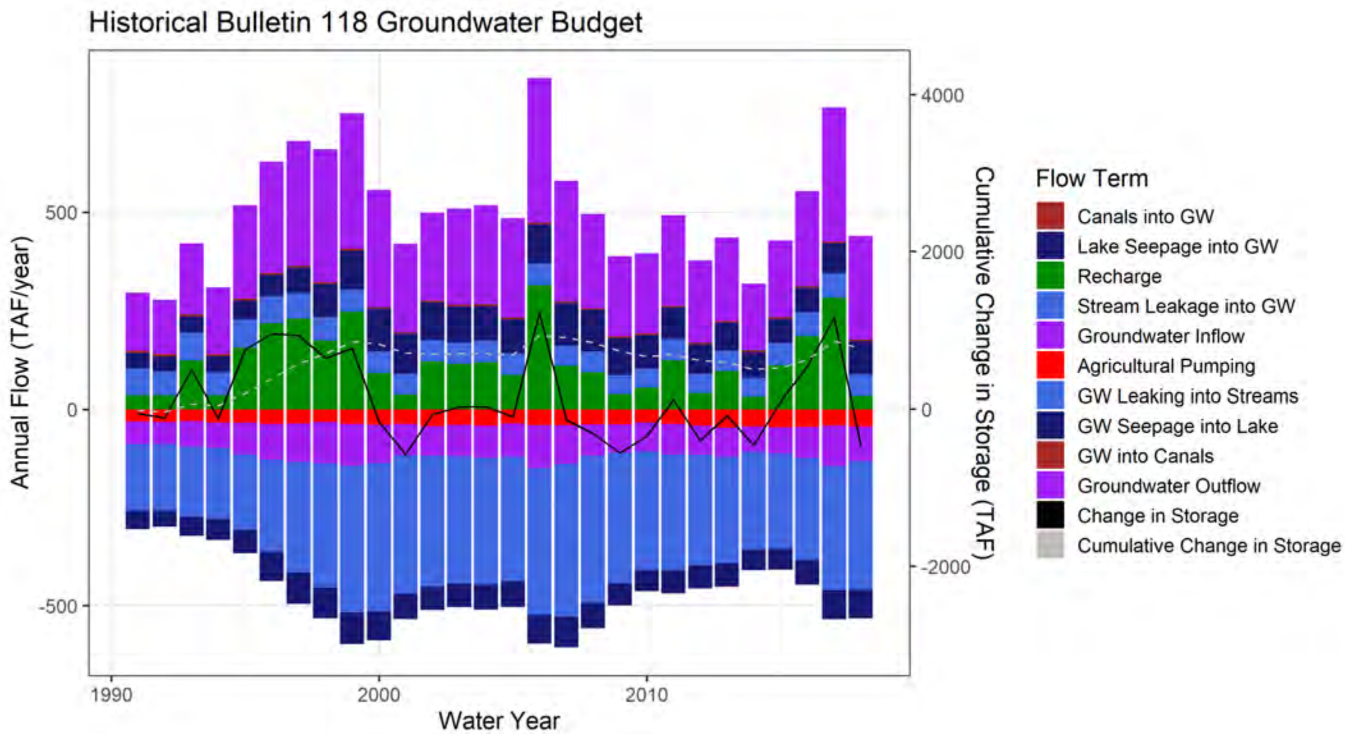


Figure 2.62: Annual water budgets for all flow terms for the Shasta Basin Bulletin 118 boundary.

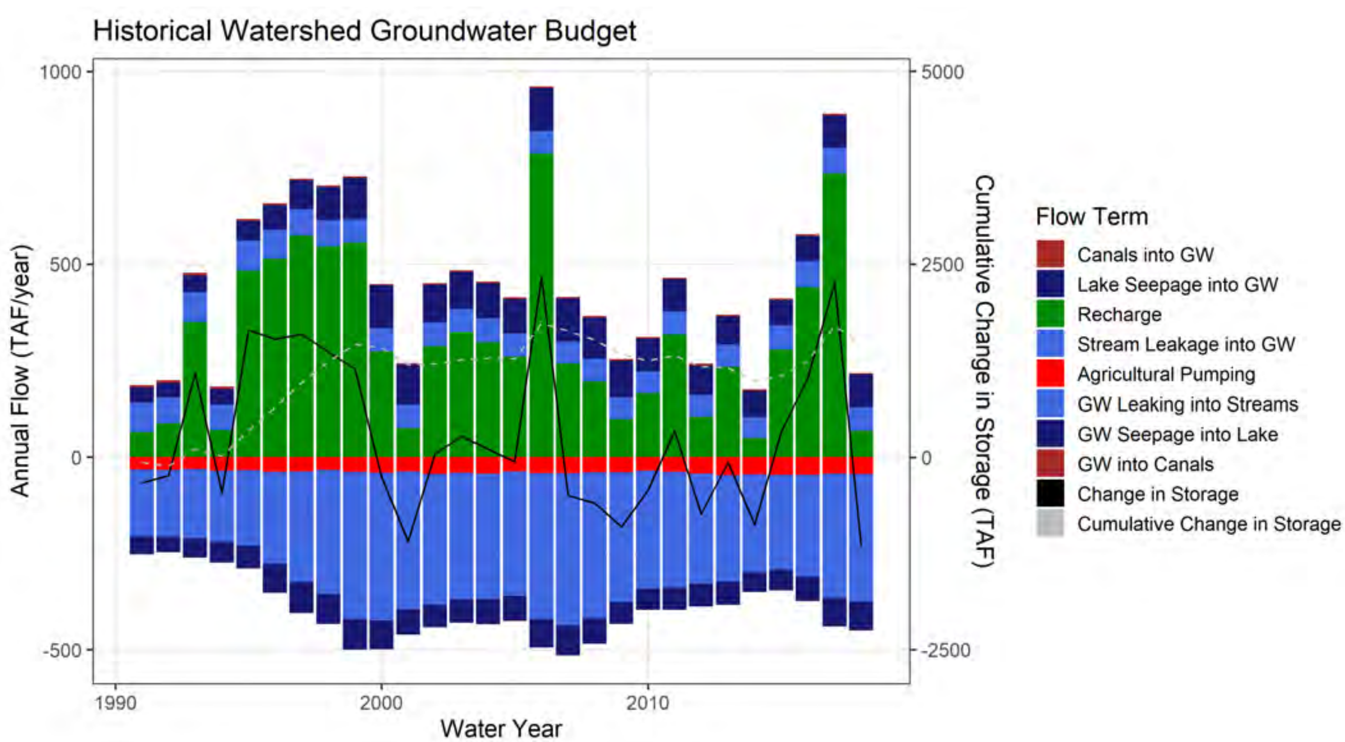


Figure 2.63: Annual water budgets for all flow terms for the Watershed.

2.2.3.1 Summary of Model Development

A three subsystem model was used to represent the hydrology of the Basin, the surrounding Watershed, and the Basin-Watershed hydrologic connections. The three sub-systems are as follows:

- Basin and Watershed surface water system (SW)
- Basin and Watershed land/soil system (land use and soil/vadose zone) (L)
- Basin and Watershed groundwater (aquifer) (GW)

The Shasta Watershed Groundwater Model (SWGM) was used to estimate the stream and groundwater inflows from the upper Watershed to the Basin, and the fluxes into, out of, and between the three sub-systems within the Watershed and within the Basin. Full documentation on SWGM can be found in Appendix 2-E.

In brief, the SWGM consists of three interlocking simulation modules: two land/soil subsystem modules, of which one is specifically designed for the agricultural and developed (urban) landscape and of which the other is designed to represent all other (natural) landscapes. Together they represent the land/soil subsystem (L) of the entire Basin and of the entire Watershed. The third simulation module is a groundwater-surface water model that represents both, the surface water (SW) and groundwater (GW) subsystems of the Basin and of the Watershed:

- The land/soil subsystem of the irrigated landscape is simulated using a Crop Root Zone Water Model (CRZWM, Davids Engineering Report[9]). 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 is simulated using the USGS PRMS software (Markstrom et al. 2008). This simulation module generates spatio-temporally distributed groundwater recharge for the 1989-2018 simulation period. The spatial discretization is 888 ft (270 m). The temporal discretization is daily.
- The groundwater subsystem and the surface water subsystem are simulated with the USGS MODFLOW 2005 software (Harbaugh 2005). Pumping and recharge output from the land subsystem simulation is used as input for the 29-year groundwater subsystem simulation. Surface runoff from the PRMS simulation (L) is used as input to the surface water routing simulation within MODFLOW. The transient, three-dimensional groundwater-surface water simulation has a spatial discretization of 888 ft (270 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 second and third simulation modules are implicitly coupled through the USGS GSFLOW software (Markstrom et al. 2008). The CRZWM module is coupled explicitly: the 29-year agricultural and developed area pumping output from the CRZWM simulation is generated first, then provided as input to the groundwater simulation. The explicit coupling (rather than intrinsic, more integrated

[9]{David’s Engineering Report. Appendix 2-F.}

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 estimating groundwater pumping.

MODFLOW is a finite difference groundwater-surface water model that simulates spatial and temporal dynamics of groundwater (GW) and surface water (SW) conditions in the Watershed (including the Basin) aquifer system and it's overlying stream system. The aquifer system consists of a mixture of alluvial and volcanic formations, with the latter consisting of features ranging from water-laden lava tubes to water-sediment-filled pockets within the cracks and crevices in the volcanic deposits. Unlike in many other alluvial groundwater basins of California, the volcanic portion of the Basin's aquifer system continues beyond the Basin boundaries into the surrounding Watershed to north, east, and south of the Basin. Non-volcanic bedrock of low permeability borders the aquifer system and Basin on the westside. The MODFLOW model simulates the spatially and temporally variable dynamics of each of the flow terms presented in Figure 2.62 and Figure 2.63 for the Basin and the Watershed, respectively:

- Contributions to groundwater include
  - Canal seepage (from SW)
  - Lake seepage (from SW)
  - Recharge (from L)
  - Stream leaking (from SW)
- Contributions from groundwater include:
  - Agricultural pumping (to L)
  - Leaking into streams (to SW)
  - Seepage into lakes (to SW)
  - Canal leakage (to SW)
  - Subsurface outflow toward areas to the north of the Watershed

These groundwater module simulation results are driven in the model by the Basin's hydrogeologic properties and by the spatially and temporally variable dynamics of:

- Groundwater pumping and recharge provided by the Land/soil (L) simulation modules.
- Surface runoff, computed from daily, spatially distributed precipitation and temperature data by the land/soil (L) simulations. Surface runoff becomes input to the stream-lake-canal surface water subsystem (SW). The SW subsystem in turn interacts with the GW subsystem through recharge to and discharge from groundwater.
- Direct groundwater evapotranspiration in wetlands (determined by modeled land use ET demand as a model input). The spatial discretization of the land/soil subsystem in SWGM largely follows the digital land use maps published to date by the California Department of Water Resources as adapted by the GSP stakeholder group. The spatial discretization in MODFLOW (GW and SW subsystem) is 270 m horizontally. Vertical discretization of the aquifer follow the hydrogeological conceptual model and the geological model previously described (Appendix 2-E).

2.2.3.2 Description of Historical Water Budget Components

The section describes the full water budget of the Watershed as well as the Basin including inflows to the Watershed and Basin, outflows from the Watershed and Basin, and the internal accounting of flow terms presented previously.

This section also describes fluxes between the three subsystems, L, SW, and GW. 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: the account balance increases). 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).

Tabular summaries of flow term summary statistics are presented followed by a discussion. Comprehensive documentation of the water budget development process is presented in Appendix 2-E.

Flows from Surface Water to the Groundwater subsystem

An overview of flows from surface water to the groundwater subsystem for the historical modeled period is presented for the Bulletin 118 Basin boundary and the Watershed in Table 2.14 and Table 2.15, respectively.

Flows from the Groundwater Subsystem to Surface Water

An overview of flows from the groundwater subsystem to surface water for the historical modeled period is presented for the Bulletin 118 Basin boundary and the Watershed in Table 2.14 and Table 2.15, respectively.

Flows Between the Land/soil Subsystem and Groundwater

An overview of flows between the Land/soil subsystem and Groundwater for the historical modeled period is presented for the Bulletin 118 Basin boundary and the Watershed in Table 2.14 and Table 2.15, respectively.

Table 2.14: Summary of Average Annual Groundwater Budget Flows (TAF/year) within the Basin boundary.

Flow Term	Minimum	Mean	Maximum
Groundwater Inflow	138.4	244.5	368.4
Canals into GW	3.7	4.5	6.4
GW into Canals	0.1	0.2	0.3
Lake Seepage into GW	38.7	77.1	109.8
GW Seepage into Lake	41.0	63.4	80.1
Stream Leakage into GW	48.2	57.1	71.3
GW Leaking into Streams	169.1	290.4	389.1
Groundwater Outflow	56.3	81.7	110.2
Recharge	30.5	118.3	314.3
Agricultural Pumping	29.8	38.6	46.7

Table 2.15: Summary of Average Annual Groundwater Budget Flows (TAF/year) within the Watershed boundary.

Flow Term	Minimum	Mean	Maximum
Canals into GW	3.7	4.6	6.5
GW into Canals	0.1	0.2	0.3
Lake Seepage into GW	38.9	80.2	112.7
GW Seepage into Lake	41.0	63.4	80.1
Stream Leakage into GW	54.7	63.2	78.3
GW Leaking into Streams	172.7	295.6	395.5
Recharge	49.9	302.5	786.5
Agricultural Pumping	30.3	39.2	47.4

2.2.3.3 Summary of Historical Water Budget

Stream and lake seepage account for 96.7% of the contributions from the Surface Water to the Groundwater subsystem within the Basin (134.3 TAF/year) as well as the broader Watershed (143.3 TAF/year).[10] Canal seepage accounts for only 3.3% of the flux to the Groundwater subsystem (4.6 TAF/year) for both the Basin and Watershed (Table 2.14 and Table 2.15). Fluxes from the Groundwater subsystem to surface waters is driven predominantly by groundwater leaking into streams with 82% and 82.3% of flows to surface water from the Groundwater subsystem for the Basin boundary and Watershed (290.4 and 295.6 TAF/year), respectively. Groundwater seepage into lakes accounts for 17.9% of fluxes between these two subsystems for both the Basin and Watershed area (63.4 TAF/year for both areas) with canal seepage accounting for a near negligible contribution at 0.1% (0.2 TAF/year for both areas) of the total volume (Table 2.14 and Table 2.15).

Agricultural pumping to the Land/soil subsystem in the Basin (38.6 TAF/year) is about one-third of the total land/soil subsystem recharge within the Basin (118.3 TAF/year). But total Watershed

[10] The Mean values from the Water Budget tables are used in the Section on Summary of Historical Water Budget

pumping (39.2 TAF/year, almost all within the Basin) amounts to only 13% of the total recharge across the Watershed Land/soil subsystem (302.5 TAF/year) (Table 2.14 and Table 2.15). Groundwater pumping is limited to fields with groundwater as the source of irrigation water. The pumping amount varies as a function of soil type, crop, and irrigation type, which in turn determine soil moisture, irrigation efficiency, ET, among others. Groundwater pumping only occurs during the irrigation season, which is a function of the crop type and the dynamics of spring soil moisture depletion.

At the Watershed scale, L inflows to GW (302.5 TAF/year) are more than twice as large as SW inflows to GW (147.9 TAF/year) due to highly permeable infiltration conditions across the volcanic soils of the Watershed. The L and SW recharge to the GW subsystem are of similar magnitude within the Basin (118.3 TAF/year and 138.8 TAF/year). The GW outflow to the SW subsystem (353.9 TAF/year) is five times larger than pumping to the L subsystem (38.6 TAF/year). The difference between L and SW inflows to GW (257.2 TAF/year) and total outflows to L and SW (392.5 TAF/year) are met by a groundwater inflow of 244.5 TAF/year and groundwater outflow of 81.7 via the subsurface from outside the Basin.

2.2.3.4 Groundwater Dynamics in the Shasta Valley Aquifer System: Key Insights

The Basin consists of an aquifer with various water-bearing geologic formations, whose complexity and juxtaposition of alluvial and volcanic formations result in a multitude of springs or diffuse wetlands where groundwater discharges to the surface. Spationally, seasonally, and yearly, spring discharge levels can vary over many orders of magnitude. The Big Springs complex discharges a significant quantity of water to the surface and is an important source of water for the Shasta River.

For most of the year, groundwater discharges into the main stem of the Shasta River and into the lower sections of the tributaries, but also emerges in springs and drainages. During critical summer months, portions of the main stem of the Shasta River and its tributaries become losing streams and discharge water into the groundwater system. Precipitation occurs predominantly in the winter months, from October through April. Irrigation with surface water and groundwater between April and September is used to grow perennial crops (alfalfa, in occasional rotation with grains, and pasture). Groundwater pumping affects baseflow conditions during the summer. Winter rains and winter/spring runoff recharge the aquifer system between October and April. Groundwater pumping further exacerbates the natural lowering of water levels during the dry season, leading to less baseflow and less groundwater outflow from the Basin's northern boundary.

Water levels are highest near the valley margin and slope from all sides of the valley toward the interior of the Basin, near the lower portions of the Pluto's Cave Basalt and toward the main-stem Shasta River below Lake Shastina and from there toward the Basin's northern boundary. Higher recharge during the winter months increases the slope of the water table from the valley margins toward locations of groundwater discharge into springs and streams. The lack of recharge for most of the dry period lowers the slope of the water table slope over the summer months, decreasing discharge from groundwater into the stream system.

Seasonal variability of recharge is accentuated by year-to-year climate variability: years with low precipitation lead to a smaller snowpack and lower runoff and groundwater inflow from the surrounding Watershed, hence less recharge from the tributaries into the alluvial fans, less recharge across the landscape of the Basin, and therefore less winter groundwater storage increase in the aquifer system. This in turn leads to a reduced slope of the water table to the Shasta River and stream system at the beginning of the irrigation season when compared to wetter years, and lower winter and spring water levels, particularly near the margins of the Basin.

Any significant long-term decrease or increase of precipitation totals over the Watershed along with Watershed scale changes to anthropogenic recharge will lead to commensurate lowering or raising, respectively in the average slope of the water table from the Watershed and Basin margins toward the center of the Basin, leading to a dynamic adjustment of water levels, even under otherwise identical land use and land use management conditions. These climate-induced adjustments will be relatively small near the Shasta River, but larger near the valley margins. Such changes, however, are unlikely to lead to groundwater overdraft. However, they will affect baseflow conditions, the timing of the spring recess in Shasta River flows and the arrival of the first fall flush flows in the river system. Water level slopes may change nearly imperceptibly in sections of the aquifer system that are highly conductive (e.g., lava tubes), despite these changes in groundwater flow through that part of the aquifer system.

Similarly, any increase or reduction in groundwater pumping leads to an equal decrease or increase in groundwater discharge to both the stream systems and the subsurface outflow to the north of the Basin. Any managed increase in recharge will also lead to an equal increase in groundwater discharge to both, the stream system within the Basin and subsurface outflow to the north of the Basin. The response of the groundwater discharge to the stream system will be delayed relative to the timing of the changes in pumping or recharge – by a few days if changes occur within a few tens or hundreds of feet of a stream, by weeks to months if they occur at larger distances from the stream. But when these changes occur permanently (even if only seasonally each year), the annual total change to groundwater discharge into the stream system will be approximately the same as the change in pumping (leading to less discharge) or in recharge (leading to more discharge).

This delay in timing may be taken advantage of with managed aquifer recharge or in-lieu recharge during periods of excess flows in the stream system, used for recharge or irrigation (in lieu of pumping), but creating additional discharge of groundwater to the stream during the critical low flow period in the summer and (early) fall.

2.2.4 Projected Water Budgets

The future projected water budget contains all of the same components as the historical water budget. 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 "Baseline" climate record (see Appendix 2-E for details). The Baseline 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 (ET_o), 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. The SWGM was run for the 50-year period of water years 2022 to 2071 for the Baseline 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-E.

Method Details

The climate record for the projected 50-year period of water years 2022 to 2071 (October 2021 to September 2071) was constructed from model inputs for the years 1991 to 2011. The minimum bound of 1991 was imposed by (ET_o) data, which is not available prior to historical model period; the maximum bound of 2011 was imposed by DWR change factors, which are only available through 2011 (Appendix 2-E).

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 4 different climate change scenarios (California Department of Water Resources (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.

2.2.4.1 Summary of Projected Water Budgets

The 2030 (Near) and 2070 central tendency (Far) scenarios predict marginally more rainfall conditions to the Baseline. The 2070 DEW (Dry) shows less cumulative rainfall while the 2070 WMW (Wet) scenarios shows more cumulative rain (Figure 2.64 and Figure 2.65). All scenarios predict higher future ET than the Baseline (Figure 2.66 and Figure 2.67).

Projected annual water budgets for the baseline and four DWR climate scenarios including the 2070 DEW (Dry), 2070 (Far), 2030 (Near), and 2070 WMW (Wet) are presented in Figure 2.68. An overview of projected streamflow conditions at the Shasta River near the Yreka gage under the baseline and projected scenarios is presented in Figure 2.70 and Figure 2.71. Summary statistics and a tabular summary of annual flow terms for the baseline and each projected scenario is presented in Appendix 2-E.

The 2030 (Near) and 2070 (Far) climate change scenarios show slightly higher streamflow and recharge throughout the Watershed. The 2070 WMW (Wet) scenario shows much higher recharge and river flows while the 2070 DEW (Dry) scenario shows diminished river flows and recharge.

2.2.4.2 Discussion of Future Water Budget

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 Shasta River, 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. However, they will affect baseflow conditions, the timing of the spring recess in Shasta River flows, and the arrival of the first fall flush flows in the river system.

Similarly, any increase or reduction in groundwater pumping leads to an equal decrease or increase in groundwater discharge to the stream systems. Any managed increase in recharge will also lead to an equal increase in groundwater discharge to the stream system within the Basin. The response of the groundwater discharge to the stream system will be delayed relative to the timing of the changes in pumping or recharge – by days when changes occur within a few tens or hundreds of feet of a stream, by weeks to months at larger distances. But when these changes occur permanently (even if only seasonally each year), the annual total change to groundwater discharge into the stream system will be approximately the same as the change in pumping (leading to less discharge) or in recharge (leading to more discharge).

This delay in timing can be taken advantage of with managed aquifer recharge or in-lieu recharge during periods of excess flows in the stream system, used for recharge or irrigation (in lieu of pumping), but creating additional discharge of groundwater to the stream during the critical low flow period in the summer and (early) fall.

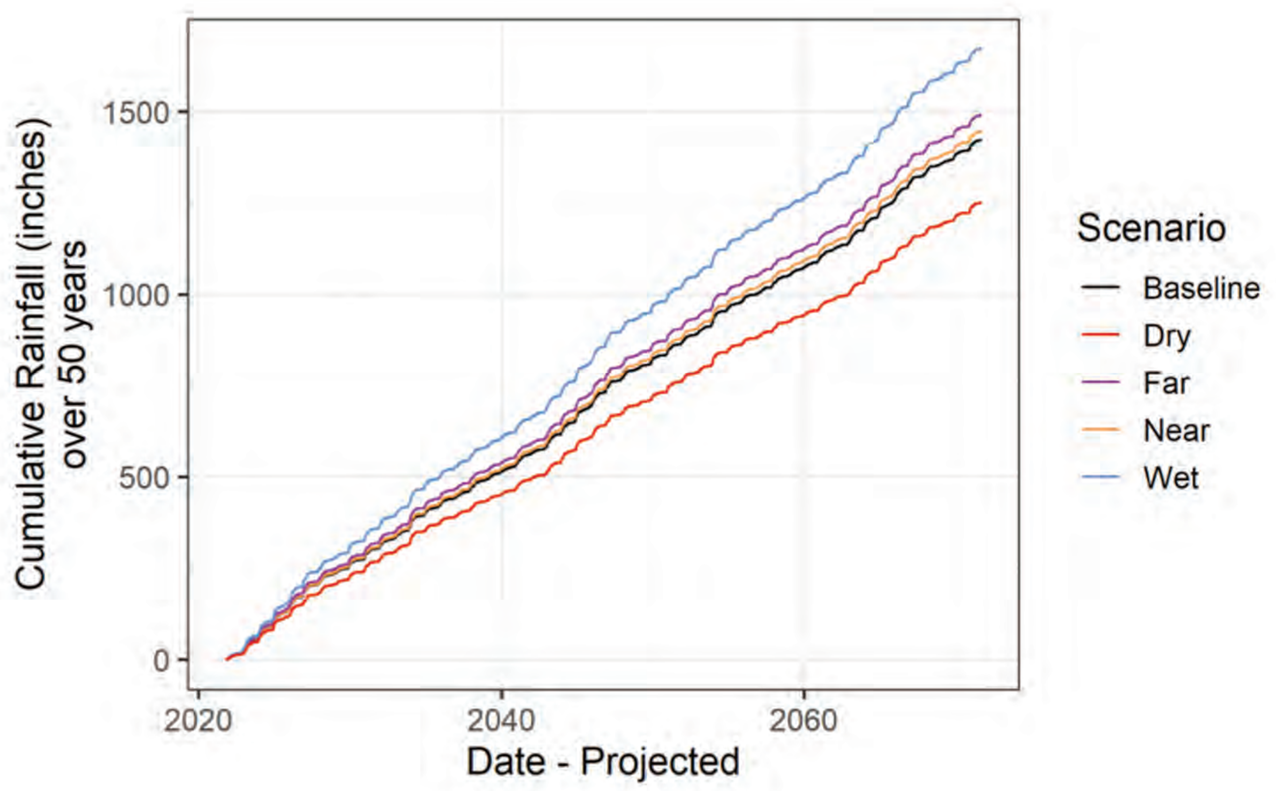


Figure 2.64: Cumulative precipitation for the future projected climate conditions, with baseline and four DWR climate scenarios including the 2070 DEW (Dry), 2070 (Far), 2030 (Near), and 2070 WMW (Wet) projections.

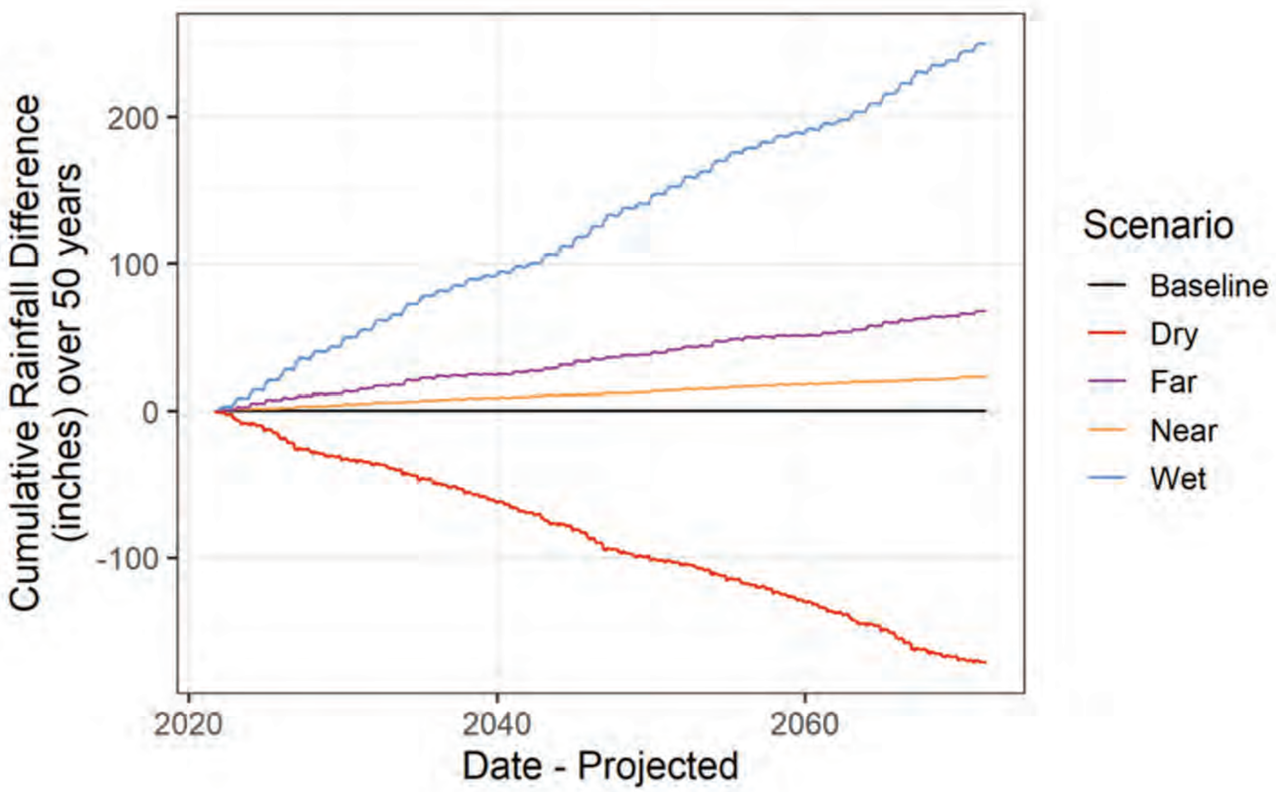


Figure 2.65: Projected change in cumulative precipitation for the future climate conditions, with baseline and four DWR climate scenarios including the 2070 DEW (Dry), 2070 (Far), 2030 (Near), and 2070 WMW (Wet) projections.

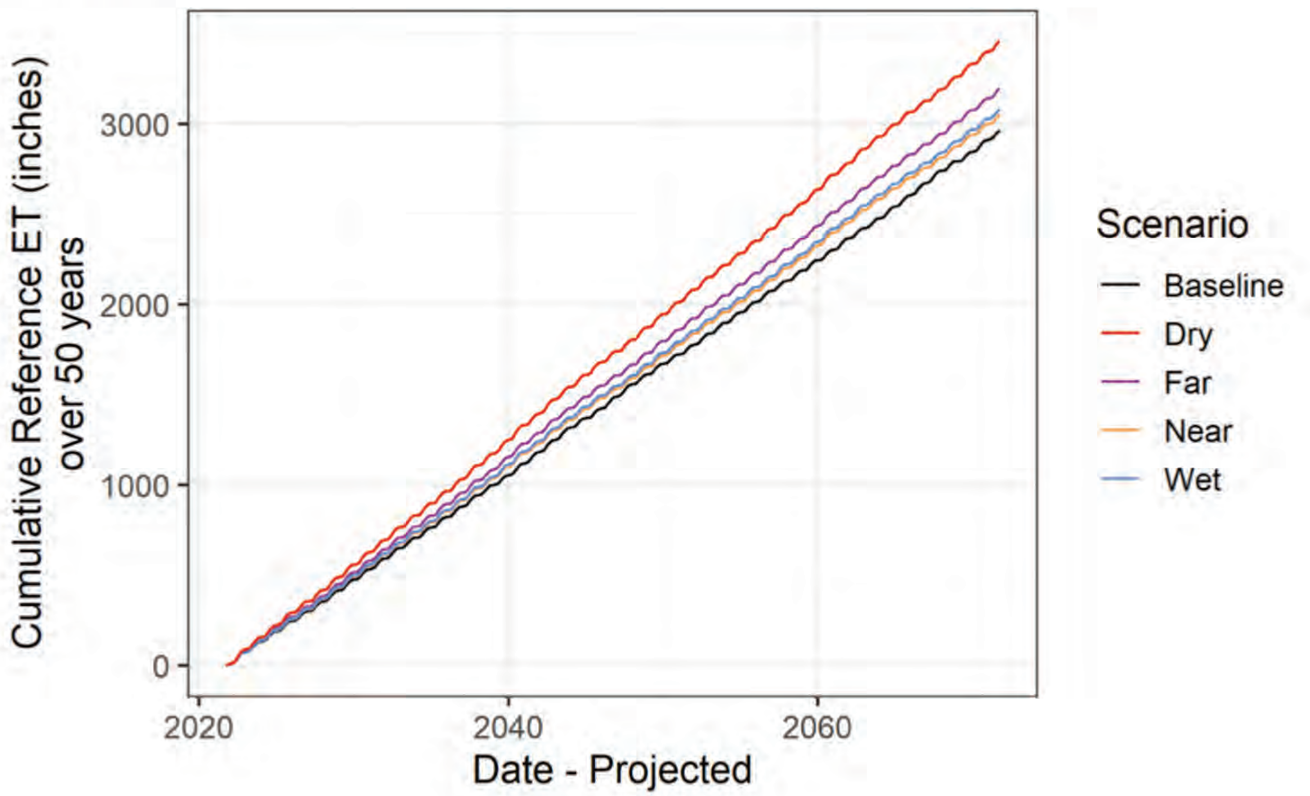


Figure 2.66: Cumulative reference evapotranspiration (ET_o) for the future projected climate conditions, with baseline and four DWR climate scenarios including the 2070 DEW (Dry), 2070 (Far), 2030 (Near), and 2070 WMW (Wet) projections.

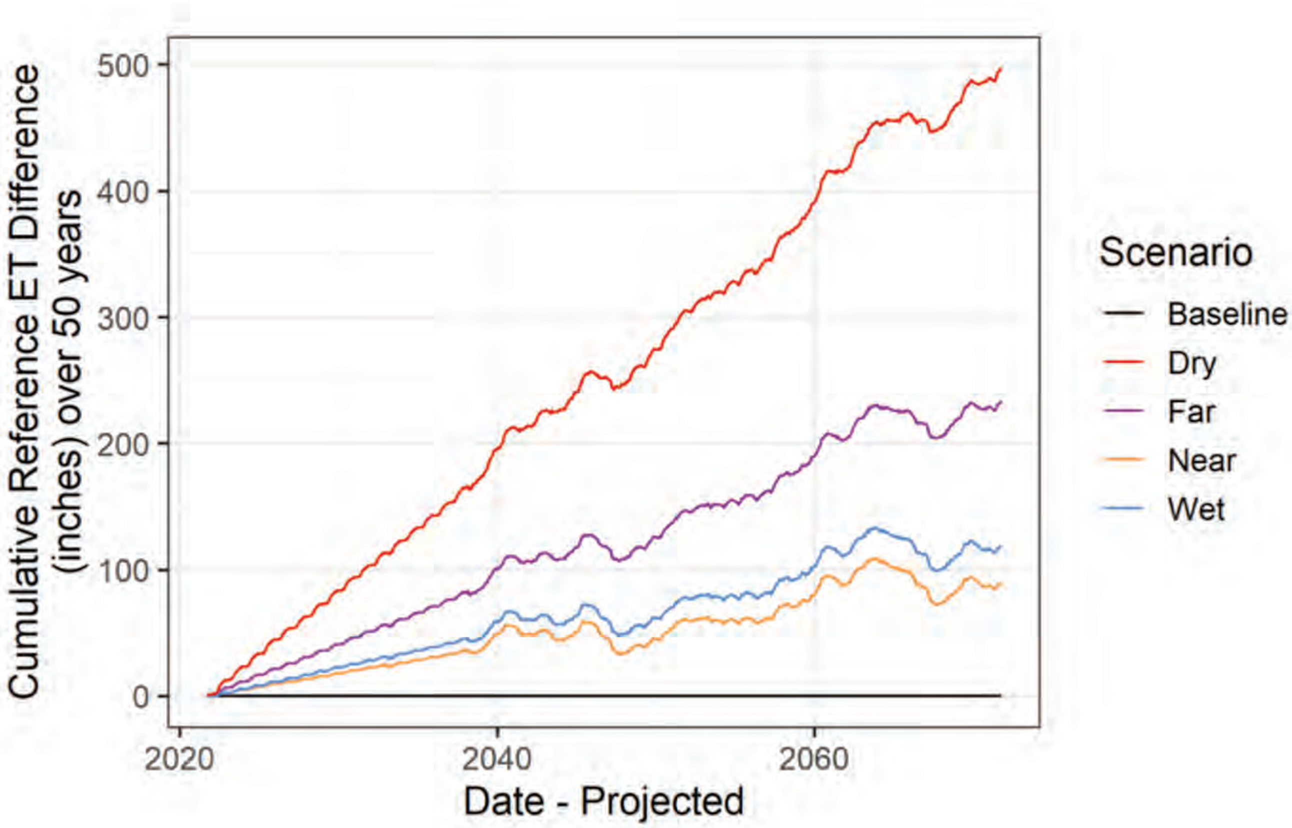
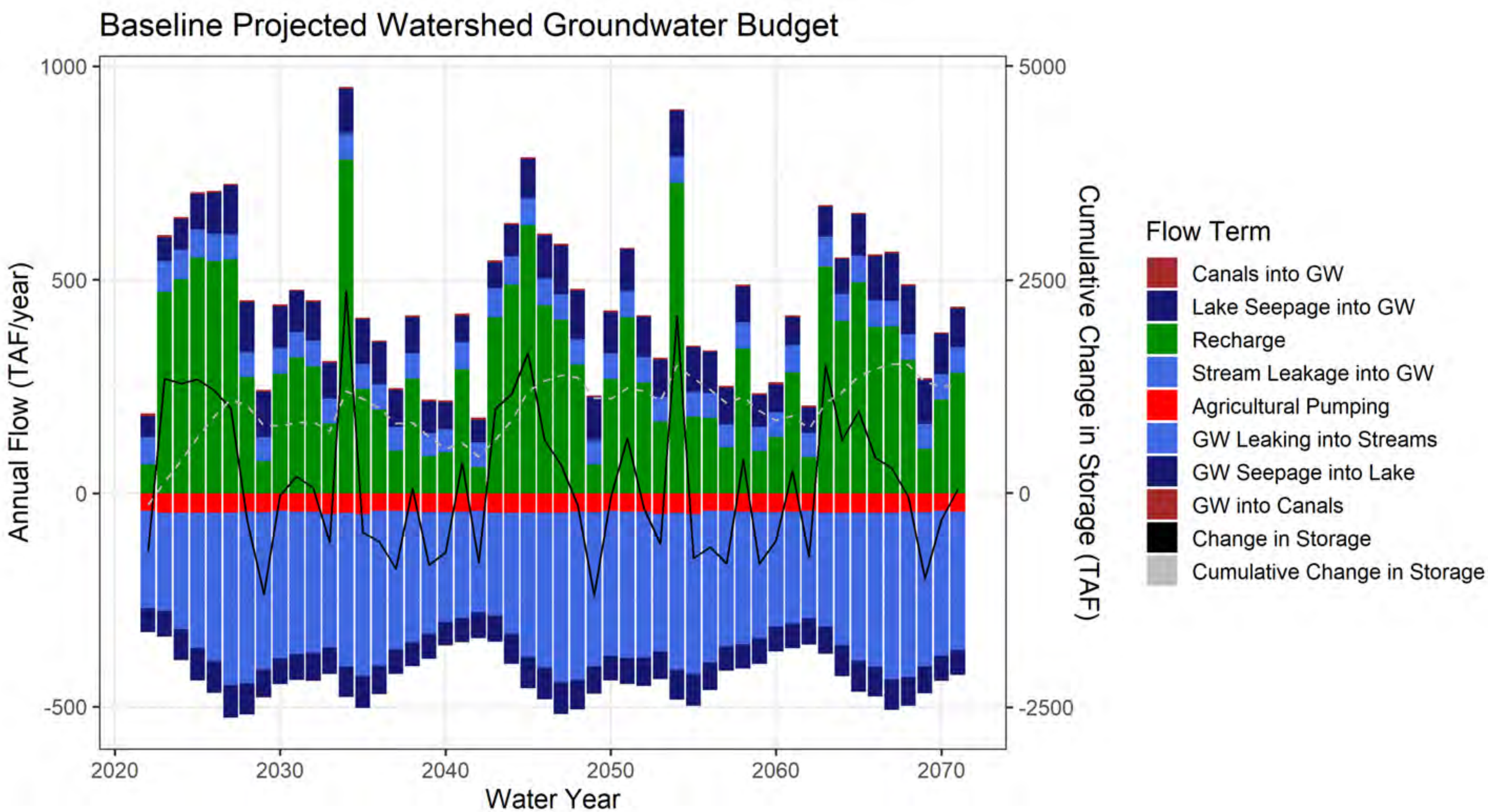
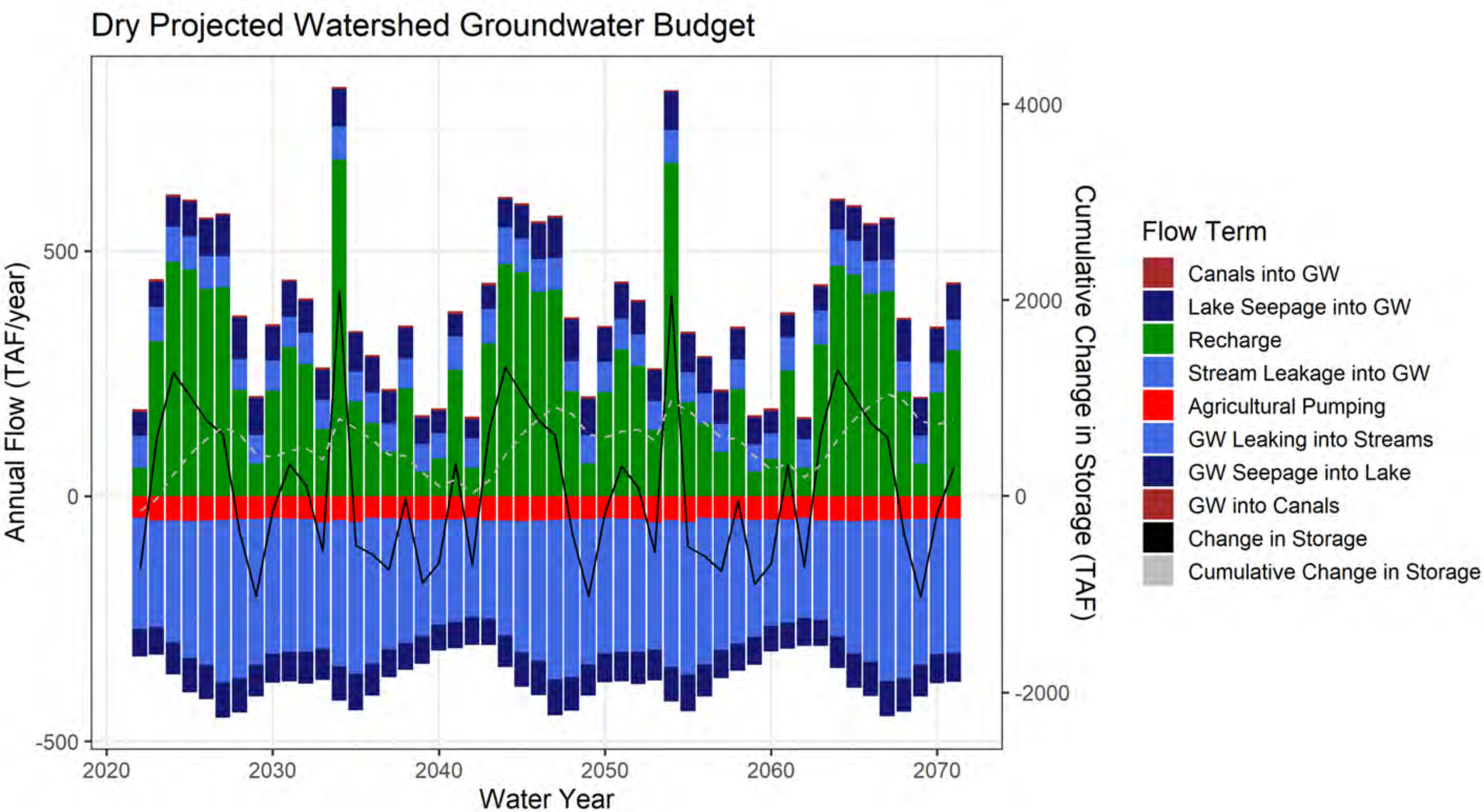
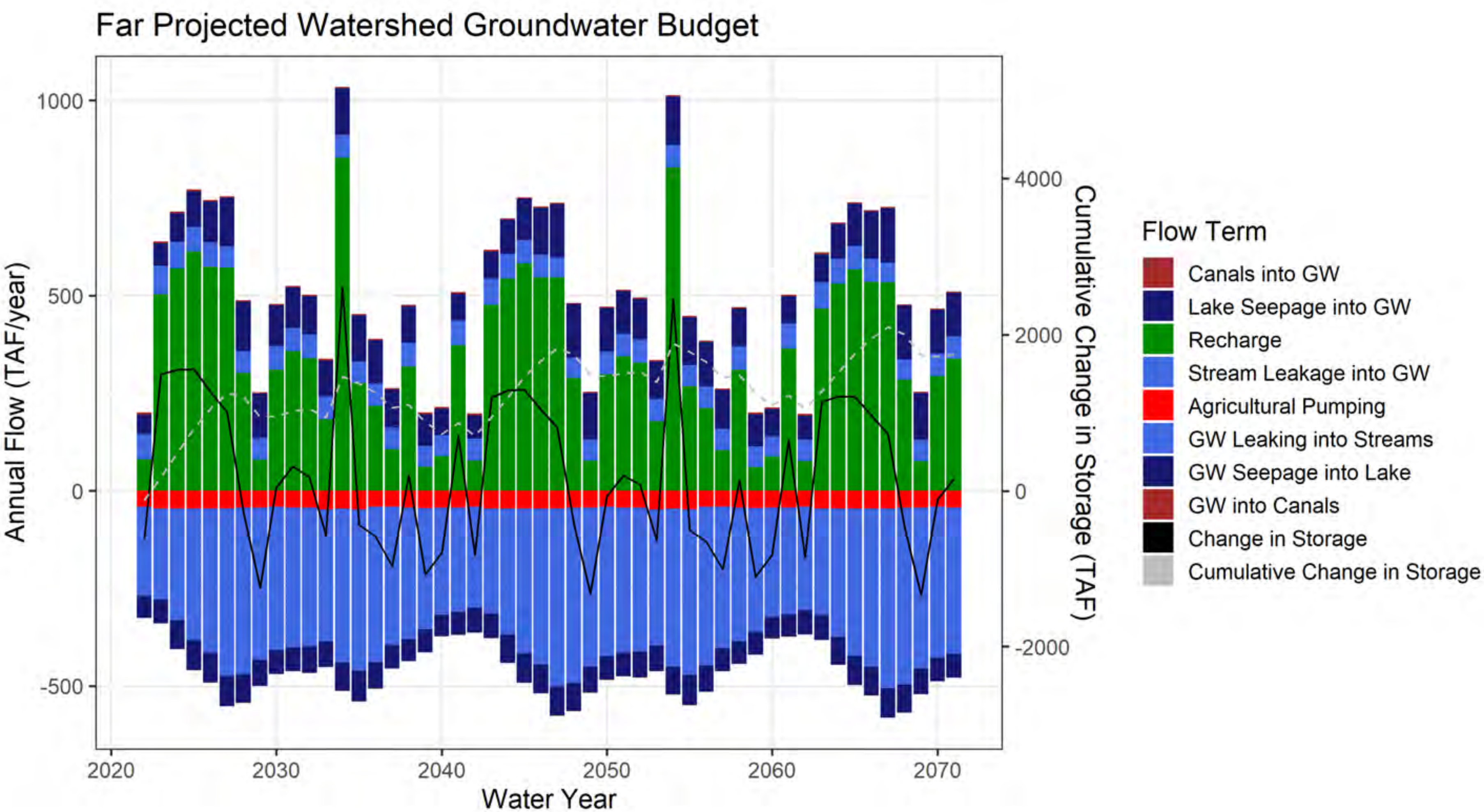


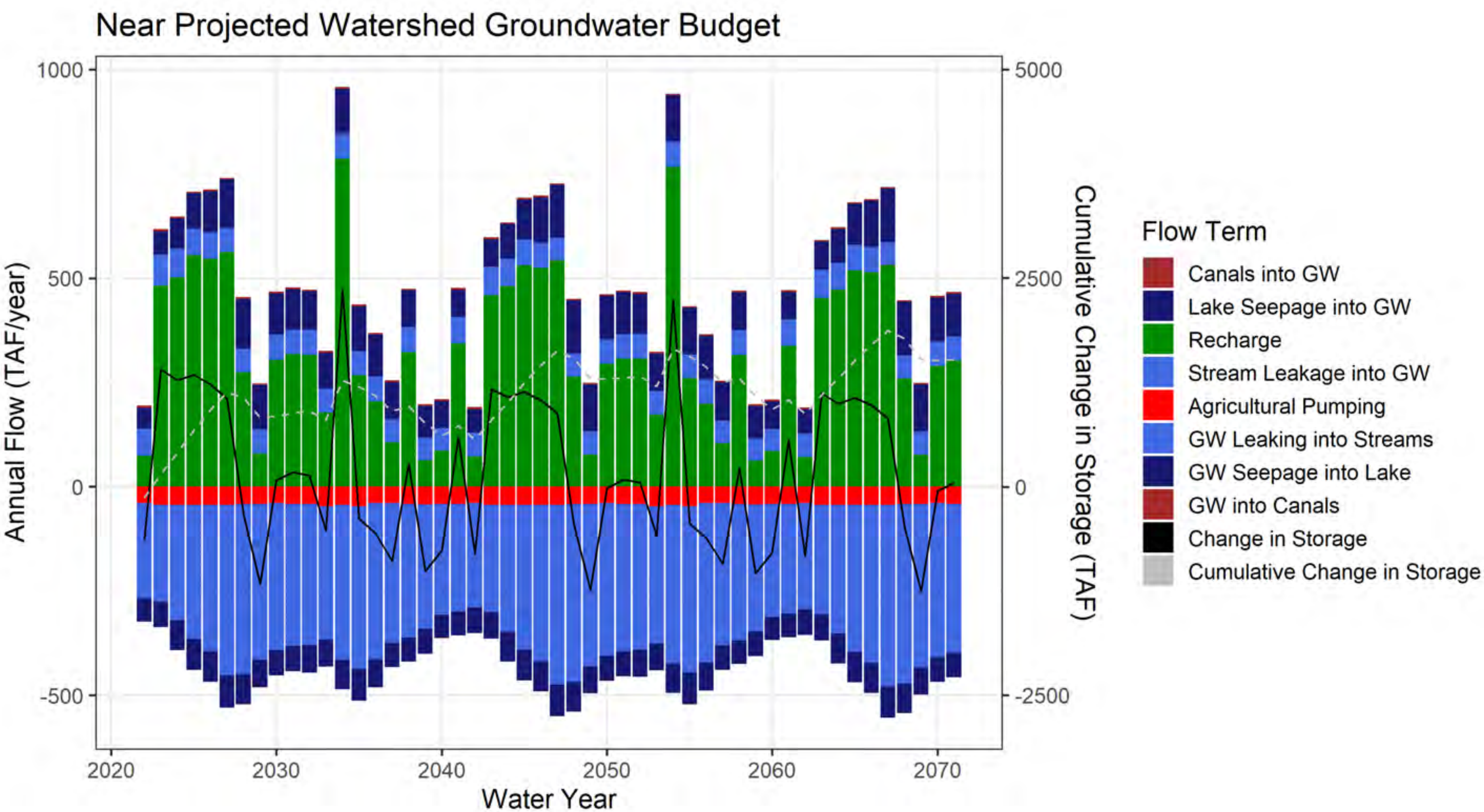
Figure 2.67: Projected change in cumulative reference evapotranspiration (ET_o) for the future climate conditions, with baseline and four DWR climate scenarios including the 2070 DEW (Dry), 2070 (Far), 2030 (Near), and 2070 WMW (Wet) projections.


Baseline Projected Watershed Groundwater Budget
Annual Flow (TAF/year)
1000
500
0
-500
Cumulative Change in Storage (TAF)
5000
2500
0
-2500
2020
2030
2040
2050
2060
2070
Water Year
Flow Term
Canals into GW
Lake Seepage into GW
Recharge
Stream Leakage into GW
Agricultural Pumping
GW Leaking into Streams
GW Seepage into Lake
GW into Canals
Change in Storage
Cumulative Change in Storage


Dry Projected Watershed Groundwater Budget
Annual Flow (TAF/year)
500
0
-500
2020
2030
2040
2050
2060
2070
Water Year
Cumulative Change in Storage (TAF)
4000
2000
0
-2000
Flow Term
Canals into GW
Lake Seepage into GW
Recharge
Stream Leakage into GW
Agricultural Pumping
GW Leaking into Streams
GW Seepage into Lake
GW into Canals
Change in Storage
Cumulative Change in Storage



Far Projected Watershed Groundwater Budget
Annual Flow (TAF/year)
1000
500
0
-500
2020
2030
2040
2050
2060
2070
Water Year
Cumulative Change in Storage (TAF)
4000
2000
0
-2000
Flow Term
Canals into GW
Lake Seepage into GW
Recharge
Stream Leakage into GW
Agricultural Pumping
GW Leaking into Streams
GW Seepage into Lake
GW into Canals
Change in Storage
Cumulative Change in Storage


Near Projected Watershed Groundwater Budget
Annual Flow (TAF/year)
1000
500
0
-500
Cumulative Change in Storage (TAF)
5000
2500
0
-2500
2020
2030
2040
2050
2060
2070
Water Year
Flow Term
Canals into GW
Lake Seepage into GW
Recharge
Stream Leakage into GW
Agricultural Pumping
GW Leaking into Streams
GW Seepage into Lake
GW into Canals
Change in Storage
Cumulative Change in Storage

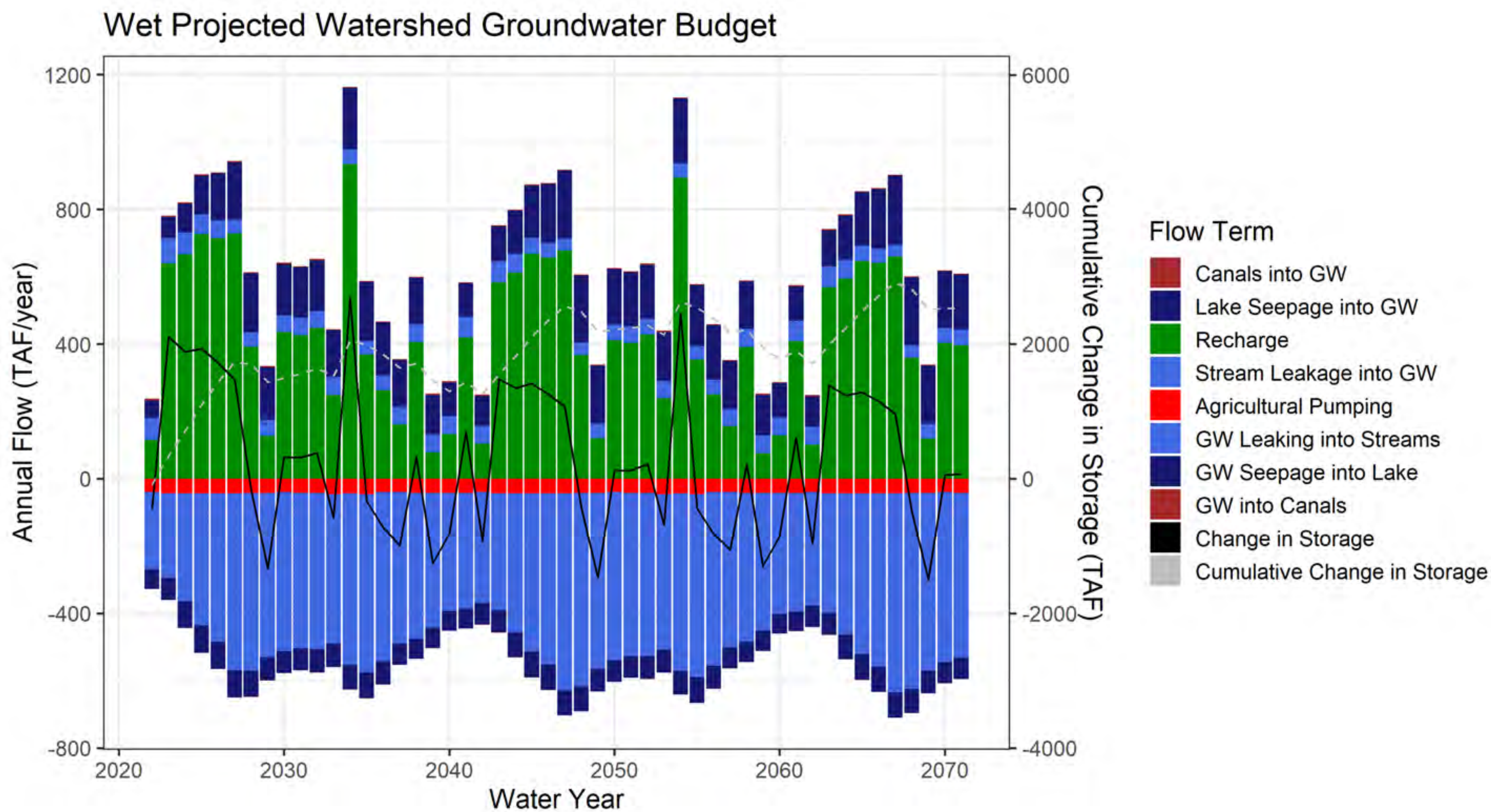


Figure 2.68: Annual budget summaries for the baseline and four projected climate change scenarios.

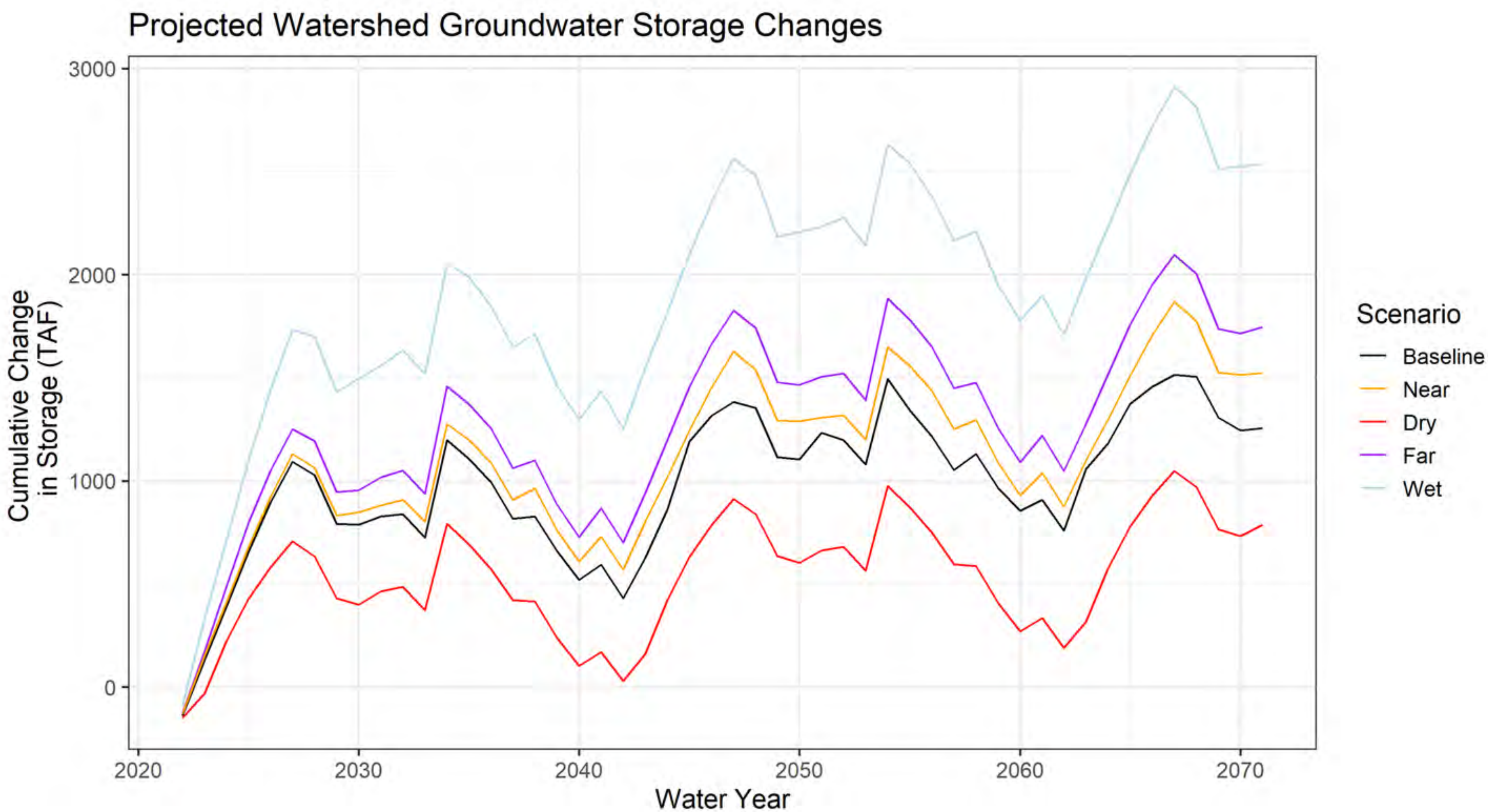


Figure 2.69: Cumulative groundwater storage change summaries for the baseline and four projected climate change scenarios.

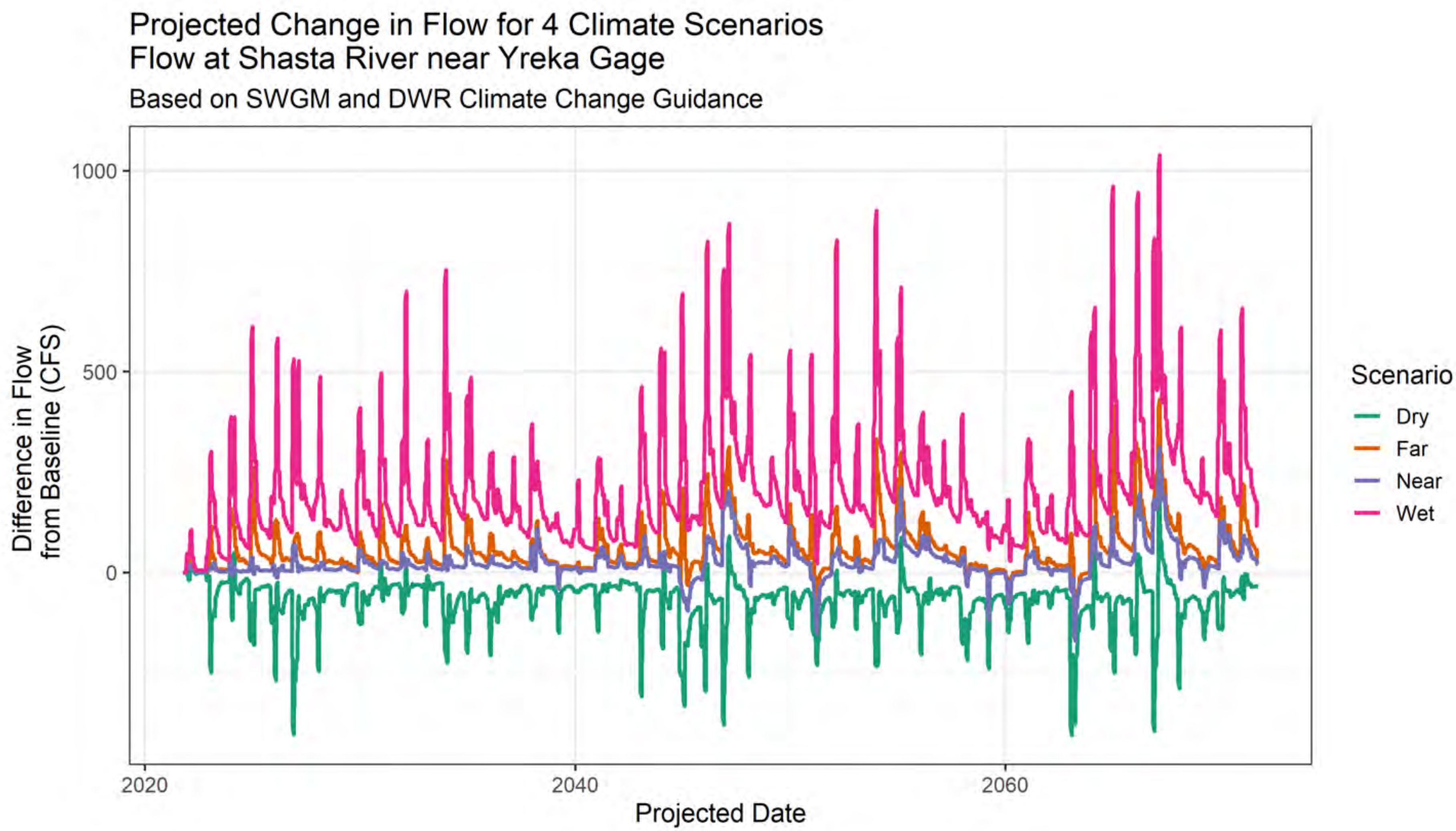


Figure 2.70: Projected flow at the Shasta River near Yreka gage, in difference (cfs) from Baseline, for four future projected climate change scenarios.

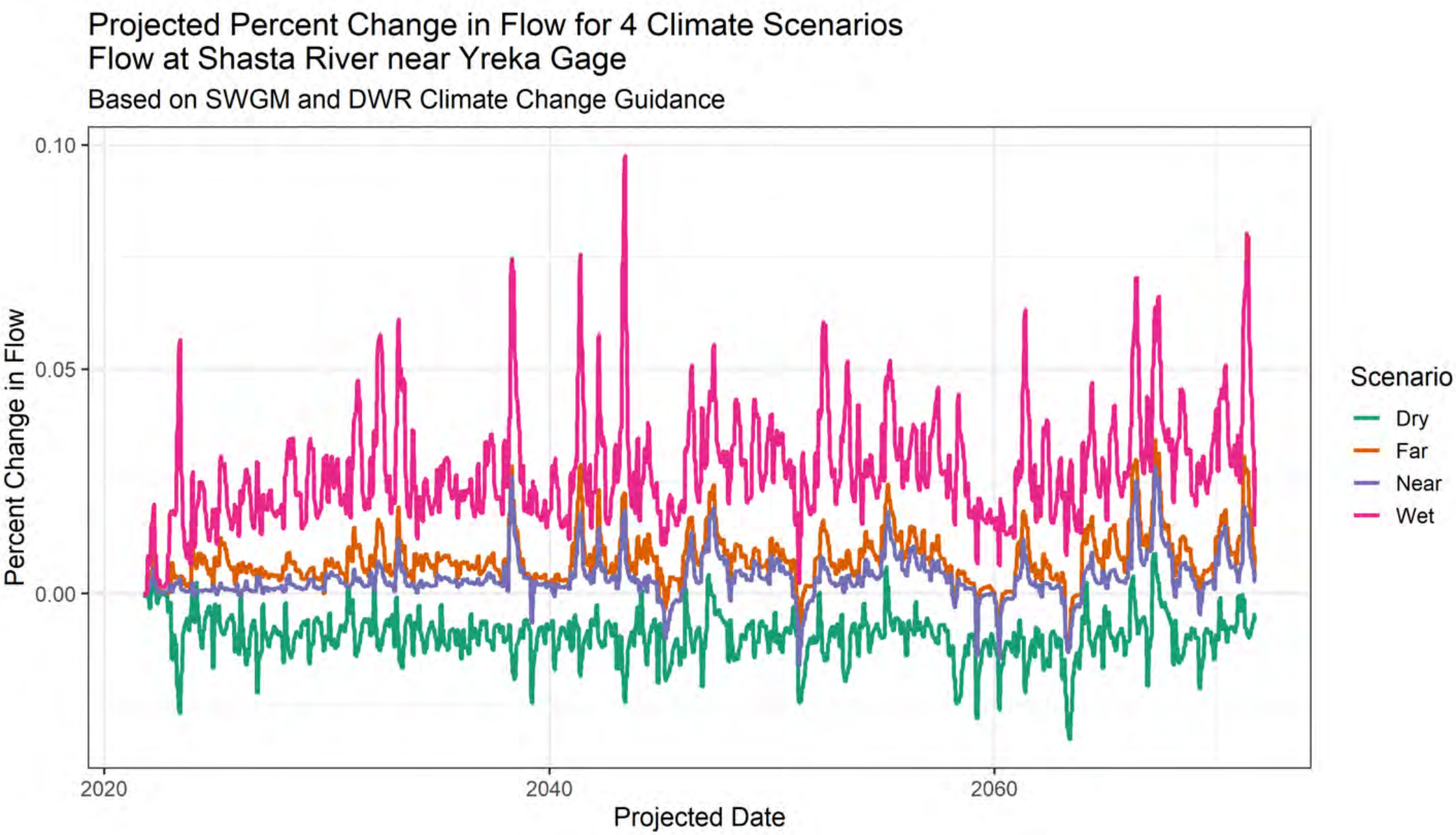


Figure 2.71: Projected flow at the Shasta River near Yreka gage, in percent change from Baseline, for four future projected climate change scenarios.

2.2.5 Sustainable Yield

Sustainable yield is defined in the California Water Code as the "maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result." (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 currently in overdraft and has not incurred undesirable results with respect to the sustainability indicators (SI) for water level and groundwater storage. Since 2014, ongoing groundwater pumping has also not incurred new known undesirable results with respect to SI for land subsidence, water quality, and GDEs. Water levels and groundwater storage have been in a long-term dynamic equilibrium between inflows to and outflows from the aquifer system. For ISW, 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 Basin, **the sustainable yield is currently equal to the 28-year average annual groundwater pumping of 42 to 45 TAF/year** as estimated with the SWGM for the 1992 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 projects and management actions (PMAs). Chapter 4 defines PMAs that the GSA will implement as needed to avoid future undesirable results. Individual PMAs to address future undesirable results, including those that will reverse stream depletion, may include managed aquifer recharge, some reduction of pumping demand, both, or neither (see Chapter 4). Updated simulations, analyses, and technical-scientific assessments 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 the spatial extent of undesirable results. For example, winter recharge to enhance summer stream flow does not require reductions in groundwater pumping for implementation. Similarly, 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 SMCs. Hence, the sustainable yield will be continually adjusted from the 1991 to 2018 baseline average annual groundwater pumping of 42- to 45-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 SI. 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.

2.2.6 Management Areas

There are currently no management areas in the Shasta Valley GSP, but may be reconsidered and added in the five-year GSP update in 2027.

Chapter 3

Sustainable Management Criteria

3.1 Introduction and Definition of Terms

This section defines sustainable groundwater management in the Shasta Valley groundwater basin (Basin) through the description and quantification of sustainable management criteria (SMC) for each of the sustainability indicators (SI) and definition of the sustainability goal. 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 SI.

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 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, measurable objectives, and undesirable results, consistent with the sustainability goal, that must be defined for each SI.

Undesirable Results (UR): Conditions, defined under SGMA as:

> … one or more of the following effects caused by groundwater conditions occurring throughout the basin:
>
> - Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon [….]
> - Significant and unreasonable reduction of groundwater storage.
> - Significant and unreasonable seawater intrusion.
> - Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.
> - Significant and unreasonable land subsidence that substantially interferes with surface land uses.
> - 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 Thresholds (MT): 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 SMC with a defined maximum limit (e.g., groundwater quality and stream depletion).

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 toward MOs and the sustainability goal.

Representative Monitoring Sites (RMP): for each SI, 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.

Overdraft: overdraft refers to a long-term trend in groundwater storage, not to short-term fluctuations in water levels that may seasonally lead to some undesirable results. However the Shasta Valley groundwater basin may have critical periods during the summer with seasonal negative effects on beneficial users. Continuous monitoring data within the Basin will be critical to better understanding the system and timing for the groundwater sustainability agency (GSA; see Appendix 3-A).

3.2 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 Shasta Valley, for generations to come. This includes managing groundwater conditions for each of the applicable SI in the Basin so that:

- Groundwater elevations and groundwater storage do not significantly decline below their historically measured range, protect the existing well infrastructure from outages, protect groundwater dependent ecosystems (GDEs), and avoid significant additional stream depletion due to groundwater pumping.
- 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 Shasta River Valley remain safe from permanent land subsidence.
- Groundwater will continue to provide river baseflow as ISW with no significant or unreasonable reduction in volume.

The GSA's groundwater management is efficiently and effectively integrated with other watershed and land use planning activities through collaborations and partnerships with local, state, and federal agencies, private landowners, and other organizations, to achieve the broader "watershed goal" of sufficient surface water and groundwater flows that sustain healthy ecosystem functions.

3.3 Monitoring Networks

The full monitoring network presented here will be used to continue to investigate hydrologic relationships within the Basin. A subset of the full monitoring network will be used to evaluate SMCs for individual SI for the Basin and will be used to demonstrate the sustainability of the Basin through 2042. Table 3.1 details all of the available information the GSA will be collecting during implementation to fill identified data gaps within the Basin.

Per 23 C.C.R. § 354.34(b)(1-4), 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; and
- Quantify annual changes in water budget components.

Monitoring networks are required to have sufficient spatial density and temporal resolution to evaluate the 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 time span of one to five years, and long-term is considered five to twenty years. The spatial densities and frequency of data measurement are specific to monitoring objectives, the quantity to be measured, degree 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 are provided for each sustainability indicator in the following sections. An overview of all wells included in the initial monitoring networks established for each sustainability indicator is provided in Table 3.1.

Identification and Evaluation of Potential Data Gaps

Per 23 CCR Section 351(l), 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 SMC, 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 groundwater sustainability plan (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:

- Spring discharge (either continuous or monthly).
- Continuous groundwater level measurements.
- Additional stream gauges and monitoring of Big Springs and the Little Shasta River.
- Additional wells near the main stem of the Shasta river and, as needed, near some of the main tributaries such as Big Springs, to measure groundwater levels near the river (see Section 3.3.5) for use in model calibration, as part of ISW monitoring, and for measuring PMA efficacy.
- Pumping volumes and locations.
- 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.

Pumping Volume and Location Data Gap

Volunteer owners and/or operators of groundwater wells, meeting a certain criteria, are encouraged to report pumping volumes. The reporting of pumping volumes will establish baseline values as well as provide information for the Shasta Watershed Groundwater Model. The suggested criteria for wells that should report are:

- Pumps operated above 500 gallons per minute.
- Pumps used for commercial purposes.

Reporting can be done one of three ways:

- A flow meter or totalizer will be installed and read on a monthly basis.
- Monthly electrical use from the pump can be reported in-lieu of pump volume.
- Monthly report of acres of irrigated land, irrigation method, and crop.

Where possible, all three types of data should be collected on one site. This would allow the comparison of the power meter and land use to the values from the totalizer and evaluation of how close they come. This can then be used as a correction for other areas where only land use or power data are available.

Possible subsidies in installation of flow meters from future grants will be explored.

Monitoring Network to Fill Identified Data Gaps

To fill data gaps, data is being collected at new locations, with the potential for further expansion with additional funding. The current groundwater level network is shown in Figure 3.1 with detailed maps in Appendix 3-A and discussion about the GSA commitment for guaranteeing measurements of critical locations in Chapter 5 (Table 5.1). Continuous monitoring offers the best data coverage while periodic monitoring is generally completed twice a year (spring and fall). A subset of the monitoring wells is instrumented with continuous datalogger (temperature and water level measured every 15 minutes) with telemetry, while for the rest of the California Statewide Groundwater Elevation Monitoring (CASGEM) Program wells, by-annual measurements have been collected. If funding allows, CASGEM wells will be monitored quarterly. Transects collect continuous data for ISW and the report with the details on location and instrumentation of the transect are provided in Appendix 2-H. Surface water monitoring includes spring discharge (monthly data are currently available, continuous are being evaluated), river flow, and river stage (Figure 3.2 and Figure 3.3). Additional monitoring includes atmosphere (ie., precipitation), diversions, and lake storage (Figure 3.2). Additional details are included in Appendix 3-A.

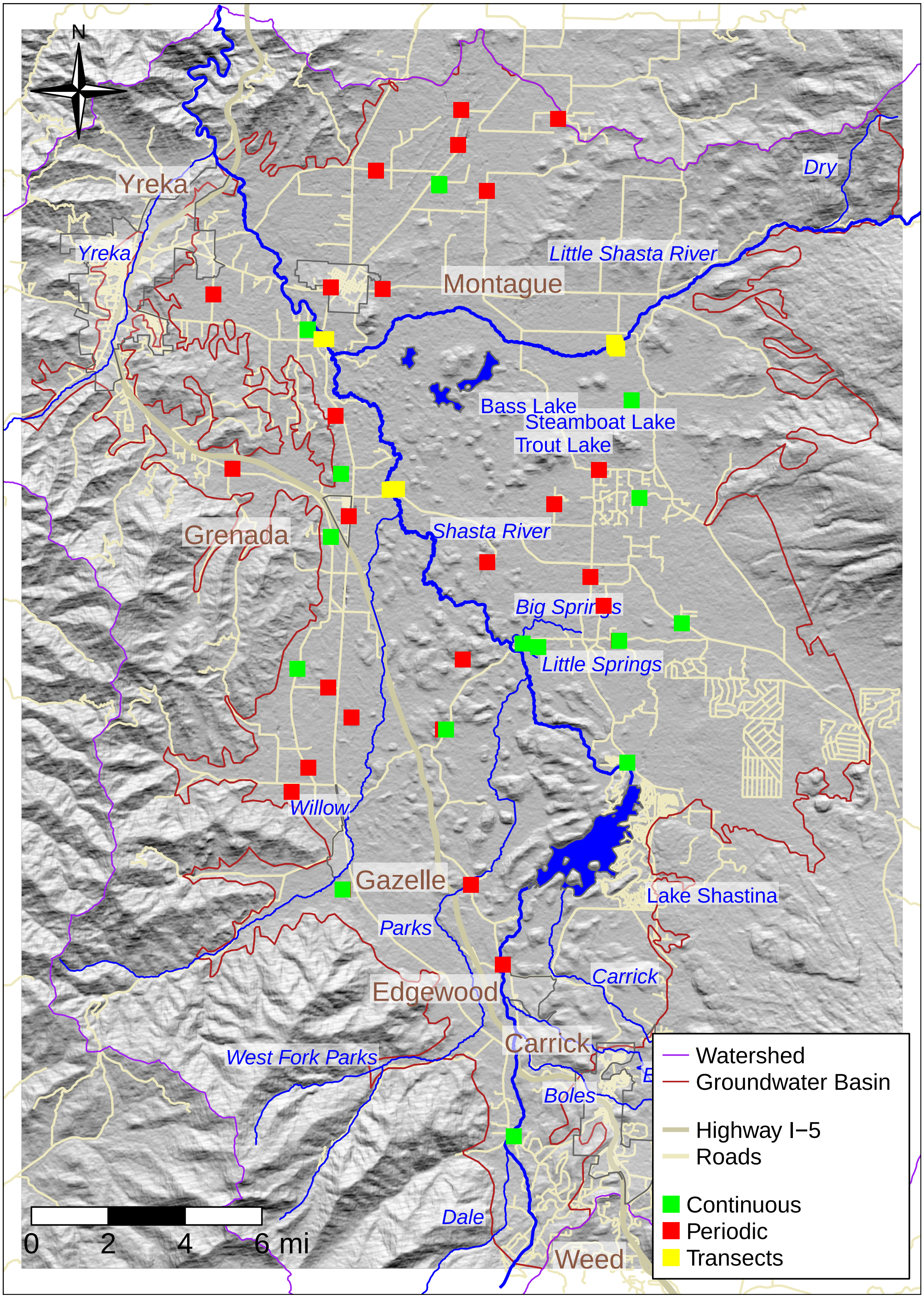


Figure 3.1: Groundwater Level Monitoring Network.

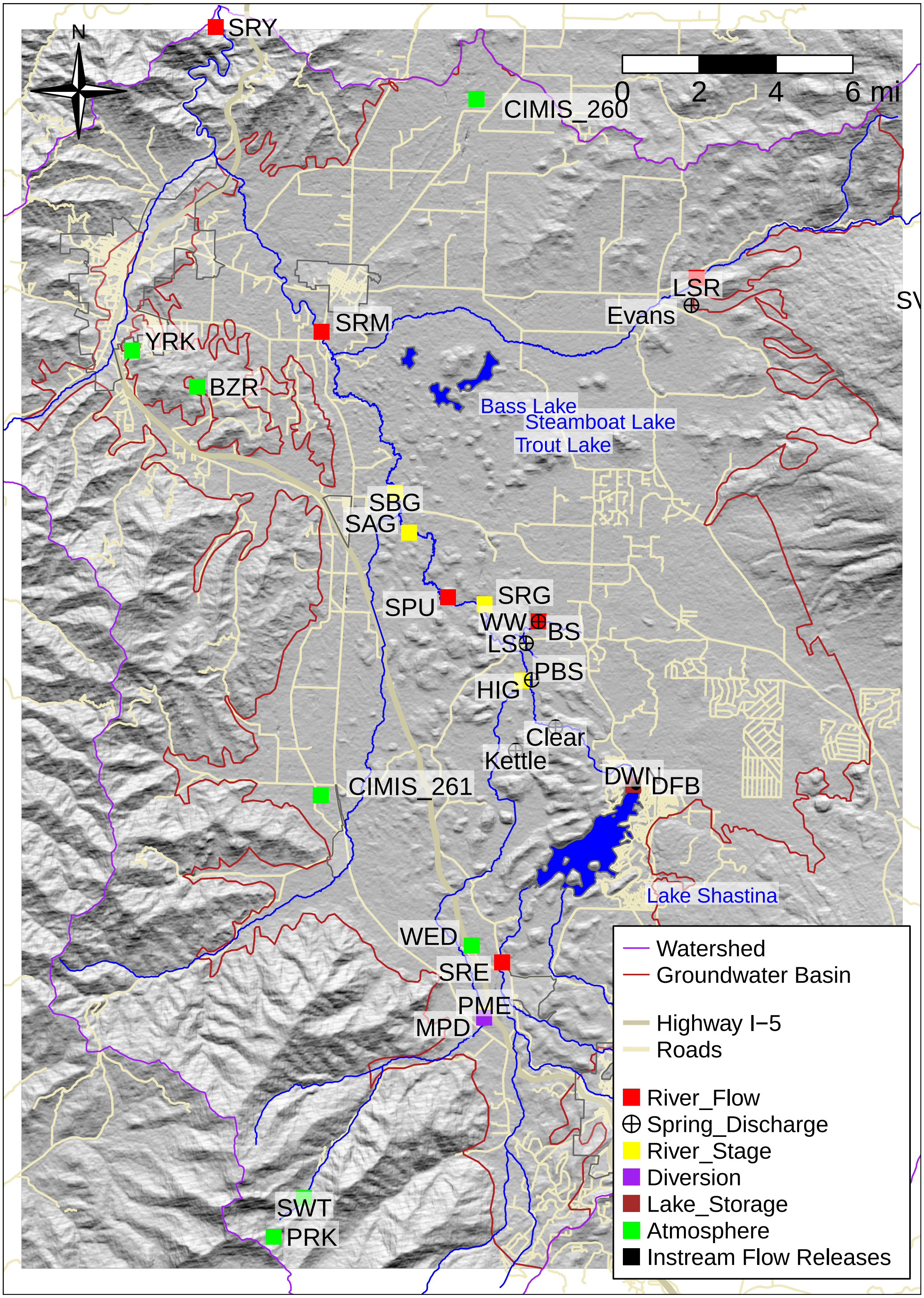


Figure 3.2: Hydrology and Surface Water Monitoring Networks.

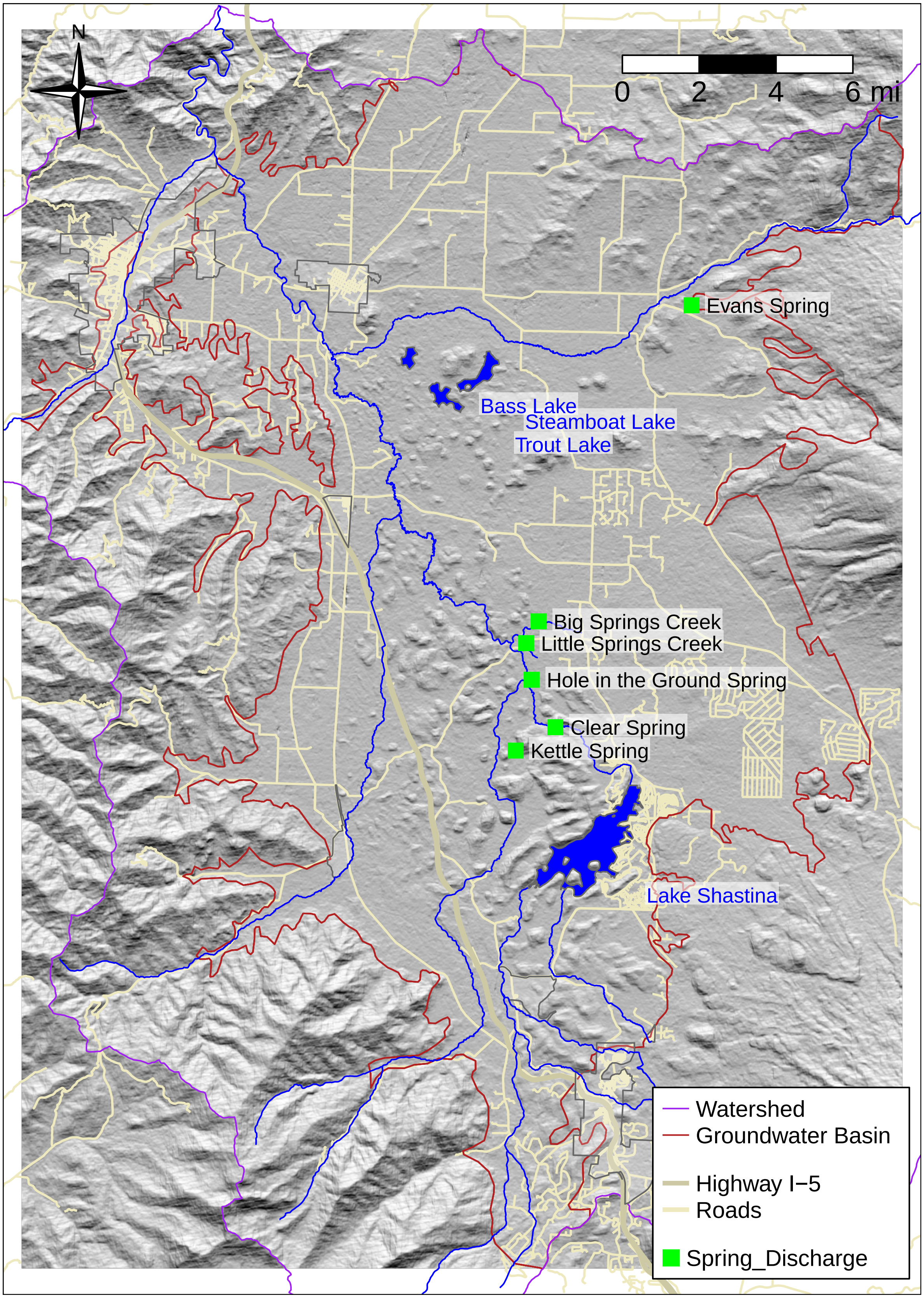


Figure 3.3: Monthly Spring Monitoring Networks.

Network Enrollment and Expansion

With the exceptions of streamflow, land subsidence, and stream depletion due to groundwater pumping, monitoring is performed using wells. Some wells will be monitored for water level, some for water quality, some for both. Prior to enrolling wells into the GSA's monitoring network, wells will be evaluated, using the selection criteria listed below, to determine their 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. Objectives for network design include sufficient coverage and density of wells to capture hydraulic gradients and overall groundwater in storage. Additionally, wells important for the measurement of groundwater level and groundwater quality must be included in areas within or adjacent to planned GSP projects and management actions and locally defined areas where existing operations are found to pose a significant risk of affecting groundwater levels or quality. Statistical methods will be used to aid in extrapolating measurements from a limited number of monitoring sites to groundwater conditions the entire Basin to measure compliance with the minimum or maximum thresholds set and to measure progress towards interim milestones.

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. Such wells were preferentially selected for a network over wells with limited monitoring data.

Well Information

In addition to well location, information about the construction of the well, including the well depth and screened interval(s) is necessary to provide context for the measurement taken at the well, such as which water bearing formation is being sampled. Well information is critical for an effective well network, so the groundwater aquifer can be efficiently monitored. 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

To be a functional component of 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, particularly for water quality, are located near populated areas, leaving sections of the remainder of the Basin without monitoring data. The planned additional wells for inclusion in a network are intended to provide data representative of different land uses, activities, and geologic units to 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. A more detailed evaluation of the required spatial density and monitoring frequency of the individual sustainability indicator monitoring network(s) has been conducted to determine appropriate attributes so that the monitoring network is representative of Basin conditions and enables evaluations of seasonal, short-term, and long-term trends.

The monitoring networks will continue to be developed throughout GSP implementation. Individual sustainability indicator monitoring networks will be expanded throughout GSP implementation, as necessary, to address monitoring objectives and support any PMAs. The RMPs currently included are the ones with a long enough period of data, spanning different year types, that allows to properly define SMCs. This explains why the wells instrumented with continuous data are not currently included as RMPs (Table 3.1): only few months of data have been collected for those wells and they will be included in the GSP network at the 5-years update. A similar approach applies to the monthly spring discharge measurements: as soon as a few years of data are available, they will included as RMPs. Expansion of individual sustainability indicator monitoring networks that rely on wells will involve identification of existing wells in the Basin that could be included in the monitoring network once evaluated, using the selection criteria, and approved for inclusion in the network.

Evaluations of the monitoring network will be conducted at least every five years to determine whether additional wells are required to achieve sufficient spatial density, whether wells are representative of land uses in the Basin, and whether wells provide 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. The monitoring frequency and timing that enable evaluation of seasonal, short-term, and long-term trends will also be assessed throughout GSP implementation. Where it is necessary, the GSA will coordinate with existing programs to develop an agreement for data collection responsibilities, monitoring protocols, and data reporting and sharing. For existing monitoring programs implemented by agencies, monitoring would be conducted by agency program staff or their contractors. For water quality monitoring, samples will be analyzed at contracted analytical laboratories. To prevent bias associated with date of sample collection, all samples should be collected on approximately the same date (i.e., +/- 30 days of each other) each year.

Table 3.1: All monitoring locations and data in Shasta Valley Groundwater Basin, with indicated SI networks (i.e., groundwater quality (GWQ) and groundwater level (GWL).

Site	Type	Agency	SI Network
BZR	Atmosphere	DFFP	–
CIMIS_260	Atmosphere	CIMIS	–
CIMIS_261	Atmosphere	CIMIS	–
LSH	Atmosphere	GRD	–
PRK	Atmosphere	MSRD	–
SVB	Atmosphere	SVRCD	–
SVG	Atmosphere	SVRCD	–
SWT	Atmosphere	MSRD	–
WED	Atmosphere	DFFP	–
YRK	Atmosphere	USFS	–
MPD	Diversion	DWR	–
Surface Water Diversions	Flow	SSWD	ISW
4700523-003	Groundwater Quality	Grenada Sanitary District	GWQ
4700528-001	Groundwater Quality	Siskiyou Co. Rolling Hills MWC	GWQ
4700557-001	Groundwater Quality	Caltrans-Weed Rest Stop	GWQ
4700557-002	Groundwater Quality	Caltrans-Weed Rest Stop	GWQ
4700559-001	Groundwater Quality	Butteville Union School	GWQ
4700577-001	Groundwater Quality	Big Springs Union Elementary School	GWQ
4700582-001	Groundwater Quality	Gazelle School	GWQ
4700591-002	Groundwater Quality	Delphic Elementary School	GWQ
4700626-001	Groundwater Quality	Cove Mobile Villa	GWQ
4700627-002	Groundwater Quality	Juniper Creek Estates	GWQ
4700638-001	Groundwater Quality	Oak Valley Acres P.O.A	GWQ
4700663-001	Groundwater Quality	WEED GOLF CLUB, INC.	GWQ
4710011-003	Groundwater Quality	City of Yreka	GWQ
4710013-001	Groundwater Quality	Lake Shastina C.S.D	GWQ

Table 3.1: All monitoring locations and data in Shasta Valley Groundwater Basin, with indicated SI networks (i.e., groundwater quality (GWQ) and groundwater level (GWL). *(continued)*

Site	Type	Agency	SI Network
4710013-002	Groundwater Quality	Lake Shastina C.S.D	GWQ
4710013-004	Groundwater Quality	Lake Shastina C.S.D	GWQ
SHA_01	GWL - continuous	GSA	–
SHA_02	GWL - continuous	GSA	–
SHA_03	GWL - continuous	GSA	–
SHA_04	GWL - continuous	GSA	–
SHA_05	GWL - continuous	GSA	–
SHA_06	GWL - continuous	GSA	–
SHA_08	GWL - continuous	GSA	–
SHA_09	GWL - continuous	GSA	–
SHA_10	GWL - continuous	GSA	–
SHA_11	GWL - continuous	GSA	–
SHA_17	GWL - continuous	GSA	–
SHA_172	GWL - continuous	GSA	–
SHA_174	GWL - continuous	GSA	–
SHA_18	GWL - continuous	GSA	–
SHA_24	GWL - continuous	GSA	–
SV01	GWL - continuous	CASGEM	GWL
SV02	GWL - continuous	CASGEM	ISW / GDE
27D002M	GWL - periodic	CASGEM	GWL
42N05W08E001M	GWL - periodic	CASGEM	–
42N05W20J001M	GWL - periodic	CASGEM	–
42N06W10J001M	GWL - periodic	CASGEM	–
43N05W07K001M	GWL - periodic	CASGEM	–
43N05W11A001M	GWL - periodic	CASGEM	GWL
43N05W19F002M	GWL - periodic	CASGEM	GWL
43N06W15F003M	GWL - periodic	CASGEM	–
43N06W22A001M	GWL - periodic	CASGEM	–
43N06W33C001M	GWL - periodic	CASGEM	GWL
44N05W14M002M	GWL - periodic	CASGEM	GWL
44N05W21H001M	GWL - periodic	CASGEM	–
44N05W32C002M	GWL - periodic	CASGEM	GWL
44N05W34H001M	GWL - periodic	CASGEM	–
44N06W10F001M	GWL - periodic	CASGEM	–
44N06W18Q001M	GWL - periodic	CASGEM	GWL
44N06W27B001M	GWL - periodic	CASGEM	GWL
45N05W07H002M	GWL - periodic	CASGEM	GWL
45N06W10A001M	GWL - periodic	CASGEM	–
45N06W26C002M	GWL - periodic	CASGEM	–
45N06W30E001M	GWL - periodic	CASGEM	–

Table 3.1: All monitoring locations and data in Shasta Valley Groundwater Basin, with indicated SI networks (i.e., groundwater quality (GWQ) and groundwater level (GWL). *(continued)*

Site	Type	Agency	SI Network
46N05W31F001M	GWL - periodic	CASGEM	–
46N05W33J001M	GWL - periodic	CASGEM	GWL
SV03	GWL - periodic	CASGEM	GWL
SV03A	GWL - periodic	CASGEM	GWL
SV04	GWL - periodic	CASGEM	–
A12-LBF	GWL - transects	GSA	–
A12-LBN	GWL - transects	GSA	–
A12-RBF	GWL - transects	GSA	–
A12-RBN	GWL - transects	GSA	–
A12-SWE	GWL - transects	GSA	–
A28-LBF	GWL - transects	GSA	–
A28-LBN	GWL - transects	GSA	–
A28-RBF	GWL - transects	GSA	–
A28-RBN	GWL - transects	GSA	–
A28-SWE	GWL - transects	GSA	–
LL-LBF	GWL - transects	GSA	–
LL-LBN	GWL - transects	GSA	–
LL-RBF	GWL - transects	GSA	–
LL-RBN	GWL - transects	GSA	–
LL-SWE	GWL - transects	GSA	–
DWN	Lake Storage	USBR	–
Big Springs Creek	Monthly Spring Discharge	GSA	–
Clear Spring	Monthly Spring Discharge	GSA	–
Evans Spring	Monthly Spring Discharge	GSA	–
Hole in the Ground Spring	Monthly Spring Discharge	GSA	–
Kettle Spring	Monthly Spring Discharge	GSA	–
Little Springs Creek	Monthly Spring Discharge	GSA	–
LSR	River Flow	TNC	–
SPU	River Flow	DWR	–
SRE	River Flow	DWR	–
SRM	River Flow	USGS	ISW
SRY	River Flow	USGS	–
WW	River Flow	CDFW	–
PBS	River Stage	DWR	–
PME	River Stage	DWR	–
SAG	River Stage	DWR	–

Table 3.1: All monitoring locations and data in Shasta Valley Groundwater Basin, with indicated SI networks (i.e., groundwater quality (GWQ) and groundwater level (GWL). *(continued)*

Site	Type	Agency	SI Network
SBG	River Stage	DWR	–
SRG	River Stage	DWR	–
InSAR	Subsidence	DWR	Subsidence
DFB	Superceded	DWR / MWCD	ISW
DRE	Superceded	DWR	–
DSW	Superceded	DWR	–
SRX	Superceded	DWR	–
YCK	Superceded	SVRCD	–

3.3.1 Groundwater Level Monitoring Network

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 quantitively show the absence 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. The groundwater level (GWL) monitoring network is a subset of wells presented in Table 3.1 that meets the Department of Water Resources (DWR) GSP reporting requirements.

3.3.1.1 Description of Monitoring Network

The groundwater level (GWL) monitoring network consist of thirteen CASGEM wells (Table 3.2) in the Basin. Four wells are located within the fractured basalt aquifer, seven in the alluvial aquifer, and three in various other geologic material. The distribution of monitoring wells is shown in Figure 3.4. The currently designed network satisfies DWR requirements with respect to spatial distribution and can be expanded using recently installed new instruments that will be evaluated over the first five years of implementation.

Table 3.2: Groundwater level monitoring network.

well_name	Sample Schedule	Principal Formation	Well Depth (ft)	First Perforated Top (ft)	First Perforated Bottom (ft)	Second Perforated Top (ft)	Second Perforated Bottom (ft)	Likely geologic unit(s) in perforation interval
43N05W11A001M	Continuous	Volcanics	120	8	250	–	–	Qv
43N06W33C001M	Twice Annual	Alluvium	317	60	238	–	–	Q, Qvs, SOd (Basement)
44N05W14M002M	Twice Annual	Volcanics	95	8	90	–	–	Qv
45N05W07H002M	Twice Annual	Alluvium	80	40	80	–	–	Q, Tv
27D002M	Twice Annual	Alluvium	45	28	45	–	–	Q
44N05W32C002M	Twice Annual	Other	79	40	69	–	–	Qvs
46N05W33J001M	Twice Annual	Alluvium	200	22	200	–	–	Q, Tv
44N06W27B001M	Twice Annual	Other	110	50	110	–	–	Qvs
SV01	Continuous	Alluvium	150	33	84	–	–	Q
SV03	Twice Annual	Alluvium	300	120	250	270	285	Q, Qvs
43N05W19F002M	Twice Annual	Other	150	120	150	–	–	Qvs
44N06W18Q001M	Twice Annual	Alluvium	165	17	160	–	–	Q, Qvs
SV03A	Twice Annual	Volcanics	102	17	102	–	–	Qv

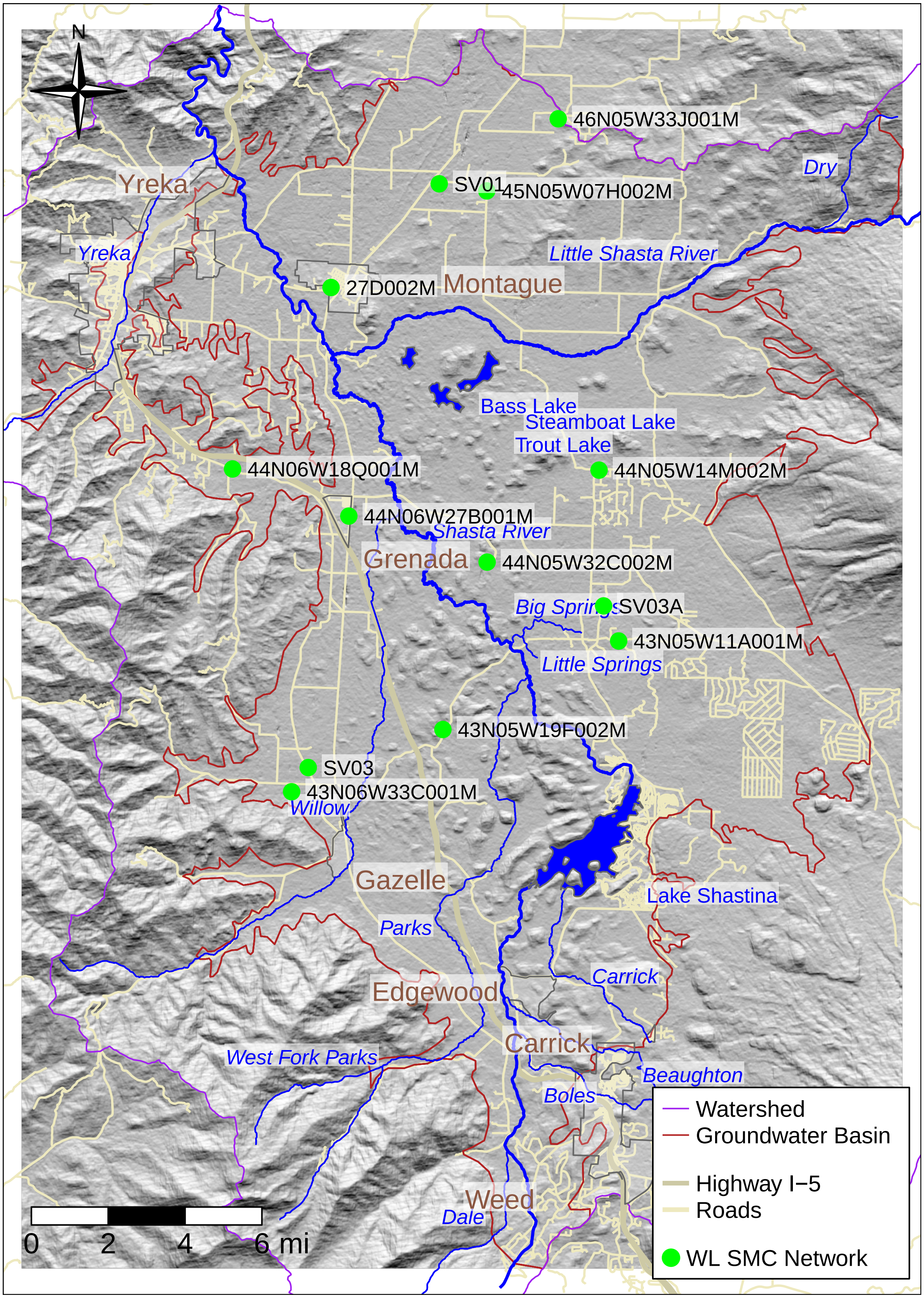


Figure 3.4: Water Level Monitoring Network.

3.3.1.2 Assessment and Improvement of Monitoring Network

The 14 wells provide good coverage of the central part of the Basin, with data gaps on the Basin edges such as near Weed, Yreka, Lake Shastina, Little Shasta River and Pluto's Cave. Specific PMAs are outlined to address including additional groundwater monitoring wells into the GSP monitoring network.

Spatial coverage criteria

DWR's guidance on monitoring networks (California Department of Water Resources (DWR) 2016) 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 square miles (sq mi; 259 square kilometer [sq km]). Because the Basin covers approximately 82 sq mi (212 sq km), these recommendations would translate directly into a range from 1 to 10 RMP wells, evenly spaced in the Basin. A total of 14 wells are included in the groundwater level monitoring network, exceeding the minimum well density set by DWR guidance.

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. Two wells in the network have continuous data and provide higher resolution water elevation measurements. Additional frequency of measurement, to quarterly or monthly, may be conducted to better enable determination of seasonal trends.

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 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 SI.

Historic groundwater storage changes are computed with the Shasta Watershed Groundwater Model (SWGM). Throughout the implementation period of this Plan, updates the model 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, SWGM 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 model-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 the model 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.

This regression-based method allows for computation of groundwater storage change from measured groundwater level monitoring for the years between the end of the model simulation period (to be updated at least every five years) and the current reporting year (currently 2021). As the model 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 model-simulated groundwater storage changes for the same year.

In summary, the combination of simulated groundwater storage change in model 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 that groundwater conditions are maintained below maximum thresholds. The monitoring network is used to identify when maximum thresholds are exceeded, when trends indicate a path towards undesirable results, or when undesirable results occur. 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, which are shown in Figure 3.5. 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: nitrate and specific conductivity (Table 3.3). The well depths and well screens of wells outside the network are not well defined and sampled water bearing formation cannot be confirmed. The existing network will therefore be augmented with well logging of those additional wells. 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.

The design of the monitoring network must enable adequate spatial coverage (distribution, density) to describe groundwater quality conditions at a local and Basin-wide scale for all beneficial uses. Future revisions to the monitoring network and schedule will be considered after review of the initial 5-years of observation data and during any future GSP updates. Additional wells may be added throughout GSP implementation in response to changes in land use, project implementation, or with new water quality concerns.

Prior to enrolling wells into the GSA monitoring network, wells will be evaluated, using the selection criteria listed in Section 3.3. Wells in existing monitoring programs are located near populated areas, leaving much of the remainder of the Basin without monitoring data. The planned additional wells are intended to gather groundwater quality data representative of different land uses and activities and geologic units and to improve upon the existing spatial coverage in the Basin. Current data gaps include no domestic and agricultural wells. Any wells added to the monitoring network will be evaluated using the criteria listed above to ensure well suitability. A more detailed evaluation of the required spatial density and monitoring frequency of the monitoring network will be conducted to determine appropriate attributes so that the monitoring network is representative of Basin conditions and enables evaluations of seasonal, short-term (one to five years) and long-term (five to ten year) trends.

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

Name of Network	Well Name	Agency	Nitrate Frequency	Specific Conductivity Frequency
Municipal	4710011-003	City of Yreka	Annually	9 years
Municipal	4700528-001	Siskiyou Co. Rolling Hills MWC	Annually	9 years
Municipal	4700627-002	Juniper Creek Estates	Annually	3 years
Municipal	4700638-001	Oak Valley Acres P.O.A	Annually	3 years
Municipal	4700626-001	Cove Mobile Villa	Annually	9 years
Municipal	4700591-002	Delphic Elementary School	Annually	–
Municipal	4700577-001	Big Springs Union Elementary School	Quarterly	–
Municipal	4710013-001	Lake Shastina C.S.D	Annually	9 years
Municipal	4710013-002	Lake Shastina C.S.D	Annually	9 years
Municipal	4710013-004	Lake Shastina C.S.D	Annually	9 years
Municipal	4700582-001	Gazelle School	Annually	–
Municipal	4700557-001	Caltrans-Weed Rest Stop (north bound)	Annually	–
Municipal	4700557-002	Caltrans-Weed Rest Stop (north bound)	Annually	–
Municipal	4700559-001	Butteville Union School	Quarterly	–
Municipal	4700663-001	WEED GOLF CLUB, INC.	Annually	–
Municipal	4700523-003	Grenada Sanitary District	Annually	9 years

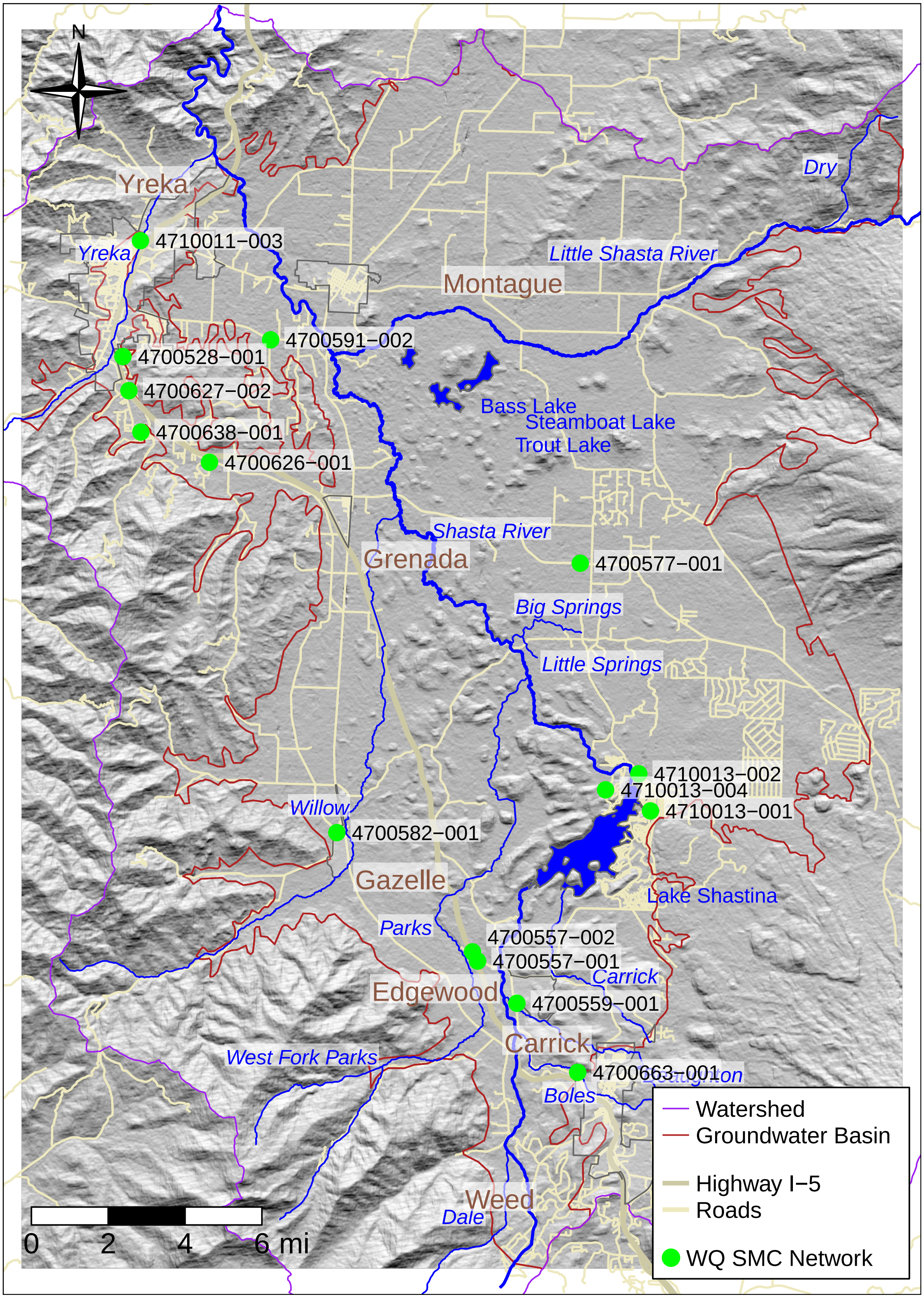


Figure 3.5: Water Quality Monitoring Network.

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. Funding has been made available through the NCRWQCB for sample analysis and results of this sampling will be used to help inform the monitoring network expansion. Additionally, increasing temporal resolution to quarterly is necessary to enable evaluation of seasonal trends. Specifically the expansion of specific conductivity should increased beyond the requirements in current water quality plans. 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, particularly with regard to the sufficiency of the monitoring network in meeting the monitoring objectives and demonstrating the sustainability of the Basin with respect to water quality. The monitoring network may be modified or expanded based on an evaluation of the data collected or future changes in land use, or as new information becomes available.

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 3.3.4.1. Data gaps have been identified, particularly in spatial coverage, well information and representation of all land and beneficial uses in the Basin. Temporal data gaps have been identified as intra-annual data is required to evaluate seasonal trends. These data gaps will be resolved through 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, resulting from the process outlined in Section 3.3.

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 Association 2012), as applicable, in addition to the general sampling protocols listed in Appendix 3B.

3.3.4 Depletion of Interconnected Surface Water Monitoring Network

3.3.4.1 Description of Monitoring Network

The GSP Regulations provide that the monitoring network for Depletions of ISW should include "[m]onitor[ing] surface water and groundwater where interconnected surface water conditions exist, to characterize 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. (23 CCR 354.34(c)(6).)

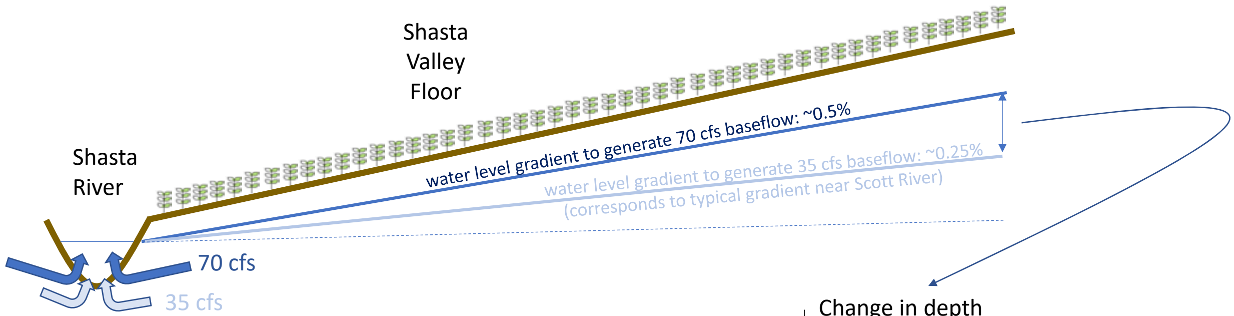
The monitoring of ISW will be conducted to establish two objectives. The first objective of the ISW monitoring network is to evaluate groundwater contributions to the Shasta River during the irrigation season. The second objective is to monitor shallow groundwater for protection of vegetative GDEs, as identified in Chapter 2. The monitoring network will use surface water gaging stations, measured surface water diversions, and groundwater elevations to assess sustainability. Section 3.4.3 provides background and justification on site location and methodology.

Groundwater Levels as Proxy for Stream Depletion Monitoring – not suitable

Water levels are not a suitable proxy for surface water depletion in the Shasta Valley, although they have been proposed in other groundwater basins. This is because in the Shasta Valley system (1) groundwater levels are affected by many factors including, but not limited to groundwater use, and (2) the typical variability induced by seasonal climate, recharge, and pumping changes is greater than the change in head that would correspond to a significant change in outflow to the stream system. In other words, the head data currently available are too noisy to be useful for assessing stream depletion due to groundwater pumping or stream depletion reversal due to specific projects and management actions (PMAs).

The hypothetical numbers of change in depth presented in Figure 3.6 show values that are much smaller than the typical transient variations induced by pumping wells and seasonal climate variability in water levels measured in monitoring wells near the river (see Chapter 2). Additionally, water levels near the stream - and more so away from the stream - are influenced by factors other than groundwater, including proximity to tributaries and their recharge history, proximity to wells and their pumping history, irrigation methods and agricultural return flows in nearby fields, and aquifer heterogeneity.

However, the GSP recognizes that groundwater levels are fundamentally linked with groundwater-stream flux rates, and these measurements can be useful when judiciously used in combination with the SWGM. In addition, use of observing long-term trends in the hydraulic gradient between the aquifer and stream has been suggested as a tool to comply with SGMA requirements for depletion of ISW (Hall et al. 2018). While groundwater levels as a proxy for stream depletion monitoring are by themselves not suitable for the Basin, these measurements will be collected and used to assess long-term trends in water level gradients and to avoid long-term, Basin-scale water level declines (see Sections 3.3.1 and 3.4.1). These data, among many others, will also be used to calibrate and improve SWGM. The refined and calibrated version of SWGM over the next five years will be able to account for and process a much wider range of relevant land use, hydrologic, and geologic data that would not be reflected in water level data alone. Using more appropriate, comprehensive information, including measured water level dynamics, SWGM will be used to compute water level changes due to PMAs and to estimate stream depletion reversal occurring specifically due to PMAs in ways that cannot be achieved with water level measurements alone (see below).



Distance [ft]	Change in depth to water table [ft]
100	0.25
300	0.75
1,000	2.5
3,000	7.5

This simple concept ignores any other interfering factors affecting water level changes: recharge in nearby tributaries, recharge from nearby irrigation return flows, pumping in nearby wells

Figure 3.6: Conceptual cross-section across the valley floor near the Shasta River (left), showing the land surface (brown, with crop cover) and two hypothetical water tables: at a gradient of about 0.5 percent, corresponding to a baseflow of about 70 cubic feet per second (cfs), and at a gradient of about 0.25 percent, corresponding to a baseflow of about 35 cfs. Gradients are approximate. The inserted table shows the resulting difference in water table depth between these two hypothetical water table locations, at different distances from the Shasta River. The conceptual cross-section does not account for water table influences from nearby pumping, irrigation return flows, or tributaries.

Streamflow as Proxy for Stream Depletion Monitoring – not suitable

Direct measurement of streamflow at the Yreka gauge or any other gauge is also not a suitable proxy for surface water depletion in the Shasta Valley because it is affected by several factors other than groundwater use. The Yreka gauge provides an overall water balance of the region because it is near the outlet of the Basin. During the summer baseflow season, stream gauges along the main stem of the Shasta River can provide a direct measure of the total groundwater contribution from the Shasta River Valley Basin to the stream (see approach for ISW MTs). That groundwater contribution to streamflow is a function of groundwater use for pumping, of winter and spring recharge from precipitation and irrigation on the valley floor, of winter and spring recharge from tributaries on the upper alluvial fans, of mountain front recharge, and of surface water diversions (Chapter 2.2.3.3.). It is a function of both, their total amounts and the temporal dynamics of these amounts (pumping, recharge, diversions, etc.).

Quantifying Stream Depletion Using a baseflow measurement approach (preliminary approach for the first 5-years of implementation)

Due to data gaps, at this time the ISW cannot be defined with groundwater levels or streamflow as proxies. In future GSP updates, after data gaps are addressed, an updated version of the SWGM can be used to define ISW. For this GSP, a baseflow approach has been developed where stream flows are measured upstream and downstream and diversions are measured in between, and any differences between these flows can be attributed to contributions from groundwater. The goal is to use this approach for the first five years of implementation, collect more data, and at the GSP update provide a stream depletion approach based on more reliable results produced by a better calibrated SWGM.

The ISW monitoring network includes two surface water gaging locations, measured surface water diversions, and one groundwater elevation. A table of monitoring sites for ISW is provided as Table 3.4 and Figure 3.7. Three piezometer transects are also part of the ISW monitoring network and will be integrated into the SMC network at the 5-year GSP update (see Appendix 2-H).

These are the Shasta River near Montague (SRM) maintained by the USGS and the Instream Flow Releases from Dwinnell Reservoir/Shasta River Dam No. 60 (F21396). Both stations record and store data at 15-minute intervals. The monitoring network will also include surface water diversions manually measured by the Scott and Shasta Watermaster District (SSWD). These measurements are done bi-monthly throughout the irrigation season.

Table 3.4: Monitoring locations for monitoring ISWs.

Monitoring Location	Monitoring Type	Agency	Measurement Frequency
Shasta River near Montague (SRM)	Stream Gage	USGS	Continuous
Instream Flow Releases (DFB)	Stream Gage	MWCD	Continuous
Diversions	Manual	SSWD	Bi-monthly
SV02	GWL	GSA	Continuous

3.3.4.2 Assessment and Improvement of Monitoring Network

Inclusion of additional stream gaging stations, including Shasta River near Yreka (SRY), Shasta River at Grenada Pump Plant (SPU), Water Wheel, and Parks Creek are expected to be part of the 2027 ISW monitoring network (Table 3.5). These sites are not included in the current monitoring network due to insufficient historical data. If sufficient funding is available for monitoring at these sites, they will be added to the monitoring network and SMCs set.

The ISW monitoring network currently has Big Springs and the Little Shasta River as a data gap (see Appendix 3-A). Monthly spring monitoring was begun in 2020 by the GSA, including Big Springs (see Section 2.2.2.6 and Figure 3.3). Monitoring of Big Springs will be the priority for the 2027 GSP update. Ongoing work by the State Water Resources Control Board (SWRCB) and the University of California, Davis (UCD) Watershed Sciences in evaluating the interconnection of groundwater and surface water in the area are expected to inform the work of the GSP. Monitoring of the upper Little Shasta River watershed using the water balance method is expected to be implemented during the 2032 GSP update, or sooner if funding is available. The three piezometer transects (see Appendix 2-H) will continue to be monitored, and may be expanded to additional sites dependent on funding.

Table 3.5: Future monitoring locations for monitoring ISW, dependent on funding.

Monitoring Location	Monitoring Type	Agency
Shasta River near Yreka (SRY)	Stream Gage	USGS
Shasta River at Grenada Pump Plant (SPU)	Stream Gage	DWR
Big Spring Creek (Water Wheel)	Stream Gage	CDFW
Parks Creek	Stream Gage	–

3.3.4.3 Monitoring Protocols for Data Collection and Monitoring

Monitoring will be done yearlong. Stream gages SRM and Instream Flows (F21396) are connected via a telemetry network and available online for inclusion into the data management system. Estimates of surface water diversions from SSWD will be submitted to the County when finalized based on SSWD internal reporting requirements. Surface diversions will be entered into the County data management system and calculations for the groundwater contributions will be done within the data management system.

Groundwater elevation data is collected continuously as much as possible when sufficient funding is available. Otherwise a minimum sampling of bi-annual will be conducted to verify levels. Water levels for evaluating ISW will be conducted in accordance with sampling protocols outlined in Section 3.3.1.3 - Monitoring Protocols for Data Collection and Monitoring of Groundwater Elevation Data.

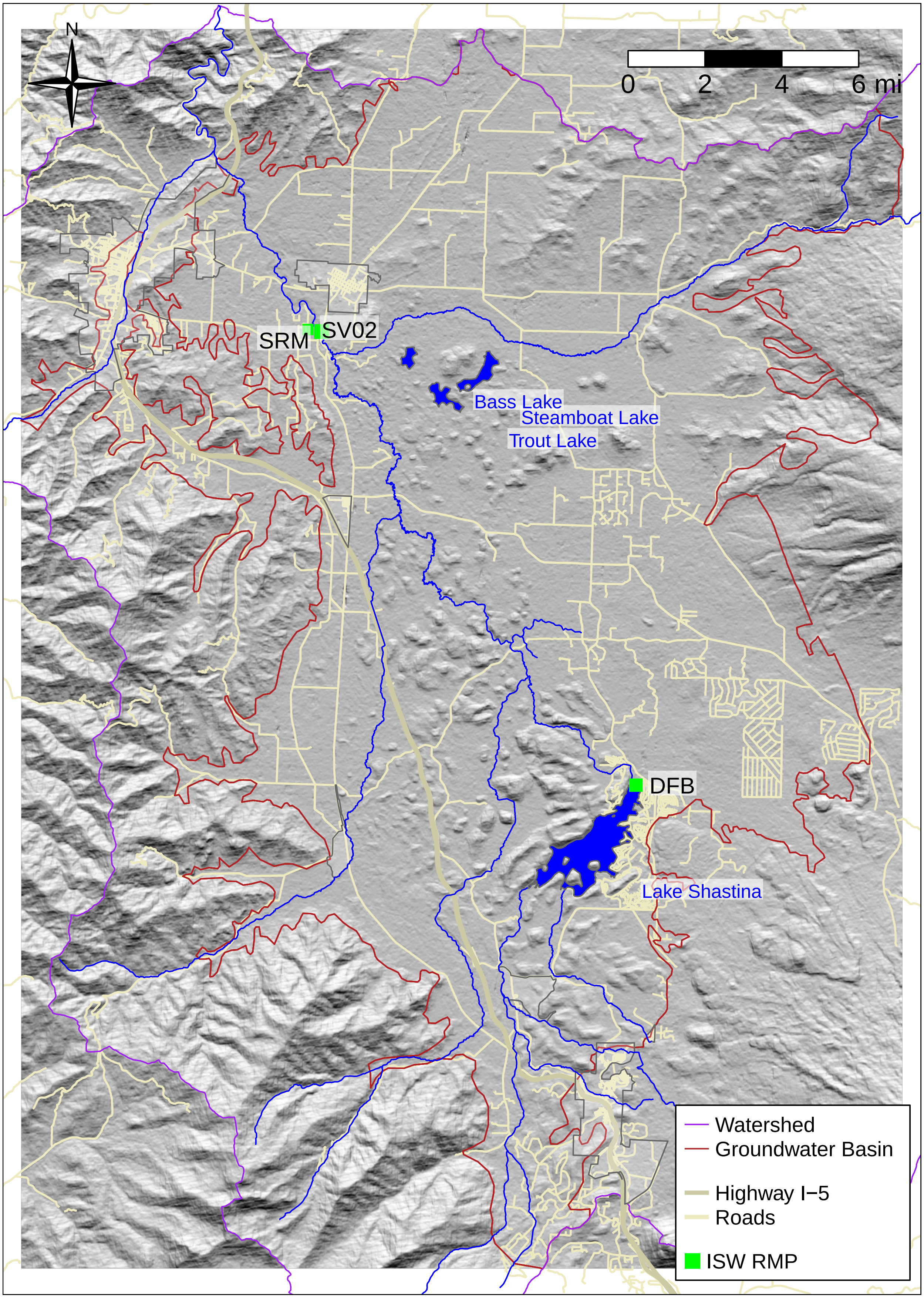


Figure 3.7: ISW monitoring gages and wells for the current GSP implementation in 2022.

3.3.5 Subsidence Monitoring Network

3.3.5.1 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 328 by 328 feet (100 meter) 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 Shasta Valley 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 Shasta Valley. There are no explicitly identified representative subsidence sites because the satellite data consists of thousands of points. Figure 2.42 (Chapter 2) 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 MO is being met.

3.3.5.2 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 useful borehole extensometer stations located within or near the Basin boundary. The single borehole strainmeter in the Basin (UNAVCO station #B039) does not record vertical strain or displacement, only horizontal, is not useful for recording inelastic subsidence signal (Figure 2.42; Chapter 2). The strainmeter is also on the very edge of the Basin boundary on a foundation of andesite and serpentinite with minimal sediment overburden, also effectively invalidating this station as a monitoring location for groundwater basin subsidence monitoring. There are no other strainmeters or extensometers located within the Basin boundary or close enough to be relevant.

Due to little current evidence of subsidence since 2015, see Section 2.2.2.4, no future CGPS or additional 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 need to be conducted.

3.3.5.3 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-A 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 the MT, further study will be needed.

3.4 Sustainable Management Criteria

3.4.1 Groundwater Elevation

Groundwater elevations in the Basin have generally been high enough to satisfy demand for agricultural and other users. Groundwater elevation MTs will be determined based on recorded historic lows as measured by the CASGEM monitoring network. The compliance point for GWL monitoring will be conducted in the Fall. CASGEM measurements have historically been recorded in October.

3.4.1.1 Undesirable Results

Chronic lowering of groundwater levels is considered significant and unreasonable when a significant number of private, agricultural, industrial, or municipal production wells can no longer pump 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. The lowering of water levels during a period of drought is not the same as (i.e., 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.

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, significant and unreasonable depletion of supply was identified to 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 to local agricultural interests.
- Adverse impacts to environmental uses and users, including ISW and GDEs.

These conditions were defined quantitatively for the groundwater level sustainability indicator as any water level measurement that goes below the Management Trigger for two consecutive years within the Basin.

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

Historic data from CASGEM wells located in the Basin were used to develop the specific SMCs for each well. Each CASGEM well in Table 3.6. Depth to water is used as the measurement for each well. Fall Range refers to the maximum and minimum of measurements collected at each well in the months Sept-Nov. The MO is set as the 75th percentile of the fall measurement range - i.e., the measurement at which 25% of groundwater elevation measurements fall below it. The Action Trigger (AT) is set at the historic low groundwater elevation measurement. The MT is set at the historic deepest depth to groundwater plus a buffer. The buffer is either 10% of the historic low, or 10 feet, whichever is smaller. As the water table becomes more shallow, ie., closer to the land surface, the buffer will continue to decrease. This allows for near-stream well monitoring to operate at a smaller range due to the impact GWL drawdowns can have on streamflow and stream leakage. There are currently no state, federal, or local standards that relate to this sustainability indicator in the Basin.

3.4.1.3 GWL SMCs

A summary of the SMCs for each well is shown on Table 3.6. Figure 3.8 shows an example of the ‘thermometer’ for GWL levels. Figure 3.9 shows an example hydrograph for development of GWL SMCs.

Table 3.6: SMC values for GWL (feet below ground surface [ft bgs]).

Well Code	Well Name	Station ID	Well Depth (ft bgs)	Fall Low (ft bgs)	Fall High (ft bgs)	MT (ft bgs)	AT (ft bgs)	MO (ft bgs)
415952N1223848W001	43N05W11A001M	22370	120	156.5	121.0	166.5	156.5	144.1
415351N1225474W001	43N06W33C001M	22373	317	71.9	36.4	79.1	71.9	61.0
416595N1223971W001	44N05W14M002M	22375	95	59.8	52.5	65.8	59.8	56.5
417638N1224574W001	45N05W07H002M	24045	80	27.9	15.1	30.7	27.9	22.3
417258N1225337W001	27D002M	24067	45	7.9	5.1	8.7	7.9	6.8
416237N1224524W001	44N05W32C002M	36753	79	66.4	40.4	73.0	66.4	51.3
417916N1224217W001	46N05W33J001M	36892	200	41.1	25.5	45.2	41.1	34.4
416397N1225224W001	44N06W27B001M	36999	110	20.2	11.7	22.2	20.2	17.4
417660N1224811W001	SV01	37001	150	48.5	6.4	53.4	48.5	24.2
415444N1225387W001	SV03	49002	300	80.1	70.4	88.1	80.1	76.0
415601N1224718W001	43N05W19F002M	49294	150	12.1	9.8	13.3	12.1	10.0
416563N1225813W001	44N06W18Q001M	49295	165	30.3	6.7	33.3	30.3	27.1
416083N1223932W001	SV03A	50631	102	62.7	42.8	69.0	62.7	47.3

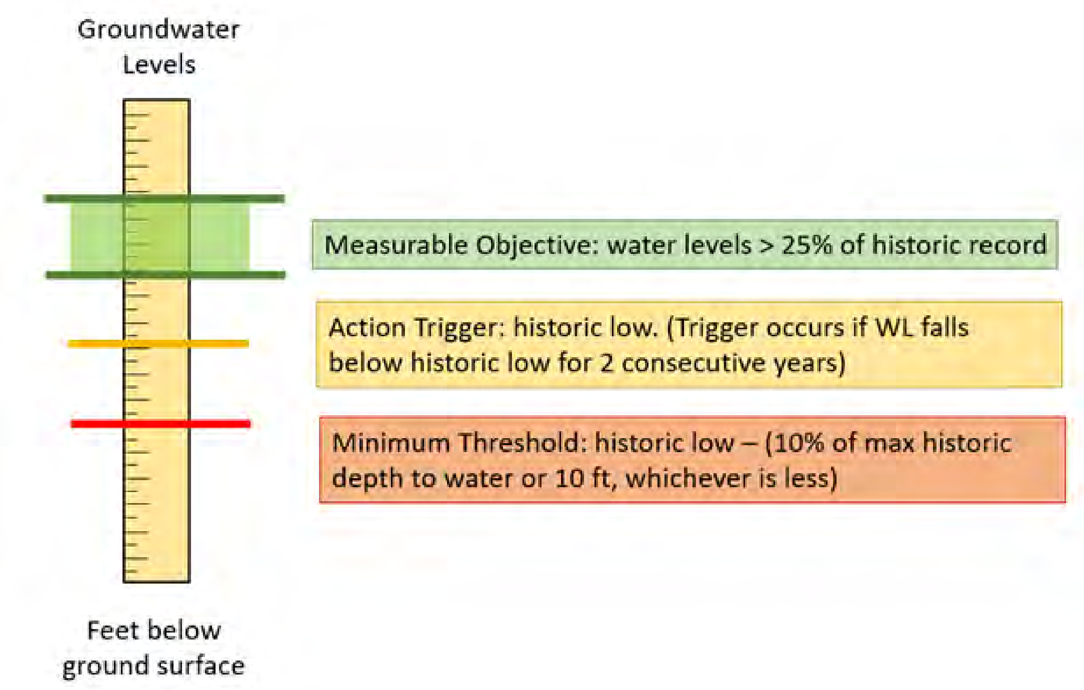


Figure 3.8: Example thermometer for evaluating GWL SMCs.

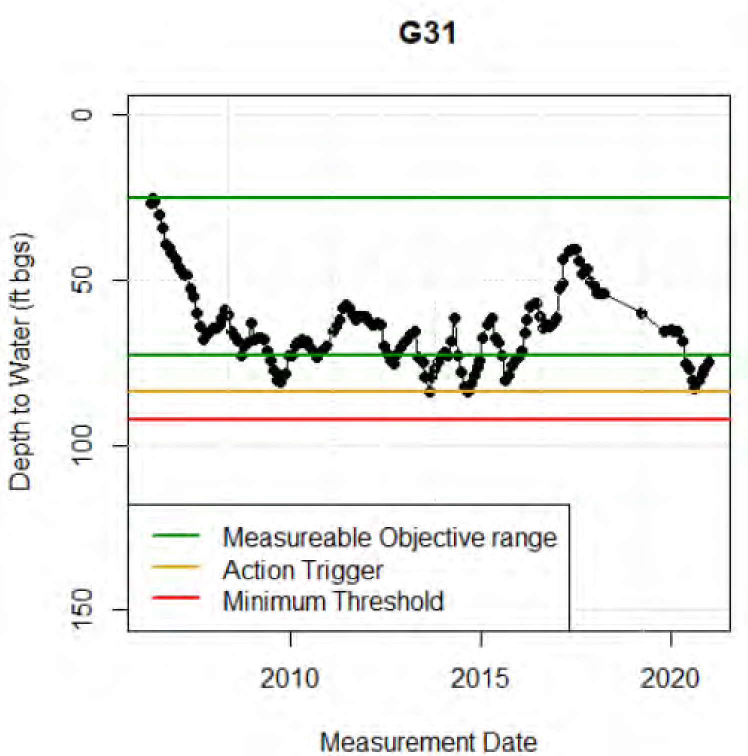


Figure 3.9: Example of Shasta Valley hydrograph for SMC development.

3.4.1.4 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 is intended to provide 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 the MT everywhere across the Basin, about 25 to 45 wells out of approximately 1,000 wells would be at risk of well outage. Well outage risk may also be unevenly distributed across the Basin, with a lower risk for wells in the Western Cascade Volcanics and Pleistocene Volcanics, but higher risks elsewhere.

The following provides greater detail regarding the potential impact of declining groundwater levels 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. Additionally, the lowering of the water table may lead to decreased groundwater quality drinking water wells.
- **Agricultural Users** – Excessive lowering 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** – Lowered groundwater levels may result in significant and unreasonable reduction of groundwater flow toward streams and groundwater dependent ecosystems. This would adversely affect their ecological habitats and resident species. This would adversely affect ecosystem functions related to baseflow and stream temperature, as well as resident species.

To avoid undesirable outcomes beneficial users, 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 ISW and GDEs, where they exist, as it preserves baseline water levels.

3.4.1.5 Relationship to Other Sustainability Indicators

MTs are selected to avoid undesirable results for other SI. Groundwater levels is an important influence on the groundwater storage, depletion of ISWs, water quality, subsidence, and impacts on GDEs. The relationship between groundwater level MTs and MTs for other SI are discussed below.

- **Groundwater Storage** – Groundwater levels are closely tied to groundwater storage, with high groundwater levels related to high groundwater storage. The undesirable result for groundwater storage is measured and thus defined as the occurrence of an undesirable result for groundwater elevations.
- **Depletion of Interconnected Surface Waters** - Currently ISW MTs are based on measured groundwater contributions to a hydraulically connected area of the stream network. Continued data collections will help determine the connection of near-stream wells and groundwater contributions to streams and how that changes based on different management actions. Section 3.3.3.2 provides information on how groundwater levels will be incorporated into ISW in future updates.
- **Seawater Intrusion** - This sustainability indicator is not applicable in this Basin.
- **Groundwater Quality** - A significant and unreasonable condition for degraded water quality is exceeding drinking water standards for COCs in supply wells due to projects and management actions proposed in the GSP. Groundwater quality could potentially be affected by projects and management action-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** - Subsidence has not historically been a problem in Shasta Valley. The groundwater level SMC will ensure that there is no onset of subsidence in the future. The MT for water level is sufficiently close to historic water levels that, under the hydrogeologic conditions prevalent in Shasta Valley, no significant subsidence can occur due to lowering of water levels within the limits set by the MT.

3.4.2 Groundwater Storage

Groundwater levels is the proxy for groundwater storage and the SMCs are identical (Section 3.4.1). According to the United States Geologic Survey, 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. The reduction of groundwater storage is a volume of groundwater that can be withdrawn from a basin or management area, based on measurements from multiple representative monitoring sites, without leading to undesirable results. 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 to chronically low levels, 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 SI. 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 3.4.1.5 for the water level indicator equally applies to define the relationship of the groundwater storage SMC to other SI.

The MO for groundwater storage is the MO for groundwater levels, as detailed in Section 3.4.1.6. 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 3.4.1.7.

3.4.3 Depletion of Interconnected Surface Water

3.4.3.1 Undesirable Results

Undesirable Results in the Context of Interconnected Surface Water

As described in Section 2, groundwater throughout the Basin is interconnected with the Shasta River stream network including its tributaries. As also described in Section 2, the Shasta River stream network is ecologically stressed due, in part, to periodically insufficient baseflow conditions during the summer and fall. Summer baseflow levels are, in part, related to groundwater levels and storage which determine the net groundwater contributions to streamflow. Adverse conditions impact, among others, two species of native anadromous fish, Coho and Chinook salmon. There exists no long-term trend in streamflow minima, but the frequency of low precipitation years has been higher over the past 20 years than in the second part of the 20th century.

The undesirable result that is relevant to SGMA is the stream depletion that can be attributed to groundwater pumping to the degree it leads to significant and unreasonable impacts on beneficial uses of surface water. SGMA also requires that the design of the SMC is consistent with existing water rights and regulations (23 CCR § 354.28(b)(5)). With respect to the ISW SMC in the Basin, relevant rights and regulations include (Cantor et al. 2018): Porter-Cologne Water Quality Control Act (NCRWQCB Basin Plan and TMDL), and Endangered Species Act (ESA). These programs are described in Chapter 2 and briefly summarized here as they relate to the SMC development.

Potential Causes of Undesirable Results

Causes of the overall low flow challenges in the Shasta River stream system include consumptive use of surface water and groundwater and climate variability (which must be accounted for in the GSP). Some consumptive uses of groundwater may have a more immediate impact on streamflow than others; for example, a well that begins pumping groundwater 66 feet (20 meters) from the river bank may cause stream depletion hours or days later, while a well that begins pumping two miles (3 kilometers) east of the river bank may not influence streamflow for months or even a year. Possible causes of undesirable results include increasing frequency or duration of drought conditions, increased groundwater extraction, and continued surface water diversions.

Changes in pumping distribution and volume may occur due to unplanned or unregulated rural, residential, agricultural, and urban growth that depend on groundwater as a water supply. Climate change or an extended drought can lead to reduced snowpack, rainfall reductions, prolonged periods of lowered groundwater levels, and reduced recharge. It may also lead to reduced recharge in surrounding uplands, lowering groundwater inflow to the Basin

The depletion of ISW is considered significant and unreasonable when there is a significant impact to environmental and agricultural uses of surface water in the Basin.

Potential impacts and the extent to which they are considered significant and unreasonable include:

- Inadequate flows to support riparian health and ecosystems (see Section 2.2.2.6 and 2.2.2.7).
- Diminished agricultural surface water diversions, beyond typical reductions for any given water year type.

Because the surface flow of the Shasta River, which is sustained by ISW, is currently inadequate in many years to meet the needs of both the environment and agriculture, a sustained reduction in ISW would constitute an undesirable result.

Under the California Water Action Plan the State Water Resources Control Board is tasked with developing instream flow recommendations based on recommendations developed by the California Department of Fish and Wildlife to allow for sufficient flows for salmonid species within the Shasta River. The development of CDFW flow standards are considered part of the Aspirational Watershed Goal detailed in Section 3.2.

Effects of Undesirable Results on Beneficial Uses and Users

- **Agricultural Land Uses and Users** - depletions of ISW due to groundwater pumping can reduce the surface flow available to downstream diverters.
- **Domestic and Municipal Water Uses and Users** - depletions of ISW can negatively affect municipalities that use surface water as a drinking water source.

  None of the PMAs considered in the GSP development process would change operations for domestic water users pumping less than 2 AFY (2,467 m3/year), as these are *de minimis* groundwater users who are not regulated under SGMA. Similarly, none of the PMAs prioritized in the GSP development process would negatively affect municipal water users.

- **Recreation** - depletions of ISW can affect the ability of users to partake in recreational activities on surface water bodies in the Basin.

- **Environmental Land Uses and Land Users** - depletions of ISW may negatively affect the following: near-stream habitats for plant and animal species; instream ecosystems, including habitat necessary for reproduction, development, and migration of fish and other aquatic organisms; terrestrial ecosystems reliant on surface water; and wildlife that rely on surface waters as a food or water source. Additionally, low flow conditions can result in increased stream temperature that can be inhospitable to aquatic organisms, including anadromous fish. Low streamflow can also lead to increased concentrations of nutrients which can result in eutrophication.

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

Groundwater contributions during the irrigation season

The GSA will not be using a numerical groundwater-surface water model to evaluate ISW at this time and groundwater levels as proxies has been considered not appropriate. A temporary approach based on baseflow calculation will be used. The analytical calculation used to determine Depletion of ISW adequately provides information on the location, quantity, and timing of the identified ISW. The system and identified reaches for ISW monitoring are known to have no surface water inputs during the months of July through September. This allows for direct measurements of groundwater contributions.

MTs for ISWs are based on a water balance approach for lower Parks Creek and Shasta River from Dwinnell Reservoir to the SRM gage. Groundwater contributions to river flows are estimated with a simplified surface water balance.

Technical studies produced in 2016 and 2017 (SVRCD 2017, 2018a) provide detailed water balance measurements for both inflows and diversions on the mainstem of the Shasta River. Reports provided by the SSWD for WYs 2018, 2019, and 2020 were provided to quantify diversion flows from the water balance segment of interest. However this historical record is relatively short and does not include a drought or dry year. Instream flow releases are estimated at 1.5 cfs for WY 2019 and 2020, information from MWCD will be incorporated to accurately reflect true daily instream flow releases. Riparian diversions from the segment of interest is estimated at 20 cfs throughout the growing season. Based on conversations with SSWD staff (SSWD 2021) riparian diverters do not continuously divert flow, estimates are set at approximately 2/3 of total riparian diversion rights. The remaining diversions were measured by the SSWD on the dates show on Table 3.7 and summarized on Figure 3.10. Values of flows from gaging stations are aggregated to mean daily flows of the days of interest. The water balance equation for groundwater contributions during late irrigation season is:

$$Groundwater_{contributions} = SRM - Instream + Diversions$$

Where:

$Groundwater_{contributions}$ is groundwater contributions to baseflow during irrigation season;

SRM is flow out of the USGS maintained SRM gage;

$Instream$ is instream flow releases out of Dwinnell Reservoir;

$Diversions$ are the sum of estimate riparian right holders and measured SSWD diverters.

The equation can be generalize to:

$$Groundwater_{contributions} = Outflow_{reach} - Inflow_{reach} + Diversions_{reach}$$

Where:

$Outflow_{reach}$ is flow leaving a stream reach of interest;

$Inflow_{reach}$ is flow entering a stream reach of interest, may be summed if tributary flow is present;

$Diversions_{reach}$ are the sum of consumptive diversions in the reach of interest.

There are multiple sources of uncertainty in the water balance measurements. Accuracy of stream gages can have up to 10% error in continuous measurements, though uncertainty is likely less with the USGS support in maintaining accurate flow monitoring. Riparian diverters are not measured. Best estimates are, and will continue to be, used to quantify riparian right holders. Water diversions measured by SSWD also operate on variable speed pumps and typically on an 'as needed' schedule. Measured diversions are only applicable to time of measurement, this methodology assumes the diversion rate holds steady throughout the day. No estimates of an energy balance on stream flow is implied with this methodology. Estimates from 2016 through 2020 show groundwater contributions range from 88 to 176 cfs, the evaporative losses and water uptake of riparian plants for ET are not accounted for. While this reach, as a whole, is a gaining stream, this is not proof that no areas in this reach may be losing.

The water balance approach will only be considered valid while surface water uses do not change. If significant changes to near river water use or application change, this approach and quantification of SMCs will need to be adjusted accordingly.

Table 3.7: Data used in estimating groundwater contributions during August and September for quantification of ISW SMCs. (*) Signify estimated values.

Date	SRM Gage (CFS)	Instream Releases (CFS)	Total Diversions (CFS)	Groundwater Contributions (CFS)
8/24/2016	48.8	1.3	89.6	137.1
9/1/2016	65.6	1.2	103.3	167.7
9/19/2016	67.4	1.2	91.6	157.8
8/24/2017	71.4	1.2	99.3	169.5
9/6/2017	75.0	1.5	102.3	175.8
9/21/2017	NA	1.6*	98.9	97.3
8/2/2018	29.2	4.7	84.0	108.5
8/16/2018	34.2	0.9	79.7	113.0
8/23/2018	42.6	2.9	71.6	111.3
8/27/2018	42.2	3	71.4	110.6
9/10/2018	19.8	2.9	76.6	93.5
9/18/2018	53.7	1.1	86.6	139.2
8/7/2019	31.0	1.5*	103.4	132.9

Table 3.7: Data used in estimating groundwater contributions during August and September for quantification of ISW SMCs. (*) Signify estimated values. *(continued)*

Date	SRM Gage (CFS)	Instream Releases (CFS)	Total Diversions (CFS)	Groundwater Contributions (CFS)
8/16/2019	50.7	1.5*	94.9	144.1
8/28/2019	46.9	1.5*	81.4	126.8
9/13/2019	48.9	1.5*	96.2	143.6
9/16/2019	72.4	1.5*	87.6	158.5
8/6/2020	22.3	1.5*	67.4	88.2
8/25/2020	23.6	1.5*	73.1	95.2
9/9/2020	24.5	1.5*	77.7	100.7
9/24/2020	32.9	1.5*	70.7	102.1
9/30/2020	57.3	1.5*	70.5	126.3

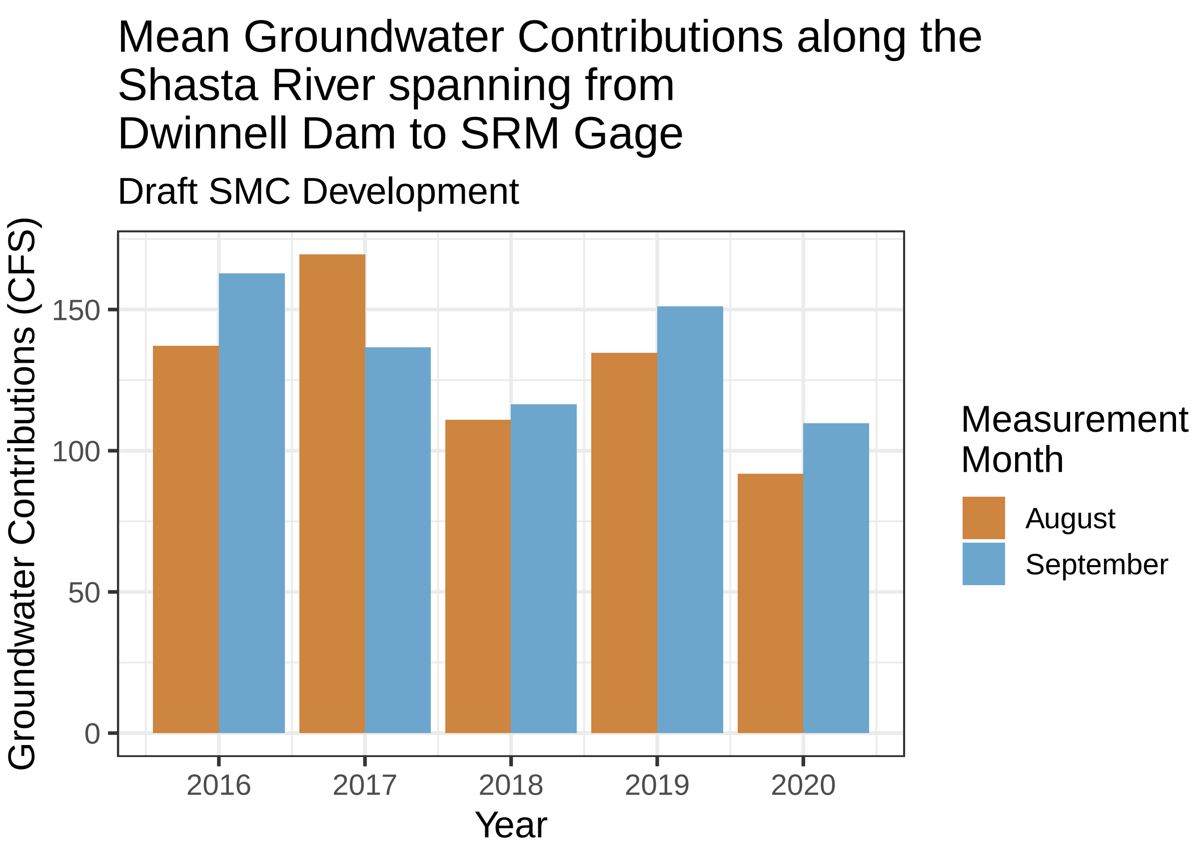


Figure 3.10: Mean groundwater contributions for 2016 through 2020. Data used in establishing MTs and MOs.

Water Levels for Vegetative GDEs

Mapped GDEs in northern section of the Valley (Figure 2.61 in Chapter 2) will be monitored by groundwater elevations in the vicinity. GDE monitoring is best served by continuous monitoring wells within the GDE, but this type of data has been already highlighted as a data gap in the Basin. Water levels in well SV02 are monitored continuously and is currently the best candidate for monitoring groundwater levels for GDEs in the vicinity. Well SV02 is outside any GDE but near enough to monitor groundwater levels. In Section 2.2.2.7, GDEs are identified through historical groundwater levels so nearby monitoring wells should also remain within historical levels. Though SMCs for GDEs are not required by SGMA, the MT for SV02 will be set to protect beneficial users such as GDEs and set at the Fall minimum. Further data collection based on other continuous well monitoring near critical GDEs and satellite images to evaluate twice per year the health of GDEs will be included in the management actions for future monitoring.

3.4.3.3 Minimum Threshold

SGMA defines that depletion of ISW (354.16) is based on groundwater conditions occurring throughout the Basin and not explicitly groundwater extraction or use. The GSP sets the MT based on the calculated baseflow contributions from groundwater, a function of groundwater conditions in the Basin. However, the Basin is expected to operate above the MO at 145 CFS; the difference between the MO and MT is and should be treated as an operational buffer zone to prevent the Basin from approaching the MT. At this time a preliminary MT of 100 cfs of baseflow has been chosen by looking at the typical baseflow under recent conditions, which is limited by a short historical record that lacks sufficient drought year representation. The MT is set at 100 cfs and not higher (closer to 150 cfs in some years) to account for the lack of baseflow data during drought years that would result in lower baseflow contribution. This will prevent the MT from being passed under current conditions in a drought year. Additionally, riparian vegetation and evaporative losses are not included in the MT calculation. If an estimate for these two are included in the calculation, it would reduce the baseflow contribution, which means that the current baseflow estimate is conservative. The two terms will be included in the numerical model update. Additionally, the baseflow calculation does not include tributary contributions. For this reason, the calculation is limited to the critical summer period when major tributaries are dry. Further, the MT may increase pending further discussion with the watermaster and analysis of new groundwater and surface water monitoring data under a greater variety of water year types.

Fundamentally, the GSA currently lacks sufficient groundwater and surface water monitoring data and models to identify depletion of surface water specifically from groundwater pumping and appropriately calibrate the model. At this time there is insufficient groundwater and surface water monitoring data to distinguish what baseflow contribution occurs during periods of influence from groundwater pumping and what baseflow occurs during periods of no influence from groundwater pumping, however, baseflow is still a direct measure of ISW. The numerical groundwater-surface water model cannot be used for this calculation until the identified data gaps (see Appendix 3-A and Chapter 4) are filled. After the data gaps are addressed, the model can be calibrated to properly represent the flow exchange and evaluate groundwater contributions during the entire year.

The focus of the 2027 GSP update is to address data gaps related to the Big Springs Complex, and the focus of the following GSP update will be the Little Shasta River and other Shasta River tributaries, dependent on funding. The GSA plans to collaborate with CDFW to develop in-stream flow requirements with the SWRCB to better protect environmental beneficial users. The UC Davis

Center for Watershed Sciences (CWS) is in the process of developing an in-stream flow assessment of the Little Shasta River (LSR) and have been sharing information that will support the GSP in eventually creating ISW criteria for the LSR as currently there is insufficient data to quantify streamflow depletions or more specifically streamflow depletions due to groundwater extraction.

Due to these data gaps, the GSP also does not have detailed interim milestones for the ISW SMC. These will be developed during first five-year implementation period as additional data become available and the integrated hydrologic model becomes available for developing a more specific ISW SMC, including interim milestones. This may also include determining which reaches that could benefit from reduction in pumping or recharge projects during critical times of the year.

Groundwater contributions during the irrigation season (April 1-October 1)

Based on the limited 5-year history of measurements for the groundwater contributions SMC, a preliminary MT will be set at 100 cfs of average monthly groundwater contributions. Updated MTs will be developed as additional years of data are collected. It is expected that MTs will be developed for different water year types, ie. Critical, Dry, Normal, Above Normal, and Wet.

Trigger measurements will be set at 15 cfs higher than the MT. If the trigger is exceeded for two consecutive non-dry years, additional investigations will be conducted.

Water Levels for Vegetative GDEs

The well SV02 is being used as a proxy until shallow groundwater wells within GDEs can be added to the monitoring network. Based on the seven year history of data recorded in the CASGEM system for SV02, the MT for SV02 will be set at 31 feet below ground surface for the Fall measurement. The MT is set below the possible rooting depths of nearby GDEs because it resides outside GDEs and is simply monitoring nearby groundwater levels.

3.4.3.4 Measurable Objective

A summary of MT, Trigger, and MO can be found on Table 3.8

Groundwater contributions during the irrigation season (April 1 to October 1)

The MO for groundwater contributions during irrigation season will be set at 145 cfs. Updated MO are expected as additional years of data of different water year types are experienced.

Water Levels for Vegetative GDEs

Due to the proximity to the Shasta River to the northeast, approximately 1,000 feet, and the northwest, approximately 2,700 feet, the MO for water levels in this well are constrained.

It is assumed the proximity to the Shasta River, approximately 1,000 feet and 2,700 feet to the northeast and northwest, respectively, provide a large degree of control over the groundwater elevation in the well. The MO will be set to 30 feet below ground surface.

Table 3.8: Summary of SMC values for ISW. The buffer zone of +/- 20 percent stems from the large error in the current MT due to data gaps, short historical record, seasonable variability and regular error.

Measurement Point	Minimum Threshold	Trigger	Measurable Objective
Baseflow	100 CFS (+/- 20%)	115 CFS	145 CFS
SV02	31' bgs	–	30' bgs

3.4.3.5 Relationship to Other Sustainability Indicators

MTs for depletion of ISW are set to measure the direct contribution of groundwater to the surface water system. The magnitude of the contribution should be correlated to groundwater level SI upgradient of the identified contributing area. Due to the complexity of the geologic and hydrogeologic system, additional investigations are required to establish any specific correlations between groundwater levels and ISW. Specific planned monitoring and investigations are documented in Chapter 4 Project and Management Actions.

3.4.3.6 Expected approach modification at the 5-years GSP update

Quantifying Streamflow Depletion due to Groundwater Pumping with the integrated hydrological model

The SWGM model remains the best available tool to evaluate surface water depletion conditions in the Basin and to quantify the amount of depletion attributable to groundwater use. However, to use the model to set SMC for depletion of ISW, the GSA needs to fill critical data gaps such as continuous groundwater level measurements along the monitoring transects and streamflow and spring measurements.

At the five-year update, the approach to calculate ISW SMC will be reevaluated. Depletion of ISW will be calculated using a combination of measured and modeled. Measured information includes high-frequency groundwater level measurements at monitoring network wells, streamflow measurement at assigned gages, spring monitoring and available surface water diversion data. The integrated hydrological model will be updated based on the measured data and re-calibrated to sufficiently match the streamflow and groundwater elevation measurements for the recently collected data. The calibrated model will quantify changes in stream depletion due to pumping by comparing stream depletion of the "business-as-usual" scenario and stream depletion of the no-pumping scenario. The business-as-usual scenario is the simulation of the current conditions using best available data and methods and includes existing and implemented PMAs. The no-pumping scenario is a replicate of the business- as-usual scenario with two primary differences: 1) all pumping from the Basin is removed from the simulation, and, 2) no PMAs are included in the simulation.

This is designed to be an adaptive management process that evolves as new knowledge is gained. A detailed description of the relationship between the numerous data collection efforts and the process of updating the integrated hydrological model is provided in the following subsections. The approach expected at the 5-years update may also be a combination of the currently proposed baseflow approach and the stream depletion calculation based on model results. The model-based approach is the approach currently suggested for Scott Valley, where the model has been implemented for many years and can rely on extensive data for calibration and evaluation.

Adaptive Sustainable Management Criteria Approach for Depletion of Interconnected Surface Waters due to Existing Data Gaps

As explained in the previous section, the lack of historical and high-frequency groundwater elevation data in the Basin, spatial gaps in streamflow and spring measurements, and uncertainty in the historical and current data regarding surface water diversions and groundwater makes current model predictions of location and timing of impacts uncertain. Acknowledging these uncertainties and existing data gaps, the GSA finds it inappropriate to define the ISW SMC at this stage using modelled results of stream depletion. Instead, the GSA proposes an adaptive approach that would help improve the SMC setting in the future using newly collected data while addressing SGMA requirements and avoiding undesirable results throughout the implementation period. This adaptive approach uses the five-year assessment periods as an opportunity to adapt the SMC. The implementable SMC will be set ideally at the first, or ultimately the second five-year assessment period and must be followed for the rest of the implementation period.

The adaptive approach can be summarized as follows:

$$SMC_{MT,MO} = \begin{cases} 1 & \text{if sufficient data is gathered} : f(\text{calculated river depletion}) \\ 0 & \text{otherwise} : f(\text{preliminary baseflow at RMPs}) \end{cases}$$

The GSA will use the baseflow approach in the first five years of the implementation. The GSA will gather data and information during this period to improve its understanding of the surface water and groundwater interaction, cover existing data gaps, and re-calibrate and improve its integrated hydrological model. Upon gathering sufficient data and information, the GSA may proceed to the revision of the SMC for the depletion of ISWs to be based on the volume or rate of depletion of surface water due to groundwater pumping at monitoring transect locations using measured data and model estimation, with an approach similar to what is currently suggested in the Scott Valley GSP.

Assessment and Improvement of the Monitoring Network Assessing and Improving Related Monitoring Network

As discussed above, the identified data gaps include high-frequency groundwater level measurements, streamflow and spring measurements, surface water diversion and groundwater pumping information. If the need is identified, the RMPs network will be expanded by adding new wells, springs and stream gages.

Assessing and Improving the integrated hydrological model

The integrated hydrological model, as a monitoring instrument for surface water depletion due to groundwater pumping, will be assessed and updated every 5 years, utilizing the data and knowledge used for the original/previous model development update plus any additional monitoring data collected since the last model update. New data to be considered in the assessment and update of the model can be grouped into three general categories:

- *Validation and re-calibration data ("target" data)*: These include independently-collected field data, typically collected on a daily, monthly, or seasonal basis. These data are also produced by the model as outputs, which include groundwater levels and streamflows within the Basin and the upper watershed. They are commonly used as calibration targets during model calibration. In other words, model simulation results will be compared with measured data to adjust model parameters (within the limits of the conceptual model) to increase the precision of simulated results including groundwater levels, streamflow rates, etc.
- *Conceptual model data*: hydrologic and hydrogeologic conditions (concept and "input" data). These are the model input data used to parameterize or conceptually design the model. Examples of these data include precipitation data, hydrogeologic data obtained from well logs and aquifer characterization tests (such the one suggested in Chapter 4, under Project and Management Actions), and research insights obtained from projects to further understand the hydrogeology of the Basin. Data from the new AEM surveys collected by DWR will be used the revise the HCM and geologic model as needed.
- *Data about implementation of projects and management actions ("PMA" data)*: These are (monitoring) data collected specifically to characterize the implementation of PMAs to inform the GSA, stakeholders, and the design of future model scenario updates. The specific data to be collected depend on each PMA and are described in Chapter 4.

These newly collected data will be used by the model in three ways:

1. Precipitation and streamflow data measured at weather stations and stream gages will be used to extend the simulation time horizon of the model without any adjustments to parameters, boundary conditions, or scenarios included in the original time horizon of the model. This is a relatively inexpensive model application that allows for updated comparison of simulated water level and streamflow predictions against measured data under baseline and (existing) scenario conditions through the most current time period for which data are available. This type of model application is anticipated to occur at least once every five years concurrently with the five-year assessments, or possibly annually.
2. In addition to (1), data about PMA implementation will be used to update the model to include new, actual PMA implementation data on the correct timeline. This provides a model update that appropriately represents recent changes in PMA implementation and a more consistent evaluation of simulated versus measured water level and streamflow data. This type of model application is anticipated to occur at least once every five years concurrently with the 5-year assessments.
3. In addition to (1) and (2), conceptual model data are used to update model parameters and model boundary conditions unrelated to PMAs to improve the conceptual model underlying the integrated hydrological model based on newly measured data and information. This will typically (but not automatically) require a re-calibration of the model against measured target data. After the re-calibration, all scenarios of interest will be updated using the re-calibrated model to allow for consistent comparison of streamflow. This type of model application is anticipated to occur at least every ten years.

The above protocol ensures tight integration between monitoring programs, PMAs implementation, and the integrated hydrological model. It provides the most accurate estimation not only of streamflow depletion, but also of associated information about water level dynamics, streamflow dynamics and their spatial, seasonal, interannual, and water-year-type-dependent behavior. Examples of future field monitoring data used to assess and improve the model are listed below:

1. Validation and re-calibration data ("target" data):
    - Groundwater levels from the groundwater elevation monitoring network.
    - Daily streamflows measured at the existing and newly installed stream gages.
    - Data documenting dates and locations of dry sections in the stream network.
2. Hydrologic and hydrogeologic conditions (concept and "input" data):
    - Precipitation data from existing climate stations.
    - Potential ET data computed from existing climate stations.
    - Daily streamflows measured at locations near tributary streamflows.
    - Pump test data that contain information about hydrogeologic properties in the vicinity of a well.
    - Geologic information obtained from the new well drilling logs and new DWR AEM surveys.
    - Data collected in conjunction with research and pilot projects characterizing hydrologic and hydrogeologic conditions in the Basin.

3.4.4 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 C. In Section 2.2.2.3, constituents that are identified as groundwater quality concerns include arsenic, benzene, boron, iron, manganese, nitrate, pH, and specific conductivity. SMCs are defined for a select group of constituents: nitrate and specific conductivity. Benzene is already being monitored and managed by the Regional Board through the Leaking Underground Storage Tank (LUST) program. Arsenic, boron, iron, manganese, and pH are naturally occurring and as such, SMCs are not defined.

Groundwater quality monitoring in the Basin in support of the GSP will rely on the monitoring network described in Section 3.3.4.1. Groundwater quality samples will be collected and analyzed in accordance with the monitoring protocols outlined in Section 3.3.4.3. 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 minimum threshold in other sustainability management criteria or in the SGMA regulations.

Surface water is not always available in some areas of the Basin and does not satisfy all agricultural, domestic, and municipal water needs. Groundwater has an important role for those beneficial users of water in certain locations in the valley. Groundwater is also an important component of streamflow and its water quality benefits GDEs and instream environmental resources. 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), Native American

Culture (CUL), and Industrial Service Supply (IND). Potential beneficial uses include Aquaculture (AQUA) and Industrial Process Supply (PRO).

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 sustainability management criteria.

Sustainable management of groundwater quality includes maintenance of water quality within regulatory and programmatic limits (Section 2.2.2.3) while executing GSP projects and actions. 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 Regional Board of any issues that arise and working with the Regional Board to rectify the problem. All future projects and management actions 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.

3.4.4.1 Undesirable Results

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. Degraded groundwater quality is considered an undesirable result if concentrations of COCs exceed defined maximum thresholds or if a significant trend of groundwater quality degradation is observed for the identified COCs. Groundwater quality changes that occur independent of SGMA activities do not constitute an undesirable result. 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 that is determined to be significant and unreasonable. NCRWQCB and the SWRCB are the two entities that determine if water quality degradation is inconsistent with Resolution No. 68-16.

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 ten-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.

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

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 maximum thresholds for concentration, MT, in more than 25% of wells in the monitoring network. Values for maximum thresholds are defined in Section 3.4.3.4. Mathematically, this second condition can be expressed by the following equation:

$$conc75_{2year} – MT \leq 0$$

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.

Potential Causes of Undesirable Results

Future GSA activities with potential to affect water quality may include changes in location and magnitude of Basin pumping, declining groundwater levels and groundwater recharge projects. 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. Fertilizers and other agricultural activities can elevate analytes such as nitrate and specific conductivity. Wastewater, such as sewage from septic tanks and animal waste, can elevate nitrate and specific conductivity. The GSA cannot control and is not responsible for natural causes of groundwater contamination. Natural causes (e.g., local volcanic geology and soils) can elevate analytes such as arsenic, boron, iron, manganese, pH, 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 underground 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 pasture, grain and hay, and alfalfa. 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 seven years of alfalfa production. 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 the valley, but the degree of concern for the effects of animal farming it is not yet known (Harter et al. 2017). The GSP plans to add monitoring wells in Shasta Valley from dairies that would provide additional information on whether these animal farms of concern and will be included in the next GSP update.

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 municipal suppliers, impacted wells may potentially be taken offline until a solution is found, depending on the configuration of the municipal system in question. Where this temporary solution is feasible, it will add stress to and decrease the reliability of the overall system.
- **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, changes in crops that can be grown in an area, and other effects.
- **Environmental Uses** – Poor quality groundwater may result in migration of contaminants which could impact groundwater dependent ecosystems or instream environments, and their resident species, to which groundwater contributes.

3.4.4.2 Maximum Thresholds

Maximum thresholds 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 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 two constituents of concern in the Basin: nitrate, and specific conductivity. Although benzene is identified as a potential constituent of concern in Section 2.2.2.3, no SMC is defined for the constituent as current benzene data is 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 projects and management actions undertaken by the GSA, as applicable. Arsenic, boron, iron, manganese, and pH do not have an SMC because they are naturally occurring.

The selected maximum thresholds for the concentration of each of the two constituents of concern and their associated regulatory thresholds are shown in Table 3.9.

Table 3.9: Constituents of concern and the associated maximum thresholds. Maximum thresholds also include a 15 percent average increase per year over ten years in no more than 25 percent of wells, and no more than 25 percent of wells exceeding the maximum threshold for concentration listed here.

Constituent	Maximum Threshold	Regulatory Threshold	Units
Nitrate as Nitrogen	5 trigger only	10 (Title 22)	mg/L
Nitrate as Nitrogen	9 trigger only	10 (Title 22)	mg/L
Nitrate as Nitrogen	10 MT	10 (Title 22)	mg/L
Specific Conductivity	500 trigger only	500 (50% of Basin Plan Upper Limit)	micromhos
Specific Conductivity	800 trigger only	800 (90% of Basin Plan Upper Limit)	micromhos
Specific Conductivity	900 MT	900 (Title 22)	micromhos

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^{th} percentile value of the monthly means for a calendar year and a 90% upper limit or 90^{th} percentile values for a calendar year. The triggers provided in Table 3.9 for nitrate 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 3.3.4.1. 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 maximum threshold for concentration values are shown in Table 3.9

and Figure 3.11. Figure 3.11 shows example "thermometers" for each of the identified constituents of concern in Shasta Valley Groundwater Basin with the associated maximum thresholds, range of MOs, and triggers.

3.4.4.3 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.

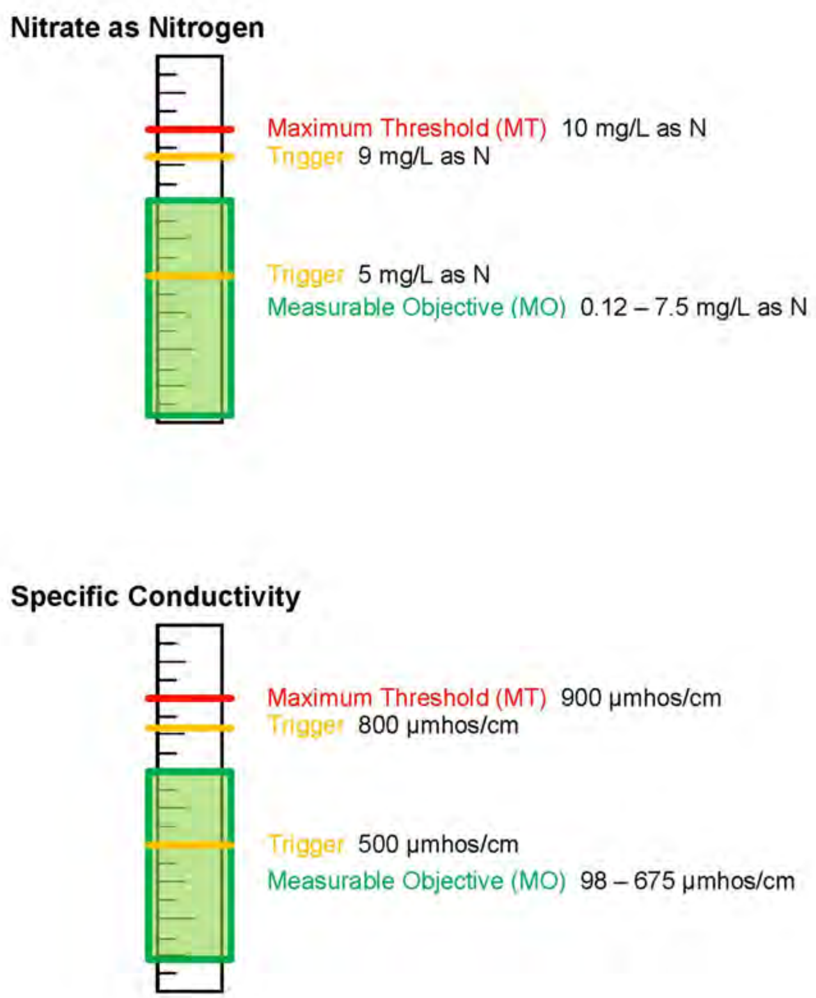


Figure 3.11: Example Shasta Valley MOs of Nitrate and Specific Conductivity. MOs are specific to each well in the monitoring network.

Description of Measurable Objectives

The groundwater quality MO for wells within the GSA's monitoring network, where the concentrations of constituents of concern historically have been below the maximum thresholds for water quality in recent years, is to continue to maintain concentrations at or below the current range, as measured by long-term trends. The MO is defined using the identified constituents of concern, nitrate and specific conductivity.

Specifically, for these COCs, the MO is to maintain groundwater quality at a minimum of 90% 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.

3.4.4.4 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 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 maximum threshold (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 3.12.

If a degraded water quality trigger is exceeded, the GSA will investigate the cause and source and implement management actions 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.

The impacts of high nitrate and specific conductivity in groundwater is discussed in Section 2.2.2.3. Exceedances of 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.

3.4.4.5 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 COCs were identified using current and historical groundwater quality data, this list may be reevaluated during future GSP updates. In establishing maximum thresholds 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 COCs.
- Input from stakeholders resulting from the consideration of the above information in the form of recommendations regarding maximum thresholds and associated management actions.

The historical and current groundwater quality data used in the effort to establish groundwater quality maximum thresholds 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 WQOs) are appropriate to define maximum thresholds for groundwater quality. These maximum thresholds are summarized in Table 3.9, as noted above. The established maximum thresholds for groundwater quality protect and maintain groundwater quality for existing or potential beneficial uses and users. For most analytes, the maximum thresholds align with the state standards listed in Title 22.

New COCs may be added with changing conditions and as new information becomes available.

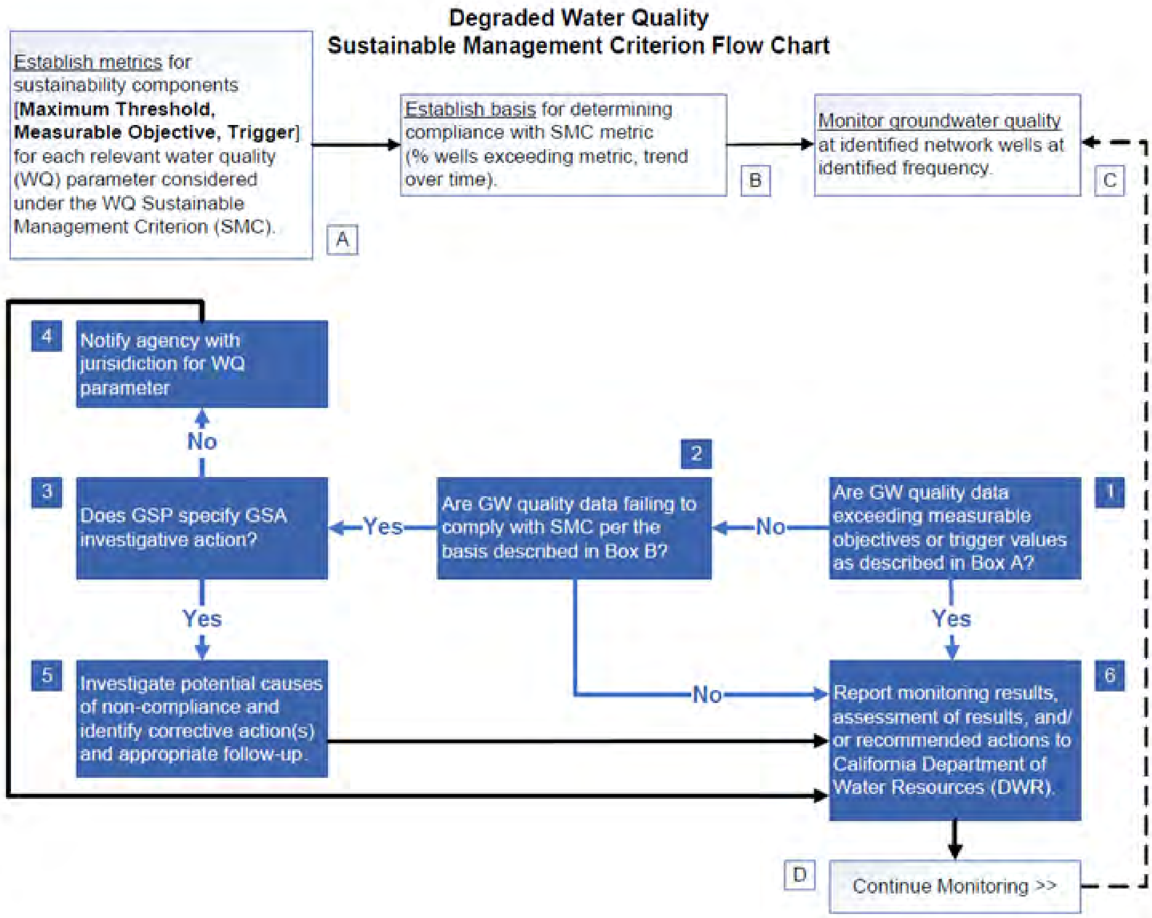


Figure 3.12: Degraded water quality SMC flow chart. The flow chart depicts the high-level decision making that goes into developing SMC, monitoring to determine if criteria are met, and actions to be taken based on monitoring results.

3.4.4.6 Relationship to Other Sustainability Indicators

Groundwater quality cannot typically be used to predict responses of other SI. 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 SI.

- **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 plumes. Changes in water levels may also mobilize contaminants that may be present in unsaturated soils. The maximum thresholds 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** – Groundwater quality that is at or near maximum thresholds is not likely to influence pumping.

- **Depletion of Interconnected surface waters** – Groundwater quality that is at or near maximum thresholds may affect stream water quality.
- **Seawater Intrusion** – This sustainability indicator is not applicable in this Basin.
- **Subsidence** – This sustainability indicator is not affected by groundwater quality.

3.4.5 Subsidence

3.4.5.1 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. 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 and the aquifer materials are unlikely to present such a risk, 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 MT of 0.1 feet (0.03 meters) in any single year, essentially zero subsidence accounting for measurement error. This relies on the fact that the point measurement error of vertical surface displacement measured by InSAR is +/- 0.1 feet (0.03 meters), which is explained in more detail in Section 2.2.2.4 and in Appendix E.

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.

3.4.5.2 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 MT 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 Shasta Valley and neighboring groundwater basins. There are currently no other state, federal, or local standards that relate to this sustainability indicator in the Basin.

3.4.5.3 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.

Land subsidence risk in Shasta Valley is considered low because there is no historical record of subsidence in the Basin and the local geology is composed of alluvial aquifer and volcanic materials that are not susceptible to inelastic subsidence due to groundwater overdraft (see Section 2.2.2.4). Recent InSAR data show no significant subsidence occurring during the period of mid-June 2015 to mid-September 2019.

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 2.2.2.4).

3.4.5.4 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 minimal thresholds) 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.

3.4.5.5 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 the groundwater sustainability plan (GSP) sustainability goal by 2042 and avoid undesirable results as required by the Sustainable Groundwater Management Act (SGMA) regulations, multiple projects and management actions (PMAs) have been designed for implementation by the GSA. This section provides a description of PMAs necessary to achieve and maintain the Shasta 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 goals and measurable objectives, 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.

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 Shasta Valley, the PMAs are designed to achieve two major objectives related to the sustainable management criteria (SMCs) presented in Chapter 3:

1. To achieve the thresholds and objectives for the interconnected surface water sustainability indicator (Section 3.4.5).
2. To prevent lowering of groundwater levels to protect wells from outages.
3. To preserve groundwater dependent ecosystems (GDEs) and avoid additional stresses on interconnected surface water (ISW) and their habitat.

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, organizations, 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 on achieving overlapping, complementary, multi-benefit goals across the integrated water and land use management nexus in the Basin. Particularly PMAs related to water quality, interconnected surface waters, and groundwater-dependent ecosystems will be most successful if implemented to meet multiple objectives with co-operating or collaborating partners. For many of the PMAs, the GSA will therefore enter informal or formal partnerships with other agencies, non-governmental organizations (NGOs), or individuals. These partnerships may be in various formats, 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 which will be defined at the beginning of any collaboration or partnership. 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 respective implementing, lead 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, surface water supply augmentation, stream 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, an example of this type of project is instream flow leases. Habitat improvement projects can include restoration and upland management projects and groundwater recharge projects include managed aquifer recharge (MAR), in-lieu recharge (ILR). Examples of project types within these four categories are shown in Table 4.1. Further, PMAs are organized into three tiers reflective of the 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 (2022-2027) by individual member agencies.
3. **TIER III**: Additional PMAs that may be implemented in the future, as necessary (initiation and/or implementation 2027-2042).

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 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 Shasta Watershed Groundwater Model (SWGM), the effectiveness of each project, or a combination of projects, was assessed to identify those projects that, if implemented, can most likely bring the Basin to achieve 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 and for projects with a capital improvement component. As such, state 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:

1. Supply Enhancement (in Streams)
    - Siskiyou Land Trust (website)
2. Demand Management (of Groundwater)
    - 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)
    - Scott Valley and Shasta Valley Watermaster District (website)
    - Shasta Valley Resource Conservation District
3. Recharge
    - Existing reports, proposals
4. Habitat Improvement
    - National Fish and Wildlife Foundation Grant Slates (website)
    - Shasta RCD (website)
    - Klamath National Forest (website)

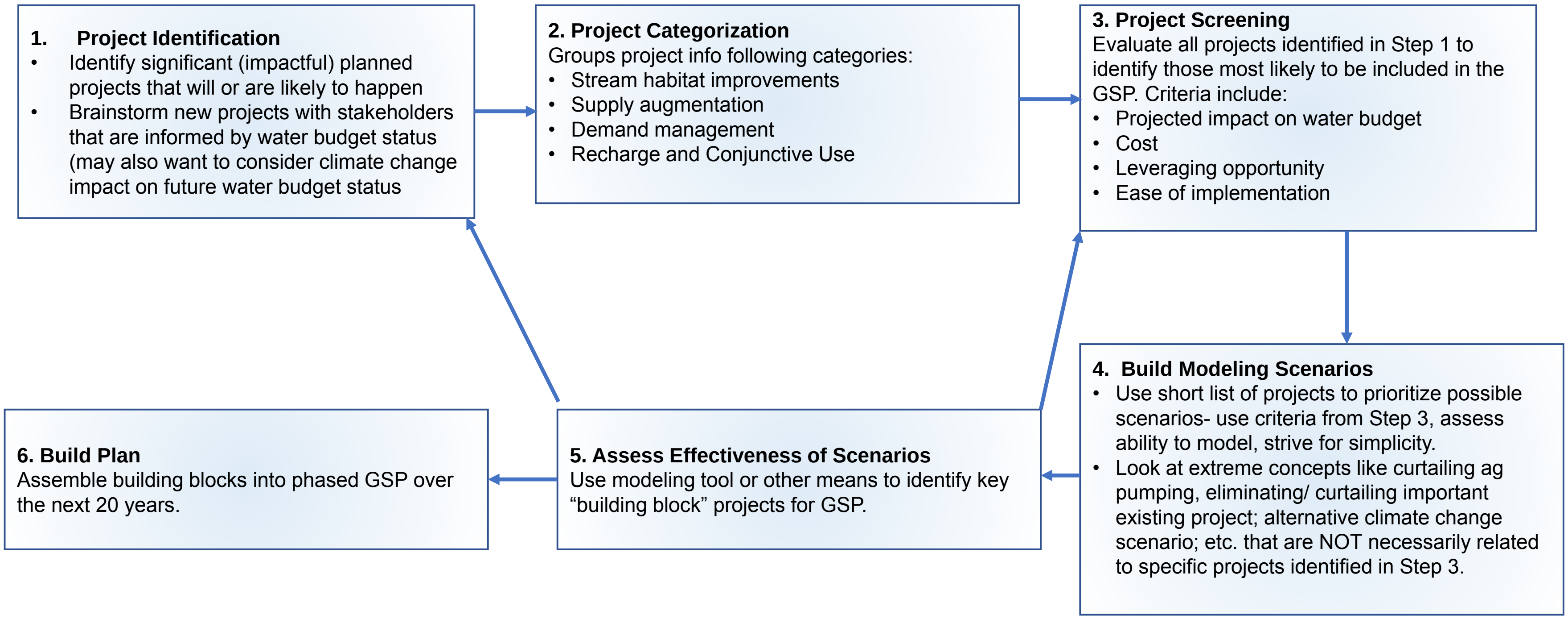


Figure 4.1: Process for identification and prioritization of PMAs. Further details, such as authority and finalized prioritization, are shown in Chapter 5.

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 and County of Siskiyou Groundwater Use Restrictions	Siskiyou County Well Drilling Permits (Standards for Wells, Title 5, Chapter 8 of Siskiyou County Code of Ordinances).	County of Siskiyou	Demand Management	Existing/ Ongoing	Active	1. Groundwater levels
							2. Interconnected surface water.
I	Scott and Shasta Valley Watermaster District	Implements Shasta River Decree. Among other things, a watermaster assists in managing water leases under the authority of Shasta River Water Trust and 1707 dedications and transfers.	Scott Valley and Shasta Valley Water-master District	Demand Management	Existing/ Ongoing	N/A	Interconnected surface water
I	Shasta Watershed Groundwater Model (SWGM) Model Update and Isotope Results	Update the Shasta Watershed Groundwater Model and conduct a groundwater isotope study.	LWA / LLNL	GSA Implementation	Active	Active	GSA Implementation
I	Novy Rice Zenkus Fish Passage Improvement Project	Improve fish habitat on the Shasta River.	Regional Water Quality Control Board, Region 1 (North Coast)	Habitat Improvement			

Table 4.1: Projects and Management Actions Summary. *(continued)*

Tier	Title	Description	Lead Agency	Category	Status	Anticipated Timeframe	Targeted Sustainability Indicator(s) / Benefits
I	Montague-Grenada Weir Modification Project	Improve fish passage on the Shasta River.	Shasta Valley Resource Conservation District	Habitat Improvement	Active	2020-2021	Interconnected surface water
I	Piezometer Transect Study Project	Conduct piezometer transects at key reaches of primary surface water bodies in the Basin.	Shasta Valley Resource Conservation District	Demand Management	Active	2020	Groundwater levels
I	City of Yreka Water Demand	City water shortage contingency ordinance.	City of Yreka	Demand Management	Active	Active	Groundwater levels
I	Shasta River Safe Harbor Agreement	Improve fish habitat on the Shasta River.	CDFW	Habitat Improvement	Active	Active	Habitat Improvement
I	Enhancement of Survival Permits Authorizing Shasta River Template Safe Harbor Agreement and Associated Site Plans/ Recovery of Southern Oregon/Northern California Coast (SONCC) Coho Salmon	Habitat enhancement on private land.	NOAA Fisheries	Habitat Improvement	Active	Active	Interconnected surface water

Table 4.1: Projects and Management Actions Summary. *(continued)*

Tier	Title	Description	Lead Agency	Category	Status	Anticipated Timeframe	Targeted Sustainability Indicator(s) / Benefits
I	Shasta River Tailwater Reduction Plan	Reduce tailwater's negative impacts to water quality.	Shasta Valley Resource Conser-vation District	Conjunctive Use	Active	Active	Groundwater quality
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
	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	Aquifer Charac-terization Analysis	Conduct aquifer characterization studies with large capacity wells.	GSA, TBD	Demand Management	Conceptual Phase	Conceptual Phase	1. Groundwater levels
							2. Interconnected surface water.

Table 4.1: Projects and Management Actions Summary. *(continued)*

Tier	Title	Description	Lead Agency	Category	Status	Anticipated Timeframe	Targeted Sustainability Indicator(s) / Benefits
II	Avoiding Significant Increase of Total Net Groundwater Use from the Basin	Avoid significant future increase of total net groundwater use above the most recent 20 year period (2000-2020) within the Basin through planning and coordination with land use zoning and well permitting agencies.	GSA, County of Siskiyou	Demand Management	Conceptual Phase	Conceptual Phase	1. Groundwater levels
							2. Interconnected surface water.
II	Conservation Easements	Conservation easements in Shasta Valley that enhance stream flow during the critical low flow period.	TBD	Supply Augmentation	Planning Phase	Development expected over the next five years	Interconnected surface water
II	Upslope Water Yield Projects	Building green infrastructure in the upper watershed to increase water yield. Green infrastructure includes fuel reduction, road improvements, canopy opening to manage snow shade and accumulation, and other large landscape projects that increase water storage within the upper watershed during wet periods and baseflow from the upper watershed during dry periods.	TBD	Supply Augmentation	Planning Phase	Planning Phase	Interconnected surface water
II	Habitat Improvement in Shasta Watershed	Improve wildlife habitat conditions in the Shasta watershed	GSA, TBD	Habitat Improvement	Planning Phase	Implementation	Interconnected surface water
II	Instream Flow Leases	Temporary transfer of a water right to protect instream flows	GSA, TBD	Supply Augmentation	Planning Phase	Planning Phase	Interconnected surface water

Table 4.1: Projects and Management Actions Summary. *(continued)*

Tier	Title	Description	Lead Agency	Category	Status	Anticipated Timeframe	Targeted Sustainability Indicator(s) / Benefits
II	Irrigation Efficiency Improvements	Increase irrigation efficiency (and in some cases, yields) through infrastructure or equipment improvements. Consider funding incentives through the NRCS EQIP program.	GSA, UCCE	Demand Management	Planning Phase	Planning Phase	1. Groundwater levels
							2. Interconnected surface water.
II	Juniper Removal	Remove juniper	GSA, USFS, TBD	Habitat Improvement	Conceptual Phase	Conceptual Phase	1. Groundwater levels
							2. Interconnected surface water.
II	Public Outreach	Public outreach and education for GSA stakeholders.	GSA	GSA Implementation	Planning Phase	Implementation	GSA Implementation
II	Reporting of Pump Volumes	Reporting of pump volumes for pumps above 500 gpm and commercial purposes.	GSA, TBD	Demand Management	Conceptual Phase	Conceptual Phase	Groundwater levels
II	Voluntary Managed Land Repurposing	Reduce water use through voluntary managed land repurposing activities including term contracts, crop rotation, irrigated margin reduction, conservation easements, and other uses	GSA, TBD	Demand Management	Conceptual Phase	Conceptual phase	1. Groundwater levels
							2. Interconnected surface water.
II	Well Inventory Program	Improve the GSA database of wells within the Basin.	GSA	GSA Implementation	Planning Phase	Planning Phase	GSA Implementation

Table 4.1: Projects and Management Actions Summary. *(continued)*

Tier	Title	Description	Lead Agency	Category	Status	Anticipated Timeframe	Targeted Sustainability Indicator(s) / Benefits
	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	1. Groundwater levels
							2. Interconnected surface water.
III	MAR & ILR	Managed aquifer recharge and - during the irrigation season - in lieu recharge on irrigated agricultural land to increase baseflow during the critical summer and fall low flow period.	GSA	Recharge	Planning Phase	Planning Phase	1. Groundwater levels
							2. Interconnected surface water.
III	Shasta Recharge Pilot Project	Baseline study and pilot project in Grenada and Gazelle	GSA, TBD	Recharge	Conceptual Phase	Conceptual Phase	1. Groundwater levels
							2. Interconnected surface water.
III	Strategic Groundwater Pumping Restriction	Strategic timing of groundwater pumping restrictions. This management action would only be developed if Tier I and Tier II PMAs are insufficient. It would be an alternative tool for the GSA in support of the groundwater level SMC.	GSA	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
III	Reservoirs	Capture and store runoff and excess streamflow.	TBD	Demand Management	Conceptual Phase	Conceptual Phase	Groundwater levels
III	Coordinated Shasta Valley Irrigation Management	Rotate diversions and other tools to maintain instream flows.	SSWD or RCD	Demand Management	Conceptual Phase	Conceptual Phase	Interconnected surface water.

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.

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, these management actions benefit multiple sustainability indicators, including declining groundwater levels, groundwater storage, and depletion of interconnected surface waters.

Scott and Shasta Valley Watermaster District

Water master services currently exist for the Shasta River and its tributaries. Other than their primary duties of carrying out the Shasta River Decree, a water master may provide monitoring of water leases and Water Code 1707 dedications and transfers.

Shasta Watershed Groundwater Model (SWGM) Model Update and Isotope Results

A partnership between Larry Walker Associates (LWA) and Lawrence Livermore National Laboratory (LLNL) is updating the SWGM for further evaluation of isotope data collected by LLNL by updating the model to the current date, refining the calibration, developing MODPATH simulations, and including isotope results. The current version of the SVIHM simulates the period from 1991 to 2018 because it was the period of data available at the time model development began. The project is adding three years (2019 to 2021) of new hydrologic data to the model inputs to extend the simulation period to near present day, water year 2021. The Shasta Valley PRMS simulation will use updated PRISM rainfall and evapotranspiration datasets and modeled surface water results from Paradigm to extend the modeled runoff, infiltration and streamflow that compose the major inputs to the groundwater model.

The current version of SWGM uses periodic groundwater elevation measurements (typically biannual) and streamflow data from a limited number of sites from 1991 to 2018 to compare simulated groundwater elevations and streamflows to observed data. The current calibration of the groundwater model is limited to biannual groundwater level measurements which allow adequate calibration of the hydraulic conductivity however, more continuous groundwater level data is needed in the calibration to improve estimates of the storage coefficients based on seasonal trends. Continuous groundwater and surface water data have been collected from 2019 to present that will allow the calibration period of the SVIHM to be extended and provide much more data both on groundwater storage dynamics and groundwater-surface water interaction dynamics.

MODPATH simulations will be developed using the groundwater flow vectors calculated by SWGM from the period 1991 to 2018 which will be used to forward and backward track the paths of particles. Forward flow tracking will be used initially to understand where water from different types of model recharge such as streams, soil infiltration and canals flows. Backward particle tracking will be used to identify the location of source water from observation wells that were sampled for isotope analysis and will indicate which recharge source it likely comes from. The MODPATH backward tracking simulation can be used to approximate the age of water by injecting many particles at the observation point and tracking the time it takes between the particle reached the well and was initially recharged.

The MODPATH backward tracking resulting in source area identification and approximate groundwater age will be compared to the isotope analysis of groundwater age and likely source. The isotope analyses will assist in validating MODPATH results and identifying areas where the model may need further refinement to improve the representation of recharge and groundwater flow dynamics.

Novy Ice Zenkus Fish Passage Improvement Project

The goal of the project is to improve habitat conditions, water quality, and fish passage on the main-stem Shasta River. The project includes irrigation dam improvements, fish screen relocation and improvements, and irrigation pipeline installation. Relocating the fish screen to the point of diversion will reduce fish entrainment in irrigation canals and eliminate the need for the existing fish return bypass channel, which results in warm water discharges to the Shasta River and potential fish stranding. Piping irrigation water will reduce ditch loss in the system and will result in a reduction of the quantity of water diverted.

Montague-Grenada Weir Modification Project

The purpose of this project is to improve fish passage for salmon species through all life stages while preserving the ability of the existing measuring weir to provide accurate flow measurements in the Shasta River. This project will also improve flow control at the pump station just downstream from this concrete structure.

Piezometer Transect Study Project

As part of the monitoring network, the SVRCD is conducting piezometer transect studies, herein referred to as “the Project,” at three discrete locations in the Basin. At each of the three locations the Project consists of installation of a stilling well to measure river stage within the channel, and up to four piezometers, or shallow monitoring wells, in a series spanning key reaches of primary surface water bodies within the Basin. The piezometer transects will provide critical information about when a given reach is gaining water, losing water, and increase understanding of interactions between surface water and groundwater through better representation of the gradient between river and aquifer and for model refinement. Details on the location of the transects are provided in Chapter 2 and in Appendix 2-H.

City of Yreka Water Demand

The City adopted a water shortage contingency ordinance in August 2015 and is found in Chapter 12.12 “Water Efficiency” of the Yreka Municipal Code.

Shasta River Safe Harbor Agreement

The Shasta River Safe Harbor Agreement supports recovery of federally threatened coho salmon while also supporting local farms and ranches. The voluntary agreement was signed in early 2021, between private landowners and the California Department of Fish and Wildlife (CDFW). Other key partners include California Trout, The Nature Conservancy, and NOAA Fisheries. Private landowners agree to maintain or improve habitat for instream wildlife, specifically Coho salmon, in exchange for regulatory assurances that remove the risk of additional regulation and penalty under the Endangered Species Act (NOAA 2021).

Enhancement of Survival Permits Authorizing Shasta River Template Safe Harbor Agreement and Associated Site Plans/ Recovery of Southern Oregon/Northern California Coast (SONCC) Coho Salmon

Safe Harbor agreements allow private landowners to implement habitat enhancement projects on their land in support of recovery of species protected under the Endangered Species Act (ESA).

Shasta River Tailwater Reduction Plan

Watershed-wide planned and prioritized approach that guides efforts to reduce tailwaters’ negative impacts to water quality, mostly temperature. Temperature has not been the main focus of this GSP, but it will be considered in further developments.

Upland Management

Upland management includes removal of excess vegetation, which reduces evapotranspiration and increases rainfall percolation to groundwater. This can occur on US Forest Service, Bureau of Land Management, or private land. The US Forest Service regularly manages sections of US Forest Service land. Juniper removal can have a long-term effect on water levels. More details on future expanded upland management are provided under the “Upslope Water Yield Projects” described under Tier II.

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**
  - **Shasta Watershed Groundwater Model 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. Aquifer Characterization Analysis**
- **iii. Avoiding Significant Increase of Total Net Groundwater Use from the Basin**
- **iv. Conservation Easements**
- **v. Upslope Water Yield Projects**
- **vi. Habitat Improvement of Shasta Watershed**
- **vii. Instream Flow Leases**
- **viii. Irrigation Efficiency Improvements**
- **ix. Juniper Removal**
- **x. Public Outreach**
- **xi. Reporting of Pump Volumes**
- **xii. Voluntary Managed Land Repurposing**
- **xiii. Well Inventory Program**

Shasta Watershed Groundwater Model Update (High Priority)

Project Description

Planned future updates to the SWGM will build on the Tier I PMA "Shasta Watershed Groundwater Model (SWGM) Model Update and Isotope Results" and will include:

- After the PMA "Interconnected Surface Water Data Gaps" has been addressed, the GSA will update SWGM to include include an improved representation of surface water - groundwater interaction.
- Update with more new data and extend the model to more recent years to capture additional climate and pumping patterns, particularly the last drought. Also the new continuous groundwater level data will aid the calibration of the SWGM 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 that triggered a water right curtailment in the Shasta River Watershed (Order WR 2021-0082-DWR). The GSA will analyze all data collected within the 2021 water year to study how the 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:

1. Expansion of the groundwater level monitoring network to areas of interest, with an emphasis on continuous monitoring data. Monitoring wells near surface water and potential GDEs are needed. Additional monitoring of domestic wells is needed.
2. 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 Shasta Valley 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 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.

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 5-year GSP update.

Interconnected Surface Water Data Gaps (High Priority)

Project Description

The GSA will work with CDFW and other interested stakeholders to address the data gaps related to interconnected surface water (ISWs) in the Basin (Appendix 3-A). This includes:

- Establishing a monitoring station at Big Springs Creek (Water Wheel) to collect data for the Big Spring Complex
- Installing stream gages on Shasta River tributaries to record seasonal flow.
- Extending the groundwater level monitoring network to areas near ISWs.
- Conducting a pilot study of shallow monitoring wells or alternative options to analyze if surface water bodies are connected or disconnected to groundwater.
- Collecting surface water data for the numerical model such as surface water diversions, canal seepage, streamflow losses, and percolation from wetlands.
- Reanalyze potential ISWs after additional data is collected and surface water has been incorporated into the numerical model.
- Redevelop or create new 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).

Aquifer Characterization Analysis

Coordinate with parties that have large capacity wells to conduct aquifer characterization studies throughout the Basin. Typically, these studies would include collection of one week of baseline data including static water level of the pumping well and static water level and water level trends of nearby wells, spring discharge measurements of any nearby springs, and an upstream and downstream flow measurements of any nearby streams. This data will be critical to better understand the geology and hydrogeology of the Basin and will be used to:

1. Update the Shasta numerical model to better represent hydrogeologic conditions.
2. Evaluate groundwater-surface water interactions for specific springs, reaches, and areas.
3. Evaluate location specific project and management actions.

Robust aquifer characterization will have high upfront costs but information from these tests will be incorporated and used indefinitely in sustainable groundwater management in the Basin. Areas of interest include:

- Pluto's Cave area, located east, northeast, and southeast of the Big Springs Complex.
  - Area identified to increase understanding of potential flow paths of the Big Spring Complex.
- Big Springs Irrigation District service area.
  - Identified to understand groundwater-surface water interactions of the BSID area and flow in the Shasta River.
- Grenada and Gazelle areas
  - Areas identified as potential areas for Flood MAR. Timing and flow of recharge required to better evaluate climate impacts and potential management actions.
- Little Shasta River upper watershed
  - Poorly understood hydrogeologic area with multiple springs of different characteristics. Identified as a data gap in understanding how recharge and flow connects with the larger Shasta Basin.

Avoiding Significant Increase of Total Net Groundwater Use from the Basin

Project Description

The goal of this MA is to avoid water level declines and additional stream depletion in Shasta Valley that would result from significant expansion of net groundwater use relative to the practice over the past two decades. 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, canal leakage, 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 are indicative of significant increases in long-term average net groundwater use. While not leading to overdraft, such increase of net groundwater use would result in less groundwater discharge toward the Shasta River and, hence, lower dynamic equilibrium water levels in the Basin or portions of the Basin, possibly at levels lower than the minimum threshold (MT) for groundwater levels or for ISWs, for significant periods of time (see Chapter 2.2.3.3). This management action (MA) helps to ensure that the sustainable yield of the Basin is not exceeded (see Chapter 2.2.4) and that sustainable management criteria are met.

The MA sets a framework to develop a process for avoiding significant long-term increases in average net groundwater use in the Basin, while protecting current groundwater and surface water users, allowing Basin total groundwater extraction to remain at levels that have occurred over the most recent twenty-year period (2000 to 2020). By preventing future declining water levels, the MA will help the GSA achieve the measurable objectives of several sustainability indicators: groundwater levels, groundwater storage, subsidence, and ISWs and GDEs.

Due to the direct relationship between net groundwater use and ET, implementation of the MA is measured by comparing the most recent five- and ten-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 increase of total net groundwater use. This can be achieved 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 due to additional recharge dedicated to later extraction. 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 – avoiding declining water levels below those corresponding to the most recent twenty-year period.
- Groundwater storage – avoiding declining water levels below those corresponding to the most recent twenty-year period.
- Depletion of Interconnected Surface Waters and Protection of Groundwater-Dependent Ecosystems – Avoiding depletion of interconnected surface waters with declining groundwater levels.

Circumstances for Implementation

Currently, there is no threat of chronically declining water levels in Shasta Valley. The Basin is not in a condition of overdraft. Future threats to groundwater levels fall into two categories, further explained below:

- Increased total net groundwater use in the Basin (total net groundwater use: difference between Basin landscape recharge and Basin pumping).
- Reduced recharge into and runoff from the watershed surrounding the Basin

This MA ensures that future declining water levels are not the result of any significant expansion of groundwater pumping in the Basin (first category), which would lead to new, lower equilibrium groundwater level conditions (see Chapter 2). While not constituting a condition of overdraft, these new dynamic equilibrium conditions may possibly exceed the MT for water level, also affecting the protection of GDEs and increase the depletion of ISW due to groundwater pumping at periods of critically low streamflow and spring flow conditions (summer and fall). Groundwater levels in the Basin are fundamentally controlled by:

- The elevation and location of the Shasta River along the valley. The Shasta River is a net gaining stream, naturally draining the Basin. Segments of the river switch from gaining to losing during the year, but on annual average the entire river is always a gaining system. Water budget analysis presented in Chapter 2 provides more details.
- The amount of recharge from surface water feature in the upper part of the Basin, including Shasta River, Lake Shastina, and along westside creeks over their upper and middle alluvial fan sections; and the amount of recharge over the watershed to the south and east of the Basin and subsequent groundwater inflow from the upper watershed into the Basin.
- The amount of recharge from the Basin landscape due to precipitation, irrigation return flows, canal recharge, flooding, and MAR.
- The amount of groundwater pumping for irrigation (the net consumptive groundwater use from domestic and public users is relatively small after accounting for return flows from septic systems and wastewater treatment plants to either groundwater or streams).

A dynamic equilibrium already exists between subsurface inflows, subsurface outflows, recharge across the Basin, groundwater pumping, and net discharge to the Shasta River. Water levels near the Shasta River vary within a relatively small range due to the interconnectedness of groundwater and surface water at the Shasta River. Water levels generally slope from the valley margins toward the Shasta River. Water levels fluctuate most near the valley margins: in the upper eastside gulches and near the western mountain front.

A significant future increase in net groundwater use within the Basin would lead to less groundwater discharge toward the Shasta River and, hence, a lowering of the water level gradient toward the Shasta River. A lower water level gradient means permanent lowering of the water table in the Basin or portions of the Basin. By preventing a significant long-term increase in total net groundwater use through proactive planning, Basin, which is not in overdraft conditions, remains at a dynamic equilibrium in water level conditions, above the MT, as long as natural recharge from streams flowing into the Basin remains stable. Other sources of recharge include canal leakage and percolation from excess irrigation.

Decreasing Recharge in or Runoff from the Surrounding Watershed

The Basin is part of the larger Shasta Valley watershed (Watershed). The Watershed has negligible groundwater inflows, but significant, if limited groundwater outflow along its northern boundary, which it shares with the northern Basin boundary. The Watershed's volcanic aquifer system is fully connected with the Basin's volcanic aquifer system. As a result, significant groundwater inflow to the Basin occurs on the southern and eastern Basin boundary, within the Watershed, as a result of recharge in the upper sections of the Watershed. Hence, groundwater pumping outside the Basin may significantly impact groundwater within the Basin.

Long-term climate changes cause changes in both precipitation amount and in snowmelt timing over the Watershed. This will affect the dynamics of groundwater flow from the upper Watershed, outside the Basin, into the Basin. On the westside of the Watershed, stream inflow dynamics at the Basin boundary may be affected as well and thus recharge into the alluvial aquifer portions of the Basin. Finally, the amount of surface water diversions may change, which in turn affects pumping in the Basin. The SWGM will be used throughout the implementation period to assess the impacts of these changes on sustainable yield. Preliminary scenarios of future climate change impacts evaluated using the parameters suggested by Department of Water Resources in its climate change guidelines are presented in Chapter 2.

Historic water levels indicated that there is no overdraft and no long-term decline in water levels. Where water levels have been observed since the 1960s, declines in dry year fall water levels occurred in the 1970s, relative to prior decades, but have been steady over the past forty years. Average precipitation over the past twenty years (2000 to 2020) has been significantly lower than the average precipitation during the measured record in the 20th century (Figure 4.2, also see Chapter 2).

Based on current conditions in the Basin, this MA will be implemented immediately upon approval of the GSP by DWR and negotiation of partnerships with relevant agencies. During MA implementation, if groundwater levels stabilize at higher elevations due to GSA activities or climate change, total net groundwater use and the sustainable may be adjusted upward. The mechanism for off-ramping the MA is described in the implementation section below.

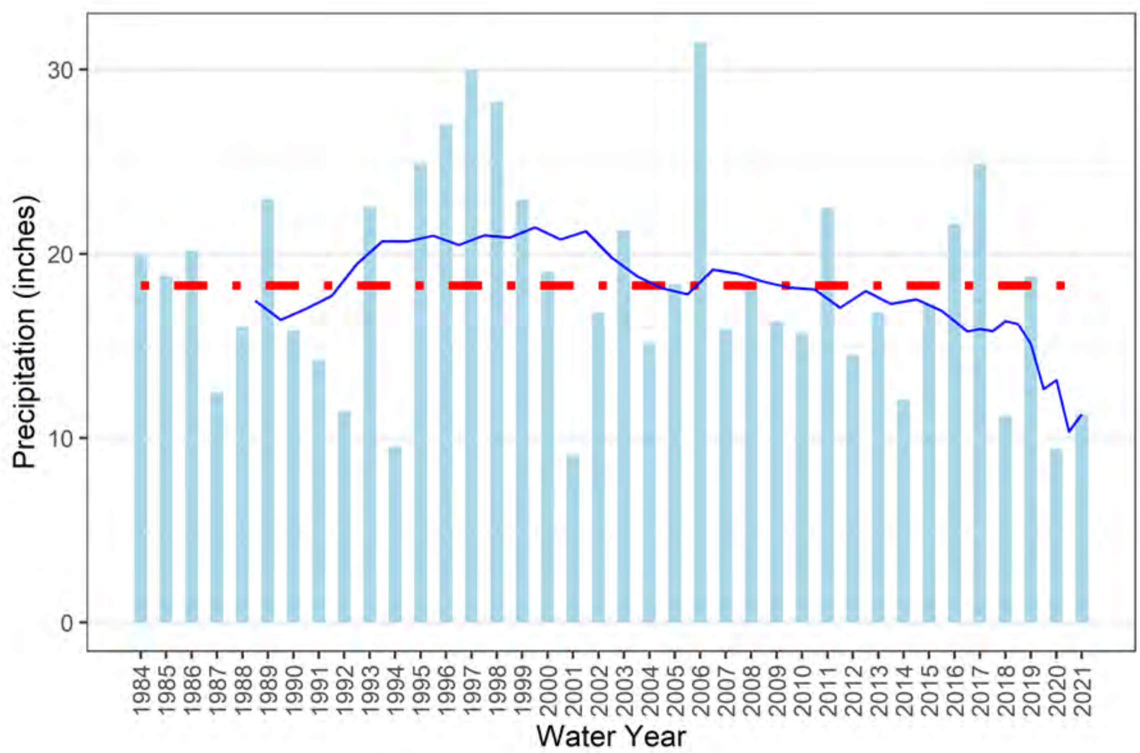


Figure 4.2: Annual precipitation over the 1982 to 2021 record as measured at Yreka CDEC station (YRK). The long term mean (18 in) shown as a red dashed line, and the 10 year rolling mean is the blue trendline.

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 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 Shasta Valley Basin. The permitting program would ensure that construction of new extraction wells does not significantly expand current total net groundwater use in the Basin (to the degree that such expansion may cause the occurrence of undesirable results). This can be achieved through commensurate well retirements and through 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 ten-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 in the Basin include:

- Siskiyou County
- City of Montague
- City of Yreka
- City of Weed

The objective of the partnership is for those agencies to develop land use zoning and land use permitting programs that are supportive of and consistent with the GSA's goal not to expand total net groundwater use in the Basin. Developing close partnerships and timely transfer of information will best prevent an expansion of total anthropogenic consumptive water use in the Basin. 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 not currently planned to occur in Shasta Valley in the near future. If needed it would be by expansion into either agricultural or natural lands, within the constraints of land use planning objectives and zoning laws. 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 ecologic, public interest, and hydrologic or hydrogeologic constraints to such exchanges.

Agricultural expansion, where permissible under zoning regulations, is similarly made possible, e.g., 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 prolonged 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.

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 house-hold water use other than irrigation is returned to groundwater via septic systems leachate, while irrigation contribute as deep percolation. 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.

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 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.

Implementation: Monitoring

In a groundwater basin where agricultural pumping exceeds 95% of applied groundwater use in the Basin, 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 evapotranspiration (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). Monitoring of Basin ET, together with the monitoring programs outlined in Chapter 3 and use of the SWGM provide the basis for comprehensive monitoring of net groundwater use in the Basin. Furthermore, water level and groundwater storage monitoring (Chapter 3) provide an instrument to continually assess the effectiveness of avoiding the expansion of total net groundwater use.

Legal Authority

The GSA only has authority for groundwater within the Shasta Valley Groundwater Basin. The GSA has no land use zoning authority. The GSA will collaboratively work with the County of Siskiyou, other land use zoning agencies, and stakeholders within the Shasta Valley Basin to implement this MA.

Schedule

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 2000 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 voluntary market instruments.

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 projects and management actions.

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 PMA is to avoid water level declines in Shasta River Valley that are due to further expansion of total net groundwater extraction in the Basin.
- The PMA sets a framework to develop a process for avoiding significant long-term increases in net groundwater extraction in the Shasta Valley.
- Total net groundwater use remains at levels that have occurred over the most recent twenty-year period (2000 to 2020).
- Monitoring: Compliance with the PMA is measured by determining whether the most recent ten-year running average Basin sum of agricultural and urban ET remains at or below levels measured for the 2010 to 2020 period, within the limits of measurement uncertainty (about 10%).

Upslope Water Yield Projects

Project Description

The objective of these types of projects is to increase water yield from the upper watershed, through green infrastructure. Green infrastructure may include fuel reduction, road improvements, canopy opening to manage snow shade and accumulation, and other actions that reduce direct runoff to surface waters.

The project is currently in the feasibility and planning phase, and areas that would be suitable are being evaluated. Anticipated benefits from these types of projects include increased water storage in the upper watershed during the wet season, improved flows from the upper watershed during the dry season, and the support of desired instream flow conditions.

Changes in streamflow entering the Basin will be monitored and evaluated through existing and proposed new streamflow gauges on key tributaries and mostly on the main stem of the Shasta river (see Section 3.3) and through statistical analyses of these data.

Habitat Improvement in Shasta Watershed

The GSA will cooperate with a combination of agencies to improve habitat conditions within the Shasta watershed. This will include a combination of treatments including adding large woody debris along four miles of stream, modification of stream crossing structures, and meadow restoration. Other treatments include riparian fencing, tree planting, and bank enhancement. These treatments will add stream habitat structure and complexity, improve connectivity and aquatic organism passage. These improvements will not directly have an impact on groundwater conditions and/or on groundwater use, but they should be included as potential multi-benefit projects where the GSA can develop collaboration with other agencies and enhance opportunities for funding.

Instream Flow Leases

The GSA and will work with stakeholders to research developing a program of instream flow leases.

Irrigation Efficiency Improvements

Project Description

Achieving increases in irrigation efficiency through equipment improvements are anticipated to reduce irrigation pumping and diversions during the growing season, lessening the chance of river disconnection during critical periods. This is expected to support desired instream flows, fish migration, and aquatic habitat. However, improving irrigation efficiency may have both positive and negative impacts on surface flows, but because of differences in timing, the net effect during the dry season is expected to be positive. Higher irrigation efficiencies reduce the amount of surface water diversion and groundwater pumping during the irrigation season, benefitting stream flows. Higher irrigation efficiencies also reduce the amount of recharge to groundwater to the degree that ET is not significantly reduced. This will increase stream depletion. For pumping near streams, the effect of reduced pumping has a more immediate impact on surface water depletion, whereas the effect of reduced recharge on stream depletion may be delayed in time. This may provide short-term gains in stream depletion reversal, balanced by later increases in stream depletion (from lack of recharge), but outside of the summer baseflow season. More direct gains in stream depletion reversal come from reducing the amount of evaporation from irrigation spray, e.g., when converting to highly efficient LESA systems on center pivots.

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. This may also include incentives for switching to less water-intensive crops. Cost estimates have not yet been completed for this PMA.

Future benefits of actual implementation status to streamflow depletion reversal (and remaining streamflow depletion) will be evaluated and assessed with SWGM using the methodology described in Chapter 3.3 and using monitoring data describing the implementation of the irrigation efficiency improvement program.

Monitoring data in the 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, ET) based on equipment specification, scientific literature, or field experiments
- Cropping systems in fields with improved irrigation efficiency equipment
- Metering of water use

Juniper Removal

The GSA, USGS and other agencies and private stakeholders will remove excess juniper within the watershed to improve groundwater levels. While it is conceptually possible to increase water yield for some number of years following juniper removal, it is difficult to actually implement at a watershed scale and maintain over time. Furthermore, juniper removal will not necessarily increase water yield in all climates, so local conditions will be evaluated (Niemeyer et al. 2017). This project will be considered within a holistic management framework that re-establishes historical fire regimes and does not focus solely on water yield. Maintenance would be needed because the benefits of one-time removal projects are likely to be short-lived (Fogarty et al. 2021).

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 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.

Reporting of Pump Volumes

Owners of groundwater wells meeting certain criteria would be responsible for implementing a reporting system of groundwater pumped over the next five years. Reporting over the next five years will be done on a volunteer basis The criteria for reporting pumping volume are:

- Pumps operated above a specific pumping volume with values will be provided by pump and by owner; or
- Pumps used for commercial purposes.

Reporting can be conducted one of three ways:

1. A flow meter or totalizer will be installed and read on a monthly basis.
2. Monthly electrical use from the pump can be reported in-lieu of pump volume (when possible). However, using power consumption does not work for variable frequency drives (VFDs).
3. Monthly report of acres of irrigated land, irrigation method, and crop type. Data will be used to better quantify groundwater extraction spatially and temporally throughout the Basin. Possible subsidies in installation of flow meters from Prop 68 Implementation funds.

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 and instream flow during the critical late spring recess, summer baseflow, and early fall flush flow period. The GSA will have ongoing outreach to encourage volunteers for these activities. 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. The Shasta River Water Transactions Program is an example of such a term contract.

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. Other voluntary managed land repurposing projects include conservation easements that reduce or eliminate surface water diversion for irrigation (streamflow augmentation). Such streamflow augmentations effectively offset an equivalent amount of (pre-existing) depletion of interconnected surface water due to groundwater pumping. Conservation easements or similar instruments may also include temporary, seasonal, or permanent restriction of groundwater, where the restriction may be defined either by an amount of groundwater pumping restriction or by the acreage not receiving irrigation from groundwater. 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.

Anticipated benefits from this type of project include improvement in instream flow conditions on the Shasta River and its tributaries during critical late spring recess, summer and fall baseflow, and fall flush flow periods.

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 (ET; consumptive water use) and applied water use.
- Description of the alternative management on repurposed land with:
  - Quantification and timeline of surface water dedications to instream flow specified in the easement.
  - Quantification and timeline of groundwater pumping restrictions, including water year type or similar rule to be applied and specified in the easement.
- Annual Water Master certification of easement implementation, as appropriate.

Future benefits of implemented projects to streamflow depletion reversal (and remaining streamflow depletion) will be evaluated and assessed with SWGM using the methodology described in Chapter 3 and using the above monitoring data that describe the implementation of voluntary managed land repurposing programs.

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 SWGM.

Shasta Recharge Pilot Project

Project Description

The project will divert water from the Shasta River or its tributaries onto target land near Gazelle and Grenada for winter groundwater recharge when enough water is available in the river. Specific locations for the pilot recharge project will be proposed, and initial baseline studies will occur. Following results, long term and larger recharge projects will be designed and built.

The goal for this project is to provide a preliminary assessment of more large scale as in future recharge opportunities in the Basin. It will also provide a good opportunity to start exploring availability of water, based on year type and climate conditions in general. This project should be considered as a pilot explorative project that will enhance data collection and understanding of the Basin characteristics.

Measurable Objective

The purpose of this study is to evaluate the use of groundwater recharge to augment Shasta River flows during critical periods (i.e. late summer and fall). Key outcomes of this study include determination of when and where water that is recharged enters the Shasta River, the amount of water that recharges the groundwater system and potential water quality benefits associated with groundwater recharge.

Circumstances for Implementation

This project is included in the Tier II projects, as planned for implementation during the first five years after GSP acceptance. The MWCD Parks Creek Water Right depends on excess winter runoff to fill the reservoir. This project will need to occur below the Parks Creek diversion and those diversions above will need to be restricted to their current water rights.

Public Noticing

Public notice will be provided prior to the start of the project and outreach conducted to landowners. Outreach will continue to be conducted for additional recharge activities following project completion. Findings from this project will be made publicly available following project completion.

Permitting and Regulatory Process

A temporary Water Rights Permit (i.e., SWRCB Application for Temporary Permit filed pursuant to Water Code 1425 to Divert to Underground Storage During High Flow Events) is needed to allow diversion of water from the Shasta River during winter months. As permits can be issued for up to 180 days, this permit will be needed for every application year. CDFW also requires a Lake and Streambed Alteration Agreement when a project may affect fish and wildlife resources and the appropriate coordination will be completed to secure these permits.

Schedule for Implementation

The first phase of this project will be initiated within five years of GSP implementation.

Implementation

Prior to implementation of this project, baseline conditions will be monitored at potential pilot sites, site selection will be conducted, water conveyance infrastructure will be added, if not already in place, and landowner permission and outreach will be conducted. Monitoring equipment installation will be completed, as necessary to ensure data collection according to the monitoring plan and the appropriate permitting for diversions in the winter will be obtained.

Expected Benefits

This study is expected to provide information on the amount and timing of groundwater recharge and evaluate the use of groundwater recharge to augment Shasta River flows during critical periods (i.e., late summer and fall).

Future benefits from actual implementation status on streamflow depletion reversal (and remaining streamflow depletion) will be evaluated and assessed with SWGM using the methodology described in Chapter 3.3 and using monitoring data describing the implementation of this managed aquifer recharge program.

Monitoring data collected in this managed aquifer recharge program include, but are not limited to:

- Total acreage used each winter for MAR
- Location of fields used for MAR
- Monthly total volume of MAR applied
- Groundwater level monitoring data, if any are collected as part of this project
- Scientific and technical reports

Legal Authority

This project would require appropriate permitting from the State Water Board. Permitting includes temporary Water Rights Permit which provides the authority to divert water from the Shasta River during winter months for groundwater recharge. Landowner permission and agreements are also required. The project would need to avoid infringement on any existing water rights, including the Montague Water Conservation District Parks Creek Water Right which depends on excess winter runoff to fill reservoir.

Estimated Costs and Funding Plan

Costs and funding for this project have not yet been explored. Potential funding sources will be explored during the first five years of GSP implementation.

4.3 TIER III: POTENTIAL FUTURE PROJECT AND MANAGEMENT ACTIONS

- **i. Alternative, Lower ET Crops**
- **ii. MAR and ILR**
- **iii. Strategic Groundwater Pumping Restriction**
- **iv. Reservoirs**
- **v. Coordinated Shasta Valley Irrigation Management**

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 (evapotranspiration; ET) of water in the Basin, as needed. The management action 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. This will also lead to an increase in instream flows and some reversal of streamflow depletion will occur. The potential benefits associated with transitioning to alternative, lower ET crops were investigated using the SWGM. Implementation of this project will include an assessment of the economic value of alternative, lower ET crops to growers.

Future benefits of actual implementation status to streamflow depletion reversal (and remaining streamflow depletion) will be evaluated and assessed with SWGM using the methodology described in Chapter 3.3 and using monitoring data describing the implementation of the alternative, lower ET program.

Monitoring data in the 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

MAR and ILR

Project Description

As already mentioned in the description of the Shasta pilot recharge project, Managed Aquifer Recharge (MAR) is the process of intentionally adding water to aquifers and In-Lieu Recharge (ILR) is storing or preserving groundwater through replacement of some or all of groundwater use with surface water. This project builds on findings obtained from the Shasta pilot recharge project and plans on extending the areas where MAR and ILR (during the irrigation season) can be used to recharge groundwater at a watershed scale. If winter water rights can be obtained. Winter recharge could help prevent recurrence of domestic well outages near these cities.

Measurable Objective

Use of MAR and ILR has been explored in the Basin and elsewhere in California as an option to increase groundwater recharge. The purpose of this PMA is to increase baseflow in Shasta River during the critical summer and fall low period and support the reversal of streamflow depletion presented in Chapter 3 as part of the discussion on SMC for ISW.

Public Noticing

Public noticing for this project will be conducted by the GSA prior to project implementation and will include submittal of the appropriate California Environmental Quality Act (CEQA), National Environmental Policy Act (NEPA), or other environmental documentation, if required. Public notification is planned to be executed with significant project changes or additional project elements.

Permitting and Regulatory Process

A temporary Water Rights Permit (i.e., SWRCB Application for Temporary Permit filed pursuant to Water Code 1425 to Divert to Underground Storage During High Flow Events) is needed to allow diversion of water from the Shasta River during winter months. As permits can be issued for up to 180 days, this permit will be needed for every application year. CDFW also requires a Lake and Streambed Alteration Agreement when a project may affect fish and wildlife resources and the appropriate coordination will be completed to secure these permits.

Schedule for Implementation

This PMA is in the planning and conceptualization stage. An exploration of funding sources, project location and project feasibility are planned within the first five years of GSP implementation.

Implementation

This PMA utilizes excess winter and spring flows for recharge to temporarily increase groundwater storage to augment streamflow's during critical periods (increased baseflow). The project includes:

- Finding landowners willing to participate
- Securing project funding
- Obtaining water rights and other permit requirements as necessary
- Constructing infrastructure and installing monitoring equipment as necessary to identify potential project impacts and quantify project benefits.

Expected Benefits

The primary benefit of MAR and ILR is to reverse streamflow depletion through augmenting baseflow in Shasta River during the critical summer and fall periods. This is expected to provide benefits to aquatic species, including anadromous fish (as discussed in Chapter 2), water quality and habitat.

Legal Authority

With the appropriate permitting, and without infringement on existing water rights, the GSA is authorized to divert surface water for use with MAR and ILR.

Estimated Costs and Funding Plan

Costs and funding for this project have not yet been explored. Potential funding sources will be explored during the first five years of GSP implementation.

Strategic Groundwater Pumping Restriction

In Shasta 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 PMA's 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 SWGM 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.

Reservoirs

The objective of this PMA is to capture and store runoff and excess stream flows to augment Shasta River flows during critical periods. This project is still in the conceptual phase; details on feasibility and most promising locations will be considered during a preliminary evaluation phase.

Anticipated benefits from this project include reversal of stream depletion to increase instream flows in Shasta River during critical periods. Quantification of potential benefits will be evaluated using the SWGM model to run scenarios. One or multiple reservoirs may be implemented to meet the interconnected surface water minimum threshold (as described in Chapter 3). Temperature consideration may limit direct discharge into streams or require management of discharge, i.e., as recharge near streams (to lower temperatures) or use for irrigation in lieu of groundwater pumping and (cold) surface water diversions.

Significant regulatory, policy, and funding challenges come with this PMA. A first step for the GSA would be to implement a feasibility and scoping study to develop a long-term strategy, if any, for determining feasibility, funding, design, and implementing of this PMA option.

Coordinated Shasta Valley Irrigation Management

A PMA proposed by the Scott Valley and Shasta Valley Watermaster District, a voluntary locally-led initiative amongst all water users to rotate diversions and employ other tools to keep more water instream and avoid additional regulations. Potentially led by SSWD or RCD.

4.4 Other Management Actions

Monitoring Activities

Chapter 3 and data gap appendix (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 both the mainstem of Shasta River and in key tributaries
- Use of satellite images, twice per year, to evaluate status of GDEs
- Continue to ongoing effort from LLNL to further understand groundwater flow and SW/GW interaction through the use of isotopes data.

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 modelling, and in decision-making. Additionally collection of pumping data is useful for tracking the effectiveness of the proposed demand reduction PMAs, including residential wells. Public outreach will be done to encourage participation.

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 Shasta Valley 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. 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 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 the Department of Water Resources (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 Basin, 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, and an evaluation of groundwater elevations at each of the representative monitoring points (RMPs) in relation to minimum thresholds.

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, SMC, 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. 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 thirteen wells which are already part of either the existing CASGEM network or the current monitoring performed by the GSA. 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 and depletions of interconnected surface waters. All 13 wells that have been selected for the groundwater level monitoring network are either existing GSA monitoring wells that are currently monitored by GSA or 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, except two wells with continuous monitoring.

Criteria for new wells is established in Chapter 3 and priorities listed in Appendix 3-A. Wells added to the monitoring network will be included among the RMPs in the five-year GSP update. If funding is secured, additional 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 sixteen existing wells selected for the water quality monitoring network are part of the 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.

Interconnected surface water and GDEs

The interconnected surface water monitoring network is preliminary with a planned expansion for the five-year update. It consists of two continuously-monitored stream gages, one continuously monitored GDE proxy well, bi-monthly diversion data from SSWD, three piezometer transects, and six monthly-monitored springs. If funding is available, four additional stream gauges will be added for the five-year update. Additional expansion will depend on funding.

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.

Technical support, including SWGM model updates, SMC tracking, other data analysis and technical support

Model updates – Management activities and ongoing performance evaluation of the SMC are informed by SWGM 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 SWGM 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.

Table 5.1: Monitoring and Planned Expansion for Sustainable Mangement Criteria in Shasta Valley.

SMC	Wells (Existing)	Wells (New)	Measurement (Existing)	Measurement (New)	Other, Based on Future Funding Availability
Groundwater Levels	13 CASGEM wells	Dependent on funding	Measured at least 2x/year	(a)	See Appendix 3-A (Data Gap Appendix)
			2 wells have continuous monitoring		
Storage	Groundwater Levels as Proxy				N/A
Water Quality	16 wells	At least 2 (b)	Once every two years, unless otherwise specified (see Chapter 3) (c)	Once every 2 or 3 years	See Appendix 3-A (Data Gap Appendix)
ISW	2 stream gauges (continuous)	4 stream gages (d)	13 at least quarterly	Spring Monitoring	See Appendix 3-A (Data Gap Appendix)(e)
	1 GDE well (continuous)		4 continuously		
	Diversion data from SSWD (bi-monthly)				
	3 piezometer transects				
Subsidence	InSAR Data	N/A	InSAR Data (f)	N/A	N/A

[a] Telemetry may be employed to increase data collection frequency and minimize field visits.

[b] Two wells from the dairy monitoring program may be added after at least ten years of historical data has been collected. In the North Coast Hydrologic Region, dairy operators are required to monitor and report groundwater data to the NCRWQCB, making them good candidates for network expansion. Annual groundwater monitoring of nitrate was first required in 2012 as a part of Waste Discharge Requirements for Dairies (Order No. R1-2012-0002). Order No. R1-2019-0001 extends the monitoring program but increases sampling frequency to every three years after the year 2022.

[c] Coordinate with existing GAMA water quality monitoring to obtain data

[d] If funding is available, four new stream gages will be added.

[e] More continuous data in existing shallow wells may be considered in the future as implementation funding become available and as the model provides more certainty about locations where these data are critical. Shallow wells will be paired with flow and/or stage gauges, pending funding availability over the first 5 years of the implementation period. Feasibility study required to assess potential locations. Gauges may benefit by using telemetry to provide continuous data.

[f] InSAR data analyzed as it becomes available from DWR, but no more frequently than once every two years.

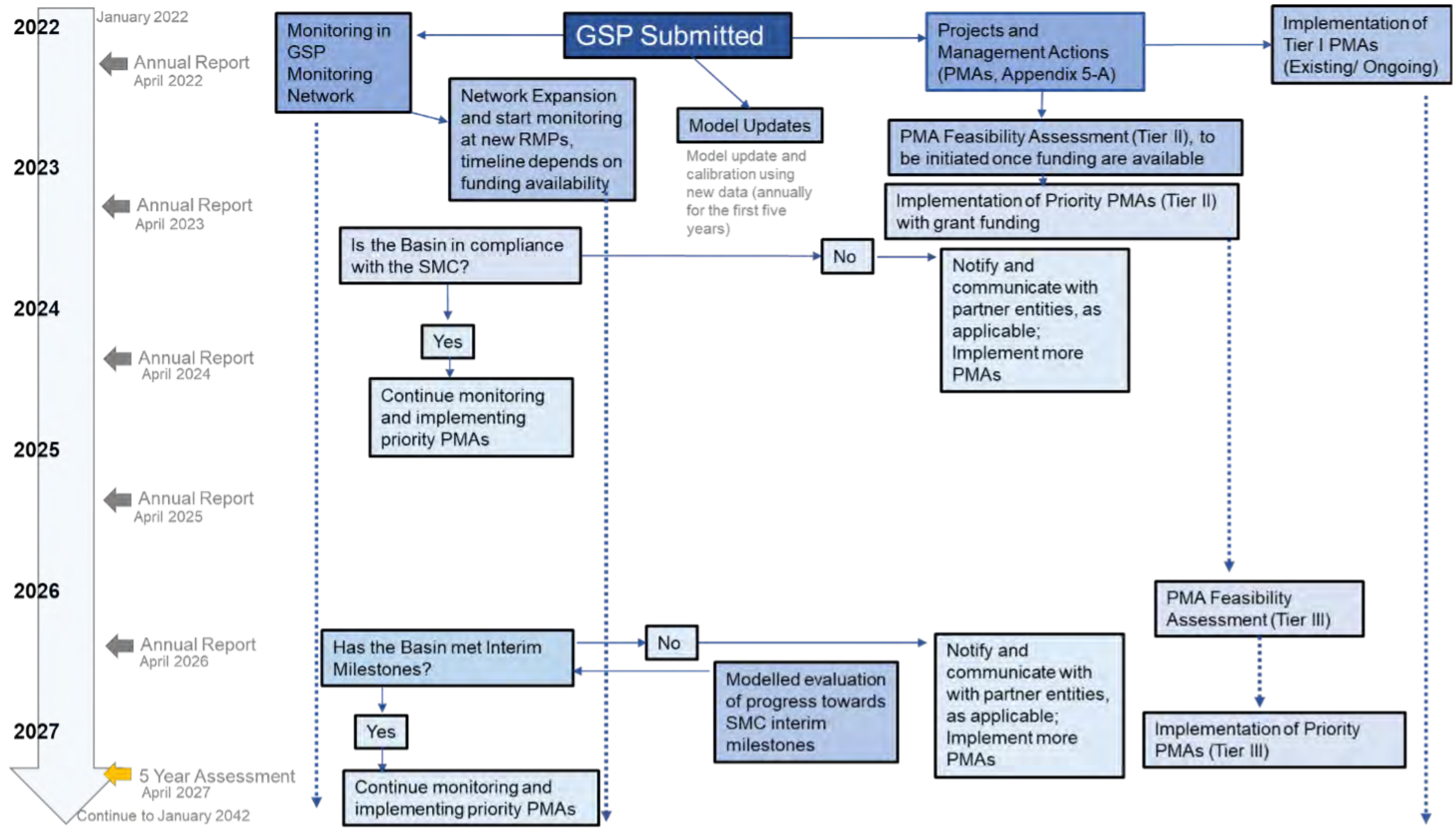


Figure 5.1: GSP implementation process for the first 5-years implementation. The road map is expected to be similar for the following 5-years cycles.

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 projects and management actions (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, 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 Shasta 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 twenty-year planning horizon is projected to cost between $150,000 and $262,500 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 $168,750 to $287,500 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	**$12,500-$31,250**
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	$50,000-$100,000
Monitoring, data analysis and management	$56,250-$75,000
GSP Reporting	
Annual Reports	$18,750-$31,250
5-Year GSP Assessments	$12,500
GSP Management Actions	
Management Action - Coordination activities	TBD
Ongoing Outreach Activities to Stakeholders	
Outreach & Education	$12,500-$25,000
Contingency	
Contingency (10%)	
Total	**$150,000-$262,500**

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 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

References and Technical Studies

ATSDR. 2007a. "Toxicological Profile for Arsenic." U.S. Department of Health; Human Services, Public Health Service - Agency for Toxic Substances; Disease Registry.

———. 2007b. "Toxicological Profile for Benzene." U.S. Department of Health; Human Services, Public Health Service - Agency for Toxic Substances; Disease Registry.

———. 2010. "Toxicological Profile for Boron." U.S. Department of Health; Human Services, Public Health Service - Agency for Toxic Substances; Disease Registry.

Blodgett, J. C., K. R. Poeschel, and J. L. Thornton. 1985. "A water-resources appraisal of the Mount Shasta area in northern California." U.S. Geological Survey - Water-Resources Investigations Report 87-4239.

Brezing, B. 2020. "TRE Altamira InSAR Data Error (personal communication - February 27, 2020)."

Buck, Christina Rene. 2013. "Managing Groundwater for Environmental Stream Temperature." PhD thesis, University of California, Davis.

California Department of Water Resources (DWR). 2016. "Monitoring Networks and Identification of Data Gaps." 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.

———. 2018. "Resource Guide: DWR-Provided Climate Change Data and Guidance for Use During Groundwater Sustainability Plan Development." https://doi.org/10.1300/J057v03n01_10.

Canadell, J., R. B. Jackson, J. B. Ehleringer, H. A. Mooney, O. E. Sala, and E. D. Schulze. 1996. "Maximum rooting depth of vegetation types at the global scale." *Oecologia* 108: 583–95. https://link.springer.com/article/10.1007/BF00329030.

Cantor, Alida, Dave Owen, Thomas Harter, Nell Green Nylen, and Michael Kiparsky. 2018. *Navigating groundwater-surface water interactions under the Sustainable Groundwater Management Act*. Berkeley, CA. https://scholarship.law.berkeley.edu/cleepubs/53.

CDFG. 1997. "A biological needs assessment for anadromous fish in the Shasta River, Siskiyou County, California." California Department of Fish and Game. http://www.krisweb.com/biblio/biblio_klamath.htm.

CDFW. 2016. "Little Shasta River – a compendium of available information." California Department of Fish and Wildlife. https://kbifrm.psmfc.org/file/little-shasta-river-a-compendium-of-available-information/.

Chesney, W. R., C. Adams, W. B. Crombie, H. D. Landendorf, S. Stenhouse, and K. M. Kirkby. 2009. "Shasta River Juvenile Coho Habitat & Migration Study." Report prepared for the U.S. Bureau of Reclamation, Klamath Area Office. http://svrcd.org/wordpress/wp-content/uploads/2012/02/2009%20Shasta%20River%20Juvenile%20Coho%20Study%2012-30-09.pdf.

County of Siskiyou. 1972. "General Plan, Open Space Element." https://www.co.siskiyou.ca.us/sites/default/files/pln_gp_openspaceelement.pdf.

———. 1973. "The Conservation Element of the General Plan, Siskiyou County, California."

———. 2019. "County of Siskiyou Zoning Ordinance." https://library.municode.com/ca/siskiyou_county/codes/code_of_ordinances?nodeId=TIT10PLZO.

———. 2020. "Standards for Wells." https://library.municode.com/ca/siskiyou_county/codes/code_of_ordinances/353445?nodeId=TIT5SAHE_CH8STWE_S5-8.21WEST.

Crandell, D. R. 1989. "Gigantic Debris Avalanche of Pleistocene Age From Ancestral Mount Shasta Volcano, California, and Debris Avalanche Hazard Zonation." U.S. Geological Survey - Bulletin 1861.

Crandell, D. R., C. D. Miller, H. X. Glicken, R. L. Christiansen, and C. G. Newhall. 1984. "Catastrophic debris avalanche from ancestral Mount Shasta volcano, California." *Geology* 12 (3): 143–46.

Davids Engineering. 2020. "DRAFT Monitoring Results of Shallow Piezometer Transect Study from May 2020 through October 2020 in the Shasta Valley, Siskiyou County, CA." Davids Engineering, Inc.

Davids Engineering, Inc. 2011. "Shasta Springs Ranch irrigation efficiency study." Cooperative investigation undertaken by the California Department of Fish; Game; Emmerson Investments. Funding provided by the Pacific States Marine Fisheries Commission under NOAA Award NA07NMF4540337.

Deas, M. 2006. "Big Springs Creek and Spring Complex - Estimated Quantification." Watercourse Engineering, Inc.

Deas, M. L., P. B. Moyle, J. Mount, J. R. Lund, C. L. Lowney, and S. Tanaka. 2004. "Priority actions for restoration of the Shasta River." Technical report prepared by for The Nature Conservancy.

Deas, M. L., A. L. Nichols, C. A. Jeffres, K. Phillips, and A. Willis. 2015. "Little Springs Creek 2013-14 Baseline Assessment." Report prepared for The Nature Conservancy by the UC Davis Center for Watershed Sciences; Watercourse Engineering. https://watershed.ucdavis.edu/files/biblio/Little%20Springs%20Creek%20Baseline%20Assessment_021515%20Final.pdf.

DOC. 2016. "The California Land Conservation Act of 1965: 2016 Status Report." December. California Department of Conservation - Division of Land Resources Protection.

DWR. 1932. "Shasta River Adjudication and Decree, No.7035, recorded in Siskiyou County Superior Court." California Department of Water Resources (DWR). https://www.sswatermaster.org/shastamaps.

———. 2004. "Shasta Valley Groundwater Basin." California Department of Water Resources - Bulletin 118. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Bulletin-118/Files/2003-Basin-Descriptions/1_004_ShastaValley.pdf.

———. 2010. “2010 Land Use Survey.” California Department of Water Resources (DWR). https://gis.water.ca.gov/app/CADWRLandUseViewer/.

———. 2011. “Shasta Valley, Siskiyou County Groundwater Data Needs Assessment.” California Department of Water Resources (DWR).

———. 2016. “Disadvantaged Communities Mapping Tool.” https://gis.water.ca.gov/app/dacs/.

———. 2019a. “DWR Online System for Well Completion Reports (OSWCR).” https://civicnet.resources.ca.gov/DWR%7B/_%7DWELLS/.

———. 2019b. “DWR SGMA Basin Prioritization Dashboard.” https://gis.water.ca.gov/app/bp-dashboard/p2/.

———. 2019c. “Groundwater Monitoring (CASGEM) Website.” https://water.ca.gov/Programs/Groundwater-Management/Groundwater-Elevation-Monitoring--CASGEM.

———. 2019d. “SGMA Data Viewer.” *California Department of Water Resources*. https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#landsub.

———. 2021a. “California Data Exchange Center (CDEC).” https://cdec.water.ca.gov/cdecstations.

———. 2021b. “Groundwater Monitoring (CASGEM) Website.” https://water.ca.gov/Programs/Groundwater-Management/Groundwater-Elevation-Monitoring--CASGEM.

Fan, Y., G. Miguez-Macho, E. G. Jobbágy, R. B. Jackson, and C. Otero-Casal. 2017. “Hydrologic regulation of plant rooting depth.” *Proceedings of the National Academy of Sciences of the United States of America* 114 (40): 1–6.

Fisheries, NOAA. 2014. “Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (Oncorhynchus kisutch).” National Marine Fisheries Service (NOAA Fisheries). Arcata, CA. https://www.fisheries.noaa.gov/resource/document/final-recovery-plan-southern-oregon-northern-california-coast-evolutionarily.

Fogarty, D. T., C. de Vries, C. Bielski, and D. Twidwell. 2021. “Rapid Re-encroachment by Juniperus virginiana After a Single Restoration Treatment.” *Rangeland Ecology & Management* 78: 112–16. https://doi.org/https://doi.org/10.1016/j.rama.2021.06.002.

Fuis, G. S., J. J. Zucca, W. D. Mooney, and B. Milkereit. 1987. “A geologic interpretation of seismic-refraction results in northeastern California (USA).” *Geological Society of America Bulletin* 98 (1): 53–65.

Grenada Irrigation District. 2019. “Grenada Irrigation District (personal communication).”

Griffith, G. E., J. M. Omernik, D. W. Smith, T. D. Cook, E. Tallyn, K. Moseley, and C. B. Johnson. 2016. “Ecoregions of California (poster): U.S. Geological Survey Open-File Report 2016–1021, with map, scale 1:1,100,000.” United States Geological Survey. https://pubs.er.usgs.gov/publication/ofr20161021.

Gwynne, B. A. 1993. “Interim Report - Investigation of Water Quality Conditions in the Shasta River, Siskiyou County.” California Regional Water Quality Control Board - North Coast Region.

Hall, M., C. Babbitt, A. Saracino, and S. Leake. 2018. “Addressing Regional Surface Water Depletions in California: A Proposed Approach for Compliance with the SGMA.” San Francisco, CA: Environmental Defense Fund. https://www.edf.org/sites/default/files/documents/edf_california_sgma_surface_water.pdf.

Harbaugh, Arlen W. 2005. *MODFLOW-2005, the US Geological Survey Modular Ground-Water Model: The Ground-Water Flow Process*. US Department of the Interior, US Geological Survey Reston, VA.

Harter, T., K. Dzurella, G. Kourakos, A. Hollander, A. Bell, N. Santos, Q. Hart, et al. 2017. "Nitrogen Fertilizer Loading to Groundwater in the Central Valley. Final Report to the Fertilizer Research Education Program, Projects 110301 and 150454." California Department of Food; Agriculture; University of California Davis. http://groundwaternitrate.ucdavis.edu.

Holliday, J. 1982. "The Bedrock Geology of the Southeast Part of Shasta Valley, Siskiyou County, California." Oregon State University - Masters Graduate Thesis.

Hotz, P. E. 1977. "Geology of the Yreka quadrangle, Siskiyou County, California." United States Geological Survey - Bulletin 1436. https://pubs.er.usgs.gov/publication/b1436.

Irwin, W. P. 1981. *Tectonic accretion of the Klamath Mountains*. Prentice-Hall. https://pubs.er.usgs.gov/publication/70197814.

James, E. R., M. Manga, T. P. Rose, and G. B. Hudson. 2000. "The use of temperature and isotopes of O, H, C and noble gases to determine the pattern and spatial extent of groundwater flow." *Journal of Hydrology* 237: 100–112.

Jefferson, A., G. Grant, T. Rose, and S. L. Lewis. 2006. "Influence of volcanic history on groundwater patterns on the west slope of the Oregon High Cascades." *Water Resources Research* 42 (W12411).

Jeffres, C. A., E. M. Buckland, M. L. Deas, B. G. Hammock, J. D. Kiernan, A. M. King, N. Y. Krigbaum, J. F. Mount, D. L. Moyle P. B. Nichols, and S. E. Null. 2008. "Baseline Assessment of Salmonid Habitat and Aquatic Ecology of the Nelson Ranch, Shasta River, California Water Year 2007 ." Report prepared for: United States Bureau of Reclamation, Klamath Area Office.

Jeffres, C. A., R. A. Dahlgren, M. L. Deas, J. D. Kiernan, A. M. King, R. A. Lusardi, J. F. Mount, et al. 2009. "Baseline Assessment of Physical and Biological Conditions Within Wate rways on Big Springs Ranch, Siskiyou County, California." Report prepared for California State Water Resources Control Board by the UC Davis Center for Watershed Sciences; Watercourse Engineering.

Jeffres, C. A., A. L. Nichols, A. D. Willis, M. L. Deas, J. F. Mount, and P. B. Moyle. 2009. "Assessment of Restoration Actions on Big Springs Creek, Shasta River, California 2009-2010." Report prepared for the National Fish; Wildlife Foundation by the UC Davis Center for Watershed Sciences; Watercourse Engineering. https://watershed.ucdavis.edu/pdf/Jeffres-et-al-Big-Springs-2010.pdf.

Jurgens, Bryant C., Miranda S. Fram, Jeffrey Rutledge, and George L. Bennett V. 2020. "Identifying areas of degrading and improving groundwater-quality conditions in the State of California, USA, 1974–2014." *Environmental Monitoring and Assessment* 192 (4). https://doi.org/10.1007/s10661-020-8180-y.

Klamath NF. 2010. "Land and Resource Management Plan." US Forest Service - Klamath National Forest. https://www.fs.usda.gov/main/klamath/landmanagement/planning.

Lestelle, L. 2012. "Effects of Dwinnell Dam on Shasta River Salmon and Considerations for Prioritizing Recovery Actions." Prepared for the Karuk Tribe by Biostream Environmental, Poulsbo, WA.

Mack, Seymour. 1960. “Geology and Groundwater Features of Shasta Valley , Siskiyou County California.” United States Geological Survey. https://doi.org/10.3133/wsp1484.

Markstrom, Steven L, Richard G Niswonger, R Steven Regan, David E Prudic, and Paul M Barlow. 2008. “GSFLOW-Coupled Ground-Water and Surface-Water FLOW Model Based on the Integration of the Precipitation-Runoff Modeling System (PRMS) and the Modular Ground-Water Flow Model (MODFLOW-2005).” *US Geological Survey Techniques and Methods* 6: 240. https://pubs.usgs.gov/tm/tm6d1/pdf/tm6d1.pdf.

McBain & Trush, Inc. 2017. “Shasta River Big Streams Complex Interim Instream Flow Needs Assessment.” Prepared for Ocean Protection Council California Department of Fish; Wildlife by Humboldt State University.

Mcclain, Cynthia N. 2008. “Provenance and Pathways : A geochemical and isotope analysis of Mt . Shasta groundwater.” PhD thesis, University of California, Davis.

McNab, W. H., and P. E. Avers. 1994. “Ecological subregions of the United States: WO-WSA-5.” United States Department of Agriculture Forest Service. https://www.fs.fed.us/land/pubs/ecoregions/.

MRLC. 2019. “2019 National Land Cover Database.” Multi-Resolution Land Characteristics (MRLC) Consortium. https://www.mrlc.gov/viewer/.

Nathenson, M., and J. M. Thompson. 2003. “Slightly thermal springs and non-thermal springs at Mount Shasta, California: Chemistry and recharge elevations.” *Journal of Volcanology and Geothermal Research* 121: 137–53.

NCRWQCB. 2006. “Staff Report for the Action Plan for the Shasta River Watershed Temperature and Dissolved Oxygen Total Maximum Daily Loads.” North Coast Regional Water Quality Control Board (NCRWQCB). https://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/shasta_river/.

NCRWQCB. 2018a. “Order No. R1-2018-0019 Shasta River TMDL Conditional Waiver of Waste Discharge Requirements.” California North Coast Regional Water Quality Control Board.

NCRWQCB. 2018b. “Water Quality Control Plan for the North Coast Region.” North Coast Regional Water Quality Control Board.

NCRWQCB (California North Coast Regional Water Quality Control Board). 2006. “Report for the Action Plan for the Shasta River Watershed Temperature and Dissolved Oxygen Total Maximum Daily Loads.”

Nichols, A. 2008. “Geological Mediation of Hydrologic Porcess, Channel Morphology, and Resultant Planform Response to Closure of Dwinnell Dam, Shasta River, California.” PhD thesis, University of California, Davis - Masters Graduate Thesis.

Nichols, A, C. A. Jeffres, A. D. Willis, N. J. Corline, A. M. King, R. A. Lusardi, M. L. Deas, J. F. Mount, and P. B. Moyle. 2010. “Longitudinal Baseline Assessment of Salmonid Habitat Characteristics of the Shasta River, March to September, 2008.” Report prepared for United States Bureau of Reclamation, Klamath Basin Area Office by UC Davis Center for Watershed Sciences; Watercourse Engineering, Inc.

Nichols, A, R. Lusardi, and A. Willis. 2017. “Little Shasta River Aquatic Habitat Assessment.” Report prepared for The Nature Conservancy by the UC Davis Center for Watershed Sciences. https://watershed.ucdavis.edu/files/biblio/Little%20Shasta%20River%20Aquatic%20Habitat%20Assessment%202016.pdf.

Nichols, A, A. Willis, D. Lambert, E. Limanto, and M. Deas. 2016. "Little Shasta River Hydrologic and Water Temperature Assessment: April to December 2015." Report prepared for The Nature Conservancy by the UC Davis Center for Watershed Sciences; Watercourse Engineering. https://watershed.ucdavis.edu/files/biblio/LittleShasta_2015assessment_final_04-11-2016.pdf.

Niemeyer, R. J., T. E. Link, R. Heinse, and M. S. Seyfried. 2017. "Climate moderates potential shifts in streamflow from changes in pinyon-juniper woodland cover across the western U.S." *Hydrological Processes* 32 (20): 3489–3503. https://doi.org/https://doi.org/10.1002/hyp.11264.

Nilsen, T. H. 1993. "Stratigraphy of the Cretaceous Hornbrook Formation, southern Oregon and northern California." *US Geological Survey Professional Paper* 1521.

Niswonger1and, R. G., and G. E. Fogg. 2008. "Influence of perched groundwater on base flow." *Water Resources Research* 44 (W03405).

NOAA. 1981. "Authorization of Incidental Take and Implementation of Fruit Growers Supply Company's Multi-Species Habitat Conservation Plan: Environmental Impact Statement." National Oceanic; Atmospheric Administration. https://books.google.com/books?id=fCE3AQAAMAAJ.

———. 2021. "Shasta River Safe Harbor Agreement Delivers Win for Coho Salmon and for Landowners." National Oceanic and Atmospheric Administration - West Coast Regional Office. https://www.fisheries.noaa.gov/feature-story/shasta-river-safe-harbor-agreement-delivers-win-coho-salmon-and-landowners.

Null, S. E., M. L. Deas, and J. R. Lund. 2010. "Flow and Water Temperature Simulation for Habitat Restoration in the Shasta River, California." *River Research and Applications* 26: 663–81. https://watershed.ucdavis.edu/pdf/Null_Deas_Lund_final(2010).pdf.

O'Geen, A. T., Matthew B. B. Saal, Helen Dahlke, David Doll, Rachel Elkins, Allan Fulton, Graham Fogg, et al. 2015. "Soil suitability index identifies potential areas for groundwater banking on agricultural lands." *California Agriculture* 69 (2): 75–84. https://doi.org/10.3733/ca.v069n02p75.

Pace Engineering. 2016. "City of Yreka 2015 Urban Water Management Plan, Job No. 69.47.102." Prepared by Pace Engineering, Redding, California. https://wuedata.water.ca.gov/uwmp_plans.asp.

Pelto, Mauri S. 2008. "Impact of Climate Change on North Cascade Alpine Glaciers, and Alpine Runoff." *Northwest Science* 82 (1): 65–75.

PGS. 2001. "Peninsula Geological Society and Stanford GES-052Q combined field trip, Mount Shasta-Klamath-northern Coast Range area, NW California, 05/17-05/20/2001." Peninsula Geological Society (PGS). http://www.diggles.com/pgs/2001/PGS01-05c.html.

Rice, E. W., L. Bridgewater, and American Public Health Association. 2012. "Standard methods for the examination of water and wastewater." American Water Works Association & Water Environment Federation. https://www.standardmethods.org/.

Saleeby, J., G. D. Harper, A. W. Snoke, and W. Sharp. 1982. "Time relations and structural-stratigraphic patterns in ophiolite accretion, west central Klamath Mountains, California." *Journal of Geophysical Research* 87: 3831–48. https://authors.library.caltech.edu/48904/.

Schenk, H. J., and R. B. Jackson. 2002. "Rooting depths, lateral root spreads and below-ground/above-ground allometries of plants in water-limited ecosystems." *Journal of Ecol-*

ogy 90 (2): 480–94. https://besjournals.onlinelibrary.wiley.com/doi/full/10.1046/j.1365-2745.2002.00682.x.

Shasta-Trinity NF. 1995. "Land and Resource Management Plan." US Forest Service - Shasta-Trinity National Forest. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5209391.pdf.

SSWD. 2021. "Riparian Diverters (personal communication - 2021)." Scott; Shasta Watermaster District (SSWD).

Stanley, W. D., W. D. Mooney, and G. S. Fuis. 1990. "Deep crustal structure of the Cascade Range and surrounding regions from seismic refraction and magnetotelluric data." *Journal of Geophysical Research* 95 (B12).

State of California. 2014. "California Water Action Plan."

———. 2015. "Senate Bill No. 88." https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB88.

———. 2019. "California Code of Regulations - Title 22 - Division 4 - Chapter 15." https://oal.ca.gov/publications/ccr/.

Superior Court of Siskiyou County. 2018. "Notice of Reduction of Shasta River Watermaster Service Area." https://www.sswatermaster.org/shastamaps.

SVRCD. 2017. "Lower Shasta River Water Balance: September 2016." Shasta Valley Resource Conservation District.

———. 2018a. "Middle Shasta River Water Balance: September-October 2017." Shasta Valley Resource Conservation District.

SVRCD. 2018b. "Shasta River Watershed Stewardship Report." Shasta Valley Resource Conservation District (SVRCD) in collaboration with North Coast Regional Water Quality Control Board,; with technical assistance provided by Klamath Basin Monitoring Program.

———. 2021. "Spring Discharge Monitoring Program Results (personal communication - July, 2021)." Shasta Valley Resource Conservation District.

SVRCD, and McBain & Trush. 2013. "Study Plan to Assess Shasta River Salmon and Steelhead Recovery Needs." September. U.S. Fish; Wildlife Service.

SWRCB. 2018. "Shasta River Watershed Characterization and Model Study Plan."

———. 2019a. "California Drinking Water System Area Boundaries, Division of Drinking Water." State Water Resources Control Board. https://gispublic.waterboards.ca.gov/portal/apps/webappviewer/index.html?id=272351aa7db14435989647a86e6d3ad8.

———. 2019b. "Drinking Water Watch, Division of Drinking Water." State Water Resources Control Board. https://sdwis.waterboards.ca.gov/PDWW/index.jsp.

SWRCB. 2019c. "GeoTracker Database." *State Water Resources Control Board*. https://geotracker.waterboards.ca.gov/.

Tague, C., M. Farrell, G. Grant, S. L. Lewis, and S. Rey. 2007. "Hydrogeologic controls on summer stream temperatures in the McKenzie River basin, Oregon." *Hydrological Processes* 21: 3288–3300.

Tague, C., and G. E. Grant. 2004. "A geological framework for interpreting the low-flow regimes of Cascade streams, Willamette River Basin, Oregon." *Water Resources Research* 40 (4).

Tilley, Sloane K, and Rebecca C Fry. 2015. "Chapter 6 - Priority Environmental Contaminants: Understanding Their Sources of Exposure, Biological Mechanisms, and Impacts on Health." In *Systems Biology in Toxicology and Environmental Health*, edited by Rebecca C Fry, 117–69. Boston: Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-801564-3.00006-7.

Trout, California. 2010. "Mt. Shasta Springs 2009 Summary Report." Report prepared for California Trout by AquaTerra Consulting; SGI Environmental, with assistance from the University of California, Davis.

USDA, and USDI. 1994. "Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl, including Standards and Guidelines for Management of Habitat for Late-Successional and Old. Portland, OR." https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3843201.pdf.

USGS. 2015. "National Field Manual for the Collection of Water Quality Data." *U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9*. United States Geological Survey. https://www.usgs.gov/mission-areas/water-resources/science/national-field-manual-collection-water-quality-data-nfm.

USGS. 2018. United States Geological Survey (USGS). https://help.waterdata.usgs.gov/codes-and-parameters/daily-value-qualification-code-dv_rmk_cd.

USGS. 2021. "Sustainable Groundwater: Groundwater-Storage Reductions." United States Geological Survey, California Water Science Center. https://ca.water.usgs.gov/sustainable-groundwater-management/groundwater-storage-california.html.

Vignola, E., and M. Deas. 2005. "Lake Shastina Limnology." Watercourse Engineering, Inc.

Wackernagel, H. 1995. *Ordinary Kriging. In: Multivariate Geostatistics*. Springer, Berlin, Heidelberg. https://doi.org/https://doi.org/10.1007/978-3-662-03098-1_11.

Wagner, D. L., and G. J. Saucedo. 1987. "Geologic Map of the Weed Quadrangle, California, 1:250,000." California Division of Mines and Geology.

Watercourse Engineering. 2006. "Shasta River Field Monitoring Report 2001-2002." Sponsored by the Shasta Valley Resource Conservations District with funding from the Klamath River Basin Fisheries Task Force, United States Fish; Wildlife Service. Watercourse Engineering, Napa, CA.

Weed, City of. 2017. "City of Weed 2040 General Plan." https://ceqanet.opr.ca.gov/2016122001.

Wilde, F. D. 2008. "General Information and Guidelines: U.S. Geological Survey Techniques of Water-Resources Investigations." United States Geological Survey. https://pubs.er.usgs.gov/publication/twri09A6.0.

Williams, H. 1949. "Geology of the Macdoel Quadrangle, California." U.S. Geological Survey - Bulletin 151.

Willis, A., M. Deas, C. Jeffres, J. Mount, P. Moyle, and A. Nichols. 2012. "Executive Analysis of Restoration Actions in Big Springs Creek March 2008-September 2011." Report prepared for the National Fish; Wildlife Foundation by the UC Davis Center for Watershed Sciences; Watercourse Engineering. https://watershed.ucdavis.edu/pdf/Willis_etal_2012.pdf.

Willis, A., A. Nichols, E. J. Holmes, C. A. Jeffres, A. C. Fowler, C. A. Babcock, and M. L. Deas. 2017. "Seasonal Aquatic Macrophytes Reduce Water Temperatures via a Riverine Canopy in a Spring-Fed Stream." *Freshwater Science* 36: 508–22. https://watershed.ucdavis.edu/files/biblio/Willis%20et%20al.%202017%20Riverine%20canopy.pdf.

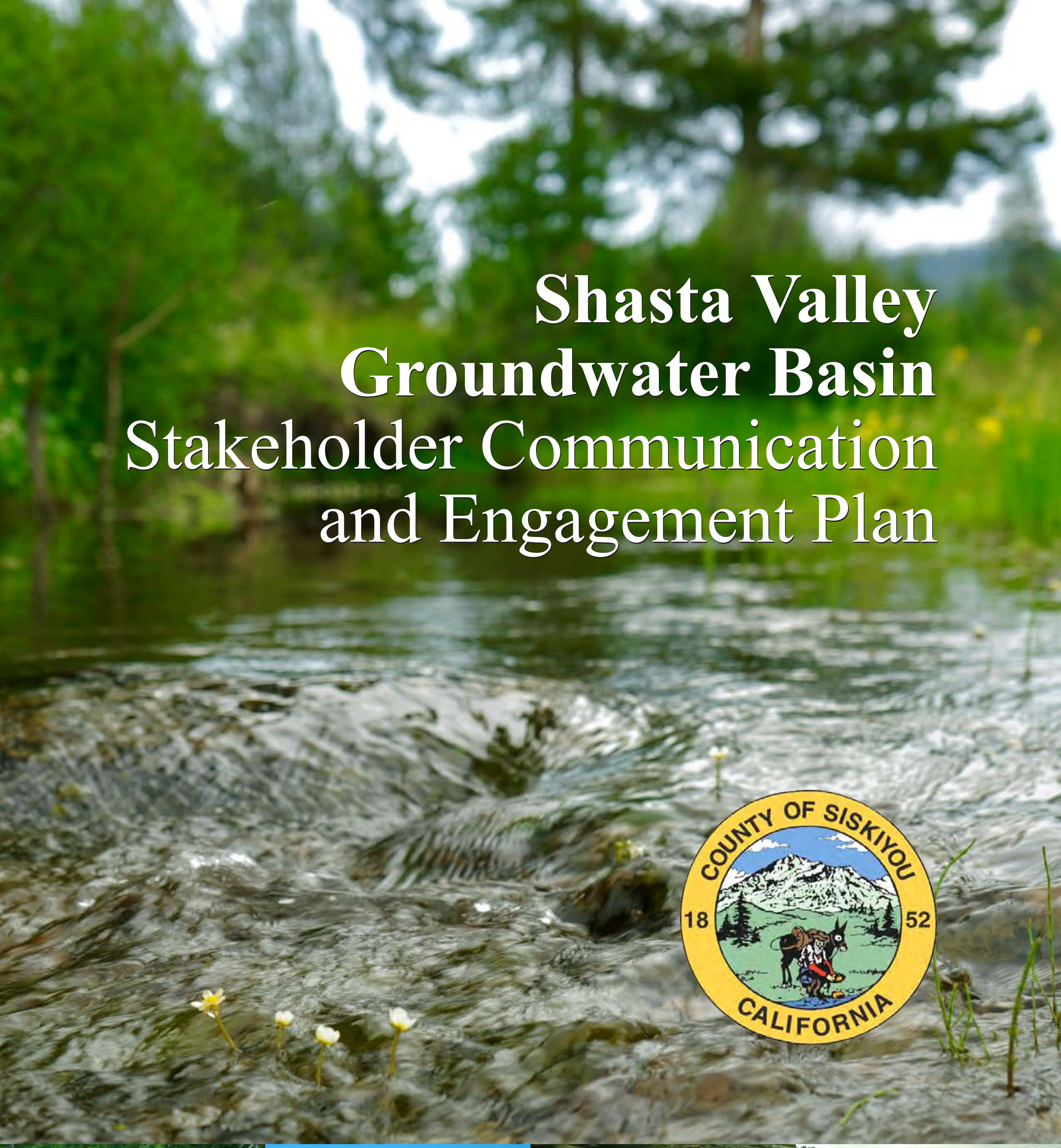
Willis, A., A. Nichols, C. A. Jeffres, and M. L. Deas. 2013. "Water Resources Management Planning: Conceptual Framework and Case Study of the Shasta Basin." Report prepared for the National Fish; Wildlife Foundation by the UC Davis Center for Watershed Sciences; Watercourse Engineering. https://watershed.ucdavis.edu/files/biblio/Shasta%20Basin%20Planning%20Framework%2010-23-2013.pdf.

Yreka, City of. 2003. "City of Yreka General Plan Update 2002 - 2022." https://ci.yreka.ca.us/DocumentCenter/View/119/General-Plan-PDF.

Appendix 1-A Shasta Valley Communication and Engagement Plan

Shasta Valley Groundwater Basin

Stakeholder Communication and Engagement Plan



Shasta Valley Groundwater Basin

Stakeholder Communication and Engagement Plan

Siskiyou County Groundwater Sustainability Agency.
2020. Shasta Valley Groundwater Basin - Stakeholder Communication and Engagement Plan.
Siskiyou County, California. 17 pp.

Photo credits:
Main cover, cattle: Alexandra Hart; Coho salmon: NOAA Fisheries.

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.

TABLE OF CONTENTS

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 groundwater basins throughout California, including places like Shasta 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. Shasta 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 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
- The federal government

[1] California Department of Water Resources. 2017. Draft – Best Management Practices for the Sustainable Management of Groundwater: Sustainable Management Criteria BMP.

- 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 Shasta 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 (FSS) 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.

---

[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

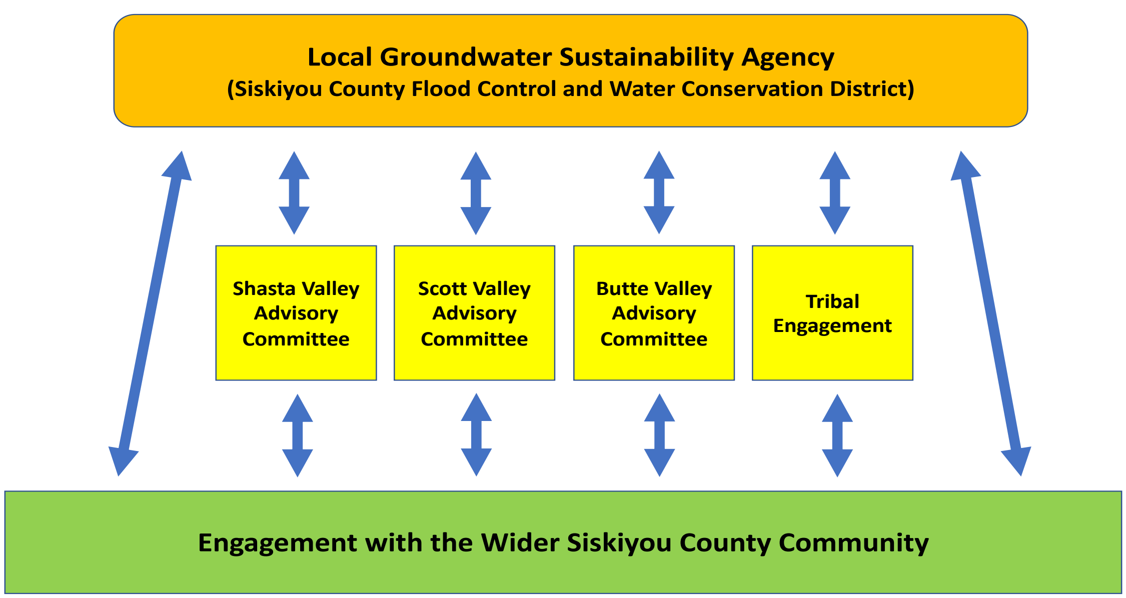
The District Board, in its capacity as the final decision-maker in the GSP process, will:

- 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 Shasta 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 Shasta Valley (See Appendix I – Advisory Committee membership; see also Shasta 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 Shasta 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 Shasta Valley, the Karuk Tribe 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 Shasta Valley community. Originally developed by GSA staff, the table has been reviewed and improved by the Shasta 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. Shasta Valley Stakeholder Groups

Interest Group	Engagement Purpose	Shasta 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 and domestic/residential users; cooperative groundwater users (small water systems)
Urban/Ag Users	Collaborate to ensure sustainable management of groundwater	Big Springs Irrigation District; Cities of Yreka, Grenada and Weed; Grenada Irrigation District; Shasta River Water Users Association; "All local school districts;" Montague Water Conservation District; Shasta Water Users Association; Siskiyou County Farm Bureau; Siskiyou County Cattlemen's Association; surface water diverters; Shasta Watershed Conservation Group, Big Springs Ranch
Industrial Users	Inform and involve to avoid negative impact to other users	Lumber industry
Environmental /Ecosystem	Inform and involve to sustain a vital ecosystem	The Nature Conservancy; CalTrout; North Groups Sierra Club; National Marine Fisheries Service; Klamath Riverkeepers; Pacific Coast Federation of Fisherman's Associations
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; Chambers of Commerce;
Human Right to Water	Inform and involve to provide safe and secure groundwater supplies to disadvantages communities	Edgewood; Lake Shastina Community District; Siskiyou County Service Area 5 – Carrick, Gazelle and Montague
NGOs/Local Associations/ Clubs	Inform and involve to ensure sustainability for local industry	Siskiyou County Realtors Association; Siskiyou County Water Users Friends of the Shasta River

	and businesses	Association; Local Granges; Shasta Valley RCD; Lions Club
State Land Management or Agencies	Inform, involve and collaborate to ensure basin sustainability	California Department of Fish & Wildlife; California Department of Fish and Wildlife – Shasta Valley Wildlife Area and Shasta Big Springs Ranch Wildlife Area; State Water Resources Control Board, North Coast Regional Quality Control Board
Native American Tribes	Inform, involve and consult with tribal governments (See DWR Tribal Engagement with Tribal Guidance Document[7])	Shasta Indian Nation; Karuk Tribe; Quartz Valley Tribe; Yurok Tribe; Modoc Tribe of Oklahoma
Federal Agencies	Inform, involve and collaborate to ensure basin sustainability	US Forest Service Bureau of Land Management; National Marine Fisheries Service; USDA/ NRCS; US Fish and Wildlife Service
Integrated Water Management	Inform, involve and collaborate to improve regional sustainability	Scott Valley/Shasta Valley Watermaster District, North Coast Resource Partnership (DWR IRWM region)

Phases of Groundwater Sustainability Plan Development

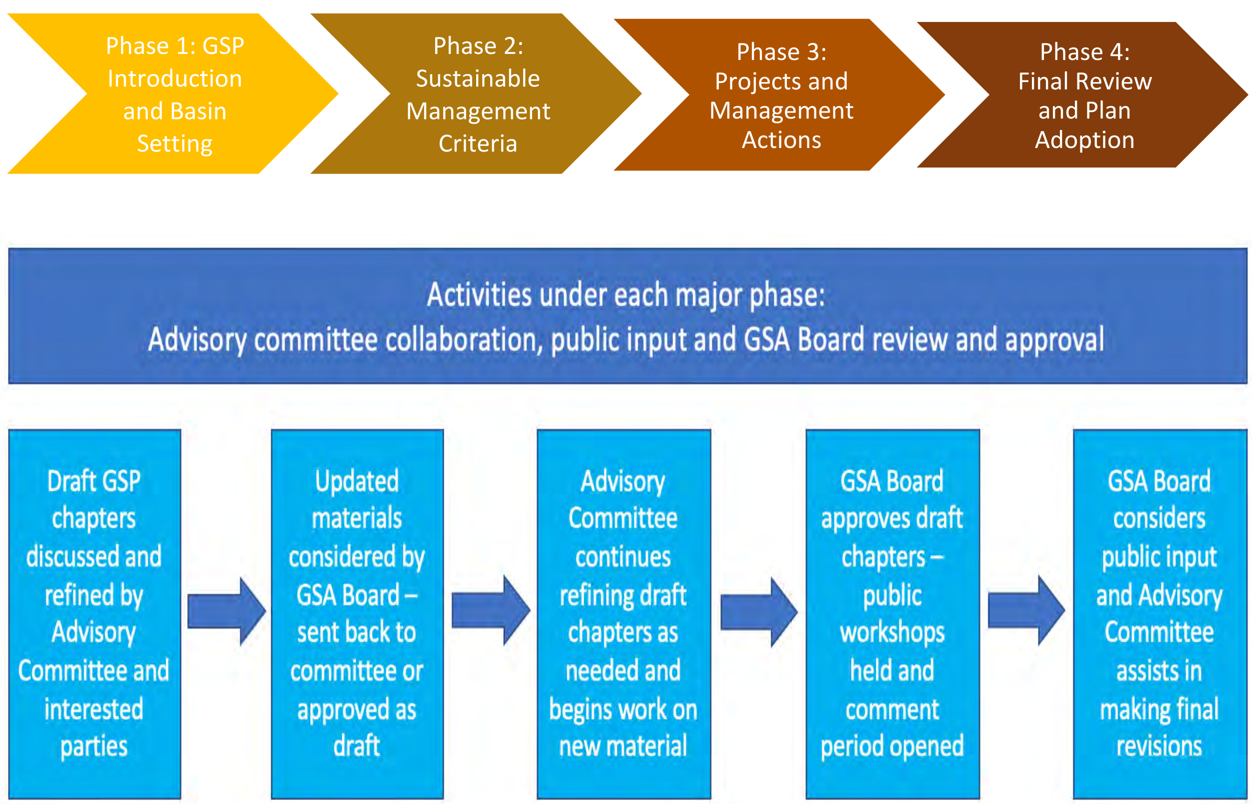
GSP development in the Shasta Valley groundwater basin will occur in three major phases, with each phase offering significant opportunities for the public to provide input on draft material developed and presented by the GSA's technical consultants. Each phase will be linked to core elements of the GSP, 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.

[7] *DWR Guidance Document for the Sustainable Management of Groundwater: Engagement with Tribal Governments*.

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 materials, soliciting input on draft material and communicating next steps in the GSP development process. A central goal of this 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; 1-2 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, are 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 – November, 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 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 Shasta 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 Local Resource Conservation District: The Shasta Valley Resource Conservation District has secured a Proposition 1 grant and is working collaboratively with local landowners on water conservation practices, groundwater monitoring and developing improved understanding of local groundwater conditions. The GSA may at times request RCD staff to present information and solicit input on its work at Advisory Committee or public meetings. GSA staff, with support from its technical and facilitation consultants, will, as needed, update the RCD on GSP development, scientific studies, and relevant committee work.

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.

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.

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.

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

- Tristan Allen, Montague Water Conservation District
- Lisa Faris, Big Springs Irrigation District
- Susan Fricke (Vice-Chair), Karuk Tribe Representative
- Blair Hart, Private Pumper
- Justin Holmes, Edson-Foulke Ditch Company
- Steve Mains, Grenada Irrigation District
- Robert Moser, Municipal/City (Lake Shastina Community)
- Peter Scala, Private Pumper
- John Tannaci (Chair), Residential
- Gregg Werner, Environmental/Conservation Representative
- Justin Sandahl, Shasta River Water Users Association

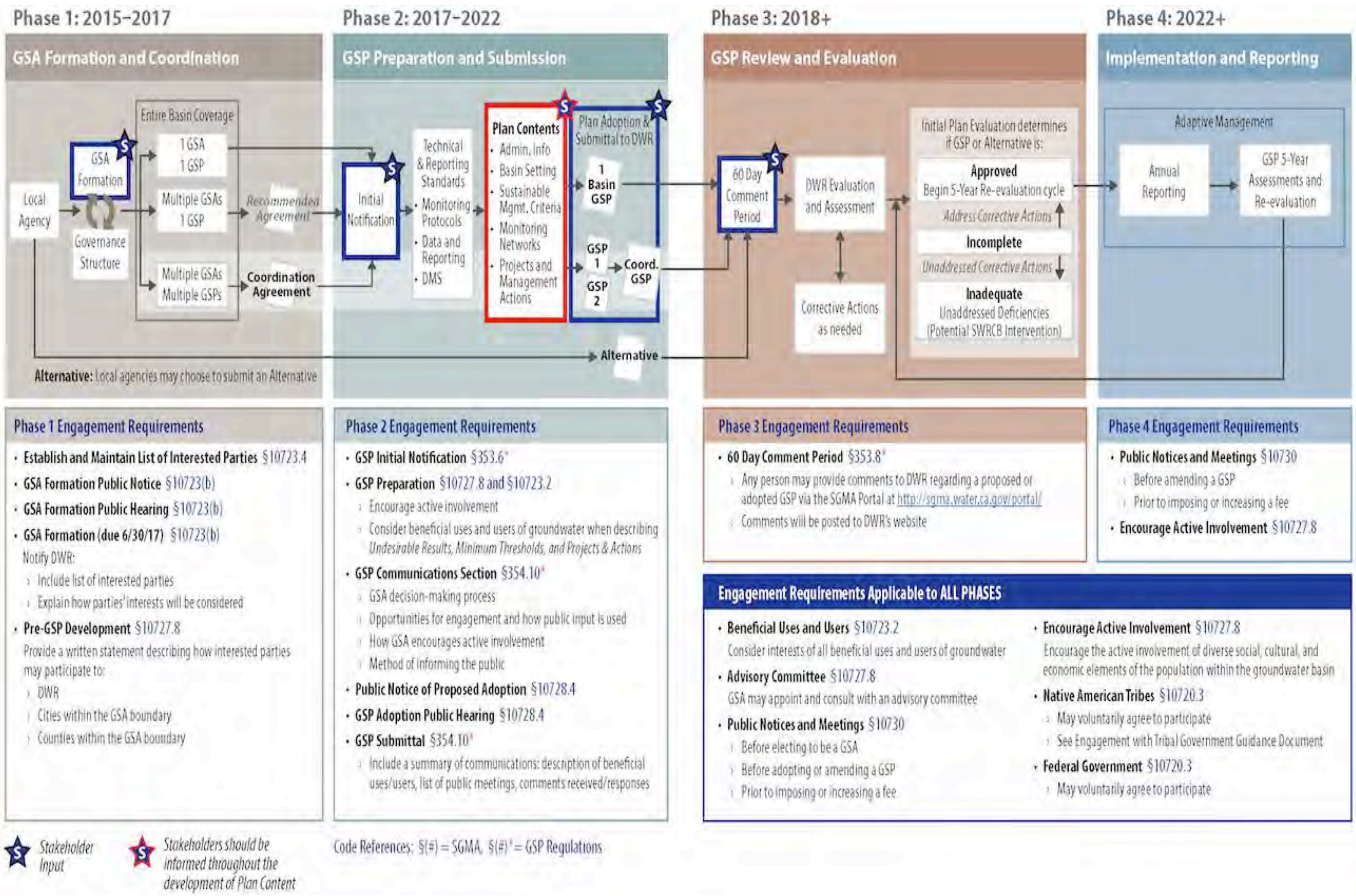
Appendix II – SGMA Educational Materials and References

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 Shasta 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. Additionally, the GSA held a tribal outreach meeting on November 9, 2021, with the Karuk tribe representatives.

Date	Meeting
3/5/18	Advisory Committee Meeting
6/8/18	Advisory Committee Meeting
7/18/18	Advisory Committee Meeting
10/11/18	Advisory Committee Meeting
12/18/18	Advisory Committee Meeting
1/23/19	Advisory Committee Meeting
4/24/19	Advisory Committee Meeting
5/29/19	Advisory Committee Meeting
9/25/19	Advisory Committee Meeting
11/6/19	Advisory Committee Meeting
1/28/20	Advisory Committee Meeting
3/4/20	Advisory Committee Meeting
4/15/20	Advisory Committee Meeting
5/11/20	Advisory Committee Meeting
5/27/20	Advisory Committee Meeting
9/15/20	Advisory Committee Meeting
10/14/20	Shasta Valley SGMA Virtual Public Workshop
10/28/20	Advisory Committee Meeting
11/18/20	Advisory Committee Meeting
1/27/21	Advisory Committee Meeting
2/24/21	Advisory Committee Meeting
3/17/21	Advisory Committee Meeting
4/28/21	Advisory Committee Meeting
5/27/21	Advisory Committee Meeting
6/23/21	Advisory Committee Meeting
11/1/19	Chapter 2.1 Public Review Version
3/1/21	Chapter 3 Public Review Version (Water Quality and Subsidence)
4/23/21	Chapter 3 and 4 Public Review
5/27/21	Chapter 2 Public Review
11/12/20	Shasta Surface Water Ad hoc Committee
12/15/20	Shasta Surface Water Ad hoc Committee
5/4/21	Shasta PMA Ad hoc Committee
6/8/21	Shasta PMA Ad hoc Committee
9/15/21	Scott & Shasta 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
10/12/20	Email
10/15/20	Email

10/16/20	Email
10/22/20	Email
11/12/20	Email
11/17/20	Email
1/21/21	Email
2/18/21	Email
2/23/21	Email
2/25/21	Email
2/26/21	Email
3/2/21	Email
3/11/21	Email
3/12/21	Email
4/14/21	Email
4/22/21	Email
4/23/21	Email
4/26/21	Email
4/27/21	Email
5/5/21	Email
5/13/21	Email
5/17/21	Email
5/20/21	Email
5/24/21	Email
5/27/21	Email
5/28/21	Email
6/3/21	Email
6/17/21	Email
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 Shasta Valley Comment Response Summary

Shasta 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.

This page left blank intentionally.

SHASTA VALLEY GROUNDWATER SUSTAINABILITY PLAN
PUBLIC COMMENT SUMMARY

November 2021

Table of Contents

LIST OF TABLES

ABBREVIATIONS

Advisory Committee	Shasta 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 – Shasta Valley Groundwater Sustainability Plan Comment and Comment Response Matrix

This page left blank intentionally.

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 Shasta 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 2E: Model Documentation
- Appendix 2I: ET and Applied Water Estimates
- Appendix 2J: Surface Diversion Estimates
- Appendix 3C: Water Level SMC
- Appendix 3D: ISW SMC

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:

- Montague City Hall & Library, 230 S 13th St, Montague, CA 96064
- Weed City Hall, 550 Main St, Weed, CA 96094
- Weed Library, 150 Alamo Ave, Weed, CA 96094
- Yreka City Hall, 701 4th St, Yreka, CA 96097
- Yreka Library, 719 4th St., Yreka, CA 96097

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 Cities of Yreka, Weed, and Montague, 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 and a local Yreka newspaper. The GSA received an informal request for government-to-government consultation with the Karuk Tribe on September 7. The GSA and Karuk attempted to coordinate a meeting prior to the close of the public comment period; however, they were not able to find a time given the short window of opportunity. Subsequently, the Karuk Tribe submitted a formal request for government-to-government consultation on September 20, pursuant to section III (v.) of the Memorandum of Understanding between the District and the Tribe. The GSA coordinated with the Karuk Tribe to conduct this government-to-government consultation. 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 Shasta 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 and 27, 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 15 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 13 comment letters on the Draft GSP during the public comment period. One letter was submitted by an individual contributor. Twelve 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
California Trout	Non-Governmental Organization	9/24/2021
Friends of the Shasta River	Non-Governmental Organization	9/26/2021
Ginger Sammito	Individual Contributor	8/30/2021
Karuk Tribe	Tribe	9/24/2021
Klamath Tribal Water Quality Consortium	Tribes	9/24/2021
Mount Shasta Ecology Center	Non-Governmental Organization	9/26/2021

National Marine Fisheries Service	Federal Agency	9/23/2021
NGO Consortium	Non-Governmental Organizations	9/23/2021
Quartz Valley Indian Community	Tribe	9/24/2021
Salmonid Restoration Federation	Non-Governmental Organization	9/24/2021
Scott Valley and Shasta Valley Watermaster District	Special District	9/26/2021
Shasta Headwaters Community Partnership	Non-Governmental Organization	9/26/2021

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 13 letters received, a total of 384 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 Shasta 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. Shasta 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.
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.
Chapter, Page, and Line Number	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.

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 384 comments received, 58 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 384 comments received, 145 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 384 comments, 180 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 Shasta 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 26, 2021, the Shasta 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 21 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
- Groundwater Dependent Ecosystems
- State Water Resource Control Board Emergency Regulations
- Interconnected Surface Waters
- Project and Management Action Selection Criteria

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. The Advisory Committee representative for the Karuk Tribe could not endorse the plan and the GSA is pursuing ongoing coordination with the Karuk Tribe to resolve any outstanding concerns.

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 (530) 842-8005
Yreka, California 96097 FAX (530) 842-8013
www.co.siskiyou.ca.us 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

Karuk Community Health Clinic
64236 Second Avenue
Post Office Box 316
Happy Camp, CA 96039
Phone: (530) 493-5257
Fax: (530) 493-5270

Karuk Tribe

Administrative Office
Phone: (530) 493-1600 • Fax: (530) 493-5322
64236 Second Avenue • Post Office Box 1016 • Happy Camp, CA 96039

Karuk Dental Clinic
64236 Second Avenue
Post Office Box 1016
Happy Camp, CA 96039
Phone: (530) 493-2201
Fax: (530) 493-5364

September 7th, 2021

Ray Haupt, Chair
P.O. Box 750
1312 Fairlane Road
Yreka, CA 96097

RE: Government to Government Meeting Request; Comments Sustainable Groundwater Management Plan

Ayukîi Supervisor Haupt:

The Karuk Tribe appreciates the efforts of you and the County of Siskiyou to develop Sustainable Groundwater Management Plans for the Scott and Shasta Valleys. Groundwater use impacts stream flows and fisheries habitat critical to the survival of salmon, steelhead, lamprey and other species the Karuk rely on not only for our sustenance but our cultural identity as well. Therefore, we are very interested in the development of a Sustainable Groundwater Management Plan for the Scott and Shasta Valleys.

We are writing to request an informal consultation meeting pursuant to the Memorandum of Understanding (MOU) between the Siskiyou County Flood Control and Water Conservation District and the Karuk Tribe, Section III (v). the purpose of the meeting is to discuss the timeline for comments on the draft Sustainable Groundwater Management Plan and specific concerns with the Plan.

As per the MOU, we would like to convene two elected offices from the County and the Tribe along with pertinent staff. Current COVID protocols are such that an electronic teleconference would be most appropriate.

Barbara Snider is the Tribal Council executive secretary and can work with a designated counterpart from the County to arrange meeting details. Barbara can be contacted either via phone, (530) 493-1600 extension 2036, or email bsnider@karuk.us.

Yootva,

Russell "Buster" Attebery
Chairman

Enclosure: Memorandum of Understanding between the Siskiyou County Flood Control and Water Conservation District and the Karuk Tribe

Karuk Community Health Clinic
64236 Second Avenue
Post Office Box 316
Happy Camp, CA 96039
Phone: (530) 493-5257
Fax: (530) 493-5270

Karuk Tribe

Administrative Office
Phone: (530) 493-1600 • Fax: (530) 493-5322
64236 Second Avenue • Post Office Box 1016 • Happy Camp, CA 96039

Karuk Dental Clinic
64236 Second Avenue
Post Office Box 1016
Happy Camp, CA 96039
Phone: (530) 493-2201
Fax: (530) 493-5364

October 20th, 2021

Ray Haupt, Chair
PO Box 750
1312 Fairlane Road
Yreka, CA 96097

RE: Government to Government Meeting Request

Ayukîi Supervisor Haupt:

On September 7, 2021, pursuant to section III. (v.) of the Memorandum of Understanding (MOU) between the Siskiyou County Flood Control District (District) and the Tribe signed in March of 2020, the Tribe transmitted a request for an informal consultation meeting to discuss "the timeline for comments on the draft [Scott and Shasta] Sustainable Groundwater Management Plans and specific concerns with the Plan."

District staff communicated by email that there were no available meeting times to meet our request prior to the deadline for comments on the draft Plans.

On September 24, 2021 the Tribe received a letter from the District offering to meet with the Karuk Tribe. However, one of our key issues was the deadline for comments. Because the District did not release all of the 600+ pages of technical information used to develop the draft Plans when the draft Plans were released, it was difficult for Tribal staff and consultants to prepare thorough comments. By failing to meet with the Tribe in a timely manner, the District provided no opportunity to resolve issues arising from the development of the Plans.

Because our issue was not addressed or resolved in a timely manner consistent with section III. (v.) of the MOU, the Karuk Tribal Council invites the District to participate in an official Government to Government consultation meeting that would include a majority of the Karuk Council and the District Board and held in accordance with the Ralph M. Brown Act pursuant to section III. (vi.) of the MOU. The meeting will be held virtually due to COVID-19, please have appropriate staff contact Executive Secretary Barbara Snider to schedule at 530-493-1600 ext2036 or bsnider@karuk.us

The agenda of this meeting shall include a discussion of the ground water crisis the Plans are supposed to address, the consequences of failing to address the groundwater crisis, and our specific concerns with the draft Plans. Any unresolved issues in addition to our already filed comments shall be documented and forwarded to the District Board in accordance with Section III (vii.) of the MOU.

Yôotva,

Russell "Buster" Attebery
Karuk Tribe Chairman

Attachment B – Annotated Comment Letters Received on Draft Groundwater Sustainability Plan

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

Review Form

Shasta Groundwater Sustainability Plan

Dear Reviewer,

Per SGMA requirements, a Groundwater Sustainability Plan (GSP) has been developed for the Shasta Valley groundwater basin. The GSA has released a complete draft GSP and has initiated a 45-day public review and comment period and seeks input from all beneficial users of groundwater.

REVIEWER INSTRUCTIONS:
Given the large number of reviewers, accommodating track changes or other editing options within the original draft sections distributed to all committee members is not possible. Please consider using this reviewer form with the following instructions:

- Use the form below to provide comments. Feel free to add additional lines to the form as needed.
- For suggested text changes, please copy and paste the text you wish to change and place your suggested edits in track changes or strikethrough features in this document. What's important is that technical staff can see *both* the original draft text and your distinct suggestions.
- Note the **Chapter, Page, Section, and line number**—from the ***PDF version*** of the draft GSP section—where your comment, question or suggested text edit begins.
- Examples of how to provide feedback are listed in the review form below. These examples are not actual comments and are made up to show how the table should be used. Feel free to delete these examples with your submission, and only include your feedback.
- To comment on a figure or table, in the line number column on the reviewer form note the figure number *and* the page number and type your comment in the text section to the right.

Please email comments directly to (sgma@co.siskiyou.ca.us). Include in the subject line the basin you are commenting on. If you are making comments on multiple basins, send as separate comments.

Please send your comments no later than end of day September 26, 2021. Comments will not be accepter on or after September 27th, 2021.

Please use the following file nomenclature in saving your review document:
ShastaGSP_PublicReviewDRAFT_[Your name]_date

Thanks for contributing to the draft Groundwater Sustainability Plan for the Shasta Valley Groundwater Basin

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

Reviewer name:
Submission date:
GSP sections reviewed:

Chapter	Page	Section	Line/Table/Figure #	Comment (*please delete example text below once you submit*)	
Chapter 2:			151-153	Need to define what constitute a domestic well upper bound. Is it 450 gpm? 100gpm?	GS-001
	35	2.2.1.2	figure#8	Graph depicts data up to 2005 yet verbiage states 2020	GS-002
	39	2.2.1.2	Figure #12	Need to define xxx place holders. Probably just overlooked	GS-003
Chapter 3:	7	3.3	178-188	What about large capacity well which are on large generators and do not have a large land base case in point is APN: 019-661-410-000 which has a 2,500-gallon capacity well on 4.06 acres.	GS-004
Chapter 3:	9,10		Figure 1,2	x-axis needs to be cleaned up. Maybe just being/end value	GS-005
	35	3.4.1.1	599-605	Excessive number is ambiguous statement. What number determined excessive?	GS-006

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

		3.4.3.2	Table 7	What is the significance defined by the asterisk next to the values? Maybe just need a statement here.	GS-007
Chapter 4:	4	4.1	153	A permit is required for extraction within and outside basin now	GS-008
Chapter 4:	14	4.2	335	The only way to acquire valid data is to house the well drillers report within this county so the information will be readily available to SGMA	GS-009

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

Review Form

Shasta Groundwater Sustainability Plan

Dear Reviewer,

Per SGMA requirements, a Groundwater Sustainability Plan (GSP) has been developed for the Shasta Valley groundwater basin. The GSA has released a complete draft GSP and has initiated a 45-day public review and comment period and seeks input from all beneficial users of groundwater.

REVIEWER INSTRUCTIONS:
Given the large number of reviewers, accommodating track changes or other editing options within the original draft sections distributed to all committee members is not possible. Please consider using this reviewer form with the following instructions:

- Use the form below to provide comments. Feel free to add additional lines to the form as needed.
- For suggested text changes, please copy and paste the text you wish to change and place your suggested edits in track changes or strikethrough features in this document. What's important is that technical staff can see *both* the original draft text and your distinct suggestions.
- Note the **Chapter, Page, Section, and line number**—from the ***PDF version*** of the draft GSP section—where your comment, question or suggested text edit begins.
- Examples of how to provide feedback are listed in the review form below. These examples are not actual comments and are made up to show how the table should be used. Feel free to delete these examples with your submission, and only include your feedback.
- To comment on a figure or table, in the line number column on the reviewer form note the figure number *and* the page number and type your comment in the text section to the right.

Please email comments directly to (sgma@co.siskiyou.ca.us). Include in the subject line the basin you are commenting on. If you are making comments on multiple basins, send as separate comments.

Please send your comments no later than end of day September 26, 2021. Comments will not be accepter on or after September 27th, 2021.

Please use the following file nomenclature in saving your review document:
ShastaGSP_PublicReviewDRAFT_[Your name]_date

Thanks for contributing to the draft Groundwater Sustainability Plan for the Shasta Valley Groundwater Basin

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

Reviewer name:
Submission date:
GSP sections reviewed:

Chapter	Page	Section	Line/Table/Figure #	Comment (*please delete example text below once you submit*)	
ES	3	ES-1	98	Available for the Basin dates back to ~~e~~at least (typo)	CT-001
101	3	ES-1	101	What is Error! Reference source not found?	CT-002
2	4	2.1.1	91	cover ~~a~~ the northern (typo)	CT-003
2	12	2.1.2	162	This section never mentions the Public Trust Doctrine despite the GSP acknowledging that groundwater and surface water in the basin are interconnected (line 110)	CT-004
2	28	2.1.4.2	695-697	"[t]here is not substantial enough data to include groundwater use estimates from illegal cannabis production in the overall and future water budgets." → How can the GSA ensure accurate water budgets if it excludes this potentially significant, albeit illegal, use of groundwater?	CT-005
2	39	2.2.1.2	Figure 12	Is this the updated figure?	CT-006
2	63	2.2.1.4	1136	"soil groups are described in Table (XXX)" → what table does this refer to?	CT-007
2	105	2.2.2.6	2052-2054	"the Shasta River surface water network contains many miles of stream channel that are connected to groundwater. The Shasta River and	CT-008

				its major tributaries are all considered part of the interconnected surface water system in the Basin." → Given this statement, the GSP needs to include Public Trust considerations, as the public trust doctrine applies to the management of groundwater that impacts a public trust resource (here, the Shasta River).	CT-008 (contd.)
3	6	3.3	134	Per 23 C.C.R. § 354.34(b)(1-4)	CT-009
3	6	3.3	152	Section 351(l)	CT-010
3	7	3.3	179-180	"Owners and/or operators of groundwater wells, meeting a certain criteria, are *encouraged* to report pumping volumes" (emphasis added) → what is landowners do not want to share information?	CT-011
3	30	3.3.4.2	511	Why will this take 10 years?	CT-012
			1138-1139	"Arsenic, boron, iron, manganese, and pH do not have an SMC because they are naturally occurring." → what if groundwater pumping increases the concentration of these constituents?	CT-013
4	6-10	4.1	Table 4.1	General thoughts about PMAs: - Most of the tier 1 actions rely on another entity acting - If the restriction of groundwater pumping is in Tier 3, it will likely not be implemented soon enough to improve conditions. This	CT-014

				triggers public trust doctrine concerns.	CT-014 (contd.)
5	10	5.1.2	299-337	Concerning that the only concrete action the GSA commits to is "coordination." What is the GSA's strategy for implementing this GSP?	CT-015

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Northern Region
601 Locust Street
Redding, CA 96001
(530) 225-2300
www.wildlife.ca.gov

GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

September 23, 2021

Via Electronic Mail

Matt Parker
Natural Resources Specialist
Siskiyou County Flood Control and Water Conservation District
1312 Fairlane Road
Yreka, CA 96097
MParker@co.siskiyou.ca.us
SGMA@co.siskiyou.ca.us

SUBJECT: CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE COMMENTS ON THE SHASTA VALLEY BASIN DRAFT GROUNDWATER SUSTAINABLITY PLAN

Dear Matt Parker:

The California Department of Fish and Wildlife (Department) appreciates the opportunity to provide additional comments on the Draft Groundwater Sustainability Plan (GSP) for Shasta Valley Basin (Basin) prepared by 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), it must be managed under a Groundwater Sustainability Plan (GSP) by January 31, 2022. In addition to the comments herein, the Department has provided other input into the proposed Draft GSP. On April 28, 2020, the Department provided comments in advance of the preparation of the Draft GSP which outlined general guidance, basin information, and recommended tools available to the GSA. The Department's April 28, 2020, comments focused on the Department's role as a trustee agency. In that role, the Department has an interest in the sustainable management of groundwater, as many sensitive ecosystems and species depend on groundwater and interconnected surface waters (ISWs). Specifically, the Department is concerned with the decline of salmonid populations due to the lack of quality aquatic habitat. The Department provided the Shasta River Canyon Instream Flow Needs Assessment (McBain and Trush 2014) as guidance when developing an interim target flow to avoid extirpation of salmonids. The Department recognizes a more thorough watershed wide study is required to achieve the needs of all sensitive ecosystems and species dependent on groundwater and ISW in 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 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. 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 nine key areas of concern: (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; (7) implementing projects and management actions (PMAs); (8) Public Trust Doctrine and California Endangered Species Act (CESA) requirements; and (9) SWRCB Emergency Regulations. 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. In addition, the model documentation, water budget information, water level sustainable management criteria, and interconnected surface water sustainable management criteria were not provided until September 13, 2021. Since the completed 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 Shasta River watershed (included in the Klamath River watershed) provides aquatic habitat for four species of anadromous fish: Chinook Salmon, Southern Oregon/Northern California Coast (SONCC) Coho Salmon (CESA and Endangered Species Act (ESA) threatened), Steelhead Trout, and Pacific Lamprey (State species of special concern). The Shasta River watershed also supports populations of bank swallow (CESA threatened), western pond turtle (State species of special concern), foothill yellow-legged frog (State species of special concern), greater sandhill crane (CESA threatened), willow flycatcher (CESA and ESA endangered), black tailed deer, pronghorn and other fish and wildlife species that rely on habitats supported and supplemented by groundwater. In addition, the Shasta River watershed is one of five priority streams under the 2019 California Water Action Plan, which includes an objective for the Department to protect and restore important ecosystems through flow enhancement activities (Action 4).

The Department has significant concerns about potential impacts of groundwater pumping on GDEs and interconnected surface waters (ISWs), including ecosystems on Department-owned and managed lands within SGMA-regulated basins. The Department owns the Shasta Valley Wildlife Area, on Little Shasta River, and Big Springs Wildlife Area within the Big Springs complex of the headwaters of Shasta River. 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. The Draft GSP identifies in Table 6 of Chapter 2, ESA or CESA species found in Siskiyou County. The Draft GSP identifies in Table 7 of Chapter 2, 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. The Draft GSP species prioritized for management were identified as "riparian vegetation," which is a vegetation type, not an ecosystem or species. While this column identified salmonids as a species prioritized for management, the Draft GSP did not provide objectives that would be anticipated to support salmonids. Instead, the GSP provided objectives intended to minimize sediment erosion into streams where bank swallows exist that depend on erosion for their management. This choice of objectives suggests that the Draft GSP does not recognize the unique life histories of these species that may give rise to differences in management needs between salmonids and other species. In addition, many species, including special-status species, that are known to depend on or may be vulnerable to groundwater fluctuations were not identified in the first column. These include bank swallow, foothill yellow legged frog, western pond turtle, greater sandhill crane and willow flycatcher to name a few. The Draft GSP does not indicate where these species are found in the basin and how these individual species could be impacted by groundwater.

CDFW-002

CDFW-003

CDFW-004

<u>Identification and Consideration of GDEs</u>

GSPs must **consider impacts to GDEs**. (Water Code § 10727.4(l); *also see* 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 included in the Draft GSP and rationale for the methods used. The Draft GSP mentions tabletop methods of using existing mapping tools, root depth to groundwater modeling and other tools for identifying GDEs. However, it also fails to include Advisory Committee input or field verification of the identified GDEs. Without these means of verification, the Department cannot evaluate or comment on the accuracy of the GSP's GDE classification or mapping. The Department recommends that GDE mapping is informed by science-based vegetation classification or similar methods, such as the Department's *Survey of California Vegetation Classification and Mapping*

CDFW-005

Standards.[1] The Draft GSP's 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-005 contd.

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).)

While the Draft GSP includes an HCM, the Department is uncertain that the HCM accurately characterizes the physical components and surface water-groundwater interactions in the Basin. For example, the GSP does not properly identify and characterize the principal aquifers and aquitards within the Basin as required by applicable SGMA regulations. (23 CCR §354.14 (b)(4)(B) and (C).) The Draft GSP provides a regional description of the aquifer system(s) within the Basin without specifying the principal aquifer system is collectively within the basin. It would be helpful to identify the principal aquifer system within the Basin, and characterize the vertical and lateral extent of these assemblages in relation to one another. The Draft GSP should characterize associated aquifer parameters (i.e., hydraulic connectivity and specific yield/storativity) where each of the forementioned aquifer assemblages are located, and characterize or define the lateral and vertical extent of existing aquitards/confining layers within the Basin. In addition, the Department's understanding is that the Draft GSP does not clearly identify a definable bottom of the Basin as required by applicable SGMA regulations. (23 CCR §354.14 (b)(3).) The Draft GSP provides a discussion of the geologic units from oldest to youngest within the Basin but does not identify a definable base between the alluvial material and deeper hard rock material in the Basin.

CDFW-006

CDFW-007

The Draft GSP is required to provide a description of historic and current water level trends within the Basin. Pursuant to that requirement, the Draft GSP needs to provide groundwater level elevation contour maps depicting the

CDFW-008

[1] https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=102342&inline

groundwater table or potentiometric surface associated with current seasonal highs and seasonal lows and hydraulic gradients between principal aquifers. CDFW-008 contd. Different sections of the Draft GSP provide varying yields for Pluto's Cave, ranging from 1,000-4,000 gallons per minute. The Draft GSP should be consistent in its description of yields. If a range is used for this location or other springs in the Basin, it should not have a large range of variation. CDFW-009 In addition, the source of recharge for the springs should be identified if known. The Department suspects the source of the recharge for the springs is likely snowmelt. It would be beneficial if this could be confirmed and included in the Draft GSP. CDFW-010 Similarly, for extractions, it would be helpful to describe the points of diversion of surface water in text and with a map, including extractions from water districts and municipalities. CDFW-011 The Department was unable to locate groundwater elevation contour maps that complies with applicable SGMA regulations that require characterization of the current seasonal highs and lows of the principal aquifer within the Basin. (23 CCR §354.16 (a)(1).) The referenced appendices include a set of presentation slides. The Department recommends supplementing these slides with discussion of the model inputs and associated literature cited to provide a greater understanding of the model and facilitate evaluation of compliance with applicable SGMA requirements. CDFW-012

<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 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 Department has concerns about the analysis and data underlying 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 and measurable objectives, CDFW-013 that meet requirements including the following:

<u>Measurable Objectives and Minimum Thresholds for ISW Depletions</u>
For each relevant sustainability indicator, the GSP must describe quantitative measurable objectives to achieve the sustainability goal for the basin by 2042 and maintain sustainable management thereafter. (23 CCR § 354.30(a).) 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. (*Id*. at § 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*.)

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 set minimum thresholds 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. CDFW-014

In the Draft GSP, sustainable management criteria related to depletions of interconnected surface water have not been clearly defined. The GSP claims to have considered measured groundwater contributions and the protection of GDEs through equations and numbers identifying the minimum thresholds and measurable objectives. Based on the limited explanation and justification in the GSP, the Department does not understand how the equations and numbers will ensure adequate protection of fish and wildlife resources and habitat. These equations and general numbers do not clearly articulate how they will affect beneficial users' needs or how data gaps in the understanding of the basin have been addressed. The numbers and equations do not relate to flows needed to support species and habitat, and the equations do not appear to produce specific quantitative metrics protective of resource needs. CDFW-015 While interim milestones are provided, it is unclear how they will provide a "reasonable path" to achieving sustainability because they are also framed in terms of equations and percentages without relation to a specific value to ensure sustainability. CDFW-016 The Department is also concerned that the analysis omits Upper Little Shasta River and fails to account for the fact that the stream annually CDFW-017

CDFW-017 contd.

disconnects. As required per SGMA regulations, 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 interests of beneficial users. CDFW-018

The Draft GSP's sustainability criteria also fail to account for the fact that the State Water Resources Control Board (SWRCB) has declared Shasta River a fully appropriated stream system (FASS) during part of the year, meaning insufficient supply is available for new water right applications at this time (Water Right Order 98-08). The FASS determination was based on numerous water rights decisions and orders that determined that allocated water likely exceeds available supplies from May 1 to October 31 each year (i.e., supplies are likely over-allocated at this time). The Draft GSP anticipates that surface water users and the Scott Valley and Shasta Valley Watermaster District (SSWD) will be able to maintain sufficient flows instream. However, given likely over-allocation and potential surface water depletions from groundwater pumping, which the GSA has not analyzed adequately, this assumption may not be realistic. CDFW-019 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.

Furthermore, the GSA should not wait for additional California Water Action Plan deliverables for the Shasta River before determining and implementing "sufficient flows for salmonid species within the Shasta River." The Department has provided best available science that can be used to answer this question now rather than referring to an "aspirational watershed goal." Please see the Department's previous April 28, 2020, letter for details on this best available science and the needs of other special-status species that require attention beyond salmonids. CDFW-020 In sum, the Department recommends that the GSA establish sustainable management criteria based on the best available science that meets the needs of all beneficial users.

<u>Water Budget</u>
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 Shasta Valley Integrated Hydrologic Model (SVIHM). The Department acknowledges that

Department of Water Resources (DWR) allows the use of models to prepare Water Budget in Basins; however, DWR also stresses the importance of using reliable data sets when available to increase the accuracy of the models output. The Draft GSP indicates no extraction information was available for wells within the Basin at the time of preparing the model. The Draft GSP does not discuss the utilization of evapotranspiration (ET) estimates to determine rates of aquifer pumping specific to crop type to quantify groundwater extraction values for development of the water budget. The Department understands that this method may be the best available science at present but suggests that the GSA consider remedying the issues regarding lack of accurate well information and groundwater usage data sets needed to adequately characterize groundwater levels and groundwater in storage within the Basin. CDFW-021

The Draft GSP provides a discussion in Chapter 2 about estimating specific yield using the SVIHM. The Draft GSP states the Basin is not overdrafted and "while groundwater levels declined during the 2012-2015 drought, levels quickly rebounded back." Similarly, the Draft GSP discusses how irrigation efficiency improvement projects result in a reduction of groundwater pumping and recharge. The Department recommends revisiting the sections regarding specific yield and irrigation efficiency improvement projects to clearly identity how the SVIHM and water budget demonstrate a sustainable use of groundwater for all beneficial users. The Draft GSP needs to include a clearer explanation of the connection between groundwater that goes to surface water runoff and groundwater infiltration, or evaporation. Based on the information provided in the Draft GSP, it is difficult to understand these components of the SVIHM and water budget, the potential relationship with the surface water in GDEs, and how groundwater will impact species throughout the year. 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. CDFW-022 The GSA should also consider developing PMAs that promote more efficient water use through water conservation where feasible. CDFW-023

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 should elaborate on the description the proposed monitoring network, which must be 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, the locations of these wells, the aquifer unit, and specific well construction information (i.e., well completion depth) for the wells used. Chapter 3, Table 2 identifies wells designated for potential inclusion in the groundwater level monitoring and storage monitoring network as Representative Monitoring Points (RMPs); however, the map provided for these wells does not provide any designation (well identification) for the points shown on the map. The Draft GSP should include the well ID and associated information needed to assist in the evaluation of the proposed observation point for its potential to accurately characterize groundwater occurrence at that location. As reference, the data set should include the ground surface elevations for each well, reference point elevations for water level measurements, and important well construction information (i.e., well screen perforation intervals). CDFW-024

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).) The Draft GSP does not contain a basin-wide groundwater-surface water model, analysis of the surface water depletion rate, or basin-wide groundwater monitoring, all of which are necessary to assess potential surface water depletions and impacts to beneficial surface water users, including Chinook Salmon, Coho Salmon, and Pacific Lamprey. CDFW-025 The GSP also lacks quantitative criteria for instream flows (discussed more fully below), which are needed to assess compliance with SGMA and avoid significant and unreasonable depletions of ISW. CDFW-026 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-027

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 such depletions. GSP characterizes instream flows as “aspirational watershed goals” within sustainable management criteria. This characterization ignores the plain language of SGMA, which clearly indicates sustainable management criteria and objectives must be developed to avoid undesirable results within the planning and implementation horizon. CDFW-028 (23 CCR §§ 354.24, 354.26, and 354.28.)

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 and the water budget. Specifically, the GSP lacks consideration of current versus historic surface water extractions, agriculture ditch losses and gains, new or improved wells in the basin, and local springs that feed into Shasta River. In addition, the GSP fails to analyze data from Little Shasta River, a tributary of Shasta River, and may exclude smaller tributaries that regularly disconnect, including Willow and Whitney Creeks. These deficiencies in the analysis suggests the model 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 must take a basin-wide approach. The GSA should identify the data gaps, set basin-wide sustainable management criteria, and 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.

CDFW-029

CDFW-030

CDFW-031

Implementing Projects and Management Actions (PMAs)

GSPs must include projects and management actions that are feasible and likely to prevent undesirable results and ensure that the basin is operated within its sustainable yield. (23 CCR § 355.4(b)(5).) The Department encourages and 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 deferring nearly all PMAs through an "integrative and collaborative approach" will make it difficult to achieve sustainability even by 2042 as contemplated under SGMA. The Department encourages the GSA to start working on PMAs like the reservoirs sooner than described.

CDFW-032

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-033

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-034

Most critically, the GSA should consider the implications of its GSP development and implementation on species listed under the California Endangered Species Act (CESA). As previously identified in our April 28, 2020 letter, the highest priority recovery actions for protection of CESA threatened Coho Salmon include CDFW-035

[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.

increasing instream flows, increasing cold water input in the Upper Shasta basin, reducing overall water temperature, increasing dissolved oxygen, and reducing warm tailwater inputs to the stream. The current Draft GSP does not support all beneficial users including aquatic species like salmonids by not accounting for their needs in the sustainable management criteria and deferring the PMAs to a future date. In addition to the Department, the North Coast Regional Water Quality Control Board (Regional Water Board) provided a recommendation for an increase of 45 cubic feet per second (CFS) of cold water from the Big Springs Complex into the Shasta River. (Regional Water Board, 2006. Staff Report for the Action Plan for the Shasta River Watershed Temperature and Dissolved Oxygen Total Maximum Daily Loads. Chapter 6. Temperature TMDL.) According to their modeling analysis, this cold water is the most beneficial flow contribution in the Shasta River with respect to temperature and is critical for temperature TMDL compliance and support of the most sensitive beneficial uses the Regional Water Board identified in their analysis, which include cold freshwater habitat and spawning, reproduction, and/or early development of aquatic species. The Total Maximum Daily Load (TMDL) analysis provides clear evidence that these beneficial uses depend on supporting conditions provided by the recommended increase in cold groundwater, which in turn supports groundwater dependent ecosystems. These ecosystems may be currently threatened by unsustainable groundwater use. Additionally, the Temperature TMDL assigns load allocations for riparian shade and riparian areas are inherently groundwater dependent ecosystems. Actions may need to go beyond SGMA minimum requirements to meet Public Trust Doctrine requirements.

CDFW-035 contd.

CDFW-036

CDFW-037

The GSA has also suggested that it will defer PMAs for protection of Public Trust resources and CESA-listed species. Delaying these actions is not likely to ensure protection of public trust resources, particularly since ongoing groundwater pumping is causing significant adverse impacts to those resources. The GSA's proposal to spend the next 5 years increasing monitoring and fleshing out the outstanding sections of the GSP unduly delays tangible actions needed in the immediate term for protection of public trust resources.

CDFW-038

SWRCB Emergency Regulations

Per SGMA regulations, GSP minimum thresholds must be consistent with existing regulatory standards absent clear justification for differences. (23 CCR § 354.28(b)(5).) Emergency regulations approved by SWRCB on August 17, 2021, and effective on August 30, 2021, set forth minimum instream flows needed to avoid extirpation of certain fish species in the Scott and Shasta rivers during the

CDFW-039

CDFW-039 contd.

current drought emergency. Per the SWRCB's Informative Digest, these emergency regulations are intended to preserve minimum instream flows for migration, rearing, and spawning of fall-run Chinook and SONCC coho salmon in the Scott and Shasta rivers during the current drought emergency. (pp. 21-22.) These regulations must be accounted for in the draft GSPs for the Scott and Shasta basins.

However, the minimum instream flows set forth in the SWRCB emergency regulations are not intended to preserve all aquatic species in the Scott and Shasta rivers during all life stages, seasons, and water year types. The regulations merely set forth minimum instream flows that are needed to avoid extirpation of certain fish species during the current drought emergency. The Public Trust Doctrine requires the GSA to manage groundwater pumping in the basin to ensure instream flows in interconnected surface waters (e.g., the Scott and Shasta rivers) are maintained at levels that fully support all life stages of all fish species during all seasons and water year types when feasible. In certain seasons and water year types, this may require maintenance of additional flow beyond the minimum instream flows set forth in the SWRCB emergency regulations.

CDFW-040

The Department appreciates the opportunity to provide comments on the Draft GSP. If you have any 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,

DocuSigned by:
Curt Babcock
974D273FEE784E2...

Tina Bartlett
Regional Manager

ec: California Department of Fish and Wildlife

Joshua Grover, Branch Chief
Water Branch
Joshua.Grover@wildlife.ca.gov

Robert Holmes, Environmental Program Manager
Statewide Water Planning Program
Robert.Holmes@wildlife.ca.gov

Angela Murvine, Statewide SGMA Coordinator
Groundwater Program
Angela.Murvine@wildlife.ca.gov

Curt Babcock, Environmental Program Manager
Region 1 – Habitat Conservation Planning
Curt.Babcock@wildlife.ca.gov

Joe Croteau, Environmental Program Manager
Region 1 – Klamath Watershed Program
Joe.Croteau@wildlife.ca.gov

Jason Roberts, Environmental Program Manager
Region 1 – Fisheries Program
Jason.Roberts@wildlife.ca.gov

Brad Henderson, Senior Environmental Scientist (Supervisor)
Region 1 – Habitat Conservation Planning
Brad.Henderson@wildlife.ca.gov

Janae Scruggs, Senior Environmental Scientist (Specialist)
Region 1 – Klamath Watershed Program
Janae.Scruggs@wildlife.ca.gov

California Department of Water Resources

Craig Altare, Supervising Engineering Geologist
Sustainable Groundwater Management Program
Craig.Altare@water.ca.gov

Pat Vellines, Senior Engineering Geologist
Sustainable Groundwater Management Program
Patricia.Vellines@water.ca.gov

National Marine Fisheries Service

Jim Simondet, Klamath Branch Chief
West Coast Region
Jim.Simondet@noaa.gov

State Water Resources Control Board

Natalie Stork, Chief
Groundwater Management Program
Natalie.Stork@waterboards.ca.gov

Erik Ekdahl, Deputy Director
Division of Water Rights
Erik.Ekdahl@waterboards.ca.gov

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

Review Form

Shasta Groundwater Sustainability Plan

Dear Reviewer,

Per SGMA requirements, a Groundwater Sustainability Plan (GSP) has been developed for the Shasta Valley groundwater basin. The GSA has released a complete draft GSP and has initiated a 45-day public review and comment period and seeks input from all beneficial users of groundwater.

REVIEWER INSTRUCTIONS:
Given the large number of reviewers, accommodating track changes or other editing options within the original draft sections distributed to all committee members is not possible. Please consider using this reviewer form with the following instructions:

- Use the form below to provide comments. Feel free to add additional lines to the form as needed.
- For suggested text changes, please copy and paste the text you wish to change and place your suggested edits in track changes or strikethrough features in this document. What's important is that technical staff can see *both* the original draft text and your distinct suggestions.
- Note the **Chapter, Page, Section, and line number**—from the ***PDF version*** of the draft GSP section—where your comment, question or suggested text edit begins.
- Examples of how to provide feedback are listed in the review form below. These examples are not actual comments and are made up to show how the table should be used. Feel free to delete these examples with your submission, and only include your feedback.
- To comment on a figure or table, in the line number column on the reviewer form note the figure number *and* the page number and type your comment in the text section to the right.

Please email comments directly to (sgma@co.siskiyou.ca.us). Include in the subject line the basin you are commenting on. If you are making comments on multiple basins, send as separate comments.

Please send your comments no later than end of day September 26, 2021. Comments will not be accepter on or after September 27th, 2021.

Please use the following file nomenclature in saving your review document:
ShastaGSP_PublicReviewDRAFT_[Your name]_date

Thanks for contributing to the draft Groundwater Sustainability Plan for the Shasta Valley Groundwater Basin

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

Reviewer name: Scott Valley and Shasta Valley Watermaster District
Submission date: September 26, 2021
GSP sections reviewed:

Chapter	Page	Section	Line/Table/Figure #	Comment (*please delete example text below once you submit*)
2	14	2.1.2.2	Line 233	Recommend: Amend to specify that "during dry seasons, groundwater springs in the Big Springs Complex provide an estimated 95 percent of baseflow to the lower Shasta River via the Big Springs Creek tributary" (Nichols et al, 2010). SSWD-001
2	19-20	2.1.2.12	449	Recommend: list BSID and MWCD separately, to identify them as the only irrigation districts that divert groundwater. Comment: If the descriptions of SWRA and GID are to remain in the plan, need to make clear that these are adjudicated surface water users that are not subject to SGMA. SSWD-002
2	20	2.1.2.12	450	Correction Needed: BSID abandoned 25 of 30 cfs priority 24 from Big Springs Lake in a letter dated 6/18/1987 to DWR. BSID then abandoned the remaining 5cfs in a letter dated 12/17/1996 to DWR. Therefore, BSID has no active water rights from Big Springs Lake. SSWD-003
2	20	2.1.2.12	451	Question: what entity will manage BSID's groundwater diversion? SSWD-004

2	20	2.1.2.12	454	Correction needed: Please clarify that BSID does not divert surface water. Is the "surface water management" described here referring to their delivery system? SSWD-005
2	20	2.1.2.12	456-462	Correction needed: Please clarify that GID has surface water rights via the Shasta River Decree that are not subject to SGMA. Question: how/why will GID surface water management be incorporated into the GSP? SSWD-006
2	20	2.1.2.12	472-476	Correction needed: Please clarify that SWRA has surface water rights via the Shasta River Decree that are not subject to SGMA. Question: how/why will SWRA surface water management be incorporated into the GSP? SSWD-007
2	23	2.1.2.16	519-530	Comment: Thank you for editing this section from the previous draft. Lines 519-530 are now largely duplicative to lines 531-566, and could be deleted. SSWD-008
2	24	2.1.2.16	567-568	Comment: SSWD may be prohibited from providing this level of diversion detail due to privacy regulations. However, we can consult with legal counsel as to what type of aggregate data we could provide. SSWD-009

2	78	2.2.1.5	1466-1468	Comment: This statement is not accurate. Please provide supporting documentation for the Willis source.	SSWD-010
2	107	2.2.2.6	2087	Recommend: Since Big Springs accounts for 95% of lower Shasta River baseflow during the irrigation season, please pursue research to address this data gap first, rather than the current research focus along the Little Shasta River.	SSWD-011
2	116	2.2.2.6	2209	Correction needed: No surface irrigation diversions were occurring at the time of this study. Please edit this sentence to reflect this fact.	SSWD-012
3	6	3.3	All	Comment: SSWD can assist in collecting data that will inform the "Depletions of Interconnected Surface Water (ISW)" component of the GSP. SSWD has a particular interest in addressing the SGMA undesirable result of "depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water" *Wat. Code § 10721(x)(1)- 93 (6).*	SSWD-013
3	14-17	3.3	Table 1	Recommend: Highly recommend adding ISW monitoring sites near known groundwater pumping locations.	SSWD-014

3	26	3.3.4.1	436	STRONGLY RECOMMEND: Need to evaluate groundwater contributions to the Shasta River year-round, or at least before, during, and after irrigation season. SSWD-015
3	29	3.3.4.1	474	Recommend: SPU gage has value as indicator of surface water depletions, particularly immediately before and after the majority of groundwater pumps turn on in the spring. SSWD-016
3	30	3.3.4.2	504	Recommend: SPU is currently maintained by DWR and has been since 2013. Please include the data from this gage. SSWD-017
3	31	3.3.4.3	513	Recommend: Monitoring needs to occur prior to groundwater pumps turning on in the spring, in order to capture data to help determine how much groundwater pumping is depleting surface flows in the lower Shasta River. SSWD-018
3	31	3.3.4.3	522	Recommend: If groundwater level sampling only occurs twice per year, it should be done pre and post irrigation season. SSWD-019
3	42	3.4.3.2	791	Question: What are the identified reaches for ISW? Again, any useful ISW measurements need to be taken prior to, during, and after irrigation season. SSWD-020
3	42	3.4.3.2	807-812	Comment: Computing baseflows at SRM using this formula for gaging SSWD-021

minimum thresholds during the irrigation season on a real-time basis can be very cumbersome and inaccurate due to all the variables involved including the large number of adjudicated and riparian surface water diversions between Dwinnell Reservoir and SRM, unknown surface and subsurface return flows from irrigation as well as the large flow travel time between these two sites which is estimated at about 18 hours at lower flows. For this method to be reliable, the flow at the upstream and downstream gages and the surface water and ground water diversions would have to be in a steady state at least 18 hours before the measurements as well as during the measurements. The watermaster would also need permission from the riparian diverters to measure their diversions along with the adjudicated diversions within a given day. Even so, this method does not account for the depletion of surface water due to ground water diversions.

SSWD-021 contd.

Given all the variables involved, SSWD recommends that minimum thresholds be determined for SPU and real-time baseflows be computed

				using the SPU gage instead of SRM. When baseflows are approaching minimum thresholds, only a few surface water diversions will be occurring between Dwinnell Reservoir and SPU, no riparian diversions exist, the flow travel time is only about 6 hours and as the available flow data for SPU indicates, the baseflow at this gage equals near 100% of the inflow to the Lower Shasta during low flow periods and the actual flow at this gage would be close to the baseflow.	SSWD-021 contd.
3	43	3.4.3.2	Table 7	Correction needed: The SRM mean daily flow values for 2016 and 2017 in Table 7 do not agree with the USGS final data. These values should be 40.6, 48.8, 65.6, 67.4, 71.4 and 75.0 cfs, respectively. The flow values for 2018 – 2020 agree with the final data. Also, it appears that the terms “Baseflow” and “Groundwater Contributions” as used in Table 7 and Figure 10 are the same values, but this is confusing.	SSWD-022
3	45	3.4.3.4	Table 8	Recommend: SSWD recommends that the preliminary minimum threshold for baseflow be set at 115 cfs instead of 100 cfs and a trigger be	SSWD-023

				set at 130 cfs instead of 115 cfs at SRM and that these values do not change depending on the year type.	SSWD-023 contd.
3	45	3.4.3.3	849	Recommend: using 115 as the minimum threshold. This is consistent with the recent SWB Emergency Drought Regulation. If the SGMA process doesn't address drought conditions, the SWB likely will. Note: The recent SWB Emergency Drought Regulation included a schedule of water right priorities for both surface water and groundwater users. It would behoove the SGMA Team to include this in the GSP.	SSWD-024
3	47	3.4.3.6	932	Recommend: CDFW will be installing a stream gage in Big Springs Creek, which is a major ISW area. Recommend including this gage into the monitoring network to provide real-time continuous flow data.	SSWD-025
4	6	4.1	Table 4.1	Correction needed: on Watermaster Tier 1: Please add first sentence: "Implements Shasta River Decree." Then, please replace "enforce" with "assists in managing."	SSWD-026
4	10	4.1	Table 4.1	Recommend: adding Tier 3 project titled "Coordinated Shasta Valley Irrigation Management," as a voluntary locally-led initiative	SSWD-027

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

				amongst all water users to rotate diversions and employ other tools to keep more water instream and avoid additional regulations. Potentially led by SSWD or RCD.	SSWD-027 contd.
4	11	4.2	304	Recommend: For new well permits, add a restriction of how close to surface water the well can be placed, based on modeling of if surface water will be depleted by well pumping.	SSWD-028
4	19	4.2	501	Same recommendation as above.	SSWD-029

Perez-Reyes, Marisa

From: Matt Parker <mparker@co.siskiyou.ca.us>
Sent: Monday, September 27, 2021 8:07 AM
To: Perez-Reyes, Marisa; Duncan, Katie
Subject: FW: Draft plan comments
Attachments: Ch2.docx; Ch3.docx; Ch4.docx

-----Original Message-----
From: David Webb <Dave.webb@shastariver.org>
Sent: Sunday, September 26, 2021 8:51 PM
To: SGMA <sgma@co.siskiyou.ca.us>
Subject: Draft plan comments

Please accept the attached comments to the latest version of the SGMA plan.

We would like to have it noted that we are filing under protest, in that the entire document has not been available for the entire 45 days, and that some of it is still not available, hence we were not able to review either all that has been posted, nor the entire document since some is not posted at all. At eh same time, we do recognize that DWR seems to not be willing to allow additional time for completion and proper review. FOSR-001

Thank you.

David Webb

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

Reviewer name: David Webb for Friends of the Shasta River
Submission date: 9/26/2021
GSP sections reviewed: Chapter 2

Chapter	Page	Section	Line/Table/ Figure #	Comment (*please delete example text below once you submit*)
2	8		1	The numbers appear to be for the entire watershed. They should be subsetted out for the management area only. FOSR-002
2	9		3	Unclear what the X and Y axes are. There should be a link to an electronic version that can be downloaded and viewed at such a scale as to be meaningful FOSR-003
2			450-4	Check with Lisa Faris, but I think BSID has formally abandoned its right to Big Springs as a water source FOSR-004
2	20		466	MWCD has a storage right to 35,000 af from the Shasta and ~14,000 af from Parks Creek, with no restriction on flow from the Shasta, and 150 cfs max from Parks Creek. And you should be more explicit about their gw usage since it has already been the target of an interference lawsuit. They pump gw from both the Pacy Wells and the Flying L pumps, and until the last few years their canal leaked to groundwater 20-30 cfs constantly when running full, which is now gone as a result of public funding for canal lining. Also MWCD has blocked public access to any of the data from the gauges below the dam, so they may not be worth mentioning. FOSR-005
2	22		494	I don't think the SVRCD has had funding for operation of the Yreka Creek gauge for some years. Better check. FOSR-006
2	23-4		519-68	This contains internal inconsistencies and errors, is overly long. Needs to be completely rewritten FOSR-007
2	26		637-45	2014 data should be updated from current county records. Additionally, note should be made that the reduced property tax income to the county has not been offset by state subvention funds since 2009. FOSR-008
2			650-658	This sections should include information on the impacts of the recently lost lawsuit where the county is now required to do CEQA analysis on new well permits, providing a basis for future gw demand management. FOSR-009
2				

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

2	27-28	660-701	This illegal use needs to be put into perspective, with the range of water usage estimates converted to estimated acre feet, with comparison to other agricultural uses of groundwater in the Shasta Valley. The county is already under fire for claimed racist treatment of illegal growers. Not adding this perspective adds to that issue.	FOSR-010
2	28	712-19	This could be a whole lot clearer. Rewrite please	FOSR-011
2	29	726-7	This ignores the de facto replenishment from the extensive network of irrigation ditches. And it should be noted that public funding is steadily reducing that recharge through payments for pipelines and canal lining, both of which need to be factored into availability calculations going forwards from baseline years.	FOSR-012
2	30	738-69	You really should mention the lahar forming the bulk of the flat portion of the Shasta Valley, and much of the gw basin, and which is responsible for forcing water in Pluto's cave basalt to surface as springs.	FOSR-013
2	35	Fig 8	Text of caption does not quite match illustration	FOSR-014
2	43-4	814-	Completely ignoring the lahar filling the Shasta Valley presents a very outmoded interpretation of surficial geology. See USGS Bulletin 1861	FOSR-015
2	44	819-21	It should be clearly noted that the Hornbrook formation does not yield potable or agriculturally useful water and serves as the lower extent of usable aquifer space	FOSR-016
2	48-9	975-980	This needs to be re-written so as to be meaningful to the ordinary reader	FOSR-017
2	78	1480	Range of data years not correct.	FOSR-018
2	85	1586-94	For proper understanding, merely saying gw levels are stable doesn’t impart the most important pieces of the picture. More accurate would be to say something along the lines that overall, full recharge occurs by the spring of each year, but because measurement are taken only spring and fall nothing is known about the timing or maximum depth of summer drawdown as it may be changing over time.	FOSR-019
2	86	1615-6	It is also important for domestic uses which must be noted here. Additionally, the importance for fish should be further highlighted with the need for gw levels to be sufficiently high to sustain cold gw discharges in the stream bed and from springs feeding the river. Without that discharge no cold water fish habitat will survive, and its maintenance will necessarily serve to guide future gw management	FOSR-020

2	86	1621-2	Reference is made to section 2.3, which doesn't seem to exist. Why not go into gw storage here along with the following maps, rather than making a reader jump around?	FOSR-021
2	87-91	figs	These figs would be improved if you added the east-west roads--HY 3, A-12, Louie Rd and Jackson Ranch Road.	FOSR-022
2	87	Fig 35	Elevations throughout should be converted to MSL also with a 2nd map set to show that, since surface elevation is highly variable, hence depth to water is largely meaningless, especially without surface elevation..	FOSR-023
2	93	1627 ff	Mention in this background section needs to be made of the absolutely crucial role gw discharge to surface water plays on surface water quality in terms of temperature, and while gw temperature isn't going to change, reduction in gw discharge will/has negatively impacted surface water quality and placed an possibly insurmountable burden on surface water users in terms of meeting TMDL goals without integrating gw depletion into TMDL targeted efforts.	FOSR-024
2	94 ff	1668 ff	You fail to provide any insight into the marked degradation in water quality resulting from extraction from the Hornbrook formation vs. overlying sediments. That degradation effectively makes the Hornbrook unsuitable for any current uses and limits water availability in the basin to those sediments overlying it only.	FOSR-025
2	94	1675-77	In this section it is not clear, but it appears that what may have been done is approach the contamination question backwards--taking existing wells and using them as the basis for a monitoring plan. A proper approach would be to first determine what areas and constituents needed to be monitored, then looking to see if any existing wells were located where needed. If so, their usage would be appropriate Limiting investigations to only existing wells is completely faulty and needs to be done properly.	FOSR-026
2	95	1718	Refers to Appendix 2-b, which is the correct title as posted, but the document itself is called Appendix C in the headers and title sheet.	FOSR-027
2	105	2055-59	Surface diversion has an arguably greater impact on flow most of the year than any of the natural factors except winter floods. As such, to keep flow variation in perspective, irrigation diversion absolutely must be pointed out here as taking 90% or more of the total natural flow at times in nearly all summers,	FOSR-028

FOSR-028 contd.

				overwhelming other factors.
2		108	2095-8	Data was presented to the consultants by representatives of the water master district strongly indicating that in 2020 considerable losses of surface water to groundwater was occurring between the CDEC gauges SPU and SRM. While not part of any planned study, the implications and magnitude are too great not to be mentioned here. Also important is that the apparent placement of the SRU transect near the apparent confluence of Julien Creek may have inadvertently left it influenced by stream underflow from Julien creek and its near-stream associated springs to the west of the Montague Grenada Road. As such, its findings should be clearly explained as not necessarily representative of any other portion of the river, and the data from between SPU and SRM should be included here to offset any misperceptions. FOSR-029
2		110	Fig 46	Need a more detailed location of transects please. FOSR-030
2				
2	120 ff, 126,	2.2.2.7	2230, 2331-3	The GDE screening use of DWR's identified irrigated areas in an effort to exclude man-made wet areas yields faulty results in that (in the words of UC Extension agent Dan Drake describing one such area in particular) there are irrigated areas of natural wetland which he described as " an irrigated swamp". That situation of rising groundwater creating small to large wetlands is relatively common in the Shasta Valley with its confused surface and subsurface geology, and the impossibility of fine-tuning flood irrigation to not irrigate such wet areas if the surrounding areas below the ditches need irrigation. Failing to identify and capture the seeps, springs, and wetlands effectively eliminates many early-warnings of declining groundwater, and will ultimately result in decreased surface flows. Many such areas are also irrigated, or surrounded by irrigated lands, making them impossible to identify by DWR. There needs to be further study, perhaps along the lines of performing remote sensing of leaf moisture content in the Fall of the year well after irrigation has ceased to identify areas with leaf moisture levels higher than surrounding areas, regardless of whether irrigation ditches are present near-by or not. Large areas meeting this description can be found south of the Parks Creek crossing of HY 99 and north of the Edgewood Exit , north of the Hy 3 crossing of the Shasta River, South of FOSR-031

			the Montague-Grenada Road Crossing, and along a broad swath of the little Shasta west of Harry Cash Road and East of Montague, and elsewhere. In addition, the tiny maps in the document do not allow review of any specific areas for inclusion or exclusion and are useless eye candy. GIS data needs to be posted and accessible and also detailed PDF maps so the general public can draw proper conclusions.	FOSR-031 contd.
2	130 ff	2394-2400	This appears to be saying that an acceptable depth to gw will be at the extreme end of the maximum depth of willow rooting, or even beyond. That provides no margin of error for climatic fluctuations, and ignores the necessity of water reaching the surface in order to allow seedling propagation. If this is correct, it is not at all conservative and needs to be reduced to some mid depth value for dry years, and near surface for wet years. The same applies further on for other gw dependent species also. If this is incorrect, the topic needs additional clarification please.	FOSR-032
2	133-3	2412-2433, fig 58	Given the unique geology of much of the Shasta Valley, there needs to be some sort of validation that "*These grid or raster geospatial datasets were developed 2428 by interpolating between statistical representations of observed groundwater elevations for each three-year rolling period using data obtained from the California Statewide Groundwater Elevation Monitoring (CASGEM) Program using the well-establish kriging method*" can in fact be accurately used to interpolate between known points. Common methods won't always work in uncommon situations, and there is no discussion/documentation of their applicability in an area dominated by the largest volcanic lahar on the planet and with large areas of volcanic deposits which collectively funnel groundwater to the surface or restrict it below the surface in ways not consistent with conditions found in purely alluvial areas. See also lines 2679-82 in Chapter 2 confirming this complexity. Finally, depth to gw seems to be a relatively useless metric in an area of highly varying surface elevation, again as different from typically fully alluvial areas. All gw data should be also presented in height relative to mean sea level.	FOSR-033
2	135	2434-2437	The processes described seem reasonable, assuming the data is accurate, but in fact it necessarily relies on multiple layers of approximations. As far as I know,	FOSR-034

				elevation for most of the Shasta Valley is only available as 30 m digital elevation models (DEMs), making comparisons of measured depth to gw at one well location impossible to compare to depth to water at another potential GDE location, since the electronic surface elevations are not nearly sufficiently accurate at the elevations involved. As with the rest of the document, there isn't sufficient time to adequately research this other than to bring it up as an apparent problem. While the normal accuracy of 30 M DEM's is stated as "3.04 meters." It is followed by the following caveat "It is important to note that the vertical accuracy actually varies significantly across the U.S". Given the target depth for willow roots of 13', or 4 meters, there is ample room for mis-classification of all species.	FOSR-034 contd.
2	136		2504-09	This paragraph claims the analysis (described in our prior comment above) describes "the maximum possible extent" of vegetated GDEs. As stated above, surface elevation data appears to be inadequate to support the analysis used, and hence the conclusion stated. It goes on to note that it is not a definitive determination, but the plan includes no sub sample analysis type project proposal to validate its accuracy, and instead will leave unknown acres unprotected.	FOSR-035
2	138-9		2513-4, fig 60 and 61	Sufficient data is not provided in appendix 2E as here stated. We have asked for numeric data used to produce the two figures, and the sources of that data and have received no response as of 9/26. This appears to be the validation period for the model, and a cursory look suggests multiple problems with the data assumptions built into the figures. Those problems cannot be evaluated without the above information. Included are: A static leakage value from canals despite ongoing canal lining, seemingly static lake leakage into gw, despite variable lake elevations and consequent leakage, increasing gw leakage into streams over time, despite expanding gw usage, and apparently unrelated to water year type, and no change in streams leaking into gw, despite presentation of data suggesting just that in the course of plan development..	FOSR-036
2	143-5	2.2.3.2, 2.2.3.3	Tables 13-18, 2637-2656	Collectively these pages and lines describe values used in depicting annual water budgets for a ~20 year period from 1991-2018. No source of the data values sued is provided. No explanation is given for how the values are	FOSR-037

FOSR-037 contd.

prorated for the various water years, The absence of this sources and methods information makes proper review and commenting on all terms impossible. Other published data strongly suggests significant inaccuracies exist in the numbers used. This information was presumably used to calibrate and validate the model outputs. If so, the model itself needs to be re-configured: As an example, Appendix 2-B page 23 includes a map of the longer leaky ditches within the watershed. Looking at just one of those explicitly identified ditches--the Montague Water Conservation District Main Canal--A study by Willis and Deas in 2010 for the Montague Water Conservation District (District) determined that the canal lost 28 cfs on a continuous basis when running at capacity. That quantity over a 180 day irrigation season equates to 10.1 TAF. In table 13 and 14, the **maximum** value for canal leakage to gw for the entire GW basin and watershed both is listed as 10 TAF, less than the measured leakage from this one ditch alone, let along all the other major and minor ditches throughout the watershed. To offset this error, some other factor(s) must be proportionally smaller than what is real, and a model built to target those inaccurate numbers will necessarily predict poorly. The other values shown are not so easily disputed in the absence of more source information, but would seem to be equally suspect. This error is compounded by the District's ongoing efforts to eliminate that leakage, and they currently have ~ $4 million in public grant funds to complete the lining of the canal, with an obvious impact on gw supply. Nowhere does the model make mention of subtracting an appropriate amount of recharge to compensate for this loss. Instead it calls for spending more public money to duplicate the effect of leaky ditches with MAR type projects. A proper plan should address this. It is also worth noting that the District doesn't necessarily operate for a full irrigation season in a dry year, nor does the Grenada Irrigation District, which also utilizes an unlined canal reported in their own documents as losing as much as 12 cfs when full, making for what should be a dynamic amount of canal leakage to gw value in the water budget, while the chart shows it as essentially straight line amount through all water year types. It appears that numbers have been over simplified with unknown consequences.

2	145	2605-7	The word "enhanced" while technically correct, presents the opposite feeling than what is needed to characterize conditions. Exacerbated would be a better word.	FOSR-038
2	146	2708-10	The reduction in discharge isn't caused solely by the absence of natural recharge, but is also reduced by GW pumping. Since this is a plan leading to management of gw usage, its impacts should never be ignored.	FOSR-039
2	146	2717-8	This sentence should include not just reduction in precipitation , but also reduction in anthropogenic recharged, as from ditch and canal lining, projects which should include offsetting measures if publicly funded.	FOSR-040
2	146	2722-4	The claim that climatic reductions in recharge will not cause overdraft is not supported by the identified consequences in these sentences--all of these are undesirable effects. GW usage and hence what constitutes overdraft is going to shift in harmony with gw supply in order not to cause a diminishment of surface flows.	FOSR-041
2	146	2724-2726	This concept is not given proper adherence elsewhere in the document when talking about monitoring--The amount of decline in gw levels is going to be apparently related to a great degree to the underground flow rate/underground porosity. Nowhere is that factor captured in changes in gw elevation standards proposed. I.e. all wells are treated as equal in terms of % decline before requiring management action..	FOSR-042
2	148	2797-8	No factual basis is provided for this assertion. It should be removed here and elsewhere.	FOSR-043
2	150	Fig 66	This is too small to be useful. It needs to be available full sized electronically. The apparent if slight increase in discharge of gw into streams needs to be explained. Nowhere has that been done.	FOSR-044
2	151	2826-8	Her and elsewhere this plan fails to recognize the critical role of gw in supplying cold water to the system, and the fact that existing usage levels are already significantly diminishing that cold inflow, jeopardizing attainment of the TMDL, further endangering coho salmon, and putting Fall Chinook salmon more at risk.	FOSR-045
2		2826-8	The claim that the sustained yield for the Shasta Valley is 42-45 TAF/year hasn't been substantiated anywhere. AS such it is an unsubstantiated assertion here	FOSR-046

			and absolutely needs to have its basis fully documented. That volume translates to 115-125 net CFS on a continuous basis for a 6 month growing season. That translates to 10,500-11,250 acres cropped with 4' of water per acre. In 2010 DWR estimated that approximately 10,200 acres were irrigated with just GW, an additional 1,230 acres were irrigated with a combination of surface and ground water, and no accounting was made of domestic use. At best there is no room for further expansion and that should be clearly noted. Also domestic use and illegal use needs to be factored in, along with planned reductions in gw irrigated acreages as recharge from canals is eliminated over time. We appear to have actually to have exceeded supply already, assuming that 115-125 cfs is even sustainable, which remaining instream flows say absolutely is not..	FOSR-046 contd.
2	151	2816-2822	While the assertion that the basin is not in overdraft, the previous comments suggests we are right on the edge. Beyond that, the experience of people whose wells have gone dry suggests that the out dated definition that looks only at long term ability to regain a spring-time gw level completely fails to protect gw users in mid summer if heavy irrigation use draws down summer levels below well depths, yet winter precipitation and soil porosity is still sufficient to allow full recharge. Hiding behind this interpretation does the citizens of the county no good, and only highlights the failure of the count to allow designating special management areas to address those areas experiencing summer water shortages. Reliance on this definition is a violation of state policy *" It is the policy of the State of California that every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes"*	FOSR-047

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

Reviewer name: David Webb for Friends of the Shasta River
Submission date: 9/26/2021
GSP sections reviewed: Chapter 3

Chapter	Page	Section	Line/Table/ Figure #	Comment (*please delete example text below once you submit*)	
3	6		155	Appendix Z should read Appendix 3-A	FOSR-048
3	7		167-74	It would seem prudent to have these needed study items consolidated into a master PMA list to facilitate future funding.	FOSR-049
3	7		178-93	If the collection of the indicated data is needed, then there needs to be a fall-back approach identified to be utilized when/if voluntary measures fail to yield needed results. More detail is needed in terms of where the identified data is needed, at what well density, etc.	FOSR-050
3	8-11		maps	These maps are somewhat redundant, are too small to convey much useful information, and there is an excess of white space. The maps could be larger, and have key roads on them for helping know what is where.	FOSR-051
3	12		221-5	PMAs should be recognized as being made up of both actions taken, **and actions avoided/not taken.** The county has made it clear that any actions that will reduce existing gw usage are going to be stringently avoided--an example of actions deliberately not taken. Monitoring wells should be adequately distributed in areas where those actions avoided are likely to have undesirable impacts to adjoining gw users and or ISW.	FOSR-052
3	12		236-7	This sentence imparts no useful information. If it is supposed to be saying something it needs to be written.	FOSR-053
3			246-50	Activities on the West side of the River need to be tracked and monitored separately from those on the East side. Likewise Pluto's Cave Basalt really needs its own monitoring plan with triggers and actions.	FOSR-054
3	12		256-8	While they may lack numeric data for depth to water over multi-years, the fact that domestic wells near A-12 are going dry should be treated as a long term trend if the owners can indicate that in past years no such problems existed	FOSR-055

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

			and as a result of declining water levels, now they do. With luck some or all of them will have a reliable depth to water at the time of drilling, to be compared to current problematic depths, providing an indication of long term trends.	FOSR-055 contd.
3	18	281-4	It would seem prudent to add to the list of projects the securing of extra well loggers to be standing by so that wells deemed potentially needed can be monitored on a preliminary basis and/or added immediately should they prove to be essential to proper management. they would also be good to have in the event of logger failure.	FOSR-056
3	18	286-7	Given the importance of the wells supplying Lake Shastina, it seems like they should be immediately added to the monitoring network if the CSD is willing. Specific outreach to them is in order.	FOSR-057
3	18	288-90	It seems likely that DWR guidance for well density is poorly suited to a volcanic area such as the Shasta Valley, with its convoluted and confused geology and hence hydrology. that should be clearly noted so as to allow finding funding for a greatly expanded monitoring network.	FOSR-058
3	22	305-8	2x annual monitoring may be good enough for some purposes, but protection of domestic wells in a meaningful fashion requires near-real time monitoring during critical periods. There should be a separate focus on meeting domestic needs in near real time, with monitoring, triggers and actions defined.	FOSR-059
3	22	318-21	It appears that the SWGM cannot provide a numeric value for Storage as the text here states, but only an indication of whether it is increasing or decreasing or staying the same based on gw elevation. Is this correct? If so the language needs to be corrected. If not, additional information needs to be included in Appendix 2-E to explain how a model utilizing cross section data with an unknown boundary between usable water bearing strata and the Hornbrook formation, with seemingly no data known for subsurface porosity, and gw levels at the edge of the river varying from above and below stream water level, is able to estimate volume of groundwater. Perhaps an illustration.	FOSR-060
3	23	363-6	Developing a plan based solely on what is available free or cheap seems arbitrary at best. It would be more appropriate to first develop an ideal plan, then see what if any existing wells approximate it. After that others need to be	FOSR-061

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

			secured. Having such a plan should facilitate securing funding for additional wells.	FOSR-061 contd.
3	24	366-7	This speaks to the need for equipment, specifically a down-hole camera to be used to capture screening details. Use of it might also help to further validate well logs, and cause those not accurate to be discarded from use.	FOSR-062
3	24	367-8	USGS examined 21,400 well logs (as reported in USGS Bulletin 1766) in eh Central Valley, and found that only 590 of them had sufficient information on screening and water depths to be usable in assessing gw availability in the Central Valley--2.8%. We should expect no better here. A program needs to be established and funded where-by a trained geologist accompanies drillers to perform well logging in key areas when wells are being drilled there, along with a down hole camera to capture and/or validate well log information or add to it.	FOSR-063
3	24	381-2	Does it matter if a well to take a water sample from is domestic or Ag? Might other parameters matter more especially water source depth and proximity to known or suspected sources of Water Quality problems?	FOSR-064
3	27	397	It seems as if a plan should have sequential steps evaluated for relevance via the prioritization process, then organized into a table, making it clear that each is an essential step that is part of a well organized plan. This SGMA plan is long on explanation, which is good, but short on identified and organized action items. That really needs to be fixed. Here, there needs to be an action item explicitly committing to doing something specific with regards to adding more wells and/or drilling dedicated wells, or at least a process for deciding those details.	FOSR-065
3	27	408-10	Section 3.3.4.1 really doesn't provide any enlightenment on where and how and how many additional wells will be selected.	FOSR-066
3	29	Fig 6	Description does not match illustration. Illustration needs to be made clear--is it hypothetical for the Shasta Valley, or data based? Does the table refer to the 70 cfs discharge or 35 cfs?	FOSR-067
3	29-30	487-95	While this methodology could be able to work well given proper targets, there seem to be unrecognized issues that need to be resolved before it can hope to be reliable. First, aquatic organisms do not live on 2 year averages, or any	FOSR-068

			other long term metrics. They live or die in the moment, depending on river flow, temperature, and dissolved oxygen levels. Properly protecting GDEs and ISW will require a real time monitoring and response process, not one apparently intending to look at 2 years of data prior to taking anything seriously, and even then perhaps not acting on those observations other than study them more. As a "Plan" this needs to recognize that reality and specify triggers and actions to be taken. Secondly, , many diverters, either by choice or at the direction of the water master do not divert their full water right continuously. Somehow that needs to be captured in a real time basis. At present that is not possible and needs to be created ASAP so as to utilize the full 5 year window. Third, from 20+ years of working with irrigators, developing irrigation efficiency studies, and educating myself on irrigation practices, it is painfully obvious that no one is 100% efficient. 50% is as good as is normally encountered. Persons with difficult to irrigate ground, or excessive water rights can do even worse. The excess water they apply is not consumed, and in instead generally finds its way back to the river, either very quickly as surface tailwater, or a little more slowly as subsurface return flow. The rapidity of those process can be visualized by the response of the river at the end of the irrigation season when the river rapidly rises to a static flow, but doesn't rise up then decline as diversion ceases and tailwater continues to supplement natural flow. Having the water master inform you of the gross diversion Q every 2 weeks is of little or no value in terms of determining surface depletion or meeting the minute by minute needs of aquatic systems. Somehow you will have to arrive at a real time value for ET in order to be able to know what the depletion is from surface diversion. Finally, as a general observation the SPU gauge seems far more useful as an index of GW discharge to the stream from nearly all sources than would a complicated process of trying to work out a water balance with multiple users doing unpredictable things as the whim strikes them.	FOSR-068 contd.
3	30	Table 4	SV02 seems to be oddly placed to monitor GW levels for anywhere except very close to where it exactly is. I have seen no explanation as to why this	FOSR-069

			location was chosen--it appears to have been arbitrarily selected on some other basis other than functionality. It is completely unclear how it can be expected to be representative of GW levels anywhere else, especially in areas where GW is discharging to the stream. Review of data from SRM and SRY suggest that about 5-10 cfs is added to stream flow between SRM and SRY in the absence of precip., suggesting that GW is of little significance between those two stations, especially when compared to the 70-150 cfs that discharges tot eh river upstream of SPU, where monitoring of gw levels would seemingly be far more useful. This site either needs to be fully justified vs. other potential sites, or some other site(s) than can be justified chosen. Given the acknowledges uncertainty of how best to properly manage gw in the absence of adequate information, it would seem far more sensible to monitor multiple sites in the expectation that one will be unpredictably better than he others, rather than arbitrarily settle on one location and hope for the best while waiting for 5 years to discover no useful information was gained. These observations are supported by lines 871-5 in this document, ch 3.	FOSR-069 contd.
3	30	509-11	While a target of 2032 may or may not be reasonable, I have not seen any specific steps identified that will make addressing the details of the Little Shasta any easier or more doable in 2032 than it is now. Data gaps, along with proposed steps that need to be taken to fill them need to be identified, along with a timeline for accomplishing them.	FOSR-070
3	31	513-521	The validity of this approach isn't immediately apparent, and needs to be more fully developed and explained especially with regards tot eh rationales used. In >30 years of driving I-5 over Parks Creek, and always driving in the fast lane when going across the Parks creek bridge so as to be able to see the creek where it crossed the Mills ranch low water crossing under I-5. In all those years, I have never seen a no flow condition other than this summer. I question if it should be adopted at the expected target prior to initiation of monitoring. Both Parks Creek has spring flows both above and below the "dry reach", flow that is in large part diverted. Again, I am not sure exactly what is being tracked by this process. The Little Shasta has substantial flow upstream of the dry reach, again diverted, and possibly about to be supplemented by	FOSR-071

			1707 water from the Hart Ranch. Again, just how this process yields useful information isn't clear.	FOSR-071 contd.
3	31	522-3	These two sentences seem contradictory--will the monitoring be continuous or 2x annually?	FOSR-072
3	35	599-605	"Excessive" needs to be defined or described, as does "adverse". Without definition this section is meaningless.	FOSR-073
3	36	614-5	Selecting as a target the drying up of domestic wells as an acceptable and anticipated outcome when it could be prevented by proper management and sharing of eh GW resource is not acceptable as a planned approach. I hope the people likely to be affected are outraged. Will your recommend red tagging homes with no water supply for that portion of the summer when there is none?	FOSR-074
3	36	638-42	This 75th percentile and 10% buffer seems to be completely arbitrary, with no basis for determining if it is protective of all uses. Additionally, it appears that it would allow pockets of severe impacts to the functionality of most wells, as long as elsewhere in the watershed things were doing better enough to meet the 75th percentile overall. Given the complicated geologic conditions and substantial unknowns, this doesn't seem like an acceptable approach. Something more protective of domestic users along with GDEs and ISW needs to be selected, especially for the first 5 years. It needs to be recognized that all existing wells almost certainly have been adequate for meeting domestic needs for all years since they were drilled, until the last 2 years. That potentially decades long history shouldn't be ignored, just because a depth to water value is unknown. It is known that the depth to water was above the level of the pump until excessive extraction relative to supply occurred in 2020 and/or 2021.	FOSR-075
3	40	720-21	The Shasta River jumps up within 2-3 days of the cessation of most irrigation on or before October 1, regardless of any precip. That flow is a direct measure of the then-impaired gw discharge to the stream. This sentence appears to belong in the Scott watershed, not the Shasta	FOSR-076
3	40	723	This sentence appears to refer to the Scott River also.	FOSR-077
3	40	727-28	This sentence appears to refer to the Scott River also.	FOSR-078

3	41	751-2	It needs to be noted that adverse impacts happen to junior water users in all or essentially all water year types (i.e. GID always gets curtailed sooner or later each summer). That is easy to document. Equally important, aquatic organisms are negatively impacted each year as a result of low flows, excessive temperatures, low levels of dissolved oxygen and passage barriers. The presence of those impairments should be sufficient to define a gw dependent ecosystem as in chronic overdraft during each summer and Fall. there is certainly no need to wait for 2 years in a row of some other impacts to make that determination. This has been the case since 1916,	FOSR-079
3	42	796-801	The multiple deficiencies of this approach were described above.	FOSR-080
3	44	842	Artificially imposing the "Fall Minimum" (plus buffer?) as an acceptable target is likely to result in reproductive failure when GDE plants generally need surface water for seed germination, followed by a slow decline in water level below the surface. This will potentially yield the same results as are seen in the Shasta River at eh beginning of the irrigation season when water levels unnaturally drop in advance of the release of willow seeds, effectively eliminating natural recruitment.	FOSR-081
3	44	844-5	It seems unlikely that satellite imagery will be able to discern the above reproductive failure, but will instead track the presence of mature over story plants until they get old and die, with nothing to replace them. By that point cause and effect are likely to be unlinked in people's minds.	FOSR-082
3	45	849	Again, selecting 100 cfs as the MT appears to be entirely arbitrary, especially given that Figure 10 shows that flows that low only occurred in one unusually dry year since 2010. At this point, there would seem to be sufficient data to select targets based on average conditions or past water year types for which we have data, pending the collection of more data, not the lowest number available. Setting a low number will only provide an opportunity to allow additional gw development to take place while the next 5 years pass, assuming they are normal water years and not a continuation of drought. Adding to the existing overdraft condition will only make future management harder. In the face of considerable uncertainty, a conservative approach should be taken.	FOSR-083

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

3	45	856-7	To be useful, it is necessary to know the surface elevation of the river closest to this well--what is it vs. the MSL elevation of the water target in this well?	FOSR-084
3	45	857	This depth to water appears to preclude the establishment or survival of any GDE native to the Shasta Valley. Please explain how that relates to line 855.	FOSR-085
3	45	Table 8	Suddenly this table says the MT can now be 80cfs (20% less than 100 cfs). Nowhere is that mentioned nor justified. 100 cfs is already unreasonably low. This is bait and switch. If a 20% buffer is needed, then the MT should be set 20% higher than any acceptable minimum, or 125 cfs.	FOSR-086
3	45	864-8	The importance of these lines is not clear and they need to be better explained. Historic data needs to be supplied for this well to allow the numbers presented to be evaluated.	FOSR-087
3	49	1003-4	No adequate justification is provided for limiting water quality tracking to these tow constituents only. In addition, language in lines 1073-5 acknowledges that subsurface gw flows in any direction are possible in the presence of heavy gw pumping, potentially mobilizing naturally occurring contaminants from where they are naturally found to areas where they won't be expected nor looked for. Less frequent but periodic monitoring is needed to provide indications of this should it begin to occur.	FOSR-088
3	51	1096-7	I have looked through the Harter reference, and can find no justification for the statement here to the effect that Shasta Valley CAFO stocking densities are not of concern. As such, that assertion is not supported by any facts and must be seen as arbitrary. Please provide a page number if I am mistaken.	FOSR-089
3	61	1349-51	I was unable to find any such reference document. Please provide a proper link and/or title	FOSR-090
3				
3				
3				
3				
3				
3				
3				
3				

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

Reviewer name: David Webb for Friends of the Shasta River
Submission date: 9/26/2021
GSP sections reviewed: Ch 4

Chapter	Page	Section	Line/Table/ Figure #	Comment (*please delete example text below once you submit*)	
4	2		60-3	The GSA should be explicitly identified as having responsibility for commenting both in favor and opposed to activities, both those brought to it for endorsement, and other publicly funded activities that further or retard GWMP goals	FOSR-091
4			80-5	The plan fails to live up to this goal, particularly in regards to its failure to in any way acknowledge or address the absolutely essential role discharged groundwater plays in providing cold water refugia and in overall water temperature protection.	FOSR-092
4			88-9	Again, as a responsible management agency the GSA should be prepared to speak up to both support and oppose future proposed activities. Merely staying silent on detrimental projects isn't acceptable.	FOSR-093
4			131-3	I have not seen criteria for rejection of any project, just higher or lower scores, with no suggested threshold for rejection either as inadequately beneficial vs. cost, or likely to cause harm. That leaves the door open for "smokescreen" and "sweetheart" projects	FOSR-094
4	9		Table, row 2	In addition to leasing, higher priority should be given to permanent purchase of water. Leasing is appropriate for temporary situations. These issues are not temporary.	FOSR-095
4	9		Table, row 3	"irrigation efficiency" should never be given blanket endorsement--such projects often lead to an expanded irrigation footprint, reduction in anthropogenic recharge, and the transfer of "saved" water to more upstream junior users. Where mentioned language should include something along the lines of "carefully vetted" irrigation efficiency projects "scrutinized to assure no unintended consequences result". Particular scrutiny should be given to NRCS projects, in that NRCS is legislatively constrained to looking at only "on farm" impacts for the project recipient, not community, basin	FOSR-096

			wide or off farm unintended consequences.	FOSR-096 contd.
4	10	Table, row 2	ILR sounds like a benign approach, but to the extent that it allows a diminution of gw discharge to the stream by replacing it with a similar volume of the mixed natural water and tailwater that constitutes current river flow, it undermines essential water quality needs and goals in terms of water temperature and potentially nutrient loading. It is often unlikely to be overall beneficial at meeting the combined water management goals the river must achieve from all regulatory agencies.	FOSR-097
4	10	Table, row 3	It is inappropriate to propose large physical project such as this without first doing a preliminary engineering study to document its likelihood of success. Nowhere is that essential first step proposed.	FOSR-098
4	10	Table, Row 4	This approach also needs to have a preliminary study and action plan in place well before any needed implementation so that actual implementation can be carried out in a fair and effective fashion, with minimal surprises or discussion-related delays. No such study and plan development is proposed anywhere, effectively preventing groundwater curtailment as a real option.	FOSR-099
4	11	211 ff	Significant portions of this project have been the subject of a Notice of Violation from the SWRCB for violation of state water law. It is an example of a (deliberately?) flawed examination of project details before investing money in preliminary studies, and/or the preparation of funding requests. Endorsing projects with illegal components undermines the credibility of the GSA and will impact the future effectiveness of it.	FOSR-100
4	12	225	This project needs to be expanded, especially in the area between river mile 15.5 and 31 that becomes a losing reach over the course of the summer under current gw usage conditions.	FOSR-101
4	12	236	As of 9/22 this appendix appears not to exist	FOSR-102
4	13	264-73 ff	Needing to be added here are projects to perform preliminary engineering studies of most Tier 3 actions, to complete instream flow studies so as to quantify the availability of "excess water" for storage projects or MAR, to define likely benefits of proposed MAR experiment, funding for water acquisition, funding for well installation to fill data gaps, funding for hiring a qualified geologist to accompany well drillers to prepare reliable well logs,	FOSR-103

			either local legislation requiring above geologist on wells, or incentive payment to landowner and driller for allowing geologist to log well while being drilled, funding or additional piezometer transects between rm 15.5 and 31, and elsewhere, studies to quantify accurately the recharge occurring from unlined ditches so as to respond appropriately as they become lined over time, studies to define underground transit times in various areas to set a foundation for evaluating recharge and water banking proposals, FOSR-103 contd.
4	14	309	Add "canal leakage" to the list of recharge sources FOSR-104
4	14	311	Replace "lead to" with "are indicative of" FOSR-105
4	14	321-23	As noted elsewhere in the plan, gw usage has decreased the flows from Big Springs alone by approximately 1/2 (~60 cfs),, severely degrading the ability of the river to support groundwater dependent ecosystems, specifically cold water fish, or to support existing surface water users. This plan needs to acknowledge that failure to reverse, or partially reverse that impact will guarantee continued uncertainty and risk of litigation. Using as a stated goal the continuation of the current usage levels is not acceptable. FOSR-106
4	14	328-9	Comparing the 5 or 10 year average ET to the maximum ET observed between 2010 and 2020 will result in an increase in gw usage. It should be compared to the comparable average between 2010 and 2020; FOSR-107
4	15	350	To meet this standard, it isn't sufficient to minimize future extraction. It will also be necessary to reduce current extraction proportionately to identifiable reductions in recharge. Specifically, 8 miles of publicly funded canal lining by the Montague Irrigation District slated for completion in 2021, and is intended to reduce gw recharge by approximately 28 cfs continuously, during all periods when the canal is running full. Estimates and modeling were based on a time frame when that leakage was customarily part of the working gw system. See further comments on the topic in Ch2 comments. Other individuals and entities are similarly taking steps that will reduce their recharge, with no effort within this plan to track, offset, or oppose the substantial and measurable losses. FOSR-108
4	16	402	The unsubstantiated statement, that "Currently, there is no threat of chronically declining water levels in Shasta Valley" is not supported by any FOSR-109

			preventative measures yet in place to limit gw extraction to its current levels, let along levels that would not result in undesirable results. In fact numerous domestic users are finding that they are increasingly without water as a result of declining water levels that is becoming more problematic each year.	FOSR-109 contd.
4	16	403	The unsubstantiated statement "the basin is not in an overdraft condition" here and elsewhere is in direct contradiction to data documenting that Spring flows in summer, as measured at Big Springs, have declined by ~ 60 cfs. That loss of cold water both where measured in Big Springs, and presumably from other springs fed by the Pluto's Cave Basalt has directly and adversely affected the ability of the river to support its most iconic GDE species--salmon, both coho and Chinook. Additionally, the decrease in gw discharge to the surface has directly impacted junior water users who are increasingly frequently curtailed by the water master. The presence of one or more undesirable results is the definition of an overdraft condition., The Shasta River meets that definition. All statements claiming not to be in overdraft condition should be removed.	FOSR-110
4	16	416-7	The Shasta River is not a gaining stream at all times as a direct result o excessive gw pumping. Specifically, data has been presented to the project consultants by the water masters showing that the Shasta between River miles 15.5 and 31 became a losing reach by the end of the summer in 2020. Data for other years is not available, but since little has changed in terms of gw usage in 2020 vs. recent years, there is no reason to presume this has not been an ongoing condition. That data documenting the annual development of a losing reach in the river should be included as an appendix so the public can readily see and understand it, and support appropriate measures to address it.	FOSR-111
4	17	427	Add the words "canal leakage" as another source of recharge.	FOSR-112
4	17	436-7	The observation that gw levels slope from the basin margins towards eh Shasta River should color MAR concepts. MAR on the west side of the river (as is proposed herein elsewhere) will not benefit gw levels or users on the East side of the river, where identifiable shortages now exist. No explanation is provided as to why MAR is being proposed in this unfruitful	FOSR-113

			area.	FOSR-113 contd.
4	17	446-7	This statement conveniently ignores the other sources of recharge, specifically canal leakage and deep peculation from excess irrigation, reductions in both of which are currently and for years have been the focus of public and private pending.	FOSR-114
4	18	470-1	This statement ignores the SGMA use of the presence of one or more undesirable conditions as the indicator of overdraft, an error made throughout the document.	FOSR-115
4	18	473-5	Merely stating the existence of diminishing amounts of precip. isn't enough. Where is the response to this fact? Instead throughout the document there is a concerted effort to continue the slowly expanding and demonstrably excessive usage of gw, and to ignore the developing climatic trend that calls out for a conservative approach until climatic conditions prove otherwise. That is not a plan. at best it is an ex That is not a plan. at best it is an excise in wishful thinking.	FOSR-116
4	19	511 ff	Reliance on zoning seems misplaced, particularly with the proposed urban "partners" within whose jurisdiction little or no gw usage for irrigation occurs. Why is there no mention of a moratorium on the issuance of new well drilling permits for wells >6" diameter or similar county level actions that would immediately halt gw usage expansion, but instead pointing to a long, cumbersome and difficult process not likely to occur?	FOSR-117
4	19	518--box	Example 2--There is no existing nor proposed county staff position that will be monitoring agreements such as is described, nor is there a penalty nor other recourse if the agreement isn't adhered to. It is also unclear if this example agreement runs in perpetuity, or only for 10 years.	FOSR-118
4	22	558-60	There should be an appropriate sharing of additional gw between gw users, surface users and GDEs.	FOSR-119
4	23	588-9	The plan should note where this baseline data is located, and how it was calculated so that it can be independently verified over time.	FOSR-120
4	24	635-6	Deliberately positioning the GSA to endorse someone's pet projects with little or no relevance to gw management is inappropriate. The GSA members have had many years of opportunity during which time they have	FOSR-121

			frequently met with the specific "other agencies" responsible for such projects. This is a transparent effort to enhance the fundability of projects that should stand on their own, and not deplete gw related funding.	FOSR-121 contd.
4	24	641-4	Irrigation efficiency improvements cannot be given a blanket endorsement. Each needs to be individually assessed to determine all its effects. As already pointed out, recharge from leaking ditches is substantial, and is relied upon unknowingly by many gw users in the basin, as is deep percolation. Reduction in those avenues of recharge need to be offset by equivalent reduction in gw demand.	FOSR-122
4	25	669-70	Published University of California Extension Service research by Kuhn et. al. (*Juniper removal may not increase overall Klamath River Basin water yields*, California Agriculture, Volume 61, #4, 2007) suggests that gw benefits from this effort will be negligible. If it is undertaken as a gw management exercise, any benefits need to be documented by measured gw results, not by theoretical expectations.	FOSR-123
4	25	674	Complete reliance on voluntary participation is at best disingenuous. There needs to be a fall-back method in place for when voluntary efforts are inadequate to generate needed data. Additionally, the existing well log based data base of existing wells is incomplete to an unknown degree. Without an accurate accounting of the total number of wells, evaluating the representative nature of any voluntary data will be impossible. There at minimum needs to be a method proposed for arriving at a count of total wells so that the representative nature and locations of any volunteered wells can be verified. One approach would be to secure from PP&L a total count of agricultural pump power drops, and subtracting from that the number of surface diversion pumps.	FOSR-124
4	26	724-6	While stream flow augmentation by reducing diversions will yield desirable results, it cannot be overlooked that in addition to wet water ESA listed coho salmon require cold water, water already depleted by existing gw usage. Further planned depletion might well violate section 9 of the ESA. Given that, they cannot be accurately said to "effectively offset" an increase in gw usage.	FOSR-125

4	27	766-9	Use of the SWHM model for project assessment alone is not consistent with claimed plans to work with other agencies in that it has apparently no water quality component, most importantly for assessing temperature impacts on large and small refugia areas. Neither does it attempt to address minimum instream flow requirements. Project evaluation needs to be more appropriately comprehensive focusing on not reducing the likelihood of attaining all other mandatory water related targets, and in spreading any burdens fairly.	FOSR-126
4	27	771 ff	As presented, this appears to be a construction project, without first performing proper feasibility and preliminary engineering studies to document availability of "excess water", reasonable locations and size, potential costs, residence time, and reasonably expected benefits. If it is intended to be a preliminary study, then it should clearly be described that way only, with no fore-ordained outcome in terms of a physical project to follow, as it is currently described. It is worth noting that no mention of a gw shortage for **existing** gw users in the area identified have been made known at the advisory committee meetings. Beyond a project specific preliminary investigation, there needs to be the completion of an instream flow study in order to document the availability of excess water with which to do recharge on a regular enough basis to be useful. Proposed ownership of the stored water needs to be identified, as does its planned disposition, and how this meshes with the Grenada Irrigation Districts plans to initiate reliance on groundwater in lieu of river water so as to avoid water master curtailments.	FOSR-127
4	28	792	There is no such thing in the Shasta Watershed as "excess winter runoff" in almost all years.	FOSR-128
4	31	931	In essentially all years there are no excess winter and spring flows in the Shasta River given the presence of Dwinnell Res. and diversions from the Little Shasta.	FOSR-129
4	31	944-5	This appendix doesn't seem to exist.	FOSR-130
4	33	1020	This appendix doesn't seem to exist.	FOSR-131
4	32	991-97	This information should be collected as part of a plan development project	FOSR-132

COUNTY OF SISKIYOU

Flood Control & Water Conservation District

			so as to be in place when needed. Existing well logs are known to be incomplete. An alternative count of production wells needs to be done, probably via securing from PP&L a count of irrigation power drops. That in turn would allow accurately assessing the level of incompleteness of the well log dataset. FOSR-132 contd.
4	34	1055 ff	A project intended to generate geologically accurate well logs needs to be initiated. It could consist of paying for a qualified geologist to accompany well drillers as they drill new wells, and/or should include the drilling of dedicated wells to better characterize the subsurface geology and water bearing strata. It might be necessary to include incentive FOSR-133
4			
4			
4			
4			
4			
4			
4			
4			
4			
4			
4			
4			
4			
4			
4			

September 26, 2021
To: The Siskiyou County Flood Control and Water Conservation District
re: Shasta GSP Comments
submitted via email to: sgma@co.siskiyou.ca.us

Thank you for the opportunity to comment on the Shasta Valley Groundwater Sustainability Plan.

The Mount Shasta Bioregional Ecology Center submits the following comments:

We believe that this current document, at its heart, will fail to address ongoing impacts to the public trust resources of the Shasta Valley. This plan de-emphasizes the fact that the Shasta River is in a perilous state due to agricultural diversions of surface water and over pumping of groundwater.

MSEC-001

The Shasta River, as is described many times in the draft document, is intimately connected to the ground water in the basin. The river is listed 303(d) impaired for both temperature and dissolved oxygen. Many past assessments have described a river system that is heavily impacted by irrigation diversion of surface water and groundwater extraction. This summer agricultural users nearly de-watered the river and one of the lowest flow events ever recorded resulted (3.5 cfs at the Yreka gage).

MSEC-002

We believe parts of this plan will serve to improperly establish baseline coverage of current practices, delay implementation of management actions, or even promote projects which could increase groundwater pumping. In doing so, the GSP seems to be designed to protect agricultural overreliance on groundwater in the Shasta River basin.

MSEC-003

The GSP points towards an over reliance on future studies or future projects when it is evident that in order to consider groundwater sustainability in the Shasta Valley, one could simply consider only the agricultural water use during agricultural irrigation season. During the driest time of the year, agricultural use of interconnected surface water and groundwater vastly tips the water budget out of any semblance of sustainable. Once the irrigation season ends, groundwater recharge is rapid.

MSEC-004

As this region has continued to experience more “very dry” years, it has become more and more apparent that there is simply not enough water during the summer months to support current agricultural users, protect the public trust resources, and maintain suitable aquatic habitat for native salmonids.

MSEC-004 contd.

The county remains averse to addressing the current conditions, minimizing the evidence that agricultural groundwater use plays an increasing role in pushing the Shasta Valley further from groundwater sustainability.

MSEC-005

We assert that generic projects in the preliminary list of PMA's aimed at "irrigation efficiency" or "flow management strategies/plans" (SHA's) will simply allow increased water consumption and expansion of irrigated acreages. None of these theoretical projects puts more water in the river or ground; they would simply ratify extractive water uses under a banner of "beneficial" use.

MSEC-006

This GSP does little to acknowledge the shifting considerations being made throughout state code which serve to address issues of racial and environmental justice (see SWRCB Racial Equity Initiative and the CA Fish and Game Commission working on an equity resolution and initiative). We have reached a critical moment in the evolving state regulatory structure where we must not only acknowledge the systemic tribal, racial, and environmental harms and injustices that have been propagated through land and water use laws, but we must now act to cease such harms. As such, by not addressing this, the plan will act to extend the historic "beneficial" use of water in Shasta Basin to grow food for cattle and only secondarily extend considerations to the environment or disadvantaged communities.

MSEC-007

With respect to developing, installing, and maintaining a modern monitoring system, we are troubled to see a shift in financing away from groundwater users and towards some notion that the whole county "benefits" from the cattle industry's continued overreliance on groundwater extraction. We do not think any taxpayers who reside outside of a specific basin should be asked to pay for any basin-specific monitoring network (tax increase). We believe that all monitoring equipment paid for with taxpayer money should be available in real time to the public. We believe that agricultural wells should be required to be metered for accuracy in reporting.

MSEC-008

MSEC-009

MSEC-010

Overall, we would like to acknowledge the effort that has gone into this GSP. We hope that this document can remain buoyed by collaborative efforts and common goals and that it continues to evolve into a true guiding document for sustainable groundwater for all users in the Shasta Valley.

Nick Joslin
nick@mountshastaecology.org
Forest and Watershed Watch Program Director
Mount Shasta Bioregional Ecology Center

Salmonid Restoration Federation

September 24, 2021

Ray Haupt, Chair
Siskiyou County Flood Control & Water Conservation District
P.O. Box 750
1312 Fairlane Rd.
Yreka, CA 96097

Submitted by email to: SGMA@co.siskiyou.ca.us

RE: Comments on Public Draft of Scott Valley and Shasta Valley Groundwater Sustainability Plans

Dear Chairman Haupt:

The mission of Salmonid Restoration Federation (SRF) is to promote restoration and stewardship of California's native salmon, steelhead, and trout populations and their habitat. We appreciate the opportunity to comment on the public drafts of the Groundwater Sustainability Plans (GSPs) for Scott Valley and Shasta Valley. We have briefly reviewed the GSPs and comments submitted by other entities.

We appreciate the County stepping up to lead development of the GSPs, and the tremendous amount of effort put into GSP development; however, we are disappointed by the contents of the GSPs. Our concerns fall primarily into two categories: 1) failure to properly characterize the adverse impacts on beneficial uses of the surface water caused by groundwater pumping, including a failure to propose actions that adequately address these adverse impacts, and 2) a lack of transparency which will severely impair the effectiveness of groundwater management.

The rivers and streams in the Scott and Shasta watersheds are severely depleted of water throughout large portions of each year. Due in large part to this flow depletion, salmon populations are in these two watersheds have declined precipitously from historical abundance over the past century and have continued their decline in recent decades and years. There are multiple factors contributing to this water depletion, including excessive diversion of surface water, excessive extraction of groundwater, and a warming climate that is diminishing snowpack and increasing the prevalence of droughts. Groundwater extraction from areas where wells can be regulated under SGMA are just one of these causes of flow depletion. Therefore, GSPs are not SRF-001 responsible for reversing the streamflow depletion caused by surface diversions or groundwater outside SGMA jurisdiction (e.g., wells near the mainstem Scott River, in the zone subject to surface water adjudication). However, the draft GSPs do not meet the SGMA requirements for addressing the impacts of groundwater extraction from wells inside SGMA jurisdiction. SRF-001 contd.

SGMA requires that a GSP define minimum thresholds for streamflow depletion that cause adverse impacts on beneficial uses of the surface water, and then propose actions to ensure that such thresholds are avoided. Instead, the Scott Valley GSP does that process backwards, first defining actions that are easily achievable by groundwater users and then setting the minimum thresholds based on that. There is no consideration of the actual effects of streamflow depletion on surface water beneficial uses. This approach does not meet SGMA requirements. SRF-002

The lack of transparency in the GSPs is troubling. Effective water management requires reliable data upon which to develop scientific understanding of how the hydrologic system operates, how the system is likely to respond to potential management actions, and ongoing monitoring to track progress in meeting goals. The methods and data used must be transparent and verifiable. There is currently a lack of basic information such as the amount of groundwater extracted. Neither the Scott or Shasta GSP require metering of groundwater extraction, nor public sharing of groundwater elevation data in a form that is transparent and verifiable (i.e., sharing the actual raw data rather than summaries). Without metering and data sharing, GSP policies such as “Avoiding Significant Increase of Total Net Groundwater Use from the Basin” are illusory and easy to game. SRF-003 In the absence of universal metering, the only other way to ensure avoiding increases in net groundwater use would be to not allow new well construction and not allow irrigation in areas not currently irrigated; however, the GSPs contain no such prohibition. SRF-004

Thank you for your consideration of these comments.

Sincerely,

Dana Stolzman

Dana Stolzman, Executive Director
Salmonid Restoration Federation

425 Snug Alley, Unit D, Eureka, CA 95501 • *www.calsalmon.org* • *info@calsalmon.org* • (707) 923-7501

Sept. 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 Shasta Valley Draft Groundwater Sustainability Plan

Dear Dr. Laura Foglia, Matt Parker, GSA advisory committee, and technical team,

Shasta Headwaters is a forming coalition working to improve source water protection, resource conservation, and ecosystem restoration in Mount Shasta's three distinct drainages; the Upper Sacramento, McCloud and Shasta River watersheds.

These comments focus primary on effective Stakeholder Engagement to ensure that PMA implementation translates into equitable, reasonable and practical actions that encourage appreciation for ecosystems, and generate tangible benefits for marginalized stakeholders, as well as ongoing opportunities for improved stewardship at the local level. Though we have only conducted a cursory review the draft plan, we participated in multiple GSA meetings throughout plan formation. Thank you for compiling such a comprehensive initial draft, and incorporating these comments into the final plan.

Recovering from a century of extractive resource management, and reeling from another summer of extreme drought and wildfire, public stakeholders in Northern California are relieved that groundwater is finally about to be regulated. To preempt state intervention in local water management, and avoid the most deleterious threats of climate disruption, Siskiyou County must embrace the urgency of issues outlined in its GSP's, and the state must empower local water managers to adjust policies and practices to accommodate SGMA compliance.

Local grassroots organizations have participated in multiple collaborative efforts to conserve natural resources over the past few decades throughout the region. These include, but are not limited to: Renew Siskiyou - Climate Adaptation plan drafted in 2016, and the Upper Sacramento Integrated Regional Water Management (IRWM) Plan ratified in 2014. We have seen public and private funds spent on drafting smart plans, just to stagnate and collect dust on shelves. While the enforceability of SGMA is encouraging, we are concerned that without sufficient community buy-in and effective diverse stakeholder participation, GSP's will primarily serve to allocate corporate welfare to large land-owners, and continue current "regulatory" trends that broaden economic disparities and favor private over public interests. SH-023

In general, the draft plan underestimates the Shasta River's immense natural values, and it understates its historical significance to the third most productive salmon-supporting river in the contiguous western United States, and largest river restoration project in the nation/world. The plan should convey a tone of pride, honor, and duty to protect and restore the remarkable natural heritage of the Shasta River. By framing the task at hand through a solution-oriented lens, the plan should clarify that a thriving, charged, salmon-laden Shasta River is the ultimate indicator of sustainable groundwater management throughout the valley. SH-001

In addition to acknowledging its status as one of five priority anadromous fish spawning habitats by the state, we recommend:

- At the end of section 2.2.1.1 after line 784, emphasize how the valley's hydrogeology including its shallow grade, unique mineral deposits/chemical composition, and continual copious inputs of cold, clean, glacial-fed spring water made Shasta River prime salmon habitat, that historically boasted a significant majority percentage of salmon returning to spawn in the Klamath River system. SH-002
- Such hydrological conditions were guaranteed by consistent winter snowpack that is diminishing under current and projected warming. Please highlight how state and local water policy reform is necessary to adjust current practices to prospects of natural recharge, now and in the near future. SH-003

During one of the GSA sub-committee meetings, I inquired that since the ground-to-surface water interconnection is established, and it's common for the Shasta River to flow at a tiny fraction of its naturally occurring volume, how can the basin not be overdrafted? The team provided a lengthy explanation that sounded like technically, the basin may not be in overdraft. But practically speaking, a month later the state issued emergency drought curtailments to irrigators throughout the basin for the first time ever. If the basin is not in a state of overdraft, while the river that defines the basin is routinely getting dewatered, perhaps we need to redefine overdraft? SH-004

- I was unable to find an explanation of what constitutes overdraft in the draft plan. Please point me toward it, or include it as point of discussion/clarification.

The plan also underestimates the power of coordinated, widespread, voluntary conservation efforts, grassroots stewardship, and community buy-in. We urge you to include more meaningful opportunities for public interest representation, as well as Tribal leadership. SH-005 In addition to establishing a monitoring network and making important water information available to the public, we recommend: SH-006

- Include residential, municipal, and small agricultural water conservation education to the list of Tier I or II PMA's. SH-007
- Incorporate a mechanism for generating diverse stakeholder consensus on PMA prioritization and implementation. SH-008
- Include Friends of Shasta River in the Table 1 list of Shasta Valley Stakeholder Groups as an environmental organization or local NGO. SH-009
- Provide financial support for Tribal and/or environmental stakeholder leadership during plan implementation and maintenance. SH-010

Data access and water-use accountability are essential for sustainable water management. The plan does a good job of acknowledging the lack of existing data used to inform water use throughout the region. In addition to bridging data gaps, we urge the GSA to pay more attention to making better use of data we do have, and synthesize the many avenues of watershed data monitoring into a comprehensive, user-friendly, consistent data management system. SH-011

We applaud the significant expansion of acreage that was included into the basin under the initial boundary modification, and we are aware that unlimited, unmonitored uses upstream may intensify conflicts between farmers and fish advocates downstream. We recommend:

- Coordinate PMA implementation among the four basins; Shasta, Scott, Butte, Tule Lake. SH-012
- Consolidate resources – combine the multiple water conservation/irrigation/service districts into one comprehensive Shasta River watershed authority. SH-013
- Coordinate data monitoring and plan performance between GSA's and Integrated Regional Water Management (IRWM) groups operating in Siskiyou County. Specifically, the North Coast Resource Partnership and the Upper Sacramento Regional Water Action Group (RWAG). SH-014
- In the "upslope water yield projects' category, include a mechanism for monitoring non-beneficial, industrial extraction. SH-015
- Include incentives for switching to less water-intensive crops, and adopting regenerative agricultural practices in Tier I or Tier II PMA's SH-016
- Identify periodic updates of Bulletin 118 as an opportunity to mandate monitoring of unregulated groundwater upstream. SH-017

Distributing powers of authority to local jurisdictions is an important step toward long-term sustainable water management. Impediments to sustainability, however, often exist at the state level. For GSA's to achieve SGMA compliance, regional, state, and local jurisdictions must remedy glaring obstacles to watershed stewardship, such as:

- Revisit and revise overly-complicated, fragmented, outdated, profit-motivated water management policies, and over-allocated water rights. SH-018
- Over-regulating small business, while under-regulating big business thereby pitting farmers against fish, while industrial users deplete dwindling supplies. SH-019
- Streamline permit processes and provide incentives for the deconstruction of impoundments that are not subject to FERC, but have outlived their useful lives. SH-020

For California to recover from climate disruption, and for communities to minimize exposure to incessant drought, the state must shift our water ethics from "use it or lose it" to "less is more". GSP's should allocate a substantial percentage of SGMA grant funds to management actions that reward behavioral alternatives to wasteful water use, across sectors. SH-021 Business-as-usual is threatening basic conditions for quality of life, enabled by many decades of neglecting the complicated task of regulating groundwater. In order for GSA's to achieve desired results, stakeholders must do more than meter wells and monitor groundwater elevation. We must learn to appreciate ecosystem services, limit consumptive uses that primarily benefit private interests, invest downstream stakeholders in protecting supplies upstream, restore biodiversity habitat, and heed traditional ecological knowledge. SH-022

Overall the plan is a refreshing consolidation of relevant data that is long overdue in a modern, democratic society. While we are mindful of California's tendency to talk more than it walks, we also recognize this unique opportunity to galvanize shared interests around common goals. In short, we are tentatively hopeful that SGMA will provide a reliable platform for protecting communities against wildfire and drought by restoring a healthy Shasta River watershed.

Respectfully,

Angelina Cook
(530) 859-2083
angelina@shastaheadwaters.com

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1655 Heindon Road
Arcata, California 95521-4573

Refer to NMFS No: AR#10012WCR2021AR00040

September 23, 2021

Matt Parker, Natural Resources Specialist
Siskiyou County Flood Control and Water Conservation District GSA
1312 Fairlane Drive
Yreka, California 96097

Re: NOAA's National Marine Fisheries Service comments on the Shasta Valley Groundwater Sustainability Plan -- draft GSP

Dear Mr. Parker:

NOAA's National Marine Fisheries Service (NMFS) is the federal agency responsible for managing, conserving, and protecting living marine resources in inland, coastal, and offshore waters of the United States. We derive our mandates from numerous statutes, including the Federal Endangered Species Act (ESA). The purpose of the ESA is to conserve threatened and endangered species and their ecosystems.

On August 11, 2021, the Siskiyou County Flood Control and Water Conservation District GSA - Shasta River (SR GSA) released their draft GSP of the Shasta Valley Goundwater Sustainability Plan (SV GSP). Waterways that overlie portions of the Shasta Valley Basin (*e.g.*, Shasta River and tributaries) support federally threatened Southern Oregon/Northern California Coasts coho salmon (*Oncorhynchus kisutch*), as well as Chinook salmon (*O. tshawytscha*) and steelhead (*O. mykiss*). This letter transmits our comments on the draft GSP.

We previously commented on draft Chapters 3 of the SV GSP . However, many of those comments do not appear to have been considered by the SV GSA, so we have reiterated them in this letter. In the future, we recommend the SR GSA compile a publicly available summary of comments received on the SV GSP, along with the GSA's response to each comment. NMFS-001

Comments

Page 16, Figure 1: The chosen monitoring wells are generally located too far from waterways to adequately analyze and monitor streamflow depletion. We recommend the SR GSA develop a plan for installing paired streamflow gauges and groundwater monitoring wells located in close proximity to each other. These monitoring points should be strategically located throughout the basin where potential streamflow depletion impacts are likely occurring. NMFS-002

Page 25, line 426: The draft GSP proposes monitoring groundwater contributions to the Shasta River during the "irrigation season", yet does not explain why monitoring is limited to this season only. Streamflow depletion does not usually occur instantaneously with the causative groundwater pumping, but can instead be delayed by days, weeks, months or years (Barlow and Leake 2012). For instance, groundwater pumping during the irrigation season could deplete streamflow when adult coho salmon are migrating in December, well after the irrigation season. To account for this temporal variability, streamflow depletion and augmentation monitoring should occur year-round. NMFS-003

Page 25, line 439: The proposed protocol for monitoring interconnected surface water dynamics pairs streamflow gauging data collected at 15 minute intervals with bi-monthly surface water diversion data. The low frequency with which surface water diversion data is collected may hinder the intended analysis; we suggest gathering data on surface water diversions more frequently to alleviate this concern. NMFS-004

Page 25, Table 4: As alluded to above, a grand total of four monitoring locations within the Shasta Valley is likely insufficient to characterize interconnected surface water dynamics. NMFS-005

Page 25, line 449: Waiting until the 2032 GSP update to begin monitoring the upper Little Shasta River watershed is not appropriate, given that a 2032 start date leaves just 10 years to address streamflow depletion impacts prior to the SGMA deadline for achieving sustainable groundwater management. The SR GSA should design a plan now to gather the required data so that significant progress can be achieved at the first 5-year check-in in 2027. NMFS-006

Page 35, line 663: The draft GSP lists potential impacts resulting from streamflow depletion as diminished agricultural surface water diversions, and inadequate flows to support riparian health and ecosystems. The list should also include impacts to ESA-listed salmonids and their habitat that depend on significant groundwater accretion to maintain habitat suitability. NMFS-007

Page 35, line 676: Growth in groundwater demand that changes the distribution of pumping and volume pumped cannot be characterized as "unforeseen", since the GSA is responsible for managing current and future groundwater extraction, and SGMA gives broad power to GSAs to accomplish that task. NMFS-008

Page 36, line 694: The draft chapter forgoes developing a groundwater/surface water analytical model as required under SGMA, and instead proposes using an analysis that uses the location, quantity and timing of interconnected surface water. The analysis focuses on the months of July through September based upon the lack of surface water input at that time of year. However, streamflow depletion impacts to beneficial uses of surface water, and specifically ESA-listed salmonids and their habitat, is not restricted to that time period. For instance, juvenile coho salmon migrate out of the Shasta River watershed during the spring months, well before July, and rearing juvenile coho salmon and steelhead inhabit the Shasta River throughout the year. Furthermore, the streamflow depletion response to groundwater pumping is not likely instantaneous, but can vary from days to months or years depending on factors such as aquifer composition, pumping depth, and other factors. NMFS recommends the SR GSA develop an NMFS-009 integrated surface water/groundwater analytical model considering the inherent complexity of Shasta River hydrogeology. NMFS-009 contd.)

Page 36, line 704: For computing groundwater contributions during the irrigation season, riparian diversions are estimated at 20 cfs throughout the growing season. However, the following sentence states that riparian diverters do not continuously divert flow. The plans approach is to use a 2/3 of the 20 cfs estimate**.** How was this estimate determined? NMFS-010

Page 37, top paragraph: Another uncertainty that requires acknowledgement is the sparse gauging network proposed for the "water balance" analysis. Using just two surface water gauges to characterize discharge within the groundwater basin is clearly inadequate for a number of reasons. For instance, both gauges are located on the mainstem Shasta River, with none located on tributary reaches. Also, the two existing gauges are separated by approximately 10 miles of river channel. Finally, the proposed addition of a future monitoring site (SPU on Figure 3) between the two gauges, while a worthwhile effort, does not address the lack of tributary gauges. NMFS-011

Page 39, Line 743: There appears to be no justification given as to how a minimum threshold of 100 cfs of average monthly groundwater contribution avoids significant and unreasonable impacts to surface water beneficial uses caused by groundwater pumping. NMFS recommends the SR GSA include this justification. NMFS-012

Page 39, line 754: As discussed earlier, focusing sustainable management criteria on the irrigation season is unlikely to adequately account for the spatial and temporal scale of groundwater/surface water interaction within the Shasta River basin. A groundwater/surface water analytical model is the appropriate tool for this type of analysis. NMFS-013

How is the CDFW Water Action Plan streamflow prescriptions going to be worked into the GSAs streamflow depletion SMCs?" NMFS-014

We hope these comments effectively clarify important concerns we have regarding potential significant impacts to SONCC coho salmon, Chinook salmon, and steelhead likely to result from the draft Chapters 3 of the Shasta Valley Basin GSP. If you have any questions, please do not hesitate to contact Rick Rogers (707-578-8552, or Rick.Rogers@noaa.gov) for further assistance.

Sincerely,

Jim Simondet
Klamath Branch Supervisor
California Coastal Office

cc: Janae Scruggs, CDFW Senior Environmental Scientist Specialist (janae.scruggs@wildlife.ca.gov)

Joe Croteau, CDFW, Supervisor

Pat Vellines, SGMA Point of Contact Scott Rive Valley Basin (Patricia.Vellines@water.ca.gov)

Natalie Stork, SWRCB Chief -- Groundwater Management Program (Natalie.Stork@waterboards.ca.gov)

Craig Altare, DWR Chief, GSP Review Section (craig.altare@water.ca.gov)

References

Barlow, P.M., and Leake, S.A. 2012. Streamflow depletion by wells—Understanding and managing the effects of groundwater pumping on streamflow: U.S. Geological Survey Circular 1376. 84 pages. Available at: http://pubs.usgs.gov/circ/1376/).

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 Shasta 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 Shasta 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 Shasta 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

Samantha Arthur
Working Lands Program Director
Audubon California

Danielle V. Dolan
Water Program Director
Local Government Commission

E.J. Remson
Senior Project Director, California Water Program
The Nature Conservancy

Melissa M. Rohde
Groundwater Scientist
The Nature Conservancy

Attachment A

Specific Comments on the Shasta 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 five DACs in the basin, but these areas are not mapped and the population is not provided. NGO-001
- The GSP provides a map of domestic well density in Figure 4, 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 DAC 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 DACs in the basin. The DWR DAC mapping tool[1] can be used for this purpose. Include the population of each DAC in the GSP text or on the map. NGO-001 cont.
- Include a map showing domestic well locations and average well depth across the basin. NGO-002 cont.
- Identify the sources of drinking water for DAC members, including an estimate of how many people rely on groundwater (e.g., domestic wells, state small water systems, and public water systems). NGO-003 cont.

[1] The DWR DAC mapping tool is available online at: https://gis.water.ca.gov/app/dacs/

Interconnected Surface Waters

The identification of Interconnected Surface Waters (ISWs) is **insufficient**, due to lack of supporting information provided for the ISW analysis. To assess ISWs, the plan relied on previous reports by Shasta Valley Resource Conservation District (SVRCD) and an on-going transect study for the Little Shasta River and Shasta River to determine the direction of flow exchange. The transect study commenced in May 2020. NGO-004

The GSP states (p. 2-105): "The Shasta River and its major tributaries are all considered part of the interconnected surface water system in the Basin." Figure 43 maps streams in the basin, but only shows Shasta River and Little Shasta River as being interconnected. No other data is presented in this section of the GSP, including depth-to-groundwater data and well locations.

RECOMMENDATIONS

- Describe available groundwater elevation data and stream flow data in the basin. ISWs are best analyzed using depth-to-groundwater data from multiple seasons and water year types (e.g., wet, dry, average, drought), to determine the range of depth and capture the variability in environmental conditions inherent in California's climate. NGO-005

- Overlay the stream reaches shown on Figure 43 with depth-to-groundwater contour maps to illustrate groundwater depths and the groundwater gradient near the stream reaches. Show the location of groundwater wells in the basin. NGO-006

- For the depth-to-groundwater contour maps, use the best practices presented in Attachment D. Specifically, ensure that the first step is contouring groundwater elevations, and then subtracting this layer from land surface elevations from a Digital Elevation Model (DEM) to estimate depth-to-groundwater contours across the landscape. This will provide accurate contours of depth to groundwater along streams and other land surface depressions where GDEs are commonly found. NGO-007

- On the stream reaches map (Figure 43), consider any segments with data gaps as potential ISWs and clearly mark them as such on the map. NGO-008

- Describe data gaps for the ISW analysis. Reconcile these 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. NGO-009

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 presented in Appendix 2-H. 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-H, 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. Change the vertical scale such that shallow groundwater elevations are presented more clearly. For example, change the largest depth on the scale to a depth of 100 or 200 feet (instead of 3000 feet). The manner in which the depths are presented make it very difficult to distinguish between depths ranging from 0-100 feet, which is the depth range pertinent to GDEs. NGO-013

- 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). Instead of using groundwater elevation data from 2011 - 2020, we recommend the pre-SGMA baseline period of 2005 - 2015. NGO-012 cont.

- 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-011 cont.

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 into the water budget is **insufficient**. The water budget did not explicitly include the current, historical, and projected demands of native NGO-014

[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]

vegetation. The omission of explicit water demands for native vegetation is problematic because key environmental uses of groundwater are not being accounted for as water supply decisions are made using this budget, nor will they likely be considered in project and management actions. Managed wetlands are not mentioned in the GSP, so it is not known whether or not they are present in the basin. NGO-014 cont. NGO-015

RECOMMENDATIONS
● 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. NGO-014 cont.
● State whether or not there are managed wetlands in the basin. If there are, ensure that their groundwater demands are included as separate line items in the historical, current, and projected water budgets. 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).

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 the GSP website. There is no specific outreach described for members of the DAC communities or domestic well owners. NGO-016
- The Stakeholder Communication and Engagement Plan does not include a plan for continual opportunities for engagement through the *implementation* phase of the GSP for DACs, domestic well owners, and environmental stakeholders. NGO-017

RECOMMENDATION
● In the Stakeholder Communication and Engagement Plan, describe active and targeted outreach to engage DAC 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.

[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)]

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. NGO-018 The GSP does not sufficiently describe how the existing minimum threshold groundwater levels are consistent with avoiding undesirable results in the basin. NGO-019

For degraded water quality, minimum thresholds for two constituents of concern (COCs), nitrate and specific conductivity, are set at the maximum contaminant levels (MCLs). However, the GSP does not set SMC for the other COCs in the basin (benzene, arsenic, boron, iron, manganese, and pH). The GSP states on p. 3-49 that because benzene is 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 arsenic, boron, iron, manganese, and pH are 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

To determine undesirable results for water quality, the GSP performs a statistical analysis that describes the undesirable result as follows (p. 3-50): "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. It also assures that water quality does not exceed maximum thresholds for concentration, MT, in more than 25% of wells in the monitoring network." The GSP does not, however, discuss impacts on drinking water users, DACs, or tribes when defining this undesirable result, such as describing how many domestic wells would be impacted by degraded water quality. NGO-021

RECOMMENDATIONS
Chronic Lowering of Groundwater Levels
• Describe direct and indirect impacts on DACs, drinking water users, and tribes when describing undesirable results for chronic lowering of groundwater levels. NGO-018 cont.
• Consider and evaluate the impacts of selected minimum thresholds and measurable objectives on DACs, drinking water users, and tribes within the basin. Further describe NGO-019 cont.

[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 impact of passing the minimum threshold for these users. For example, provide the number of domestic wells that would be de-watered at the minimum threshold. NGO-019 cont.

Degraded Water Quality

- Describe direct and indirect impacts on DACs, drinking water users, 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 DACs, drinking water users, and tribes.
- Set minimum thresholds and measurable objectives for water quality constituents within the basin including naturally occurring constituents that can be exacerbated as a result of groundwater use or groundwater management. Ensure they align with drinking water standards[9]. NGO-020 cont.

Groundwater Dependent Ecosystems and Interconnected Surface Waters

The GSP states (p. 3-44): "Though SMCs for GDEs are not required by SGMA, the minimum thresholds for SV02 will be set to protect beneficial users such as GDEs and set at the Fall minimum." The GSP further states (p. 3-45): "Based on the 7 year history of data recorded in the CASGEM system for SV02, the MT for SV02 will be set at 31 feet below ground surface for the Fall measurement." The seven year period for which data is available is not provided in the GSP. NGO-022 Furthermore, the GSP does not discuss or analyze the potential impacts to GDEs based on the proposed minimum threshold. If minimum thresholds are set to historic low groundwater levels (or lower) and the basin is allowed to operate at or close to those levels over many years, there is a risk of causing catastrophic damage to ecosystems that are more adverse than what was occurring at the height of the 2012-2016 drought. This is because California ecosystems, which are adapted to our Mediterranean climate, have some drought strategies that they can utilize to deal with short-term water stress. However, if the drought conditions are prolonged, the ecosystem can collapse. NGO-023

The minimum threshold for depletion of ISW is set to 100 cubic feet per second (cfs). The GSP states (p 3-45): "Based on the limited 5-year history of measurements for the groundwater contributions SMC, a preliminary Minimum Threshold will be set at 100 CFS of average monthly groundwater contributions." Based on discussion in the GSP, it is not clear how this value is derived and how it relates to beneficial users. NGO-024 Furthermore, the GSP makes no attempt to evaluate the impacts of the proposed minimum threshold on environmental beneficial users of surface water. The GSP does not explain how the chosen minimum thresholds and measurable objectives avoid significant and unreasonable effects on surface water beneficial users in the basin, such as increased mortality and inability to perform key life processes (e.g., reproduction, migration). NGO-025

[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 cont.

- 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-025 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 moderately 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, 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

NGO-026

[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)]

project and management actions are added. The GSP states (p. 2-151): “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.” Furthermore, the GSP states: “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-026 cont.

NGO-026 cont.

RECOMMENDATIONS

- Estimate sustainable yield based on the projected water budget with climate change incorporated, to inform the basis for development of projects and management actions.
- Incorporate climate change scenarios into projects and management actions. NGO-027

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-028

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. 3-7): “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 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-028 cont. NGO-028 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)]

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-029 NGO-030
- 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-031
- 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. Appendix 3-A mentions the use of satellite images to evaluate the health of GDEs over time, however no further details are provided in the GSP. NGO-032

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-033

We commend the GSA for including several projects and management actions with explicit benefits to the environment. 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. NGO-033 cont. Groundwater sustainability under SGMA is defined not just by sustainable yield, but by the avoidance of undesirable results for *all* beneficial users.

RECOMMENDATIONS

- For DACs and domestic well owners, include a drinking water well impact mitigation program to proactively monitor and protect drinking water wells through GSP implementation. Refer to Attachment B for specific recommendations on how to implement a drinking water well mitigation program. NGO-034
- 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-033 cont.
- 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 NGO-035

integrate multi-benefit recharge projects into your GSP, refer to the "Multi-Benefit Recharge Project Methodology Guidance Document"[16].

NGO-035 cont.

- Develop management actions that incorporate climate and water delivery uncertainties to address future water demand and prevent future undesirable results.

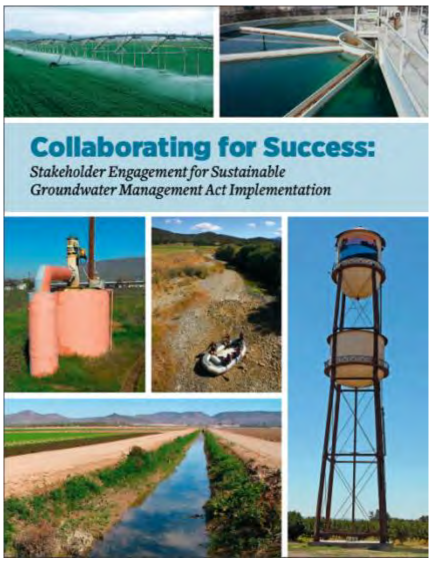
NGO-036

[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

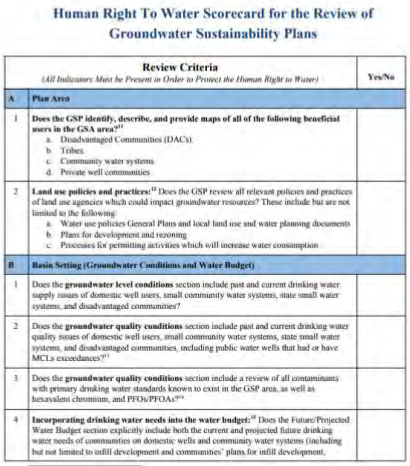
Stakeholder Engagement and Outreach



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

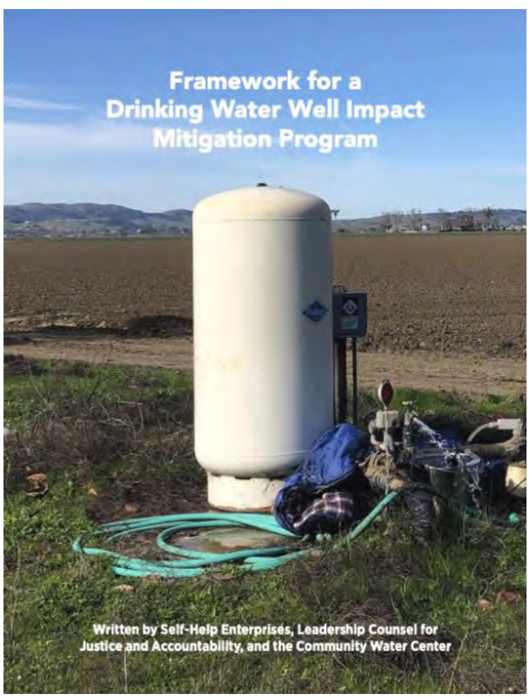


Human Right To Water Scorecard for the Review of Groundwater Sustainability Plans

	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?**[11] a. Disadvantaged Communities (DACs). b. Tribes. c. Community water systems d. Private well communities	
2	**Land use policies and practices:**[12] Does the GSP review all relevant policies and practices of land use agencies which could impact groundwater resources? These include but are not limited to the following: a. Water use policies General Plans and local land use and water planning documents b. Plans for development and rezoning c. Processes for permitting activities which will increase water consumption	
B	**Basin Setting (Groundwater Conditions and Water Budget)**	
1	Does the **groundwater level conditions** section include past and current drinking water supply issues of domestic well users, small community water systems, state small water systems, and disadvantaged communities?	
2	Does the **groundwater quality conditions** section include past and current drinking water quality issues of domestic well users, small community water systems, state small water systems, and disadvantaged communities, including public water wells that had or have MCLs exceedances?[13]	
3	Does the **groundwater quality conditions** section include a review of all contaminants with primary drinking water standards known to exist in the GSP area, as well as hexavalent chromium, and PFOs/PFOAs?[14]	
4	**Incorporating drinking water needs into the water budget:**[15] Does the Future/Projected Water Budget section explicitly include both the current and projected future drinking water needs of communities on domestic wells and community water systems (including but not limited to infill development and communities' plans for infill development,	

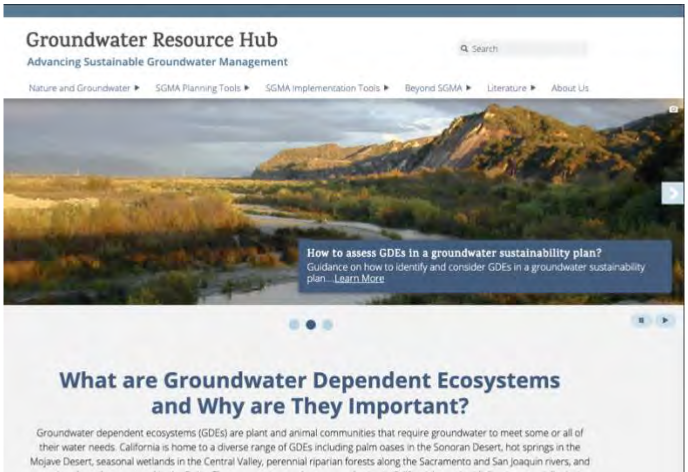
The Human Right to Water Scorecard was developed by Community Water Center, Leadership Counsel for Justice and Accountability and Self Help Enterprises to aid Groundwater Sustainability Agencies (GSAs) in prioritizing drinking water needs in SGMA. The scorecard identifies elements that must exist in GSPs to adequately protect the Human Right to Drinking water.

Drinking Water Well Impact Mitigation Framework



The Drinking Water Well Impact Mitigation Framework was developed by Community Water Center, Leadership Counsel for Justice and Accountability and Self Help Enterprises to aid GSAs in the development and implementation of their GSPs. The framework provides a clear roadmap for how a GSA can best structure its data gathering, monitoring network and management actions to proactively monitor and protect drinking water wells and mitigate impacts should they occur.

Groundwater Resource Hub



The Nature Conservancy has developed a suite of tools based on best available science to help GSAs, consultants, and stakeholders efficiently incorporate nature into GSPs. These tools and resources are available online at GroundwaterResourceHub.org. The Nature Conservancy's tools and resources are intended to reduce costs, shorten timelines, and increase benefits for both people and nature.

Rooting Depth Database

The Plant Rooting Depth Database provides information that can help assess whether groundwater-dependent vegetation are accessing groundwater. Actual rooting depths will depend on the plant species and site-specific conditions, such as soil type and availability of other water sources. Site-specific knowledge of depth to groundwater combined with rooting depths will help provide an understanding of the potential groundwater levels are needed to sustain GDEs.

How to use the database

The maximum rooting depth information in the Plant Rooting Depth Database is useful when verifying whether vegetation in the Natural Communities Commonly Associated with Groundwater (NC Dataset) are connected to groundwater. A 30 ft depth-to-groundwater threshold, which is based on averaged global rooting depth data for phreatophytes[1], is relevant for most plants identified in the NC Dataset since most plants have a max rooting depth of less than 30 feet. However, it is important to note that deeper thresholds are necessary for other plants that have reported maximum root depths that exceed the averaged 30 feet threshold, such as valley oak (*Quercus lobata*), Euphrates poplar (*Populus euphratica*), salt cedar (*Tamarix spp.*), and shadescale (*Atriplex confertifolia*). The Nature Conservancy advises that the reported max rooting depth for these deeper-rooted plants be used. For example, a depth-to groundwater threshold of 80 feet should be used instead of the 30 ft threshold, when verifying whether valley oak polygons from the NC Dataset are connected to groundwater. It is important to re-emphasize that actual rooting depth data are limited and will depend on the plant species and site-specific conditions such as soil and aquifer types, and availability to other water sources.

The Plant Rooting Depth Database is an Excel workbook composed of four worksheets:

1. California phreatophyte rooting depth data (included in the NC Dataset)
2. Global phreatophyte rooting depth data
3. Metadata
4. References

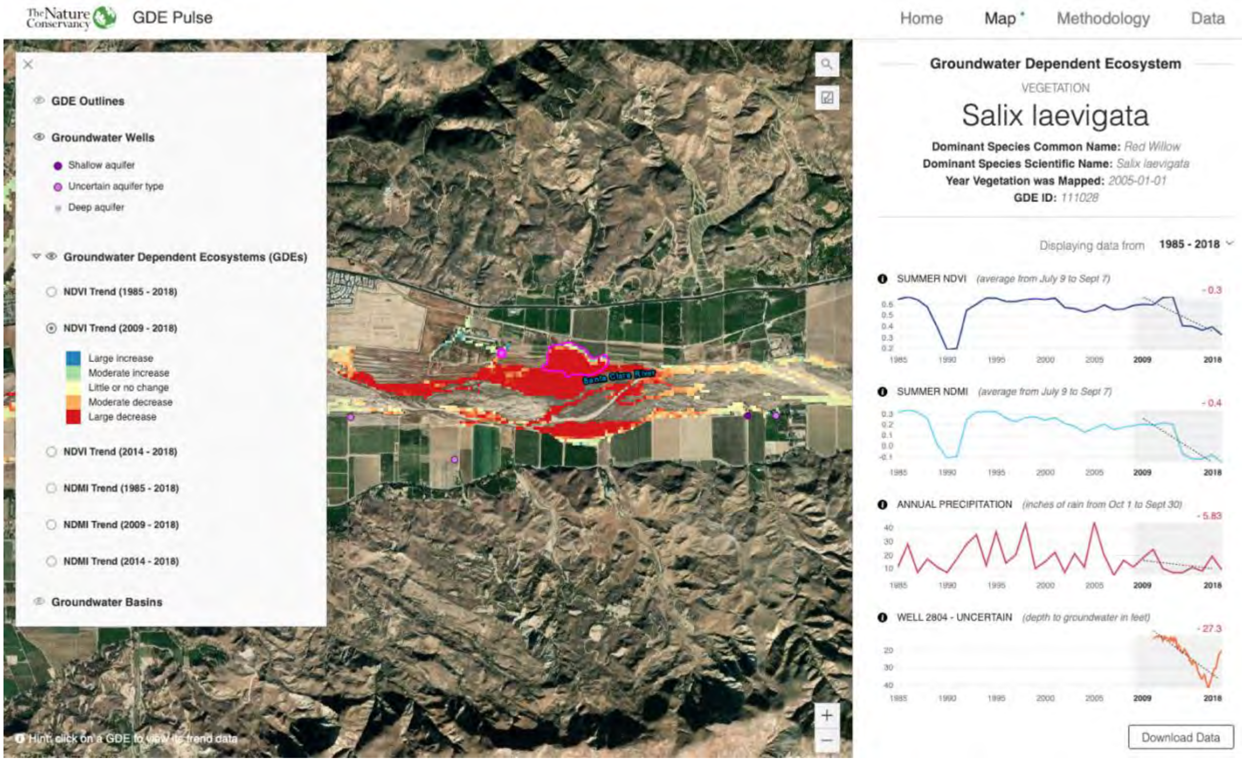
How the database was compiled

The Plant Rooting Depth Database is a compilation of rooting depth information for the groundwater-dependent plant species identified in the NC Dataset. Rooting depth data were compiled from published scientific literature and expert opinion through a crowdsourcing campaign. As more information becomes available, the database of rooting depths will be updated. Please Contact Us if you have additional rooting depth data for California phreatophytes.

---

[1] Canadell, J., Jackson, R.B., Ehleringer, J.B. et al. 1996. Maximum rooting depth of vegetation types at the global scale. Oecologia 108, 583–595. https://doi.org/10.1007/BF00329030

GDE Pulse



GDE Pulse is a free online tool that allows Groundwater Sustainability Agencies to assess changes in groundwater dependent ecosystem (GDE) health using satellite, rainfall, and groundwater data. Remote sensing data from satellites has been used to monitor the health of vegetation all over the planet. GDE pulse has compiled 35 years of satellite imagery from NASA's Landsat mission for every polygon in the Natural Communities Commonly Associated with Groundwater Dataset. The following datasets are available for downloading:

Normalized Difference Vegetation Index (NDVI) is a satellite-derived index that represents the greenness of vegetation. Healthy green vegetation tends to have a higher NDVI, while dead leaves have a lower NDVI. We calculated the average NDVI during the driest part of the year (July - Sept) to estimate vegetation health when the plants are most likely dependent on groundwater.

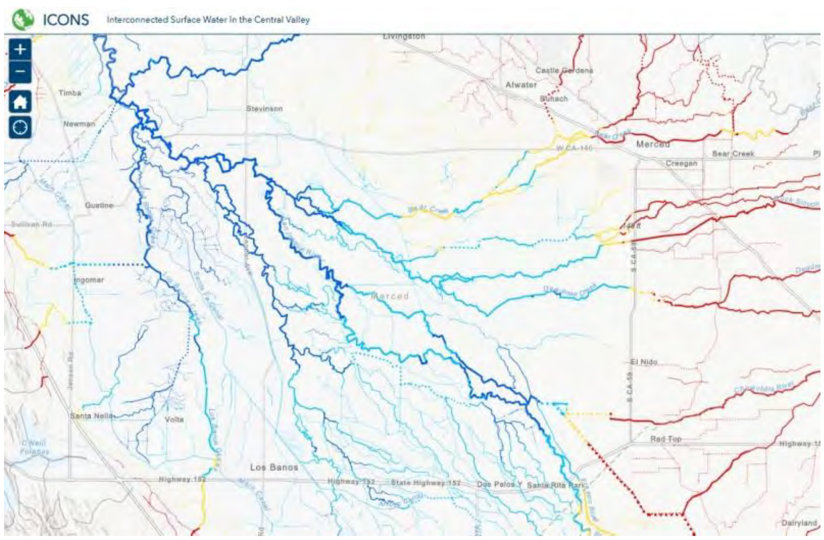
Normalized Difference Moisture Index (NDMI) is a satellite-derived index that represents water content in vegetation. NDMI is derived from the Near-Infrared (NIR) and Short-Wave Infrared (SWIR) channels. Vegetation with adequate access to water tends to have higher NDMI, while vegetation that is water stressed tends to have lower NDMI. We calculated the average NDVI during the driest part of the year (July–September) to estimate vegetation health when the plants are most likely dependent on groundwater.

Annual Precipitation is the total precipitation for the water year (October 1st – September 30th) from the PRISM dataset. The amount of local precipitation can affect vegetation with more precipitation generally leading to higher NDVI and NDMI.

Depth to Groundwater measurements provide an indication of the groundwater levels and changes over time for the surrounding area. We used groundwater well measurements from nearby (<1km) wells to estimate the depth to groundwater below the GDE based on the average elevation of the GDE (using a digital elevation model) minus the measured groundwater surface elevation.

ICONOS Mapper

Interconnected Surface Water in the Central Valley



ICONS maps the likely presence of interconnected surface water (ISW) in the Central Valley using depth to groundwater data. Using data from 2011-2018, the ISW dataset represents the likely connection between surface water and groundwater for rivers and streams in California's Central Valley. It includes information on the mean, maximum, and minimum depth to groundwater for each stream segment over the years with available data, as well as the likely presence of ISW based on the minimum depth to groundwater. The Nature Conservancy developed this database, with guidance and input from expert academics, consultants, and state agencies.

We developed this dataset using groundwater elevation data available online from the California Department of Water Resources (DWR). DWR only provides this data for the Central Valley. For GSAs outside of the valley, who have groundwater well measurements, we recommend following our methods to determine likely ISW in your region. The Nature Conservancy's ISW dataset should be used as a first step in reviewing ISW and should be supplemented with local or more recent groundwater depth data.

Attachment C

Freshwater Species Located in the Shasta Valley

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 Shasta 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				
Grus canadensis tabida	Greater Sandhill Crane		Threatened	
Actitis macularius	Spotted Sandpiper			
Aechmophorus occidentalis	Western Grebe			
Agelaius tricolor	Tricolored Blackbird	Bird of Conservation Concern	Special Concern	BSSC - First priority
Agelaius tricolor	Tricolored Blackbird	Bird of Conservation Concern	Special Concern	BSSC - First priority
Aix sponsa	Wood Duck			
Aix sponsa	Wood Duck			
Anas acuta	Northern Pintail			
Anas americana	American Wigeon			
Anas americana	American Wigeon			
Anas americana	American Wigeon			
Anas clypeata	Northern Shoveler			
Anas clypeata	Northern Shoveler			
Anas crecca	Green-winged Teal			
Anas cyanoptera	Cinnamon Teal			
Anas platyrhynchos	Mallard			
Anas platyrhynchos	Mallard			
Anas strepera	Gadwall			

[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

Anas strepera	Gadwall			
Anser albifrons	Greater White-fronted Goose			
Ardea alba	Great Egret			
Ardea herodias	Great Blue Heron			
Ardea herodias	Great Blue Heron			
Aythya affinis	Lesser Scaup			
Aythya affinis	Lesser Scaup			
Aythya collaris	Ring-necked Duck			
Aythya valisineria	Canvasback		Special	
Botaurus lentiginosus	American Bittern			
Bucephala albeola	Bufflehead			
Bucephala albeola	Bufflehead			
Bucephala albeola	Bufflehead			
Bucephala albeola	Bufflehead			
Butorides virescens	Green Heron			
Calidris mauri	Western Sandpiper			
Calidris minutilla	Least Sandpiper			
Cinclus mexicanus	American Dipper			
Cinclus mexicanus	American Dipper			
Cinclus mexicanus	American Dipper			
Cistothorus palustris palustris	Marsh Wren			
Cygnus columbianus	Tundra Swan			
Fulica americana	American Coot			
Fulica americana	American Coot			
Fulica americana	American Coot			
Gallinago delicata	Wilson's Snipe			
Gallinago delicata	Wilson's Snipe			
Gallinago delicata	Wilson's Snipe			
Grus canadensis	Sandhill Crane			
Grus canadensis	Sandhill Crane			
Grus canadensis	Sandhill Crane			
Haliaeetus leucocephalus	Bald Eagle	Bird of Conservation Concern	Endangered	
Haliaeetus leucocephalus	Bald Eagle	Bird of Conservation Concern	Endangered	
Icteria virens	Yellow-breasted Chat		Special Concern	BSSC - Third priority
Limnodromus scolopaceus	Long-billed Dowitcher			

Megaceryle alcyon	Belted Kingfisher			
Mergus merganser	Common Merganser			
Mergus merganser	Common Merganser			
Oxyura jamaicensis	Ruddy Duck			
Oxyura jamaicensis	Ruddy Duck			
Oxyura jamaicensis	Ruddy Duck			
Pelecanus erythrorhynchos	American White Pelican		Special Concern	BSSC - First priority
Phalacrocorax auritus	Double-crested Cormorant			
Phalaropus tricolor	Wilson's Phalarope			
Podilymbus podiceps	Pied-billed Grebe			
Porzana carolina	Sora			
Rallus limicola	Virginia Rail			
Riparia riparia	Bank Swallow		Threatened	
Setophaga petechia	Yellow Warbler			BSSC - Second priority
Tachycineta bicolor	Tree Swallow			
Tachycineta bicolor	Tree Swallow			
Tringa melanoleuca	Greater Yellowlegs			
Xanthocephalus xanthocephalus	Yellow-headed Blackbird		Special Concern	BSSC - Third priority
Xanthocephalus xanthocephalus	Yellow-headed Blackbird		Special Concern	BSSC - Third priority
HERPS				
Actinemys marmorata marmorata	Western Pond Turtle		Special Concern	ARSSC
Actinemys marmorata marmorata	Western Pond Turtle		Special Concern	ARSSC
Anaxyrus boreas boreas	Boreal Toad			
Anaxyrus boreas boreas	Boreal Toad			
Ascaphus truei	Coastal Tailed Frog			
Ascaphus truei	Coastal Tailed Frog			
Dicamptodon tenebrosus	Pacific Giant Salamander			
Dicamptodon tenebrosus	Pacific Giant Salamander			

Pseudacris regilla	Northern Pacific Chorus Frog			
Rana boylii	Foothill Yellow-legged Frog	Under Review in the Candidate or Petition Process	Special Concern	ARSSC
Rana boylii	Foothill Yellow-legged Frog	Under Review in the Candidate or Petition Process	Special Concern	ARSSC
Rana cascadae	Cascades Frog	Under Review in the Candidate or Petition Process	Special Concern	ARSSC
Rana cascadae	Cascades Frog	Under Review in the Candidate or Petition Process	Special Concern	ARSSC
Taricha granulosa	Rough-skinned Newt			
Taricha granulosa	Rough-skinned Newt			
Thamnophis sirtalis sirtalis	Common Gartersnake			
Thamnophis sirtalis sirtalis	Common Gartersnake			
Actinemys marmorata marmorata	Western Pond Turtle		Special Concern	ARSSC
Actinemys marmorata marmorata	Western Pond Turtle		Special Concern	ARSSC
Actinemys marmorata marmorata	Western Pond Turtle		Special Concern	ARSSC
INSECTS & OTHER INVERTS				
Agabus lutosus				Not on any status lists
Anax junius	Common Green Darner			
Dytiscus marginicollis				Not on any status lists
Lestes congener	Spotted Spreadwing			
Libellula forensis	Eight-spotted Skimmer			
Libellula nodisticta	Hoary Skimmer			
Libellula pulchella	Twelve-spotted Skimmer			
Libellula saturata	Flame Skimmer			
Plathemis lydia	Common Whitetail			
Sympetrum madidum	Red-veined Meadowhawk			
Sympetrum pallipes	Striped Meadowhawk			
Tanypteryx hageni	Black Petaltail			
MAMMALS				

Castor canadensis	American Beaver			Not on any status lists
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
Neovison vison	American Mink			Not on any status lists
Ondatra zibethicus	Common Muskrat			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				
Gonidea angulata	Western Ridged Mussel		Special	
Margaritifera falcata	Western Pearlshell		Special	
Gonidea angulata	Western Ridged Mussel		Special	
Margaritifera falcata	Western Pearlshell		Special	
PLANTS				
Bidens cernua	Nodding Beggarticks			
Carex lasiocarpa	Slender Sedge		Special	CRPR - 2B.3
Euthamia occidentalis	Western Fragrant Goldenrod			
Scirpus pendulus	Pendulous Bulrush		Special	CRPR - 2B.2

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.

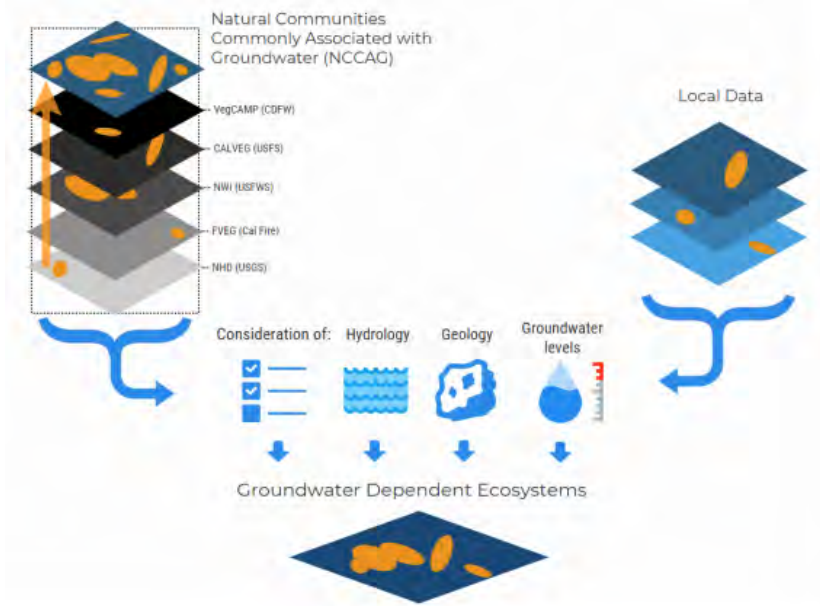


Figure 1. Considerations for GDE identification.
Source: DWR[2]

[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

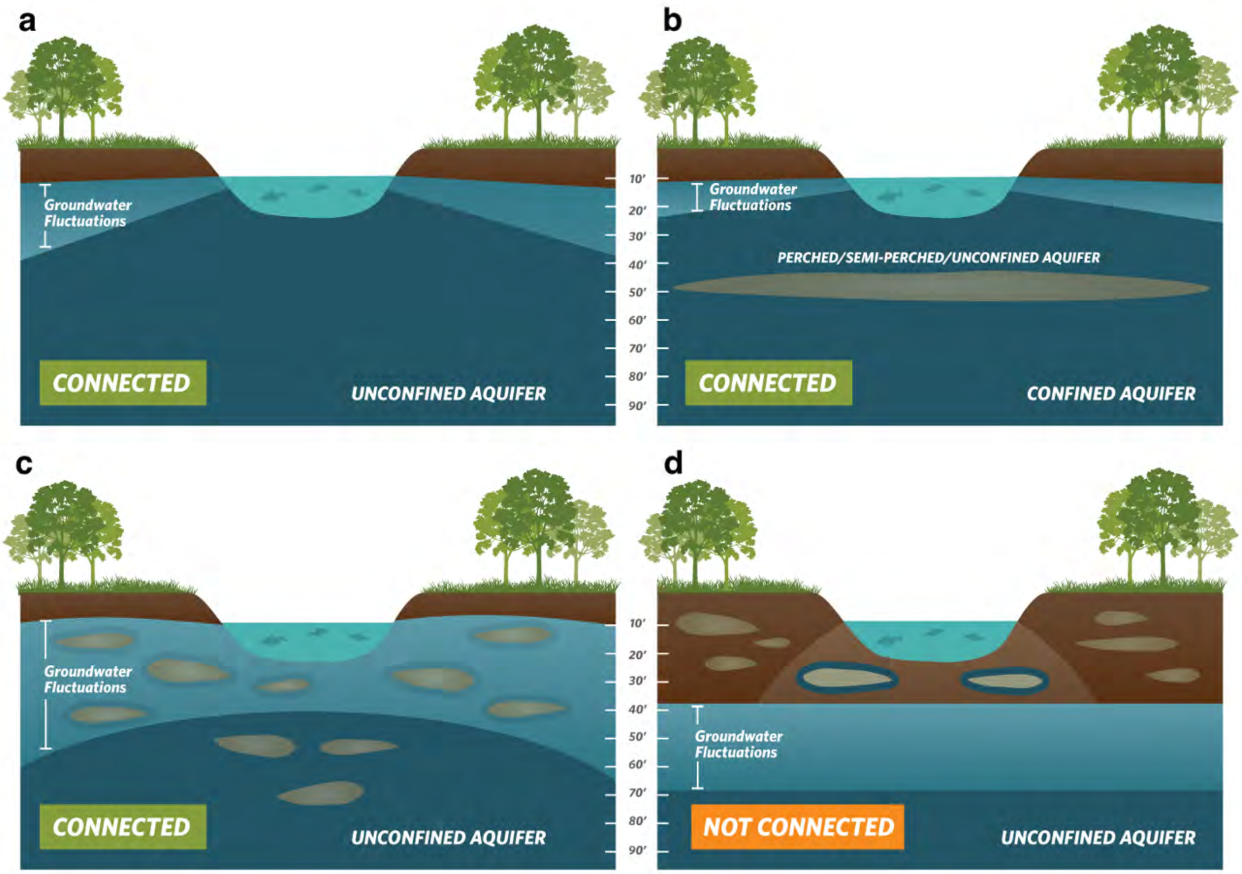


Figure 2. Confirming whether an ecosystem is connected to groundwater. Top: (a) Under the ecosystem is an unconfined aquifer with depth-to-groundwater fluctuating seasonally and interannually within 30 feet from land surface. **(b)** Depth-to-groundwater in the shallow aquifer is connected to overlying 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).

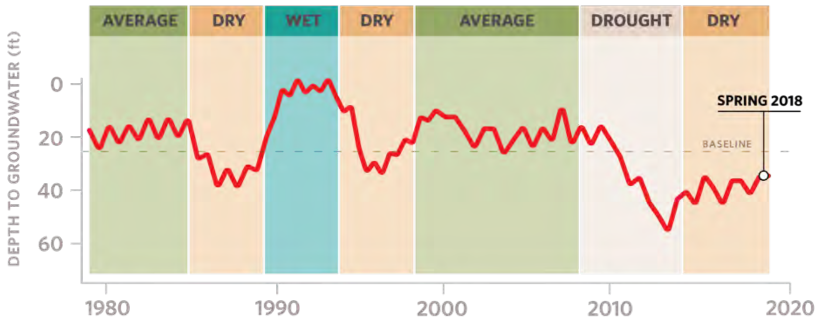


Figure 3. Example seasonality and interannual variability in depth-to-groundwater over time. Selecting one point in time, such as Spring 2018, to characterize groundwater conditions in GDEs fails to capture what groundwater conditions are necessary to maintain the ecosystem status into the future so 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).

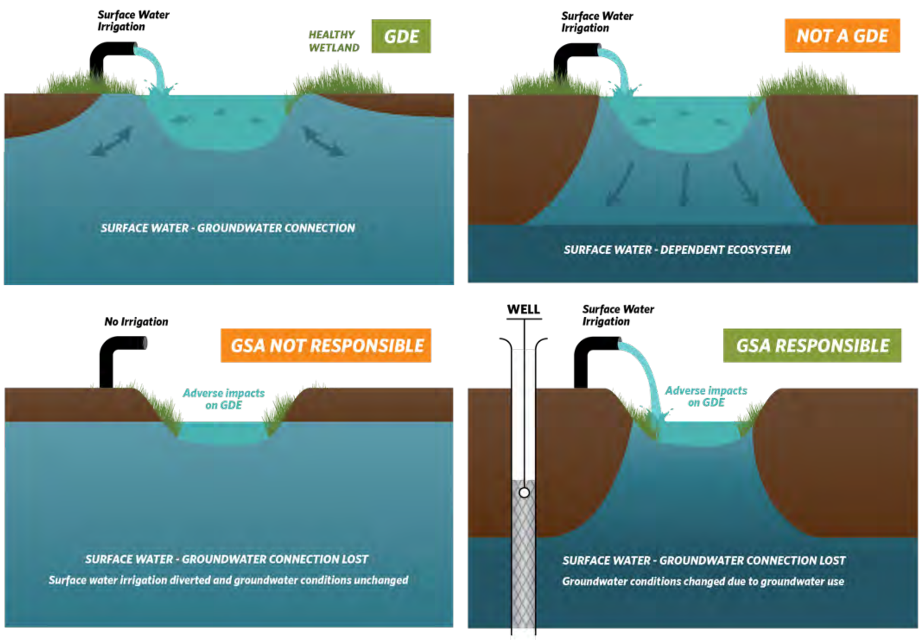


Figure 4. Ecosystems often depend on multiple sources of water. Top: (Left) Surface water and groundwater are interconnected, meaning that the GDE is supported by both groundwater and surface water. **(Right)** Ecosystems that are only reliant on non-groundwater sources are not groundwater-dependent. **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.

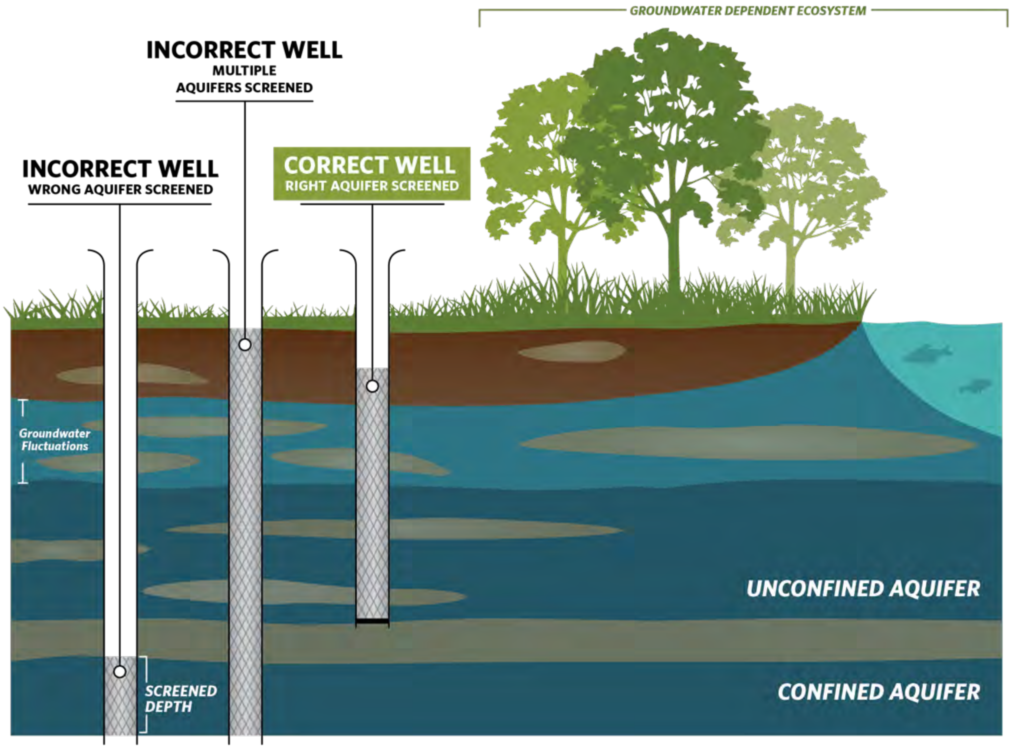


Figure 5. Selecting representative wells to characterize groundwater conditions near GDEs.

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.

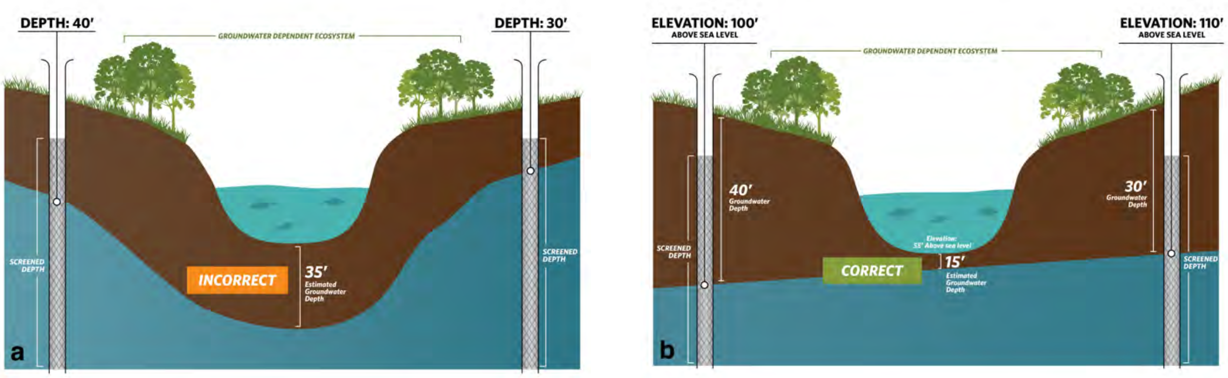


Figure 6. Contouring depth-to-groundwater around surface water features and GDEs. (a) Groundwater level interpolation using depth-to-groundwater data from monitoring wells. **(b)** Groundwater level interpolation using groundwater elevation data from monitoring wells and DEM data.

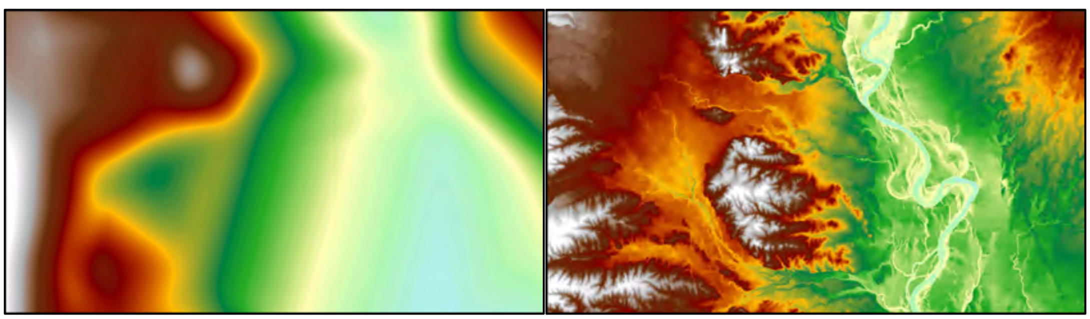


Figure 7. Depth-to-groundwater contours in Northern California. (Left) Contours were interpolated using depth-to-groundwater measurements determined at each well. **(Right)** Contours were determined by interpolating groundwater elevation measurements at each well and superimposing ground surface elevation 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.

Karuk Community Health Clinic
64236 Second Avenue
Post Office Box 316
Happy Camp, CA 96039
Phone: (530) 493-5257
Fax: (530) 493-5270

Karuk Tribe

Administrative Office
Phone: (530) 493-1600 • Fax: (530) 493-5322
64236 Second Avenue • Post Office Box 1016 • Happy Camp, CA 96039

Karuk Dental Clinic
64236 Second Avenue
Post Office Box 1016
Happy Camp, CA 96039
Phone: (530) 493-2201
Fax: (530) 493-5364

September 23, 2021

Ray Haupt, Chair
Siskiyou County Flood Control & Water Conservation District
P.O. Box 750
1312 Fairlane Road
Yreka Ca 96097

Re: Karuk Tribe Comments on Scott and Shasta Groundwater Sustainability Plans

Ayukîi Chairman Haupt:

The careful and sustainable management of our groundwater is critically important to ensuring Siskiyou County residents have ample water supplies to meet future drinking, agricultural, and environmental needs. For the Tribe, proper management of groundwater is a critical part of ensuring that the in-stream flow needs of fisheries are met today and into the future.

The Sustainable Groundwater Management Act (SGMA) was enacted to protect and sustainably manage California's groundwater resources. The Karuk Tribe continues to be disappointed and frustrated by the Siskiyou County's implementation of SGMA. Since 2017, requests to form a Groundwater Sustainability Agency that includes tribes have been ignored. Despite efforts to craft a Memorandum of Understanding to facilitate good faith communication and exchange of information, the County has largely ignored the Tribe's requests for government-to-government meetings and our input into the SGMA process.

This most recent comment period on the draft Groundwater Sustainability Plans for the Scott and Shasta are another example of the County's refusal to act in good faith with the Karuk Tribe or other entities. The County did not share all of the technical materials that support the documents to be reviewed in a timely manner. This resulted in Tribes, agencies, and others scrambling to perform a technical review on hundreds of pages of materials, draft comments, and get comments approved by governing councils or management in two weeks.

This process has been deeply flawed and mismanaged from the outset and does a disservice to the Tribes, non-tribal constituents, agricultural operators, fishermen, and others seeking certainty and resolution of the water resource conflicts in our region. In fact, because of the deep flaws in the process and the work product, its likely to create more uncertainty for everyone.

<u>Comments on the Scott Groundwater Sustainability Plan</u>

1. The GSP Fails to Properly Specify Undesirable Results, Minimum Thresholds and Measurable Objectives for the Interconnected Surface Waters Sustainability Goal

Despite the known impacts of low flows on protected species, the GSP fails to properly define undesirable results, minimum thresholds, and measurable objectives for the interconnected surface waters (ISW) sustainability indicator.

SGMA sets out a three-step process for defining these terms. The undesirable result is an "effect" caused by over pumping; here, the depletion of streamflow. (Wat. Code § 10721, def (x)(6); Cal. Code Regs. tit. 23, § 354.26.) The minimum threshold is the numeric value that determines when an effect becomes "undesirable," i.e. when it becomes "significant and unreasonable." (Wat. Code § 10721, def. (x); Cal. Code Regs. tit. 23, § 354. It must

> 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....

(Cal. Code Regs., tit. 23, § 354.28, subd. (a).) With regard to depletions of interconnected surface water, the regulations require that the minimum threshold be defined as 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." (*Id.* § 354.28, subd. (c)(6).) And the measurable objective represents numeric targets to achieve sustainability; that is, to avoid undesirable results by keeping the basin above the minimum threshold. (Cal. Code Regs. tit. 23, § 354.30.)

The GSP defines these terms for interconnected surface waters in a way that fails, as the statute requires, to tie the results of over pumping to concrete effects in the basin. The GSP distinguishes between a "SGMA undesirable result" and an "aspirational 'watershed goal.'" (GSP at 3.57-59.) The former is defined as "stream depletion that can be attributed to groundwater pumping outside of the adjudicated zone to the degree it leads to significant and unreasonable impacts on beneficial uses of surface water." (GSP at 3.57.) The minimum threshold is defined as the "the amount of stream depletion reversal achieved by one or an equivalent set of multiple minimum required PMAs to meet the intent of SGMA (no additional undesirable results), and Porter Cologne and the PTD (some reversal of existing undesirable results)."[1] (GSP at 3.60.) And the measurable objectives are defined by percentages of streamflow depletion reversed by PMAs. (GSP at 3.63-64.)

2. The Undesirable Result Definition is Tautological and Fails to Achieve Basin-Wide Sustainability as SGMA Requires

As part of achieving a basin's "sustainability goal," a GSP must "identify" "undesirable result[s]." (Wat. Code §§ 10721 subds. (u)-(x); 10727.2, subd. (b).) An "undesirable result" means an "effect[] caused by groundwater conditions throughout the basin." (Id. § 10721, subd. (x).) Undesirable results include "[d]epletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water." (Id. § 10721, subd. (x)(6).)

The GSP must define these "significant" and "unreasonable" effects. (Cal. Code Regs. tit. 23, § 354.26(a).) But the GSP's definition of "undesirable results" is a tautology. The GSP defines it as "significant and unreasonable stream depletion due to groundwater extraction from wells subject to SGMA (i.e., outside of the Adjudicated Zone)." (GSP at 3.59.) By including the terms "significant and unreasonable" in the definition, the GSP fails to provide a workable definition: an effect is defined as unreasonable if it is unreasonable. This is nonsensical and unworkable. In *Asociacion de Gente Unida por*

[1] The GSP finds that the ISW undesirable result existed prior to 2015 and thus the GSP need not address it under SGMA. (GSP at 3.55-56; Wat. Code § 10727.2.) This memo discusses this finding below.

el Agua v. Central Valley Regional Water Quality Control Board (2012) 210 Cal.App.4th 1255, 1280, the Court of Appeal disapproved a waste discharge requirement for dairy pollution where "the basis for concluding that any degradation of groundwater will be of maximum benefit to the people of California is that the Order states that it prohibits any further degradation of groundwater." The court found that this reasoning was "circular." (*Ibid.*) The same is true here.

What the GSP could have done, but did not do, is establish a streamflow target that is protective of beneficial uses in the Scott. It then could have determined the relative contributions of groundwater users inside and outside the adjudication along with surface users. It could then establish the needed reductions in use by all three categories of water users. Even though the GSA lacks authority over surface users and the adjudicated zone, the exercise would inform the amount that pumpers outside the zone need to reduce by to reach a satisfactory flow rate. And making these calculations would inform the County, the State Board, the Watermaster, and potentially the courts and other agencies about the scale and nature of needed actions. This approach would also comply with SGMA by quantifying the undesirable result and minimum threshold.

Starting with a streamflow target and working backwards is consistent with SGMA because the statute measures compliance at the basin scale. For instance, the "sustainability goal" means ensuring that the "applicable basin is operated within its sustainable yield." (Wat. Code § 10721, def. (u).) And an "undesirable result" means "one or more of the following effects caused by groundwater conditions occurring throughout the basin." (*Id.* def. (x).) And DWR evaluates GSPs to determine whether they are "likely to achieve the sustainability goal for the basin covered by the groundwater sustainability plan." (Wat. Code § 10733, subd. (b).) The regulations reiterate that undesirable results are "significant and unreasonable effects...occurring throughout the basin." (Cal. Code Regs. tit. 23, § 354.26(a).) Again, the regulations and the statute include the language "throughout the basin." If the legislature did not want to include consideration of effects in the adjudicated areas, it could have done so but did not. By focusing solely on pumping outside the adjudicated zone, the GSP fails to ensure, or even analyze what would be necessary to ensure that the basin as a whole reaches sustainability.

3. The Undesirable Result Is Not Quantified, in Violation of the SGMA Regulations

The SGMA regulations require the GSP to quantify the undesirable result:

> 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.

(Cal. Code Regs., tit. 23, § 354.26, subd. (b)(2) (emphasis added).) The description in the GSP is inadequate because it is not a "quantitative description." The regulations are clear that the result must be in the form of numbers tying minimum threshold exceedances to the significant and unreasonable effects. The GSP's description is entirely qualitative. In addition, the description lacks "criteria" for "when and where" groundwater conditions cause significant and unreasonable depletions. Again, SGMA and the regulations make crystal clear that the undesirable results analysis must be tied to physical conditions and physical locations, not solely a model output.

This violates the regulations.

4. The Reasonableness Analysis Fails to Consider Costs to Beneficial Users of Surface Waters

The GSP is required to determine whether the depletions of surface waters have "unreasonable impacts on beneficial users of surface waters." But instead of focusing its discussion on the harms to beneficial users, it focuses solely on the costs to groundwater users. This violates SGMA.

The GSP fails to properly consider the "unreasonableness" of stream depletions by failing to analyze not only of the costs of compliance but of the costs to the public, tribes, and commercial fisheries of the loss of fish populations—loss which may include the incalculable consequences of extinction or extirpation. For instance, courts have held that when setting water quality objectives under Water Code section 13241, the "Water Control Boards are charged with taking into account economic considerations, not merely costs of compliance with a permit. As noted, economic considerations also include, among other things, the costs of not addressing the problems of contaminated water." (*City of Duarte v. State Water Resources Control Board* (2021) 60 Cal.App.5th 258, 276.) The same is true here: determining whether an effect is reasonable requires looking at both costs to comply with any restrictions and also the costs to the public of over-extraction.

The GSP states: "In the context of assessing MTs for the ISW SMC, it is reasonable to only hold groundwater producers outside the adjudicated zone to a modest percentage of stream depletion reversal because any greater responsibility would unreasonably constrain groundwater users in the basin." (GSP at 3.58.) Later, the GSP purports to analyze "what is an "unreasonable" amount of stream depletion, which could be reframed as: what is a "reasonable" amount of avoided groundwater use?" (GSP at 3.59.) This is not the question the statute asks: SGMA requires the definition of significant and unreasonable effects to focus on the *results* of stream depletion, not the cost of avoiding it. (Wat. Code § 10721, def. (x); Cal. Code Regs. tit 23, § 354.26(a).) Any costs associated with any constraint on groundwater users has to be balanced against the effect of their actions on groundwater conditions. A reasonableness analysis that focuses entirely on costs to groundwater users is incomplete.

5. The Unreasonableness Analysis Ignores Legally Binding Streamflow Limits in the Scott River

The analysis also misses the fact that the State Board recently adopted emergency regulations setting flow levels (embodied in the CDFW drought minimum flows) below which extractions are deemed to be unreasonable. (See Wat. Code § 1058.5. (State Board authority to adopt emergency regulations to "prevent the waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion, of water"); Cal. Code Regs. tit. 23, § 875 et seq.) Rather than focusing on the cost of compliance, the GSP must revisit its significant and unreasonable analysis in light of the State Board's determination of what is "reasonable." It is within the State Board's authority to determine which uses are reasonable. (*Stanford Vina Ranch Irrigation Company v. State* (2020) 50 Cal.App.5th 976, 1002–1003 ("[T]he Board is charged with acting to prevent unreasonable and wasteful uses of water, regardless of the claim of right under which the water is diverted.").)

Nor does the fact that extraction has been continuing at these levels for the last several decades (a fraction of the time that the Karuk Tribe has existed in the Klamath basin) make over-extraction of groundwater reasonable. (Wat. Code § 100.5 ("conformity of a use, method of use, or method of diversion of water with local custom shall not be solely determinative of its reasonableness.") The GSP must account for the fact the State Board has now declared flows below the CDFW drought minimum flows to be unreasonable.

6. Minimum Thresholds Inadequately Defined

The GSP defines the minimum threshold for interconnected surface waters as "the amount of stream depletion reversal achieved by one or an equivalent set of multiple minimum required PMAs to meet the intent of SGMA (no additional undesirable results), and Porter Cologne and the PTD (some reversal of existing undesirable results)." (GSP at 3.60.) It goes on specify: "**average stream depletion reversal** of the implemented PMAs during September–November **must exceed 15% of the depletion caused by groundwater pumping from outside the adjudicated zone in 2042 and thereafter**..." (GSP at 3.60 (emphasis in original).) There are at least three problems with this. First, it is circular. Second, the 15% figure is arbitrary and unsupported by evidence. Last, it is not tied to a "monitoring site or representative monitoring site" as required by the regulations.

The minimum threshold is circular because it starts from the premise that the ILR/MAR scenario is all that need be done. The GSP states that Advisory Committee determined it was "reasonable" implement the MAR/ILR scenario of PMAs. (GSP at 3.60.) This involves flooding fields using excess flows in the winter and switching from groundwater to surface water irrigation using excess water in the spring. This scenario does not involve reducing pumping by groundwater users. Having determined the costs associated with the MAR/ILR scenario are reasonable, the GSP simply states that the streamflow associated with that scenario is the minimum threshold. (GSP at 3.61.) This depletion reduction figure is 15%.

By defining the minimum threshold as the results of simulated PMAs, the GSP creates a circle. It can define the undesirable result and achieve it without demonstrating any real-world impact on flows, fish, or the people that rely on them. This violates SGMA.

In addition, the 15% figure is completely lacking in evidence. An agency's action is invalid if it is "arbitrary, capricious, or without evidentiary support." (E.g. *Association of Irritated Residents v. San Joaquin Valley Unified Air Pollution Control Dist.* (2008) 168 Cal.App.4th 535, 542.)

While the GSP implies that it was discussed at the Advisory Committee meetings, there is no justification for why 15% was chosen, and not 50%, 100%, or 5%. Indeed, although the key driver of the GSP's MT analysis is the cost of the MAR/ILR scenario, the GSP *does not consider the cost of the scenario!* (GSP at 3.60-61, 4.27 ("Costs and funding for [the ILR/MAR] project have not yet been explored.") Here, the failure to consider the costs of the ILR/MAR scenario—which is the only basis for the selection of the 15% reduction figure—is arbitrary and capricious because it is not based on any evidence in the record.

Moreover, there is no analysis of the impacts of the 15% depletion reduction on the stream itself. Without this analysis, there is no way to know whether this level of reduction is "significant" or "unreasonable," no matter how the terms are defined. And this illustrates the problem with defining the minimum threshold in terms of a modeled output rather than, as required by the regulations, a value at a monitored site.

The "minimum thresholds" must "quantify groundwater conditions for each applicable sustainability indicator *at each monitoring site or representative monitoring site.*" (Cal. Code Regs., tit. 23, § 354.28(a), emphasis added.) Therefore, the definition of the undesirable result must be "quantitative" and must be tied to minimum threshold exceedances at *particular monitoring sites.*[2] In other words, the SGMA regulations require a GSP to express an undesirable result in terms of a real-world impact to a directly measured value, in this case, streamflow.

The SVIHM model will doubtless be a useful tool and provides invaluable insights into those parameters that cannot be directly measured. But it is not a "monitoring site." The GSP must include minimum thresholds that inform the GSA and the public when physical conditions in the basin have reached the point of being "significant and unreasonable" impacts on interconnected surface waters.

---

[2] Section 352.4 of the regulations makes clear that a monitoring site is a physical location, not a model output. (Cal. Code Regs., tit. 23, § 352.4.)

7. Measurable Objectives are not Properly Defined

The GSP attempts to avoid the requirement to define the minimum threshold and measurable objectives in terms of stream flow by referring to section 354.30, subdivision (b) of the regulations. The GSP states, "Choosing the aspirational watershed goal itself as MO would not meet the requirement that quantification/measurement of streamflow depletion that is used to establish the minimum threshold, Section 3.3.5.1, must also [be] used to quantify the MO."[3] But this is precisely backwards. As discussed above, the minimum threshold must be defined with reference to a measured value at a monitoring site. And there is no requirement that the measured value be identical, only that the metrics and monitoring sites be the same. Again, SGMA is clear that measurable objectives, like minimum thresholds and undesirable results, be defined in terms of measurable stream flow, not as a portfolio of PMAs or solely as a model output.

8. The GSP Does not Consider the 2021 Emergency Regulations or the CDFW Drought Flows

On June 15. 2021, CDFW transmitted Minimum Flow Recommendations for the Scott and Shasta Rivers to the State Board.[4] The minimum flow recommendation largely tracks the USFS water right at the Fort Jones Gage, with deviations in September (33 cfs), November (60 cfs), and December (150 cfs.)

Based on these recommendations, the 2017 CDFW flow recommendations, and a Petition for Emergency Rulemaking filed by ELF and the Karuk Tribe on July 1, 2021, the State Board adopted emergency regulations setting minimum flows on the Scott and Shasta River in August 2021. (See Cal. Code Regs. Tit. 23, § 875 et seq.)

The emergency regulations establish the CDFW Minimum Flow Recommendations as the minimum permissible flows in the Scott River. (Cal. Code Regs. tit. 23, § 875(c)(1).) State Board staff is authorized to curtail diversions—both surface waters and groundwater—that reduce river flow below those levels. Curtailment orders have now gone out to diverters.

The GSP does not acknowledge either of these events. Rather, it states "However, neither the ESA, TMDL, or PTD specify mandatory targets, minimum thresholds, or specific project requirements." (GSP at 3.57) This statement is not true. The emergency regulation now sets a minimum flow for the Scott River. Thus, the goal of restoring adequate flows in the Scott is no longer "aspirational"—a minimum flow is now the law. The GSP must be revised to account for this.

9. The GSP Fails to Consider Undesirable Effects that Have Occurred After 2015

Water Code section 10727.2, subdivision (b)(4) states that a GSP "may, but is not required to, address undesirable results that occurred before, and have not been corrected by, January 1, 2015. Notwithstanding paragraphs (1) to (3), inclusive, a groundwater sustainability agency has discretion as to whether to set measurable objectives and the timeframes for achieving any objectives for undesirable results that occurred before, and have not been corrected by, January 1, 2015."

---

[3] GSP, Chapter 3, at p. 53. The cited regulation states: "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." (Cal. Code Regs., tit. 23, § 354.30, subd. (b).)

[4] Available at https://www.waterboards.ca.gov/drought/scott_shasta_rivers/docs/swb_2021_shasta_scott_drought_emergency_final.pdf, accessed September 15, 2021.

The GSP says, "In Scott Valley, undesirable results associated with depletion of interconnected surface water that have occurred since January 1, 2015, had already existed for over thirty years prior as of 2015. No additional undesirable results have occurred since January 1, 2015 (Section 2.2.1.6). Additional future surface water depletion due to groundwater pumping will be avoided by rigorous controls set on maintaining current water level conditions (Section 3.4.1) and by avoiding significant additional consumptive water use in Scott Valley (see chapter 4)." (GSP at 3.55.)

This misstates the facts. It is clear that there is sufficient water in the Scott River system to sustain fish populations in almost every year. This is evident from the pre-1980 record showing that the river could sustain the USFS flow right and the CDFW recommended flows prior to the adjudication and the expansion of groundwater pumping. And it is clear from the information contained in the GSP that almost every year, precipitation is sufficient to bring flows up to a level that would support those flows for most of the year, absent irrigation. (See GSP at App. 4-A, at pp. 73-75.)

Therefore, the effects of stream depletion did not "exist" prior to 2015. Indeed, on January 1, 2015, the Scott River flowed at over 500 cfs, well above the CDFW-recommended 362 cfs.[5] The "undesirable result" for the purposes of SGMA is the disconnection and low flow in the river. (Wat. Code § 10721, def. (x)(6).) In the summer of 2015, growers made a choice to withdraw water from a full aquifer. And in 2015, just as in every prior summer, the County, the State Board, and other responsible agencies allowed the depletions to occur.

This does not mean that the undesirable result "existed." Courts have "long settled that separate, recurring invasions of the same right can each trigger their own statute of limitations." (*Aryeh v. Canon Business Solutions* (2013) 55 Cal.4th 1185, 1198.) This a similar situation: the stream depletions are not a continuous problem that occurred long ago and has not been corrected, like seawater intrusion or permanent subsidence. Depletions are discrete events that recur anew each year, but the GSP treats them as permanent. Indeed, the GSP claims that there is no chronic lowering of groundwater levels in the Scott. (GSP at 3.32.)

The GSP should be revised to make clear that the stream depletions did not "exist" prior to 2015 because each year they are caused again.

10. The GSA's Baseline Analysis Must Include Consideration of Other Laws

SGMA also does not absolve the County or the GSA of its duty to comply with other environmental laws. SGMA contains at least four explicit savings clauses making explicit that SGMA's requirements are in addition to, and do not replace, the requirements of other laws, including the Clean Water Act, the public trust doctrine, the state and federal Endangered Species Acts, or Fish and Game Code 5937, to name just a few.

SGMA's savings clauses include:

- "Nothing in this part, or in any groundwater management plan adopted pursuant to this part, determines or alters surface water rights or groundwater rights under common law or any provision of law that determines or grants surface water rights." (§ 10720.5, subd. (b).)
- "A groundwater sustainability agency may exercise any of the powers described in this chapter in implementing this part, in addition to, and not as a limitation on, any existing authority . . . ." (§ 10725, subd. (a).)

[5] USGS Flow Meter Data available at https://nwis.waterdata.usgs.gov/ca/nwis/uv/?ts_id=16566&format=img_default&site_no=11519500&begin_date=20150101&end_date=20150101

- "This part is in addition to, and not a limitation on, the authority granted to a local agency under any other law." (§ 10726.8, subd. (a).)
- "Nothing in this part is a limitation on the authority of the [State Water Board], the [Department of Water Resources], or the State Department of Public Health." (§ 10726.8, subd. (c).)[6]

The GSP purports to consider other laws. But it does so in the context of doing as little as possible to comply with those laws. The GSP states that SGMA requires it to only not cause more undesirable results than "existed" in 2015 (e.g. GSP at 3.60). But it characterizes any "additional" reduction in pumping as in response to the public trust doctrine the Clean Water Act, not SGMA. As discussed above, the conclusion that SGMA does not require further reductions below the 2015 baseline is incorrect. The analysis of undesirable results and minimum thresholds needs to be revised to take into account the requirements of all other relevant laws.

For instance, the analysis of temperature impacts is insufficient. Groundwater extractions reduce cold-water inflows. (GSP at 2.25.) And this occurs not just in the August-November period, but throughout the year. And some of these cold pools may exist in tributaries that are not part of the adjudicated area, such as the East Fork.[7] These areas would thus be fully under the jurisdiction of SGMA. But the GSP does not model or account for cold water refugia, which are crucial for salmonid over-summering and rearing, especially for Coho. (GSP at 2.73.) The TMDL Action Plan reinforces that these thermal refugia are necessary for species recovery: "Where reaches of the Scott River and its tributaries are providing suitable freshwater salmonid habitat, including cold water refugia for coho and other salmonids, protection of these areas should be a priority for restoration efforts."[8]

The GSP's failure to model and consider impacts of groundwater extraction on this crucial habitat implicates the Clean Water Act, by failing to comply with the TMDL for temperature, and the Endangered Species Act, for failing to protect critical habitat. Moreover, temperature impacts are an "effect" that the GSP wholly fails to evaluate the significance and reasonableness of when defining the undesirable result and minimum thresholds for either water quality or interconnected surface waters.

The GSP should, at the very least, incorporate a plan to identify and protect these cold water refugia where they occur.

11. The GSP Fails to Consider Surface Water Quality

The GSP's identification of undesirable results for water quality is insufficient because it fails to consider groundwater extraction's impacts to surface water quality. SGMA provides that "[s]ignificant and unreasonable degraded water quality" is an undesirable effect required to be avoided (Wat. Code § 10721, subd. (x)(4), and SGMA does not limit this definition to degraded *groundwater* quality. But the GSP limits its discussion of the water quality undesirable result to groundwater quality. (GSP at 3.42) This limitation violates SGMA because it does not consider the significant effects that groundwater conditions have on surface water quality, namely, temperature—including cold water refugia. The GSP acknowledges that the Scott is listed as impaired for temperature under section 303(d) of the Clean Water Act. (GSP at 2.23) And extractions of groundwater affect flows and therefore temperature in the Scott. (GSP at 2.25.)

---

6 The "part" mentioned in each provision refers to Part 2.74 of the Water Code—that is, the entire Sustainable Groundwater Management Act. (§ 10720.)

7 North Coast Regional Water Quality Control Board, Staff Report for the Action Plan for the Scott River Watershed Sediment and Temperature Total Maximum Daily Loads (2005) at p. 4-35.

8 North Coast Regional Water Quality Control Board, Staff Report for the Action Plan for the Scott River Watershed Sediment and Temperature Total Maximum Daily Loads (2005) at p. 5-4.

The GSP must be revised to describe impacts to surface water temperature as an undesirable result and to develop minimum thresholds, measurable objectives, and projects and management actions to remedy the undesirable result.

12. Additional technical comments to be incorporated by reference

The Karuk Tribe supports and incorporates by reference the technical comments prepared by Riverbend Sciences on behalf of the Klamath Tribal Water Quality Consortium dated September 21, 2021 regarding review and comments on *Public Draft Scott Valley Groundwater Sustainability Plan*. These comments are attached.

Comments on the Shasta Groundwater Sustainability Plan

The Karuk Tribe supports and incorporates by reference the technical comments prepared by Riverbend Sciences on behalf of the Klamath Tribal Water Quality Consortium dated September 21, 2021 regarding review and comments on *Public Draft Shasta Valley Groundwater Sustainability Plan*. These comments are attached. Karuk-001

The Karuk Tribe hopes that the Groundwater Sustainability Agency/ Siskiyou County Flood Control & Water Conservation District will work to amend the draft plans based on the extensive feedback based on the legal and technical merits of the draft plans. The Karuk Tribes remains interested forging a collaborative relationship with the County despite the apparent lack of such interest by the County.

Yôotva,

Russell "Buster" Attebery
Karuk Tribe, Chairman

Cc: Anecita Augustinez
Tribal Policy Advisor
Department of Water Resources
P.O.Box 942836
Sacramento, CA 94236-0001

Patricia Vellines, P.G.
Regional Coordinator
Northern Region Office
Department of Water Resources
2440 Main Street
Red Bluff, CA 96080

Riverbend Sciences
1614 West Ave.
Eureka, CA 95501
(707) 832-4206
www.riverbendsci.com

MEMORANDUM REPORT

To: Klamath Tribal Water Quality Consortium
From: Eli Asarian, Riverbend Sciences
Date: September 20, 2021
Re: Review and comments on *Public Draft Shasta Valley Groundwater Sustainability Plan*

The public draft of the "Shasta Valley Groundwater Sustainability Plan" was circulated for public comment by the Siskiyou County Flood Control & Water Conservation District in August, 2021. To assist the member Tribes of the Klamath Tribal Water Quality Consortium in the preparation of their comments, Riverbend Sciences and subcontractors have reviewed the document and prepared the comments provided here for the Tribes' use.

A) COMMENT OVERVIEW

We have reviewed the public draft of the Shasta Valley Groundwater Sustainability Plan (GSP) and wish to provide the following comments. Our comments are arranged into three sections: A) Comment overview in which we provide a summary of our most important big-picture comments, B) comments on specific sections of the GSP chapters using the comment form provided.

A summary of our big-picture comments is provided in the following bullets, which are then discussed in the paragraphs below:

- The GSP lacks transparency
- Many GSP actions and goals sound great but are loosely defined so do not actually achieve much
- The GSP's monitoring plan is good, but without sufficient funding it cannot be implemented, and critical data gaps will remain unfilled
- The Minimum Threshold for Interconnected Surface Water should use direct measurements of springs, not a water balance that relies heavily on highly uncertain diversion estimates
- Parts of the GSP do not acknowledge the hydrologic reality of the sources of water to a well
- Even if the model will not be used for sustainable management criteria, it is still informative to look at its predictions for streamflow depletion
- The GSP does not deal appropriately with climate change

The GSP lacks transparency

Collaborative management and transparency and core tenants of SGMA. How will transparency and public access to data be incorporated into reporting and data sharing agreements? All data that is paid for with public money should be accessible to the public. All GSP reporting (i.e., annual and five-year review reports) should include electronic appendices with easily accessible data, so others could run their own analyses on the data. TC-001

We understand the political sensitivity of well metering, but how can groundwater be managed at a basinwide scale without metering? At least some subset of the wells should be mandated to be metered. Examples could include the largest wells, or new wells drilled after the passage of the SGMA legislation or after adoption of the Shasta Valley GSP. How can existing ordinances, such as the prohibition on the use of groundwater for cannabis production or the requirement for permits being needed for inter-basin transfers of groundwater, be enforced without the well metering? How can the effects of efficiency projects be verified without metering? The lack of metering requirements suggests a lack of transparency, which further suggests a lack of will to actually manage groundwater extraction. TC-002

We also have serious concerns with the lack of transparency with the current Scott Valley and Shasta Valley Watermaster District program. Watermastering should be returned to the State of California, with well-organized publicly accessible records of diversions. TC-003

Many GSP actions and goals sound great but are loosely defined so do not actually achieve much

The GSP full of things like that sound great like the "Avoiding Significant Increase of Total Net Groundwater Use from the Basin" project and management action (PMA), but when we look closely at the details we see that the wording is loosely defined so that it does not actually guarantee anything. Since all well metering is voluntary, how is it possible to verify this? TC-004

If the GSP is to actually achieve the stated objectives, it needs more things that can actually be readily verified. Examples that we recommend include:

- No additional wells for new land use or additional cropping will be permitted in the basin. Only new wells intended to replace old wells and existing crops will be permitted, and these replacement wells will be metered. The intent here is to avoid net increase in groundwater use.
- Wells intended to replace stream diversions will not be permitted, even if there will be no additional net water usage (i.e., pumped groundwater will be used to replace surface water irrigation of existing crops). The intent here is to allow the SWRCB to ascertain and regulate surface water rights and stream and spring flows. The use of groundwater wells in place of stream or spring diversions simply moves the point of diversion and lessens the ability of the SWRCB to carry out its mission.

The GSP's monitoring plan is good, but without sufficient funding it cannot be implemented, and critical data gaps will remain unfilled

We generally agree with sites and parameters proposed in Section 3.3 Monitoring Networks, but we are extremely concerned that funding will not be available to actually implement the monitoring. The GSA has a responsibility to provide the funding needed to collect these data. Without the monitoring, critical data gaps will persist and it will be impossible to understand or properly manage the intricate Shasta Valley groundwater system. TC-005

From our perspective, monitoring the flow of the springs is the most important. The output of these springs is what sustains aquatic ecosystems and agriculture in the Shasta River. In addition, the ability to predict flow in these springs is the primary endpoint upon which we will judge the performance of the Shasta Watershed Groundwater Model. We need to understand how groundwater elevations and groundwater pumping affect the flow in these springs. The monitoring plan proposes monthly monitoring of the springs, however, this is insufficient given the importance of these springs and the potential insights that high-resolution data could provide into the complex dynamics of Shasta Valley groundwater. At what time scales do the flow of these springs fluctuate (seasonal, weekly, daily, hourly, etc.) and what do these fluctuations appear to correspond with (e.g., Dwinnell reservoir levels, nearby groundwater pumps cycling on/off, flood irrigation, snowmelt, storm events, etc.)? How can we understand this without data? The two largest springs, Big Springs and Little Springs, are especially important. Other critically important springs that need continuous flow monitoring include Bridge Field Springs (on Shasta Springs Ranch, owned by Emmerson), Black Meadow Springs (on Shasta Springs Ranch, owned by Emmerson), Kettle Springs (on Shasta Springs Ranch, owned by Emmerson), and Hole in the Ground Spring. We noticed that Bridge Field Springs and Black Meadow Springs, were not included in the monitoring plan. We strongly urge that both these springs be added to the monitoring plan. TC-006

The Minimum Threshold for Interconnected Surface Water should use direct measurements of springs, not a water balance that relies heavily on highly uncertain diversion estimates

The GSP proposed a Minimum Threshold (MT) for Interconnected Surface Water (ISW) of 100 cfs groundwater contributions, based on a water balance of the Shasta River reach between Dwinnell Dam and the USGS flow gage near Montague. The estimated diversions used in the water balance are highly uncertain and unreliable, derived from private watermaster records. The bounds of uncertainty on these diversion estimates are so large as to make them nearly useless as a decision-making tool. Rather than estimating groundwater contributions based on a highly uncertain water balance, we would much rather have the MT ISW be based on the sum of measured discharges from key individual springs (i.e., Big Springs, Little Springs, Bridge Field Springs, Black Meadow Springs, Kettle Springs, and Hole in the Ground Spring). While these individual springs do not represent the entirety of the groundwater contributions (i.e., there may be some diffuse contributions as well as additional smaller springs), data on the spring flows are required anyway for management and model calibration, and should provide a more reliable relative metric of groundwater contributions than the water balance. There are not yet much data yet on these spring flows, but measurements need to begin as soon as possible. TC-007

Parts of the GSP do not acknowledge the hydrologic reality of the sources of water to a well

It is important to note that there are only three sources of water to a pumping well: 1) reductions in discharges from the system (e.g., discharges to streams and springs); 2) an increase in recharge to the system (capture of rejected recharge), and 3) change in storage (change in groundwater levels, which is only a temporary source of water and is not sustainable).

Because the Shasta work includes the entire watershed, item "2" would only result in robbing Peter to pay Paul – there is no net increase in yield when viewing the system as a whole. Item "3" is not important when looking at the long-term (sustainable) response of the system to pumping – it's only a matter of time before the impacts show up.

The point to be made here is that all groundwater pumping eventually comes at the expense of surface water systems (e.g., stream flow), the only real question is how long it will take for these depletion effects to reach the surface water systems. This delay is a function of distance from the stream and aquifer properties. It doesn't matter if the well is 10 feet or 10,000 feet from a surface water feature– the result will ultimately be impact to surface water features. This assumes that the basin does not simply go into overdraft, at which point there are no additional sources of surface water to deplete, or that they are already being depleted as rapidly as possibly given aquifer properties.

We highlight this issue because at times the GSP document seems to not acknowledge this fundamental physical reality. For example, from Chapter 3, page 46:

> As explained in the previous section, the lack of historical and high-frequency groundwater elevation data in the Basin, spatial gaps in streamflow and spring measurements, and uncertainty in the historical and current data regarding surface water diversions and groundwater does not allow the development of a reliable estimate of stream depletion due to pumping. Acknowledging these uncertainties and existing data gaps, the GSA finds it inappropriate to define the interconnected surface water SMC at this stage using modeled results of stream depletion. Instead, the GSA proposes as adaptive approach that would help improve the SMC setting in the future using newly collected data while addressing SGMA requirements…

TC-008

What other long-term source of water is there for the wells (see Theis, 1940, The Sources of Water Derived from Wells)? It is important to strike "…does not allow the development of a reliable estimate of stream depletion due to pumping." and replace with something like " …makes current model predictions of location and timing of impacts uncertain."

Even if the model will not be used for sustainable management criteria, it is still informative to look at its predictions for streamflow depletion

The GSP states that the model is not complete and therefore was not used for assessing sustainable management criteria. A primary reason given for this is lack of data. Our comment regarding this issue (Chapter 3, page 30) is:

> The text states "*The goal is to use this approach for the first 5 years of implementation, collect more data, and at the GSP update provide a stream depletion approach based on more reliable results produced by the further calibrated SWGM.*" Two fundamental questions regarding groundwater development in the Shasta Valley are "What effect has past and present groundwater

TC-009

pumping had on surface-water flow in the Shasta River, tributaries, and springs in the Valley?" "What effect will future groundwater pumping have on surface-water resources in the Shasta Valley?" From the stated text, it seems that the Shasta Watershed Groundwater Model (SWGM) will not be used to answer these questions for at least 5 years. If the groundwater part of the model can be used to calculate water budget components as has already been done, why can't it be used to calculate streamflow depletions? Conversely, if the model can't be used to reliably calculate streamflow depletions, why can it be used to calculate water-budget components? Using a groundwater model, streamflow depletion from groundwater pumping is always determined using model-calculated water budget components. At this stage of development of the groundwater model, uncertainty in computed streamflow depletion will most likely be in the timing of the depletion, rather than the relative amounts that various surface-water features are affected. In five years, there will still be uncertainty in the timing of depletion, but perhaps that uncertainty will be lower. Nonetheless, a delay of five years in tackling fundamental questions seems to be ignoring the current value of the model. If key calculations were run and re-run as the model was being improved, then the modelers would learn the sensitivity of model results to changes in parameters.

TC-009 contd.

We would add that the modeling process itself is an invaluable tool in gaining stakeholder buy-in on the local physical conditions and the model itself. This buy-in is especially important down the road when the model is used to make critical decisions. Letting stakeholders clearly see the difficulties in simplifying the system for input into the computer program and illustrating the uncertainties that arise from data gaps is invaluable as part of building trust. Unfortunately, this was not our experience on this project.

The GSP does not deal appropriately with climate change

The GSP appears to treat climate change as a check-the-box exercise rather than seriously grappling with what it will mean for groundwater management. The GSP does include model runs for future climate change, these results are not presented in a coherent way that highlights the major challenges that climate change will pose to water management. A warming climate will cause a shift in precipitation form (less snow, more rain) that will in turn shift the seasonal timing of tributary surface flows into the valley. Regardless of what happens to total precipitation or total runoff, this change in precipitation form and runoff timing is a huge issue that water management is going to need to recon with. Perhaps we missed it (and if so, we apologize), but we did not see evidence that the GSP recognizes the severity of the coming changes to climate, nor presents a coherent plan to adapt to it.

TC-010

B) COMMENTS ON SPECIFIC GSP SECTIONS USING THE COMMENT FORM PROVIDED

Chapter	Page	Section	Line/Table/ Figure #	Comment	
2	79	2.2.1.5	1500-1504	"Streamflow data from all available sources will be further assessed during hydrologic model development to identify important critical conditions. Data quantity and quality impact both selection of data to be used for calibration and interpretation of model performance during associated time periods. More weight is given to locations and time periods with higher quality data." This wording seems to suggest this work was not done as part of model calibration to date, but this appears incorrect, true? If so, it should be reworded in past tense.	TC-011
2	87-91	2.2.2.2	Figure 35-39	Based on the values this is, indeed, a depth to water map, but then it is not an "Elevation Map" as stated. It is a bit confusing as it appears to show cones of depressions in the far eastern and western areas, but as the land is sloping it is not clear how much these values reflect changes in land surface elevation versus water groundwater surface elevation. Why not present WL elevation maps and depth to water maps separately? In the latter case, it would be good to include a more detailed land surface elevation map than that provided in Figure 6 (which is in 2,000 foot increments).	TC-012
2	107	2.2.2.6	2071	This is supposed to read "south to north" not "~~north to south~~", right?	TC-013
2	108	2.2.2.6	2124-2166	We assume these measurements will continue into the future and measurements obtained throughout the year. This is important because winter periods may prove best for understanding the ultimate degree of GS/SW interaction because of the lack of nearby irrigation pumping. In addition, a year-round analysis would provide a fuller picture of this interaction.	TC-014
2	111	2.2.2.6	2128	It is coinciding, so suggest following edit: "~~potentially coinciding~~" to "coincident".	TC-015
2	133-134	2.2.2.7	2433, Figure 58	Why are these maps (Figure 58 and in Appendix 2-G) so different from Figures 35-39? Is it simply a matter of scale? Suggest replacing Figures 35-39 with these figures and including WL Elevation maps separately.	TC-016
2	136-137	2.2.2.7	2506, Figure 59	Why is this survey considered a maximum and not a minimum possible extent? There are a lot of acknowledged generalizations in this section. We would think you'd want a relatively quick field check before dismissing all the "Assumed not a GDE" areas. In addition, as noted, perched zones were not captured in the analysis. Recommend that you include something like "Representative areas currently classed as 'Assumed not a GDE' will be reviewed in the field as part of future work".	TC-017
2	138	2.2.3	Figure 60	This graph (or an additional one) should include change in storage through time.	TC-018

Chapter	Page	Section	Line/Table/ Figure #	Comment	
2	138	2.2.3	Figure 60	It is important that groundwater ET be modeled explicitly in the GSFLOW model to better understand and illustrate the changes in amount and location of potential impacts to GDEs through time in areas of shallow water tables. We assume this was done. In any case, it is easy to do in MODFLOW by adding in an ET surface corresponding to ground surface with general groundwater ET extinction point rules. We assume there is a comparable simple way to do this in GSFLOW. This needs to be reported as part of the water budgets (Figures 60-61). This would be in addition to the analysis mentioned on page 141, which we don't fully understand – given groundwater ET changes as a function of WLs, how could it be calculated ahead of time and then used as input? We realize we may misunderstand this. Clarification in the text would be very useful.	TC-019
2	138	2.2.3	2521-2531	It appears that you deem domestic and public pumping to be inconsequential. We do not necessarily disagree, but an estimate of these values needs to be provided to substantiate this position.	TC-020
2	141	2.2.3.1	2603-2609	It is important that the GSFLOW model be used to calculate groundwater ET because the water table fluctuates through time due to changing stresses. What is the benefit to calculating this outside the model and then using it as input?	TC-021
2	143	2.2.3.1	Table 15 & 16	Delete one of the "~~within the~~" in each, and in Table 16 we think you mean watershed boundary, not ~~Basin~~ boundary	TC-022
2	144	2.2.3.1	Table 18	Looks like Average and Maximum values are reversed for Agricultural Pumping, or one of the values is erroneous.	TC-023
2	145	2.2.3.4	2695	"Winter rains and winter/spring runoff ~~fill~~recharge the aquifer system between October and April (Figure 23)." Replace ~~fill~~ with recharge. If it filled there wouldn't be many of the issues we are dealing with here.	TC-024
2	146	2.2.3.4	2731-2734	"The response of the groundwater discharge to the stream system will be delayed relative to the timing of the changes in pumping or recharge – by a few days if changes occur within a few tens or hundreds of feet of a stream, by weeks to months if they occur at larger distances from the stream." This statement requires proof. Assuming delay calculations were performed for the local aquifer they should be included somewhere in the document.	TC-025
2	151	2.2.4.2	Figure 67	"Baseline" line should be removed from graph and legend because it is confusing and same color as "Wet"	TC-026

Chapter	Page	Section	Line/Table/ Figure #	Comment	
2	151	2.2.4.2	Figure 67	"Figure 67. Projected flow at the Shasta River near Yreka gage, in difference (cfs) from Baseline, for four future projected climate change scenarios" Perhaps we are mis-understanding what these scenarios are, but are extremely skeptical of any claims that the temperature-driven changes in precipitation form due to climate change (i.e., more rain and less snow) are not going to substantially decrease river flows in summer and fall, regardless of what happens to total annual amount of precipitation. The GSP should acknowledge these realities and then describe how the model predicts that this will seasonally change river flow and groundwater. The format of the graph makes it very difficult to see meaningful seasonal patterns. The y-axis scale that ranges from -2,000 to +12,000 cfs makes it impossible to see what is happening during low flows. Can you add a second panel that to graph so that the low-flow period is legible (maybe -100 to +100 cfs?)? Or maybe limit the months to just show April through October?	TC-027
2	151	2.2.5	2816-2818	Delete "~~Groundwater pumping has not caused significant and unreasonable conditions in the Basin during the last 20 years~~". The Basin has recognized problems and is a Medium Priority to the State and its why we are doing this SGMA Plan. You can say it's not in overdraft (continuously declining WLs), but that's it.	TC-028
2	151	2.2.5	2827	Suggest: "…acre-feet per ~~year minus any future~~ reduction in…" to "…acre-feet per year. It may change in the future due to reduction in…"	TC-029
2	152	2.2.5	2849-2857	It appears you are saying that the sustainable yield is less than the current value of pumping. The sustainable yield needs to be defined as part of this SGMA plan and then used as the management target. As it is currently worded in the document, there is apparently no lower limit to reductions in pumping.	TC-030
3	5	3.2	114-116	The first sustainability goal listed is "Groundwater elevations and groundwater storage do not significantly decline below their historically measured range, protect the existing well infrastructure from outages, protect groundwater-dependent ecosystems, and avoid significant additional stream depletion due to groundwater pumping." There is not definition of what "significant" means, so we suggest removing that word. Without a definition, isn't this meaningless? It should probably either be percent (e.g., 1%) or volume?	TC-031
3	5	3.2	123	In "Groundwater will continue to provide river baseflow as interconnected surface water with no ~~significant or unreasonable~~further reduction in volume." strike "~~significant or unreasonable~~" and replace with "further'. Without a definition, significant is too vague.	TC-032

Chapter	Page	Section	Line/Table/ Figure #	Comment	
3	6-33			We generally agree with sites and parameters proposed in Section 3.3 Monitoring Networks, but we are extremely concerned that funding will not be available to actually implement the monitoring. As described in our comments on Chapter 3, Section 3.3, pages 16-17, Table 1, we also recommend continuous flow monitoring of the springs, and adding two additional springs to the flow monitoring sites: Bridge Field Springs and Black Meadow Springs.	TC-033
3	16-17	3.3	Table 1	From our perspective, monitoring the flow of the springs is the most important. The output of these springs is what sustains aquatic ecosystems and agriculture in the Shasta River. In addition, the ability to predict flow in these springs is the primary endpoint upon which we will judge the performance of the Shasta Watershed Groundwater Model. We need to understand how groundwater elevations and groundwater pumping affect the flow in these springs. The monitoring plan proposes monthly monitoring of the springs, however, this is insufficient given the importance of these springs and the potential insights that high-resolution data could provide into the complex dynamics of Shasta Valley groundwater. At what time scales do the flow of these springs fluctuate (seasonal, weekly, daily, hourly, etc.) and what do these fluctuations appear to correspond with (e.g., Dwinnell reservoir levels, nearby groundwater pumps cycling on/off, flood irrigation, snowmelt, storm events, etc.)? How can we understand this without data? The two largest springs, Big Springs and Little Springs, are especially important. Other critically important springs that need continuous flow monitoring include Bridge Field Springs (on Shasta Springs Ranch, owned by Emmerson), Black Meadow Springs (on Shasta Springs Ranch, owned by Emmerson), Kettle Springs (on Shasta Springs Ranch, owned by Emmerson), and Hole in the Ground Spring. We noticed that Bridge Field Springs and Black Meadow Springs were not included in the monitoring plan. We strongly urge that both these springs be added to the monitoring plan.	TC-034
3	6	3.3	155	“A detailed discussion of potential data gaps, and strategies for resolving them, is included as Appendix 3-A~~Z~~”	TC-035
3	25	3.3.3.1	Table 3	Specific conductivity can readily be obtained at the wellhead using a meter. We suggest taking annually when sampling for nitrate.	TC-036
3	28	3.3.4.1	458-472	Suggest using WLs from “permanent” stilling well in stream and WLs from two nearby adjacent piezometers at different depths to track changes in gradients through time.	TC-037

Chapter	Page	Section	Line/Table/ Figure #	Comment	
3	29	3.3.4.1	Figure 6	Should "gradient near Scott River" be changed to "gradient near Shasta River?" If you did mean this to be for the Scott River, then some discussion should be added to justify using conditions in the Scott Valley for analyses in the Shasta valley. Also, not all information is given in explaining the generation of 70 cfs of baseflow for a single water-level gradient. That gradient would have to apply to some length of the river. Is the baseflow number for the entire basin? And would one water-level gradient explain that number (70 cfs)? Normally the quantity would be given as "cfs per unit length of river," or "cfs for reach X," where reach X has some defined length.	TC-038
3	29	3.3.4.1	Figure 6 caption	This caption seems to be for a map figure, not for the schematic cross section shown.	TC-039
3	30	3.3.4.1	490-492	The text states "*The goal is to use this approach for the first 5 years of implementation, collect more data, and at the GSP update provide a stream depletion approach based on more reliable results produced by the further calibrated SWGM*." Two fundamental questions regarding groundwater development in the Shasta Valley are "What effect has past and present groundwater pumping had on surface-water flow in the Shasta River, tributaries, and springs in the Valley?" "What effect will future groundwater pumping have on surface-water resources in the Shasta Valley?" From the stated text, it seems that the Shasta Watershed Groundwater Model (SWGM) will not be used to answer these questions for at least 5 years. If the groundwater part of the model can be used to calculate water budget components as has already been done, why can't it be used to calculate streamflow depletions? Conversely, if the model can't be used to reliably calculate streamflow depletions, why can it be used to calculate water-budget components? Using a groundwater model, streamflow depletion from groundwater pumping is always determined using model-calculated water budget components. At this stage of development of the groundwater model, uncertainty in computed streamflow depletion will most likely be in the timing of the depletion, rather than the relative amounts that various surface-water features are affected. In five years, there will still be uncertainty in the timing of depletion, but perhaps that uncertainty will be lower. Nonetheless, a delay of five years in tackling fundamental questions seems to be ignoring the current value of the model. If key calculations were run and re-run as the model was being improved, then the modelers would learn the sensitivity of model results to changes in parameters.	TC-040
3	30	3.3.4.2	502-511	Suggest incorporating the in-stream stilling well and adjacent vertical gradient piezometers as future improvements	TC-041
3	30	3.3.4.2	Table 5	We are confused why the "Shasta River near Yreka (SRY)" is listed in the Table 5 "Future monitoring locations for monitoring" with the Agency listed "NA"? Isn't that a long-term flow gage that has been operated for decades by the USGS?	TC-042

Chapter	Page	Section	Line/Table/ Figure #	Comment	
3	31	3.3.4.3		"Surface diversions will be entered into the County data management system" Please describe whether or not these data will be publicly accessible. Data collected for demonstrating SGMA compliance should be publicly accessible.	TC-043
3	35	3.4.1.1	607	You appear to use Management Trigger as a formal term, but it is not in Acronym list and is only used here. If used it should be formally defined and listed in Acronyms (would conflict with Minimum Threshold)	TC-068
3	36	3.4.1.2	641-642	Suggest change "the ~~historic low~~" to "the historic smallest depth to groundwater"	TC-044
3	36-37	3.4.1.2-.3	641, Table 6, Fig 8	Why is MT set below historic low? This conflicts with previous statements of trying to reduce GW pumping and maintain or raise WLs (see Section 2.2.5)	TC-045
3	37	3.4.1.3	Table 6	"AT" is not in Acronym list.	TC-046
3	41	3.4.3.1	772-773	It is not at all clear why municipal water users are apparently de minimis. No data have been supplied to support this claim.	TC-047
3	42	3.4.3.2	787-792	"The GSA will not be using a numerical groundwater-surface water model to evaluate ISW at this time. A temporary approach based on baseflow calculation will be used." We strongly suggest using the model in parallel with the planned approach to better understand model behavior recalibration (as you note in 3.4.3.6).	TC-048
3	43	3.4.3.2	Equation, table 7	Some additional explanation would be helpful. First, mention somewhere that change in storage in the reach is assumed to be zero. We suggest changing "SRM is flow out of the USGS maintained SRM gage" to "SRM is flow at USGS maintained Shasta River near Montague (SRM) gage 11517000, located at the downstream end of the reach" A schematic with arrows for various components would help. More importantly, some sort of error analysis should be done to determine uncertainty in groundwater contributions. If an uncertainty can be estimated for each of the components of the water budgets, an analysis can be carried out to determine uncertainty in computed groundwater contributions.	TC-049

Chapter	Page	Section	Line/Table/ Figure #	Comment	
3	42-44	3.4.3.2	784-832	A very important factor that does not appear to us to be mentioned in "Information and Methodology Used to Establish Minimum Thresholds and Measurable Objectives" is that there appears to be no accounting for return flows such as tailwater. If much of the irrigation along this reach of the river uses flood irrigation (i.e., in contrast to sprinklers), then isn't there a substantial quantity of tailwater that returns to the river from agricultural fields? If tailwater returns are not accounted for, then "baseflow" could be substantially overestimated in the methods described. While there are some records of tailwater quantities (i.e., from the SVRCD reports), it likely is not possible to estimate these quantities very accurately. But wouldn't it be better to at least make some educated guess about the percent of the diversions that return as tailwater (e.g., perhaps it is in the range of 10-50%) and include that in the calculation, instead of completing ignoring it? You are calling it "Groundwater Contributions" so, it should be your best estimate of groundwater. If you don't apply an adjustment for tailwater, then you should call it something else, like "Groundwater Contributions Plus Tailwater Returns," otherwise it is misleading. We do not have access to the all the reports and data sources cited in the chapter, so perhaps tailwater was indeed already accounted for and we are not aware of it, but from the descriptions provided in the GSP it appears that tailwater was ignored.	TC-050
3	43	3.4.3.2	821	We suggest changing "Riparian diverters are not measured" to "Riparian diverters are not measured, despite requirements to measure and report diversions under California Senate Bill 88"	TC-051
3	45	3.4.3.4	846	The proposed Minimum Threshold (MT) for Interconnected Surface Water (ISW) is 100 cfs of groundwater contributions, based on a water balance of the Shasta River reach between Dwinnell Dam and the USGS flow gage near Montague. The estimated diversions used in the water balance are highly uncertain and unreliable, derived from private watermaster records. The bounds of uncertainty on these diversion estimates are so large as to make them nearly useless as a decision-making tool. Rather than estimating groundwater contributions based on a highly uncertain water balance (i.e., not the dramatic week to week fluctuations in Table 7), we would much rather have the MT ISW be based on the sum of measured discharges from key individual springs (i.e., Big Springs, Little Springs, Bridge Field Springs, Black Meadow Springs, Kettle Springs, and Hole in the Ground Spring). While these individual springs do not represent the entirety of the groundwater contributions (i.e., there may be some diffuse contributions as well as addition smaller springs), data on the spring flows are required for anyway for management and model calibration, and should provide a more reliable relative metric of groundwater contributions than the water balance. There are not yet much data yet on these spring flows, but measurements need to begin as soon as possible.	TC-052

Chapter	Page	Section	Line/Table/ Figure #	Comment	
3	46-47	3.4.3.6	906-913	What other long-term source of water is there for the wells (see Theis, 1940, The Sources of Water Derived from Wells)? It is important to strike "…~~does not allow the development of a reliable estimate of stream depletion due to pumping~~." and replace with something like " …makes current model predictions of location and timing of impacts uncertain."	TC-053
4	14	4.2	304	The "Avoiding Significant Increase of Total Net Groundwater Use from the Basin" PMA does not provide a definition of what "significant" means, so we suggest removing that word. Without a definition, isn't this PMA meaningless? It should probably either be percent (e.g., 1%) or volume? See related comment regarding Chapter 4, page 19, section 4.2, line 505-508.	TC-054
4	14	4.2	326-331	We are unable to understand exactly what the "Avoiding Significant Increase of Total Net Groundwater Use from the Basin" PMA means, especially, this excerpt: "Due to the direct relationship between net groundwater use and ET, implementation of the MA is measured by comparing the most recent five- and ten-year running averages of agricultural and urban ET over both the Basin and watershed, to the maximum value of Basin ET measured in the 2010-2020 period, within the limits of measurement uncertainty." Can it be re-stated more clearly, such as, "The goal of this MA is for X not to exceed Y by Z percent?" Can you provide information on the limits of measurement uncertainty? What is the rationale for using the maximum as the basis for the comparison? Is the purpose of the running averages to smooth out climatic variation (i.e., is ET higher in wet years than dry years)? If there is substantial variation between water year types, then should the goal be different in different water year types? What about the contribution of surface water irrigation to ET? We anticipate that climate change will cause increased reliance on groundwater because surface water flows are going to recede earlier in the irrigation season (due less snowmelt), which could result in ET staying the same but groundwater extraction will increase and flows be lower, all without violating this MA.	TC-055
4	15	4.2	341-343	"To be flexible in adjusting the limit on total net groundwater extraction if and where additional groundwater resources become available due to additional recharge dedicated to later extraction." Groundwater is already over-extracted, and there is not extra water available to use in enhancing recharge. See comments on Chapter 4, Section 4.3, page 30, line 895.	TC-056
4	19	4.2	505-508	"The permitting program would ensure that construction of new extraction wells does not significantly expand current total net groundwater use in the Basin (to the degree that such expansion may cause the occurrence of undesirable results)." How are "undesirable results" defined? Please add a definition or citation here. See related comment regarding Chapter 4, page 14, section 4.2, line 304.	TC-057