NAPA VALLEY GROUNDWATER SUSTAINABILITY

A Basin Analysis Report for the Napa Valley Subbasin

Prepared by

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FINAL DRAFT REPORT

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GROUNDWATER SUSTAINABILITY:

A BASIN ANALYSIS REPORT FOR THE
NAPA VALLEY SUBBASIN

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LIST OF ABBREVIATIONS AND ACRONYMS

AF	acre-feet
AFY	acre-feet per year
AOI	Areas of Interest
As	Arsenic
AWC	Available Water Capacity
BCM	U.S. Geological Survey Basin Characterization Model
BMP	Best Management Practices
BOS	Board of Supervisors
CalEPA	California Environmental Protection Agency
CASGEM	California Statewide Groundwater Elevation Monitoring
CCP	Center for Collaborative Policy
CDPH	California Department of Public Health
CEMAR	Center for Ecosystem Management and Restoration
CEQA	California Environmental Quality Act
CFS	cubic feet per second
CFWS	California Fish and Wildlife Service
CGPS	Continuous Global Positioning System
CGS	California Geological Survey
Cl	chloride
CIMIS	California Irrigation Management Information System
DMS	Database Management System
DWR	California Department of Water Resources
DFW	California Department of Fish and Wildlife
EC	electrical conductivity
ET	Evapotranspiration
eWRIMS	State Water Resources Control Board Electronic Water Rights Information Management System
GAMA	Groundwater Ambient Monitoring Assessment
GDE	Groundwater Dependent Ecosystems
GIS	Geographic Information Systems

GPM	Gallons per minute
GRAC	Groundwater Resources Advisory Committee
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
GPS	Global Positioning System
GWE	Groundwater Elevation
GWL	Groundwater Level
GWQ	Groundwater Quality
In/yr	Inches-per year
IRWMP	Integrated Water Resources Management Plan
ITRC	Irrigation Training & Research Center
Ksat	Saturated hydraulic conductivity
LGA	Local Groundwater Assistance
LSCE	Luhdorff & Scalmanini, Consulting Engineers, Inc.
MCL	Maximum Contaminant Level
mg/L	milligrams per liter
MST	Milliken-Sarco-Tulucay
m.y.	Million years
Na	sodium
NBA	North Bay Aqueduct
NCFCWCD	Napa County Flood Control and Water Conservation District
NO3	nitrate
NO3-N	nitrate as nitrogen
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NSH	Napa State Hospital
POD	Points of Diversion
QA	Quaternary Alluvium
Qsb	Quaternary sedimentary basin
RCD	Resource Conservation District
RWMG	Regional Water Management Group
SAGBI	Soil Agricultural Groundwater Banking Index

SGMA	Sustainable Groundwater Management Act
SMR	Soil moisture retention
SSURGO	Soil Survey Geographic Database
SWN	State Well Number
SWP	State Water Project
SWRCB	California State Water Resources Control Board
Tba	To be addressed
Tca/b	Sonoma Volcanics conglomerate/breccias
Tcg/b	Tertiary Conglomerate/breccias
Td	Tertiary marine rocks
TDS	total dissolved solids
TQsb	Tertiary and early Quaternary sedimentary basin deposits
TQsbu	Tertiary - Quaternary sedimentary basin deposits undivided
Tsct	Tuff beds
Tss/h	Tertiary sedimentary rocks
Tsv	Sonoma volcanics
Tsva	Sonoma volcanics andesite
Tsvab	Andesite lava flows or breccias
Tsvt	tuffs
µg/L	Micrograms Per Liter
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UWMP	Urban Water Management Plan
WAA	Water Availability Analysis
WDL	Water Data Library
WELO	Water Efficient Landscape Ordinance
WICC	Watershed Information & Conversation Council
WQ	Water Quality
WTP	Water Treatment Plant
WY	Water Year

EXECUTIVE SUMMARY

OVERVIEW

In response to the 2014 Sustainable Groundwater Management Act (SGMA), Napa County has prepared a Basin Analysis Report, an Alternative Submittal per the requirements of Water Code Section 10733.6 (b)(3). This analysis of basin conditions demonstrates that the basin has operated within its sustainable yield over a period of at least 10 years. The Basin Analysis Report covers the entire Napa Valley Subbasin, which has been designated by the State as a medium priority basin and is subject to specific requirements under SGMA. While the report analyzes areas outside the Subbasin to determine how those areas affect recharge and runoff in the Subbasin, the areas outside the Subbasin are not subject to SGMA.

Since 2008, the County and others' efforts, have been instrumental in implementing groundwater management actions to better understand groundwater conditions, establish monitoring to track conditions, conduct education and outreach, and develop other programs to maintain groundwater sustainability. These efforts have included the adoption of Goals and Policies in the 2008 General Plan and creation of the Groundwater Resources Advisory Committee (GRAC; 2011 to 2014) for implementation and community outreach.

Groundwater conditions in the Napa Valley Subbasin have been and continue to be assessed using current and historical groundwater level and groundwater quality data. An extensive network of over 100 wells is used in this endeavor. Groundwater level trends in the Napa Valley Subbasin are stable in a majority of wells having long-term groundwater level records. While several wells have shown at least some degree of response to recent drought conditions, levels are generally higher than they were in the same wells during the 1976 to 1977 drought.

The Napa River system is affected by a number of factors, groundwater being only one of them. It can also be more sensitive during dry (low rainfall) years and also drier periods within the year. The Napa River system has experienced these temporal and seasonal effects over many decades (since the 1930s), particularly during the summer to fall period. More recently, new groundwater monitoring wells and surface water monitoring facilities have been constructed under a California Department of Water Resources grant. These new monitoring wells provide for the collection of continuous groundwater level and stream data to better assess the spatial and temporal interconnection of surface water and groundwater resources. The timing and occurrence/amount of precipitation and natural groundwater recharge events affect the amount of groundwater baseflow discharged to the Napa River system.

While outflows from the Subbasin, including groundwater pumping, affect the surface water system, monitoring indicates that effects on the Napa River due to more or less groundwater pumping have not changed over time. Additionally, groundwater pumping is a relatively small outflow component compared to surface water stormflows and groundwater baseflow discharged to the River and ultimately to the San Pablo Bay. Flow and other aspects of the Napa River are affected by many factors beyond the County's control (e.g., precipitation and climate change), and some factors potentially within the County or State's control (e.g., upstream damming or withdrawal of water from tributaries and historical removal of natural wetlands and floodplains). These are not under the purview of SGMA, though the Board of Supervisors is addressing many of them in other appropriate forums.

Groundwater and surface water supplies, including water imports serving municipal areas, in the Napa Valley Subbasin are dependent on population trends and land uses and their associated water demands. Long-term conditions in the Napa Valley Subbasin during the 1988 to 2015 base period (e.g., Basin Analysis Report study period) have been marked by stable land uses and stable supplies of imported surface water. While most of the population in the Subbasin lives in the four incorporated municipalities (Cities of Napa, St. Helena, Calistoga, and Town of Yountville), the majority of the land is outside the municipalities and used for agriculture. Municipal water use for the entire Valley was 16,655 AFY in 1988 and 14,729 AFY in 2015 (i.e., an average of 18,700 acre-feet per year (AFY)) over the 1988 to 2015 study period). The majority of this water is provided by reservoirs, increasing amounts of imported State Water Project water, and to a much smaller extent groundwater. Over the 28-year base period, water uses in the unincorporated part of the Subbasin have increased from about 4,000 AFY to about 5,000 AFY, and are mostly supplied by groundwater.

Agricultural water supplies include groundwater pumped from the Subbasin, recycled water, surface water diverted from the Napa River system within the Subbasin, and surface water diverted from the Subbasin watershed (i.e., hillside areas). On average, the rate of total water use (surface water and groundwater) by agriculture within the Subbasin has decreased slightly from approximately 18,000 AFY in 1988 to approximately 16,000 AFY in 2015. With variations in the water supply mix on a year-to-year basis, surface water use has decreased by about 8,900 AFY, while groundwater utilization has increased by about 7,400 AFY over the same period. These changes are affected by a number of factors, including increases from new and expanded wineries and vineyards, balanced against greatly improved conservation practices and decreased residential population in the unincorporated areas. The analysis includes estimated additional groundwater needs for wineries and vineyards looking forward through 2025, based upon the past five years of development proposals within the Subbasin.

A combined surface water and groundwater watershed-scale water budget for the Subbasin was developed to assess inflows and outflows to the Subbasin and to determine the average annual change in groundwater storage over the base period (using a model with a monthly time step). The magnitude of the surface water components in the budget demonstrates that large quantities of water that move through the Subbasin in most years are the predominant factor as compared to the amounts of groundwater pumped from the Subbasin or flowing out of the Subbasin as subsurface outflow. Average annual changes in groundwater storage over the base period are positive, indicating that current groundwater pumping rates are below the sustainable yield for the Subbasin. The average annual increase in storage is estimated to be 5,900 AFY, which is consistent with stable to slightly above average cumulative precipitation inputs over the 28-year base period. A separate independent analysis of groundwater levels and corresponding spring-to-spring changes was also conducted to compute the change in groundwater storage; this analysis also shows positive average annual changes in groundwater storage for the 1988 to 2015 base period.

The analyses presented in the Napa Valley Subbasin Basin Analysis Report demonstrate that the basin has operated within its sustainable yield over a period of more than 20 years. Stable groundwater levels observed during recent drought conditions (from 2012 through 2015) suggest that recent rates of groundwater pumping have not exceeded the sustainable yield of the Subbasin. The sustainable yield analysis establishes the maximum amount of water that can be withdrawn annually from the Subbasin groundwater supply without causing an undesirable result. The sustainable yield is within approximately 17,000 AFY to 20,000 AFY. By comparison, groundwater pumping has averaged about 18,000 AFY during the 2012 to 2015 drought.

During the past 7 years, Napa County has made significant progress towards implementing groundwater-related studies and recommendations provided by those studies. In conformance with SGMA, the intent of the GRAC, and the vision of the Napa County Board of Supervisors (April 2014), the *Napa Valley Subbasin SGMA Sustainability Goal* is:

> *To protect and enhance groundwater quantity and quality for all the people who live and work in Napa County, regardless of the source of their water supply. The County and everyone living and working in the county will integrate stewardship principles and measures in groundwater development, use, and management to protect economic, environmental, and social benefits and maintain groundwater sustainability indefinitely without causing undesirable results, including unacceptable economic, environmental, or social consequences.*

The Napa Valley Subbasin Basin Analysis Report will implement SGMA monitoring and reporting requirements and also provide additional recommendations to maintain or improve groundwater conditions and ensure overall water resources sustainability. In order to meet the goals established by the Board of Supervisors, it is critical that the County continue to invest in the Groundwater Program to expand the range of information and understanding of this complex water resources system. Where the County has discretionary authority, permit holders should be required to monitor their use, and data must be made available for analysis when needed. Abusive water use, when identified, must be corrected. Education and outreach should be made available to all users; only by collaborating as a community and sharing stewardship responsibilities can the people living and working in Napa County ensure that water resources are sustainable. This report should be treated as a dynamic “living” document that continually informs the County and the public of water resources conditions and actions that need to be implemented to maintain sustainability.

ES 1 INTRODUCTION

ES 1.1 Purpose of Basin Analysis Report

In response to the 2014 Sustainable Groundwater Management Act, Napa County has prepared this Alternative Submittal, Basin Analysis Report, per the requirements of Water Code Section 10733.6 (b)(3) where an analysis of basin conditions demonstrates that the basin has operated within its sustainable yield over a period of at least 10 years. This Basin Analysis Report covers the entire Napa Valley Subbasin, which has been designated as a medium priority basin and is subject to the Act.

ES 1.2 Background

Long-term, systematic monitoring programs are essential to provide data that allow for improved evaluation of water resources conditions and to facilitate effective water resources planning. For this reason, Napa County embarked on a countywide project referred to as the "Comprehensive Groundwater Monitoring Program, Data Review, and Policy Recommendations for Napa County's Groundwater Resources" (Comprehensive Groundwater Monitoring Program) in 2009, to meet action items identified in the 2008 General Plan update (Napa County, 2009). The program emphasizes developing a sound understanding of groundwater conditions and implementing an expanded groundwater monitoring and data management program as a foundation for future coordinated, integrated water resources planning and dissemination of water resources information.

The program covers the continuation and refinement of countywide groundwater level and quality monitoring efforts (including many basins, subbasins and/or subareas throughout the county) for the purpose of understanding groundwater conditions (i.e., seasonal and long-term groundwater level trends and also quality trends) and availability. This information is critical to enable integrated water resources planning and the dissemination of water resources information to the public and state and local decision-makers.

Napa County's Comprehensive Groundwater Monitoring Program involved many tasks that led to the preparation of five technical memoranda and a key foundational report on *Napa County Groundwater Conditions and Groundwater Monitoring Recommendations* (LSCE, 2011a). This report and the other related documents can be found at: **http://www.napawatersheds.org/**. This program detailed eighteen recommended near-term to long-term "implementation steps" (LSCE, 2011; Report Executive Summary) directed towards groundwater sustainability. The County has implemented most of the recommended steps since completion of that report and has also implemented many additional actions.

On June 28, 2011, the Napa County Board of Supervisors adopted a resolution to establish a Groundwater Resources Advisory Committee (GRAC), and an outreach effort for applicants began. On September 20, 2011, the Board of Supervisors appointed 15 residents to the GRAC, and the GRAC held its first organizational meeting on October 27, 2011. The GRAC was created to assist County staff and technical consultants with recommendations, including development of groundwater sustainability objectives that can be achieved through voluntary means and incentives and building community support for these activities and next steps.

Napa County's combined efforts through the Comprehensive Groundwater Monitoring Program along with the related AB 303 Public Outreach Project on groundwater (CCP, 2010) and the efforts of the GRAC and the Watershed Information & Conservation Council (WICC) of Napa County create a foundation for the County's continued efforts to increase public outreach and participation in water resources understanding, planning, and management. Although the County did not have a formal groundwater management plan under SB 1938, the County's and others' efforts have been instrumental in the implementation of functionally equivalent groundwater management actions to better understand groundwater conditions, establish monitoring to track conditions, conduct education and outreach, and other programs to maintain groundwater sustainability.

ES 1.3 Sustainable Groundwater Management Act

In September 2014, the California Legislature passed the Sustainable Groundwater Management Act (SGMA). SGMA changes how groundwater is managed in the state. SGMA defines "sustainable groundwater management" as the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results (Section 10721 (u)). Undesirable results, as defined by SGMA, means one or more effects caused by groundwater conditions occurring throughout the basin (Section 10721 (w)) (see Section 6.2). SGMA applies to basins or subbasins that the California Department of Water Resources (DWR) designates as medium- or high-priority basins. Previously under the California Statewide Groundwater Elevation Monitoring Program (CASGEM), DWR classified California's groundwater basins and subbasins as either high, medium, low, or very low priority. The priority classifications are based on eight criteria that include the overlying population, the reliance on groundwater, and the number of wells in a basin or subbasin. In Napa County, the Napa Valley Subbasin was ranked medium priority. All other Napa County basins and subbasins were ranked as very low-priority (see **Figure 1-1**).

For most basins designated by DWR as medium or high priority, SGMA requires the designation of groundwater sustainability agencies (GSA) and the adoption of groundwater sustainability plans (GSP); however, there is an alternative to a GSP, provided that the local entity (entities) can meet certain requirements. Under SGMA, Section 10733.6, a local entity (or entities) can pursue an Alternative to a GSP provided that certain sustainability objectives are met. An Alternative to a GSP may include:

> (b) (3) "An analysis of basin conditions that demonstrates that the basin has operated within its sustainable yield over a period of at least 10 years. The submission of an alternative described by this paragraph shall include a report prepared by a registered professional engineer or geologist who is licensed by the state and submitted under that engineer's or geologist's seal."
>
> The County would need to submit the alternative plan no later than January 1, 2017, and every five years thereafter.
>
> (d)The assessment required by subdivision (a) shall include an assessment of whether the alternative is within a basin that is in compliance with Part 2.11 (commencing with Section 10920). If the alternative is within a basin that is not in compliance with Part 2.11 (commencing with Section 10920), the department shall find the alternative does not satisfy the objectives of this part.

ES 2 PHYSICAL SETTING AND HYDROGEOLOGY

The Napa Valley Subbasin lies entirely within Napa County, and is overlain in part by the City of Napa, Town of Yountville, City of St. Helena, and City of Calistoga. No part of the City of American Canyon is included in the basin boundaries. Napa County has been subdivided into a series of groundwater subareas based on watershed boundaries, groundwater basins, and the County's environmental resource planning areas, for the purposes of local planning, understanding and studies. These subareas include the Knoxville, Livermore Ranch, Pope Valley, Berryessa, Angwin, Central Interior Valleys, Eastern Mountains, Southern Interior Valleys, Jameson/American Canyon, Napa River Marshes, Carneros, Western Mountains, Calistoga, St. Helena, Yountville, Napa, and Milliken-Sarco-Tulucay (MST)). The Napa Valley Subbasin includes four subareas: Calistoga, St. Helena, Yountville, and Napa.

Geologically, the Napa Valley Subbasin is an active zone of complex tectonic deformation and downwarping generally associated with the San Andreas Fault. Most of the faults are northwest trending, and this region of the Coast Range is characterized by low mountainous ridges separated by intervening stream valleys. The geology of the Napa Valley has been studied and published for over a hundred years. Three major geologic units in the Napa Valley area include: Mesozoic rocks (pre-65 million years which underlie all of Napa County), Tertiary volcanic and sedimentary rocks (older Cenozoic volcanic and sedimentary deposits 65 million years old to 2.5 million years old, including the Tertiary Sonoma Volcanics), and Quaternary sedimentary deposits (including younger Cenozoic volcanic and sedimentary volcanics including the Quaternary alluvium of the Valley Floor, from 2.6 million years old to present).

The geologic setting of the Napa Valley Subbasin provides a basis for understanding the physical properties of the aquifer system and the structural properties that influence groundwater flow. The complex structural geology of the Napa Valley plays an important role in providing potential natural barriers to groundwater flow near certain faults. An updated hydrogeologic conceptual model has been developed to understand the hydrogeologic conditions and responses to management actions, and also to account for the major physical components and interactions of surface water and groundwater systems within the Subbasin (LSCE and MBK, 2013). The major hydrogeologic conceptual model components can be divided into three main categories: Subbasin Inflows, Subbasin Outflows, and Subbasin Groundwater Storage.

Subbasin Inflows include:

- Root Zone Groundwater Recharge (net inflow from total applied water minus evaporation and/or transpiration)
- Net Napa Valley Subbasin Uplands Runoff (total runoff minus stream infiltration)
- Napa Valley Subbasin Uplands Subsurface Inflow, and
- Surface Water Deliveries

Subbasin Outflows include:

- Surface Water Outflow: Stormflow and Baseflow
- Subsurface Groundwater Outflow

- Consumptive Use by Surface Water Diversions and Groundwater Pumping, and
- Urban Wastewater Outflow

Subbasin Groundwater Storage consists of Quaternary Alluvial Deposits Groundwater Storage. The Quaternary Alluvial Deposits comprise the primary aquifer units of the Napa Valley Subbasin.

Groundwater recharge is a key component of the water balance, and important for understanding the spatial distribution of groundwater recharge for interpreting groundwater conditions and trends for sustainable groundwater management. In the Napa Valley Subbasin, groundwater recharge primarily occurs via infiltration and deep percolation of rainfall and applied irrigation water (i.e., the volume of total water applied to the land surface (naturally or otherwise) minus the amount evaporated and/or transpired by native vegetation, crops, bare ground or hardscape areas. Precipitation falling on upland areas adjacent to the Napa Valley can also contribute groundwater to the Napa Valley Subbasin via percolation and lateral movement. Recharge of groundwater also occurs through surface water infiltration of water flowing within stream and river channels, occurring during times and at locations where groundwater levels are below the stream stage.

ES 3 MONITORING NETWORK AND PROGRAM

In order to characterize groundwater and related surface water conditions in the basin and evaluate changing conditions, a monitoring network is designed to collect data of sufficient quality, frequency, and distribution. Napa County has developed its monitoring network to monitor the impacts to the beneficial uses or users of groundwater, monitor the changes in groundwater conditions relative to measurable objectives and minimum thresholds, and to quantify annual changes in water budget components. The monitoring network and program allows for analysis of groundwater data on a short-term, seasonal, and long-term basis to determine trends in groundwater and related surface conditions.

Groundwater levels are monitored throughout the Subbasin to assess the sustainability indicators of: chronic lowering of groundwater levels and reduction of groundwater storage. Groundwater quality is monitored to assess the sustainability indicators of: seawater intrusion and degraded water quality. Surface water-groundwater monitoring is performed to assess the sustainability indicator of: depletions of interconnected surface water.

The current groundwater level monitoring network consist of 113 wells, most of which (100) are monitored by Napa County, the remainder are part of the California Department of Water Resources and the State Water Resources Control Board (SWRCB) Geotracker programs. Groundwater quality monitoring in the Napa Valley Subbasin consists of 81 sites with data collected primarily at sites regulated by the SWRCB through the Division of Drinking Water and the Geotracker program, although data from other public agencies are available as well (including DWR and the U.S. Geological Survey. Groundwater level and groundwater quality monitoring site locations in the monitoring network are well-distributed throughout the subbasin, considering factors such as data availability, current population, and groundwater utilization.

With the purpose of furthering the understanding of surface water-groundwater interaction, in 2014, Napa County constructed five well clusters consisting of a shallow and deep monitoring well and a nearby surface water at each monitoring point at each location (this is referred to as the Napa County Surface Water-Groundwater Monitoring Project). These sites consist of one shallow monitoring well, one deeper monitoring well, and a location in the nearby river/creek. These locations record water levels, river/creek stage, temperature, and electrical conductivity hourly.

Monitoring results and assessments of groundwater conditions and the suitability and effectiveness of the monitoring network itself are provided in the form of: 1) Annual Groundwater Monitoring Progress and Data Reports, and 2) Annual CASGEM reporting of water levels for those monitoring sites included in the CASGEM network.

These reports provide data to the public in the form of tabulated data accessible via database management systems (DMS), the CASGEM online database, and publicly available report documents through the County. Reports include stated goals and objectives of the groundwater monitoring program and include recommended modifications to the program and network, as needed.

The monitoring program involves utilizing Best Management Practices, including: standardized monitoring protocols for groundwater level measurements and groundwater quality sampling; standardized collection and reporting of site information (e.g., unique site identification, type of site, type of measurements taken, monitoring frequency, location, reference point elevation, well casing perforation data, well depth information, well completion reports, identification of principal aquifers monitored, well capacity, well casing diameter, etc.).

ES 4 GROUNDWATER AND SURFACE WATER CONDITIONS

ES 4.1 Groundwater Levels

The assessment of groundwater conditions of the Napa Valley Subbasin is based on historical groundwater levels and groundwater quality, as well as the incorporation of interconnected surface water. The subareas of the Napa Valley Subbasin are the Calistoga, St. Helena, Yountville, and Napa subareas from north to south respectively. Groundwater level conditions in each of these areas are examined in context of the Napa Valley Subbasin as a whole. Generally, groundwater flows over the length of the Napa Valley through the older and younger alluvium from Calistoga to San Pablo Bay, and the alluvium for purposes of the analyses described herein is assumed to represent an unconfined part of the aquifer system. Groundwater trends and conditions in the Napa Valley Subbasin are largely dependent upon precipitation inputs, so groundwater levels are reviewed in context of seasonality (spring and fall) and water year types.

Groundwater hydrographs are selected for representative wells to illustrate typical groundwater elevations (and corresponding depth to groundwater) over time. Groundwater level trends in the Napa Valley Subbasin are stable in the majority of wells with long-term groundwater level records. While many wells have shown at least some degree of response to recent drought conditions, levels are generally higher than they were in the same wells during the 1976 to 1977 drought. The majority of wells with long-term groundwater level records exhibit stable trends, however, a few wells located near the Napa Valley margin in the northeastern Napa Subarea, southwestern Yountville Subarea, and southeastern St. Helena Subarea show periods of declines in groundwater levels, particularly during the recent drought.

ES 4.2 Groundwater Quality

Groundwater quality records from representative monitoring sites provide information on important constituents whose concentrations influence the quality of water for irrigation and human consumption. Despite a typical lack of historical groundwater quality records in Napa County, available data suggest that groundwater is generally of good quality throughout most subareas. Poor groundwater quality does, however, exist in the south and the north-central parts of the County. The poor groundwater quality includes concentrations of naturally occurring metals such as arsenic, iron, and manganese that exceed drinking water standards throughout the county. Naturally occurring elevated levels of boron are also prevalent in most subareas. Subareas south of the Napa Valley Floor, such as the Carneros and Napa River Marshes, have poor quality water due to naturally elevated levels of salinity and chloride. The Calistoga Subarea of the Napa Valley Floor also has poor quality water in many wells due to hydrothermal conditions resulting in higher concentrations of metals. Nitrate concentrations are not a concern throughout the county, but tend to be somewhat higher in agricultural areas in the Napa Valley Floor.

ES 4.3 Surface Water

Surface water in the Napa Valley Subbasin is dominated by the Napa River fed by its many ephemeral, intermittent, and more notable perennial surface water tributaries. The Napa River flows southeast-southward out of the Coast Ranges, through Napa Valley, and into the lowland marshes before entering San Pablo Bay at American Canyon. Historically, the Napa River near the City of Napa generally flows between several hundred to several thousand cubic feet per second (CFS) during peak winter conditions, and then tapers off to about 1 CFS during the fall.

In the Napa River, a hydrologic process called baseflow (i.e., when groundwater discharges to surface water) occurs in both gaining and losing stream reaches, as a result of basin-wide groundwater conditions in the Napa Valley as they are expressed within a given stream channel where surface water drainage can occur. Baseflow can be related to groundwater discharge, and an analysis of baseflow in the Napa River has been performed on Napa River flow data near St. Helena and Napa. Hydrographs of Napa River flows have been analyzed and dismantled to understand what components make up the surface water flow (i.e., how much of the river flow is attributable to baseflow and how much of the river flow is attributable to stormwater discharge or runoff). The study of the relationship between Napa River baseflow and groundwater levels within the Subbasin is ongoing, but shows a relationship between water year type, total water year precipitation, among other factors that can contribute water to the River. When groundwater levels have temporarily declined during drier years or seasonal dry periods during the year, the river system can also be more sensitive during drier years and also drier periods of the year when baseflow is diminished. The Napa River has experienced these effects over many decades (since the 1930s), particularly during the summer to fall period. The timing and occurrence of natural recharge events (i.e., the timing and amount of precipitation and opportunity for recharge) significantly affect the amount of groundwater baseflow discharged to the Napa River system. Outflows from the Subbasin, including groundwater pumping, also affect the surface water system;

groundwater pumping is a relatively smaller outflow component compared to stormflows and baseflow discharged to the San Pablo Bay.

In order to further the understanding of the relationships between groundwater baseflow in the Napa River and precipitation, groundwater levels, and groundwater pumping in the Napa Valley Subbasin, statistical analyses were performed to evaluate correlations between these variables over multiple time periods. For the longest continuous period of record available, groundwater level measurements and total annual precipitation data were compared independently to data describing periods of little to no flow[1] in the Napa River at two stream gages: Napa River near Napa (USGS station 11458000) and Napa River near St. Helena (USGS station 11456000). The results indicate that some of the variability in the first day of no flow conditions in a given water year and the length of the no flow period is related to variability in groundwater levels near the Napa River (strong correlations at a representative monitoring well) as well as to the amount of precipitation in that water year (moderate to strong correlations). These results support the understanding that no flow conditions in the Napa River have been historically and continue to be influenced by annual precipitation and groundwater levels near the Napa River[2].

The relationship between groundwater pumping in the Subbasin and baseflow in the Napa River was evaluated for the 1988 to 2015 hydrologic base period evaluated in this Basin Analysis Report. A subset of more recent years, 1995 to 2015, was also analyzed in order to test whether a substantial change has occurred in the relationship between pumping and baseflow in more recent years. The 1995 to 2015 period was chosen to allow for an approximately equal number of years with above average and below average precipitation in order to minimize the potentially confounding influence of variations in precipitation on the analysis. For the period from 1988 to 2015, linear correlation coefficients show relatively strong relationships between groundwater pumping and baseflow and both the first day of no flow conditions and the length of no flow conditions for a given water year. Correlations evaluated for the more recent 1995 to 2015 period show relatively moderate to strong relationships between baseflow conditions and groundwater pumping. These results indicate that, as with annual precipitation and groundwater levels, some of the variability in no flow conditions is related to the variability in groundwater pumping. Additionally, the results do not indicate a substantial change in the relationship between no flow conditions and rates of groundwater pumping between the base period and more recent years.

While the individual correlation coefficients address the relative strength of relationships between baseflow in the Napa River and precipitation, groundwater levels, and groundwater pumping in the Napa Valley Subbasin individually, a multiple linear regression analysis was performed to assess the degree to which groundwater pumping and precipitation, as independent variables, together correlate with baseflow at the Napa River Near Napa gage. Regression coefficients suggest that the influence of precipitation and groundwater pumping on baseflow were, on average, 79% and 21%, respectively for the 1988 to 2015 period. The multiple regression results show that precipitation and groundwater

[1] These analyses use an effective no flow ceiling of 0.1 cubic feet per second (CFS) to avoid under representation of no flow conditions due to uncertainties in streamflow measurements.

[2] Groundwater pumping data were not included in the linear correlation coefficient analysis because pumping data were only available for the water years 1988 to 2015 as part of the water budget analysis performed for this Basin Analysis Report.

pumping are the primary controls of baseflow in the Subbasin, with precipitation being the much more dominant variable.

ES 4.4 Seawater/Freshwater Interface

The natural seawater/freshwater interface occurs south of the Napa Valley Subbasin; its exact location has not been determined. Tidal fluctuations in San Pablo Bay influence water level elevations along the lower Napa River. The magnitude and timing of these fluctuations indicate a close connection between tidal-surface water-river water where mixing of fresh and saline waters can occur. South of the Subbasin, several wells have been historically monitored. The highest historically observed concentrations of naturally occurring salt-related constituents, such as chloride and total dissolved solids concentrations, are observed in the three groundwater subareas south of the Napa Valley Subbasin in the Napa River Marshes, Jameson/American Canyon, and Carneros Subareas.

ES 4.5 Potential for Managed Groundwater Recharge

The potential for groundwater recharge is an important aspect of understanding groundwater conditions. Soil factors relating to the potential for groundwater recharge on agricultural lands were recently mapped by O'Geen et al. (2015) as part of the development of a Soil Agricultural Groundwater Banking Index (SAGBI). The SAGBI considers various parameters including soil characteristics and interprets them on how they influence groundwater recharge. Other factors considered include land slope, root zone residence time (related to hydraulic conductivity, drainage, etc.), deep percolation, any chemical limitations (such as soil salinity), and surface conditions (erosion and crusting). Based on slope (topographic limitation), the SAGBI suggests that most areas of the Napa Valley Floor have relatively high recharge potential. In terms of root zone residence time, the areas with the highest recharge potential are generally located along the valley margins and in proximity to distributary fan areas or along active river channels, and increase in occurrence toward the northern end of the Valley Floor. Taking all of the factors of the SAGBI into consideration, areas of higher recharge potential appear to correspond largely with the soil hydraulic properties indicated by the root zone residence time and deep percolation factor rating, and is consistent with mapped areas of various shallow and permeable geologic units throughout the Napa Valley Subbasin. Assuming no deep ripping, the SAGBI rating of recharge potential indicates "Excellent" potential in areas of exposed Napa Valley Alluvium, most notably in the vicinity of an alluvial fan-head area where Sulphur Creek flows over and into the Napa Valley Subbasin.

ES 5 HISTORICAL, CURRENT, AND PROJECTED WATER SUPPLY

The water supply in the Napa Valley Subbasin is dependent on population trends and land uses and their associated water demands. Census data from the U.S. Census Bureau is available to assess the population in Napa County from 1980, 1990, 2000, 2006, and 2010. An increasing trend in population is observed between 1980 and 2010, growing across all four of the incorporated municipalities in the Subbasin, from 62,549 to 90,817. While most of the population in the Subbasin lives in the four incorporated municipalities (City of Napa, St. Helena, Calistoga, and Yountville), the majority of the land is outside the municipalities and used for agriculture.

Wine grape production has long been a substantial component of land use in Napa County. Detailed land use surveys of Napa County performed by DWR in 1987, 1999, and 2011 indicate that agricultural land uses overall, and vineyard acreages in particular, were consistent over that 24-year period. These three recent land use surveys provide total acreages of agricultural classes, native classes, and urban/semi-agricultural classes within the subbasin (including agricultural processing facilities such as wineries), as well as separating out different agricultural class acreages for vineyards, orchards, pasture, grain, truck/field crops, and land that is idle.

Sources that provide water to the growing population and that support the agricultural land uses include groundwater pumped from the Subbasin, surface water within the Subbasin, recycled water, and State Water Project water. The amounts of each of those sources vary according to the land use and location in the Subbasin.

Agricultural water supplies include groundwater pumped from the Subbasin, recycled water, surface water diverted from the Napa River system within the Subbasin, and surface water diverted from the Subbasin watershed. Due to a lack of available data, a root zone water balance model was developed to quantify the rates of water application to meet evapotranspiration demands by crops or other irrigated vegetation. Results from the root zone model provide calculated values for applied water demands for all irrigated crops in the Subbasin, and accounts for applications of groundwater, surface water, and recycled water to meet crop water demands. On average, the rate of total water use by agriculture in the Subbasin has decreased slightly from approximately 18,000 AFY to approximately 16,000 AFY, with variations on a year-to-year basis. A decline in the use of surface water as a source and an increase in groundwater use from 1988 to 2015 is noted. Use of recycled water for irrigation of all crops has been stable over time, but may increase in the future.

In addition to the water demand associated with the agricultural land use types, farmers of perennial crops in the Subbasin (including but not limited to wine grapes) may apply additional water in some years to protect against frost damage. The need for frost protection varies based on many factors including crop type, stage of crop development, and the duration and intensity of a given frost event. The average annual demand for frost protection is estimated to be 116 acre-feet per year from 1988 to 2015.

Another cultural practice that has the potential to change the water use requirement of crops in the Subbasin is the practice of actively draining shallow groundwater from the root zone to benefit crop health at certain stages of growth, which can be accomplished by installing drain tiles in the soil below a field. No public data on the specifics of drain tiles in the Subbasin are available at this time, but the prevalence of farm ponds across the Valley and the incentive to reuse water when possible suggests that a portion of the drained water offsets groundwater pumping.

Municipal water use data is available by municipality for the City of Napa, City of St. Helena, City of Calistoga, and the Town of Yountville. Long-term municipal water use for the entire Valley has averaged 18,700 acre-feet per year over the base period (Water Years (WY) 1988-2015). The majority of this water use is provided by local surface water supplies, increasing amounts of imported State Water Project water, and groundwater. The City of Napa utilizes imported State Water Project water, local surface waters from Lake Hennessey and the Milliken Reservoir, as well as a growing contribution from recycled water. The City of St. Helena receives some imported surface water from the State Water Project, as well as local surface water from Bell Canyon, and groundwater. The City of Calistoga uses imported surface water from the State Water Project, local surface water from the Kimball Reservoir, groundwater, and a relatively constant amount of recycled water. The Town of Yountville receives surface water from the State Water Project and locally from the Rector Reservoir.

In addition to the uses to meet agriculture and municipal demands, water use occurs throughout the unincorporated parts of the Subbasin to meet a variety of demands. These uses include domestic indoor water uses, irrigation uses, and commercial winery uses. Over the base period of 1988 to 2015, water uses in the unincorporated part of the Subbasin have increased from about 4,000 AFY to about 5,000 AFY, and are mostly supplied by groundwater.

Total water uses for all categories of water types have remained stable from 1988 through 2015, despite the observed population growth. Total annual use fluctuates over that time from a low of about 21,000 acre-feet per year to as much as 40,000 acre-feet per year. Driven largely by the transition in agricultural sources of supply, groundwater has increased as a proportion of the overall sources of supply during this time period, while diversions of local surface water (particularly from the Napa River System within the Subbasin itself) have declined by about half of initial levels.

ES 6 SUSTAINABLE YIELD ANALYSIS

SGMA requirements include the development of a water budget as well as an estimate of sustainable yield for subbasins deemed high or medium priority. Water budget analyses are provided for the base period (1988-2015), water year 2015, and for projected hydrology (in the future). The base period determination and water budget analyses are tools that together are used to estimate sustainable yield for the Napa Valley Subbasin. The selection of a base period is necessary to remove any bias in the groundwater data in order to develop the water budget and determine the sustainable yield (e.g., water levels during a wet period would result in a higher amount of sustainable yield, and a period of dry conditions would result in a lower amount of sustainable yield). For the Napa Valley Subbasin, the base period selected spans from WY 1988 to 2015, as this period of time represents:

- Long-term annual water supply
  - Long-term mean water supply, or the measure of whether the basin has experienced natural groundwater recharge during a particular time period and also what the primary component is that contributes to natural groundwater recharge (in this case, precipitation).
  - Long-term precipitation records and daily average streamflow discharges for the Napa River are used.
- Inclusion of both wet and dry stress periods
  - This removes any bias that might shift the sustainable yield number away from what is representative
- Antecedent dry conditions

  - This is intended to minimize differences in groundwater in the unsaturated (vadose) zone at the beginning and at the end of the base period, assuming that any water unaccounted for in the unsaturated zone is minimized.
- Adequate data availability
  - Available hydrologic and land and water use data is sufficient during the base period.
- Inclusion of current cultural conditions
  - There are relatively stable trends in major land uses, particularly the agricultural classes which are most dependent on water sources within the subbasin.
  - Based on three snapshots in time of the land use and water use (1987, 1999, and 2011), the acreages of agriculture classes, native classes, and urban/semi-agricultural classes remain very similar.
  - Vineyards dominate the agricultural land use, and the amount of irrigated acreage in the Napa Valley Subbasin fluctuates very little between those three snapshots (ranging between almost 17,000 acres to over 21,000 acres).
- Current water management conditions
  - Water sources for agricultural and urban entities during the base period are consistently from groundwater, surface water from local water ways, and imported surface water delivered from the State Water Project via the North Bay Aqueduct.

Water Year 2015 is of particular interest in the SGMA Basin Analysis Report, and its hydrologic conditions specific to the Napa Valley Subbasin are provided in this document. 2015 was the fourth consecutive year of below average precipitation for the area. Groundwater level trends in 2015 are stable in the majority of wells with long-term groundwater level records, with some wells showing at least some degree of response to recent drought conditions. Groundwater quality trends also show stable conditions through 2015.

Projected subbasin water budgets rely on projected hydrologic inputs, which are available from a climate change projection tool from the U.S. Geological Survey's Basin Characterization Model (BCM) (Flint, 2013). The BCM provides hydrologic data for the "warm and moderate rainfall" scenario, based on the comparison of historical climate data between 1951 and 1980 and climate projections from 2070 to 2099.

The water budget developed for SGMA provides a quantitative approach to assessing the total annual volume of groundwater and surface entering and exiting the basin, including the change in volume of water stored. The main hydrologic processes affecting the subbasin include:

- Surface Water Inflows
  - Inflows to the Subbasin as streamflow from the Napa River Watershed Uplands;
  - Inflows to the Subbasin conveyed from municipal reservoirs located in the Napa River Watershed Uplands;

- Inflows to the Subbasin from outside the Watershed through State Water Project facilities

- Surface Water Outflows
  - Outflows from the Subbasin as runoff and groundwater discharge to the Napa River
- Groundwater Inflows
  - Inflows to the subbasin from groundwater recharge and subsurface inflows from the bedrock of the Napa River Watershed Uplands adjacent to the Subbasin
- Groundwater Outflows
  - Outflows from the Subbasin that enter the adjoining Napa-Sonoma Lowlands Subbasin;
  - Outflows from the Subbasin due to evapotranspiration and groundwater pumping
- Changes in annual groundwater storage

In order to quantify one of the most difficult components, the recharge component, a GIS-based root zone model was developed. The root zone model is a complex tool based on the water balance within the soil root zone taking into consideration: precipitation, irrigation, evapotranspiration, land use, runoff, soil root zone depths, soil moisture, and vertical hydraulic conductivity in order to estimate groundwater recharge percolating below the soil root zone. The root zone model results indicate that during the base period (WY 1988-2015), groundwater recharge always exceeds groundwater pumping within the Subbasin on a year-to-year basis, resulting in a net positive contribution to groundwater storage.

A combined surface water and groundwater watershed-scale water budget for the Subbasin was developed using all of the components listed above and including the results from the root zone model. The results of the water budget show variations in Net Subbasin Storage from year to year that are largely driven by fluctuations in the Uplands Runoff and Streamflow components. The magnitude of the surface water components demonstrates that large quantities of water move through the Subbasin in most years compared to the amounts of water pumped from the Subbasin or flowing out of the Subbasin as subsurface outflow. Average annual changes in storage over the base period are positive, indicating that current groundwater pumping rates are below the sustainable yield for the Subbasin. The magnitude of annual changes in storage indicate the sensitivity of water budget components to environmental factors and data uncertainties. For this reason, the average annual change in storage represents a more useful measure of Subbasin conditions. The average annual increase in storage of 5,900 AFY is consistent with stable to slightly above average cumulative precipitation inputs over the 28-year base period.

A projected water budget is developed using the “warm and moderate rainfall” future climate scenario from the BCM that includes projections for precipitation and reference evapotranspiration; streamflow is projected based on a regression of precipitation and streamflow; water demands are based on most recent municipal demand and land use data; and water supply is based on most recent imported surface water deliveries. Future development in the larger Subbasin watershed is not explicitly considered as part of the projected Subbasin water budget; however, any reductions in runoff or subsurface inflow to the Subbasin as a result of future development are believed to be minor relative to the overall inflow volumes.

To complement the water budget analysis described above, an analysis of changes in groundwater storage computed separately through observed changes in groundwater levels over the base period is provided. Groundwater contours and potentiometric surfaces are utilized along with the depth to the base of the aquifer to determine the groundwater storage volume (multiplying the saturated aquifer volume with an estimated specific yield). Large year-to-year fluctuations in calculated groundwater storage using this technique occur likely due to the relative spacing of available groundwater level data throughout the subbasin and the uncertainty of the interpolated depth to water grids, but these fluctuations follow trends observed in precipitation records for the same base period.

A sensitivity analysis was performed to understand how small changes in certain parameters can affect the resulting water budget outcomes. Sensitivity in the root zone model to crop coefficient values, root depths, and soil moisture retention were analyzed for estimated average annual vineyard irrigation in the subbasin. Another sensitivity analysis was performed on the groundwater level change in storage analysis to demonstrate what impact an uncertainty of one foot difference in groundwater levels across the subbasin would have as well as the uncertainty of the specific yield value selected.

Long-term conditions in the Napa Valley Subbasin during the base period of WY 1988-2015 have been marked by stable land uses and stable supplies of imported surface water. Groundwater utilization has increased over time. Results from the Root Zone Model and water budget analyses, as well as the groundwater level change in storage analysis show positive average annual changes in storage over this period. As the basin is currently managed, stable groundwater levels observed during recent drought conditions (from 2012 through 2015) suggest that recent rates of groundwater pumping have not exceeded the sustainable yield of the Subbasin. As a result, the sustainable yield analysis establishes the maximum amount of water that can be withdrawn annually from the Subbasin groundwater supply without causing an undesirable result is within 17,000 acre-feet per year to approximately 20,000 acre-feet per year. The sustainable yield is not a constant value and could change with variations in water budget components or as a result of management decisions that could lead to increased or decreased sustainable yields in the future.

ES 7 NAPA VALLEY SUBBASIN SUSTAINABILITY GOALS

ES 7.1 Sustainability Goals

Napa County's Groundwater Resources Advisory Council defined "groundwater sustainability" as (GRAC, February 2014):

> *Groundwater sustainability depends on the development and use of groundwater in a manner that can be maintained indefinitely without causing unacceptable economic, environmental, or social consequences, while protecting economic, environmental, and social benefits.*

The GRAC has developed the following sustainability goal:

> *GRAC Sustainability Goal: To protect and enhance groundwater quantity and quality for all the people who live and work in Napa County, regardless of the source of their water supply.*

In order to achieve this sustainability goal, the GRAC developed the following five (5) Sustainability Objectives that were presented and accepted by the Napa County Board of Supervisors in April 2014:

1. Initiate and carry out outreach and education efforts.
    a. Develop public outreach programs and materials to make everyone who lives and works in the County aware that the protection of water supplies is a shared responsibility and everyone needs to participate.
    b. Through education, enable people to take action.
2. Optimize existing water supplies and systems.
    a. Support landowners in implementing best sustainable practices.
    b. Enhance the water supply system and infrastructure – including but not limited to system efficiencies, reservoir dredging, recycled water, groundwater storage and recharge, conjunctive use – to improve water supply reliability.
3. Continue long-term monitoring and evaluation.
    a. Collect groundwater and surface water data and maintain a usable database that can provide information about the status of the county's groundwater and surface water resources and help forecast future supplies.
    b. Evaluate data using best analytical methods in order to better understand characteristics of the county's groundwater and water resources systems.
    c. Share data and results of related analytical efforts while following appropriate confidentiality standards.
4. Improve our scientific understanding of groundwater recharge and groundwater-surface water interactions.
5. Improve preparedness to address groundwater issues that might emerge.
    a. Improve preparedness for responding to long-term trends and evolving issues, such as adverse groundwater trends (including levels and quality), changes in precipitation and temperature patterns, and saltwater intrusion.
    b. Improve preparedness for responding to acute crises, such as water supply disruptions and multi-year drought conditions.

These supplemental recommendations, developed by the GRAC in February 2014 well before SGMA was adopted, emphasize the County's intent to integrate groundwater stewardship and sustainability planning in future planning and resource management.

In conformance with SGMA and the intent of the GRAC (February 2014) and the County Board of Supervisors (April 2014), the GRAC sustainability goal is expanded to:

> *Napa Valley Subbasin SGMA Sustainability Goal: To protect and enhance groundwater quantity and quality for all the people who live and work in Napa County, regardless of the source of their water supply. The County and everyone living and working in the county will integrate stewardship principles and measures in groundwater development, use, and management to protect economic, environmental, and social benefits and maintain groundwater sustainability indefinitely without causing undesirable results, including unacceptable economic, environmental, or social consequences.*

ES 7.2 SGMA Sustainability Indicators and Metrics to Maintain Sustainability

The current understanding of hydrogeologic conditions and management measures demonstrates that the basin has already been operated within the sustainable yield for at least 10 years. On a subbasin scale, the water budget details developed for this document show that the basin has been operated within the sustainable yield, and the Napa County Board of Supervisors establishment of the GRAC, acceptance of the GRAC's sustainability goal and objectives for all of Napa County, and implementation of key GRAC recommendations demonstrates the County's intent to maintain sustainable conditions indefinitely.

According to SGMA definitions, Undesirable Results include: chronic lowering of groundwater levels (overdraft); significant and unreasonable reduction of groundwater storage; significant and unreasonable seawater intrusion; significant and unreasonable land subsidence that substantially interferes with surface land uses and; depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water. For the Napa Valley Subbasin, the basin is generally full, benefitting from: high precipitation, corresponding high potential for substantial amounts of recharge, and land use dominated by vineyards that have a comparatively low water requirement. Other water uses (e.g., municipal and uses in unincorporated areas of the Subbasin) have remained generally stable (e.g., municipal uses have been approximately 17,000 over the base period) and unincorporated area uses have increased slightly from 4,000 AFY to 5,000 AFY. Overall, total water use (agricultural, municipal and uses in unincorporated areas) has decreased over the 28-year base period.

There is, however, an interplay between the groundwater systems of the subbasin and the river system, which has shown that when groundwater levels have temporarily declined during drier years or seasonal dry periods during the year, the river system can also be more sensitive to seasonally lower flows during drier years and also drier periods of the year when baseflow is, or is prone to being, diminished. This historical occurrence of diminished baseflow could be considered an undesirable result, but it only occurs at some locations during the summer to fall period. Since the river system is considered to be the most sensitive sustainability indicator in the Napa Valley Subbasin, the measurable objectives and minimum thresholds developed in this document are recommended to ensure groundwater sustainability or improve groundwater conditions, and provide ongoing monitoring targets devised to address potential future effects on surface water.

SGMA defines “representative monitoring” as “a monitoring site within a broader network of sites that typifies one or more conditions within the basin or an area of the basin” (Section 351). A subset of monitoring sites in the Napa Valley Subbasin has been developed for the purpose of monitoring groundwater conditions that are representative of the basin or an area of the basin (Section 354.36). For SGMA purposes for the Napa Valley Subbasin, these 18 sites are where sustainability indicators are monitored, and minimum thresholds and measurable objectives are defined. Many sites are monitored for more than one sustainability indicator.

The representative monitoring sites are designed to monitor the sustainability indicators including: chronic lowering of groundwater levels, reduced groundwater storage, seawater intrusion, degraded groundwater quality, land subsidence, and streamflow depletion. Minimum thresholds (in feet above mean sea level) to avoid chronic lowering of groundwater levels, land subsidence, reduced groundwater storage, and streamflow depletion are provided in the Basin Analysis Report for sixteen representative monitoring sites (and one additional representative monitoring site that is too far from the Napa River and is not used for streamflow depletion); minimum thresholds to avoid degraded groundwater quality (e.g., for nitrate) are provided in this document for seven representative monitoring sites; a minimum threshold to avoid seawater intrusion is provided in this document for one representative monitoring site (for TDS concentration).

Measurable objectives, or specific quantifiable goals for maintaining or improving groundwater conditions, are provided in this document for streamflow depletion and other sustainability indicators, again using 16 of the representative monitoring sites. The measurable objective to maintain or improve groundwater quality is set for seven representative monitoring sites; for one representative monitoring site to avoid seawater intrusion; and for 17 of the representative monitoring sites for avoiding chronic lowering of groundwater levels, reducing groundwater storage, and land subsidence. The measurable objectives and minimum thresholds developed for this document do not require the subbasin to be divided into “management areas”, but the County is planning to evaluate a study (planned to begin in fall 2016) to determine if potential groundwater management measures or controls (similar to those that have been successfully implemented in the MST Subarea) or a Management Area designation are warranted.

ES 8 MONITORING DATA MANAGEMENT AND REPORTING

Groundwater data in the Napa Valley Subbasin is managed, used, and shared, utilizing Napa County’s Data Management System (DMS). Data are collected from a variety of sources and monitoring programs, including public and volunteered wells, and also permit-required monitoring. The DMS has been constructed to incorporate existing and new data about groundwater resources in Napa County, and that data are used on an ongoing basis by the County to evaluate county-wide (and Subbasin-wide) groundwater supply and quality conditions and functions as a secure central data storage location. Data security and confidentiality is of utmost importance; Napa County employs a tiered approach that allows property owners to choose their level of participation and sharing.

There are three main data collection programs that are part of the monitoring data management: the Napa County Program, the DWR Water Data Library (WDL), and the CASGEM Program. Data from other sources include several different public agencies that collect and maintain groundwater data, including

DWR, the USGS, the California Department of Public Health (CDPH), and the State Water Resources Control Board (SWRCB; GeoTracker; GeoTracker-GAMA ;and Division of Drinking Water).

Napa County has historically routinely reported groundwater level data to DWR for inclusion in the WDL, and as of 2012, the County also reports a subset of the groundwater level data to DWR as part of the CASGEM program. Monitoring data stored in the County's DMS will be submitted to DWR electronically for SGMA purposes[3], and a copy of the monitoring data will be included in the Annual Report, submitted electronically on forms provided by DWR.

There are five different outlets for reporting the groundwater conditions in the Napa Valley Subbasin:

- Annual Groundwater Monitoring Progress and Data Report
    - Reviews the groundwater monitoring program and network;
    - Reviews the year's monitoring data in context with the historical record, water level and quality trend analyses, and consideration of issues of interest
- Annual CASGEM Reporting
    - Summarizes the results and findings of the countywide CASGEM program, and is integrated into the County's Annual Progress Report
- Triennial Countywide Reporting on Groundwater Conditions
    - Recommended report that contains countywide groundwater level and quality conditions and other monitoring network modifications;
    - Recommended to include summaries of the groundwater level and quality data, figures illustrating groundwater level trends, figures showing contours of equal groundwater elevation, figures illustrating groundwater quality trends, and a summary of coordinated efforts with other local, state, and federal agencies.
- SGMA Annual Report
    - This report will use GSP Section 356.2 as guidelines for reporting groundwater conditions for the preceding water year with additions and modifications appropriate for the Napa Valley Subbasin
    - This report will include: general information covered by report; detailed description and graphical representation of groundwater conditions of the basin managed in the Plan (including groundwater elevation data in the form of contour maps and hydrographs, groundwater extraction estimates, surface water supply used or available for use, and total water use); changes in groundwater storage (including change in storage maps and graphs); and a description of monitoring, data evaluation, and other actions in support of continued sustainability, including implementation of projects or management actions since the previous annual report.

[3] All submittals to DWR will be made subject to the terms and conditions of any monitoring agreements between well owners and Napa County.

- SGMA Five-Year Update
  - Every five years, the County will prepare an updated Basin Analysis Report to assess whether the basin is in compliance with California Water Code Part 2.11 (commencing with Section 10920)
  - The report would evaluate the sustainability of the basin in terms of sustainability indicators, corresponding measurable objective, and minimum thresholds.
  - The report would provide an assessment of the adequacy of monitoring data for evaluating whether the basin has continued to be operated within its sustainable yield.

ES 9 SUSTAINABLE GROUNDWATER MANAGEMENT

Many management actions, education and outreach, and projects have been implemented by Napa County, along with other potential future programs, to achieve the sustainability goal for the basin. Napa County's General Plan (2008, amended in June 2009) outlines water resources goals and policies. It recognizes that "water is one of the most complex issues related to land use planning, development, and conservation… and in Napa County, more than two dozen agencies have some say in decisions and regulations affecting water quality and water use." With the adoption of SGMA in 2014, the County is actively continuing outreach and education efforts that promote water resources sustainability. The General Plan in 2008 set forth six goals within the Conservation Element relating to the County's water resources, including surface water and groundwater. Complementing these goals are twenty-eight policies and ten water resources action items that address monitoring needs (on a watershed basis, for surface water, and for groundwater), resources analyses and studies, basin-level watershed management plans, establishing standards for well pump testing and reporting, and collaboration with other agencies (including SWRCB, DWR, CDPH, CalEPA, and applicable County and City agencies).

Napa County has developed a Groundwater Ordinance to regulate groundwater usage and well development through its Code of Ordinances, Title 13. The ordinances are designed to be relevant and support the General Plan objectives through the establishment of specific water resources goals. One such ordinance, the conservation ordinance, is intended to regulate the extraction and use, and to promote the preservation of the county's groundwater resources. Compliance with this particular ordinance applies to development of new water systems or improvements to an existing water system that may use groundwater and imposes conditions on that use if it exceeds pre-determined thresholds, as well as ensuring the most current efficiency standards (the State's Water Efficient Landscape Ordinance, or WELO).

Napa County has developed guidelines for developing a Water Availability Analysis (WAA), which supports the preparation and evaluation of applications related to discretionary projects submitted to the County for approval to comply with the California Environmental Quality Act (CEQA) Guidelines. A WAA is required for any discretionary project that may utilize groundwater or will increase the intensity of groundwater use of any parcel through an existing, improved, or new water supply system, and is not prescriptive, as project specific conditions may require more, less, or different analyses in order to meet the requirements of CEQA. The procedure of the WAA determines if a proposal may have an adverse impact on the groundwater basin as a whole or on the water levels of neighboring non-project wells or on surface waters.

Three major avenues that Napa County employs to promote education and collaboration with regards to water resources sustainability include: the establishment of the Watershed Information & Conservation Council (WICC), Well Owner Outreach and Self-Directed Well Monitoring Education, and Napa County's participation in San Francisco Bay Area and Westside's Integrated Water Resources Management Plan (IRWMPs). The WICC represents the diversity of Napa County's community and assists the County's Board of Supervisors in their decision-making process, serving as a conduit for citizen input by gathering, analyzing, and recommending options related to the management of watershed resources countywide. Well owner outreach was performed to help educate and encourage participation in groundwater monitoring, contacting friends, neighbors, and others, resulting in approximately 48 volunteered wells being added to the monitoring program (as of spring 2016). The County has also launched a new service for County residents that are interested in monitoring the status of their own wells, providing a water-depth measuring device available on a short-term loan basis, providing the opportunity for residents to learn first-hand how water depth changes and recharge occurs in their well over the course of a year. Information distributed by the WICC to the public has been available online in an electronic newsletter, called Sustainable Napa County E-News.

Napa County has actively collaborated with the San Francisco Bay and Westside Regional Water Management Groups (RWMGs) to update the IRWMP for the San Francisco Bay and to develop a new IRWMP for the Westside Sacramento Region. Participation in these two IRWMPs has enabled further coordination and sharing of information on water resources management planning programs and projects, as well as other information for IRWMP grand funding and implementation.

Implementation of the monitoring and reporting actions outlined in this Report over time may require the incremental implementation of a variety of management strategies or actions to ensure the long-term sustainability of the Napa Valley Subbasin. Actions may include future changes to local land use controls, well permitting, groundwater metering and usage limits, changes to County ordinances, and direct coordination with other municipal agencies to effectively protect and sustain groundwater and surface water resources. As evident by results of this Report, the Napa Valley Subbasin has been operating within its sustainable yield for more than 20 years and far-reaching management actions are not necessary at this time.

It is recommended that the standard Conditions of Approval used by Napa County for discretionary projects be revised to include, for all future projects, groundwater monitoring and water use monitoring, reporting data to the County when requested, and use of project wells for monitoring when requested and needed to support this Report, and provisions for permit modification based on monitoring results.

Napa County will conduct ongoing assessments (annual and five-year updates) of groundwater conditions in the Napa Valley Subbasin. These assessments will be supported by new information from monitoring efforts, as well as changes in water use, and will discuss any potential changes in subbasin groundwater conditions. The assessments will also include management actions implemented and their effects on subbasin conditions, and additional management tools or actions needed to maintain subbasin sustainability.

Best Management Practices (BMPs) are already in place for several aspects of the County's existing monitoring and reporting programs. This Basin Analysis Report has included protocols and data/reporting standards, and the five-year Basin Analysis Report update will include additional BMPs (which are either in use but not yet formally documented, or not yet released by DWR) for the County to consider adopting.

ES 10 FINDINGS AND RECOMMENDATIONS

ES 10.1 Findings

In response to the 2014 Sustainable Groundwater Management Act, Napa County has prepared this Alternative Submittal, Basin Analysis Report, per the requirements of Water Code Section 10733.6 (b)(3) where an analysis of basin conditions demonstrates that the basin has operated within its sustainable yield over a period of at least 10 years. This Basin Analysis Report covers the entire Napa Valley Subbasin, which has been designated as a medium priority basin and is subject to the Act.
This Executive Summary has presented Findings stemming from the analyses conducted as part of this Basin Analysis Report and in consideration of prior activities by Napa County, the GRAC, the WICC, and others.

ES 10.2 Recommendations

As discussed above, Napa County has made much progress towards implementing recommendations made in 2011 as part of the Comprehensive Groundwater Monitoring Program. The recommendations and the status of actions on these recommendations are summarized in **Table ES-1**. The GRAC provided groundwater sustainability objectives and metrics to accomplish those objectives in February 2014 (**Appendix A**). These objectives/recommendations (where not duplicative of earlier recommendations) are also summarized in **Table ES-1**.

As an outcome of this Basin Analysis Report, additional recommendations, numbered 13 through 25, are summarized in **Table ES-1**.

Table ES-1. Summary of Recommended Implementation Steps

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
Napa County Groundwater Conditions and Groundwater Monitoring Recommendations (2011)				
1.1a	Entry of archived data not previously available, link WellMA table information, add well construction data from wells the County monitors, add recent surface water delivery information, add municipal pumping data, and other information along with development and implementation of quality control protocols for inputting new data and reviewing existing data discrepancies	**Near to Long Term**	**1**	**Complete**
1.1b	Establishment of a map-interface with the DMS to enhance the use of the database by non-database users	**Near Term to Mid Term**	**3**	**2018**
2.1a	Input CASGEM groundwater level data into the DMS	**Ongoing**	**1**	**Complete**
2.1b	Establish data format to meet DWR guidelines for electronic data transfer	**Near Term**	**1**	**Complete**
2.1c	Optimize CASGEM monitoring well network per DWR guidelines by filling in data gaps where identified	**Mid to Long Term**	**3**	**Complete**
3.1a	Update County field procedures for measuring groundwater levels	**Near Term**	**1**	**Complete**

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
3.1b	Develop and/or expand aquifer-specific groundwater monitoring network in Napa Valley Floor, Pope Valley and Carneros Subareas by identifying existing wells with well construction data and constructing new aquifer-specific monitoring wells as needed where data gaps may exist	**Near to Mid Term**	**2**	**Ongoing**
3.1c	Develop aquifer-specific groundwater monitoring network in other Subareas by identifying existing monitored wells with well construction data and constructing new wells where data gaps may exist	**Mid to Long Term**	**3**	**Ongoing**
4.1a	Update geologic cross sections for the Napa Valley Floor and Carneros Subareas (previous ones were 50 years old)	**Near to Mid Term**	**2**	**Complete**
4.1b	Develop new geologic cross sections in those areas with the greatest short- and long-term growth and/or land use potential	**Near to Long Term**	**2**	**2019**
4.1c	Investigate groundwater/surface water interactions and the effect of recharge and pumping on groundwater levels in the Napa Valley Floor Subareas, along with the Carneros Subarea to assess the sustainability of groundwater resources. May include groundwater modeling, as needed.	**Near to Mid Term**	**1**	**Complete/ Ongoing**

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
5.1a	Prepare workplan for the purposes of preparing a Groundwater Sustainability Plan; workplan includes steps to implement County Monitoring Program and CASGEM Program	**Near Term**	**1**	**Complete (Basin Analysis Report; Monitoring Program and CASGEM Plan)**
5.1b	Utilize the Watershed Information & Conservation Council (WICC) Board for various public outreach components related to groundwater sustainability planning	**Near Term**	**2**	**Ongoing**
5.1c	Develop objectives for public outreach, including information sharing and education about the County's groundwater resources	**Near to Mid Term**	**2**	**Complete**
5.1d	Preparation of a Groundwater Sustainability Plan for Napa County	**Near to Mid Term**	**2**	**Complete (Basin Analysis Report)**
5.2a	Public outreach, including information sharing and education about the County's groundwater resources	**Ongoing**	**3**	**Ongoing**
6.1a	Updating of Ordinances 13.04, 13.12, and 13.15	**Mid Term**	**2**	**Complete**
6.1b	Update Groundwater Permitting Process	**Mid Term**	**3**	**Complete**

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
Groundwater Resources Advisory Committee (February 2014)				
7	Develop and widely distribute public outreach programs and materials; educate people about opportunities for taking action	**Near Term/ Ongoing**	**1**	**Ongoing**
8	Support landowners in implementing best sustainable practices; Solicit information on, and widely share best practices with regard to water use in vineyards, wineries, and other agricultural/commercial applications	**Near Term/ Ongoing**	**1**	**Ongoing**
9	Enhance the water supply system and infrastructure to improve water supply reliability (regional and local)	**Near Term (evaluate and rank opportunities); Long Term – seek funding for high value projects**	**2**	**Ongoing**
10	Share groundwater conditions data and results; updates through BOS/WICC/Other	**Near Term/ Ongoing**	**1**	**Ongoing**
11	Continue to improve scientific understanding of groundwater recharge and groundwater- surface water interactions	**Near Term/ Ongoing**	**1**	**Ongoing**

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
12	Improve preparedness for responding to long- term trends and evolving issues; improve preparedness for responding to acute crises, such as water supply disruptions and multiyear drought conditions	**Long Term**	**3**	**2020**
Basin Analysis Report for the Napa Valley Subbasin (2016)				
13	Address groundwater monitoring data gaps to improve spatial distribution of water level measurements in the alluvial aquifer	**Near Term**	**1**	**Ongoing**
14	Evaluate and address groundwater monitoring data gaps to improve spatial distribution of water level measurements in the semi-confined to confined portions of the aquifer system	**Near Term**	**1**	**Ongoing**
15	Implement Napa County groundwater quality monitoring program; includes water quality monitoring in a subset of current monitoring network wells	**Near Term**	**1**	**Ongoing**
16	Coordinate with existing discretionary permit applicants (e.g., wineries and others) regarding existing groundwater level and/or water quality information)	**Near Term**	**1**	**2018**

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
17	Coordinate with RCD and others regarding current stream gaging and supplemental needs for SGMA purposes; consider areas that may also benefit from nearby shallow nested groundwater monitoring wells (similar to LGA SW/GW facilities)	**Near- to Mid Term**	**2**	**2019**
18	Install test hole(s) and multiple completion monitoring wells at south end of Napa Valley Subbasin/Napa Sonoma Lowlands Subbasin for improved understanding of freshwater/salt water interface	**Mid Term**	**2**	**2020**
19	Evaluate strategic recharge opportunities, particularly along Subbasin margin and in consideration of hydrogeologic factors and O'Geen (2015) mapping	**Near- to Mid Term**	**2**	**2019**
20	Evaluate distribution of Groundwater Dependent Ecosystems and relationships to depth to groundwater; coordinate evaluation with BMPs or guidance developed by DWR, Nature Conservancy, California Native Plant Society or others	**Near Term**	**1**	**2019**
21	Review of and coordination with BMPs published on DWR's web site (DWR is due to post BMPS by January 1, 2017)	**Near Term**	**1**	**2018**

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
22	Evaluate and address uncertainties in historical water budgets to improve calibration of budget components and reduce uncertainty of projected future water budgets	**Near- to Mid Term**	**1-2**	**2020**
23	Revise the standard Conditions of Approval used by Napa County for discretionary projects to include, for all future projects, groundwater monitoring and water use monitoring, reporting data to the County when requested, and use of project wells for monitoring when requested and needed to support this plan, and provisions for permit modification based on monitoring results	**Near Term**	**2**	**2017**
24	Expand the capacity to encourage groundwater stewardship/groups through education, facilitation, and equipment	**Near term**	**2**	**2018**
25	Develop an improved understanding of surface water and groundwater uses in unincorporated areas in the County, and trends in those uses	**Near Term**	**1**	**2019**

[1] Implementation schedule reflects relative multi-year time frames for completing or conducting the task. Near, Mid, and Long Terms are reflective of 3, 5, and 10 year periods.

[2] Priority ranking is on a scale of 1 to 3 with 1 being the highest priority and 3 being the lowest.

1 INTRODUCTION

In response to the 2014 Sustainable Groundwater Management Act, Napa County has prepared this Basin Analysis Report, as an Alternative Submittal, per the requirements of Water Code Section 10733.6 (b)(3). The Report provides an analysis of basin conditions of the Napa Valley Subbasin and demonstrates that the basin has operated within its sustainable yield over a period of at least 10 years. This Basin Analysis Report covers the entire Napa Valley Subbasin, which has been designated as a medium priority basin and is subject to the Act. Furthermore, this Report advances current and future efforts in meeting Napa County's water resource goals, particularly those that speak to resource management and long-term sustainability.

Groundwater and surface water are highly important natural resources in Napa County. Together, the County and other municipalities, water districts, commercial and industrial operations, the agricultural community, and the general public, are stewards of the available water resources. Similar to other areas in California, businesses and residents of Napa County face many water-related challenges including:

- Sustaining the quality, availability and reliability of local and imported water supplies;
- Meeting challenges that arise during drought conditions;
- Avoiding adverse environmental effects due to water use; and
- Changes in long-term availability of supplies due to global warming and/or climate change.

As a part of the General Plan update in 2008, , six goals are set forth within the Conservation Element relating to the County's water resources, including goals specific to surface water and groundwater. Complementing these goals are twenty-eight policies and ten water resources action items. The County's six water resources goals are included below

> **Goal CON-8**: Reduce or eliminate groundwater and surface water contamination from known sources (e.g., underground tanks, chemical spills, landfills, livestock grazing, and other dispersed sources such as septic systems).
>
> **Goal CON-9**: Control urban and rural storm water runoff and related non-point source pollutants, reducing to acceptable levels pollutant discharges from land-based activities throughout the county.
>
> **Goal CON-10**: Conserve, enhance and manage water resources on a sustainable basis to attempt to ensure that sufficient amounts of water will be available for the uses allowed by this General Plan, for the natural environment, and for future generations.
>
> **Goal CON-11**: Prioritize the use of available groundwater for agricultural and rural residential uses rather than for urbanized areas and ensure that land use decisions recognize the long-term availability and value of water resources in Napa County.

Goal CON-12: Proactively collect information about the status of the County's surface and groundwater resources to provide for improved forecasting of future supplies and effective management of the resources in each of the County's watersheds.

Goal CON-13: Promote the development of additional water resources to improve water supply reliability and sustainability in Napa County, including imported water supplies and recycled water projects.

Additional information on the water resources goals, policies, and action items are provided in the Napa County General Plan Update-2008 (also see additional discussion in **Chapter 8**).

As described in this Report, Napa County's long-term efforts have created a strong foundation for public outreach and participation in water resources understanding, planning, and management. Following completion of the General Plan update (Napa County, 2008), these efforts included a Groundwater Public Outreach Project with the Center for Collaborative Policy (CCP, 2010/AB 303 related), creation of a new Groundwater Resources Advisory Committee, and the long-term support of the Watershed Information & Conservation Council (WICC-2002). From this foundation, the County developed a Comprehensive Groundwater Monitoring Program, based upon numerous technical memorandums, and a key foundational report on *Napa County Groundwater Conditions and Groundwater Monitoring Recommendations* (LSCE, 2011a; http://www.napawatersheds.org/) While there was no formal groundwater management plan (under SB 1938), Napa County's efforts have been instrumental in the development and implementation of functionally equivalent groundwater management actions to better understand groundwater conditions, establish monitoring to track conditions, conduct education and outreach, and other programs to maintain groundwater sustainability.

1.1 Background

This section provides an overview of the following:

- Napa County's established role in the management of groundwater within the county (includes a summary of the Comprehensive Groundwater Monitoring Program implemented in 2009, the Board of Supervisors appointed Groundwater Resources Advisory Committee and the sustainability objectives developed through that process);
- Review of the Sustainable Groundwater Management Act's (SGMA) authorization of Alternatives to Groundwater Sustainability Plans (Alternative);
- Designation of the Napa Valley Groundwater Subbasin by the CA Department of Water Resources (DWR) as a medium priority pursuant to SGMA;
- Napa County's decision to develop a Basin Analysis Report as an appropriate Alternative defined by California Water Code Section 10733.6(b)(3); due January 1, 2017;
- DWR final regulations for Groundwater Sustainability Plans and Alternative submittals (adopted by the California Office of Administrative Law, August 15, 2016); and
- A list of references and technical studies referenced by Napa County in developing the Basin Analysis Report.

Long-term, systematic monitoring programs are essential to provide data that allow for improved evaluation of water resources conditions and to facilitate effective water resources planning. For this reason, Napa County embarked on a countywide project referred to as the "Comprehensive Groundwater Monitoring Program, Data Review, and Policy Recommendations for Napa County's Groundwater Resources" (Comprehensive Groundwater Monitoring Program) in 2009, to meet action items identified in the 2008 General Plan update (Napa County, 2008). The program emphasizes developing a sound understanding of groundwater conditions and implementing an expanded groundwater monitoring and data management program as a foundation for future coordinated, integrated water resources planning and dissemination of water resources information. On February 14, 2011, the Napa County Board of Supervisors held a special meeting and workshop to review and discuss the recommendations contained in the Comprehensive Groundwater Monitoring Program report (2011). At the workshop the Board of Supervisors voiced their commitment to protection and management of the county's groundwater resources and directed further study and development of a an updated hydrogeologic conceptualization and characterization of conditions together with the creation of a community advisory committee to guide further groundwater study, data collection and policy (see Section 1.2.1)

1.1.1 Groundwater Resources Advisory Committee

On June 28, 2011, the Napa County Board of Supervisors adopted a resolution to establish a Groundwater Resources Advisory Committee (GRAC), and an outreach effort for applicants began. On September 20, 2011, the Board of Supervisors appointed 15 residents to the GRAC, and the GRAC held its first organizational meeting on October 27, 2011. The members represented diverse interests, including environmental, agricultural, development, and community interests.

The GRAC was created to assist County staff and technical consultants with recommendations regarding:

- Synthesis of existing information and identification of critical data needs;
- Development and implementation of an ongoing non-regulatory groundwater monitoring program;
- Development of revised well pump test protocols and related revisions to the County's groundwater ordinance;
- Conceptualization of hydrogeologic conditions in various areas of the County and an assessment of groundwater resources as data become available;
- Development of groundwater sustainability objectives that can be achieved through voluntary means and incentives; and
- Building community support for these activities and next steps.

From January 2012 until January 2013, the GRAC reviewed and provided feedback on the development of the *Napa County Groundwater Monitoring Plan 2013* (Plan) (LSCE, 2013a).
The Plan was prepared to formalize and augment groundwater monitoring efforts [levels and quality] to better understand the groundwater resources of Napa County, aid in making the County eligible for

public funds administered by the California Department of Water Resources (DWR), and regularly evaluate trends to identify changes in levels and/or quality and factors related to those changes that warrant further examination to ensure sustainable water resources. The Plan included refinement of criteria used to identify priority monitoring areas and a proposed expanded monitoring network.

The Napa County groundwater monitoring program relies on both publicly-owned and volunteered private wells. To fulfill its mission and garner community interest and support, the GRAC developed a Communication and Education Plan, designed to implement the Plan through voluntary participation. This effort included the development of an outreach brochure and a series of fact sheets on specific topics, as well as community outreach by the GRAC members themselves.

Some of the many activities accomplished by the GRAC over a two and a half year period included:

- Provided updates to agriculture industry groups, environmental organizations, business leaders, local governing bodies, and others;
- Developed and approved community outreach materials to support groundwater understanding and sustainable management;
- Led and supported outreach efforts to well owners for volunteer monitoring wells which has been very successful in adding new wells to the Napa County voluntary groundwater monitoring program;
- Held a joint public outreach meeting of the GRAC and Watershed Information & Conservation Council (WICC) (July 25, 2013);
- Reviewed and recommended modifications to the Napa County Water Availability Analysis (WAA), groundwater data management system, and Groundwater Ordinance; and
- Developed and approved Groundwater Sustainability Objectives (GRAC, 2014)[4].

The GRAC provide their final report to the Napa County Board of Supervisors on April 8, 2014.

1.1.2 Sustainable Groundwater Management Act

In September 2014, the California Legislature passed the Sustainable Groundwater Management Act (SGMA). SGMA changes how groundwater is managed in the state. SGMA defines "sustainable groundwater management" as the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results (Section 10721 (u)). Undesirable results, as defined by SGMA, means one or more effects caused by groundwater conditions occurring throughout the basin (Section 10721 (w)) (see Section 6.2).As noted in Section 2 of this Report, SGMA applies to basins or subbasins that DWR designates as medium- or high-priority basins. Previously under the California Statewide Groundwater Elevation Monitoring (CASGEM) program, DWR classified California's groundwater basins and subbasins as either high, medium, low, or very low priority. The priority classifications are based on eight criteria that include the overlying population, the reliance on groundwater, and the number of wells in a basin or subbasin. In

[4] **Chapter 7** further discusses the GRAC sustainability objectives.

Napa County, the Napa Valley Subbasin was ranked medium priority. All other Napa County basins and subbasins were ranked as very low-priority (**Figure 1-1**).

For most basins designated by DWR as medium or high priority, SGMA requires the designation of groundwater sustainability agencies (GSA) and the adoption of groundwater sustainability plans (GSP); however, there is an alternative to a GSP provided that the local entity (entities) can meet certain requirements. When required, GSPs must be developed to eliminate overdraft conditions in aquifers and to return them to a condition that assures their long-term sustainability within twenty years of GSP implementation. SGMA does not require the development of a GSP for basins that DWR ranks as low- or very low-priority basins; GSPs are voluntary for these basins.

As applicable, SGMA requires that a GSA be identified for medium- and high-priority groundwater basins by June 30, 2017. Counties are presumed to be the GSA for unmanaged areas of medium and high priority basins (Section 10724). If counties or other entities do not assume this responsibility, then state intervention may occur (Section 10735 et seq.). SGMA also provides for state intervention – a "backstop" – when local agencies are unwilling or unable to manage their groundwater basin (Section 10735 et seq.).

Under SGMA, Section 10733.6, a local entity (or entities) can pursue an Alternative to a GSP provided that certain sustainability objectives are met. The Alternative submittal relevant to the Napa Valley Subbasin is defined in the Act as:

> 10733.6(b) (3) *"An analysis of basin conditions that demonstrates that the basin has operated within its sustainable yield over a period of at least 10 years. The submission of an alternative described by this paragraph shall include a report prepared by a registered professional engineer or geologist who is licensed by the state and submitted under that engineer's or geologist's seal."*
>
> The County would need to submit the alternative plan no later than January 1, 2017, and every five years thereafter.
>
> (d) *The assessment required by subdivision 10733.6 (a) shall include an assessment of whether the alternative is within a basin that is in compliance with Part 2.11 (commencing with Section 10920). If the alternative is within a basin that is not in compliance with Part 2.11 (commencing with Section 10920), the department shall find the alternative does not satisfy the objectives of this part.*

Prior to adoption of the final GSP regulations prepared by DWR, Napa County staff met with DWR staff on December 4, 2015 and June 10, 2016 to discuss a possible approach for a GSP-alternative for the Napa Valley Subbasin. On April 5, 2016, the County Board of Supervisors received the 2015 Annual Groundwater Monitoring Report update and an update on SGMA. The Board then provided direction to staff to expand the groundwater monitoring program as recommended, include the identified special study area, and continue development of the Basin Analysis Report-Alternative as provided by SGMA.

On August 15, 2016, the Office of Administrative Law adopted the final regulations prepared by DWR for the development of GSPs and GSP-alternatives. Entities submitting an Alternative are to explain how the elements of the Alternative are functionally equivalent to the elements of a GSP as required by Articles 5 and 7 of the GSP regulations and sufficiently demonstrate the ability of the Alternative to achieve the objectives of the Act (Article 9, Section 358.2(d)).

1.1.3 Recent Napa Studies Providing the Technical Foundation for the Basin Analysis Report

1.1.3.1 Napa County's Comprehensive Groundwater Monitoring Program

Napa County has been actively monitoring groundwater levels since the mid-1960s, and some groundwater data are available since the 1920s. In the interest of long-term sustainability of county water resources and to meet action items identified in Napa County's 2008 General Plan update, in 2009 Napa County implemented a Comprehensive Groundwater Monitoring Program (Napa County, 2008). The program emphasizes developing a sound understanding of groundwater conditions and implementing an expanded groundwater monitoring and data management program as a foundation for future coordinated, integrated water resources planning and dissemination of water resources information. The program (and the Plan (LSCE, 2013a)) covers the continuation and refinement of countywide groundwater level and quality monitoring efforts (including many basins, subbasins and/or subareas throughout the county) for the purpose of understanding groundwater conditions (i.e., seasonal and long-term groundwater level trends and also quality trends) and availability. This information is critical to enable integrated water resources planning and the dissemination of water resources information to the public and state and local decision-makers. Napa County's combined efforts through the Comprehensive Groundwater Monitoring Program along with the related AB 303 Public Outreach Project on groundwater (CCP, 2010) and the efforts of the WICC of Napa County create a foundation for the County's continued efforts to increase public outreach and participation in water resources understanding, planning, and management.

Napa County's Comprehensive Groundwater Monitoring Program involved many tasks that led to the preparation of five technical memorandums and a report on *Napa County Groundwater Conditions and Groundwater Monitoring Recommendations* (LSCE, 2011a). This report and the other related documents can be found at: **http://www.napawatersheds.org/groundwater/**. The report documents existing knowledge of countywide groundwater conditions and establishes a framework for the monitoring and reporting of groundwater levels and groundwater quality on a periodic basis. The report also summarizes priorities for groundwater level and quality monitoring for each of the county subareas. As described above, the *Napa County Groundwater Monitoring Plan 2013* (LSCE, 2013a) was prepared to formalize and augment groundwater monitoring efforts [levels and quality] to better understand the groundwater resources of Napa County, aid in making the County eligible for public funds administered by the California Department of Water Resources (DWR), and regularly evaluate trends to identify changes in levels and/or quality and factors related to those changes that warrant further examination to ensure sustainable water resources. The Plan included refinement of criteria used to identify priority monitoring areas and a proposed expanded monitoring network. During Plan implementation, the GRAC led and supported outreach efforts to well owners for volunteer monitoring wells; the GRAC efforts were very successful in nearly doubling new wells to the Napa County groundwater monitoring program. These added wells filled monitoring gaps and improved the spatial distribution of the monitoring network.

1.1.3.2 Napa County Statewide Groundwater Elevation Monitoring (CASGEM)

In November 2009, Senate Bill SBX7 – 6 mandated that the groundwater elevations in all basins and subbasins in California be regularly and systematically monitored with the goal of demonstrating seasonal and long-term trends in groundwater elevations. In accordance with the mandate, DWR developed the CASGEM program. DWR is facilitating the statewide program which began with the opportunity for local entities to apply to DWR to assume the function of regularly and systematically collecting and reporting groundwater level data for the above purpose. These entities are referred to as Monitoring Entities.

Wells designated for inclusion in the CASGEM program are for purposes of measuring groundwater levels on a semi-annual or more frequent basis that are representative of groundwater conditions in the state's groundwater basins and subbasins. A key aspect of the program is to make certain elements of the groundwater level information available to the public.

On December 29, 2010, the County applied to DWR to become the local countywide Monitoring Entity responsible for designating wells as appropriate for monitoring and reporting groundwater elevations for purposes of the CASGEM program.

The wells selected by the County for this program are a *subset* of the overall wells monitored, i.e., the County has a much larger overall monitoring network. The County's participation in the CASGEM program complements other pre-existing groundwater monitoring that has been ongoing in Napa County for some time (the overall historical monitoring record began in 1920).

Following confirmation, the County, as the Monitoring Entity, proceeded to identify a *subset* of monitored wells to be included in the CASGEM network and to prepare a CASGEM Network Plan as required by DWR (LSCE, 2011b and LSCE, 2014). At the time the County's CASGEM Network Plan was initially submitted to DWR, fourteen wells were included in the program. DWR formally designated Napa County as the Monitoring Entity for two basins in August 2014, specifically:

- Napa County was designated as the Monitoring Entity for the 2-2.01 Napa Valley Subbasin (medium priority basin)
- Napa County was designated as the Monitoring Entity for the 2-2.03 Napa-Sonoma Lowlands Subbasin in Napa County (very low priority basin)

During the initial CASGEM monitoring year (beginning 2011), the County continued to monitor 14 wells that had already been part of the group of wells where groundwater levels are measured by the County and reported to DWR semi-annually, or are measured directly by DWR. The current 2014 CASGEM network wells are located primarily on the Napa Valley Floor, Carneros Subarea, and in the MST Subarea. Some of these wells do not have sufficient construction details to define which portion of the aquifer system is represented by measured water levels. Additional data gathering and surveying will be performed, and such information will be provided in future annual reports as it becomes available. Depending on the results of the County's evaluation, future actions may include removal and replacement of CASGEM wells with wells that are more representative of local groundwater conditions to better meet the objectives of the CASGEM program and also overall objectives of the County's Comprehensive Groundwater Monitoring Program.

In addition to the CASGEM well network described herein, the County added a monitoring wells in the Pope Valley Groundwater Basin[5]. Public outreach is underway through community organizations and other contacts. The Berryessa Valley Groundwater Basin has a very low DWR priority and extremely small utilization of groundwater[6]. Per discussions with DWR, outreach will continue but no monitoring is planned in this groundwater basin at this time. The County has submitted detailed information to DWR to support consideration of the removal of this basin through a Bulletin 118 update or other appropriate process (LSCE, 2014).

The Suisun-Fairfield Valley Basin and the Napa-Sonoma Lowlands Subbasin are two examples of basins that do not conform to county boundaries, and they are also basins with a very low-priority designation from DWR. While these two basins have low groundwater utilization and less extensive monitoring than other basins, they are situated adjacent to the bay and delta water ways and are important areas to monitor for protection against saltwater intrusion. The Suisun-Fairfield Valley Basin (2-3), which is mostly in Solano County and has only a very small area (less than 0.3% of the total basin area) in Napa County, is being monitored in its entirety by Solano County Water Agency as the CASGEM Monitoring Entity for Solano County. The monitoring of Napa-Sonoma Lowlands Subbasin (2-2.03), whose area is shared with Solano County in more equitable portions (63% in Napa County, 37% in Solano County), is anticipated to have monitoring that is coordinated between the two respective Monitoring Entities in the future. Currently all monitoring in this subbasin is within the Napa County portion of the Subbasin. In the future, monitoring in this subbasin will expand as necessary to ensure representative coverage and as coordinated between the two Monitoring Entities.

1.1.3.3 Updated Conceptualization and Characterization of Hydrogeologic Conditions

In 2012, activities were implemented to update the characterization and conceptualization of hydrogeologic conditions (LSCE and MBK, 2013). This work included: 1) an updated Napa Valley hydrogeologic conceptualization, 2) linking well construction information to groundwater level monitoring data, 3) groundwater recharge characterization and estimates, and 4) surface water/groundwater interrelationships.

1.1.3.4 DWR LGA Grant for Groundwater/Surface Water Monitoring Facilities

Funding from the DWR 2012 Local Groundwater Assistance Grant Program (Agreement 4600010345) enabled Napa County to construct ten monitoring wells at five sites in Napa Valley in September 2014. These wells comprise the groundwater monitoring facilities for the Napa County Surface Water-

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[5] DWR Overall Basin Ranking Score is "0.0"; the very low priority basin ranking range is 0-5.4. http://www.water.ca.gov/groundwater/casgem/pdfs/basin_prioritization/NCRO%2074.pdf

[6] DWR Overall Basin Ranking Score is "0.0"; the very low priority basin ranking range is 0-5.4. http://www.water.ca.gov/groundwater/casgem/pdfs/basin_prioritization/NCRO%2062.pdf

Groundwater Monitoring Project. A stream gage is also co-located at each of the five sites, and stream stage and groundwater levels are continuously recorded at each of the sites. Surface water quality and groundwater quality are also monitored. In addition to grant funding from DWR, Napa County provided matching funds to cover a portion of the monitoring well construction and instrumentation costs.

1.1.3.5 Selected List of Key References

Table 1-1 lists key references used in the development of the Basin Analysis Report. Many of these references are included as an Appendix to this Report (see Table 1-1); other references are available online. Additional references are included in the References section.

1.2 Beneficial Uses and Public Participation (354.10)

Everyone living and working in Napa County has a stake in protecting the county's groundwater resources, including groundwater supplies, groundwater quality, and associated watersheds (GRAC, 2014). Reliable and sustainable surface water and groundwater resources are essential to the ecological and economic health of the Napa Valley Subbasin.

The residents and visitors of the county rely on groundwater resources to provide adequate water for domestic, commercial, and agricultural purposes as well as to support the existence, use, and enjoyment of natural resources. The Napa Valley Subbasin supports a diverse assemblage of fish and wildlife. The basin is home to nearly sixteen intact communities of native fish species, including steelhead, fall-run Chinook salmon, Pacific and river lamprey, hardhead, tule perch, and Sacramento splittail (Leidy, 1997). Such native fish diversity is unsurpassed in Central Valley and Sierra streams, suggesting that the Napa River system is a regional priority watershed for native fish and aquatic wildlife conservation (Leidy, 2000, Stillwater Sciences, 2004, Becker et al., 2007). In this regard, the Napa River basin is often referred to as an "anchor watershed."

While groundwater use is not a significant source for municipal uses, groundwater typically serves as the main water supply source to meet human water demands in the unincorporated areas of the Subbasin. Unincorporated uses include residential, commercial business, institutional, wineries and related vineyards, and other minor agricultural uses. Incorporated areas with the Subbasin rely on local reservoirs and regional water providers. Greater detail on groundwater demands within the subbasin can be found in **Chapter 5**.

1.2.1 Public Meetings

Public meetings at which SGMA updates were provided, including local implementation efforts and preparation of an Alternative submittal as provided under the Act, groundwater monitoring program and current groundwater conditions updates, drought and water conservation updates, and other Napa County Groundwater Sustainability Program efforts, are listed below.

Board of Supervisors

- December 13, 2016 – Update on SGMA Implementation and Presentation of the Basin Analysis Report for the Napa Valley Subbasin for Consideration/Approval and Submittal to DWR

- April 5, 2016 - SGMA Implementation Update and Comprehensive Groundwater Monitoring Program 2015 Annual Report and CASGEM Update
- March 3, 2015 - SGMA Implementation Update and Comprehensive Groundwater Monitoring Program 2014 Annual Report and CASGEM Update

Watershed Information & Conservation Council

- WICC Public Workshop - SGMA Update and Basin Analysis Report – November 3, 2016
- WICC Public Workshop - SGMA Update and Basin Analysis Report – September 22, 2016
- WICC Meetings – bi-monthly beginning January; provide on-going SGMA updates

Community Meetings

- Resource Conservation District (RCD) Board Meeting- 1303 Jefferson St, Napa, July 14,2016
- Napa Engineers Society (NES) Meeting – 902 Main St, Napa, June 14, 2016
- Local Agency Formation Commission (LAFCO) - June 6, 2016
- League of Women Voters Public Workshop – Napa County Library, Nov. 23, 2015
- Water Education Foundation – NCTPA Conference Room, Napa, Sept. 25, 2015
- Napa County Farm Bureau Water Forum – Native Sons Hall, St. Helena, Aug. 6, 2015
- RCD Workshop-Vineyard Water Use Efficiency – Raymond Vineyards, St Helena, June 9, 2015
- Napa Valley Grape Growers Sustainable Vineyard Practices Workshop – Copia Hall, 500 1st St, Napa, April 8, 2015

Training/Workshops

- Napa County PBES Staff Training Workshop -GW Conditions & WAA- Feb.4, 2016
  "Napa County Groundwater Conditions and Water Availability Analysis (WAA) "

Conferences

- International Agriculture-Groundwater Conference – San Francisco – June 28, 2016
  "Napa County Groundwater Resources-A Comprehensive Program to Ensure Sustainability"

1.2.2 County Decision-Making Process

For purposes of communicating the preparation of the Basin Analysis Report and providing opportunities for public input, the County has conducted the outreach/presentations described above together with meetings directly related to the County's decision-making process for submittal of the Basin Analysis Report to DWR. The latter meetings include:

- **Initial BOS Update on SGMA/Direction regarding County Requirement for Medium-Priority Basin:** March 3, 2015 - SGMA Implementation Update and Comprehensive Groundwater Monitoring Program 2014 Annual Report and CASGEM Update
- **BOS Update on SGMA/Confirm Direction regarding County's Response to SGMA Requirement:** April 5, 2016 - SGMA Implementation Update and Comprehensive Groundwater Monitoring Program 2015 Annual Report and CASGEM Update
- **BOS Public Meeting/Action on Basin Analysis Report:** December 13, 2016 – Update on SGMA Implementation and Presentation of the Basin Analysis Report for the Napa Valley Subbasin for Consideration/Approval and Submittal to DWR

1.2.3 Public Information on Groundwater Conditions

Following the GRAC's work to assess the County's groundwater monitoring network and program, and final development of the 2013 groundwater monitoring plan (LSCE, 2013), the County has implemented annual reporting of groundwater conditions. Two annual groundwater reports have been presented to the County Board of Supervisors for years 2104 and 2015 (in LSCE, 2015 and 2016, respectively). These reports are also posted on the County's web site (see links in **Table 1-1** below). The Watershed Information & Conservation Council also holds public information meetings where groundwater items regularly included (see more information on groundwater communications in **Chapter 9**). Additional updates are also provided by Sustainable Napa County through their Newsletter and website, the Public Works newsletter, and other industry and group newsletters.

Table 1-1. List of Key References

Year	Title[1]	Author	Included as Appendix[2]
2008	Napa County general plan	Napa County	
2010	Task 1, Napa County data management system. Technical Memorandum prepared for Napa County	Luhdorff and Scalmanini, Consulting Engineers (LSCE)	
2010	Task 2, Review and evaluation of data collection procedures and recommendations for improvement. Technical Memorandum prepared for Napa County	LSCE	
2010	Task 3.3, Guidance on precipitation and streamflow monitoring activities, Napa County, CA	LSCE	
2011	Napa County groundwater conditions and groundwater monitoring recommendations, prepared for Napa County Department of Public Works, February 2011. Separate Executive Summary	LSCE	
2011	Napa County groundwater conditions and groundwater monitoring recommendations, Task 4 report, prepared for Napa County Department of Public Works, February 2011	LSCE	
2011	Groundwater planning considerations and review of Napa County groundwater ordinance and permit process. Task 5, Technical Memorandum prepared for Napa County	LSCE	
2013	Updated hydrogeologic conceptualization and characterization of conditions. Prepared for Napa County **http://www.napawatersheds.org/files/managed/Document/7096/FINAL_Napa_HydroGeo_Characterization_Report_Full_Report-reduced.pdf**	LSCE and MBK	B
2013	Napa County groundwater monitoring plan 2013. Prepared for Napa County. January 2013 **http://www.napawatersheds.org/files/managed/Document/7097/FINAL_Napa%20County%20GW%20Monitoring%20Plan%202013-with%20appendices_reduced.pdf**	LSCE	C

Year	Title[1]	Author	Included as Appendix[2]
2013	Napa County groundwater monitoring plan 2013. Prepared for Napa County. Appendix on monitoring protocols. January 2013	LSCE	F
2013	Approach for evaluating the potential effects of groundwater pumping on surface water flows and recommended well siting and construction criteria, Final Technical Memorandum. Prepared for Napa County	LSCE	
2013	Communication and education plan	GRAC	J
2014	Napa County California Statewide groundwater elevation monitoring (CASGEM) network plan. Originally prepared September 2011. Updated August 2014. **http://www.napawatersheds.org/files/managed/Document/7228/Napa_CASGEM_FINAL_Monitoring_Plan_20140808_sm_08082014113846.pdf**	LSCE	
2014	Groundwater Sustainability Objectives	GRAC	A
2015	Water availability analysis **http://www.countyofnapa.org/PBES/WAA/WAA**	Napa County	I
2015	Napa Country comprehensive groundwater monitoring program, 2014 annual report and CASGEM update	LSCE	
2016	Napa Country comprehensive groundwater monitoring program, 2015 annual report and CASGEM update **http://www.napawatersheds.org/files/managed/Document/7734/2015%20Annual%20GW%20Report_20160325_clean.pdf**	LSCE	D

Year	Title[1]	Author	Included as Appendix[2]
2016	Napa County groundwater-surface water monitoring facilities project report. DWR Local Assistance Grant	LSCE	E
2016	Groundwater resources in Napa County, monitoring for sustainability and Napa County's voluntary groundwater level monitoring program. Outreach brochure **http://www.napawatersheds.org/files/managed/Document/8060/2016-08-24_GW_Outreach_Brochure.pdf**	Napa County	K
2016	Napa County's voluntary groundwater level monitoring, data management and disclosure	Napa County	H
2016	Surface water-groundwater plots for representative station pairs (generated as part of this Report)	LSCE	G

1. References in this table are listed chronologically by year. Other references used for this Basin Analysis Report are shown in the References section.

2. Appendices are named in order of citation in this Report.

1.3 Agency Information (354.6)

Mailing address:

Director of Public Works
County Administration Building
1195 Third Street
Suite 101
Napa, CA 94559

Napa County has two departments that share responsibility for local groundwater resource planning and management. The County's Planning, Building and Environmental Services Department is responsible for land use planning and regulation, land development permitting, groundwater well permitting, public water system permitting and monitoring and collection of groundwater usage reporting where required. The County's Department of Public Works provides engineering and technical support in the review of development project groundwater availability studies, management of Subbasin and subarea groundwater studies, research and reporting, collection of biannual groundwater level data for CASGEM, and groundwater level monitoring of the wells enrolled in the County's Voluntary Groundwater Monitoring Program and collection and analysis of data from the County's groundwater-surface water monitoring facilities. In addition, the Department of Public Works also conducts groundwater education through local agency agreements, direct public outreach and via the Watershed Information & Conservation Council (WICC) and WICC website.

Napa County's authority to develop a Basin Analysis Report is provided for under SGMA, Section 10733.6. Basin Analysis Report contacts include:

Primary
Department of Public Works
Steven E. Lederer
Director
PH: (707) 253-4351
FAX: (707) 253-4627
EMAIL: PublicWorks

Secondary
Department of Planning, Building and Environmental Services
David Morrison
Director
PH: (707) 253-4417
FAX: (707) 299-4138
EMAIL: David.Morrison

1.4 Report Organization

To demonstrate functional equivalency between the Basin Analysis Report and the GSP regulations, **Table 1-2** compares Articles 5 and 7 of the GSP regulations to the Chapters in the Basin Analysis Report. The report includes GSP regulation reference numbers after each section heading where applicable. The Basin Analysis Report includes the following Chapters:

- Chapter 2: Physical Setting and Hydrogeology
- Chapter 3: Monitoring Network and Program
- Chapter 4: Groundwater and Surface Water Conditions
- Chapter 5: Historical, Current, and Projected Water Supply
- Chapter 6: Sustainable Yield Analysis
- Chapter 7: Napa Valley Subbasin Sustainability Goals
- Chapter 8: Monitoring Data Management and Reporting
- Chapter 9: Sustainable Groundwater Management
- Chapter 10: Findings and Recommendations

Table 1-2. Comparison Between Requirements for Groundwater Sustainability Plans and the Napa County Basin Analysis Report

GSP Regulations Reference	***Article 5. Plan Contents - GSP*** **Subarticle 1. Administrative Information**	***Plan Contents - Basin Analysis Report*** **Administrative Information**
354.4(a)	General Information	**Executive Summary**
354.4(b)	General Information	**1.1 Background**
354.6	Agency Information	**1.3 Agency Information**
354.8	Description of Plan Area	**2.1 Napa Valley Subbasin Setting and Boundary**
354.10	Notice and Communication	**1.2 Beneficial Uses and Public Participation**
	Subarticle 2. Basin Setting	**Basin Setting**
354.14	Hydrogeologic Conceptual Model	**2.3 Hydrogeologic Conceptual Model**
354.16	Groundwater Conditions	**4.0 Groundwater and Surface Water Conditions**
354.18	Water Budget	**5.0 Historical, Current, and Projected Water Supply and Demand; 6.0 Sustainable Yield Analysis**
354.20	Management Areas	**7.6 Management Area**
	Subarticle 3. Sustainable Management Criteria	**Sustainable Management Criteria**
354.24	Sustainability Goal	**7.0 Napa Valley Subbasin Sustainability Goal**
354.26	Undesirable Results	**7.2 Sustainability Indicators and Undesirable Results**
354.28	Minimum Thresholds	**7.4 Minimum Thresholds**
354.30	Measurable Objectives	**7.5 Measureable Objectives**
	Subarticle 4. Monitoring Networks	**Monitoring Network/Programs**

354.34	Monitoring Network	**3.1 Napa Valley Subbasin Groundwater and Surface Water Monitoring Network and Program Summary**
354.36	Representative Monitoring	**3.2 Monitoring Program Summary; 7.3 Representative Monitoring Sites**
354.38	Assessment and Improvement of Monitoring Network	**4.5 Data Gaps**
354.40	Reporting Monitoring Data to the Department	**8.6 Reporting**
	Subarticle 5. Projects and Management Actions	**Projects and Management Actions**
354.44	Projects and Management Actions	**9.0 Sustainable Groundwater Management**
	Article 6. Department Evaluation and Assessment	**Basin Analysis Report and Future Reports**
355.2	Department Review of Adopted Plan	**Napa County submits Basin Analysis Report (Alternative submittal) by January 1, 2017**
355.4	Criteria for Plan Evaluation	**Basin Report covers entire basin and prepared in accordance with other requirements**
355.6	Periodic Review of Plan by Department	**County will respond to Department requests as needed**
355.8	Department Review of Annual Reports	**County will provide the Department with an Annual Report by April 1 of each year following the adoption of the Basin Analysis Report (Section 8.6.4)**
355.10	Plan Amendments	**County will provide Department with substantive updates to Basin Analysis Report, if such occur prior to 5-year updates (Section 8.6.5)**
	Article 7. Annual Reports and Periodic Evaluations by the Agency	**Reporting and Evaluation**
356.2	Annual Reports	**8.6.4 Annual Report**
356.4	Periodic Evaluation by Agency	**8.6.5 Five-Year Subbasin Conditions Reporting and Evaluation**

2 PHYSICAL SETTING AND HYDROGEOLOGY

DWR has identified the major groundwater basins and subbasins in and around Napa County; these include the Napa-Sonoma Valley Basin (which in Napa County includes the Napa Valley and Napa-Sonoma Lowlands Subbasins), Berryessa Valley Basin, Pope Valley Basin, and a very small part of the Suisun-Fairfield Valley Groundwater Basin (DWR, 2003) (**Figure 2-1**). These basins and subbasins are generally delineated based on the presence of water-bearing geologic formations and boundaries to groundwater flow. The basin boundaries established by DWR are not restricted to county boundaries, and DWR-designated basins and subbasin designations do not cover all of Napa County.

2.1 Napa Valley Subbasin Setting and Boundaries (354.14)

The Napa Valley Subbasin of the Napa-Sonoma Valley Groundwater Basin (Subbasin) underlies much of Napa Valley from a southern boundary near the Highway 12/29 Bridge over the Napa River northward for approximately 30 miles to the head of Napa Valley upstream of Calistoga (**Figure 2-1**). The Subbasin lies entirely within Napa County and is overlain in part by the City of Napa, Town of Yountville, City of St. Helena, and City of Calistoga (**Figure 2-2a**).

For purposes of local planning, understanding, and studies, Napa County has been subdivided into a series of groundwater subareas (**Figure 2-2b**). These subareas were delineated based on the watershed boundaries, groundwater basins, and the County's environmental resource planning areas. These subareas include the Knoxville, Livermore Ranch, Pope Valley, Berryessa, Angwin, Central Interior Valleys, Eastern Mountains, Southern Interior Valleys, Jameson/American Canyon, Napa River Marshes, Carneros, Western Mountains Subareas and five Napa Valley Floor Subareas (Calistoga, St. Helena, Yountville, Napa, and Milliken-Sarco-Tulucay (MST)).

Consistent with the Updated Hydrogeologic Conceptualization and Characterization of Conditions Report (LSCE and MBK, 2013; **Appendix B**), four subsections of the Napa Valley Subbasin are referenced informally within this Report.

Calistoga to St. Helena – Upper Valley

The upper valley area encompasses the County's Calistoga subarea and the northern mile of the County's St. Helena subarea. The upper valley area was defined by the width of the valley floor and the nature of the geologic units found beneath the valley floor during the course of this study.

St. Helena to Oakville – Middle Valley

The middle valley extends from St. Helena to the town of Oakville. This area is about seven miles long, and the Valley Floor widens to about two miles at the north to about 3 ½ miles at the south. The middle valley area corresponds roughly to the County's St. Helena Subarea, except as noted above.

Yountville Narrows

The next area is termed the Yountville Narrows, which extends about five miles to Ragatz Lane, about half-way between Yountville and Oak Knoll (**Figure 2-2**). This area is characterized by numerous low knobs and hills of older geologic units that rise like islands above the stream valley. A preliminary three-dimensional visualization of the geology in this vicinity is shown on **Figure 2-3**.

The entire valley encompasses the County's Napa Valley Subareas. From the main mountainous side slopes, the total valley width ranges up to about three miles.

Napa to Suscol – Lower Valley

The lower valley extends about ten miles to the south beyond the City of Napa and trends more southerly to Suscol. The valley floor widens to about three miles north of Napa and then narrows to about 2 miles. The boundary between the Napa Valley Subbasin and Lowlands Subbasin is mapped as a northwest trending line spanning the valley floor at a narrow point near the Highway 12/29 Bridge over the Napa River. South of this location the extent of surficial alluvial deposits abruptly widen by several miles forming the Lowlands Subbasin.

To the east of the City of Napa, there is a unique feature of a low elevation around a central low highland. The area is drained by the tributary Milliken, Sarco, and Tulucay Creeks headed on the higher mountainous area to the north, east, and south. This area is termed the MST subarea from the contraction of the primary tributary creek names. Only the westernmost portions of the MST subarea and a narrow band of alluvial deposits along the lower reaches of Tulucay Creek are included in the Napa Valley Subbasin.

2.2 Geologic Setting

The Napa Valley Subbasin, located in the southern-central Coast Range Province north of the San Francisco Bay region, is an active zone of complex tectonic deformation and downwarping generally associated with the San Andreas Fault. This region of the Coast Range is characterized by northwest trending faults and low mountainous ridges separated by intervening stream valleys. The Napa Valley is a relatively narrow, flat-floored stream valley drained by the Napa River. The valley floor descends from elevations of about 420 feet at the northwest end to about sea level at the southern end.

The Napa Valley Subbasin is bounded by the north, east, and west by mountainous areas. The mountains to the north are dominated by Mount St. Helena at a height of 4,343 feet. The lower mountainous area to the east of the Subbasin is the Howell Mountains declining from 2,889 feet southward through lower elevations at 2,037 feet above Stag's Leap, 1,877 feet at Mount George, and 1,630 feet at Sugarloaf south of the MST area. To the west of the Subbasin, the Mayacamas Mountains decline from peaks to 2,200 feet in the north, to about 1,500 feet northwest of Napa. Farther south, the mountainous area declines to elevations of 200 to 100 feet, then disappears beneath the plains of the Carneros area and Lowlands Subbasin that border San Pablo Bay.

Figure 2-4a describes the major rock types and deposits in Napa Valley according to relative time of formation and serves as a legend for the Napa Valley surficial geology map (**Figure 2-4b**). Minor rock types and deposits are described in their respective original sources published by Bezore and others (2002, 2004 and 2005) and Clahan and others (2004 and 2005) by the California Geological Survey and Graymer and others (2002, 2006 and 2007) by the United States Geological Survey. **Figure 2-4b** shows a composite simplification of outcropping deposits, rock types, and structural fault boundaries at the land surface in and around Napa Valley Subbasin.

Surficial geologic maps of the Napa Valley area, developed by various authors spanning over a hundred years, differ through time in the detail of mapping, characterization of rock types, and nomenclature of various units. In the last forty years, the development of radiometric-age dating techniques and the evolution of plate tectonic theory have led to a better understanding of the geologic history of the region. However, even the most recent geologic reports and maps exhibit conflicting map units, lithology, and nomenclature.

Despite the differences noted above, three major geologic units in the Napa Valley area have been consistently recognized and remain largely unchanged, except in the names applied and interpretations of how they formed. These three units are Mesozoic rocks, Tertiary volcanic and sedimentary rocks, and Quaternary sedimentary deposits (**Figures 2-4a** and **2-4b**). In the Napa Valley Subbasin, the geologic units are divisible into two broad categories based on geologic age, degree of lithification (i.e., the hardness or rock-like nature), and the amount of deformation (i.e., deformed by folding and faulting). These two categories are Mesozoic (older than 63 million years (m.y.)) rocks and Cenozoic (younger than 63 m.y.) rocks and unconsolidated deposits

2.2.1 Mesozoic Rocks

The Mesozoic rocks are considered the bedrock in the area as they are very old, well lithified, and highly deformed resulting in limited groundwater in fractures (crack-like openings in the rocks). The Mesozoic rocks are divisible into two main groups: the Franciscan Complex and the Great Valley Complex. The Mesozoic rocks occur beneath all of the Napa Valley, but these rocks are most widely exposed at the surface in the adjacent mountain areas. Beneath the Napa Valley and the San Pablo Bay to the south, the Mesozoic rocks are covered by great thicknesses (possibly several thousands of feet) of younger rocks and deposits. The sole exception to this is a small area in the eastern Yountville Narrows where the Mesozoic rocks are exposed by deformation uplift.

2.2.2 Cenozoic Rocks and Unconsolidated Deposits

The Cenozoic geologic units are divisible into two main groups: 1) the older Tertiary (post 63 m.y. – 2.5 m.y.) volcanic and sedimentary rocks, 2) and the Quaternary (2.5 m.y. – present) sedimentary deposits. The main Tertiary rocks in the Napa Valley Subbasin are of the youngest age, largely Pliocene (5 m.y to 2.5 m.y). These consist of volcanic rocks and sedimentary rocks which are interfingered and interbedded. The volcanic rocks are composed of a complex sequence, including lava flows and fine-grained volcanic ejecta composed of ash and flow tuffs. Variations in mineral composition, types of volcanic processes, and the location of eruption sites lead to complex relationships in the volcanic deposits which make surface mapping difficult.

The Tertiary volcanic rocks have been termed the Sonoma Volcanics; these rocks extend across much of the Napa Valley Subbasin and across much of Sonoma County to the west. In the Napa Valley area, the Sonoma Volcanics are exposed at the surface over large areas around the upper valley, across large areas in the Howell Mountains to the east, and at more limited areas along the west margin of the Napa Valley. Beneath the Napa Valley Floor, the Sonoma Volcanics occur largely buried beneath younger geologic units. In the Yountville Narrows, there are many small knobs of outcropped Sonoma Volcanics. In the MST area, the Sonoma Volcanics occur in the surrounding mountains, the central upland, and beneath the entire area.

The Tertiary sedimentary rocks are more limited in surface exposures and commonly referred to as the Huichica Formation. North of Conn Creek, these rocks occur in a small area on the Napa Valley Floor margin and a larger area occurs in the adjacent mountainous area. In the MST area, Tertiary sedimentary rocks occur on the north margin and lap into the Napa Valley Floor margin. A large area of Tertiary sedimentary rocks is exposed across most of the Carneros area to the southwest of the Napa Valley. The relationship between these three areas and to the Sonoma Volcanics is not entirely clear.

The Sonoma Volcanics units which were formed at high temperatures as (e.g., lava flows and flow tuffs) appear to be well lithified, Sonoma Volcanics units formed at lower temperatures, such as landslide tuffs, ash falls, and volcanic-sedimentary interbeds appear to be weakly to moderately lithified. The thicker Tertiary sedimentary rocks also appear to be moderately to well lithified. Both the Sonoma Volcanics and the Tertiary sedimentary rocks are strongly deformed as evidenced by the commonality of steeply dipping beds, folding, and faulting.

The Quaternary (post 2.5 m.y) sedimentary deposits, collectively termed alluvium, cover the Napa Valley Floor. The youngest deposits of the current streams and alluvial fans are of Holocene age (100,000 years to present). Older deposits exposed as terraces, alluvial fans, and beneath the Holocene deposits are of Pleistocene age (2.5 m.y. to 100,000 years). At the south end of the Napa Valley Subbasin marshland, tidal flat, and estuary deposits occur. The Quaternary deposits appear to be only slightly deformed and weakly consolidated to unconsolidated. The Quaternary deposits are the primary water bearing formation of the Napa Valley Subbasin (LSCE and MBK, 2013; Faye 1973).

As part of the updated hydrogeologic conceptualization (LSCE and MBK, 2013), the locations and details of eight cross-valley geologic sections were developed and are shown on **Figures 2-6a** through **2-13** with a legend for the corresponding geologic units on **Figure 2-6b**. Nearly 1,300 water well drillers' reports were reviewed and located on topographic base maps; 191 of these were selected for use in developing cross sections A through H. Geologic correlations seen on the cross sections were extended laterally between sections by available well control and surficial geologic maps. A three dimensional fence diagram also depicts these cross sections in a vertically exaggerated context where they occur along the Napa Valley Subbasin (**Figure 2-14**). The following sections summarize the geologic observations on the cross sections by the various valley areas from south to north. Discussion of cross section H is omitted from this report because it is located south of the Napa Valley Subbasin.

2.2.3 Lower Valley Cross Sections

In the lower valley, four geologic cross sections were constructed: Sections D; Section E; Section F; and Section G, from north to south (**Figures 5-6 through 5-9**). These cross sections show the general geologic patterns of the lower valley. Quaternary alluvium (Qa) grades southward into fine-grained Quaternary sedimentary basin deposits (Qsb). The alluvium overlies Tertiary sedimentary rocks (Tss/h) which declines southward and transitions into thick, fine-grained Tertiary and early Quaternary sedimentary basin deposits (TQsb). The sedimentary rocks and basin deposits overlie the lower member Sonoma Volcanics andesite flows with tuffs (Tsva, Tsvt), which descends to depths of 1,000 feet or more below the City of Napa. At the south end of the valley at the Suscol Narrows, faulting has brought the Sonoma Volcanics to shallower depths.

At the north end of the lower valley, Section D appears to show Quaternary alluvium of unconsolidated deposits, including lenses of thick sands and gravel beds, especially to the east, and more widespread fine-grained clays with thin beds of sand with gravels. The alluvium thins east and west towards the margins of the valley. Below the alluvium, a thin sequence of finer-grained deposits occurs with some thin sand and gravel beds and some volcanic ash beds. This unit was correlated to the Tertiary sedimentary rocks (Tss/h) exposed in the MST area.

Deeper boreholes encountered volcanic materials of the lower member Sonoma Volcanics, but these appeared to occur in bands or zones. To the east, andesite lava flows and breccias with tuffs (Tsva) occur. In this area, thin Tertiary sedimentary rocks occur overlying the andesite unit. In the center of Section D, between two possible faults, limited information indicates tuff beds (Tsct) occur, but whether these are of the lower or upper member is not clear. To the west, a mix of andesite lava flows or breccias (Tsvab?), and tuffs (Tsvt) occur; these are probably the lower member Sonoma Volcanics.

Cross-section E (**Figure 5-7**) shows a similar pattern for the Quaternary alluvium. The east side of Section E shows Tertiary sedimentary rocks above the Sonoma Volcanics in the MST area. Beneath the alluvium, the main valley area shows thick, fine-grained deposits with some sand and gravel beds. This unit is termed Tertiary Quaternary sedimentary basin deposits. Only one deep well (projected on to this section) encountered Sonoma Volcanics of uncertain correlation at great depth. On the west side of Section E, lower member Sonoma Volcanics (Tsva) are overlain by sedimentary deposits of uncertain correlation (TQsu) in a fault band block.

Cross-sections F and G (**Figures 5-8 and 5-9**) are located south of the City of Napa where little deep well control occurs. The locations of Sections F and G were predicated on the existence of a few deep old well logs from Kunkel and Upson (1960) along each cross section. These well logs date from the first half of the 1900s. A few more recent drillers' reports were also used to construct the cross sections.

Cross-section F (**Figure 5-8**) shows Quaternary sedimentary basin deposits (Qsb) up to about 300 feet thick and largely composed of clays with thin interbeds of sand. These are believed to be floodplain (?), marshland, and estuary origin. These deposits are underlain by thick clay with sands deposits of the Tertiary-Quaternary sedimentary basin deposits (TQsb). Some thick sand or sandstone beds occur interbedded with fine-grained units. The TQsb units are believed to be marshland, estuary, and lacustrine (?) deposits. The unit may be equivalent, in part, to the diatomaceous lake beds in the MST area, and the Tertiary sedimentary rocks of the MST and Carneros areas. As such, the age of the unit would range from the Pliocene and possibly into the Quaternary (early (?) Pleistocene). Below these units, the lower member of the Sonoma Volcanics of andesite flows and tuffs rise from great depth below the center of the valley to surface exposures, or near surface, by faulting.

Cross-section G (**Figure 5-9**) occurs at the south end of the lower valley near the Suscol Narrows. The south gravity low basin rises to the Suscol Narrows and the gravity high ridge. The high ridge separates the Napa Valley from the deep gravity low basin below the San Pablo Bay to the south. At the Suscol Narrows, the Napa Valley drains through a narrow (~2,000 feet) gap between exposed lower member Sonoma Volcanics (Tsva) to the east and low hills and exposes an older Tertiary marine rocks (Td) to the west. Cross-section G shows the complexity of this area as these older units are overlain by Tertiary-Quaternary sedimentary basin deposits and Quaternary alluvium. The cause of this complexity may be the intersection of the East Napa and West Napa Fault Zones. The merged (?) fault zone may continue southeasterly across the San Pablo Bay area towards Vallejo.

2.2.4 Yountville Narrows Area – Cross-Section C

Northward in the Napa Valley, the review of water well driller's reports in the Yountville Narrows area indicated limited available well control, especially along the Napa River floodplain. Even away from the river, well control was limited. Cross-section C (**Figure 5-5**) was located near the north end of the area where well control was sufficient to extend the cross section across the valley. This cross section shows the complex structural features of the Yountville Narrows area. To the east, a possible East Napa Fault Zone separates the valley from the Howell Mountains. Beneath the Valley Floor, westward thickening Quaternary alluvium overlies the lower member Sonoma Volcanics andesite flow breccias mapped by the CGS. This unit appears to overlie a harder, more massive andesite flow and breccias (Tsvab) unit with some tuffs more typical of the Tsva in the mountains to the east. Deep well control is limited to one well, but the reported well yield (480 gallons per minute (gpm)) was much higher than nearby wells. Dips of bedding in the small hills and in the mountains to the east are somewhat lower (less than 30°) to nearly flat (less than 10°). This portion of the cross section overlies a flat shoulder of higher gravity which extends northward from the gravity ridge seen below the Yountville Narrows (Langenheim, 2006).

In the center of the Section C, the Quaternary alluvium, bound by faults, thickens and contains thick beds of fluvial sand and gravel. The underlying unit is termed Sonoma Volcanics conglomerate/breccias (Tca/b). The nature of the unit is unclear; it is uncertain whether it is a sedimentary conglomerate or volcanic flow breccias, or possibly a combination. Drillers' reports tend to log it as 'hard' gravel and boulders with some clay or volcanic ash, either as intermingled or separate beds. Two geophysical logs on the central two wells indicate high resistivity values and similar characteristic responses, but it could not be distinguished whether the deposits in these wells are sedimentary or volcanic. The four wells on the cross section were constructed for groundwater intake both in the thick coarse alluvium and this lower unit. Reported well yields were some of the highest in the valley, ranging from 770 to 2,000 gpm. Short duration test pumping of the two central wells indicated specific capacities of 17.9 and 33.9 gpm per foot of drawdown. This is higher than most wells in the valley which tend to be less than 1gpm per foot of drawdown. However, it is unclear if the extracted groundwater originated from the alluvium, which is most likely, and/or from the underlying conglomerate/breccias. The conglomerate/breccias unit was traced to north of Section A.

Further west on Section C occurs a fault-bound block of lower member Sonoma Volcanics andesite flows (Tsva). This is a continuation of the Yountville Hills just to the south.

The western remainder of Section C shows Mesozoic Great Valley Sequence rocks west of the main strand of the west Napa Fault Zone. The intervening area of the cross section shows a syncline-like or fault band block underlain by lower member Sonoma Volcanics andesite (Tsva), andesite and tuff, and tuff. The actual configuration of these units is unclear due to limited information and possible complications of faulting. Overlying these units is a fine-grained sedimentary unit termed (Tertiary-Quaternary sedimentary basin deposits undivided (TQsbu), as it does not match with either the Tertiary sedimentary rocks or the Quaternary alluvium. The gravity map shows a small, low-gravity basin from just west of the northern Yountville Hills to about halfway to Section B. This may represent a small fault band block on which late Pliocene (?) and early (?) Quaternary fine-grained sediments are deposited in a marsh-like or lacustrine environment.

2.2.5 Middle Valley – Cross-Sections A and B

The northernmost cross section, Section A (**Figure 5-3**), shows a typical Quaternary alluvium configuration of thickest depths near the center of the valley. However, thick sand and gravel beds in the central area are largely lacking. Localized thick sand and gravel beds occur, but well yields are less than seen farther south. In general, the alluvium appears to be finer-grained than farther south in the middle valley and the Yountville Narrows.

Section A appears to show the disappearance of the lower member of the Sonoma Volcanics andesite units to depths not reached by boreholes. In the easternmost part of Section A, Tertiary sedimentary rocks (Tss/h) may overlie the lower member (Tsva?) in a fault block; farther west, they overlie Sonoma Volcanics of uncertain correlation (Tsv?), or do not reach the volcanics. A narrow, fault bound (?) block appears to contain the conglomerate/breccias (Tcg/b) overlying Sonoma Volcanics of uncertain correlation (Tsv?). However, well yields are only moderate (<150 gpm), and specific capacities are lower (less than 1 gpm per foot of drawdown). Overlying thick sand and gravel alluvium may not be either present or yielding little water. On the west side of Section A, upper member Sonoma Volcanics (Tsv?) and upper member (?) tuffs (Tst?) exhibit well yields across this entire western area that are low (a few tens of gpm) with specific capacities of much less than 1 gpm per foot of drawdown.

In the middle valley, the geologic units of the Sonoma Volcanics change in their surface exposure and in the subsurface. The lower member Sonoma Volcanics dominated by the andesite flows (Tsva) and flow breccias (Tsvab) with minor tuffs (Tsvt) seen in the Yountviille Narrows descend to depths northward, and they are replaced by upper member tuffs and Tertiary sedimentary rocks. This is the result of the northern low-gravity basin where the lower member and overlying upper member of the Sonoma Volcanics have been down-dropped in relation to the adjacent mountainous areas.

Section B (**Figure 5-4**) shows Quaternary alluvium overlying older units with the greatest thickness near the center of the valley. To the east on the Valley Floor, lower member Sonoma Volcanics andesite breccias (Tsvab) occur near the valley margin, which is overlain by the Tertiary conglomerate/breccias (Tcg/b). Across the center of Section B, the conglomerate breccias occur similarly to what is seen on Section C to the south. The thickest part of the unit is overlain by thick Quaternary alluvium. The center area is bound by faults to the east and west. The four wells to the east in this area are similarly constructed with groundwater intake structures across both the alluvium and the conglomerate/breccias. Reported well yields by test pumping are high (between 1,000 to 2,400 gpm), and specific capacities are between 10.5 and 26.9 gpm per foot of drawdown (i.e., they are comparable to similar wells on Section C). It is unclear if the groundwater is sourced largely from the alluvium and/or from the conglomerate breccia.

Farther west on Section B, lower member andesite flows with tuffs (Tsva) are overlain by fine-grained beds of Tertiary sedimentary rocks, which may be in part tuff beds (Tss & t). This unit is believed to be possibly a portion of the upper member of the Sonoma Volcanics, although its exact correlation is unclear. To the west on the section, the lower member andesite appears to have been up-faulted by the west Napa Fault Zone.

2.3 Hydrogeologic Conceptual Model (354.14)

The geologic setting of the Napa Valley Subbasin provides a basis for understanding the physical properties of the aquifer system as well as the structural properties that influence groundwater flow. In order to understand Subbasin conditions and responses to management actions, a hydrogeologic conceptual model has been developed to account for the major physical components and interactions of surface water and groundwater systems within the Subbasin (**Figure 2-14)**. The hydrogeologic conceptual model presented in this report builds and improves upon the one presented previously by LSCE and MBK (2013) and includes additional components to account for surface water imported to the Subbasin, urban wastewater outflows, and groundwater pumping that were not a part of the previous conceptualization.

Table 2-1 lists the components of the hydrogeologic conceptual model of the Napa Valley Subbasin developed for this Basin Analysis Report. Together the components represent the physical properties of the Subbasin aquifer system and the primary processes that lead to inflows and outflows of water and for the basis in determining the water budget for the Subbasin (see **Chapter 6**). These components are described further in the following sections.

Table 2-1. Napa Valley Subbasin Hydrogeologic Conceptual Model Components

Component	Processes
Subbasin Inflows	
Root Zone Groundwater Recharge	Percolation of soil moisture originating as precipitation and irrigation less losses due to evapotranspiration
Napa Valley Subbasin Uplands Runoff	Surface water flow into the Subbasin from the Napa River Watershed hillsides/uplands
Napa Valley Subbasin Uplands Subsurface Inflow	Groundwater flow into the Subbasin from upslope geologic formations
Surface Water Deliveries	Includes water imported by municipal purveyors and used to meet consumptive and non-consumptive uses
Subbasin Outflows	
Surface Water Outflow: Stormflow and Baseflow	Surface water flows leaving the Subbasin through the Napa River, includes storm runoff and groundwater discharge to surface water (i.e., baseflow)
Subsurface Groundwater Outflow	Groundwater flow from the Napa Valley Subbasin into the Lowlands Subbasin through Quaternary deposits at the Subbasins' boundary
Consumptive Use of Surface Water and Groundwater	Surface water and groundwater use within the Subbasin that meet consumptive demands and result in Subbasin outflows through evapotranspiration.
Urban Wastewater Outflow	Wastewater conveyed out of the Subbasin to the Napa Sanitation District Treatment Facility
Subbasin Groundwater Storage	
Quaternary Alluvial Deposits Groundwater Storage	Groundwater stored in the unconsolidated Quaternary age deposits within the Subbasin

2.3.1 Groundwater Storage in Quaternary Alluvial Deposits

As described above, the Quaternary deposits comprise the primary aquifer units of the Napa Valley Subbasin. From the geologic cross-sections and correlations of other water well drillers' reports, the Quaternary alluvium was distinguished from underlying units, and an isopach map[7] was constructed (**Figure 2-15**). The alluvium was divided into three facies according to patterns detected in the lithologic record and used to delineate the depositional environment which formed them: fluvial, alluvial fan, and sedimentary basin (LSCE and MBK, 2013 and LSCE, 2013b) (**Figure 2-15**). The fluvial facies consists of a thin narrow band of stream channel sands and gravels deposited by the Napa River. The sand and gravel beds tend to be thicker and/or more numerous in the fluvial facies area (**Figure 2-15**). They are interbedded with finer-grained clay beds of probable floodplain origin. Groundwater production from Quaternary alluvium is variable, with yields ranging from <10 gpm in the East and West mountainous areas to a high of 3,000 gpm along the Napa Valley Floor where the alluvium is thickest (>200 feet). According to Faye (1973), average yield of wells completed in the alluvium is 220 gpm. Many wells drilled in the alluvium within the last 30 years extend beyond the alluvium and into the underlying Cenozoic units.

Wells constructed in the fluvial facies tend to be moderately high yielding (for the valley, roughly 50 to 200 gpm). Local areas where thicker sand and gravel beds are reported, the well yields are the highest in the valley, ranging from about 200 to 2,000 gpm. These areas with thick sand and gravel beds occur in the Yountville Narrows area, which extends about five miles from Oakville south to Ragatz Lane (**Figure 2-15**). Local areas of relatively lower well yield values of 200 to 500 gpm occur to the north and south. Hydraulic properties of these deposits are recorded during airlift testing, and drawdown values are generally not reported. Only a few pump test results have been found, and these are in the high yielding area just north of the Yountville Narrows.

The alluvial plain facies of the Quaternary alluvium extends outward from the central fluvial facies and thins to zero thickness at the edge of the valley sides (**Figure 2-15**). These deposits consist of interbedded sandy clays with thin beds (less than 10 feet thick) of sand and gravel and appear to have been deposited as tributary streams and alluvial fans. Wells constructed in the alluvial plain facies tend to be low yielding, ranging from a few gpm to a few tens of gpm. By at least 1970, most wells drilled on the alluvial plain facies were constructed to deeper depths into the underlying Sonoma Volcanics.

At the northern end of the lower valley, the sedimentary basin facies of the alluvium is characterized by fine-grained silt, sand, and clays with thin to scattered thicker beds of sand and gravel. The sedimentary facies is believed to be floodplain deposits that extend to the southern marshland/estuary deposits. As noted, the extent of this facies is poorly known due to lack of well control farther south. Limited information indicates low to moderate well yields of a few gpm to possibly up to 100 gpm. Again, the lack of pump test information makes hydraulic properties of the deposits difficult to assess. Portions of Napa Valley north of Deer Park Road were not characterized according to their Quaternary alluvial facies by LSCE and MBK (2013).

[7] Isopach contours are lines of equal thickness and represent the depth to the bottom of alluvial deposits from the land surface at a given location.

2.3.1.1 Other Water Bearing Geologic Deposits

Beneath the alluvium is a complex sequence of Tertiary sedimentary deposits (Huichica Formation) and igneous deposits of the Sonoma Volcanics. These units are strongly deformed by folding and faulting and have complex stratigraphic relationships. A structure contour map (elevations) of the top of these subcrop units where they are in contact with overlying alluvium (**Figure 2-16**) was developed from the geologic cross-sections, lateral correlations, and surficial map relationships (LSCE and MBK, 2013). From north of the City of Napa and southward, these deposits are dominated by fine-grained basin fill with few sand and gravels of floodplain, estuary origin.

North towards Yountville, sedimentary deposits of the Huichica Formation appear to overlie Sonoma Volcanics andesites and tuffs. Sonoma Volcanics and the older Mesozoic Great Valley sequence are exposed in a structural uplift area in the small hills in the Yountville area. Further north, a Sonoma Volcanics andesite flow breccia appears to transition into the Sonoma Volcanics conglomerate/breccia sedimentary conglomerate along the center of the valley (**Figure 2-16**). This conglomerate/breccia unit is encountered in deep, high yielding wells also completed in the overlying alluvium fluvial facies, but it is not clear if this unit is also high yielding.

Overlying the conglomerate/breccia on the east is the Tertiary sedimentary deposits sequence (Huichica Formation) of sandstones and mudstones. To the west of the unit occur older Sonoma Volcanics andesites, tuffs in the south, and possibly younger Sonoma Volcanics tuffs interbedded with Tertiary sedimentary deposits (Huichica Formation) of sand and gravels and clays.

All of the Tertiary units beneath the Napa Valley Floor appear to be low to moderately water yielding with poor aquifer characteristics (LSCE and MBK, 2013). Although wells in completed in these units may be locally capable of producing sufficient volumes of water to meet various water demands, their contribution to the overall production of groundwater within the Subbasin is limited. Accordingly, these units are not explicitly considered as part of the conceptual model applied for this Report.

2.3.1.2 Structural Geology/Barriers to Groundwater Flow

The structural geology of the Napa Valley area is extremely complex. Deformational features and structures of the pre-Sonoma Volcanics geologic units are largely unimportant relative to the groundwater storage and availability in the primary aquifer units of the Napa Valley Subbasin, as these units occur outside the valley or are at a great depth below the valley. The collapse caldera in the MST area, while fascinating and locally important, is more stratigraphically significant in its age relationship within the Sonoma Volcanics and the Napa Valley.

<u>Napa Valley Graben</u>

The simplest, generalization of the structure of the Napa Valley Subbasin is to describe it as a graben, a fault-bound, down-dropped block relative to the adjacent uplifted blocks. The best visualization of this is the isostatic gravity map of Langenheim and others (2006). The northern gravity-low basin extends northwestward beneath the middle valley, indicating, thick low density Sonoma Volcanics over older geologic units. A higher gravity ridge occurs beneath the Yountville Narrows indicating thinner Sonoma Volcanics and the exposure of older rocks on the east side of the valley. The smaller southern, gravity-low basin extends south to the Suscol Narrows, where a narrow higher gravity ridge separates it from the larger, deeper gravity-low basin below San Pablo Bay.

West Boundary Fault Zone

The graben bounding faults have been mapped variously on the different geologic maps. The best depictions of the faults are Graymer and others (2007) and the more detailed California Geological Survey (CGS) maps (see previous sections). The west boundary fault is the West Napa Fault Zone which separates the Mesozoic rocks to the west from the small Sonoma Volcanics exposures along the valley side. The main fault appears to be a steeply west-dipping reverse fault with movement up on the west side, but also right lateral movement, northwestward, strike-slip faulting reported.

The West Napa Fault Zone appears to be composed of a complex of multiple faults subparallel to one another, east of the main fault. A strand of faults appears to diverge more northward just west of the City of Napa and trends east of the Sonoma Volcanics hills through Yountville and on the east side of the Yountville Hills.

East Valley Fault Zone

The east boundary fault has been more elusive to map. A concealed fault extending northward just east of or below the river from Suscol to the Soda Creek fault in the northwest MST area has some evidence from subsurface information and from the isostatic gravity map (Langenheim and others, 2006). The study reported herein found some subsurface evidence that a concealed fault may extend northward below the trend of Napa River parallel to the valley side. This possible fault may extend further north on the east side of the Yountville Narrows as shown on the CGS map of the Yountville Quad (Bezore and others, 2005). A linear feature just south of the Yountville Narrows may be either a fault or possibly an erosional feature.

An eastern boundary fault along the eastern part of the northern Yountville Narrows and northward to Conn Creek has not been discerned. Some subsurface information in the present study indicates some possible concealed fault traces west of the valley side. At the mouth of Conn Creek Canyon, complex parallel faults occur in the Sonoma Volcanics and Tertiary sedimentary rocks; these extend northward parallel to the valley.

Strike and Dip of Bedding

The final structural element to consider is the strike and dip of beds, i.e., the geographic direction of the bed and the angle that the bed slopes into the subsurface. Around the middle valley in the north, Sonoma and Tertiary sedimentary beds trend parallel to the valley and dip steeply (greater than 45°) towards the valley center, giving a synclinal aspect to the gravity basin. In the Yountville Narrows area, strike and dips are more variable, but generally exhibit lower dip. Around the lower valley, strike and dips of the Sonoma Volcanics are poorly known. The strike and dip of the beds must be considered when evaluating the subsurface geology.

2.3.2 Groundwater Recharge

Groundwater recharge in the Napa Valley Subbasin is a key component of the water balance. Understanding the spatial distribution of groundwater recharge is important in interpreting groundwater conditions and trends and for planning and implementing sustainable groundwater management actions. Groundwater recharge within the Napa Valley Subbasin occurs primarily through infiltration and deep percolation of rainfall and applied irrigation water within the Napa Valley (where excess water percolates past the root zone to the water table). Precipitation falling on upland areas adjacent to the Napa Valley can runoff and become streamflow and/or percolate to groundwater and contribute groundwater to the Napa Valley Subbasin. A Root Zone Water Balance Model, described in **Chapter 6**, was developed to account for groundwater recharge contributions resulting from precipitation and irrigation across the Subbasin.

Surficial geologic units present at the land surface possessing hydraulic characteristics that enable infiltration and percolation of water are shown on **Figure 2-17**. These geologic materials have relatively higher permeability enabling precipitation and surface waters to more readily infiltrate and naturally recharge groundwater (**Figure 2-17**). Most of these high-permeability materials consist of unconsolidated alluvial sediments deposited within the Napa Valley Subbasin, although some areas where the Sonoma Volcanics exist, mainly in upland areas in the northern parts of the County, represent additional areas of potential groundwater recharge. Areas with low slope (<30 degrees) and high-permeability geologic units represent areas with the greatest potential for groundwater recharge because precipitation does not run off as rapidly on these flatter land surfaces and thus a larger fraction is able to infiltrate into the ground (**Figure 2-17**).

Recharge of groundwater also occurs through surface water infiltration of water flowing within stream and river channels; this occurs during times and at locations where groundwater levels are below the stream stage. Previous studies have estimated some components of historical groundwater recharge and identifies segments of the Napa River with potential for recharging groundwater (LSCE and MBK, 2013; LSCE, 2013). Based on the relationship between surface water and groundwater elevations, segments of the Napa River with potential to recharge groundwater have been interpreted. The surface and groundwater monitoring sites maintained by Napa County within the Napa Valley Subbasin highlight the dynamic and variable relationship between surface water and groundwater including both conditions of baseflow-dominated river flows and also surface water recharge to the groundwater system. The Subbasin water budget presented in Chapter 6 implicitly accounts for recharge that occurs along surface water channels within the Subbasin as part of the difference between runoff entering the Subbasin and surface water outflow from the Subbasin.

Areas of Naturally-Occurring Recharge

Geologic units present at the land surface within Napa County possessing hydraulic characteristics that enable infiltration and percolation of water are shown on **Figure 2-17**. These geologic materials have relatively higher permeability enabling precipitation and surface waters to more readily infiltrate and naturally recharge groundwater (**Figure 2-17**). Most of these high-permeability materials consist of unconsolidated alluvial sediments deposited within the Napa Valley Subbasin, although some areas where the Sonoma Volcanics exist, mainly in upland areas in the northern parts of the County, represent additional areas of potential groundwater recharge. Areas with low slope (<30 degrees) and high-permeability geologic units represent areas with the greatest potential for groundwater recharge because precipitation does not run off as rapidly on these flatter land surfaces and thus a larger fraction is able to infiltrate into the ground (**Figure 2-17**).

2.3.3 Uplands Runoff

Uplands Runoff is an inflow component to the Subbasin representing the sum of overland flow and channelized streamflow reaching the Subbasin from the uplands of the Subbasin watershed. In the case of channelized streamflow, the total flows are a composite of stormflow and shallow groundwater baseflow. Uplands Runoff is seasonally variable, with the largest flows occurring during the winter and spring rainy seasons. The Uplands Runoff component conceptualized for this Report excludes runoff that is withheld by municipal reservoirs located in the watershed above the Subbasin.

2.3.4 Upland Subsurface Inflow

Precipitation falling on upland areas adjacent to the Subbasin can percolate to groundwater and contribute groundwater to the Napa Valley Subbasin through the flow of groundwater into the Subbasin geologic formations from adjacent geologic formations. This component, Upland Subsurface Inflow, is spatially variable around the Subbasin boundary. Faye (1973) estimated average subsurface inflows of 0.50 CFS to the Napa Valley alluvial aquifer system, with the majority of the inflow occurring east and southeast of St. Helena. This corresponds to an annual inflow of 362 acre-feet per year (AFY). Johnson (1977) estimated that outflow from the MST into the Napa Valley was approximately 2,050 AFY. Subsequently, Farrar and Metzger (2003) estimated inflows of 600 AFY for the same area. The water budget presented in **Chapter 6** accounts for subsurface inflow from Quaternary geologic formations within 500 meters of the Subbasin boundary. **Figure 2-18** depicts the Upland Subsurface Inflow to the Subbasin for water year 2005 as calculated by the California Basin Characterization Model (Flint et al, 2013).

2.3.5 Imported Surface Water Deliveries

Imported Surface Water Deliveries to the Subbasin include withdrawals from municipal reservoirs in the watershed above the Subbasin as well as water conveyed to the municipal users through the North Bay Aqueduct of the State Water Project. These deliveries are accounted for separately in the conceptual model because they are largely controlled and subject to the quantifiable deliveries recorded by the four municipalities in the Subbasin and other entities that purchase surface water imported to the Subbasin.

2.3.6 Surface Water Outflow

The Surface Water Outflow component of the conceptual model represents the sum of stormflow and shallow groundwater baseflow conveyed out of the Subbasin by the Napa River. Similar to the Uplands Runoff component, Surface Water Outflow is seasonally variable. Long-term streamflow records collected by the U.S. Geological Survey (USGS) provide the basis for the majority of the total Surface Water Outflow component. Outflow from portions of the Subbasin which are not reflected in the long-term streamflow gage record are empirically estimated for this Report. **Figure 2-19** shows springs and wetlands mapped within the Subbasin. These include springs in the vicinity of Calistoga and Estuarine and Riverine tidal channels in the southern portion of the Subbasin, extending to within the City of Napa.

2.3.7 Consumptive Uses of Surface Water and Groundwater Pumping

A portion of surface water and groundwater use become outflows from the Subbasin as evapotranspiration. Groundwater is pumped from the Subbasin by a variety of users for uses, including domestic, commercial, and agricultural. Consumptive surface water use in the Subbasin occurs primarily to meet crop irrigation demands.

2.3.8 Subsurface Groundwater Outflow

Subsurface Groundwater Outflow represents the flow of groundwater leaving the Subbasin across the boundary with the Napa-Sonoma Lowlands Subbasin.

2.3.9 Urban Wastewater Outflow

Wastewater from the City of Napa is conveyed by pipeline to the Napa Sanitation District wastewater treatment plant outside of the Subbasin. This outflow is included as a separate component of the conceptual model because it occurs through a means of conveyance separate from other sources of outflow reflected by other components. Wastewater discharges by other cities and water users in the Subbasin are not accounted for as separate components because those discharges are reflected in the Surface Water Outflow component, for wastewater discharged to the Napa River, and by evapotranspiration demands accounted for by the groundwater recharge calculated by the Root Zone Model described in **Chapter 6**.

3 MONITORING NETWORK AND PROGRAM

This section describes the monitoring network, including county-wide monitoring objectives[8], monitoring protocols, and data reporting requirements. In order to characterize groundwater and related surface water conditions in the basin and to evaluate changing conditions, the monitoring network is designed to collect data of sufficient quality, frequency, and distribution. The network described below is based on Napa County's existing Groundwater Monitoring Plan 2013 (LSCE, 2013; **Appendix C**) and 2015 Annual Monitoring Report (LSCE, 2016; **Appendix D**).

3.1 Napa Valley Subbasin Groundwater and Surface Water Monitoring Network and Program Summary (354.34)

The following text describes the approaches used to monitor the impacts to the beneficial uses or users of groundwater, monitor the changes in groundwater conditions relative to measurable objectives and minimum thresholds, and to quantify annual changes in water budget components to effectively assess and report on long-term Subbasin sustainability indicators[9]. The monitoring network and program design allows for analysis of groundwater data on a short-term, seasonal, and long-term basis to determine trends in groundwater and related surface conditions. Discussion and details regarding sustainability indicators, quantitative values for the minimum thresholds and measurable objectives that will be measured can be found in **Chapter 7**.

Groundwater level monitoring is performed to assess the sustainability indicators of 1) chronic lowering of groundwater levels, 2) reduction of groundwater storage, and 3) streamflow depletion. Groundwater quality monitoring is performed to assess the sustainability indicators of 1) seawater intrusion, and 2) degraded water quality. Surface water-groundwater monitoring is performed to assess the sustainability indicator of Depletions of Interconnected Surface Water. Land subsidence is not an issue in the Napa Valley Subbasin and is not a monitoring priority, but Continuous Global Positioning System (CGPS) monitoring exists should land subsidence become a priority indicator in the future.

3.1.1 Groundwater Levels

The objectives of the groundwater level monitoring program for the Napa Valley Subbasin include the following (LSCE, 2016; *Napa County Comprehensive Groundwater Monitoring Program 2015 Annual Report and CASGEM Update*):

- Improve the understanding of the occurrence and movement of groundwater; monitor local and regional groundwater levels including seasonal and long-term trends; and identify vertical hydraulic head differences in the aquifer system and aquifer-specific groundwater conditions, especially in areas where short- and long-term development of groundwater resources are planned;
- Detect the occurrence of, and factors attributable to, natural (e.g., direct infiltration of precipitation, surface water seepage to groundwater, groundwater discharge to streams) or

[8] Measurable objectives are discussed in Chapter 7.
[9] SGMA sustainability indicators are discussed in Chapter 7.

induced factors (e.g., pumping, purposeful recharge operations) that affect groundwater levels and trends;

- Identify appropriate monitoring sites to further evaluate groundwater-surface water interaction and recharge/discharge mechanisms, including whether groundwater utilization is affecting surface water flows;
- Establish a monitoring network to aid in the assessment of changes in groundwater storage; and
- Generate data to better estimate groundwater basin conditions and assess local current and future water supply availability and reliability; update analyses as additional data become available.

In 2015, 113 wells were monitored for groundwater levels. Napa County monitored 100 sites for groundwater levels, DWR monitored four sites, and nine sites were measured as part of the SWRCB Regulated Facilities Geotracker Program. Summary information for monitored sites is provided in **Table 3.1** (from Appendix A of LSCE, 2016; *Napa County Comprehensive Groundwater Monitoring Program 2015 Annual Report and CASGEM Update)*. Site information (including well location, reference point elevation, well depth, and monitoring frequency) is also included in **Table 3.1**. Representative monitoring sites are highlighted in **Table 3.1**, with more information on these sites in **Chapter 7**. A majority of the wells in the County's network are privately owned; their information is confidential and limits some level of disclosure and data sharing, pending the terms and conditions of any monitoring agreements between well owners and the County. The data are used for local planning and management purposes. **Chapter 8** provides more information about Napa County's data management and disclosure policy related to volunteered data.

Current groundwater level monitoring sites in Napa County are totaled by groundwater subarea in **Table 3.2** below (from Table 4-2, LSCE, 2016; *Napa County Comprehensive Groundwater Monitoring Program 2015 Annual Report and CASGEM Update)*. In 2015, at the 113 wells, Napa County conducted semi-annual groundwater level monitoring at 82 wells across the county, with the majority of wells located within the Napa Valley Floor Subareas. Eight wells were monitored by Napa County on a monthly interval, and 10 wells were monitored using continuously recording instrumentation at dedicated monitoring wells constructed as part of the County's Surface Water-Groundwater Monitoring Project (LSCE, 2016; **Appendix E**). As of 2015, the Napa County CASGEM Monitoring Network included 23 privately-owned wells monitored by Napa County and the five dual-completion dedicated monitoring wells from the Surface Water-Groundwater Monitoring Project. Wells in the CASGEM monitoring network are distributed across all five Napa Valley Floor Subareas (Calistoga, St. Helena, Yountville, Napa, and MST), as well as the Carneros, Angwin, Eastern Mountains, and Western Mountains Subareas. Fourteen (14) of the CASGEM Network wells are located in Napa Valley Subbasin of the Napa-Sonoma Valley Groundwater Basin. The DWR currently monitors four wells in Napa County as part of its voluntary groundwater monitoring efforts, three of which are monitored at monthly intervals, and the other semi-annually, and are located in the Napa Valley Floor (LSCE, 2016; *Napa County Comprehensive Groundwater Monitoring Program 2015 Annual Report and CASGEM Update)*.

The locations of groundwater level monitoring sites in the monitoring network are well-distributed throughout the subbasin, considering factors such as data availability, current population, and groundwater utilization. **Figure 3.1** illustrates the locations of all current groundwater level monitoring sites and symbolizes each site according to its monitoring entity.

Table 3.1 Summary of Current Groundwater Level Monitoring Locations (from Appendix A, LSCE, 2016; *Napa County Comprehensive Groundwater Monitoring Program 2015 Annual Report and CASGEM Update*[10,11]

Subarea	SWN/CASGEM ID	Well ID	Reporting Network as of 2015	Period of Record	Location	Elevation of Reference Point	Well Depth	Monitoring Frequency
Angwin		NapaCounty-165	Local County Reporting	2014 - 2015	38.590337/-122.469367	1857	673	Semi-Annual
Angwin		NapaCounty-166	Local County Reporting	2014 - 2015	38.583742/-122.458069	1755.8	NA	Semi-Annual
Angwin		NapaCounty-167	Local County Reporting	2014 - 2015	38.570674/-122.432151	1842.3	555	Semi-Annual
Angwin		NapaCounty-168	Local County Reporting	2014 - 2015	38.560797/-122.45685	1639	307	Semi-Annual
Angwin	385684N1224485W001	NapaCounty-202	CASGEM	2014 - 2015	38.568436/-122.448517	1728.2	NA	Semi-Annual
Berryessa		T0605500298	Geotracker	2004 - 2015	38.58871/-122.2551217	93.77	45.5	Geotracker
Berryessa		T0605500304	Geotracker	2002 - 2015	38.622066753/-122.286708614	452.01	40	Geotracker
Berryessa		T0605591908	Geotracker	2006 - 2015	38.5351371/-122.2245236	573.28	34	Geotracker
Carneros	004N004W05C001M 382285N1223290W001	NapaCounty-150	CASGEM	2011 - 2015	38.229307/-122.325848	32.7	NA	Semi-Annual
Carneros	004N004W05A001M 382289N1223213W001	NapaCounty-153	CASGEM	2012 - 2015	38.228926/-122.321256	47.65	200	Semi-Annual
Carneros	005N004W31R001M 382312N1223394W001	NapaCounty-154	CASGEM	2012 - 2015	38.231151/-122.339426	96.65	300	Semi-Annual
Carneros	004N004W06M001M 382197N1223525W001	NapaCounty-155	CASGEM	2012 - 2015	38.219695/-122.35254	23.8	220	Semi-Annual
Carneros		NapaCounty-176	Local County Reporting	2014 - 2015	38.24131/-122.314262	53.4	NA	Semi-Annual
Carneros		NapaCounty-194	Local County Reporting	2014 - 2015	38.252923/-122.323518	75.1	215	Semi-Annual

[10] Cells highlighted in gray indicate Representative Monitoring Sites (see Chapter 7 for more information)
[11] Table is current through 2015 and will be updated to reflect monitoring in 2016 prior to submittal to DWR.

Subarea	SWN/CASGEM ID	Well ID	Reporting Network as of 2015	Period of Record	Location	Elevation of Reference Point	Well Depth	Monitoring Frequency
Carneros	382500N1223255W001	NapaCounty-195	CASGEM	2014 - 2015	38.250044/-122.325496	94.8	205	Semi-Annual
Carneros	382199N1223274W001	NapaCounty-200	CASGEM	2014 - 2015	38.21994/-122.32743	15.7	NA	Semi-Annual
Carneros	382187N1223385W001	NapaCounty-201	CASGEM	2014 - 2015	38.218668/-122.338546	50.4	NA	Semi-Annual
Carneros		NapaCounty-205	Local County Reporting	2014 - 2015	38.24234/-122.316635	56.8	NA	Semi-Annual
Carneros		NapaCounty-206	Local County Reporting	2014 - 2015	38.241135/-122.314102	52.4	NA	Semi-Annual
Carneros		NapaCounty-207	Local County Reporting	2014 - 2015	38.222317/-122.321136	17	NA	Semi-Annual
Central Interior Valleys		L10003756160	Geotracker	1990 - 2015	38.4538865/-122.1832631	NA	NA	Geotracker
Central Interior Valleys		NapaCounty-209	Local County Reporting	2014 - 2015	38.568028/-122.380087	918	235	Semi-Annual
Eastern Mountains		NapaCounty-175	Local County Reporting	2014 - 2015	38.539089/-122.465561	672.3	400	Semi-Annual
Eastern Mountains		NapaCounty-193	Local County Reporting	2014 - 2015	38.283119/-122.21977	693.1	NA	Semi-Annual
Eastern Mountains		NapaCounty-210	Local County Reporting	2014 - 2015	38.449048/-122.276881	1622.9	NA	Semi-Annual
Jameson American Canyon		NapaCounty-196	Local County Reporting	2014 - 2015	38.188046/-122.258736	57.4	165	Semi-Annual
NVF-Calistoga	008N006W10Q001M 385529N1225106W001	08N06W10Q001M	Monthly DWR	1949 - 2015	38.5529/-122.5106	293.43	200	Monthly
NVF-Calistoga	009N007W25N001M 385926N1225938W001	NapaCounty-127	Local County and DWR Reporting	1962 - 2015	38.593241/-122.592484	381	149	Semi-Annual
NVF-Calistoga	009N006W31Q001M 385791N1225636W001	NapaCounty-128	CASGEM	1962 - 2016	38.579352/-122.563038	341	50	Monthly
NVF-Calistoga	008N006W06L004M 385725N1225709W001	NapaCounty-129	Local County and DWR Reporting	1962 - 2015	38.571574/-122.568316	336	253	Semi-Annual
NVF-Calistoga		NapaCounty-178	Local County Reporting	2014 - 2015	38.571133/-122.533691	301.5	NA	Semi-Annual

Subarea	SWN/CASGEM ID	Well ID	Reporting Network as of 2015	Period of Record	Location	Elevation of Reference Point	Well Depth	Monitoring Frequency
NVF-Calistoga		NapaCounty-203	Local County Reporting	2014 - 2015	38.562176/-122.534889	304	180	NA
NVF-Calistoga		NapaCounty-224	Local County Reporting	2014 - 2015	38.547487/-122.50424	272	NA	Semi-Annual
NVF-Calistoga	NapaCounty-225	Local County Reporting	2014 - 2015	38.545149/-122.5086	311.75	NA	Semi-Annual	
NVF-MST	005N003W05M001M 383052N1222269W001	NapaCounty-10	Local County and DWR Reporting	1979 - 2015	38.30521142/-122.2265419	255.6	320	Semi-Annual
NVF-MST	005N003W07B00_My	NapaCounty-118	Local County Reporting	2001 - 2015	38.29963889/-122.2347444	150.45	NA	Semi-Annual
NVF-MST	006N004W26L00_M	NapaCounty-122	Local County Reporting	2001 - 2015	38.33565/-122.2744722	56.45	NA	Semi-Annual
NVF-MST	005N004W13H001M 382830N1222482W001	NapaCounty-137	CASGEM	1979 - 2015	38.283361/-122.248289	132.9	364	Semi-Annual
NVF-MST	006N004W25G00_M	NapaCounty-142	Local County Reporting	2001 - 2015	38.33793889/-122.2495194	121.5	NA	Semi-Annual
NVF-MST	005N003W05M00_M 383051N1222268W001	NapaCounty-148	Local County and DWR Reporting	2009 - 2015	38.3052/-122.2265	255.9	NA	Semi-Annual
NVF-MST	005N003W08E00_M	NapaCounty-149	Local County Reporting	2010 - 2015	38.296/-122.2252	258.9	NA	Semi-Annual
NVF-MST	005N004W13G004M	NapaCounty-18	Local County Reporting	2000 - 2015	38.28000801/-122.2543139	121.6	189	Semi-Annual
NVF-MST	383402N1222714W001	NapaCounty-191	CASGEM	2014 - 2015	38.340202/-122.271438	63.1	150	Semi-Annual
NVF-MST		NapaCounty-192	Local County Reporting	2014 - 2015	38.303778/-122.251452	156.8	496	Semi-Annual
NVF-MST	006N004W23J001M 383485N1222639W001	NapaCounty-2	Local County and DWR Reporting	1979 - 2015	38.34783867/-122.2640781	87.8	700	Semi-Annual
NVF-MST	005N003W07C003M 382998N1222375W001	NapaCounty-20	Local County and DWR Reporting	1978 - 2015	38.29982677/-122.2375189	131.5	208	Semi-Annual
NVF-MST	005N003W08E001M	NapaCounty-22	Local County Reporting	2000 - 2015	38.29603804/-122.225197	255	135	Semi-Annual
NVF-MST		NapaCounty-226	Local County Reporting	2015 - 2015	38.331152/-122.259142	84.9	NA	Semi-Annual

Subarea	SWN/CASGEM ID	Well ID	Reporting Network as of 2015	Period of Record	Location	Elevation of Reference Point	Well Depth	Monitoring Frequency
NVF-MST	005N003W18D001M	NapaCounty-35	Local County Reporting	2000 - 2015	38.28672195/-122.244836	136.9	NA	Semi-Annual
NVF-MST	006N004W23Q003M 383484N1222702W001	NapaCounty-43	CASGEM	1978 - 2015	38.34832875/-122.2702182	106.3	310	Semi-Annual
NVF-MST	005N004W14J003M 382789N1222633W001	NapaCounty-49	CASGEM	1899 - 2015	38.27866859/-122.263953	78	399	NA
NVF-MST	006N004W26G001M 383408N1222706W001	NapaCounty-56	Local County and DWR Reporting	1978 - 2015	38.34049654/-122.2708955	55.9	210	Semi-Annual
NVF-MST	006N004W35G005M	NapaCounty-69	Local County Reporting	2000 - 2015	38.32477084/-122.268585	39.4	NA	Semi-Annual
NVF-MST	005N003W07D003M	NapaCounty-72	Local County Reporting	2000 - 2015	38.30039692/-122.2450799	134.4	245	Semi-Annual
NVF-MST	005N003W06M001M 383057N1222444W001	NapaCounty-74	CASGEM	1999 - 2015	38.30570799/-122.2443772	130.6	300	Semi-Annual
NVF-MST	005N003W07F003M	NapaCounty-81	Local County Reporting	2000 - 2015	38.29657251/-122.2400029	115.9	290	Semi-Annual
NVF-MST	005N003W06B002M 383133N1222325W001	NapaCounty-91	CASGEM	1992 - 2014	38.30858628/-122.234265	279.2	415	Semi-Annual
NVF-MST	005N003W06A001M 383161N1222237W001	NapaCounty-92	CASGEM	1999 - 2015	38.31606501/-122.2237404	295.7	368	Semi-Annual
NVF-MST	006N004W36G001M 383255N1222519W001	NapaCounty-95	Local County and DWR Reporting	1979 - 2015	38.32530038/-122.2522544	111.5	195	Semi-Annual
NVF-MST	006N004W36A001M	NapaCounty-98	Local County Reporting	2000 - 2015	38.329562/-122.2482524	123	NA	Semi-Annual
NVF-MST		T0605500200	Geotracker	2014 - 2015	38.2890632/-122.2755091	NA	NA	Geotracker
NVF-MST		T10000005248	Geotracker	2013 - 2015	38.2578674/-122.2725669	NA	NA	Geotracker
NVF-Napa	006N004W27L002M 383359N1222916W001	006N004W27L002M	Monthly DWR	1966 - 2015	38.3359/-122.2916	53.6	120	Monthly
NVF-Napa	005N004W15E001M 382816N1222967W001	005N004W15E001M[12]	DWR	1949 - 1978	38.2816/-122.2967	24.92	158	NA

[12] This well is currently monitored for groundwater quality parameters. It is planned that groundwater level monitoring will resume in 2017.

Subarea	SWN/CASGEM ID	Well ID	Reporting Network as of 2015	Period of Record	Location	Elevation of Reference Point	Well Depth	Monitoring Frequency
NVF-Napa	006N004W27N001M 383316N1222987W001	NapaCounty-136	CASGEM	1979 - 2016	38.331302/-122.299419	50.5	120	Monthly
NVF-Napa	006N004W28Mx 383358N1223171W001	NapaCounty-152	Local County Reporting	2012 - 2015	38.335773/-122.317117	78.3	NA	Semi-Annual
NVF-Napa	383543N1222914W001	NapaCounty-182	CASGEM	2014 - 2016	38.354305/-122.291443	48.1	400	Monthly
NVF-Napa		NapaCounty-183	Local County Reporting	2014 - 2015	38.352626/-122.29732	48.9	310	Semi-Annual
NVF-Napa		NapaCounty-184	Local County Reporting	2014 - 2015	38.35685/-122.311274	72.5	755	Semi-Annual
NVF-Napa		NapaCounty-185	Local County Reporting	2014 - 2016	38.354875/-122.315387	83	260	Monthly
NVF-Napa		NapaCounty-187	Local County Reporting	2014 - 2015	38.335066/-122.344185	153.5	630	Semi-Annual
NVF-Napa		NapaCounty-188	Local County Reporting	2014 - 2015	38.335833/-122.345173	154.6	540	Semi-Annual
NVF-Napa		NapaCounty-189	Local County Reporting	2014 - 2015	38.340193/-122.335153	108.25	600	Semi-Annual
NVF-Napa	383411N1223434W001	NapaCounty-227	CASGEM	2015 - 2015	38.341146/-122.343444	143.3	260	Semi-Annual
NVF-Napa		NapaCounty-228	Local County Reporting	2015 - 2015	38.3567/-122.2888	50.2	206	Semi-Annual
NVF-Napa	006N004W15R003M	NapaCounty-76	Local County Reporting	2000 - 2015	38.35974845/-122.2829725	95	NA	Semi-Annual
NVF-Napa	383022N1222784W001	NapaCounty-214s-swgw1	CASGEM	2014 - 2015	38.302163/-122.278444	22.1	53	Semi-Annual/ Continuous
NVF-Napa	383022N1222784W002	NapaCounty-215s-swgw1	CASGEM	2014 - 2015	38.302163/-122.278444	22.05	98	Semi-Annual/ Continuous
NVF-Napa	383674N1223046W001	NapaCounty-218s-swgw3	CASGEM	2014 - 2015	38.367428/-122.304619	52.8	40	Semi-Annual/ Continuous
NVF-Napa	383674N1223046W002	NapaCounty-219s-swgw3	CASGEM	2014 - 2015	38.367428/-122.304619	52.85	93	Semi-Annual/ Continuous
NVF-Napa		SL0605536682	Geotracker	2005 - 2015	38.2989098/-122.2920108	28.94	24	Geotracker

Subarea	SWN/CASGEM ID	Well ID	Reporting Network as of 2015	Period of Record	Location	Elevation of Reference Point	Well Depth	Monitoring Frequency
NVF-Napa		T0605500009	Geotracker	2005 - 2015	38.29399861/-122.303016	40.36	13	Geotracker
NVF-Napa		T0605514064	Geotracker	2005 - 2015	38.2816342/-122.2941553	14.72	21	Geotracker
NVF-Saint Helena	007N005W09Q002M 384635N1224182W001	07N05W09Q002M	Monthly DWR	1949 - 2015	38.4635/-122.4182	158.24	232	Monthly
NVF-Saint Helena	007N005W16L001M 384560N1224223W001	NapaCounty-131	CASGEM	1963 - 2015	38.455743/-122.422479	171.8	221	Semi-Annual
NVF-Saint Helena	007N005W14B002M 384616N1223811W001	NapaCounty-132	CASGEM	1962 - 2016	38.4616/-122.3811	142	265	Monthly
NVF-Saint Helena	007N005W16N002M 384518N1224299W001	NapaCounty-138	CASGEM	1949 - 2015	38.4518/-122.4299	193.1	321	Semi-Annual
NVF-Saint Helena	385000N1224744W001	NapaCounty-169	CASGEM	2014 - 2015	38.5/-122.474434	273.4	400	Semi-Annual
NVF-Saint Helena		NapaCounty-171	Local County Reporting	2014 - 2016	38.495026/-122.462173	245.1	438	Monthly
NVF-Saint Helena		NapaCounty-172	Local County Reporting	2014 - 2015	38.496385/-122.476271	275.2	500	Semi-Annual
NVF-Saint Helena		NapaCounty-173	Local County Reporting	2014 - 2015	38.498073/-122.475071	268.3	362	Semi-Annual
NVF-Saint Helena		NapaCounty-174	Local County Reporting	2014 - 2015	38.500324/-122.47905	298.2	505	Semi-Annual
NVF-Saint Helena		NapaCounty-177	Local County Reporting	2014 - 2015	38.44879/-122.412071	149.3	NA	Semi-Annual
NVF-Saint Helena		NapaCounty-204	Local County Reporting	2014 - 2015	38.450245/-122.406113	141.7	NA	Semi-Annual
NVF-Saint Helena		NapaCounty-212	Local County Reporting	2015 - 2015	38.51074/-122.456663	220.5	NA	Semi-Annual
NVF-Saint Helena	385110N1224564W001	NapaCounty-222s-swgw5	CASGEM	2014 - 2015	38.510951/-122.456379	218.5	40	Semi-Annual/ Continuous
NVF-Saint Helena	385110N1224564W002	NapaCounty-223s-swgw5	CASGEM	2014 - 2015	38.510951/-122.456379	218.55	100	Semi-Annual/ Continuous
NVF-Yountville	006N004W17A001M 383721N1223189W001	06N04W17A001M	Semi-annual DWR	1949 - 2015	38.3721/-122.3189	70.26	250	Semi-Annual

Subarea	SWN/CASGEM ID	Well ID	Reporting Network as of 2015	Period of Record	Location	Elevation of Reference Point	Well Depth	Monitoring Frequency
NVF-Yountville	006N004W09Q001M 383769N1223065W001	NapaCounty-125	CASGEM	1979 - 2015	38.3769/-122.3065	62.8	160	Semi-Annual
NVF-Yountville	006N004W09Q002M 383770N1223067W001	NapaCounty-126	CASGEM	1984 - 2015	38.377/-122.3067	62.8	345	Semi-Annual
NVF-Yountville	007N004W31M001M 384116N1223530W001	NapaCounty-133	Local County and DWR Reporting	1978 - 2016	38.411578/-122.352477	92	120	Monthly
NVF-Yountville	006N004W06L002M 383948N1223497W001	NapaCounty-134	CASGEM	1963 - 2015	38.3948/-122.3497	83	260	Semi-Annual
NVF-Yountville	006N004W19B001M 383554N1223441W001	NapaCounty-135	Local County and DWR Reporting	1979 - 2016	38.3554/-122.3441	126.5	125	Monthly
NVF-Yountville	006N004W17R002M 383603N1223217W001	NapaCounty-139	CASGEM	1978 - 2015	38.360468/-122.320531	83.1	120	Semi-Annual
NVF-Yountville	383779N1223342W001	NapaCounty-179	CASGEM	2014 - 2015	38.37794/-122.334177	74.3	150	Semi-Annual
NVF-Yountville	383754N1223366W001	NapaCounty-180	CASGEM	2014 - 2015	38.375357/-122.33638	76.9	NA	NA
NVF-Yountville		NapaCounty-181	Local County Reporting	2014 - 2015	38.420774/-122.395621	163.6	630	Semi-Annual
NVF-Yountville	383652N1223375W001	NapaCounty-216s-swgw2	CASGEM	2014 - 2015	38.365159/-122.337464	105.8	50	Semi-Annual/ Continuous
NVF-Yountville	383652N1223375W002	NapaCounty-217d-swgw2	CASGEM	2014 - 2015	38.365159/-122.337464	105.8	86	Semi-Annual/ Continuous
NVF-Yountville	384176N1223527W001	NapaCounty-220s-swgw4	CASGEM	2014 - 2015	38.417589/-122.352706	99.7	45	Semi-Annual Continuous /
NVF-Yountville	384176N1223527W002	NapaCounty-221s-swgw4	CASGEM	2014 - 2015	38.417589/-122.352706	99.7	85	Semi-Annual/ Continuous
Pope Valley		NapaCounty-211	Local County Reporting	2014 - 2015	38.653348/-122.465437	708.2	NA	Semi-Annual
Western Mountains	385421N1225129W001	NapaCounty-208	CASGEM	2014 - 2015	38.542145/-122.512863	503.4	320	Semi-Annual
Western Mountains	385235N1224996W001	NapaCounty-213	CASGEM	2014 - 2015	38.523502/-122.49958	390.8	340	Semi-Annual

Table 3.2 Current Groundwater Level Monitoring Sites in Napa County by Groundwater Subarea

Groundwater Subarea	Number of Monitored Sites Through 2011	Number of Monitored Sites, Fall 2014	Number of Monitored Sites, Fall 2015
Napa Valley Floor-Calistoga	6	10	9
Napa Valley Floor-MST	29	27	27
Napa Valley Floor-Napa	18	21	20
Napa Valley Floor-St. Helena	12	14	14
Napa Valley Floor-Yountville	9	12	14
Carneros	5	12	12
Jameson/American Canyon	1	1	1
Napa River Marshes	1	1	-
Angwin	-	5	5
Berryessa	3	2	3
Central Interior Valleys	1	1	2
Eastern Mountains	-	3	4
Knoxville	1	-	-
Livermore Ranch	-	-	-
Pope Valley	1	1	1
Southern Interior Valleys	-	-	-
Western Mountains	-	2	1
Unknown1	-	3	-
Total Sites	87	115	113

1 In 2014 three sites in the Geotracker regulated groundwater monitoring network were reporting groundwater level data, but had not yet reported location information for the monitored wells.

3.1.2 Groundwater Quality

The objectives of the groundwater quality monitoring program for the Napa Valley Subbasin include the following (LSCE, 2016; *Napa County Comprehensive Groundwater Monitoring Program 2015 Annual Report and CASGEM Update*):

- Evaluate groundwater quality conditions in the various subareas of the basin, and identify differences in water quality spatially between areas and vertically in the aquifer system within a subarea;
- Detect the occurrence of and factors attributable to natural (e.g., general minerals and trace metals) or other constituents of concern;
- Establish baseline conditions in areas of potential saltwater intrusion, including the extent and natural occurrence and/or causes of saltwater beneath the Carneros, Jameson/American Canyon and Napa River Marshes Subareas;

- Assess the changes and trends in groundwater quality (seasonal, short- and long-term trends); and
- Identify the natural and human factors that affect changes in water quality.

Groundwater quality data in Napa County are collected primarily at sites regulated by the SWRCB through the Division of Drinking Water and the Geotracker program, although data are available from other public agencies as well. In addition to the regulated sites overseen by the SWRCB, data from voluntary data collection efforts conducted by Napa County at the ten Surface Water-Groundwater Project monitoring wells and by the USGS and DWR at privately-owned wells are available and incorporated in Napa County's groundwater quality conditions and trends assessments. Water quality data from the ten Napa County Surface Water-Groundwater Project monitoring wells consist of a single round of baseline sampling conducted in June 2015[13]. **Table 3.3** contains the number of recent groundwater quality monitoring sites in Napa County by entity and monitoring program.

Groundwater quality monitoring sites are fairly well distributed throughout the Napa Valley Floor (**Figure 3.2**). Locations of monitoring sites are based on data availability, current population, and groundwater utilization. The frequency of groundwater quality monitoring is dependent upon the monitoring entity, and varies from quarterly, semi-annually, annually, and every three to five years depending upon which chemical constituent is being monitored. An annual frequency is recommended for the 18 wells that are included as representative monitoring sites (see **Chapter 7**).

Table 3.3 Recent Groundwater Quality Monitoring Sites in Napa County by Entity and Monitoring Program

Entity	Reporting Program	Number of Monitored Sites, 2009 - 2015
Napa County	Napa Berryessa Resort Improvement District	2
	Lake Berryessa Resort Improvement District	5
	Surface Water-Groundwater Monitoring Sites	10
California Department of Water Resources	Volunteered Sites	8
State Water Resources Control Board	Division of Drinking Water	35
	Geotracker	3
U.S. Geological Survey	-	18
	Total Sites	**81**

3.1.3 Surface Water

The Napa County Surface Water-Groundwater Monitoring Project started construction in 2014 with ten new monitoring wells at five sites in Napa Valley (**Figure 3.3**). Four of the sites are located along the

[13] In 2017, the County plans to implement annual groundwater quality sampling at its surface water/groundwater monitoring facilities, as well as at other selected County-monitored wells.

Napa River, and one is adjacent to Dry Creek. Each of the five sites includes a dual-completion monitoring well to enable monitoring of groundwater conditions at specific depth intervals. The pair of wells at each site are constructed such that one well is shallow and constructed to represent groundwater conditions at the water table surface and at elevations similar to the adjacent surface water channel. The second well casing at each site is constructed to a deeper depth with screen intervals coinciding with aquifer materials and depths likely to be accessed by production wells in the vicinity. The construction at each site contains an intermediate seal designed to provide a physical separation such that groundwater conditions reflected by each casing are not influenced by conditions in other portions of the groundwater system (LSCE, 2016; *Napa County Comprehensive Groundwater Monitoring Program 2015 Annual Report and CASGEM Update)*. Baseline groundwater quality samples were taken after construction (June 2015), and it is recommended that groundwater quality samples for similar parameters be collected the following year to affirm baseline conditions. Following the baseline sampling and the one-year confirmation sampling, it is recommended that groundwater quality monitoring occur on a triennial basis for general minerals and drinking water metals. Continuous water level, temperature, and conductivity measurements are taken in each well and in the nearby river/creek using transducers set to take measurements on hourly intervals.

Other surface water data in the subbasin, including stream discharge, stream stage, and surface water quality exists from data collected by others (DWR and USGS). **Chapter 4.2** discusses surface water flows and quality that are available in the subbasin, including the data for Napa River, Dry Creek, Conn Creek, Redwood Creek, Milliken Creek, Napa Creek, and Tulucay Creek.

3.2 Monitoring Program Summary (354.36)

Napa County continuously makes recommendations for updates to their monitoring network, based on assessments of groundwater conditions. Napa County's reporting of monitoring results involve (see also **Chapter 8**):

1. Annual Groundwater Monitoring Progress and Data Reports;
2. Annual CASGEM reporting of water levels for those monitoring sites included in the CASGEM network; and
3. Triennial Groundwater Conditions Reports that cover the groundwater level and quality data collected in Napa County by Napa County staff and other entities.

These reports are made available online and provide data to the public in the form of tabulated data and maps, the CASGEM database online, and publicly available report documents through the Watershed Information & Conservation Council of Napa County. Reports include stated goals and objectives of the groundwater monitoring program and include recommended modifications to the program and network, as needed.

A subset of 18 wells that are selected to be representative of conditions in particular areas of the basin are discussed and identified in **Chapter 7**. These representative monitoring sites are suitable for sustainability indicator monitoring. These 18 wells are highlighted with blue shading in Table 3.1 above.

3.3 Monitoring Program Best Management Practices

Monitoring Protocols are included in **Appendix F** for measuring the depth to water in monitoring and production wells. The monitoring protocols adopted by Napa County are developed according to best management practices, and are reviewed at least every five years for potential modification. Groundwater quality monitoring protocols are dependent upon the monitoring entity. For Napa County, the groundwater quality procedures involve 1. Site inspection, 2. Well Purging and Stabilization of Field Parameters, 3. Sample Collection (following laboratory requirements), and 4. Sample Preservation, Handling and Transport for Laboratory Analysis. Detailed methods and procedures used by DWR (1994) and USGS (**http://water.usgs.gov/owq/FieldManual/**) are often used by counties and consultants as guidelines for the collection of water level measurements and water quality samples.

In terms of data and reporting standards for the monitoring network, field measurements of elevations of groundwater, surface water, and land surface are measured and reported in feet to an accuracy of at least 0.1 feet relative to NAVD88 (or another national standard that can be converted to NAVD88). The method of field measurements is described on the field sheets and/or in the annual or five-year reports. Reference point elevations are measured and reported in feet to an accuracy of at least 0.5 feet, or the best available information, using a national standard such as NAVD88. Geographic locations of each monitoring site are reported in global positioning system (GPS) coordinates (as seen in **Table 3.1**) by latitude and longitude in decimal degrees to five decimal places, to a minimum accuracy of 30 feet, relative to NAD83 (or another national standard that is convertible to NAD83).

Information about each monitoring site in the monitoring network includes:

1. A unique site identification number and narrative description of the site location (e.g. Site ID or Well ID)
2. A description of the type of monitoring (e.g., water levels, water quality, river stage, etc.), type of measurement taken, and monitoring frequency
3. Location, elevation of the ground surface (or reference point), and identification and description of the reference point (e.g., top of well casing)
4. A description of the standards used to install the monitoring site

Wells used to monitor groundwater conditions included in the monitoring network are constructed according to applicable construction standards, and provide the following information in a Data Management System (DMS) and/or Geodatabase (or GIS shapefile):

1. CASGEM well identification number (e.g. see **Table 3.1**)
2. Well location, elevation of the ground surface and reference point, including a description of the reference point (e.g., top of well casing)
3. A description of the well use (e.g., public supply, irrigation, domestic, monitoring, industrial, etc.), if the well is active or inactive, and whether the well is a single, clustered, nested, or other type of well
4. Casing perforations (screen depths), borehole depth, and total well depth, which is usually found in the driller's log

5. Well completion report (driller's log) from which the names of private well owners have been redacted
6. Geophysical logs, well construction diagrams, or other relevant information (such as geologic/stratigraphic imagery), if available
7. Identification of principal aquifers monitored
8. Other relevant well construction information, such as well capacity, casing diameter, or casing modifications, as available

If well construction information such as well depth or perforation depths is unavailable for a particular well that is used to monitor groundwater conditions, Napa County will describe a schedule for acquiring monitoring wells that have the required information, or will demonstrate to DWR that such information is not necessary to understand and manage groundwater in the basin. All of the well information is currently housed in Napa County's DMS and/or periodically retrieved from publicly accessible data sources for regional groundwater analyses.

Schematics submitted to DWR, including maps and time-series hydrographs, will follow guidelines included in Regulations § 352.4 (d) and (e) that include submitting the supporting data layers, shapefile, geodatabases, etc. provided with each map, submitted electronically. Hydrographs or other time-series plots shall be submitted electronically to DWR and will include site identification information and ground surface elevation for each site, and will use the same datum and scaling as appropriate. If groundwater and surface water models are developed for the GSP, the model will abide by the standards and input/output file guidelines outlined in § 352.4 (f) and (g).

4 GROUNDWATER AND SURFACE WATER CONDITIONS (354.16)

4.1 Current and Historical Groundwater Conditions

This chapter explores the groundwater conditions of the Napa Valley Subbasin in the context of historical levels and quality. The groundwater-surface water systems of the Napa Valley Subbasin are interconnected in such a way that their conditions involve feedback between the two. For this reason, historical surface water flow conditions were also investigated within the framework of groundwater conditions and water year type.

4.1.1 Groundwater Levels

Groundwater subareas of the Napa Valley Subbasin (**Figure 4-1**) are the Calistoga, St. Helena, Yountville, and Napa vicinities from north to south respectively. The groundwater level conditions in each of these areas are examined in context of the Napa Valley Subbasin as a whole. Over the length of the Napa Valley, groundwater flows through the older and younger alluvium from Calistoga to San Pablo Bay, and is assumed for purposes of contouring groundwater data on a regional basis, to represent a single aquifer. Groundwater trends and conditions in the Napa Valley Subbasin largely depend on precipitation inputs, so groundwater levels are reviewed in context of seasonality (spring and fall) and water year types. **Figure 4-2** depicts both the annual water year precipitation recorded at the Napa State Hospital gauge along with the cumulative departure from the mean water year precipitation value for water years 1950 through 2015. The cumulative departure values (**Figure 4-2**) provide a tally of precipitation received relative to the mean value over time. Since 1949 when most long-term groundwater monitoring records begin, comparable multi-year periods with below average precipitation occurred in 1990 – 1991 (both Dry), 1976 – 1977 (both Very Dry), and 1959 – 1962 (all Dry), 1954 – 1955 (both Dry), and 1947-1949 (all Dry). Successive years of below average precipitation in water years 2012 through 2015 provide an important context for the review of recent groundwater level trends. Notably, the eight-year span from 1987 through 1994, with only one year of above average precipitation, resulted in a net cumulative departure deficit of 38.55 inches (**Figure 4-2**). This protracted period contrasts with the Very Dry years of 1976 and 1977, which although more acute, produced a less severe net cumulative departure deficit of 26.13 inches. Groundwater level records from the Napa Valley Groundwater Subbasin that include both of these time periods generally show the lowest spring groundwater levels in 1977, as compared to the 1987 to 1994 period. This indicates that the subbasin experienced sufficient recharge to maintain relatively stable spring groundwater levels over an eight-year period when precipitation totals were below average on the whole. The four year span from 2012 through 2015 produced a net cumulative departure deficit of 17.04 inches (**Figure 4-2**).

Geologic setting and differences in aquifer zones within a subarea or groundwater subbasin are additional considerations relevant to the interpretation of groundwater levels, particularly for wells constructed entirely or partially within the alluvium in Napa Valley. **Figure 4-3a** depicts two wells located relatively near each other at the land surface which exhibit distinct groundwater levels due in part to having been constructed within different aquifer zones. Well 07N05W09Q2 is located near the center of Napa Valley, where the alluvium extends to approximately 200 feet below ground surface (LSCE and MBK, 2013). NapaCounty-138 has a total depth of 321 feet and is located closer to the western edge of Napa Valley in an area where the alluvium extends only about 50 feet below ground surface. The lower static water levels measured in the fall at NapaCounty-138 indicate that the well draws water from a geologic formation below the alluvium. Knowledge of the geologic setting and construction details for a given well are important considerations when interpreting groundwater level data. **Figure 4-3b** depicts another example of the influence that aquifer zones can have on water levels in wells located in the same area. In this case, the well located east of the Napa River is constructed in the Sonoma Volcanics, while the wells west of the Napa River are constructed within alluvial sediments.

4.1.1.1 Groundwater Contours

The resulting groundwater elevation values at each well were used to interpolate groundwater elevation contours throughout the Napa Valley Floor and in the MST area (**Figures 4-4** and **4-5**). A contour line represents a line of equal elevation of the water surface similar to the way a topographic map contour line shows a line of equal elevation of ground surface. The direction of groundwater flow is perpendicular to the contour lines. The groundwater elevation contours described below are derived from available depth to water measurements made in wells. Prior to interpolating groundwater elevations across the valley, depth to water values were converted to groundwater elevation values by subtracting the measured depth to water from the reference point elevation at each monitored well. In this way the depth to water measurements were related to the North American Vertical Datum 1988 (NAVD88) as a standard point of reference.

Groundwater levels that were determined to represent a non-alluvial part of the aquifer system were excluded from the contouring dataset. Interpreted groundwater elevation contours for spring and fall 2015 are shown in **Figures 4-4** and **4-5**, respectively. Napa Valley Subbasin groundwater elevation contours for spring 2015 appear similar to those developed for spring 2014 and spring 2010 (LSCE, 2013b and 2015). Contours across these time periods show a generally southeasterly to east-southeasterly groundwater gradient paralleling the valley axis from Calistoga to Yountville with similar groundwater elevation ranges. In the southern portion of the valley, near the City of Napa, contours indicate a more eastward flow direction consistent with the spring 2014 contours. Through the valley, groundwater elevations in spring 2015 ranged from 378 feet near Calistoga to 5 feet along the Napa River near First Street in Napa.

4.1.1.2 Representative Groundwater Hydrographs

Groundwater hydrographs for representative wells within the Northern Napa Valley Subbasin, illustrated on **Figure 4-6,** show groundwater elevations and corresponding depth to groundwater from 1970 to present, as available. Groundwater levels have been generally stable over time in the Calistoga Subarea and northern portion of the St. Helena Subarea. Groundwater levels in the representative wells are frequently very shallow at less than ten feet below the ground surface in the spring. Minor seasonal groundwater level variations of about 10 feet occur between spring and fall in the Calistoga Subarea. Groundwater levels in well 8N6W10Q1 have been lower in the late September to December timeframe in seven years since 2001. However, in every year since 1970, including 2015 groundwater levels returned to within 10 feet of the ground surface the following spring (**Figure 4-6**). Elsewhere in the St. Helena Subarea, groundwater levels exhibit greater seasonal declines of about 20 feet. Groundwater levels at well 7N5W09Q2 have remained relatively stable although somewhat susceptible to dry years. An example of this occurred in 1976 and 1977, two Very Dry years in the Napa River Watershed. In 1976, the spring groundwater level measurement was 19.3 feet below ground surface, lower by more than 10 feet from the prior spring. In 1977, the spring groundwater level measurement was 27.2 feet below ground surface, down almost 8 feet from the spring 1976 measurement. Spring water levels in the same well in 2014 and 2015 were 18.6 feet and 13.2 feet below ground surface, respectively; the spring 2014 and 2015 levels are above the levels measured in 1976 and 1977 (**Figure 4-6**). NapaCounty-132 was noted in the 2014 Annual Monitoring Report for possible signs of declining water levels. This well is recorded as having a total depth of 265 feet, screened from 25 feet to 265 feet, in an area where the thickness of alluvial deposits is likely less than 100 feet. The Driller's Log for the well indicates extensive clay (or fine grained, low permeability) layers were encountered, particularly in the upper 100 feet of the boring. In spring 2015 a depth to groundwater of 16.1 feet was measured at this well, which is more comparable to levels seen prior to 2014. A site visit to this well conducted in 2015 showed that much of the surrounding acreage is planted in young vines. A subsequent review of aerial photography showed that a large scale vineyard replanting took place in 2007. Given these observations it is possible that changing irrigation demands have been a factor in this area since 2007.

Groundwater conditions in the Southern Napa Valley Subbasin are depicted by hydrographs shown in **Figure 4-7** for the Yountville and Napa Subareas. Long-term groundwater elevations have remained for the most part stable in the Yountville Subarea. In the Yountville Subarea, the depth to groundwater in the spring is generally less than ten feet, similar in nature to the Calistoga and St. Helena Subareas to the north. Seasonal fluctuations vary by proximity to the center of the valley. Along the western and eastern edges of the subarea, levels are more subject to larger seasonal fluctuations. Groundwater elevations in the center of the valley fluctuate seasonally approximately 10 to 25 feet, and near the edge of the valley fluctuate approximately 25 to 35 feet. In the Napa Subarea, depth to water ranges from about 20 to 50 feet below ground surface during the spring. Seasonal groundwater elevations in this subarea generally fluctuate from 10 to 40 feet. Long-term trends have been generally stable with the exception of the northeastern area at NapaCounty-75 and Napa County-76 where groundwater levels have locally declined by about 20 feet to 30 feet over the past 15 years (**Figure 4-7**). NapaCounty-75 and NapaCounty-76 are located east of the Napa River and East Napa Fault and west of Soda Creek Fault. Both wells are completed below the alluvium in the Sonoma Volcanics formation. The Sonoma Volcanics formation is also present in the MST Subarea to the east (outside the Napa Valley Subbasin), where previous monitoring has shown several pumping depressions (LSCE, 2011a). The two nearest monitoring wells located west of the Napa River in the northeastern Napa Subarea constructed to depths of 120 feet or less and are completed in the alluvium. These wells have shown stable groundwater level trends. The monitoring well in the alluvium that is closest to the well constructed in the Sonoma Volcanics has shown stable water levels since the 1960s. It appears that the extent of the pumping depression beyond the MST subarea is limited to the northeastern Napa Subarea east of the Napa River. Although NapaCounty-75 is no longer actively monitored by Napa County, two additional wells have been added to the County's monitoring networks in this area in the last two years, NapaCounty-182 and NapaCounty-228. In addition to adding new monitoring wells in the northeast portion of the Napa Subarea, the County is considering a focused investigation of groundwater conditions and hydrogeologic constraints in the area east of the Napa River and west of the Soda Creek Fault to address concerns regarding groundwater conditions in this area. In the southwestern part of the Yountville Subarea and at the Napa Valley margin, groundwater levels in well NapaCounty-135 have also declined by about 30 feet since the first measurements were recorded in the late 1970s and early 1980s, with a particularly low spring groundwater level measurement recorded in 2014 (**Figure 4-7**). In response to these observations Napa County began monitoring this well at monthly intervals in summer 2015. The increased frequency of data collection is intended to fill temporal data gaps in the record for this well to understand whether groundwater levels are recovering at different times relative to other wells. Very little construction information is available for NapaCounty-135. All that is known is that it has a total depth of 125 feet. It is located in an area where the total thickness of the alluvium is likely less than 50 feet, based on contours of alluvium thickness (LSCE and MBK Engineers, 2013). In March 2015, the water level at NapaCounty-135 rebounded to a depth of 40.9 feet, comparable to the value recorded in 2013. The dedicated monitoring wells for Site 2 of the Surface Water Groundwater Monitoring Project are less than a mile from NapaCounty-135. Data from those wells will also be used in the future to differentiate between observations at that well and water level trends in the alluvial aquifer system at Site 2.

4.1.2 Summary of Groundwater Level Trends

Groundwater level monitoring was conducted at a total of 113 sites across Napa County in 2015. The overall number and distribution of monitored sites remained consistent with the monitoring conducted in 2014 and was increased relative to the 87 sites reported in the 2011(LSCE, 2013).

Groundwater level trends in the Napa Valley Subbasin of the Napa-Sonoma Valley Groundwater Basin are stable in the majority of wells. Some wells with long historical measurement records illustrate the stability of these water level trends extends over several decades. While many wells have shown at least some degree of response to recent drought conditions, the water levels observed in recent years are generally higher than groundwater levels in the same wells during the 1976 to 1977 drought.

While the majority of wells exhibit stable trends, periods of year-to-year declines in groundwater levels have been observed in a few wells. These wells are located near the Napa Valley margin in the northeastern Napa Subarea (NapaCounty-75 and Napa County-76), southwestern Yountville Subarea (NapaCounty-135) and southeastern St. Helena Subarea (NapaCounty-132). These locations are characterized in part by relatively thin alluvial deposits, which may contribute to more groundwater being withdrawn from the underlying semi-consolidated deposits (see additional discussion in **Chapter 7**).

4.1.3 Groundwater Quality

4.1.3.1 Historical Groundwater Quality

Historical groundwater quality, assessed in LSCE (2011), **Figure 4-8** illustrates all the sites in Napa County from which historical groundwater quality data are available. Historical groundwater quality records from these sites (some with multiple wells) were reviewed to select representative (currently or historically) monitored wells for purposes of illustrating groundwater quality information in Napa County and in each subarea. Some important constituents whose concentrations influence the quality of water for irrigation are TDS, electrical conductivity (EC), sodium, bicarbonate, and boron. Constituents of interest in water used for human consumption include chloride, nitrate, sulfate, fluoride, iron, and sodium. Although historical groundwater quality records can be limited in Napa County, enough data exist to summarize historical baseline conditions and areas of lesser quality.

Groundwater is generally of good quality throughout most subareas. Poor groundwater quality exists in the south and the north-central parts of the County. The poor groundwater quality includes concentrations of metals such as arsenic, iron, and manganese that exceed drinking water standards throughout the county. Elevated levels of boron are also prevalent in most subareas. Subareas south of the Napa Valley Floor, such as the Carneros and Napa River Marshes, have poor quality water due to high levels of EC, TDS, and chloride. The Calistoga Subarea of the Napa Valley Floor also has poor quality water in many wells due to hydrothermal conditions resulting in higher concentrations of metals. Nitrate concentrations are not a concern throughout the county, but tend to be somewhat higher in agricultural areas in the Napa Valley Floor.

Table 4-1 summarizes findings about groundwater quality conditions in the County pertinent to the Napa Valley Subbasin and subareas south of the subbasin.

Table 4-1 Findings: Groundwater Quality Conditions and Available Historical Data[1]

Napa Valley Subbasin (Related Subareas)	Constituents[2]	WQ Comment
Napa Valley Floor-Calistoga	As, B	Limited data record, minimal historical record
Napa Valley Floor-St. Helena	As, NO3	Generally good water quality; most wells have limited data records and very little historical data
Napa Valley Floor-Yountville	As, NO3	Generally good water quality; most wells have limited data records and very little historical data
Napa Valley Floor-Napa	Na, As, NO3	Generally good water quality; most wells have limited data records and very little historical data
Subareas South of Napa Valley Subbasin	**Constituents**	**WQ Comment**
Carneros	Cl, EC, TDS	Limited data record; minimal historic and recent records; poor water quality common; possible increasing recent trend seen in EC, chloride, and TDS
Napa River Marshes	Cl, EC, Na, NO3, TDS	Very limited long-term records; one well with historic data; generally poor water quality

1. Excerpt from Napa County Groundwater Conditions and Groundwater Monitoring Recommendations (LSCE, 2011; Table 4.5)
2. As -- Arsenic; NO3 -- nitrate; Na – sodium; Cl – chloride; EC – specific conductance (or electrical conductivity); TDS – total dissolved solids

4.1.3.2 Recent Groundwater Quality

Between 2009 and 2015, groundwater quality data were collected from a total of 81 sites (**Table 4-2** and **Figure 4-9**) primarily within the Napa Valley Subbasin. Groundwater quality data in Napa County are collected principally at sites regulated by the SWRCB through the Division of Drinking Water and Geotracker program, although data are available from other public agencies as well.

Table 4-2 Groundwater Quality Monitoring Sites with Recent Data

Entity	Reporting Program	Number of Monitored Sites, 2009 - 2015
Napa County	Napa Berryessa Resort Improvement District	2
	Lake Berryessa Resort Improvement District	5
	Surface Water-Groundwater Monitoring Sites	10
California Department of Water Resources	Volunteered Sites	8
State Water Resources Control Board	Division of Drinking Water	35
	Geotracker	3
U.S. Geological Survey	-	18
	Total Sites	**81**

Groundwater quality data reported between 2009 and 2015 were reviewed to provide an updated understanding of conditions and trends relative to the most recent County-wide review of groundwater quality data published as part of the Napa County Groundwater Conditions and Groundwater Monitoring Recommendations Report (LSCE, 2011a). In addition to the regulated sites overseen by the SWRCB, data were available from voluntary data collection efforts conducted by Napa County at the ten Surface Water-Groundwater Project monitoring wells and by the U.S. Geological Survey and DWR at privately-owned wells. Water quality data from the ten Napa County Surface Water-Groundwater Project monitoring wells consists of a single round of baseline sampling conducted in June 2015.

Groundwater quality data show generally good water quality with stable conditions in the Napa Valley Floor Subareas between 2009 and 2015 compared to the conditions reported previously based on data reported through 2008 (LSCE, 2011a). **Figures 4-10** through **4-16** show the available water quality results reported between 2009 and 2015 for a range of constituents (arsenic, boron, chloride, nitrate, sodium, specific conductance, and total dissolved solids respectively) within Napa Valley Subbasin groundwater. These figures provide an indication of recent water quality conditions. **Figures 4-17** and **4-18** present time series plots for wells within the Napa Valley Subbasin with the longest records of nitrate and total dissolved solids data (TDS) respectively. These figures provide a perspective on the trends in groundwater quality over time at a given well and location. Water quality standard exceedances in the Napa Valley Floor subareas and Napa Valley Subbasin included arsenic, with 4 of 26 sites showing maximum concentrations above the Maximum Contaminant Level (MCL) of 10 micrograms per liter (µg/L) (**Figure 4-10**). With TDS concentration of 683 milligrams per liter (mg/L), the deep monitoring well at Site 1 of the Surface Water-Groundwater Project in Napa Subarea within the Napa Valley Subbasin, exceeded the secondary MCL of 500 mg/L (**Figure 4-16**). The same well and the deep well at Site 3 of the Surface Water-Groundwater Project, located near the Napa River at the boundary of the Napa and Yountville Subareas, had boron concentrations of 1,400 µg/L and 9,100 µg/L, respectively, well above the 1,000 µg/L Notification Level (**Figure 4-11**). The results from these dedicated monitoring wells may indicate the dominant influence of a geologic source on water quality in these wells. Wells with long-term water quality data show stable TDS (**Figure 4-18**) and nitrate concentrations, with one exception (**Figures 4-17)**. Well (06N04W27L002M) in the Napa Subarea which had a peak of 7.7 mg/L NO3-N (nitrate as nitrogen) in 2011 compared to initial concentrations of 3.4 mg/L NO3-N and 4.0 mg/L NO3-N in 1982 and 1972, respectively (**Figures 4-17)**.

4.1.4 Summary of Groundwater Quality Trends

Groundwater quality data show stable conditions between 2009 and 2015 compared to the conditions reported previously with data through 2008 (LSCE, 2011). Water quality standard exceedances in the Napa Valley Floor subareas and Napa Valley Subbasin were limited to the naturally-occurring constituent arsenic, with 4 of 26 sites showing maximum concentrations above the arsenic MCL of 10 µg/L.

Wells with long-term water quality data show stable TDS and nitrate concentrations, with the exception of one well (06N04W27L002M) which had a peak of 7.7 mg/L NO3-N (nitrate as nitrogen) in 2007 compared to initial concentrations of 3.4 mg/L NO3-N and 4.0 mg/L NO3-N in 1982 and 1972, respectively.

4.2 Surface Water Flows and Quality

4.2.1 Historical Surface Water Conditions

The Napa River flows southeast-southward out of the Coast Ranges, through Napa Valley, and into lowland marshes before entering San Pablo Bay at American Canyon (**Figure 4-19**). Historically, the Napa River near the City of Napa generally flows between several hundred to several thousand CFS during peak winter conditions and then tapers off to about 1 CFS during the fall. Multiple precipitation catchments exist as sub-watersheds for the many ephemeral, intermittent, to the more notable perennial surface water flow paths that feed into the Napa River within its greater watershed area to support its flow (**Figure 4-19**). During dry seasons, these catchments, tributaries, and respective groundwater subareas, recharge the Napa Valley Subbasin, which in turn supports low-flow conditions in the Napa River as a hydraulic continuum. Shallow groundwater within the Napa Valley Subbasin surficial alluvial deposits undergoes complex hydrologic interactions with the Napa River streambed along its reaches at multiple time scales.

Reaches of the Napa River, along its lower streambed surface, or thalweg, have over many decades (since the 1930s) experienced low to no-flow conditions during the fall as groundwater discharge into the stream channel decreases as a function of seasonal fluctuations of the water table and fall groundwater declines (Faye, 1973; Grossinger, 2012). Smaller ephemeral, intermittent, and more notable perennial streams flowing into the Napa River, recharging the Napa Valley Subbasin along their way, undergo similar seasonal changes as they communicate with shallow groundwater within their respective catchments (**Figure 4-19**). Steady streamflow conditions resulting from upgradient groundwater discharge, or baseflow, at minor streams will reflect seasonal groundwater changes within their smaller precipitation catchments, while Napa River baseflow represents much larger-scale shallow groundwater conditions within the Napa Valley Subbasin. This hydrologic process, known as baseflow, occurs in both gaining and losing stream reaches as a result of basin wide groundwater conditions as they are expressed within a given stream channel where surface water drainage can occur. The timing and occurrence of natural recharge events (i.e., the timing and amount of precipitation and opportunity for recharge) significantly affect the amount of groundwater baseflow discharged to the Napa River system. Outflows from the Subbasin, including groundwater pumping, also affect the surface water system; groundwater pumping is a relatively smaller outflow component compared to stormflows and baseflow discharged to the San Pablo Bay.

USGS surface water monitoring sites and DWR groundwater monitoring sites with historical data, shown on **Figure 4-20**, provided a basis for examining historical hydrogeologic surface water-groundwater interactions and trends related to past water year types. Surface water monitoring efforts within the Napa Valley commenced in 1929 with USGS stations at the Napa River near St. Helena, the Napa River near Napa, and at Conn Creek near Oakville (**Figure 4-20**). Since that time the USGS has developed rating curves and maintained fairly continuous stream discharge records for six other surface water monitoring stations pertinent to the determination of long term trends in surface water baseflow conditions and groundwater sustainability within the Napa Valley Subbasin. USGS surface water monitoring began at Dry Creek in 1951, at Redwood Creek near Napa in 1958, at Napa Creek at Napa and Milliken Creek near Napa in 1970, at Tulucay Creek at Napa in 1971, and at the Napa River at Calistoga in 1975. More recently, starting in 1997, Napa County has installed and maintained surface monitoring sites at multiple locations of use to this Basin Analysis Report. These sites include Napa Creek at Hwy 29, Napa River at Dunaweal Ln, Napa River at Lincoln Bridge, Milliken Creek at Atlas Peak Rd, Dry Creek at Hwy 29, Salvador Channel at Big Ranch Rd, and Tulucay Creek at Shurtleff Ave. Although these sites are useful real-time indicators of stream stage and flow conditions into the future, their periods of record are relatively short (starting 2011-2014) and therefore become less useful for delineating historical trends related to baseflow conditions and water year types.

Figure 4-21 shows the Napa River annual average streamflow by water year calculated from USGS surface water stations near St. Helena and Napa. These annual averages are calculated from raw discharge data and therefore capture flashy, high-volume, surface water flows associated with winter storms. Water year types can be generally observed from relative differences between the annual average streamflows on **Figure 4-21**, however the seasonal lows, or number of days with little to no streamflow, are not well represented by an annual water year average.

In order to visualize and compare the timing magnitude of seasonal surface water declines between historical water years, the monthly average streamflow was calculated from raw USGS surface water station data near St. Helena and Napa (**Figure 4-22**). By averaging raw flow data within individual months, periods of high winter flows and low to intermittent flow conditions in the fall are better represented in terms of surface water fluxes (CFS). Closer inspection of average monthly flows within the base period[14] (**Figure 4-23**) reveals that the Napa River approaches little to no-flow conditions during the fall in the vicinity of St. Helena and Napa with notable differences between recession curves associated with late summer precipitation events, groundwater recharge, groundwater discharge, and baseflow development.

Representative groundwater monitoring sites (**Figure 4-20**) were selected based on their close proximity to the Napa River and screened depths in hydraulic connection with the Napa Valley Subbasin shallow groundwater system where underflow occurs with close relation to baseflow conditions. As one moves down-valley, along the Napa River, the contributing area of surface water and groundwater becomes larger as defined by the upgradient watershed and groundwater subarea at any given point within the Napa Valley Subbasin (**Figure 4-19**). Groundwater level data from representative sites (**Figure 4-20**) were paired to Napa River surface water monitoring sites (**Figure 4-20**) both up and down-valley for examination of Napa River baseflows related to groundwater boundary conditions across historical water years.

4.2.2 Historical Estimated Baseflow Conditions

The streamflow hydrograph during a period without precipitation will recede in a predictable exponential curve and is sustained entirely by groundwater discharge (baseflow). A variety of methods and tools have been developed for estimating baseflow rates from observed streamflow data. The most common and readily applied methods involve techniques to separate the stream hydrograph into principal components including primarily overland flow (surface runoff) and baseflow. Such methods are called “hydrograph separation” techniques which are largely based on graphical characteristics of the streamflow hydrograph as opposed to hydrologic processes (Dunne and Leopold, 1978).

Example results of the Napa River near St. Helena baseflow separation analyses are shown for the first base period water year on **Figure 4-24**, where transient spikes in the raw discharge data, associated with short-lived summer precipitation events, are digitally filtered out with the web-based hydrograph analysis tool developed by Lim et al., 2005. This tool employs a recursive digital filter based on a base flow index as outlined by Wahl and Wahl (1995) for various hydrologic settings such as a perennial stream flowing over a porous aquifer as observed in the Napa Valley Subbasin. The baseflow estimations derived from the analysis described above, provide a reasonable representation of baseflow conditions in the Napa River catchment. They appear to effectively account for streamflow fluctuations resulting from short-duration surface runoff processes while also preserving longer-term changes in baseflow resulting from groundwater discharge. Base period Napa River near St. Helena baseflow analysis results are shown on a semi-log plot (**Figure 4-25**) as well as a semi-log point cloud (**Figure 4-26**) for visualization of the general distribution flow magnitudes. Base period Napa River near Napa baseflow analysis results are shown on **Figure 4-27**.

Historically the annual streamflow hydrograph for both the Napa River near Napa and the Napa River near St. Helena gauges have typically exhibited periods of low or no streamflow conditions. This has been characterized in prior USGS investigations by Faye (1973), which observed that the Napa River was perennial except during years of less than normal rainfall. Faye (1973) highlights that the Napa River did not flow for a significant amount of time during the 1930 and 1931 water years as a result of low precipitation and groundwater levels. Grossinger (2012) also explores the steep seasonal recession in

[14] The Base Period is water years 1988 to 2015 as described in Chapter 6.

Napa River flow observed in 1910-11. The number of days in each year of the historical records at the USGS Napa River near St. Helena and Napa River near Napa gages during which measured flows less than 0.1 CFS are presented in **Figures 4-28a and 4-28b**. These data illustrate the historical occurrence of seasonal low flow conditions. During drier years, the low/no flow conditions typically start in early summer (June) with a greater number of days with low or no streamflow whereas during wetter years such low or no flow conditions tend to first occur in October and there are no or relatively fewer days experiencing low or no streamflow.

In depth review of baseflow conditions for water year types within the base period (**Figures 4-29** to **4-34**) reveals the importance of water year timing and multi-year hysteresis related to shallow groundwater contributions to fall Napa River flows. For instance, the very dry water year of 2007, as defined by the percentile of total precipitation in Napa, occurred after the very wet year of 2006, and as a result maintained baseflow near Napa until mid-September whereas three other dry years (1994, 2001, and 2014), six normal years (2008, 2009, 2012, 2013, and 2015), and even the wet year of 2003 did not sustain flow for that length of time (**Figures 4-29, 4-30,** and **4-31**). This highlights the importance of shallow groundwater levels associated with perennial Napa River flow, where shallow groundwater recharge on a wet year is observed to sustain baseflow on the following drier year as previously discussed. Inversely, the Napa River may experience lower than average baseflow conditions on wet years as a result of prior, drier, water years. For example, 2003 was the only wet water year within the base period where the Napa River stopped flowing near Napa by early September (**Figures 4-31**) as a result of lower than average groundwater and baseflow conditions during the prior normal water year of 2002 (**Figures 4-30**), and drier than average conditions in the prior dry water year of 2001 (**Figures 4-29**). Multi-water year trends toward dry intermittent Napa River flows as well as multi-water year trends toward wet conditions could superimpose single-water year seasonal declines in Napa Valley Subbasin groundwater discharge to the Napa River. Sustainable Napa River flows in the future will largely depend on the flashiness (timing and magnitude) of winter storms and the ensuing proportion of that precipitation that is naturally recharged to shallow groundwater to support healthy underflow and baseflow development.

To determine to what extent water year types exert an influence on baseflow conditions in the Napa River near Napa, daily averages were computed for each grouping of the water year types that fell within the entire period of record as well as the base period (**Figure 4-35**). The average baseflows for various water year types shown on **Figure 4-35** reveals that the Napa River near Napa historically approaches little to no flow conditions in September during very dry water years. All other water year types appear to maintain baseflow above 0.1 CFS in terms of the daily averaging approach (**Figure 4-35**). Results from the same approach when applied to the Napa River near St. Helena station (**Figure 4-36**) shows a similar magnitude in distribution between average baseflows by water year types compared to the Napa River near Napa average baseflow results (**Figure 4-35**). **Figure 4-36** suggests that the Napa River near St. Helena has historically supported streamflow throughout very dry water years and subsequently lost flow on average in early July during base period very dry water years; however, the gaging station for the Napa River near St. Helena site was relocated approximately one mile upstream to its current location in January 2005. Given the variation in the timing and degree of connection between groundwater and surface water observed in the Subbasin, it is possible that the two locations are not comparable with respect to summer and fall baseflow dominated instream conditions. **Figures 4-35** and

4-36 both illustrate relatively lower average baseflow conditions amongst water year types during the base period compared with the full period of record average baseflow results.

Another strategy can be applied by averaging baseflow estimates across all years of record, as well as the base period, irrespective of water year type (**Figure 4-37**). Results from these analyses show that, on an average water year defined by historical records extending to 1929, the Napa River baseflow near Napa and St. Helena stabilize at about 1 CFS and 0.3 CFS respectively at the end of a water year. The base period results show that the average Napa River near Napa and St. Helena baseflow diverge from the all-years baseflow stabilization curve in July and instead tend to trend in a more linear fashion to lower baseflow conditions (**Figure 4-37**). This corresponds with prior baseflow analyses results that show generally drier water years and lower streamflow conditions during the base period compared to the whole historical record.

Total discharge (in terms of acre-feet per water year) was computed for the raw discharge, estimated baseflow discharge, and stormwater discharge surface water components for the Napa River near Napa and St. Helena stations (**Figures 4-38** and **Figures 4-39**). The stormwater discharge component is estimated as it results from the raw discharge data subtracted by the estimated baseflow component. **Figure 4-38** reveals that the estimated total baseflow discharge at the Napa River near Napa has often exceeded the total stormwater runoff component throughout history. The opposite can be said for the Napa River near St. Helena, where the stormwater discharge component will more often than not exceed the estimated baseflow component (**Figure 4-39**). This difference can be explained by the fact that Napa River baseflow development in the St. Helena vicinity is supported by a much smaller upgradient shallow groundwater source area; therefore, it is more prone to intermittent flow conditions on very dry water years, compared to lower areas in the Napa Valley Subbasin such as the Napa River in the vicinity of Napa. For the purposes of groundwater budgeting, the total Napa River estimated baseflow discharge near Napa (**Figure 4-38**) provides an indicator of total water year Napa Valley Subbasin shallow groundwater losses to the Napa River streambed interface over time. **Figures 4-38** and **4-39** also indicate that about half of the raw discharge of the Napa River represents ephemeral large-scale surface water losses from the system in the form of flashy stormwater flows that could otherwise be re-routed for recharging shallow unsaturated alluvium in support of perennial, live-stream, conditions.

Figure 4-40 shows the total water year baseflow percent of total discharge (near Napa and St. Helena) compared to the total water year precipitation at Napa. Water year types are also indicated on this figure to aid in the pattern recognition of drier water years resulting in a relatively higher portion of streamflow expressed in the form of baseflow, or groundwater discharge (**Figure 4-40**). For example, on particularly very dry water years (with total precipitation at Napa less than 15 inches), about 58 to 66% of Napa River flow is estimated to be in the form of groundwater discharge (**Figure 4-40**). The linear relationships for Napa and St. Helena derived from these analyses are markedly similar, with a somewhat steeper slope for St. Helena due to its position in the watershed and increased sensitivity to lower groundwater levels and lower flow conditions (**Figure 4-40**).

4.2.3 Relationships between Baseflow and Groundwater Levels

Recent 2014-2016 investigations at surface water-groundwater monitoring site locations (**Figure 4-41**) indicate several aspects about the nature and seasonality of hydraulic boundary conditions related to the interconnectivity between the shallow Napa Valley Subbasin groundwater and surface water systems. Site 1, located within the City of Napa, is currently the farthest downstream of the four project monitoring sites along the Napa River (**Figure 4-41**). **Figure 4-42** shows that the Napa River is perennially wetted and tidally-influenced at Site 1 with a 5-foot to 7-foot tidal range observed during the period of record. Data collected at Site 1 have shown very similar water level elevations at all three monitoring locations including a similar, though dampened, response to the tidal cycles in the two piezometers. Data from Site 1 show that groundwater levels were above the elevation of the riverbed and near to or slightly above the elevation of water in the river channel, indicating a connection between groundwater and surface water. Data from Sites 3 and 4 (**Figures 4-43** and **4-44**) along the Napa River showed variability in the nature of groundwater-surface water connection during 2015, ranging from groundwater flow into the river (gaining conditions) to the opposite (losing conditions). **Figures 4-43** and **4-44** show shallow groundwater elevations above the river stage elevation inducing groundwater flow into the Napa River (gaining conditions) until September, when shallow and deep groundwater elevations at Sites 3 and 4 continue to decline, inducing losing streamflow conditions. These losing conditions persist into the 2015 winter storms, where high magnitude stormwater Napa River flows (with high stage elevations) induce recharge. Losing stream conditions are observed throughout 2015 at sites 2 and 5 (**Figures 4-45** and **4-46**), where the direction of groundwater flow is away from the streambed. At Site 5, water level data indicate that the river was hydraulically connected to shallow groundwater during the first half of the year, until flows in the river ceased in July, and again in December 2015 as storms generated runoff leading to renewed flow in the river (**Figure 4-46**). At Site 2, located along Dry Creek, groundwater levels were consistently below the streambed elevation in 2015, indicating that groundwater was disconnected from the stream, although recharge to the groundwater system was likely occurring when water flowed in the creek (**Figure 4-45**). Sites 2 and 5 also showed groundwater level differences between the shallow and deep casings of at least 5 feet for most or all of 2015. Given that most groundwater withdrawals in Napa Valley occur from depths greater than 50 feet, these water level differences show how the groundwater system's response to pumping from deeper aquifer units does not necessarily lead to an equivalent reduction in shallow groundwater levels. Although the period of record at these sites is short compared to many wells monitored by Napa County, **Figure 4-47** demonstrates how the range of groundwater elevations monitored at a Surface Water –Groundwater Network site are comparable to a well constructed in a similar part of the aquifer system nearby. NapaCounty-133 is located approximately 0.5 miles from Site 4 and a similar distance from the Napa River. The full period of record from NapaCounty-133, from 1978 through 2015, show a similar range and stable trend in groundwater elevations from spring to fall.

The relationships between baseflow and groundwater levels at site pairs (e.g., groundwater monitoring sites and stream gauges) within the Napa Valley Subbasin were investigated for the purpose of determining the ranges of shallow groundwater elevations that tend to support various ranges of fall Napa River baseflow conditions. Most notably, USGS Well 07N05W09Q002M, situated along the Napa River between St. Helena and Napa (**Figure 4-20**), has shallow groundwater elevation data extending to 1949 that can be paired to corresponding same-day, fall, baseflow estimates near St. Helena and near Napa (**Figures 4-48** and **4-49** respectively) in order to visualize surface water-groundwater relationships apparent at the Napa Valley Subbasin-wide scale. **Figures 4-48** and **4-49** show that lower groundwater elevations at the USGS Well 07N05W09Q002M in the fall are associated with a characteristically sharp curve and decline in baseflow estimates trending to no-flow conditions at the low-end range of groundwater elevation observation. The base period, also identified in these two exhibits, indicates relatively lower groundwater elevations compared to the whole period of record that track a similar trend towards no-flow stream conditions at the lower end of their range (**Figures 4-48** and **4-49**). Surface water-groundwater relationship plots for other representative station-pairs used for identifying groundwater elevation ranges suitable for sustainable Napa River flows as discussed in **Chapter 7** can be viewed in **Appendix G**.

In order to further the understanding of the relationships between groundwater baseflow in the Napa River and precipitation, groundwater levels, and groundwater pumping in the Napa Valley Subbasin, a series of statistical analyses was performed to evaluate correlations between these variables over multiple time periods. For the longest continuous period of record available[15], groundwater level measurements and total annual precipitation data were compared independently to data describing periods of little to no flow[16] in the Napa River at two stream gages: Napa River near Napa (USGS station 11458000) and Napa River near St. Helena (USGS station 11456000). Annual precipitation data from the nearest long-term precipitation gages in the Subbasin were similarly compared to the no flow period at each stream gage, including the first day[17] of no flow conditions and the length of no flow conditions for water years with data (**Figures 4-50** to **4-57**). The results show comparable, though inverse, correlations between annual precipitation and the length of no flow periods in the Napa River: -0.54 at the Napa River near Napa gage and -0.50 at the Napa River near St. Helena (**Table 4-3**). Correlations between annual precipitation and the first day of no flow conditions in a given water year were relatively stronger for the Napa River near Napa gage, -0.62, and equivalent for the Napa River near St. Helena gage, -0.50. These results indicate that some of the variability in the length of the no flow periods is related to variability in groundwater levels near the Napa River as well as to the amount of precipitation in that water year. Correlation coefficients were somewhat stronger between the first day of no flow conditions at the Napa River near Napa and annual precipitation, 0.62, and the cumulative departure from mean annual precipitation and the length of no flow conditions at the Napa River near St. Helena, -0.74.

Relationships between fall groundwater level data and baseflow show strong to insignificant linear correlations with the length of the no flow period at each stream gage (**Table 4-4**). Data from well 06N04W17A001M show relatively strong linear correlations between minimum fall groundwater level elevation and both the first day of no flow conditions and the length on no flow conditions, 0.63 and -0.68 respectively. The negative correlation between minimum fall groundwater levels and the length of no flow conditions indicates that the correlation is inverse, where decreasing groundwater level data correlate with increasing length (in days) of the no flow period. Other wells with long-term groundwater level records evaluated for this analysis show insignificant linear correlations with baseflow; however, more meaningful statistical relationships may exist between baseflow and groundwater levels in these wells that are not addressed by this analysis of fall groundwater level data. Overall, the analyses of linear correlations between annual precipitation, groundwater levels, and baseflow in the Napa River

[15] 1960 was used as the first year for the Napa River near Napa analysis because a gap in streamflow data exists between 1933 and 1959. 1950 was used as the first year of analysis for the Napa River near St. Helena because that is the first full water year in which precipitation data were recorded at the Calistoga precipitation gage without substantial gaps in the record.

[16] These analyses use an effective no flow ceiling of 0.1 cubic feet per second (CFS) to avoid under representation of no flow conditions due to uncertainties in streamflow measurements.

[17] First day of no flow conditions are relative to the first day of each water year, October 1.

provide further support to the understanding that no flow conditions in the Napa River have been historically and continue to be influenced by annual precipitation and groundwater levels near the Napa River[18].

The relationship between groundwater pumping in the Subbasin and baseflow in the Napa River was evaluated for the 1988 to 2015 hydrologic base period evaluated in this Basin Analysis Report as well as subset of more recent years. This analysis utilized total annual groundwater pumping calculated by the Root Zone Model for those portions of the Subbasin north of a line bisecting the Subbasin along Oak Knoll Avenue at the Napa River near Napa stream gage. A subset of more recent years, 1995 to 2015, was also analyzed in order to test whether a substantial change has occurred in the relationship between pumping and baseflow in more recent years. The 1995 to 2015 period was chosen to allow for an approximately equal number of years with above average and below average precipitation in order to minimize the potentially confounding influence of variations in precipitation on the analysis. For the period from 1988 to 2015, linear correlation coefficients show relatively strong relationships between groundwater pumping and baseflow and both the first day of no flow conditions and the length of no flow conditions for a given water year, -0.64 and 0.67 respectively (**Table 4-5**). Correlations evaluated for the more recent 1995 to 2015 period show relatively moderate to strong relationships between baseflow conditions and groundwater pumping. These results indicate that, as with annual precipitation and groundwater levels, some of the variability in no flow conditions is related to the variability in groundwater pumping. Additionally, the results do not indicate a substantial change in the relationship between no flow conditions and rates of groundwater pumping between the 1988 to 2015 base period and more recent years.

While the individual correlation coefficients address the relative strength of relationships between baseflow in the Napa River and precipitation, groundwater levels, and groundwater pumping in the Napa Valley Subbasin individually, a multiple linear regression analysis was performed to assess the degree to which groundwater pumping and precipitation, as independent variables, together correlate with baseflow. The analysis used monthly baseflow volumes calculated for the Napa River near Napa gage, monthly interpreted precipitation volumes for the Subbasin, and monthly groundwater pumping volumes calculated by the Root Zone Model. Cumulative monthly precipitation and groundwater pumping data were normalized for this analysis in order to account for the seasonal nature of both precipitation and groundwater pumping in the Subbasin. Regression coefficients suggest that the influence of precipitation and groundwater pumping on baseflow were, on average, 79% and 21%, respectively for the 1988 to 2015 period (**Table 4-6**). The multiple regression shows a strong coefficient of multiple correlation (multiple R = 0.97) and a high coefficient of determination (R^2 = 0.94). These coefficients show that precipitation and groundwater pumping are the primary controls of baseflow in the Subbasin, with precipitation being the much more dominant variable.

[18] Groundwater pumping data were not included in the linear correlation coefficient analysis because pumping data were only available for the water years 1988 to 2015 as part of the water budget analysis performed for this Basin Analysis Report.

Table 4-3. Linear Correlation Coefficients for Baseflow and Precipitation in the Napa Valley Subbasin

Parameter	Coefficient of Correlation[1]: Baseflow at Napa River near Napa[2,3] Water Years 1960-2015	[6]	Coefficient of Correlation: Baseflow at Napa River near St. Helena[4,5] Water Years 1950-2015	[6]	Interpretation
Annual rainfall and Length of < 0.1 CFS flow period	-0.54		-0.50		The length of the no flow period for each year shows a moderate correlation with the total annual rainfall at the Napa River near Napa gage and moderate correlation with total annual rainfall at the Napa River near St. Helena gage.
Annual rainfall and First < 0.1 CFS day in water year	0.62		0.50		Over the longest continuous period of record, the first date of no flow in a given year shows a stronger correlation with the total annual rainfall at the Napa River near Napa gage and moderate correlation with total annual rainfall at the Napa River near St. Helena gage.
Cumulative departure of rainfall and Length of < 0.1 CFS flow period	0.04		-0.74		The length of the no flow period is not correlated with the cumulative departure of rainfall at the Napa River near Napa gage, while a relatively strong correlation (inverse) is seen at the Napa River near St. Helena indicating that the length of the no flow period increases as cumulative departure values decrease, and vice versa.
Cumulative departure of rainfall and First < 0.1 CFS day in water year	0.39		-0.02		Correlation coefficients indicate weak correlations; however, visual observation of graphs suggests that cumulative departure of rainfall is correlated with the starting date and duration of no flow periods, for some portions of the period.
Number of rainy weeks in water year and Length of < 0.1 CFS period	-0.50		-0.41		The number of weeks over which rainfall occurred shows a moderate correlation (inverse) with the length of no flow period at the Napa River near Napa gage. When there are fewer weeks of rainfall, the length of the low baseflow period increases. However, the same variables show a weaker correlation at the Napa River near St. Helena gage.

1. Correlation statistics are Pearson's Correlation Coefficients (r).
2. Precipitation data from Napa State Hospital (GHCND: USC00046074), as applicable.
3. Napa River near Napa streamflow gage (USGS station 11458000).
4. The Napa River near St. Helena gage (USGS station 11456000) has a data gap from 1995 to 2000, which reduces the number of years for which correlation statistics can be calculated. This gage was also relocated about 1 mile upstream to its present location on 01/28/2005.
5. Precipitation data from Calistoga (GHCND: USC00041312), as applicable.
6. Green, yellow, and grey colors indicate strong (≥ 0.60), moderate (0.45-0.59), and insignificant coefficients of correlation, respectively. These limits are established relative terms defined for comparison.

Table 4-4. Linear Correlation Coefficients for Baseflow and Groundwater Levels in the Napa Valley Subbasin

Parameter	Coefficient of Correlation[1]: Baseflow at Napa River near Napa[2,3] Water Years 1960-2015	5	Coefficient of Correlation: Baseflow at Napa River near St. Helena[2,4] Water Years 1950-2015	5	Interpretation
Minimum fall groundwater level at 06N04W17A001M & First < 0.1 CFS day in water year	0.63		-		Minimum fall groundwater level elevation at 06N04W17A001M shows a strong correlation with the first date of no flow in a given year at the Napa River near Napa gage.
Minimum fall groundwater level at 06N04W17A001M & Length of < 0.1 CFS period	-0.68		-		Minimum fall groundwater level elevation at 06N04W17A001M shows a strong correlation with the length of the no flow period at the Napa River near Napa gage.
Minimum fall groundwater level at 07N05W09Q002M & First < 0.1 CFS day in water year	0.18		0.23		Minimum fall groundwater level elevation at 07N05W09Q002M shows a weak correlation with the first date of no flow in a given year at both Napa River gages.
Minimum fall groundwater level at 07N05W09Q002M & Length of < 0.1 CFS period	-0.21		-0.23		Minimum fall groundwater level elevation at 07N05W09Q002M shows a weak correlation with the length of the no flow period at both Napa River gages.
Minimum fall groundwater level at 08N06W10Q001M & First < 0.1 CFS day in water year	-		0.32		Minimum fall groundwater level elevation at 08N06W10Q001M shows a weak correlation with the first date of no flow in a given year at the Napa River near St. Helena gage.
Minimum fall groundwater level at 08N06W10Q001M & Length of < 0.1 CFS period	-		-0.23		Minimum fall groundwater level elevation at 08N06W10Q001M shows a weak correlation with the length of the no flow period at the Napa River near St. Helena gage.

1. Correlation statistics are Pearson's Correlation Coefficients (r).
2. Minimum fall groundwater level elevations are based on data collected in September through November, as available. Where applicable, data collected in October or November are compared to low flow conditions from the preceding water year.
3. Napa River near Napa streamflow gage (USGS station 11458000).
4. The Napa River near St. Helena gage (USGS station 11456000) has a data gap from 1995 to 2000, which reduces the number of years for which correlation statistics can be calculated. This gage was also relocated about 1 mile upstream to its present location on 01/28/2005.
5. Green, yellow, and grey colors indicate strong (≥ 0.60), moderate (0.45-0.59), and insignificant coefficients of correlation, respectively. These limits are established relative terms defined for comparison.

Table 4-5. Linear Correlation Coefficients for Napa River Near Napa Baseflow and Groundwater Pumping in the Napa Valley Subbasin

Water Years	Number of Above Average Rainfall Years	Number of Below Average Rainfall Years	Coefficient of Correlation[1]: Groundwater Pumping[2] and First < 0.1 CFS day[3]	[4]	Coefficient of Correlation[1]: Groundwater Pumping[2] Length of < 0.1 CFS period[3]	[4]	Interpretation
1988-2015 (base period)	11	17	-0.64	(green)	0.67	(green)	Over the base period, the first day of no flow and the length of the no flow period for each year show a strong correlation with groundwater pumping in the Subbasin north of the Napa River near Napa gage.
1995-2015	10	11	-0.54	(yellow)	0.77	(green)	A more recent period, with a balance of years of above and below average precipitation, shows relatively moderate to strong relationships between baseflow conditions and groundwater pumping in the Subbasin north of the Napa River near Napa gage. The results do not indicate a substantial change in the relationship between no flow conditions and rates of groundwater pumping between the 1988 to 2015 base period and more recent years.

1. Correlation statistics are Pearson's Correlation Coefficients (r).
2. Groundwater pumping data are total annual groundwater pumping calculated by the Root Zone Model for those portions of the Subbasin north of a line bisecting the Subbasin along Oak Knoll Avenue at the Napa River Near Napa stream gage.
3. Napa River near Napa streamflow gage (USGS station 11458000).
4. Green and yellow indicate strong (≥ 0.60), moderate (0.45-0.59) coefficients of correlation, respectively. These limits are established relative terms defined for comparison.

Table 4-6. Multiple Linear Regression Results: Baseflow at Napa River at Napa, Napa Valley Subbasin Groundwater Pumping, and Napa Valley Subbasin Precipitation

Variable	Correlation Coefficients	Standard Error	t Statistic	P-value	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Relative Influence (%)
Pumping	0.256	0.0146	17.5	2.23E-49	0.228	0.285	21
Precipitation	0.941	0.0133	70.6	5.8E-203	0.915	0.967	79

Intercept = 0, Number of observations = 336

4.3 Seawater/Freshwater Interface

The seawater/freshwater interface occurs south of the Napa Valley Subbasin; its specific location has not yet been determined. The spatial distribution of saline groundwater south of the Napa Valley Subbasin is assessed primarily through examination of available chemical indicators, including chloride, TDS, EC, and sodium concentrations in groundwater (**Figures 4-58 to 4-61**). The highest historically observed concentrations of each of these constituents are observed in the three groundwater subareas south of the Napa Valley Subbasin in the Napa River Marshes, Jameson/American Canyon, and Carneros Subareas (**Figures 4-58 to 4-61**). Groundwater quality and well construction data for these subareas are very limited and, therefore, restrict the spatial-temporal resolution of groundwater salinity and the location of the seawater/freshwater interface. The highest observed chloride (3,020 mg/L) and sodium (956 mg/L) values occur in well 004N004W04C003M, which is located roughly 2 miles west from the Napa County Airport, near the divide between the Carneros and Napa River Marshes Subareas (**Figure 4-58**). Other wells also indicate more saline groundwater conditions most notably along the eastern edge of the Carneros Subarea (**Figures 4-58 to 4-61**). In the Napa-Sonoma Lowlands Subbasin and Carneros Subarea, available data show that one well has shown increasing TDS trends (**Figure 4-62**). This well (4N/4W-4C2) is located nearest to the Napa River where tidal influences affect surface water and shallow groundwater quality. The construction of this well is unknown.

Wells in the Suscol area, south of the City of Napa, also exhibit elevated chloride concentrations, possibly from leakage from salty water in the Napa River, alluvial material above, or the existence of zones of unusually saline connate water deep within the Sonoma Volcanics. Moving up the Subbasin (up elevation and gradient north of the City of Napa) removes measurable tidal surface water interactions and elevated salinity on the groundwater-surface water system (**Figures 4-58 to 4-61**). The historical maximum observed chloride and TDS in groundwater are also projected onto proximal geologic cross-sections H-H’ on **Figures 4-63 and 4-64**. These figures show, with very limited well completion information, where groundwater south of the Napa Valley Subbasin contains salinity naturally associated with the corresponding geologic units. A series of nested monitoring well clusters extending from Napa to the bay would better inform the proportion and distribution of saline groundwater released from connate storage in salty clays versus the proportion of saline groundwater.

4.4 Land Subsidence

In the context of investigating potential land subsidence, the National Geodetic Survey elevation data existing within the Napa Valley Subbasin are limited to three benchmark stations (**Figure 4-65**). Elevation data over time at these stations are shown below in **Table 4-7.**

Table 4-7 Elevation Benchmark Data Reported by The National Geodetic Survey for Stations Within the Napa Valley Subbasin

NGS Elevation Benchmark Site ID	Measurement Date	Elevation (Feet) with 95% Confidence Interval as Reported by NGS[1]
JT9631 (Calistoga Vicinity)	*8/11/1994*	*316.9*
JT9631 (Calistoga Vicinity)	2/10/2007	316.5
JT9631 (Calistoga Vicinity)	6/27/2012	316.6 ± 0.2
JT9565 (Oakville Vicinity)	*5/15/1992*	*151.0039*
JT9565 (Oakville Vicinity)	*4/6/2000*	*150.6561*
JT9565 (Oakville Vicinity)	2/10/2007	150.5249
JT9565 (Oakville Vicinity)	6/27/2012	150.5905 ± 0.0547
JT9621 (Napa Vicinity)	*8/11/1994*	*10.4166*
JT9621 (Napa Vicinity)	2/10/2007	9.7736
JT9621 (Napa Vicinity)	6/27/2012	9.8425 ± 0.2814

1. Italicized values for measurements in early 1990s indicate likely greater ranges of error and confidence intervals.

The National Geodetic elevation benchmark station data within the Napa Valley Subbasin show sub-foot changes (both downwards and upwards) of land surface elevation measurements in the vicinities of Calistoga, Oakville, and Napa over the last two decades within the recently reported 95% confidence intervals (**Table 4-6**). Historical elevation measurements in the early 1990s would likely correspond to greater ranges of error and confidence intervals, so, in the context of potential land surface elevation changes, evaluation of these data relates more to probable noise and historical error. The more recent measurements at these locations (e.g., measurements in 2007 and 2012) do not suggest land subsidence has occurred. This finding is consistent with long-term stable groundwater level trends in the Napa Valley Subbasin.

4.5 Data Gaps (354.38)

For wells added to the County's monitoring networks in recent years without a record of key well construction details, continued efforts to locate construction information and link those data with aquifer units is recommended. In cases where a well owner does not have a record of the construction, a review of Well Completion Reports is recommended. Groundwater Sustainability Plan regulations published by DWR, 2016, indicate a need to add one or more wells to the CASGEM network near the southern boundary of the Napa Valley Subbasin. A well or wells in this area would be used to monitor groundwater gradients at the basin boundary where subsurface outflow occurs into the Napa-Sonoma Lowlands Subbasin and improve on the understanding of saltwater intrusion. This data will be a component of the subbasin water budget that will be a key feature of the quantitative approach to groundwater management described in SGMA. For similar reasons, the County may benefit from updating reference point elevation data for some monitored wells with surveyed values in order more accurately monitor groundwater level gradients and any potential future seawater intrusion.

Groundwater levels in Napa County Wells 132 and 135, located near to the Napa Valley margin, showed year-to-year declines in groundwater levels. Additional information is needed in order to consider the full range of possible causes for these declines and more accurately determine if the present emerging trends. Recommended actions include a review of land use data in these areas and continuation of the increased frequency of data collection at a subset of wells. More frequent data collection could be accomplished, pending agreement with the well owner, by monthly manual groundwater level measurements.

4.6 Areas of Potential Artificial Recharge

Soil factors relating to potential for groundwater recharge on agricultural lands were recently mapped as part of development of a Soil Agricultural Groundwater Banking Index (SAGBI) (O'Geen et al., 2015). Results from this analysis within the Napa Valley Subbasin, including surrounding areas contributing surface and groundwater to the Subbasin, are shown on **Figures 4-66a** and **4-66b**. The SAGBI considers various soil characteristics interpreted to influence groundwater recharge and ranks them according groundwater recharge potential. The factors included in the SAGBI include topographic limitations (slope), root zone residence time (hydraulic conductivity, drainage class, shrink-swell properties), deep percolation (lowest soil hydraulic conductivity), chemical limitations (soil salinity), and surface conditions (erosion and crusting). Each of these factors are rated and weighted in determining the final SAGBI value representing groundwater recharge potential on agricultural lands. Except for the chemical limitations factor, which is related to soil salinity and potential water quality impacts on crop production from recharge on agricultural lands, the other factors are helpful in identifying areas with greater potential for natural recharge. The four individual factors relevant to natural groundwater recharge potential are displayed in **Figures 4-67 through 4-70**.

Topographic limitations ratings from SAGBI suggest that most areas of the Napa Valley Subbasin have relatively high recharge potential based on surface slope characteristics (**Figure 4-67**). The SAGBI rating of recharge potential based on topography is intended primarily for application in agricultural areas where topographic slopes are typically very low and where potential for artificial recharge is a consideration. Consequently, while upland areas adjacent to the Napa Valley Subbasin with relatively higher slopes are shown as having very low recharge potential based on the topographic rating in SAGBI, there is likely considerable natural recharge that occurs within these areas.

The SAGBI values for root zone residence time, which is based on several soil properties related to hydraulic conductivity and drainage capacity, are displayed in **Figure 4-68**. Root zone residence time ratings highlight a number of areas within the Napa Valley where soil hydraulic characteristics suggest higher recharge potential. The areas with highest recharge potential based on root zone residence time ratings are generally located along the valley margins and in proximity to distributary fan areas or along active river channels. Soils with higher root zone residence time ratings represent an increasing percent of the Valley Floor area towards the upper (northern) end of the valley. The deep percolation factor in SAGBI is a rating based on the hydraulic conductivity of the most limiting (least permeable) soil horizon. The SAGBI rating values for deep percolation are shown on **Figure 4-69** and indicate a number of areas where the recharge potential is higher because of the absence of soils that might impede the vertical movement of water and limit the potential for groundwater recharge. The deep percolation values exhibit similar patterns to the root zone residence time ratings.

Values associated rating surface conditions in SAGBI are displayed in **Figure 4-70** and suggest that soil conditions prone to erosional or crusting properties exist mainly in southern parts of the subbasin and in areas along the active Napa River channel. As noted above, the SAGBI was developed to provide a preliminary indicator of potential for groundwater recharge on agricultural lands for use in evaluating locations where efforts to enhance groundwater recharge might be implemented. Although a map of the chemical limitations rating is not included, very few chemical limitations on recharge potential exist in the Napa Valley Subbasin.

Figure 4-66a shows the compiled SAGBI rating of artificial recharge potential based on the individual soil factors (including chemical limitations) without consideration for any deep ripping of surface soil that may historically have occurred or potentially occur. Areas of higher recharge potential shown in **Figure 4-66a** appear to correspond largely with the soil hydraulic properties indicated by the root zone residence time SAGBI factor rating (**Figure 4-68**) and deep percolation factor rating (**Figure 4-69**). This pattern is consistent with mapped areas of various shallow and permeable geologic units throughout the Napa Valley Subbasin. The SAGBI rating of recharge potential for unmodified soils (assuming no deep ripping) indicates “Excellent” potential in areas of exposed Napa Valley Alluvium, most notably in the vicinity of an alluvial fan-head area where Sulphur Creek flows over and into the Napa Valley Subbasin. When considering the potential for historical or future deep ripping of soils mapped as having a horizon that might impede vertical movement of water, the SAGBI recharge potential rating increases for a number of map units in the vicinity of the City of Napa City with few changes in other Napa Valley Subbasin map units in the other upstream groundwater subareas (**Figure 4-66b**).

4.7 Groundwater Dependent Ecosystems

Likely and potential groundwater dependent ecosystems are presented in **Figures 4-71** through **4-74**. These figures show the extent of vegetation communities and wetland types as most recently mapped in the Subbasin. The classifications of each vegetation and wetland type shown in each figure and summarized in **Table 4-8** were selected based on a review of a draft dataset of groundwater dependent ecosystems currently under development by The Nature Conservancy, in collaboration with DWR and California Department of Fish and Wildlife (DFW).

Table 4-8. Summary of Likely and Potential Groundwater Dependent Ecosystems Mapped in the Napa Valley Subbasin

	Total Subbasin Area (Acres)
Likely Groundwater Dependent Ecosystems - Vegetation Types (1)	
(Bulrush - Cattail) Fresh Water Marsh NFD Super Alliance	23
Mixed Willow Super Alliance	81
Valley Oak - (California Bay - Coast Live Oak - Walnut - Ash) Riparian Forest NFD Association	1,486
Valley Oak - Fremont Cottonwood - (Coast Live Oak) Riparian Forest NFD Association	167
White Alder (Mixed Willow - California Bay - Big Leaf Maple) Riparian Forest NFD Association	2
Total	**1,759**
Potential Groundwater Dependent Ecosystems - Vegetation Types (1)	
Valley Oak Alliance	109
Coast Live Oak Alliance	418
Total	**527**
Likely Groundwater Dependent Ecosystems - Wetland Types (2)	
Estuarine	633
Riverine	146
Depressional Natural	40
Total	**819**

Sources:
(1) Napa County vegetation community dataset, Updated in 2013
(2) California Aquatic Resources Inventory (CARI) database, v0.2, Released in May 2016

5 HISTORICAL, CURRENT, AND PROJECTED WATER SUPPLY

5.1 Land Uses and Population Trends

This chapter describes the sources of supply and amounts of water used in the Napa Valley Subbasin during the period between water years 1988 and 2015, with additional consideration of future water uses through 2025. The Napa Valley Subbasin supports a variety of land use types, including four incorporated municipalities, agricultural lands supporting annual and perennial crops and wine processing facilities, rural residences, and native vegetation among others. According to the 2008 Napa County General Plan, in 1872 the City of Napa became the first incorporated city in what would later be designated the Napa Valley Groundwater Subbasin. Between 1876 and 1965, St. Helena, Calistoga, and Yountville also incorporated within the Subbasin (Napa County, 2008).

Census data from 1980 through 2006 presented in the General Plan and 2010 census data from the U.S. Census Bureau show a trend of increasing population in Napa, St. Helena, and Calistoga. Between 1980 and 2010, the total population across all four of the incorporated municipalities in the Subbasin grew from 74,559 to 90,817, an increase of 22%[19]. Over the same period, a population decrease from 28,500 to 26,213 was recorded in unincorporated areas across the county (**Table 5-1)**. The implications of these population trends in both incorporated and unincorporated portions of the Subbasin are discussed in **Sections 5.2.2 and 5.2.3**.

Table 5-1. Napa County Population, 1980 - 2010

City/Town (Date incorporated)	1980	1990	2000	2006	2010
Calistoga (1886)	3,879	4,468	5,190	5,258	5,155
Napa (1872)	50,879	61,842	72,585	76,705	76,915
St. Helena (1876)	4,898	4,990	5,950	5,989	5,814
Yountville (1965)	2,893	3,259	2,916	3,264	2,933
Unincorporated area	30,938	28,500	27,864	28,267	26,213
Total (***includes American Canyon***)	**99,199**	**110,765**	**124,279**	**134,444**	**136,484**

Sources: 1980 – 2006 from 2008 Napa County General Plan, 2010 from U.S. Census Bureau American (factfinder.census.gov)

While the majority of the population in the Napa Valley Subbasin lives in the four incorporated municipalities, most of the land area in the Subbasin is used for agriculture (DWR, 1987; DWR, 1999; and DWR, 2011). Wine grape production, in particular, has long been a substantial component of land use in Napa County. The County's General Plan reports that Napa Valley supported 16,000 acres of vineyards as far back as the 1880s (Napa County, 2008). Detailed land use surveys of Napa County performed by DWR in 1987, 1999, and 2011 indicate that agricultural land uses overall and vineyard acreages were consistent over that 24-year period (**Tables 5-2 and 5-3**). These more recent land use surveys show a similar and relatively consistent 21,000 acres of vineyards in the Subbasin since 1987 (**Table 5-3**). Land

[19] The boundaries for all four municipalities extend beyond the Subbasin boundary, to varying degrees. The effect of this overlaps is described in Section 5.2.2 and is accounted for as part of the sustainable yield analysis presented in Chapter 6.

use mapping conducted by Napa County using 2014 aerial imagery from the National Agriculture Imagery Program found 20,894 of actively farmed vineyards in the Subbasin in that year (Napa County, 2014).

The total acreages for all agricultural classes in the Subbasin are also consistent with the Land Use Plan Map presented in the 2008 General Plan that includes 21,938 acres in the Agricultural Resource land use type and an additional 8,792 acres designated as the Agriculture, Watershed and Open Space throughout the Subbasin (**Figure 5-1**).

Land use classifications used in this report are consistent with those applied in DWR land use surveys. Under this approach agriculture classes specifically reference areas used to grow a particular crop. Crop types identified by the DWR land use surveys are summarized in **Section 6.5.5**. They include vineyards, deciduous fruit and nut crops, citrus and subtropical crops, truck, nursery, and berry crops, grain crops, field crops, and pasture (DWR, 1987 and DWR, 2011). Agricultural classes do not include facilities primarily used for the processing of harvested crops, such as wineries. This is not equivalent to the Napa County General Plan definition of agriculture which is inclusive of winery facilities.

Urban and Semi-Agricultural classes, as defined by DWR land use maps, include developed land uses that are not used for the production of a crop. Urban sub-classes include residential, commercial, industrial, urban landscaping, and vacant. Semi-agricultural sub-classes include farmsteads (with and without a residence), livestock production facilities, and miscellaneous areas such as small roads, ditches, and other areas within otherwise cropped fields that are not used for growing a crop. Wineries are not a specific land use class used by DWR, but instead may be represented as semi-agricultural or urban-commercial classifications.

Due to differences in the sources of water supply for areas served by municipal water systems in the Subbasin and those areas outside of municipal service areas, this Report includes an additional distinction between municipal and unincorporated areas. Municipal areas are those within the water system service boundaries as depicted in the spatial dataset Napa County of water system boundaries maintained by Napa County, except for agricultural land use units within those boundaries, which are considered to have an independent source of supply. Unincorporated water uses referenced within this Report refer to land use units and areas of the Subbasin not served by municipal water systems, excluding the agricultural land uses that are specific to the production of a crop. These include rural residences, which may be mapped by DWR as semi-agricultural or urban-residential land uses, and wineries.

Table 5-2. Napa Valley Subbasin Land Use Survey Summaries by Year

	1987 Acres	1999 Acres	2011 Acres
Total Agriculture Classes	24,167	23,333	21,101
Total Native Classes	8,793	9,481	10,670
Total Urban/Semi-Ag Classes	12,937	13,125	14,122
Total Napa Valley Subbasin*	**45,897**	**45,939**	**45,893**

**Slight differences in total acreage are due to gaps in datasets.*

Sources: DWR (1987, 1999, 2011)

Native land use classes used by DWR generally delineate areas that are either undeveloped for agricultural or urban uses. Native sub-classes include native vegetation, riparian vegetation, water surfaces, and barren lands.

Table 5-3. Napa Valley Subbasin Agriculture Classes Summaries by Year

AGRICULTURAL CLASSES	1987 Acres	1999 Acres	2011 Acres
VINEYARD	21,700	22,317	20,150
ORCHARD	571	135	149
PASTURE	247	6	61
GRAIN	224	120	66
TRUCK/FIELD	186	57	175
IDLE	1,238	698	500
AGRICULTURAL SUB-TOTALS	**24,166**	**23,333**	**21,101**

Sources: DWR (1987, 1999, 2011)

As shown in the following sections, the demand for water within the Subbasin is affected by both the size of the population and cropping patterns, among other factors. To address these components, the rest of this chapter describes the sources of supply and amounts of water used in the Napa Valley Subbasin during the period between water years 1988 and 2015. That 28-year period was selected as the hydrologic base period for the sustainable yield analysis presented in **Chapter 6**. Data presented in the following sections include data provided by the four municipalities in the Subbasin, as well as the Napa Sanitation District. The latter operates a wastewater treatment facility south of the Subbasin which receives influent from the City of Napa and supplies recycled water to customers in the vicinity of the City of Napa. Additional data presented below regarding irrigation water demands for agriculture and landscaping uses were calculated using the Root Zone Model presented in **Chapter 6**. Water uses by residential and commercial users in unincorporated parts of the Subbasin were estimated for this report using methods described in **Section 5.2.3**.

5.2 Water Supplies and Utilization by Sector

The major sources of supply within the Napa Valley have been well established for decades before the selected WY 1988-2015 base period. Available land use data and municipal water supply records show that during the early part of the base period (late 1980s) water demands were primarily met by diversions of surface waters from the Napa River System, including diversions by municipal reservoirs located in the Subbasin watershed to the east above the Subbasin. Groundwater pumping has provided a substantial contribution to the overall water supply for the Subbasin since at least the late 1980s. Land use mapping by DWR indicates that a shift occurred from predominantly surface water to groundwater as the source of supply for agriculture between 1987 and 2011. Local supplies have also been augmented since 1968 by water imported for municipal use from the State Water Project along the North Bay Aqueduct[20] and more recently through the use of recycled water.

[20] Prior to this water had been delivered via the North Bay Aqueduct from Lake Berryessa since 1968),

5.2.1 Agricultural Water Supply and Utilization

Water supplies available to agricultural land uses in the Subbasin include groundwater pumped from the Subbasin, recycled water, surface water diverted from the Napa River System within the Subbasin, and to a lesser extent surface water diverted outside the Subbasin from the adjacent watershed into Lake Hennessey. Diversions of surface water from the Subbasin watersheds are a minor source of supply to agriculture in the Subbasin, although there the Cities of Napa and St. Helena have reported some sales of water totaling a few hundred acre-feet in most years.

In the early part of the base period, according to the 1987 DWR land use survey, 65% of the irrigated agricultural acreage in the Subbasin was supplied solely by localized surface water diversions off of the Napa River System, while 18% of the irrigated acreage received water from pumped groundwater. The 2011 DWR land use survey indicates that groundwater has since become the source of supply for 70% of irrigated agriculture within the Subbasin, with surface water serving 16% of the irrigated acreage. Residual amounts in both survey years were acreages where either a combination of sources of supply was indicated or another source of water was used (e.g., recycled water).

Data from DWR land use maps notwithstanding, as in many areas of the state there is no comprehensive data collection effort in the Subbasin to monitor groundwater use by agriculture. Limited data on surface water diversions are available from the State Water Resources Control Board (SWRCB) Electronic Water Rights Information Management System (eWRIMS). SWRCB eWRIMS data show 329 Points of Diversion (POD) associated with 270 water rights applications within the Subbasin. Of the 329 PODs, 225 are classified as either licensed, permitted, claimed, or active (**Table 5-4**). eWRIMS stores data on the face value of water rights applications as well as a limited number of annual reports of actual diversions and use filed for individual PODs. Annual reports available on eWRIMS for the Subbasin generally span from 2007 through 2015; however, the number of reports available per year over that time account for only between 8% and 64% of the 225 currently valid PODs.

Table 5-4. Points of Diversion within the Napa Valley Subbasin

Types	Licensed	Permitted	Claimed	Registered	Active	Revoked	Inactive	Cancelled	Closed	Certified	Pending	Total Count
Point of Direct Diversion	16	5	27	0	0	25	20	1	0	0	0	94
Point of Direct Diversion Point of Storage - Unspecified	2	0	2	1	0	0	3	0	0	0	0	8
Point of Diversion to Offstream Storage	4	3	1	0	1	0	0	0	0	0	1	10
Point of Onstream Storage	0	0	0	1	0	0	0	0	0	0	0	1
Point of Storage - Unspecified	74	21	18	1	45	27	7	7	4	1	3	208
Point of Storage - Unspecified Point of Direct Diversion	2	0	1	0	0	4	1	0	0	0	0	8
Total	98	29	49	3	46	56	31	8	4	1	4	329

Because of the lack of available data, a root zone water balance model was developed for this Report to more accurately quantify rates of water application to meet evapotranspiration demands by crops or other irrigated vegetation. The Root Zone Model is described in **Chapter 6**. The results are summarized here and represent calculated values for applied water demands for all irrigated crops in the Subbasin (**Table 5-5**). The Root Zone Model accounts for applications of groundwater, surface water, and recycled water to meet crop water demands.

Water use by agriculture shows variability from year to year, with less use in wet years when late spring precipitation provides sufficient soil moisture to sustain the crop for a longer period of time into the growing season before irrigation is necessary. On average from 1988 to 2015, the rate of total water use by agriculture in the Subbasin has decreased slightly from approximately 18,000 AFY to approximately 16,000 AFY, with variations on a year-to-year basis (**Table 5-5** and **Figure 5-2**). The Root Zone Model results show a decline in the use of surface water as a source and an increase in groundwater use from 1988 to 2015 as specified by the 1987 and 2011 land use maps.

A review of the Root Zone Model results finds that the calculated surface water use from 2010 through 2015, when more annual reports are available on eWRIMS, is consistent with the use of surface water for irrigation reported to the SWRCB. Use of recycled water for irrigation of all crops has been stable over time. However, current and planned expansions of recycled water distribution infrastructure by the Town of Yountville and Napa Sanitation District are likely to increase the rate of recycled water use in the future.

Future agricultural water use is calculated by the Root Zone Model for the period from 2016 to 2025 using climate model outputs for the study area and the most recent 2011 DWR land use survey data, as described in **Chapter 6**. Projected agricultural water use also incorporates increases associated with the expansion of vineyards in the Subbasin, based on a review of proposed vineyard development projects.

As of September 2016, vineyard development permit applications indicated the potential for 8.67 acres of additional vineyard in the Napa Valley Subbasin. The future water demand associated with these and other potential vineyard development projects within the Subbasin are estimated to be 2 AFY for each year after 2015, based on a conservative annual water demand factor of 1 AF per acre and up to a 5-year period between the initial proposal and eventual vineyard planting. All other water demands for irrigation in future years are calculated by the Root Zone Model consistent with the methods applied for the base period.

From 2016 to 2025, total water use by agriculture is projected to range from 13,000 AFY to 17,900 AFY, with an average of 16,100 AFY. Demand for groundwater to irrigate crops is projected to average 13,100 AFY during the ten years following the base period. Average annual demand for surface water and recycled water is projected to be 2,500 AFY and 500 AFY, respectively.

Figure 5-2. Napa Valley Subbasin Agricultural Water Use, by Source of Supply

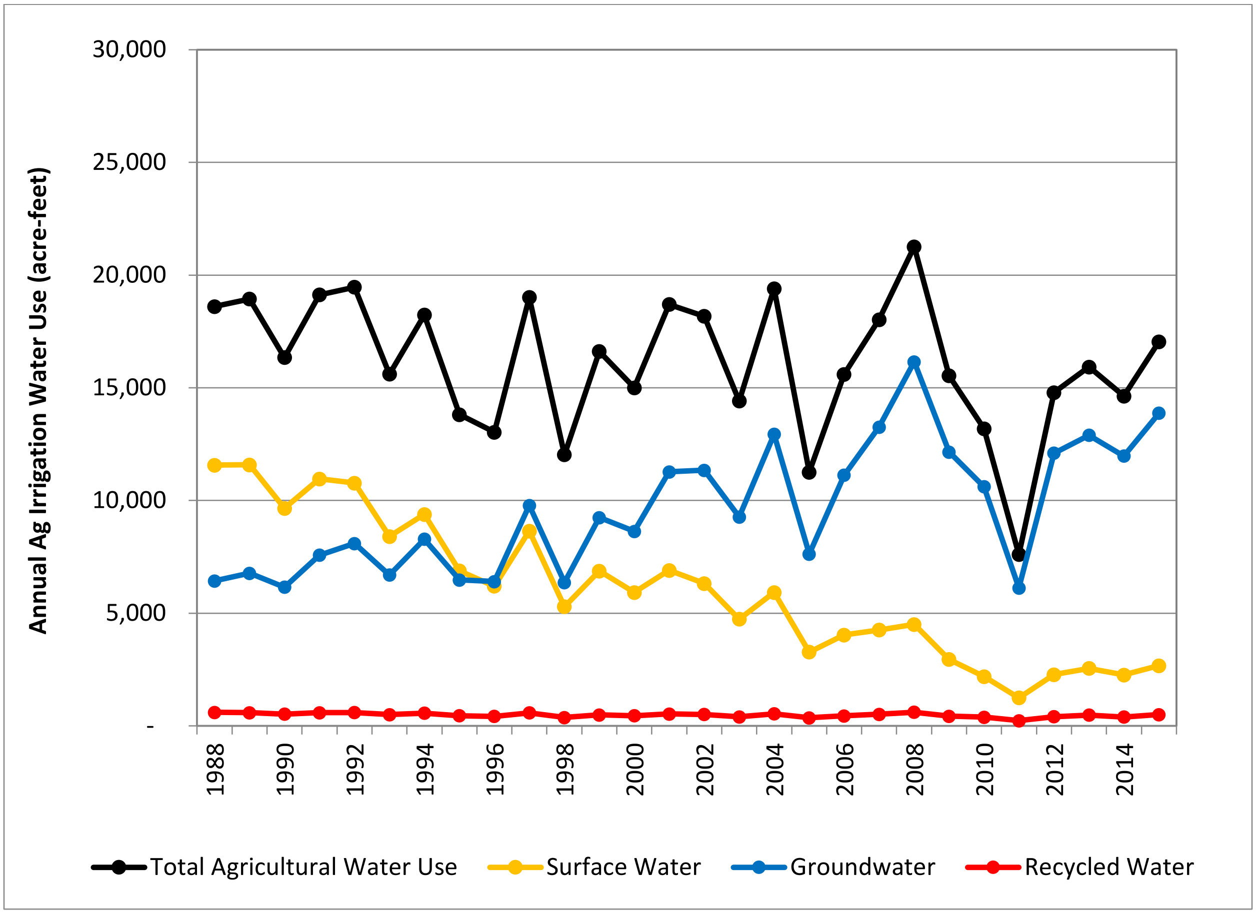
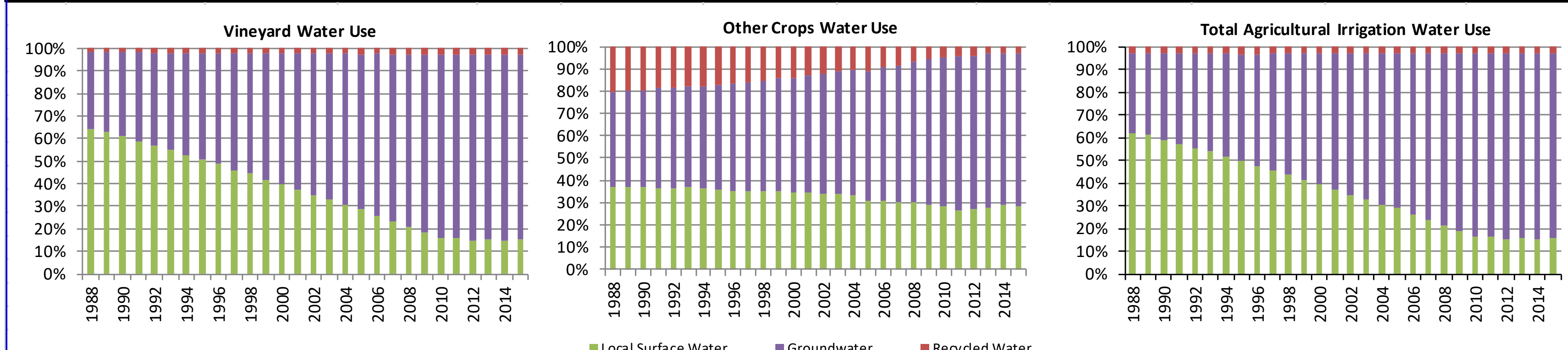


Table 5-5. Napa Valley Subbasin Agricultural Water Use

Year	Vineyards				All Other Crops				All Agricultural Irrigation			
	Local Supply				*Local Supply*				*Local Supply*			
	Surface Water (Diversions Within Subbasin) [AF]	Groundwater [AF]	Recycled Water [AF]	**Total [AF]**	Surface Water (Diversions Within Subbasin) [AF]	Groundwater [AF]	Recycled Water [AF]	**Total [AF]**	Surface Water (Diversions Within Subbasin) [AF]	Groundwater [AF]	Recycled Water [AF]	**Total [AF]**
1988	11,031	5,824	311	**17,166**	535	611	290	**1,436**	11,566	6,435	601	**18,602**
1989	11,069	6,166	315	**17,550**	510	605	271	**1,386**	11,579	6,771	586	**18,936**
1990	9,181	5,606	278	**15,065**	473	551	248	**1,272**	9,654	6,157	526	**16,337**
1991	10,457	6,960	333	**17,750**	500	616	255	**1,371**	10,957	7,576	588	**19,121**
1992	10,299	7,497	353	**18,149**	476	592	241	**1,309**	10,775	8,089	594	**19,458**
1993	7,979	6,167	293	**14,439**	427	524	208	**1,159**	8,406	6,691	501	**15,598**
1994	8,934	7,709	345	**16,988**	447	573	218	**1,238**	9,381	8,282	563	**18,226**
1995	6,487	5,969	269	**12,725**	389	507	186	**1,082**	6,876	6,476	455	**13,807**
1996	5,808	5,871	245	**11,924**	390	533	181	**1,104**	6,198	6,404	426	**13,028**
1997	8,229	9,202	393	**17,824**	419	578	189	**1,186**	8,648	9,780	582	**19,010**
1998	4,963	5,908	237	**11,108**	326	454	140	**920**	5,289	6,362	377	**12,028**
1999	6,521	8,728	343	**15,592**	354	515	146	**1,015**	6,875	9,243	489	**16,607**
2000	5,586	8,132	315	**14,033**	336	497	134	**967**	5,922	8,629	449	**15,000**
2001	6,566	10,753	403	**17,722**	333	515	124	**972**	6,899	11,268	527	**18,694**
2002	5,991	10,814	395	**17,200**	330	524	117	**971**	6,321	11,338	512	**18,171**
2003	4,448	8,788	309	**13,545**	291	481	93	**865**	4,739	9,269	402	**14,410**
2004	5,599	12,389	439	**18,427**	323	550	99	**972**	5,922	12,939	538	**19,399**
2005	3,061	7,219	282	**10,562**	215	403	76	**694**	3,276	7,622	358	**11,256**
2006	3,792	10,653	372	**14,817**	242	465	73	**780**	4,034	11,118	445	**15,597**
2007	4,001	12,744	444	**17,189**	254	512	69	**835**	4,255	13,256	513	**18,024**
2008	4,254	15,631	553	**20,438**	247	519	56	**822**	4,501	16,150	609	**21,260**
2009	2,744	11,693	392	**14,829**	205	457	39	**701**	2,949	12,150	431	**15,530**
2010	2,024	10,217	362	**12,603**	164	392	27	**583**	2,188	10,609	389	**13,186**
2011	1,133	5,810	211	**7,154**	117	308	19	**444**	1,250	6,118	230	**7,598**
2012	2,113	11,695	384	**14,192**	161	408	26	**595**	2,274	12,103	410	**14,787**
2013	2,373	12,447	458	**15,278**	181	445	21	**647**	2,554	12,892	479	**15,925**
2014	2,058	11,499	378	**13,935**	200	474	20	**694**	2,258	11,973	398	**14,629**
2015	2,479	13,412	479	**16,370**	191	465	21	**677**	2,670	13,877	500	**17,047**



SOURCE:
All agricultural water uses reported in this table are values calculated by the Root Zone Model, as described in Chapter 6

5.2.1.1 Water Use for Frost Protection

In addition to the calculated water uses for irrigation detailed above, farmers of perennial crops in the Subbasin, including but not limited to wine grapes, may apply additional water in some years to protect against frost damage. The need for frost protection varies based on many factors, including crop type, stage of crop development, and the duration and intensity of a given frost event. Using water for frost protection is one of multiple options that farmers may apply, another option is the use of wind machines, large fans permanently installed in fields at locations where mixing the column of air above a crop can prevent the coldest air from settling at ground level, thereby maintaining temperatures sufficient to avoid frost formation.

Given that more than one approach to frost protection is practiced in the Subbasin, and since the use of water for frost protection requires sprinklers to broadly apply water to the canopy of a crop, land use maps were reviewed to determine the areas within the Subbasin where wine grape, citrus, or deciduous crops are found with a sprinkler-based irrigation method capable of applying water to the crop in a way that would protect from frost (i.e., not micro-sprinklers that only apply water below the crop canopy). Once these land use units were delineated, the number and hourly duration of frost events (i.e., hours of temperatures less than or equal to 34 degree Fahrenheit) were tallied based on temperature records from ground-based stations at Oakville and Calistoga. Then a frost protection water demand was calculated based on a published estimate of frost protection water demand of 50 gallons per minute per acre for the duration of the frost event (Lewis et al., 2008).

The total acres of wine grape, citrus, and deciduous crops with an applicable sprinkler irrigation system was 3,517 in 1987. By 2011, acreage of the same crops and irrigation methods had fallen to 389 acres. Allowing for a frost protection season of March through May, the average annual demand for frost protection applications of water was 116 AFY from 1988 through 2015. This is less than one percent of the agricultural water use for irrigation described in **Section 5.2.1**.

5.2.1.2 Drain Tiles

Another cultural practice with the potential to affect the water use requirement of crops in the Subbasin is the practice of actively draining shallow groundwater from the root zone to benefit crop health at certain stages of growth. This can be accomplished by installing drain tiles in the soil below a field. No public data on the location, distribution, or construction of drain tile systems in the Subbasin are available at present. Nevertheless, given the prevalence of farm ponds across the valley and the incentive to reuse water when possible, this Report assumes that drain discharges are not discharged to streams but are retained in ponds, with negligible losses, for later application to a crop. From that assumption the conceptual approach is that water pumped from the drain networks serves to offset groundwater pumping that would otherwise occur later in the same season. The stored drain tile water is then assumed to be groundwater extracted prior to the need for irrigation, but is nevertheless accounted for by the water budget by some portion of what is calculated as irrigation pumping demand later in the season.

5.2.2 Municipal Water Supply and Utilization

Prior to the late 1980s, the major source of municipal supply in the Napa Valley had been diversion of local surface waters from the Napa River system. In 1988, deliveries from the State Water Project through the North Bay Aqueduct began to augment local supplies. A small of amount of groundwater has been part of the historical municipal water supply in the Napa Valley. More recently, increasing amounts of recycled water are also being generated and distributed around the Subbasin for municipal irrigation.

The local surface water diversions are captured in City or State-owned and operated reservoirs within the upper watersheds of the Napa Valley in accordance with water rights secured through a license with the State Water Resource Control Board, Division of Water Rights. Storage and yield details for these reservoirs are summarized in **Table 5-6**.

Table 5-6. Reservoir Storage Capacity and Yield (acre-feet per year)

Reservoir Name	Owner/Operator	Diversion Right	Storage Capacity	Average Annual Inflow	Average Yield	Firm Yield (3)
Lake Hennessey(1)	City of Napa	30,500	31,000	19,692	17,500	5,000
Milliken Reservoir(1)	City of Napa	2,350	1,390	3,656	700	400
Bell Canyon Reservoir(2)	St. Helena	3,800	2,050	3,133	1,800	530
Kimball Reservoir(2)	City of Calistoga	626	291	2,817	380	110
Rector Reservoir(2)	State of California	1,937	4,000	3,354	2,500	1,200

Source:
(1) 2010 City of Napa UWMP
(2) 2050 Water Supply Study, Technical Memorandum 4, West Yost & Associates, 2005; Average Yield is with 63% probability; Firm Yield is with 100% probability (Table 4).
(3) Firm Yield represents the supply anticipated to be available in single critically-dry water years.

The Napa County Flood Control and Water Conservation District (NCFCWCD) is the local contractor of the State Water Project (SWP) and imports surface water supplies for use in the Napa Valley. Water is diverted from the North Sacramento/San Joaquin Delta at the Barker Slough Pumping Plant and conveyed through the North Bay Aqueduct (NBA) approximately 21 miles to the Cordelia Forebay; water is conveyed an additional six miles to the SWP Napa Turnout Reservoir at Jamieson Canyon. The majority of the water delivered through the NBA is then treated at the City of Napa's Jamieson Canyon Water Treatment Plant and distributed to Napa water users and the participating municipalities within the Valley. The amount of water available to NCFCWCD is determined in the Table A of the SWP contract, further breakdown of individual municipal entitlements are summarized in **Table 5-7**.

Table 5-7 State Water Project Table A Entitlement Table (acre-feet)

	Napa	Calistoga	Yountville	St. Helena	Total
1988	3,400	220	225	0	3,845
1989	3,700	240	255	0	4,195
1990	4,000	260	283	0	4,543
1991	4,300	275	315	0	4,890
1992	4,600	295	345	0	5,240
1993	5,000	315	375	0	5,690
1994	5,400	335	400	0	6,135
1995	5,800	355	425	0	6,580
1996	6,200	375	452	0	7,027
1997	6,600	390	475	0	7,465
1998	7,000	410	500	0	7,910
1999	11,350	500	500	0	12,350
2000	11,600	525	500	0	12,625
2001	12,850	1,475	1,100	1,000	16,425
2002	13,100	1,500	1,100	1,000	16,700
2003	13,350	1,525	1,100	1,000	16,975
2004	13,600	1,550	1,100	1,000	17,250
2005	13,850	1,575	1,100	1,000	17,525
2006	14,100	1,600	1,100	1,000	17,800
2007	15,350	1,625	1,100	0	18,075
2008	15,600	1,650	1,100	0	18,350
2009	15,850	1,675	1,100	0	18,625
2010	16,100	1,700	1,100	0	18,900
2011	16,350	1,725	1,100	0	19,175
2012	16,600	1,750	1,100	0	19,450
2013	16,800	1,775	1,100	0	19,675
2014	17,100	1,800	1,100	0	20,000
2015	17,700	1,825	1,100	0	20,625

Source: NCFCWCD (P. Miller)

The ability of the SWP to deliver water to its contractors in any given year depends on a number of factors, including rainfall, size of snowpack, runoff, water in storage, and pumping capacity in the Delta. Biological opinions on threatened and endangered fish species are new significant factors affecting SWP deliveries. The actual delivery, or yield, varies from year to year and is described as a percentage of the contractual entitlement. Annual SWP deliveries are a percentage of Table A water, including additional amounts in some years from the carryover of unused allocations from prior years or water purchased from the allocation of other SWP contractors. While 100% of the Table A entitlement may be available in wet years, lesser amounts are delivered in normal, single-dry, and multiple-dry years. The current SWP

Final Delivery Capability Report 2015, issued in July 2015, projects that under existing conditions (2015), the average annual delivery of Table A water is estimated at 61%.

Historical annual water use for the municipal purveyors in the Napa Valley by source over the 1988 to 2015 base period is documented in **Table 5-8**. Most records were readily available from the respective purveyors, including: the City of Napa, the City of St. Helena, the City of Calistoga, the Town of Yountville, and the State of California. Those records are included in the summary; where records were not available, estimates have been made with the intention of obtaining those records in the future.

Groundwater usage has been the smallest component of supply over the base period, averaging about 300 AF per year (2%) (**Figure 5-4**). Long-term surface water utilization for municipal use for the entire Subbasin has averaged 16,600 AF over the base period (**Table 5-8** and **Figure 5-4**). Total municipal use increased generally in a linear trend through the 1990s from 12,800 AF, to a maximum of 20,400 AF in 2002. Since then, total use has gradually declined except for slight year over year increases from 2007 to 2008 and 2012/2013. Particularly steep declines in 2014 and 2015 (by about 25% from the 2013 usage) to a current amount of about 14,700 AF in 2015. Average annual use by all municipal purveyors has been 17,300 AFY from 1988 through 2015. The majority of that usage has been from met by local surface water supplies (peaking as high as 85% in 1997), and by increasing amounts of imported State Water generally since 2006. From 2012 through 2015, average municipal supply for the Napa Valley Subbasin was comprised of 47% (7,888 AFY) from State Water Project, 47% (7,871 AFY) from local surface water supplies, 2% (317 AFY) from groundwater, and 4% (656 AFY) from recycled water. The following sections describe sources of supply and water use trends for the four municipal water purveyors in the Subbasin.

Projected future municipal water use in the Subbasin is conservatively estimated to remain constant at the average of reported use from 2011 through 2015, as described in **Chapter 6**. From 2016 to 2025 total municipal water use is projected to average 16,700 AFY. Demand for groundwater is anticipated to average 300 AFY during the ten years following the base period. Average annual demand for surface water and recycled water during those years is projected to be 15,800 AFY and 600 AFY, respectively.

Figure 5-3. Napa Valley Subbasin Municipal Water Use, by Purveyor

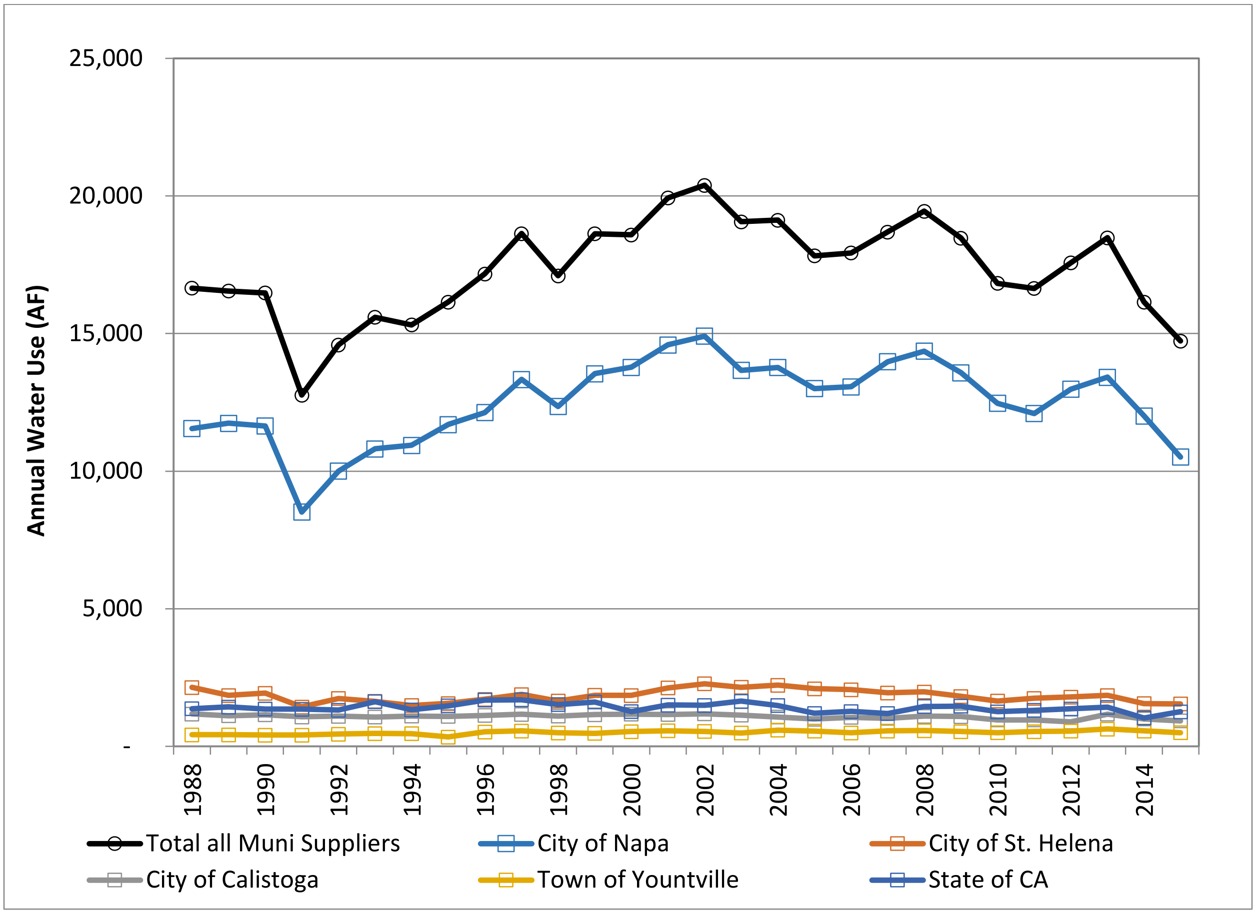


Figure 5-4. Napa Valley Subbasin Municipal Water Use, by Source of Supply

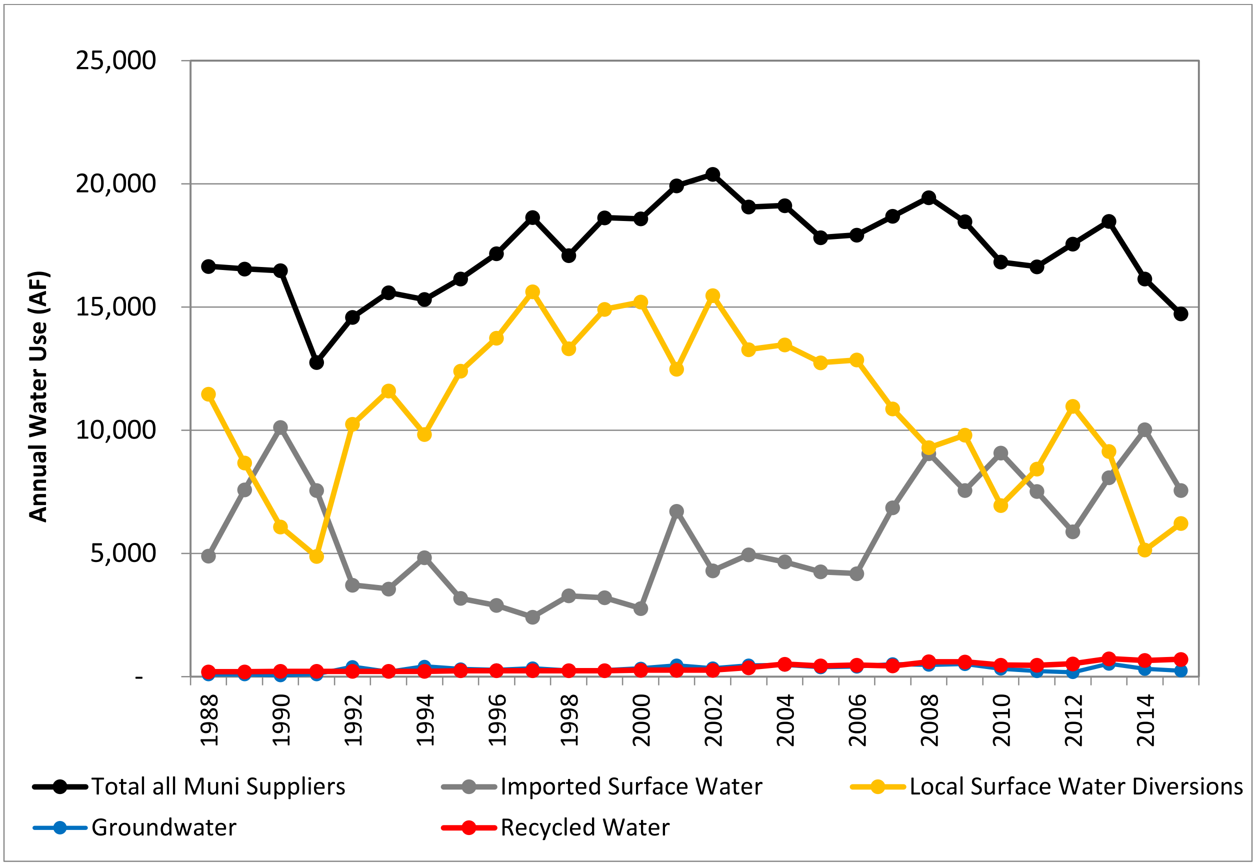
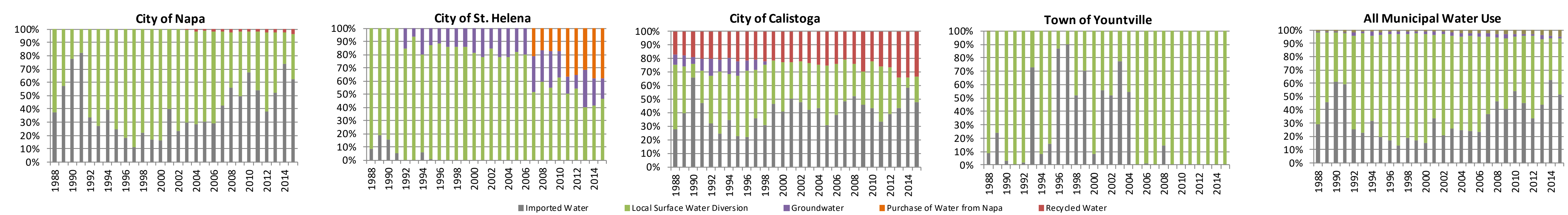


Table 5-8. Napa Valley Subbasin Municipal Water Use

Year	City of Napa					City of St. Helena				City of Calistoga					Town of Yountville			State of CA	All Municipal Suppliers				
	Imported Supply	*Local Supply*				*Imported Supply*	*Local Supply*			*Imported Supply*	*Local Supply*				*Imported Supply*	*Local Supply*		*Local Supply*	*Imported Supply*	*Local Supply*			
	State Water Project [(1)] [AF]	Lake Hennessey [(2)] [AF]	Milliken Reservoir [(2)] [AF]	Recycled Water [(2)] [AF]	**Total [AF]**	State Water Project [(1)] /City of Napa Purchase [(3)] [AF]	Bell Canyon [(4)] [AF]	Groundwater[(5)] [AF]	**Total [AF]**	State Water Project [(1)] [AF]	Kimball Reservoir [(6)] [AF]	Groundwater [(7)] [AF]	Recycled Water [(8)] [AF]	**Total [AF]**	State Water Project [(1)] [AF]	Rector Reservoir [(9)] [AF]	**Total [AF]**	Rector Reservoir [(10)] [AF]	State Water Project [(1)] [AF]	Surface Water, Local Reservoirs [AF]	Groundwater [AF]	Recycled Water [AF]	**Total [AF]**
1988	4,355	5,790	1,402	0	11,548	177	1,965	0	**2,142**	323	563	91	200	**1,177**	38	382	**420**	1,368	4,893	11,471	91	200	16,655
1989	6,698	3,839	1,203	0	11,739	348	1,500	0	**1,848**	438	383	91	200	**1,112**	102	317	**419**	1,433	7,586	8,675	91	200	16,551
1990	9,049	1,743	848	0	11,640	303	1,628	0	**1,931**	751	118	56	220	**1,145**	14	392	**406**	1,358	10,117	6,087	56	220	16,480
1991	6,985	923	606	0	8,514	76	1,354	0	**1,430**	504	250	94	220	**1,068**	1	404	**405**	1,346	7,566	4,883	94	220	12,763
1992	3,363	5,684	956	0	10,003	0	1,466	270	**1,736**	349	388	137	220	**1,094**	7	433	**440**	1,317	3,719	10,244	407	220	14,590
1993	2,967	6,660	1,183	0	10,810	3	1,526	105	**1,634**	260	483	99	220	**1,063**	337	127	**464**	1,623	3,567	11,602	204	220	15,593
1994	4,334	5,435	1,172	0	10,942	90	1,102	292	**1,484**	376	376	127	220	**1,100**	39	423	**462**	1,327	4,839	9,836	419	220	15,315
1995	2,870	7,994	832	0	11,695	12	1,343	205	**1,560**	246	486	113	245	**1,090**	54	281	**335**	1,469	3,182	12,404	318	245	16,149
1996	2,192	8,665	1,273	0	12,129	0	1,514	195	**1,709**	248	547	86	245	**1,125**	456	68	**524**	1,682	2,896	13,749	281	245	17,170
1997	1,500	10,673	1,162	0	13,334	0	1,624	262	**1,886**	418	415	87	245	**1,164**	501	56	**557**	1,694	2,419	15,623	349	245	18,635
1998	2,693	8,705	952	0	12,350	0	1,410	237	**1,647**	337	495	24	245	**1,101**	253	234	**488**	1,516	3,283	13,312	261	245	17,100
1999	2,339	10,310	896	0	13,545	0	1,589	264	**1,853**	533	371	0	245	**1,149**	335	139	**474**	1,611	3,207	14,916	264	245	18,632
2000	2,247	10,775	753	0	13,774	0	1,503	345	**1,849**	479	427	0	265	**1,171**	44	490	**534**	1,260	2,770	15,209	345	265	18,588
2001	5,826	8,288	475	0	14,589	0	1,653	468	**2,121**	578	314	0	265	**1,157**	316	247	**563**	1,503	6,720	12,480	468	265	19,932
2002	3,459	10,938	512	0	14,909	0	1,922	349	**2,271**	560	355	0	265	**1,180**	282	259	**541**	1,491	4,301	15,477	349	265	20,392
2003	4,107	8,768	683	106	13,663	0	1,683	463	**2,146**	474	396	0	265	**1,135**	372	109	**481**	1,641	4,953	13,280	463	371	19,067
2004	3,883	9,001	641	245	13,769	0	1,741	480	**2,221**	460	341	0	265	**1,066**	320	269	**589**	1,481	4,663	13,474	480	510	19,126
2005	3,956	8,120	736	189	13,001	0	1,709	382	**2,091**	302	432	0	253	**987**	0	553	**553**	1,197	4,258	12,747	382	442	17,829
2006	3,786	9,064	0	218	13,068	0	1,647	410	**2,057**	399	399	0	253	**1,051**	5	482	**487**	1,268	4,190	12,861	410	470	17,931
2007	5,959	7,050	743	225	13,977	413	1,011	521	**1,944**	490	316	0	214	**1,020**	0	559	**559**	1,191	6,862	10,869	521	439	18,691
2008	8,082	5,303	632	347	14,365	326	1,172	479	**1,977**	568	260	0	264	**1,091**	83	488	**571**	1,446	9,059	9,301	479	611	19,450
2009	6,748	5,938	607	283	13,576	314	993	508	**1,815**	494	268	0	320	**1,082**	0	536	**536**	1,461	7,556	9,802	508	603	18,470
2010	8,379	3,117	714	259	12,469	285	1,035	325	**1,645**	414	337	0	211	**962**	0	496	**496**	1,257	9,079	6,957	325	470	16,830
2011	6,552	4,623	708	216	12,098	644	874	227	**1,745**	322	386	0	252	**960**	0	533	**533**	1,307	7,518	8,430	227	468	16,642
2012	4,906	7,781	0	293	12,980	634	975	182	**1,791**	343	309	0	234	**887**	0	553	**553**	1,358	5,883	10,977	182	527	17,569
2013	6,992	5,903	191	330	13,416	583	737	526	**1,846**	505	263	0	402	**1,170**	0	630	**630**	1,421	8,080	9,144	526	732	18,483
2014	8,854	2,331	508	318	12,012	593	646	317	**1,555**	580	71	0	341	**992**	0	560	**560**	1,028	10,027	5,143	317	659	16,146
2015	6,539	2,921	660	393	10,513	582	713	244	**1,540**	439	176	0	311	**927**	0	492	**492**	1,258	7,560	6,220	244	704	14,729



SOURCE:
(1) Napa County (1999-2015) and City of Napa (1989-1998) except for 1988 where subtotals were estimated as proportion of total SWP deliveries or reported by Yountville. Total deliveries shown are 89.9% of the total amount reflecting the estimated proportion of the City of Napa Population within the Napa Valley Subbasin as of the 2010 census.
(2) City of Napa; Lake Hennessey subtotals are less sales to Ag accounts that are reported separately. Total uses shown are 89.9% of the total amount reflecting the estimated proportion of the City of Napa Population within the Napa Valley Subbasin as of the 2010 census.
(3) City of St. Helena except years 1990-1993 (estimated by 2005 WYA Water Supply Study), 2005 (report by SWRCB), 1988/1989 (estimate); not double counted as a SWP purchase
(4) City of St. Helena except years 1990-1993 (estimated by 2005 WYA Water Supply Study), 2005 and 2008 (report by SWRCB), and 1989 (estimate based on recent annual average)
(5) City of St. Helena except for years 1992-1999, 2005, 2008 (report by SWRCB)
(6) City of Calistoga except for years 1988-1989 (estimated by 2005 WYA Water Supply Study)
(7) City of Calistoga except for years 1988-1989 (estimated as average annual total from subsequent 9 years)
(8) City of Calistoga; estimated 1988-2004
(9) Town of Yountville
(10) SWRCB annual reports (2008-2014) less deliveries to Yountville; 1988-2007 and 2015 estimated at 1,750 af per year less deliveries to Yountville
Subtotals are highlighted in the table where estimates are utilized.

5.2.2.1 The City of Napa

The City of Napa is the largest municipal purveyor of water in the Napa Valley. The City of Napa currently serves a population of almost 90,000 and provides water to the other municipalities and agricultural entities in the Valley through their water treatment facilities and recycled water facilities. Total water use by the City of Napa has averaged 13,900 AFY over the base period, excluding deliveries to agricultural customers and other municipal purveyors.

Historically, the City of Napa's primary source of supply has been through the diversion of local surface waters from the upper watersheds of the Napa River system at Lake Hennessey and Milliken Reservoir (combined long-term average utilization over the base period of 8,200 AFY with 4,000 AF utilized in 2015) with increasing contributions from the State Water Project over that time (1989-1991 and since 2007) and particularly in times of drought (as low as 1,700 AF in 1997 and as high as 10,100 in 1990). The long-term average supply utilized by the City of Napa from the State Water Project is 5,500 AFY over the base period, and in 2015 SWP deliveries totaled about 7,300 AF of SWP water relative to their overall 11,300 AF demand. The City of Napa also utilizes a small amount of recycled water from the Napa Sanitation District (NSD) since 2004 when piping northward from NSD facilities was first constructed and has averaged about 300 AFY over that time. Supply from recycled water facilities is anticipated to increase a few hundred AFY more in the coming years due to the expanded distribution lines being constructed to the MST and other northern areas within the City of Napa. The City does not currently utilize groundwater as a source of supply.

The City of Napa's water service area extends beyond the Subbasin boundaries to the east and west. As a result, the water use data reported by the City of Napa have been reduced in proportion to the estimated population served by the city within the Subbasin boundary. Using 2010 U.S. Census Bureau spatial data, it is estimated that 89% of the population served by the City of Napa is within the Subbasin boundary. Spatial data from earlier Census were either not available or not delineated with sufficient detail to make similar estimates or prior years. **Table 5-9** shows the estimated distribution of water use inside and outside the Subbasin boundaries based on a static estimate of 89% of population and water use falling within the Subbasin.

According to Estimated Projections from the Draft 2015 City of Napa UWMP future annual demands (as AFY) are as follows:

2020	2025	2030	2035	2040
13,167	13,504	13,631	13,790	13,937

According to the 2010 City of Napa UWMP, new sources of supply may include the following: additional SWP water or other water imported from outside the Napa Valley Subbasin (Butte County, City of Vallejo, and Sacramento River), increased production from Milliken Water Treatment Plant following plant upgrades to make use of this source year-round, SWP reservoir storage outside of the County (i.e., Garden Bar-SSWD), groundwater from new wells inside or outside of the Subbasin, and expanded use of recycled water.

5.2.2.2 The City of St. Helena

The City of St. Helena is a municipal water purveyor to a population of about 6,000. Historically, its largest source of supply has been Bell Canyon Reservoir, with lesser amounts of water purchased from the SWP or the City of Napa, or groundwater pumped from the two City-owned groundwater wells installed in the 1990s. Total water use by the City of St. Helena has averaged about 1,850 AFY over the base period. Recycled water is not currently a source of supply.

5.2.2.3 The City of Calistoga

The City of Calistoga is a municipal water purveyor to a population of about 5,000. Historically, its largest source of supply has been SWP purchases, in addition to local surface water from Kimball Reservoir, and groundwater from City-owned wells up until 1998. Total long-term use by the City of Calistoga has averaged about 1,000 AFY over the base period. Approximately 40% of Calistoga's supply has been provided by the SWP. The City of Calistoga currently utilizes about 300 AFY of recycled water for irrigation purposes, up from about 200 AFY in the late 1980s.

5.2.2.4 The Town of Yountville

The Town of Yountville is a municipal water purveyor to a population of about 3,000. Historically the Town's primary source of supply has been Rector Reservoir, which is owned and operated by the State of California with lesser amounts taken from the SWP (as recently as 2008). Total long-term use by the Town of Yountville has averaged about 500 AFY over the base period with a stable trend. Yountville will continue to utilize State Water Project as a source of supply on an emergency basis. Additional supplies include one municipal groundwater well that would be used on a short-term emergency basis. The Town recycles almost 300 AFY of waste water and distributes that to nearby parcels for irrigation.

Table 5-9. City of Napa Water Use by Area

Year	City of Napa - Total Use					City of Napa - Estimated Deliveries to Subbasin					City of Napa - Estimated Deliveries Outside of Subbasin				
	Imported Supply	*Local Supply*				*Imported Supply*	*Local Supply*				*Imported Supply*	*Local Supply*			
	State Water Project (1) [AF]	Lake Hennessey (2) [AF]	Milliken Reservoir (2) [AF]	Recycled Water (2) [AF]	**Total [AF]**	State Water Project (1) [AF]	Lake Hennessey (2) [AF]	Milliken Reservoir (2) [AF]	Recycled Water (2) [AF]	**Total [AF]**	State Water Project (1) [AF]	Lake Hennessey (2) [AF]	Milliken Reservoir (2) [AF]	Recycled Water (2) [AF]	**Total [AF]**
1988	4,844	6,441	1,560	0	**12,845**	4,355	5,790	1,402	0	**11,548**	489	651	158	0	**1,297**
1989	7,450	4,270	1,338	0	**13,058**	6,698	3,839	1,203	0	**11,739**	752	431	135	0	**1,319**
1990	10,066	1,939	943	0	**12,948**	9,049	1,743	848	0	**11,640**	1,017	196	95	0	**1,308**
1991	7,770	1,027	674	0	**9,471**	6,985	923	606	0	**8,514**	785	104	68	0	**957**
1992	3,741	6,323	1,063	0	**11,127**	3,363	5,684	956	0	**10,003**	378	639	107	0	**1,124**
1993	3,300	7,408	1,316	0	**12,024**	2,967	6,660	1,183	0	**10,810**	333	748	133	0	**1,214**
1994	4,821	6,046	1,304	0	**12,171**	4,334	5,435	1,172	0	**10,942**	487	611	132	0	**1,229**
1995	3,192	8,892	925	0	**13,009**	2,870	7,994	832	0	**11,695**	322	898	93	0	**1,314**
1996	2,438	9,638	1,416	0	**13,492**	2,192	8,665	1,273	0	**12,129**	246	973	143	0	**1,363**
1997	1,668	11,872	1,292	0	**14,832**	1,500	10,673	1,162	0	**13,334**	168	1,199	130	0	**1,498**
1998	2,995	9,683	1,059	0	**13,737**	2,693	8,705	952	0	**12,350**	302	978	107	0	**1,387**
1999	2,602	11,468	997	0	**15,067**	2,339	10,310	896	0	**13,545**	263	1,158	101	0	**1,522**
2000	2,499	11,985	838	0	**15,322**	2,247	10,775	753	0	**13,774**	252	1,210	85	0	**1,548**
2001	6,480	9,219	529	0	**16,228**	5,826	8,288	475	0	**14,589**	654	931	53	0	**1,639**
2002	3,848	12,166	570	0	**16,584**	3,459	10,938	512	0	**14,909**	389	1,229	58	0	**1,675**
2003	4,568	9,753	760	118	**15,199**	4,107	8,768	683	106	**13,663**	461	985	77	12	**1,535**
2004	4,319	10,013	713	272	**15,316**	3,883	9,001	641	245	**13,769**	436	1,011	72	27	**1,547**
2005	4,401	9,032	818	210	**14,462**	3,956	8,120	736	189	**13,001**	445	912	83	21	**1,461**
2006	4,211	10,083	0	242	**14,536**	3,786	9,064	0	218	**13,068**	425	1,018	0	24	**1,468**
2007	6,629	7,842	827	250	**15,547**	5,959	7,050	743	225	**13,977**	670	792	84	25	**1,570**
2008	8,990	5,899	703	386	**15,978**	8,082	5,303	632	347	**14,365**	908	596	71	39	**1,614**
2009	7,506	6,606	675	315	**15,101**	6,748	5,938	607	283	**13,576**	758	667	68	32	**1,525**
2010	9,321	3,467	794	288	**13,869**	8,379	3,117	714	259	**12,469**	941	350	80	29	**1,401**
2011	7,288	5,142	787	240	**13,457**	6,552	4,623	708	216	**12,098**	736	519	79	24	**1,359**
2012	5,457	8,655	0	326	**14,438**	4,906	7,781	0	293	**12,980**	551	874	0	33	**1,458**
2013	7,778	6,566	213	367	**14,924**	6,992	5,903	191	330	**13,416**	786	663	22	37	**1,507**
2014	9,849	2,593	565	354	**13,361**	8,854	2,331	508	318	**12,012**	995	262	57	36	**1,349**
2015	7,274	3,249	734	437	**11,694**	6,539	2,921	660	393	**10,513**	735	328	74	44	**1,181**

SOURCE:

(1) Napa County (1999-2015) and City of Napa (1989-1998) except for 1988 where subtotals were estimated as proportion of total SWP deliveries or reported by Yountville. Total deliveries shown are 89.9% of the total amount reflecting the estimated proportion of the City of Napa Population within the Napa Valley Subbasin as of the 2010 census.

(2) City of Napa; Lake Hennessey subtotals are less sales to Ag accounts that are reported separately. Total uses shown are 89.9% of the total amount reflecting the estimated proportion of the City of Napa Population within the Napa Valley Subbasin as of the 2010 census.

5.2.3 Unincorporated Areas Water Supply and Utilization

In addition to the uses to meet agricultural and municipal demands described above, water use occurs throughout the unincorporated parts of the Napa Valley Subbasin to meet a variety of demands. These uses are represented in **Table 5-9** as domestic indoor water uses, landscaping irrigation uses, and commercial winery uses. The irrigation uses in unincorporated areas of the Subbasin are accounted for by the Root Zone Model calibrated according to the 1987 and 2011 land use maps from DWR. These modeled irrigation applications account for irrigation demand on any land use unit in the unincorporated area subject to the irrigation assumptions described in **Chapter 6**. The results include irrigation on residential, agricultural, and commercial land use units. Some increase in the rate of landscaping from 1988 through 2011 is due to an increase in the spatial resolution of the land use mapping efforts for those years. The 1987 land use map was available from DWR only as scanned 1:24,000 scale maps, with land use units delineated by hand. The 1987 mapping effort appears to have omitted many smaller semi-agricultural land use units that are delineated in the 2011 land use map data, provided by DWR as a GIS shapefile.

Indoor water uses for domestic purposes were calculated based on annual population estimates for the area and a per capita daily demand factor of 60.3 gallons, based on data collected from 59 single-family residences in the Sonoma County Water Agency service area as part of a study sponsored by DWR (Aquacraft, 2011). As discussed in **Section 5.1**, available Census data show a trend of decreasing populations in the unincorporated portions of Napa County from 1980 through 2010. U.S. Census Bureau GIS spatial data from the 2010 Census were analyzed to determine the population within the unincorporated Subbasin outside of municipal water system service areas. That analysis showed a total unincorporated Subbasin population of 5,617 in 2010. Annual estimates of domestic (indoor) water use for the unincorporated Subbasin were developed by linearly interpolating the population estimate for 2010 by the trend in county-wide unincorporated population from Census years 1980, 1990, 2000, and 2010.The result is a steadily decreasing trend in domestic (indoor) water use from 420 AF in 1988 to 367 AF in 2015 (**Table 5-9**). Based on the available annual reports to the State Water Resources Control Board for surface water diversions, there is very limited use of surface water to meet demands in the unincorporated Subbasin; therefore, it is assumed that all of domestic indoor water use in the Subbasin is supplied by groundwater.

The calculated winery water use shown in **Table 5-9** was developed from the Napa County Planning, Building, and Environmental Services Department's spatial dataset of currently approved wineries in the county. An estimate of 1,222 acre-feet for 2015 was derived from the permitted level of wine production for each facility in the Subbasin, along with the rate of visitation, number of events, and number of employees permitted for each winery. The calculated use for 2015 was applied throughout the base period due to the lack of available data on permitted facilities in previous years. The application of 2015 winery level usage over the entirety of the base period overestimates early usage but provides a more conservative (high) water budget estimate for future planning purposes.

As shown in **Figure 5-5** water uses in the unincorporated part of the Subbasin have increased from about 4,000 AFY to about 5,000 AFY over the base period, with the majority of the use supplied by groundwater. This includes water used for indoor domestic purposes by rural residents, landscaping irrigation for any irrigated non-cropped land use units, and uses by commercial wineries for wine-making, visitation, and events.

Projected future unincorporated area water use in the Subbasin accounts for stable indoor domestic demands and variable demands for the irrigation of landscaping and non-cropped land uses as calculated by the Root Zone Model using climate model outputs for the study area and the most recent 2011 DWR land use survey data, as described in **Chapter 6**. Projected unincorporated water uses also incorporate increases associated with the expansion of winery operations in the Subbasin, based on a review of pending winery permits and winery permits approved between 2011 and 2015.

Permit applications for new or modified winery operations through September 2016 indicate potential additional demand for 47.7 AFY, based on 21 permit applications for sites within the Subbasin; however, there is uncertainty as to whether all proposed projects will be approved. Winery permits can take several years to receive permitting approval, and even then, not all permitted projects are carried through to construction in a timely manner. A review of winery permits approved from 2011 to 2015 finds that 9 winery permits were approved during that time with a total calculated water demand of 19.55 AFY over that five-year period.[21] Considering the pending winery permit applications and recently approved winery permit applications, total winery water demand in the Napa Valley Subbasin is increased by 12 AFY for each year from 2016 to 2025 for the projected water budget.

From 2016 to 2025 total unincorporated area water use for indoor domestic demands, wineries, and irrigation of non-cropped land use units is projected to range from 4,600 AFY to 5,100 AFY, with an average of 5,000 AFY. Demand for groundwater to supply those uses is anticipated to average 4,700 AFY during the ten years following the base period. Average annual demand for surface water to supply unincorporated area water uses during those years is projected to be 300 AFY.

[21] Total water demand was calculated based on the permitted winery production and marketing details and the County's suggested water use factors presented in the Water Availability Analysis Guidance Document for activities ranging including winemaking, tasting room operations, and events.

Figure 5-5. Napa Valley Subbasin Unincorporated Area Water Use, by Source of Supply

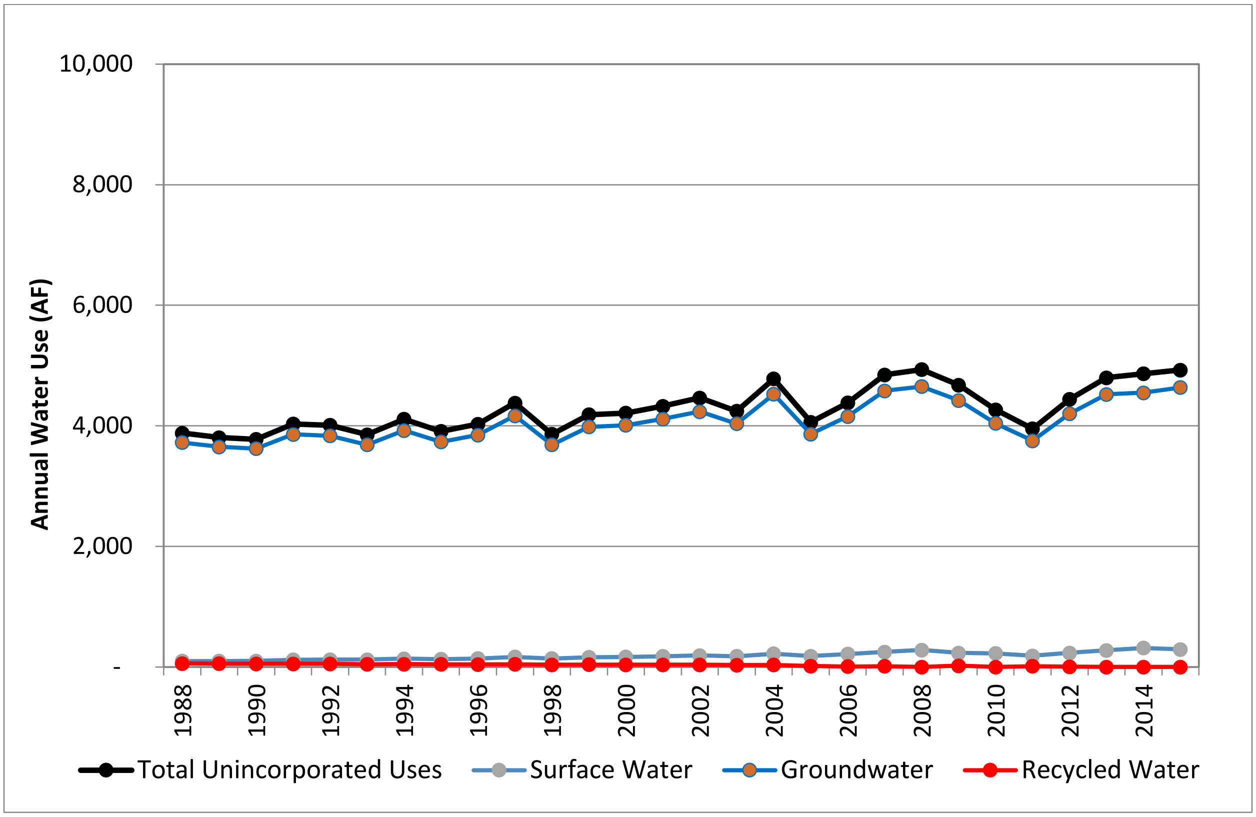
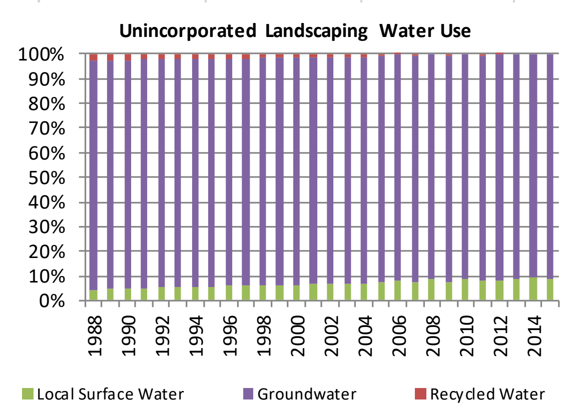
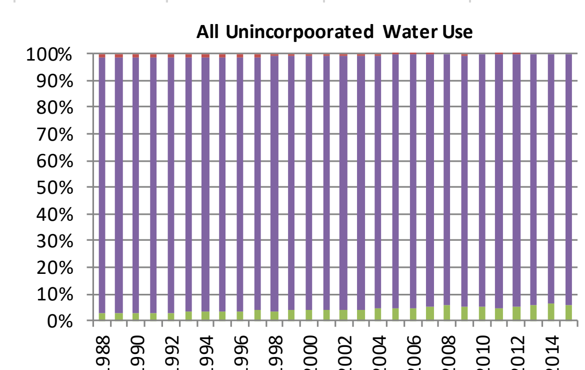


Table 5-10. Napa Valley Subbasin Unincorporated Water Use

Year	Unincorporated Domestic (Indoor) (1)		Unincorporated Landscaping Irrigation (2)				Unincorporated Wineries (3)		All Unincorpoorated (4)			
	Local Supply		Local Supply				Local Supply		Local Supply			
	Groundwater [AF]	**Total [AF]**	Surface Water [AF]	Groundwater [AF]	Recycled Water [AF]	**Total [AF]**	Groundwater [AF]	**Total [AF]**	Surface Water [AF]	Groundwater [AF]	Recycled Water [AF]	**Total [AF]**
1988	420	**420**	99	2,082	58	**2,239**	1,222	**1,222**	99	3,724	58	3,881
1989	416	**416**	98	2,015	55	**2,168**	1,222	**1,222**	98	3,653	55	3,806
1990	412	**412**	102	1,989	52	**2,143**	1,222	**1,222**	102	3,623	52	3,777
1991	411	**411**	119	2,225	54	**2,398**	1,222	**1,222**	119	3,858	54	4,031
1992	411	**411**	123	2,201	52	**2,376**	1,222	**1,222**	123	3,834	52	4,009
1993	409	**409**	122	2,055	46	**2,223**	1,222	**1,222**	122	3,686	46	3,854
1994	408	**408**	138	2,294	48	**2,480**	1,222	**1,222**	138	3,924	48	4,110
1995	407	**407**	131	2,105	44	**2,280**	1,222	**1,222**	131	3,734	44	3,909
1996	408	**408**	140	2,218	42	**2,400**	1,222	**1,222**	140	3,848	42	4,030
1997	406	**406**	166	2,540	46	**2,752**	1,222	**1,222**	166	4,168	46	4,380
1998	405	**405**	140	2,059	36	**2,235**	1,222	**1,222**	140	3,686	36	3,862
1999	404	**404**	161	2,359	39	**2,559**	1,222	**1,222**	161	3,985	39	4,185
2000	404	**404**	166	2,384	37	**2,587**	1,222	**1,222**	166	4,010	37	4,213
2001	400	**400**	178	2,491	36	**2,705**	1,222	**1,222**	178	4,113	36	4,327
2002	398	**398**	190	2,617	36	**2,843**	1,222	**1,222**	190	4,237	36	4,463
2003	396	**396**	177	2,419	31	**2,627**	1,222	**1,222**	177	4,037	31	4,245
2004	394	**394**	221	2,910	34	**3,165**	1,222	**1,222**	221	4,526	34	4,781
2005	391	**391**	180	2,252	17	**2,449**	1,222	**1,222**	180	3,865	17	4,062
2006	388	**388**	215	2,547	9	**2,771**	1,222	**1,222**	215	4,157	9	4,381
2007	386	**386**	250	2,973	14	**3,237**	1,222	**1,222**	250	4,581	14	4,845
2008	385	**385**	282	3,046	0	**3,328**	1,222	**1,222**	282	4,653	-	4,935
2009	381	**381**	233	2,819	22	**3,074**	1,222	**1,222**	233	4,422	22	4,677
2010	379	**379**	225	2,441	0	**2,666**	1,222	**1,222**	225	4,042	-	4,267
2011	377	**377**	185	2,155	13	**2,353**	1,222	**1,222**	185	3,754	13	3,952
2012	375	**375**	233	2,605	6	**2,844**	1,222	**1,222**	233	4,202	6	4,441
2013	372	**372**	277	2,928	0	**3,205**	1,222	**1,222**	277	4,522	-	4,799
2014	369	**369**	317	2,958	0	**3,275**	1,222	**1,222**	317	4,549	-	4,866
2015	367	**367**	291	3,047	0	**3,338**	1,222	**1,222**	291	4,636	-	4,927





Source:

(1) Calculated based on a per household demand of 161 gallons per day for indoor uses (Aquacraft, 2011) and annual unincorporated Subbasin population and average household size based on U.S. Census data for 1980, 1990, 2000, 2010.

(2) All water uses for irrigation reported in this table are values calculated by the Root Zone Model, as described in Chapter 6.

(3) Calculated for 2015 based on Napa County Planning, Building, and Environmental Services Dept. records of permitted wineries, includes uses for winemaking, visitation, events, and employees with average per unit water demands applied as described in the Napa County Water Availability Analysis Guidance Document (Napa County, 2015).

(4) Unincorporated uses are those that are not supplied by municipal water suppliers, as determined by the water service areas for each of the four municipalities in the Subbasin, excepting non-urban land use units in those service area with a defined water source mapped by DWR. This also excludes uses of water for the irrigation of crops in the unincorporated portions of the Subbasin.

5.3 Total Napa Valley Subbasin Water Use

Total water uses within the Napa Valley Subbasin for all categories has remained stable from 1988 through 2015, despite the observed population growth. The total annual use has fluctuated over that time from a low of about 21,000 AFY to as much as 40,000 AFY (**Table 5-10** and **Figure 5-5**). Driven largely by the transition in agricultural sources of supply, groundwater has increased as a proportion of the overall sources of supply, while diversions of local surface water, particularly localized diversions from the Napa River System within the Subbasin itself have declined by about half of initial levels.

Figure 5-5. Napa Valley Subbasin Total Water Use, by Source of Supply

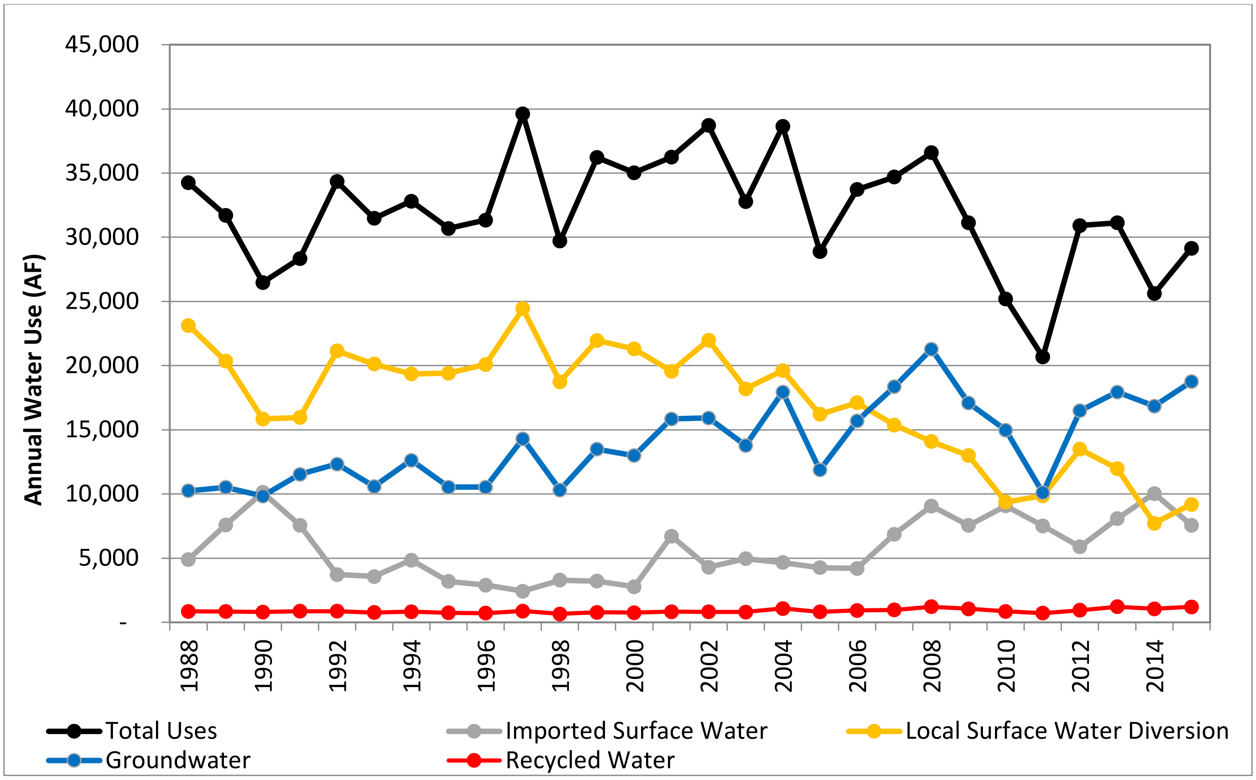
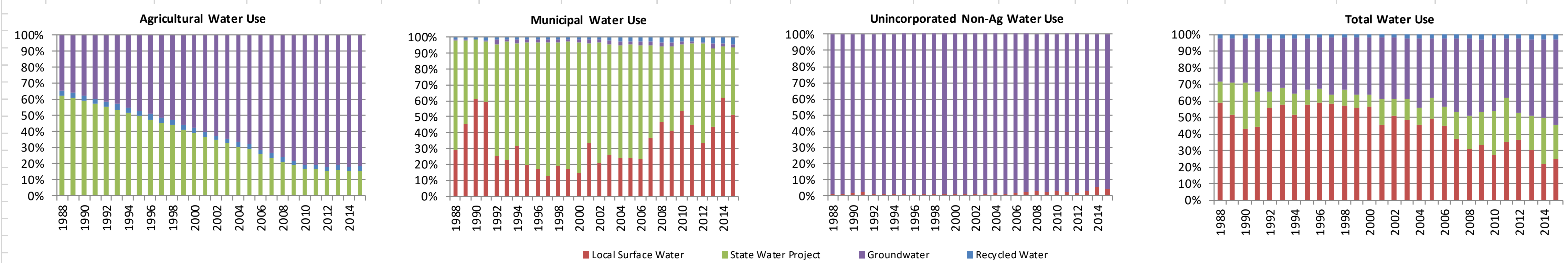


Table 5-11. Napa Valley Subbasin Total Water Use

Year	Agricultural Irrigation Uses				Municpal Uses					Unincorporated, Non-Agricultural Uses				Total Water Use				
	Local Supply				*Imported Supply*	*Local Supply*				*Local Supply*				*Imported Supply*	*Local Supply*			
	Surface Water (Diversions Within Subbasin) (1) [AF]	Groundwater (1) [AF]	Recycled Water (1) [AF]	**Total [AF]**	State Water Project (2) [AF]	Surface Water, Local Reservoirs (3) [AF]	Groundwater (3) [AF]	Recycled Water (3) [AF]	**Total [AF]**	Surface Water (Diversions Within Subbasin) (5) [AF]	Groundwater (5) [AF]	Recycled Water (5) [AF]	**Total [AF]**	State Water Project (2) [AF]	Surface Water (Local Reservoirs and Diversions Within Subbasin) [AF]	Groundwater [AF]	Recycled Water [AF]	**Total [AF]**
1988	11,566	6,435	601	**18,602**	4,893	11,471	91	200	**16,655**	99	3,724	58	**3,881**	4,893	23,136	10,250	859	**34,245**
1989	11,579	6,771	586	**18,936**	7,586	8,675	91	200	**16,551**	98	3,653	55	**3,806**	7,586	20,352	10,515	841	**31,708**
1990	9,654	6,157	526	**16,337**	10,117	6,087	56	220	**16,480**	102	3,623	52	**3,777**	10,117	15,843	9,836	798	**26,477**
1991	10,957	7,576	588	**19,121**	7,566	4,883	94	220	**12,763**	119	3,858	54	**4,031**	7,566	15,959	11,528	862	**28,349**
1992	10,775	8,089	594	**19,458**	3,719	10,244	407	220	**14,590**	123	3,834	52	**4,009**	3,719	21,142	12,330	866	**34,338**
1993	8,406	6,691	501	**15,598**	3,567	11,602	204	220	**15,593**	122	3,686	46	**3,854**	3,567	20,130	10,581	767	**31,479**
1994	9,381	8,282	563	**18,226**	4,839	9,836	419	220	**15,315**	138	3,924	48	**4,110**	4,839	19,355	12,625	831	**32,811**
1995	6,876	6,476	455	**13,807**	3,182	12,404	318	245	**16,149**	131	3,734	44	**3,909**	3,182	19,411	10,528	744	**30,683**
1996	6,198	6,404	426	**13,028**	2,896	13,749	281	245	**17,170**	140	3,848	42	**4,030**	2,896	20,087	10,533	713	**31,332**
1997	8,648	9,780	582	**19,010**	2,419	15,623	349	245	**18,635**	166	4,168	46	**4,380**	2,419	24,437	14,297	873	**39,606**
1998	5,289	6,362	377	**12,028**	3,283	13,312	261	245	**17,100**	140	3,686	36	**3,862**	3,283	18,741	10,309	658	**29,707**
1999	6,875	9,243	489	**16,607**	3,207	14,916	264	245	**18,632**	161	3,985	39	**4,185**	3,207	21,952	13,492	773	**36,217**
2000	5,922	8,629	449	**15,000**	2,770	15,209	345	265	**18,588**	166	4,010	37	**4,213**	2,770	21,297	12,984	751	**35,032**
2001	6,899	11,268	527	**18,694**	6,720	12,480	468	265	**19,932**	178	4,113	36	**4,327**	6,720	19,557	15,849	828	**36,234**
2002	6,321	11,338	512	**18,171**	4,301	15,477	349	265	**20,392**	190	4,237	36	**4,463**	4,301	21,988	15,924	813	**38,725**
2003	4,739	9,269	402	**14,410**	4,953	13,280	463	371	**19,067**	177	4,037	31	**4,245**	4,953	18,196	13,769	804	**32,769**
2004	5,922	12,939	538	**19,399**	4,663	13,474	480	510	**19,126**	221	4,526	34	**4,781**	4,663	19,617	17,945	1,082	**38,644**
2005	3,276	7,622	358	**11,256**	4,258	12,747	382	442	**17,829**	180	3,865	17	**4,062**	4,258	16,203	11,869	817	**28,889**
2006	4,034	11,118	445	**15,597**	4,190	12,861	410	470	**17,931**	215	4,157	9	**4,381**	4,190	17,110	15,685	924	**33,719**
2007	4,255	13,256	513	**18,024**	6,862	10,869	521	439	**18,691**	250	4,581	14	**4,845**	6,862	15,374	18,358	966	**34,698**
2008	4,501	16,150	609	**21,260**	9,059	9,301	479	611	**19,450**	282	4,653	0	**4,935**	9,059	14,084	21,282	1,220	**36,586**
2009	2,949	12,150	431	**15,530**	7,556	9,802	508	603	**18,470**	233	4,422	22	**4,677**	7,556	12,984	17,080	1,056	**31,121**
2010	2,188	10,609	389	**13,186**	9,079	6,957	325	470	**16,830**	225	4,042	0	**4,267**	9,079	9,370	14,976	859	**25,204**
2011	1,250	6,118	230	**7,598**	7,518	8,430	227	468	**16,642**	185	3,754	13	**3,952**	7,518	9,865	10,099	711	**20,675**
2012	2,274	12,103	410	**14,787**	5,883	10,977	182	527	**17,569**	233	4,202	6	**4,441**	5,883	13,484	16,487	943	**30,914**
2013	2,554	12,892	479	**15,925**	8,080	9,144	526	732	**18,483**	277	4,522	0	**4,799**	8,080	11,975	17,940	1,211	**31,127**
2014	2,258	11,973	398	**14,629**	10,027	5,143	317	659	**16,146**	317	4,549	0	**4,866**	10,027	7,718	16,839	1,057	**25,614**
2015	2,670	13,877	500	**17,047**	7,560	6,220	244	704	**14,729**	291	4,636	0	**4,927**	7,560	9,181	18,757	1,204	**29,143**



Source
(1) All water uses for irrigation reported in this table are values calculated by the Root Zone Model, as described in Chapter 6
(2) Napa County (1999-2015) and City of Napa (1989-1998) except for 1988 where subtotals were estimated as proportion of total SWP deliveries or reported by Yountville
(3) Data reported by individual municipalities and reservoir operators, with some estimates, as detailed in Table 5-8
(4) Calculated based on a per person demand of 0.19af/year and calculated annual unincorporated Subbasin population based on U.S. Census population data for 2000, 2010, and 2015.
(5) Includes water uses for irrigation, domestic, and commercial uses detailed in Table 5-9

6 SUSTAINABLE YIELD ANALYSIS (SECTION 354.18)

This Basin Analysis Report provides a functionally equivalent evaluation of historical, current, and projected future conditions in the Napa Valley Subbasin to assess operation of the basin within the sustainable yield for a period of at least 10 years. This section describes two methods used, including: 1) water budget analyses over a 28-year hydrologic base period, and 2) an assessment of changes in groundwater levels from spring to spring and cumulatively over the base period to determine changes in groundwater storage.

SGMA requires that a water budget be developed for each high or medium priority basin or subbasin (Section 354.18(a)); specifically:

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

In addition, SGMA requires that an agency develop “an estimate of sustainable yield for the basin” (Section 354.18(b)(7). Sustainable yield is defined by SGMA 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.*

This Basin Analysis Report presents the results of a base period determination and water budget analyses leading to an estimate of sustainable yield for the Napa Valley Subbasin. The water budget analyses are based on a land use based soil root zone water balance model for the Subbasin and a watershed scale water budget to account for inflows to the Subbasin from the adjoining Napa River Watershed and outflows from the Subbasin to the Napa-Sonoma Lowlands Subbasin.

6.1 Napa Valley Subbasin Hydrologic Base Period

A base period of time must be selected so that the analysis of sustainable yield is performed for a representative period, with minimal bias that might result from the selection of a wet or dry period or significant changes in other conditions including land use and water demands. The study period selected for this Report spans from water years[22] 1988 to 2015. This period was selected on the basis of the following criteria: long-term mean annual water supply; inclusion of both wet and dry stress periods, antecedent dry conditions, adequate data availability, and inclusion of current cultural conditions and water management conditions in the basin.

6.1.1 Long-term Mean Water Supply

Long-term mean water supply is a measure of whether the basin has experienced natural groundwater recharge of the selected time period, and the primary measured component that contributes to natural groundwater recharge is precipitation. Daily precipitation records were obtained from the National

[22] In this report a water year refers to the period from October 1 through the following September 30, designated by the calendar year in which it ends (e.g., November 1, 1987 and July 1, 1988 are both in the 1988 water year).

Oceanic and Atmospheric Administration online data center for Napa State Hospital, St. Helena, Angwin, Calistoga, Yountville, and Sonoma gages and from California Irrigation Management Information System (CIMIS) for Oakville (locations and stations summaries are shown in **Figure 6-1.** When daily data were not available, they were estimated based on the rainfall at a nearby gage for which a proportional relationship had been determined. Ultimately, two plots with annual precipitation, mean annual precipitation and cumulative departure[23] from mean annual precipitation were developed for Napa State Hospital and Calistoga gages (**Figures 6-2** and **6-3)**.

Notable on both of these plots are the long-term relatively dry period from the 1950s through the mid-1970s (negative, or downward slope of the cumulative departure curve), followed a wet late-1970s/early-1980s, dry late-1980s/early-1990s, wet late-1990s/early-2000s, and recently a dry period through 2015. A candidate base period of 1988 to 2015 was considered primarily for the relatively balanced study period lines across the lines of cumulative departure at both the Napa State Hospital and Calistoga gages (**Figures 6-2** and **6-3**). The 1988 to 2015 period includes about the same number of wet and dry years in each precipitation dataset. Nevertheless, the slightly positive slope of the study period line in each plot suggests that precipitation inputs to the Subbasin over the 1988 to 2015 period were not perfectly balanced relative to the long-term average. However, the generally shallow depth to groundwater in the Subbasin (see **Chapter 4**) and drought conditions that have persisted from 2012 to 2015 serve to limit the potential bias imparted by a small net accumulation of precipitation over the 28-year base period.

Additionally, with a long-term (1950-2015) average precipitation of 25.8 inches per year (in/yr) at Napa State Hospital, the selected base period from the 1988 to 2015 has essentially the same average annual precipitation of 26.0 in/yr, and similarly for Calistoga 38.7 in/yr over the selected base period as compared to the longer average of 38.8 in/yr.

Daily average streamflow discharge records were also obtained for Napa River near St. Helena and Napa River near Napa (**Figure 6-1**). These records were reviewed as part of the base period selection process. Ultimately, discharge records from the Napa River near Napa and Napa River near St. Helena were not utilized for base period selection because of differences in the cumulative departure curves between the streamflow gages and the precipitation gages.

6.1.2 Antecedent Dry Conditions

Antecedent (i.e., prior or left-over year) dry conditions minimize differences in groundwater in the unsaturated zone at the beginning and at the end of a study period. Given that the measure of water in the unsaturated zone is nearly impossible to determine, particularly at the scale of a large groundwater basin, selection of a base period with relatively dry conditions antecedent to the beginning and end of the period of record is preferable in that any water unaccounted for in the unsaturated zone is minimized. In this case, the selected base period begins in a dry year with one additional prior dry year and ends in a dry year with 2 prior dry years.

[23] Cumulative departure curves are useful to illustrate long-term rainfall characteristics and trends during drier or wetter periods relative to the mean annual precipitation. Downward slopes of the cumulative departure curve represent drier periods relative to the mean, while upward slopes represent a wetter period relative to the mean.

6.1.3 Data Availability

The available hydrologic and land and water use data use over the selected base period are sufficient to calculate the various parameters used to analyze groundwater conditions as related to groundwater budget and sustainability (e.g., precipitation, streamflow, land uses, groundwater pumping, groundwater levels, and imported water sources). Those data are presented in other sections of this report.

6.1.4 Cultural Conditions

For decades, the Napa Valley Subbasin has been dominated by agriculture and wine grape production in particular. It is understood that total acreages of vineyards, other agricultural commodities, and the native and urban footprints in the Valley have remained relatively constant over the selected base period. Land use surveys were conducted by DWR in 1987, 1999, and 2011 during which a comprehensive assessment of specific agricultural, urban, and native land use classes was made in the field by DWR staff. Additionally, in 1987 and 2011, irrigation water source and irrigation methods were identified which will be utilized in later analyses.

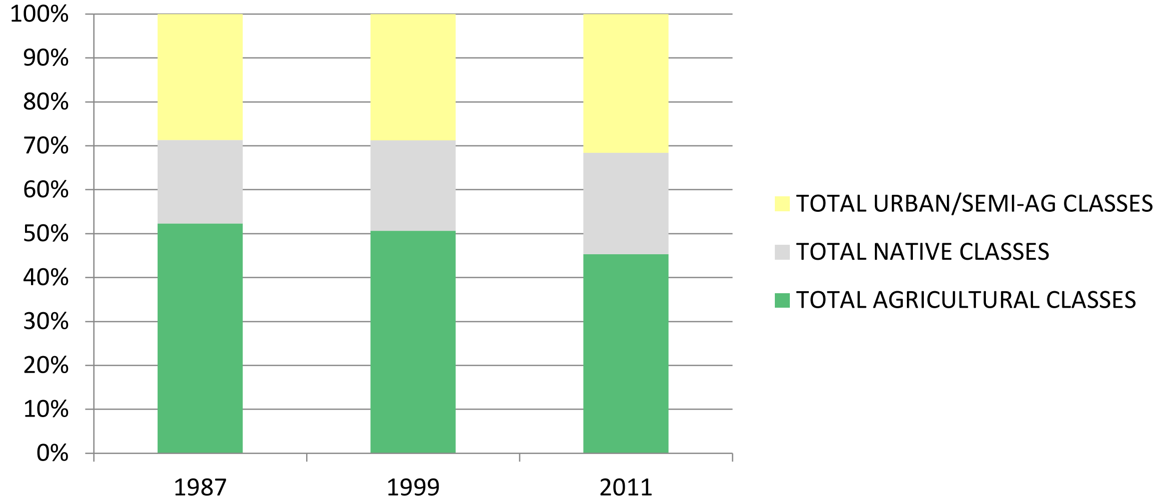
A summary of total acreages by major land use class is shown in **Table 6-1** and depicted in **Figure 6-4**. The native classes (including vegetation and water areas), have seen increased in acreage by 21% over the base period from 8,893 to 10,670. Urban classes have also increased in acreage over the base period from 12,937 to 14,122, an increase of 1,185 acres, or 9%.

Table 6-1. Napa Valley Subbasin Land Use Survey Summaries by Year

	1987 Acres	1999 Acres	2011 Acres
Total Agriculture Classes	24,167	23,333	21,101
Total Native Classes	8,793	9,481	10,670
Total Urban/Semi-Ag Classes	12,937	13,125	14,122
Total Napa Valley Subbasin*	**45,897**	**45,939**	**45,893**

**Slight differences in total acreage are due to gaps in datasets.*

Figure 6-4. Napa Valley Subbasin Major Land Use Survey Classes by Year



A further summary of the subtotals for agricultural classes is shown in **Table 6-2** and depicted in **Figure 6-5**. As first seen in **Table 6-1**, out of 46,000 acres in the Subbasin about half of the total area has been used for agricultural purposes over the base period, ranging between 21,000-24,000 acres. Out of that agricultural acreage, vineyard was the dominant class at about 20,000-22,000 acres (**Table 6-2**). While acreages for each agricultural class declined from 1987 to 2011, the declines were evenly distributed between vineyards (1,551 acre decline) and all other agricultural classes (1,515 acre decline). As a result, vineyard acreage increased as a percentage of all agriculture classes (from 90% in 1987 to 95% in 2011), apparently due to conversions of existing agricultural lands. Irrigated acreages across all agricultural classes increased over the same 1987 to 2011 period, due to an increase in irrigated vineyard acreage of 2,591 acres or 15% (**Figure 6-5**). **Figure 6-6** shows a net decrease of 161 irrigated acres across all other agricultural classes, partially offsetting the increase in irrigated vineyard acreage, though some increase in overall agricultural water demand may have occurred.

Table 6-2. Napa Valley Subbasin Agricultural Land Use Survey Summaries by Year

	1987 Acres		1999 Acres		2011 Acres	
Agricultural Class	Non-Irrigated	Irrigated	Non-Irrigated	Irrigated	Non-Irrigated	Irrigated
Vineyard	4,754	16,947	1,051	21,266	612	19,538
Orchard	489	82	80	55	62	87
Pasture	34	213	-	6	-	61
Grain	224	-	105	15	51	16
Truck/Field	-	186	-	57	19	156
Idle	1,238	-	698	-	500	-
Agricultural Sub-totals	**6,739**	**17,428**	**1,935**	**21,398**	**1,2433**	**19,858**

Figure 6-5. Napa Valley Subbasin Agricultural Land Use Survey Vineyard Class by Year – Irrigated Acreage Only

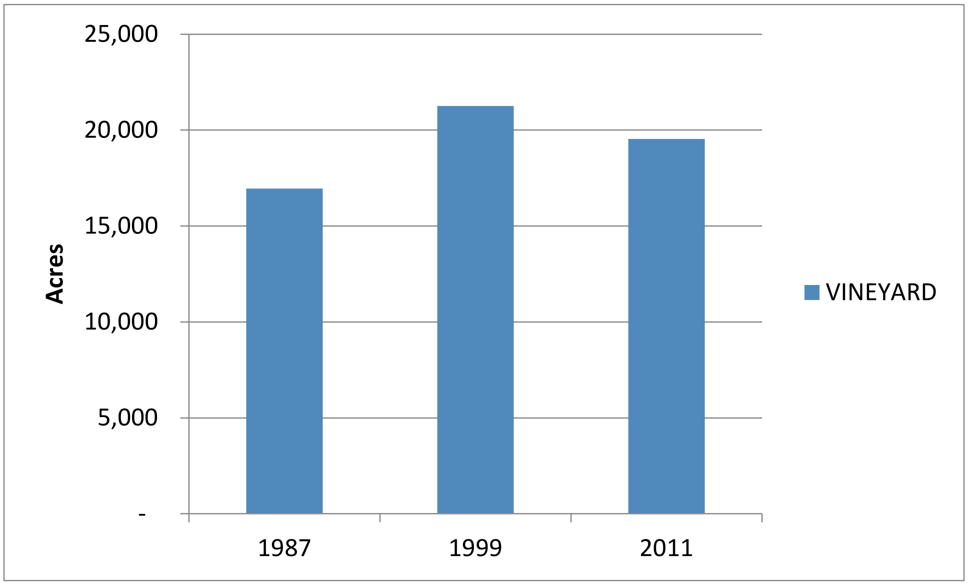
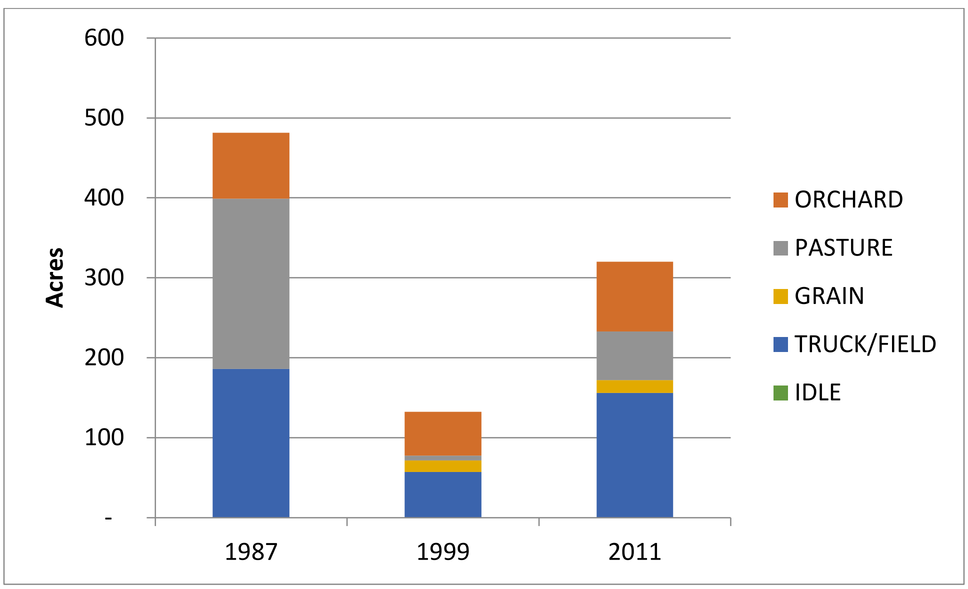


Figure 6-6. Napa Valley Subbasin Agricultural Land Use Survey Non-Vineyard Classes by Year – Irrigated Acreage Only



With relatively stable trends in major land uses, particularly the agricultural classes which are most dependent on water sources within the Subbasin, the selected base period of 1988 to 2015 provides the best period over which to assess the subbasin water budget and changes in water storage.

6.1.5 Water Management Conditions

Water supplies for agricultural and urban entities are currently sourced from groundwater pumped from the Napa Valley Subbasin, surface water diverted and captured off of local water ways within the Napa Valley Watershed, and imported surface water delivered from the State Water Project via the North Bay Aqueduct. Over the selected base period, the major water source for municipal supply has been surface water (see **Chapter 5**), so while the population within the Subbasin has increased from 1988 through 2015, the effect on water supplies within the Subbasin has been limited. For the agricultural sector, water demand is mostly met by groundwater as judged from the 2011 DWR Land Use Survey and reports of surface water diversion filed with the State Water Resources Control Board. The 1987 DWR Land Use survey indicated that agriculture was more reliant on surface water at the beginning of the base period, with about 60% of agricultural classes mapped as using surface water in 1987. However, those diversions of surface water would also have been sourced from the Subbasin, as opposed to reservoirs elsewhere, and would also be reflected in a Subbasin water budget.

Lastly, the selected base period should end near the present time, so that the study period can be used to assess groundwater conditions as they currently exist. Given these criteria, the base period of 1988 to 2015, provides an appropriate period of time to assess groundwater conditions with minimal introduced bias from land use changes or imbalances due to wet or dry conditions.

6.2 Summary of Water Year 2015 Hydrologic Conditions

Water year 2015 concluded with 20.72 inches of rain recorded at the Napa State Hospital reference gage. It was the fourth consecutive year of below average precipitation. **Table 6-3** summarizes recent annual precipitation totals for the Napa State Hospital gage. The precipitation totals shown include estimated totals for gaps in the original record based on correlations with two other gages in the Subbasin. See the Napa County Comprehensive Groundwater Monitoring Program 2015 Annual Report and CASGEM Update for additional information (LSCE, 2016).

Table 6-3. Recent Napa State Hospital Annual Precipitation Totals and Napa River Watershed Water Year Types

Water Year	Annual Precipitation (in)	Water Year Type
2009	21.31	Normal (below average)
2010	28.85	Wet
2011	36.62	Wet
2012	21.75	Normal (below average)
2013	20.26	Normal (below average)
2014	19.67	Dry
2015	20.72	Normal (below average)
Napa State Hospital (NSH) Average Annual Water Year Precipitation (1920 – 2015) = 24.86 inches		

Groundwater level trends in the Napa Valley Subbasin are stable in the majority of wells with long-term groundwater level records. While many wells have shown at least some degree of response to recent drought conditions, the water levels observed in recent years are generally higher than groundwater levels in the same wells during the 1976 to 1977 drought.

Groundwater quality data from wells with long-term records show stable conditions through 2015 compared to the conditions reported previously with data through 2008 (LSCE, 2011). Water quality standard exceedances in the Napa Valley Floor subareas and Napa Valley Subbasin were limited to the naturally-occurring constituent arsenic, with 4 of 26 sites showing maximum concentrations above the MCL of 10 µg/l. Wells with long-term water quality data in the Napa Valley Subbasin show stable TDS and nitrate concentrations, with one exception. Well 06N04W27L002M in the Napa Subarea had a peak of 7.7 mg/L NO3-N (nitrate as nitrogen) in 2011 compared to initial concentrations of 3.4 mg/L NO3-N and 4.0 mg/L NO3-N in 1982 and 1972, respectively.

6.3 Projected Hydrology

Projected Subbasin water budgets rely on projected hydrologic inputs. The baseline condition for future water budgets that is presented in this report is based on the “warm and moderate rainfall” climate change projection of the U.S. Geological Survey Basin Characterization Model (BCM) (Flint, 2013). The “warm and moderate rainfall” (BayArea_CCSM4_rcp85) scenario is based on the comparison of historical climate data between 1951 and 1980 and climate projections from 2010 to 2099. By that comparison the “warm and moderate rainfall” scenario provides “the closest future to the mean of all rainfall projections” included in the BCM (Micheli et al. 2016). The “warm and moderate rainfall” scenario is also most similar to recent conditions and is interpreted to be most consistent with the regulations for projected future water budgets described in the DWR Groundwater Sustainability Plan Regulations.

6.4 Water Budget Framework

A quantitative approach to evaluating groundwater basin conditions is a key component of the requirements for sustainable groundwater management. To this point SGMA specifies that Groundwater Sustainability Plans (GSPs) “shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form” (Section 354.18).

The 28-year base period presented in Section 6.1 encompasses a period of relatively balanced hydrologic conditions and stable water supplies and land uses within the Subbasin. With a stable base period determined, comparable water budget analysis can be performed to evaluate changes in groundwater storage within the Napa Valley Subbasin and assess whether the Subbasin has been operated within its sustainable yield.

The water budget analysis presented is a comprehensive accounting of hydrologic processes affecting the Subbasin including:

- Surface water inflows to the Subbasin as streamflow from the Napa River Watershed Uplands,

- Surface water inflows to the Subbasin conveyed from municipal reservoirs located in the Napa River Watershed Uplands,
- Surface water inflows to the Subbasin from outside the Watershed through State Water Project facilities,
- Surface water outflows from the Subbasin as runoff and groundwater discharge to the Napa River,
- Groundwater inflows to the Subbasin from groundwater recharge and subsurface inflows from the bedrock of the Napa River Watershed Uplands adjacent to the Subbasin,
- Groundwater outflows from the Subbasin that enter the adjoining Napa-Sonoma Lowlands Subbasin,
- Groundwater outflows due to evapotranspiration and groundwater pumping in the Subbasin, and
- Changes in annual groundwater storage in the Subbasin.

Figure 6-7 shows the location of the Napa Valley Subbasin and Napa River Watershed Uplands (Uplands). The Uplands correspond to those portions of the Napa River Watershed that drain into the Napa Valley Subbasin. This excludes portions of the Napa River Watershed that drain into the Napa-Sonoma Lowlands Subbasin.

The Napa Valley Subbasin is located in the southern-central Coast Range Province north of the San Francisco Bay region. This region of the Coast Range is characterized by northwest trending low mountainous ridges separated by intervening stream valleys. Napa Valley is a relatively narrow, flat-floored stream valley drained by the Napa River. The valley floor descends from elevations of about 420 feet at the northwest end of the Valley to about sea level at the southern end.

Figure 6-8 depicts the components and processes represented in the water budget. Inflows to the Subbasin include upland runoff from the surrounding Napa River Watershed, subsurface groundwater inflows from the same upland areas, and precipitation falling on the Subbasin directly. Outflows from the Subbasin include surface water outflow though the Napa River, subsurface groundwater outflow to the Napa-Sonoma Lowlands Subbasin, and evapotranspiration across the surface of the Subbasin. Inflows from upland areas adjacent to the Subbasin and outflows to the Napa-Sonoma Lowlands Subbasin are calculated based on outputs from the California Basin Characterization Model (Flint et al, 2013), streamflow data, and groundwater level data. With the exception of subsurface groundwater outflows, these components are calculated on a monthly time steps. Subsurface groundwater outflows are calculated based on semi-annual groundwater level measurements. Processes that affect the soil root zone including precipitation, infiltration, evapotranspiration, and applied water from groundwater pumping among other sources, are addressed on monthly time steps by a mathematical root zone model developed for this Basin Analysis Report.

6.5 Root Zone Model

A GIS-based Root Zone Model was developed for the Subbasin to account for vertical inflows (recharge) and outflows (pumping) to the Subbasin in response to consumptive uses of water by vegetation.

Recharge and pumping are functions of land use, soil, precipitation, and evapotranspiration (ET). Land use is defined by cropping patterns, irrigation status, irrigation method, and irrigation water source. The Root Zone Model calculates recharge and irrigation pumping individually for each mapped land unit. Results are subsequently aggregated to Subbasin-wide totals in monthly time steps. Simulations were run for the entire 1988 – 2015 base period as well a future scenario from 2016 to 2025. The future scenario incorporates downscaled climate model projections for a "warm and moderate rainfall" condition from the USGS BCM (Flint, 2013).

6.5.1 Methodology

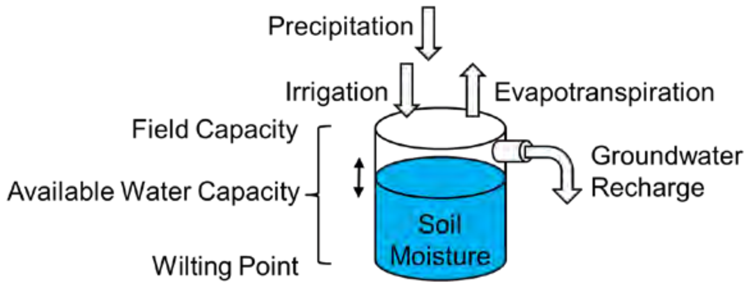
The Root Zone Model is based on the water balance within the soil root zone:

$$\frac{\partial S}{\partial t} = p + i - e - y$$

where S is the moisture storage in the soil root zone, p is precipitation, i is irrigation, e is evapotranspiration, and y is yield (e.g. groundwater recharge).

The conceptual framework for the Root Zone Model is described in **Table 6-4**. Runoff is assumed to be negligible within the Subbasin due to the flat topography, and yield y represents groundwater recharge. The amount of water that a soil can store that is available for use by plants is called the available water capacity (AWC). AWC is the water held between field capacity and the wilting point. For each monthly time step and each individual land use unit the Root Zone Model compares the potential evaoptranspiration (ET) to the sum of the initial soil moisture storage and the current month's precipitation. For irrigated land use units, the model calculates the amount of irrigation that is needed in addition to the initial soil moisture storage and precipitation to meet the potential ET demand. For non-irrigated land use units, calculated actual ET is limited by the sum of the initial soil moisture storage and the current month's precipitation. A soil moisture retention (SMR) parameter was defined in the Root Zone Model that determines the percentage of AWC to which root zone soil moisture is maintained for irrigated land units. Grismer and Asato state in their 2012 paper on Sonoma vineyard and native vegetation root zone mass balances that wine grape vineyards are typically managed with deficit irrigation, allowing soil water to be substantially depleted to between 20% and 30% capacity. For the results presented in this report, the soil moisture retention parameter was set to decrease linearly from 80% to 40% from 1988 through 2011, and to be constant at 40% from 2011 through 2015 to reflect improvements from past, less efficient irrigation management practices. Changes to this parameter affect calculated pumping and recharge rates between months with varying hydrological inputs. Groundwater recharge is calculated as the soil moisture beyond field capacity. Recharge is theoretically limited by the saturated hydraulic conductivity (Ksat) of the soil, but mapped Ksat values in the Subbasin are generally higher than average monthly precipitation by more than an order of magnitude. **Figure 6-9** illustrates how the Root Zone Model accounts for inflows and outflows of the Root Zone. Any amount of applied water (irrigation) to the root zone is assumed to leave the root zone and the Subbasin through Evapotranspiration

Figure 6-9. Root Zone Model



The effect of variations to parameter values for grape crop coefficients, rooting depth, and soil moisture retention to the Root Zone Model results were evaluated in a sensitivity analysis described in **Section 6.9.**

6.5.2 Land Use Model Inputs

The Root Zone Model performs the water balance calculations at the resolution of mapped land use units. Total acreages of vineyards, other lesser agricultural commodities, and the urban footprints in the Valley have remained relatively constant over the selected base period. The Root Zone Model was run based on the 1987 and 2011 Land Use Data from DWR. DWR's Geographic Information Systems (GIS) data for 1987 and 2011 land use includes information for land use class, irrigation status, irrigation method, and irrigation water source. **Figure 6-10** through **Figure 6-17** show the 1987 and 2011 Land Use-derived model inputs. The Root Zone Model was run separately using 1987 and 2011 land use data. Model results presented in this report are based on linear interpolation between these two runs, assuming a constant rate at which land use changed between 1987 and 2011. Model results for 2011 and beyond are based on 2011 land use data.

Additional available municipal water supply data (summarized in Section 5.2.2) were used to supplement DWR's land use data where water source was not specified; land use units within City water system boundaries of Napa and Yountville were modeled to be supplied by surface water, with the exception of a number of parcels near Yountville which are known to have been supplied by recycled water since 1977. Based on historical averages, the supply for the City of St. Helena water system was modeled to have been sourced entirely from surface water from 1988 to 1991 and to be sourced from 18% groundwater and 82% surface water from 1992 until present. Supply for the City of Calistoga water system was modeled to have been sourced from 8% groundwater up to 1998, and 250 AFY recycled water since 2005, and the remainder by surface water.

6.5.3 Soil Model Inputs

Available Water Capacity (AWC) and Saturated Hydraulic Conductivity (Ksat) were based on Soil Survey data by the Natural Resources Conservation Service (NRCS). **Figure 6-18** shows the mapped Available Water Capacity in the Subbasin. AWC depends on the mapped soils and land use class-dependent root zone depth. Root Zone depths were based on the NRCS National Engineering Handbook (NRCS, 1983). Available Water Storage is the product of AWC and root depth. Where multiple soil units have been mapped over a single land use unit, these land use units were split to maintain the different land use/soil type combinations. The combination of DWR land use and NRCS soil layers results in over

Table 6-4. Root Zone Model Framework

Soil Root Zone Budget Component and Processes	Assumptions	Approach	Data Sources
Root Zone Inflows			
Precipitation	None	Spatially continuous precipitation datasets are queried for monthly precipitation totals across the Subbasin.	BCM (1988 - 2010), PRISM Climate Group (2011 - 2015)
Infiltration	Precipitation falling on the subbasin infiltrates into soils subject to limitation by the saturated hydraulic conductivity of the upper most soil horizon.	Calculated as the difference between infiltration capacity and precipitation.	USDA NRCS Soil Survey Geographic (SSURGO) Database for Napa County (2014)
Applied Water (see Table 6-8)	Irrigated crops and land use units with a landscaping water demand may receive water in addition to precipitation. Source of applied water for a given land use unit (e.g., groundwater, surface water, or recycled water) is determined according to land use mapping.	Water is applied to land use units that have an identified source of irrigation in order to balance outflows due to evapotranspiration with available soil moisture and precipitation for each time step and to maintain a soil moisture content of 40% of total root zone available water content.	DWR 2011 Napa County Land Use Map (delineation of source water type for irrigated land use units)
Root Zone Outflows			
Evapotranspiration	Evapotranspiration occurs on all vegetated and open water (as evaporation only) land use units in the subbasin subject to the vegetation or crop type and the physical properties of soils in the root zone.	Actual evapotranspiration is calculated as a function of potential evapotranspiration, derived from meteorological data, based on the crop coefficient for appropriate crop type for each land use unit.	BCM (1988 - 2010), CIMIS (2011 - 2015)
Runoff	Runoff is assumed to be negligible within the Subbasin due to the flat topography and soil saturated hydraulic conductivity values that are generally higher than average monthly precipitation by more than an order of magnitude.	Assumed to be negligible on the Napa Valley floor.	USDA NRCS Soil Survey Geographic (SSURGO) Database for Napa County (2014)
Groundwater Recharge	Water percolating below the soil root zone is a function of land use derived water demands, soil moisture, and vertical hydraulic conductivity of the soil root zone.	Calculated as the volume of water in the soil root zone above the soil field capacity after accounting for reductions of soil moisture due to evapotranspiration.	*See above*

NOTES:

Total root zone available water content is defined as the volume difference between field capacity and wilting point for each soil unit.

BCM, Basin Characterization Model, is a hydrologic model of developed by the U.S. Geological Survey to simulate hydrologic processes including runoff and groundwater recharge across California.

CIMIS, California Irrigation Management Information System, is a program of the California Department of Water Resources to monitor meteorological conditions and provide data regarding to support efficient irrigation management.

16,000 geographic units for which the Root Zone Model individually calculates the water balance. **Table 6-5** summarizes the applied root zone depths.

Table 6-5. Assigned Model Root Depths

Land Use Class	Root Depth (feet)
BARREN AND WASTELAND	0.5
CITRUS AND SUBTROPICAL	3
COMMERCIAL	0.5
DECIDUOUS FRUITS AND NUTS	5
FIELD CROPS	3
GRAIN AND HAY CROPS	2
IDLE	2
INDUSTRIAL	0.5
NATIVE VEGETATION	5
PASTURE	2.5
RESIDENTIAL	0.5
RIPARIAN VEGETATION	10
SEMIAGRICULTURAL & INCIDENTAL TO AGRICULTURE	0.5
TRUCK, NURSERY AND BERRY CROPS	2
URBAN	0.5
URBAN LANDSCAPE	0.5
VACANT	0.5
VINEYARDS	3
WATER SURFACE	10

6.5.4 Hydrologic Model Inputs

GIS grids for historical monthly reference ET and precipitation values for 1988 to 2010 were obtained from the California BCM at 270 meter resolution. The BCM used hydrologic projections for 2011 and beyond, and historical monthly ET values for 2011 to 2015 were downloaded from the CIMIS at 5,000 foot spacing linearly interpolated to GIS grids at 270 meter resolution. GIS grids for monthly precipitation values for 2011 to 2015 were obtained from the PRISM Climate Group at 4 kilometer resolution and linearly interpolated to grids at 270 meter resolution. ET and precipitation values from the BCM warm and moderate rainfall scenario (BayArea_CCSM4_rcp85) were also used for 2016 to 2025 for the Root Zone Model future condition evaluation. **Figure 6-19** illustrates how the Root Zone Model interpolates the mean monthly precipitation and ET values for each mapped land use unit and for each time step.

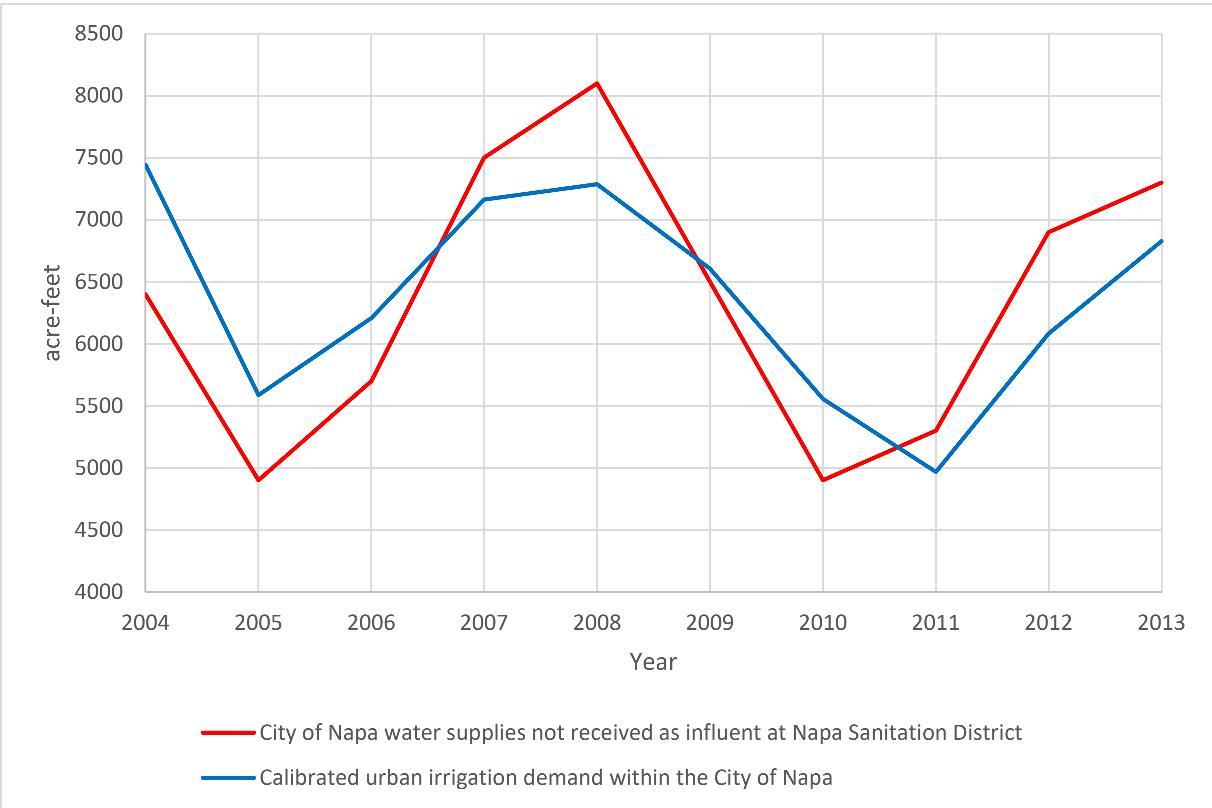
6.5.5 Crop Coefficient Model Inputs

Crop coefficients were obtained from the Irrigation Training & Research Center (ITRC). ITRC provides adjusted monthly crop coefficients for different crop types, irrigation methods, and relative precipitation year (typical, wet, and dry). The crop coefficients provided by ITRC for water balances include a reduction in ET of approximately 7% to reflect bare spots and reduced vigor typically observed in crops at the landscape scale. The Root Zone Model applies a further reduction for ET of urban land units to reflect the fraction of each land unit that is subject to landscaping (irrigation), shown in **Table 6-6**. The fractions of urban land use units that are assumed to be irrigated were estimated by calibrating the computed urban irrigation demand within the City of Napa to historical records of City of Napa water supplies that were not received as influent by the Napa Sanitation District between 2004 and 2013 (See **Figure 6-20**.

Table 6-6. Fractions of Urban Land Use Units Assumed to be Landscaped (Irrigated)

Urban Land Use Sub-Classifications	Initial Fractions of Land Use Units assumed to be landscaped (irrigated)	Calibrated/Applied Fractions of Land Use Units assumed to be landscaped (irrigated)
Residential, and No-Subclass	25%	33.75%
Commercial, and Industrial	10%	13.50%
Urban - Vacant	5%	6.75%

Figure 6-20. Calibrated Urban Irrigation Demand within the City of Napa



The Root Zone Model multiplies the typical crop coefficient that corresponds to the individual land use class and irrigation method (shown in **Table 6-7**) with the interpolated reference ET value to calculate the monthly potential ET.

Table 6-7. Applied Model Crop Coefficients, Kc

Drip/Microspray Irrigation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowers, Nursery and Christmas Tree	1.03	0.40	0.28	0.34	0.41	0.65	0.84	0.93	0.85	0.90	0.57	0.84
Grape Vines with 40% canopy	1.03	0.40	0.38	0.47	0.51	0.42	0.36	0.39	0.18	0.26	0.48	0.85
Melons, Squash, and Cucumbers	1.05	0.39	0.28	0.23	0.26	0.19	0.54	0.79	0.28	0.25	0.51	0.86
Misc. Subtropical	1.03	0.40	0.28	0.34	0.41	0.65	0.84	0.93	0.85	0.90	0.57	0.84
Misc. Deciduous	1.03	0.40	0.28	0.34	0.41	0.65	0.84	0.93	0.85	0.90	0.57	0.84
Strawberries	1.05	0.39	0.50	0.42	0.44	0.92	0.93	0.49	0.00	0.25	0.51	0.86
Sprinkler Irrigation	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Alfalfa Hay and Clover	0.53	0.93	0.97	1.06	1.14	1.19	0.82	0.93	0.94	0.94	0.51	0.74
Corn and Grain Sorghum	0.52	0.36	0.52	0.42	0.41	1.04	1.25	1.00	0.18	0.23	0.35	0.60
Flowers, Nursery and Christmas Tree	0.50	0.37	0.48	0.54	0.86	1.06	0.98	0.88	0.93	0.84	0.60	0.59
Melons, Squash, and Cucumbers	0.52	0.51	0.37	0.55	1.14	1.17	0.53	0.12	0.00	0.23	0.35	0.60
Misc Subtropical	0.51	0.36	0.35	0.37	0.48	0.56	0.51	0.48	0.32	0.24	0.33	0.59
Misc. Deciduous	0.50	0.37	0.48	0.54	0.86	1.06	0.98	0.88	0.93	0.84	0.60	0.59
Misc. field crops	0.52	0.51	0.38	0.46	0.91	1.13	1.04	0.50	0.00	0.23	0.35	0.60
Pasture and Misc. Grasses	0.52	0.70	0.76	0.95	1.12	1.12	1.07	0.98	0.99	0.89	0.65	0.60
Peach, Nectarine and Apricots	0.50	0.37	0.40	0.48	0.82	1.11	1.01	0.95	0.93	0.85	0.38	0.59
Walnuts	0.50	0.37	0.29	0.41	0.51	0.87	1.11	1.07	1.10	0.90	0.62	0.59
Surface Irrigation	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Alfalfa Hay and Clover	1.09	0.98	0.97	0.88	0.90	0.88	0.83	0.85	0.85	0.66	0.80	1.08
Apples, Plums, Cherries etc w/cover crop	1.05	1.02	0.94	0.87	0.99	1.05	1.06	1.07	1.03	1.01	0.88	1.10
Corn and Grain Sorghum	1.08	0.39	0.50	0.42	0.36	0.86	1.07	0.96	0.15	0.25	0.51	0.86
Idle	1.09	0.39	0.28	0.24	0.17	0.06	0.02	0.12	0.00	0.25	0.53	0.87
Melons, Squash, and Cucumbers	1.08	0.63	0.35	0.55	0.97	0.97	0.47	0.12	0.00	0.25	0.51	0.86
Misc Subtropical	1.04	0.40	0.46	0.50	0.74	0.88	0.84	0.86	0.86	0.89	0.88	0.85
Misc. Deciduous	1.04	0.40	0.46	0.50	0.74	0.88	0.84	0.86	0.86	0.89	0.88	0.85
Misc. field crops	1.08	0.62	0.36	0.43	0.79	0.93	0.90	0.46	0.00	0.25	0.51	0.86
Pasture and Misc. Grasses	1.08	0.74	0.72	0.89	0.96	0.93	0.92	0.95	0.91	0.97	0.96	0.86
SAFflower and Sunflower	1.08	0.50	0.56	0.91	1.07	0.97	0.28	0.12	0.00	0.25	0.51	0.86
Walnuts	1.04	0.40	0.28	0.39	0.54	0.81	0.95	0.99	0.98	0.93	0.84	0.85

6.5.6 Root Zone Model Results

The results of the Root Zone Model analysis for the base period from the 1988 to 2015 show groundwater recharge to always exceed groundwater pumping within the Subbasin on a year-to-year basis, resulting in a net positive contribution to groundwater storage. Over the base period, average annual groundwater recharge is calculated to be 68,900 AF, while average annual groundwater pumping to meet irrigation demands is 12,200 AF, with an average annual net contribution to groundwater storage of 56,700 AF. Error! Reference source not found. **Figure 6-21** shows total annual groundwater storage contributions from the root zone and precipitation for the base period from 1988 to 2015, and for projected baseline conditions from 2016 to 2025.

Figure 6-21. Root Zone Model total annual groundwater storage change and average precipitation for Subbasin from 1988 to 2025 (projected baseline condition from 2016 to 2025)

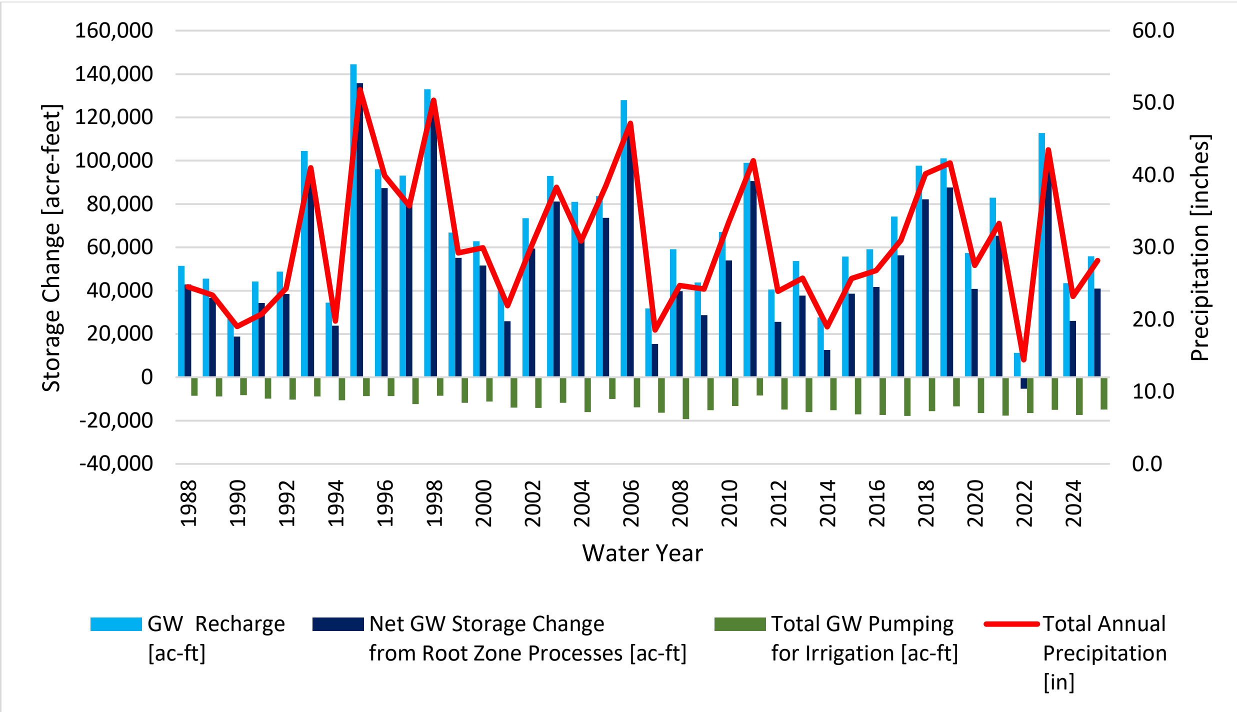


Table 6-8 summarizes the annual change in Root Zone Model components. **Table 6-9** shows the monthly totals of Root Zone Model components (WY 2010 shown). Precipitation drives recharge during the wet winter months, and the lack of precipitation and high ET during the summer months triggers groundwater pumping. This pattern is evident in **Table 6-9** where groundwater pumping to meet plant needs begins only after available soil moisture, accumulated through precipitation, has been reduced such that continuing evapotranspiration demands and the minimum soil moisture retention parameter require irrigation. In this way, the accumulation of soil moisture over the winter.

Figure 6-21. Root Zone Model total annual groundwater storage change and average precipitation for Subbasin from 1988 to 2025 (projected baseline condition from 2016 to 2025)

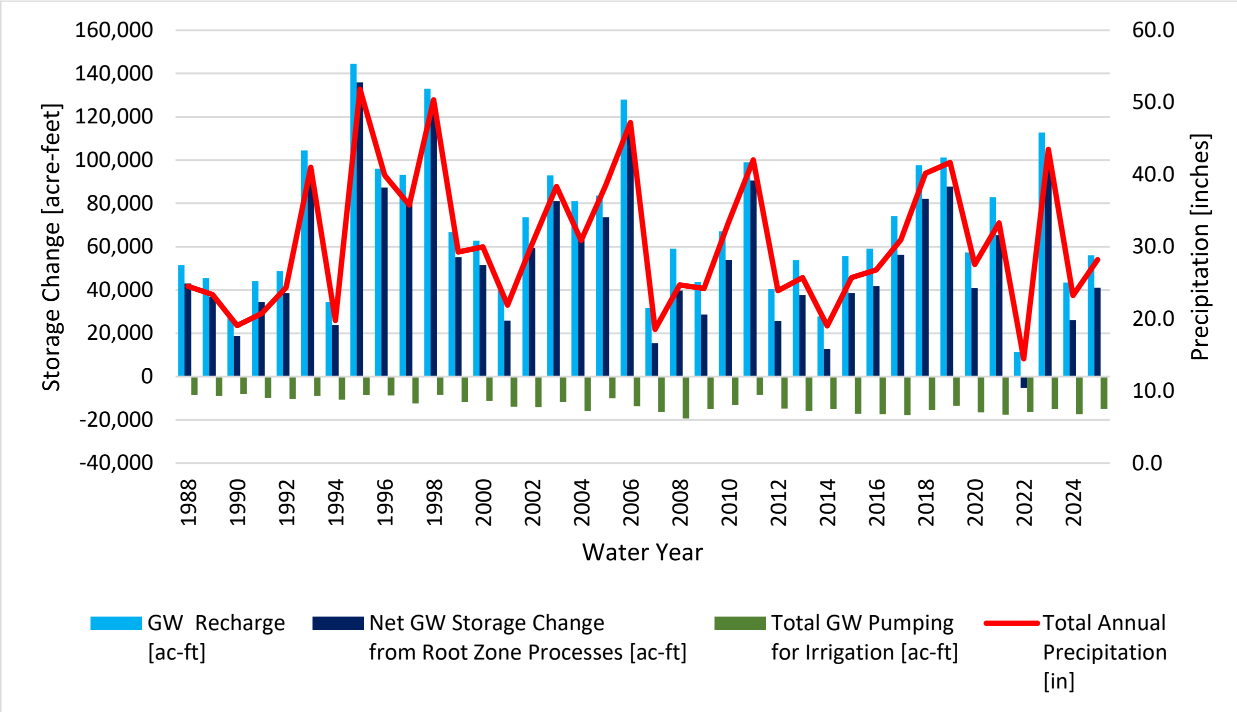


Table 6-8. Annual Change in Root Zone Model Components for Subbasin (projected baseline condition from 2016 to 2025)

Water Year	Total Annual Precipitation [in]	Infiltration from Precipitation [ac-ft]	ET [ac-ft]	GW Recharge [ac-ft]	GW Pumping for Vineyard Irrigation [ac-ft]	Total GW Pumping for Irrigation [ac-ft]	Net GW Storage Change from Root Zone Processes [ac-ft]	SW Water Use for Vineyard Irrigation [ac-ft]	Total SW Water Use [ac-ft]	Reclaimed Water Use [for Vineyard Irrigation [ac-ft]	Total Reclaimed Water Use [ac-ft]	Soil Moisture Change [ac-ft]
1988	24.5	93,886	71,297	51,507	-5,825	-8,559	42,948	-11,031	-19,983	-311	-660	284
1989	23.4	89,423	71,052	45,565	-6,166	-8,827	36,738	-11,069	-19,671	-315	-644	1,948
1990	19.1	72,948	74,409	26,974	-5,607	-8,183	18,790	-9,182	-17,606	-278	-585	-2,060
1991	20.8	79,460	65,590	44,227	-6,961	-9,846	34,381	-10,458	-19,716	-333	-652	-142
1992	24.3	93,088	74,609	48,824	-7,498	-10,335	38,489	-10,300	-19,326	-353	-660	-23
1993	41.0	156,937	78,237	104,483	-6,168	-8,788	95,695	-7,980	-16,421	-294	-566	-8
1994	19.8	75,720	70,683	34,461	-7,710	-10,623	23,838	-8,935	-18,073	-345	-634	-95
1995	51.8	198,298	77,848	144,461	-5,970	-8,623	135,839	-6,488	-14,801	-269	-522	-66
1996	39.9	152,704	80,356	96,031	-5,872	-8,667	87,363	-5,808	-14,397	-245	-496	-123
1997	35.8	136,878	74,826	93,189	-9,202	-12,371	80,817	-8,229	-18,013	-393	-664	-88
1998	50.4	192,767	81,625	133,020	-5,908	-8,463	124,557	-4,964	-12,883	-237	-446	-86
1999	29.3	111,947	72,817	66,849	-8,729	-11,739	55,110	-6,521	-15,262	-343	-567	-151
2000	30.0	114,648	77,885	62,786	-8,133	-11,158	51,627	-5,586	-14,343	-316	-528	7
2001	21.9	83,864	74,362	39,806	-10,753	-13,906	25,900	-6,567	-15,646	-403	-610	-141
2002	30.4	116,449	73,110	73,510	-10,815	-14,110	59,400	-5,991	-15,384	-395	-599	-78
2003	38.3	146,679	79,062	92,956	-8,789	-11,829	81,126	-4,448	-12,984	-310	-484	-40
2004	30.9	118,073	69,713	81,086	-12,389	-16,014	65,072	-5,600	-15,899	-439	-638	-175
2005	38.5	147,365	84,949	83,636	-7,220	-9,996	73,640	-3,062	-10,545	-283	-678	0
2006	47.2	180,602	79,691	127,920	-10,654	-13,805	114,114	-3,792	-12,305	-372	-764	-134
2007	18.6	71,007	70,435	31,791	-12,744	-16,392	15,398	-4,001	-13,910	-445	-851	-65
2008	24.7	94,519	70,196	59,144	-15,631	-19,361	39,784	-4,255	-14,394	-553	-929	-138
2009	24.2	92,645	76,611	43,794	-11,694	-15,116	28,678	-2,745	-11,914	-392	-777	47
2010	33.4	127,931	84,617	67,094	-10,217	-13,174	53,921	-2,025	-9,804	-362	-702	-101
2011	42.0	160,774	78,693	98,996	-5,810	-8,380	90,617	-1,133	-7,980	-212	-555	-1
2012	23.9	91,439	77,167	40,486	-11,696	-14,840	25,646	-2,113	-10,574	-385	-740	-61
2013	25.7	98,439	73,394	53,709	-12,448	-15,970	37,740	-2,373	-11,936	-458	-805	47
2014	19.0	72,761	72,771	27,739	-11,500	-15,087	12,651	-2,058	-11,946	-378	-689	-25
2015	25.7	98,365	73,067	55,705	-13,413	-17,081	38,625	-2,479	-12,494	-479	-827	-6
2016	26.8	102,554	74,039	59,127	-13,721	-17,358	41,769	-2,502	-12,426	-480	-826	-3
2017	30.9	118,426	75,571	74,169	-14,086	-17,843	56,326	-2,559	-12,622	-492	-842	-8
2018	40.2	153,758	83,749	97,699	-12,141	-15,535	82,164	-2,297	-11,394	-422	-783	22
2019	41.7	159,496	83,023	101,129	-10,209	-13,425	87,704	-1,882	-10,552	-359	-715	37
2020	27.5	105,310	77,294	57,347	-12,871	-16,486	40,861	-2,345	-11,982	-430	-796	-66
2021	33.3	127,489	75,467	82,915	-13,915	-17,603	65,312	-2,554	-12,461	-488	-838	10
2022	14.4	55,286	73,669	11,219	-12,732	-16,429	-5,210	-2,396	-12,374	-427	-806	9
2023	43.5	166,427	80,869	112,766	-11,544	-15,055	97,711	-2,105	-11,467	-396	-759	73
2024	23.2	88,892	76,284	43,472	-13,737	-17,422	26,050	-2,581	-12,532	-485	-846	-65
2025	28.2	107,828	78,915	55,940	-11,410	-14,899	41,040	-2,046	-11,399	-387	-748	20

Table 6-9. Monthly Change in Root Zone Model Components for Subbasin

Year	Month	Initial Soil Moisture [ac-ft]	Total Monthly Precip. [in]	Infiltration from Precipitation [ac-ft]	Available Soil Moisture [ac-ft]	ET [ac-ft]	GW Recharge [ac-ft]	Total GW Pumping [ac-ft]	GW Storage Change [ac-ft]	SW Water Use [ac-ft]	Reclaimed Water Use [ac-ft]	End of Month Soil Moisture [ac-ft]	Soil Moisture Change [ac-ft]
2009	Oct	3,961	4.62	17,659	21,620	7,709	2,405	0	2,405	0	0	11,506	7,545
2009	Nov	11,504	0.73	2,810	14,314	4,152	144	-4	140	-45	0	10,067	-1,437
2009	Dec	10,064	3.03	11,583	21,647	3,179	5,549	0	5,549	0	0	12,919	2,855
2010	Jan	12,917	10.61	40,583	53,500	4,216	32,275	0	32,275	0	0	17,009	4,092
2010	Feb	17,010	4.96	18,978	35,988	3,613	14,887	0	14,887	0	0	17,488	478
2010	Mar	17,491	3.07	11,740	29,231	6,410	5,274	0	5,274	0	0	17,548	57
2010	Apr	17,551	4.73	18,117	35,668	11,712	6,528	0	6,528	0	0	17,428	-123
2010	May	17,431	1.65	6,315	23,746	14,675	32	-431	-399	-1,032	-99	10,601	-6,831
2010	Jun	10,599	0.01	53	10,652	10,905	0	-2,549	-2,549	-2,035	-271	4,602	-5,997
2010	Jul	4,591	0.00	3	4,594	7,964	0	-4,438	-4,438	-2,723	-145	3,936	-655
2010	Aug	3,925	0.00	0	3,925	6,695	0	-4,058	-4,058	-2,420	-131	3,838	-86
2010	Sep	3,827	0.02	89	3,915	3,387	0	-1,694	-1,694	-1,548	-56	3,827	0

6.6 Subbasin Water Budget

A combined surface water and groundwater budget for the Napa Valley Subbasin was developed utilizing outputs from the Root Zone model as well as other data on Subbasin inflows and outflows that are not represented by root zone processes. **Table 6-10** summarizes the components of the overall Subbasin water budget.

6.6.1 Subbasin Inflows

Groundwater Recharge – Root Zone Model Output

Recharge from overlying soils is a function of land use derived water demands, available soil moisture, and vertical hydraulic conductivity of the soil root zone. Changes in storage in the unsaturated zone below the root zone and above the water table are assumed to be negligible at an annual scale for this analysis.

Uplands Runoff

Runoff from Subbasin Uplands occurs when precipitation falls in excess of the infiltration capacity of the Uplands soils and due to groundwater contributions to streamflow in tributaries to the Napa River that flow out of the Uplands. The runoff may reach the Subbasin as flow in stream channels. The Subbasin water budget utilizes runoff calculations from the BCM as the source for runoff from the Uplands into the Subbasin. Years for which BCM results are not available were estimated based on PRISIM precipitation data and the relationship between Uplands precipitation and Uplands runoff.

Uplands Subsurface Inflow

Subsurface inflow to the Subbasin from the surrounding bedrock is likely minor relative to the volume of precipitation received in the Subbasin and runoff to the Subbasin from the Uplands. Geologic formations surrounding the Subbasin consist of predominantly low permeability volcanic and sedimentary rocks (see **Chapter 2**). Data relating to subsurface inflow to the Subbasin from surrounding bedrock is limited to the MST. Johnson (1977) estimated that outflow from the MST into the Napa Valley was roughly 2,050 AFY. Subsequently, Farrar and Metzger (2003) estimated that 600 AFY of groundwater was entering the Napa Valley from the MST.

Applied Water - Surface Water

The Subbasin water budget implicitly and explicitly considers the fraction of applied surface waters that have the opportunity to become recharge either as applied irrigation or releases to the Napa River from wastewater treatment facilities. **Table 6-11** details the sources of applied water accounted for in the water budget. In some cases, land use mapping designates areas receiving surface water for irrigation. Those land use units are assigned surface water for irrigation purposes subject to the irrigation demand calculated by the Root Zone Model.

Other uses of surface water in the Subbasin are largely for municipal purposes and include surface waters imported from reservoirs in the Uplands and State Water Project facilities. The Subbasin Water Budget assumes that the conveyance of those surface waters from local reservoirs or State Water Project facilities occurs efficiently without seepage losses. Discharges of treated wastewater from the municipalities are implicitly considered by the streamflow gage records from the Napa River near Napa gage, which is downstream of the wastewater treatment facilities that discharge within the Subbasin.

Applied Water – Recycled Water

Recycled water utilization within the subbasin is currently limited to parcels in and near Yountville receiving recycled water from the Town’s wastewater treatment facility. Recycled water deliveries are detailed, based on available data, in Chapter 5. The Root Zone Model calculates recycled water applications based on the irrigation demands for land use units receiving recycled water.

Table 6-10. Napa Valley Subbasin Water Budget Framework

Subbasin Water Budget Component and Processes	Assumptions	Approach	Data Sources	Uncertainties
Subbasin Inflows				
Napa Valley Subbasin Soil Root Zone: Groundwater Recharge	Recharge from overlying soils is a function of land use derived water demands, soil moisture, and vertical hydraulic conductivity of the soil root zone. Changes in storage in the unsaturated zone below the root zone and above the water table are negligible at an annual scale.	Calculated as the volume of water in the soil root zone above the soil field capacity after accounting for reductions of soil moisture due to evapotranspiration and applications of applied water to meet irrigation demands.	Napa Valley Subbasin Soil Root Zone Model	In some areas of the Subbasin, the occurrence of shallow groundwater may limit the actual amount of groundwater recharge calculated by the Root Zone Model that can physically be accepted by the Subbasin. As a result, the Root Zone Model may over allocate groundwater recharge.
Napa River Watershed Uplands: Upland Runoff, surface runoff from the uplands of the Napa River Watershed to the Napa Valley Subbasin	Runoff from upland areas is represented by the mass balance modeling approach of the BCM.	Calculated as the sum of runoff calculated by BCM throughout the watershed above the Napa Valley Subbasin less the average annual diversion from major reservoirs. Uplands runoff for 2011-2015 was estimated based on PRISIM precipitation data for those years and the relationship between uplands precipitation and runoff calculated by the BCM from 1988 - 2015.	BCM (1988 - 2010), PRISM Climate Group (2011 - 2015)	Although calibrated to four streamflow gage records within Napa Valley, the BCM is a model and subject to uncertainties.
Napa River Watershed Uplands: Upland Subsurface Inflow, groundwater flow from the geologic units of the Napa River Watershed into the Napa Valley Subbasin	Subsurface inflows are a relatively minor component of total Subbasin inflows, though previous studies have calculated some subsurface inflows along the boundary with the Milliken-Sarco-Tulucay Subarea.	Subsurface inflows are represented by the volume of recharge calculated by the BCM within 500 meters of the Subbasin boundary.	BCM	Subsurface inflows are likely to be highly variable due to the range of permeabilities of geologic formations surrounding the Subbasin. Relative errors for subsurface inflow have been reported to range from 10% to 100%.[1]
Napa Valley Subbasin Soil Root Zone: Applied Water - Surface Water (see subgroup table)	Surface water applications within the Subbasin occur to meet water demands where surface water is a source of supply for irrigated areas within the Subbasin.	Surface water applications are made within the Root Zone Model to meet irrigation demands. Other, non-irrigation uses of surface water are assumed to be for municipal uses which are either implicit in the Napa River above the Napa River near Napa streamflow record or conveyed out of the subbasin to the Napa Sanitation District Treatment Facility.	DWR land use mapping, Napa Valley Subbasin Soil Root Zone Model	Records maintained by the State Water Resources Control Board for surface water diversions from within the Subbasin are incomplete complicating efforts to compare the reported diversion amounts and areas of surface water use with the areas of surface water use mapped by the Department of Water Resources.
Napa Valley Subbasin Soil Root Zone: Applied Water - Recycled Water (see subgroup table)	Recycled water applications within the Subbasin occur to meet water demands where recycled water is a source of supply for irrigated areas within the Subbasin.	Recycled water applications are made within the Root Zone Model to meet irrigation demands.	DWR land use mapping, Napa Valley Subbasin Soil Root Zone Model	Inconsistencies may exist between the areas of recycled water application mapped by the Department of Water Resources and the location of actual deliveries by various suppliers.
Subbasin Outflows				
Napa Valley Subbasin Soil Root Zone: Applied Water – Consumptive Uses of Surface Water and Groundwater Pumping (see subgroup table)	Groundwater pumping within the Subbasin occurs to meet water demands where groundwater is a source of supply for irrigation, municipal uses, wineries in unincorporated areas, and domestic use in the unincorporated areas within the Subbasin. Consumptive surface water use in the Subbasin occurs to meet crop irrigation, unincorporated area residential, unincorporated winery, and municipal demands.	The Root Zone Model accounts for surface water applications and groundwater pumping from within the Subbasin to meet the water demands of irrigated crops and landscaped land use units when available soil moisture is insufficient to meet evapotranspiration demands. Groundwater pumped to supply non-irrigation water demands (i.e., municipal uses, wineries in unincorporated areas, and domestic use in the unincorporated areas within the Subbasin) are calculated outside of the Root Zone Model (see the Applied Water subgroup).	Napa Valley Subbasin Soil Root Zone Model, U.S. Census Bureau, CA Water Plan Update 2013, Napa County Department of Planning, Building, and Environmental Services, City of Napa, City of Yountville, City of St. Helena, City of Calistoga	Groundwater pumping to meet irrigation demands assumes that water is efficiently applied to meet evapotranspiration demands with minimal losses due to irrigation inefficiencies.

Napa Valley Subbasin Stream Channels: Stormflow and groundwater baseflow leaving the subbasin as Napa River discharge	None	The sum of Napa River discharge at the USGS Napa River near Napa gage and runoff from portions of the subbasin calculated by the BCM model.	USGS Napa River near Napa stream gage, BCM (1988 - 2010), PRISM Climate Group (2011 - 2015)	Runoff calculated by the BCM model for portions of the Subbasin below the Napa River near Napa stream gage may under represent the degree of runoff from impermeable surfaces. Relative errors for gaged streamflow have been reported to range from 5% to 10%.[1]
Subbasin Groundwater Outflow: Subsurface groundwater flow to the Napa-Sonoma Lowlands Subbasin	Groundwater outflows to the Napa-Sonoma Lowlands Subbasin take place primarily in the Quaternary alluvium and Quaternary sedimentary basin deposits near the boundary between the two subbasins. Vertical gradients are negligible near the boundary and groundwater flow is horizontal.	Groundwater outflow is calculated based on measured hydraulic gradients near the boundary of the Napa Valley Subbasin and Napa-Sonoma Lowlands Subbasin and estimates of hydraulic conductivity of aquifer materials in the Quaternary alluvium and Quaternary sedimentary basin deposits depicted in Cross Section G - G' of the Napa Valley Updated Hydrogeologic Conceptualization and Characterization of Conditions Report (LSCE and MBK, 2013).	Napa Valley Updated Hydrogeologic Conceptualization and Characterization of Conditions Report (LSCE and MBK, 2013), SWRCB Geotracker network.	Available groundwater elevation data are limited temporally and spatially in the vicinity of the boundary between the subbasins. Although depths to groundwater at two sites with available data are consistent with data at other sites showing shallow depths to groundwater, more frequent data collection at long term monitoring sites could improve the quality of groundwater outflow estimates. Relative errors for subsurface outflow have been reported to range from 10% to 100%.[1]
Subbasin Change in Storage				
The net annual inflow or outflow of groundwater to the Napa Valley Subbasin	Subbasin changes in groundwater storage are not subject to delayed effects of inflows and outflows beyond the scope of the base period.	Calculated as the difference between annual inflows and annual outflows.	Subbasin inflows and outflow as represented in the Napa Valley Subbasin water budget.	

NOTES:

BCM, Basin Characterization Model, is a hydrologic model of developed by the U.S. Geological Survey to simulate hydrologic processes including runoff and groundwater recharge across California.

1 Peters, H.J. 1974. “Ground Water Data”. Ch. 9 in Concepts of Ground Water Management, University of Extension, University of California – Davis, November 14, 1974.

6.6.2 Subbasin Outflows

Applied Water - Consumptive Uses of Surface Water and Groundwater Pumping

The water budget accounts for uses of surface water and groundwater to meet irrigation demands, reported municipal pumping, calculated winery demands, and domestic uses in the unincorporated portion of the Subbasin. Surface water applications and groundwater pumping are calculated to meet irrigation demands according to the evapotranspiration and soil moisture requirement of each irrigated land use unit and soil type, as described in **Section 6.3**.

Municipal groundwater use is detailed in **Chapter 5**. Currently the City of St. Helena and Town of Yountville have the capacity to pump groundwater from the subbasin. The City of Calistoga formerly pumped groundwater for municipal use, though the wells are no longer in use. The City of Napa does not own any wells that could be used to pump groundwater from the Subbasin and has not utilized groundwater in the past.

Groundwater pumping for indoor domestic uses in unincorporated parts of the Subbasin are calculated in the water budget based the population within those areas and a per capita daily water demand factor of 60.3 gallons (Aquacraft, 2011). The annual population totals for the unincorporated areas were determined first for 2010 by spatial analysis of GIS datasets provided by the U.S. Census Bureau. Population estimates for other base period years were made by linearly interpolating based on the ratio of the total population reported for the County by the Census Bureau for years 1990, 2000, 2010, and 2015. Pumping calculated for meeting water demands associated with outdoor uses on residential, commercial, and industrial land uses in unincorporated parts of the Subbasin are determined by the Root Zone Model and are in addition to the amounts calculated based on per capita demand for indoor uses.

Groundwater pumping for winery uses in the unincorporated parts of the Subbasin were calculated based on the County's GIS dataset of active winery permits. Total winery water demands were calculated to include process water for wine production as well as water used for visitation, events, and staffing purposes as documented in the County's GIS dataset.

Outflows from the Subbasin due to these uses of surface water and groundwater occur due to evapotranspiration from crops, landscaped areas where water is applied, and from a small proportion of water discharged to septic systems used in the unincorporated Subbasin. Applications of water to meet irrigation demands are assumed to be entirely consumed as evapotranspiration outflows. Fifteen percent of groundwater use for indoor domestic uses by rural residences and groundwater use by wineries is calculated as a Subbasin outflow due to evaporation from septic system leach fields.

Streamflow

Streamflow includes both stormwater runoff and baseflow discharges of groundwater conveyed out of the Subbasin through the Napa River and its tributaries. The Subbasin water budget accounts for streamflow through a combination of discharge data from the Napa River near Napa gage operated by the U.S. Geological Survey and runoff calculated by the BCM for portions of the Subbasin below the Napa River near Napa gage.

Groundwater Outflows

Groundwater outflow from the Subbasin is calculated based on measured hydraulic gradients near the boundary of the Napa Valley Subbasin and Napa-Sonoma Lowlands Subbasin and estimates of hydraulic conductivity of aquifer materials in the Quaternary alluvium and Quaternary sedimentary basin deposits depicted in Cross Section F - F' of the Napa Valley Updated Hydrogeologic Conceptualization and Characterization of Conditions Report (LSCE and MBK, 2013) (**Figure 2-5a**). Data from two monitoring wells from the SWRCB GeoTracker network, SL0605536682MW-2 and T0605514064MW5, were utilized for the analysis of subsurface groundwater outflows. These wells are completed in unconsolidated sediments in the vicinity of the cross section approximately 6,300 feet from each other. Hydraulic conductivity values for the unconsolidated formations at Cross Section F - F’ were estimated as 30 ft/day for the Quaternary alluvium and Quaternary sedimentary basin deposits and 10 ft/day for the Tertiary/Quaternary sedimentary basin deposits. Paired spring and fall groundwater level data from each well are available from fall 2005 through fall 2012. Annual outflows calculated based on spring measurements are 20,453 AFY, while annual outflows calculated based on fall measurements are 17,718 AFY. The Subbasin water budget incorporates the average of those seasonal values, 19,085 AFY.

Table 6-11 Sources of Applied Water

Applied Water Component	Process	Assumptions	Approach	Data Sources
Groundwater Pumping	Groundwater pumped from the Napa Valley Subbasin to meet water demands including agricultural irrigation, landscaping irrigation, domestic uses (including those in municipal and unincorporated parts of the Subbasin), and commercial uses including uses by wineries.	Groundwater pumping within the Subbasin occurs only for the purpose of meeting water demands where groundwater is a source of supply within the Subbasin.	Groundwater is pumped from the Subbasin when available precipitation is insufficient to meet the water demands of irrigated crops and landscaped land use units. Groundwater is also pumped to supply other water uses reliant upon groundwater, including demands for domestic uses (in both unincorporated and incorporated areas), commercial and industrial uses within incorporated areas, and wineries in unincorporated areas.	Napa Valley Subbasin Soil Root Zone Model, U.S. Census Bureau, CA Water Plan Update 2013, Napa County Department of Planning, Building, and Environmental Services, City of Napa, Town of Yountville, City of St. Helena, City of Calistoga
Imported Surface Water from the Napa River Watershed Uplands	Water diverted from the Napa River Watershed to municipal reservoirs and later conveyed into to the subbasin by transmission pipes, includes some applications to agricultural lands documented by the municipalities.	Water from municipal reservoirs in the Napa River Watershed outside of the Subbasin is conveyed to the point of use without losses that would affect groundwater recharge or streamflows in the Subbasin.	Reported reservoir diversions are tabulated and presented in Chapter 5.	Napa County Department of Planning, Building, and Environmental Services, City of Napa, Town of Yountville, City of St. Helena, City of Calistoga
Imported Surface Water from the State Water Project (though the North Bay Aqueduct)	Water imported to the Napa Valley Subbasin from sources outside the Napa River Watershed to supply municipal water uses.	Water imported to the Subbasin from the State Water Project is conveyed to the point of use without losses that would affect groundwater recharge or streamflows in the Subbasin.	Reported reservoir diversions are tabulated and presented in Chapter 5.	Napa County Department of Planning, Building, and Environmental Services, City of Napa, Town of Yountville, City of St. Helena, City of Calistoga
In-subbasin Surface Water Diversions	Diversions of instream flow by water users with points of diversion located within the Napa Valley Subbasin.	Water diverted from instream flows in the Subbasin are reported accurately to the State Water Resources Control Board. (see Water Budget Framework Table for notes about uncertainty related to these data.)	Reported reservoir diversions are tabulated and presented in Chapter 5.	State Water Resources Control Board
Recycled Water (includes applications for municipal landscaping and agricultural irrigation)	Water re-applied to meet water demands in the Napa Valley Subbasin following treatment at municipal wastewater facilities.	Recycled water applications in the Subbasin are reported accurately to the State Water Resources Control Board.	Reported deliveries of recycled water are tabulated and presented in Chapter 5.	Town of Yountville, Napa Sanitation District

6.7 Subbasin Water Budget Results

The Subbasin water budget results show variations in Net Subbasin Storage from year to year that are largely driven by fluctuations in the Uplands Runoff and Streamflow components (**Figures 6-22 through 6-24** and **Table 6-12**). The magnitude of the surface water components, particularly uplands runoff and surface water outflow and baseflow, demonstrate that large quantities of water move through the Subbasin in most years as compared to the amounts of water pumped from the Subbasin or flowing out of the Subbasin as subsurface outflow. Average annual changes in storage over the base period are positive, demonstrating that current groundwater pumping has not contributed to chronic depletions of groundwater storage and that pumping has likely been below the sustainable yield for the Subbasin. The magnitude of annual changes in storage indicate the sensitivity of water budget components to environmental factors and data uncertainties. For this reason, the average annual change in storage represents a more useful measure of Subbasin conditions. The average annual increase in storage of 5,900 AFY is consistent with stable to slightly above average cumulative precipitation inputs over the 28-year base period (**Section 6.1**).

Figure 6-22. Subbasin Inflows, 1988 - 2015

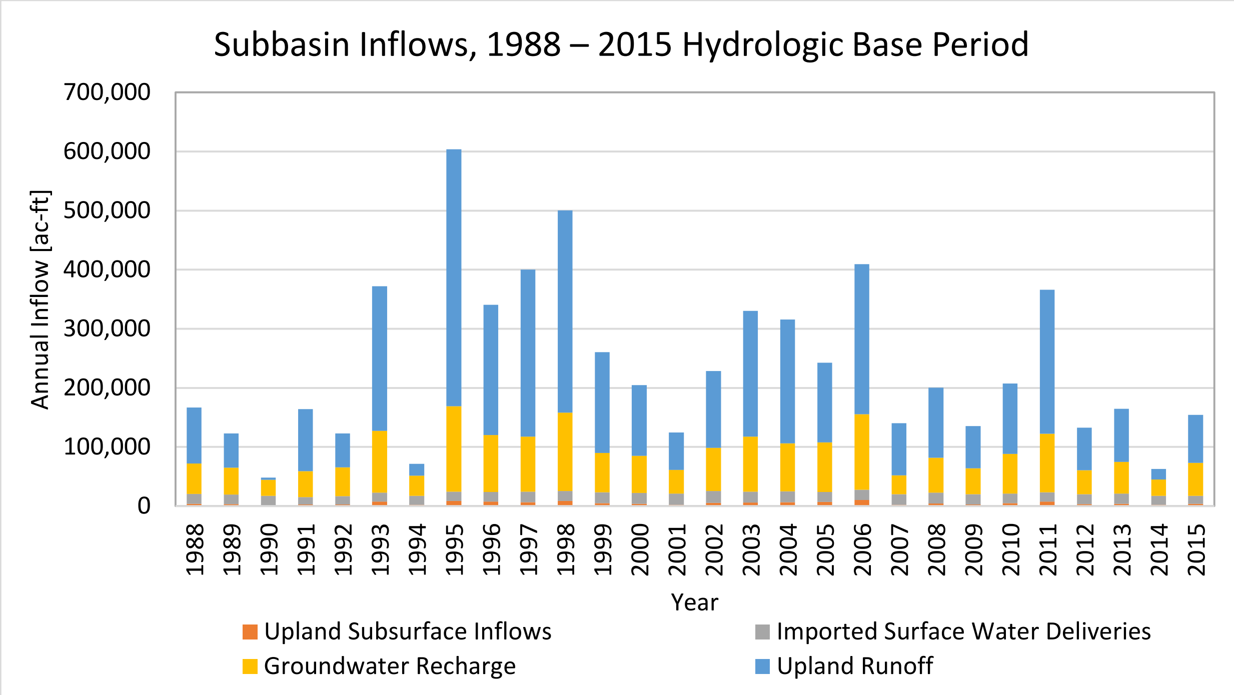


Figure 6-23. Subbasin Outflows, 1988 – 2015

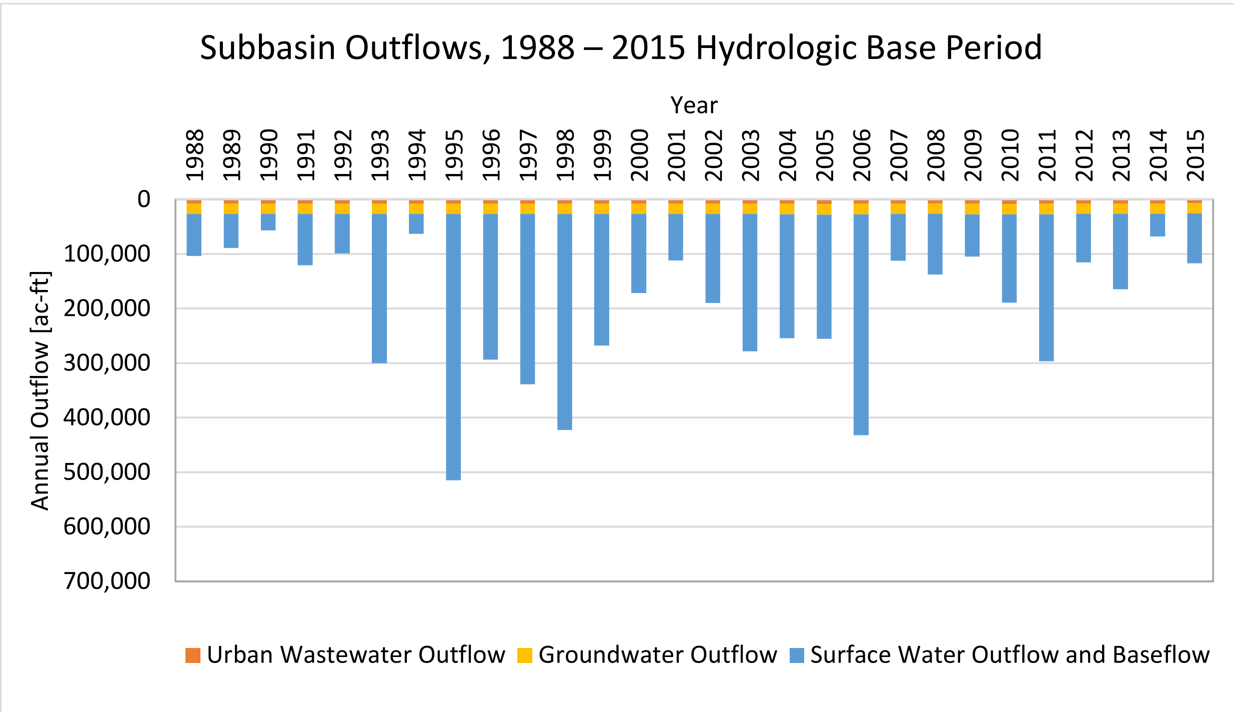
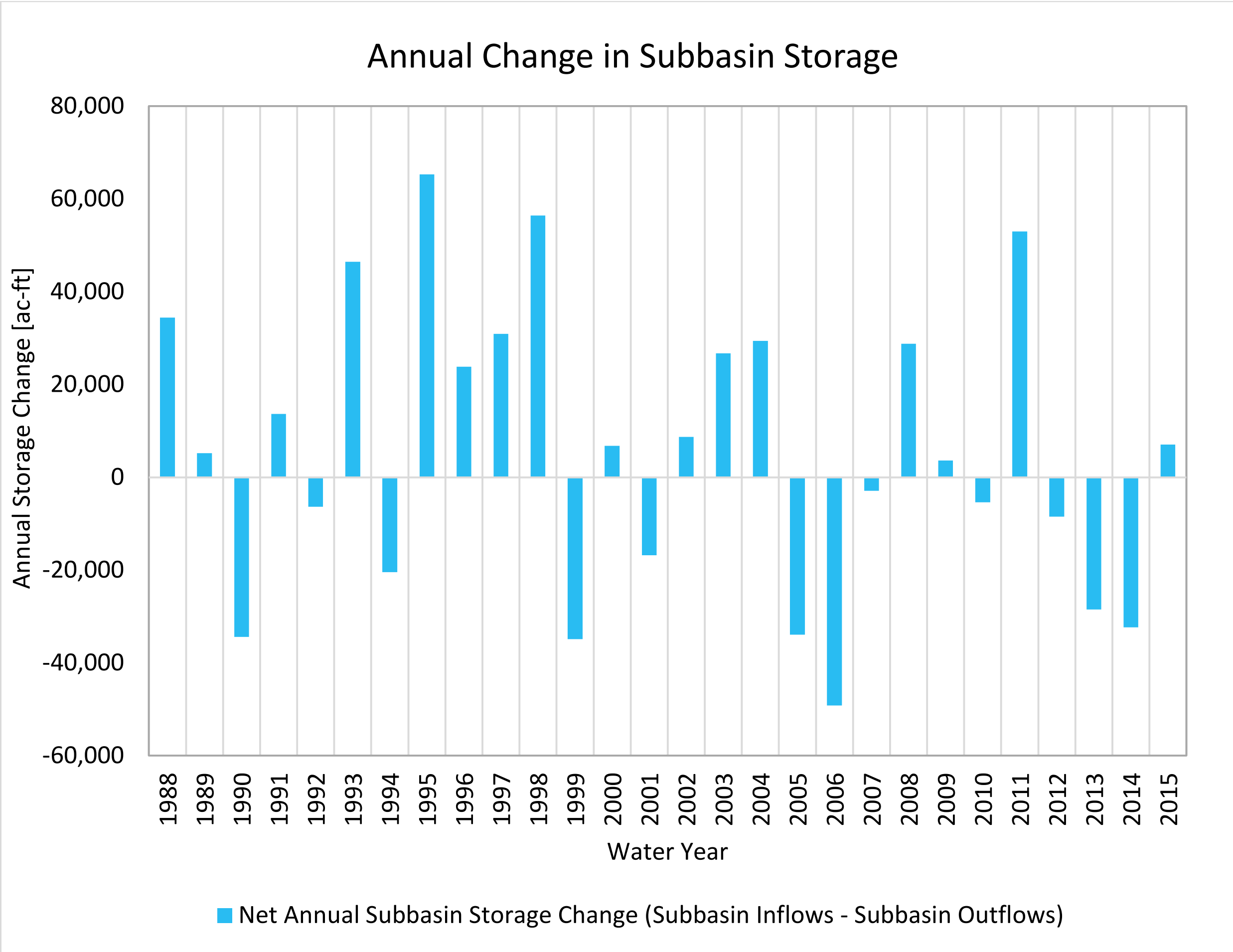


Figure 6-24. Net Annual Subbasin Storage Change, 1988 - 2015



Data on groundwater levels in the Subbasin show stable trends during the base period. The average annual change in storage volume calculated by the water budget suggest an accrual of water within the subbasin that is not consistent with the stable spring to spring groundwater levels observed. The most likely explanations for this discrepancy are that inflows are overstated, outflows are understated, or some combination of the two.

Total groundwater pumping represented in the Subbasin water budget is greater than the groundwater pumping calculated by the Root Zone Model due to the addition of groundwater pumping demands from residential indoor water uses in unincorporated parts of the Subbasin, groundwater uses by wineries in unincorporated portions of the Subbasin, as well as municipal pumping (**Table 6-13**). The growth over time in groundwater pumping for irrigation is primarily due to the change in water sources for irrigated land uses between 1987 and 2011, which show a growth in acreages supplied by groundwater.

Table 6-12. Napa Valley Subbasin Annual Water Budget Results, 1988 – 2015 Hydrologic Base Period

		Subbasin Inflows				Subbasin Outflows					
	Water Year (10/1 - 9/30)	Upland Runoff [1] [AF]	Upland Subsurface Inflow [2] [AF]	Imported Surface Water Deliveries [3] [AF]	GW Recharge [4] [AF]	Total Consumptive SW Use [5] [AF]	Total Consumptive GW Use [6] [AF]	Urban Wastewater Outflow [7] [AF]	Surface Water Outflow and Baseflow [8] [AF]	Groundwater Outflow [9] [AF]	Net Annual Subbasin Storage Change (Subbasin Inflows - Subbasin Outflows) [AF]
Drier than Average	1988	94,896	3,961	16,364	51,507	19,983	8,810	7,800	76,750	19,000	34,386
	1989	58,157	3,066	16,260	45,565	19,671	9,079	7,800	62,308	19,000	5,191
	1990	3,841	1,040	16,204	26,974	17,606	8,430	7,800	29,660	19,000	-34,437
	1991	104,893	2,436	12,449	44,227	19,716	10,097	7,800	93,771	19,000	13,621
	1992	57,083	2,909	13,963	48,824	19,326	10,632	7,800	72,345	19,000	-6,323
	1993	244,844	7,338	15,169	104,483	16,421	9,054	7,800	273,122	19,000	46,436
	1994	20,113	2,378	14,675	34,461	18,073	10,922	7,800	36,307	19,000	-20,474
Wetter than Average	1995	435,257	8,662	15,586	144,461	14,801	8,906	7,800	488,188	19,000	65,271
	1996	220,799	7,350	16,644	96,031	14,397	8,945	7,800	266,826	19,000	23,857
	1997	282,973	6,271	18,041	93,189	18,013	12,658	7,800	312,069	19,000	30,934
	1998	342,444	8,549	16,594	133,020	12,883	8,738	7,800	395,797	19,000	56,389
	1999	170,571	4,935	18,123	66,849	15,262	12,000	7,800	241,329	19,000	-34,914
	2000	119,720	3,959	17,978	62,786	14,343	11,429	7,800	145,123	19,000	6,748
Variable: Dry, Normal, and Wet	2001	63,694	2,078	19,200	39,806	15,646	14,196	7,800	84,918	19,000	-16,780
	2002	129,462	5,501	19,778	73,510	15,384	14,380	7,800	163,002	19,000	8,686
	2003	213,239	6,075	18,232	92,956	12,984	12,118	7,800	251,890	19,000	26,710
	2004	209,955	6,698	18,137	81,086	15,899	16,302	8,102	227,200	19,000	29,373
	2005	134,711	7,007	17,005	83,636	10,545	10,275	8,838	227,606	19,000	-33,906
	2006	254,046	10,260	17,051	127,920	12,305	14,086	8,102	404,988	19,000	-49,205
	2007	88,278	2,287	17,732	31,791	13,910	16,686	7,734	85,693	19,000	-2,935
	2008	118,340	4,336	18,360	59,144	14,394	19,647	7,365	110,979	19,000	28,795
	2009	71,664	2,597	17,358	43,794	11,914	15,409	8,102	77,391	19,000	3,596
	2010	119,127	5,062	16,035	67,094	9,804	13,443	8,470	161,964	19,000	-5,362
	2011	243,794	7,520	15,947	98,996	7,980	8,636	8,102	269,566	19,000	52,974
Drier than Average	2012	72,080	3,273	16,859	40,486	10,574	15,085	7,365	89,131	19,000	-8,457
	2013	89,954	3,702	17,225	53,709	11,936	16,263	7,365	138,532	19,000	-28,506
	2014	17,849	2,129	15,170	27,739	11,946	15,349	7,365	41,539	19,000	-32,312
	2015	80,861	3,697	13,781	55,705	12,494	17,331	6,629	91,549	19,000	7,042
	Average:	**145,095**	**4,824**	**16,640**	**68,920**	**14,579**	**12,461**	**7,798**	**175,698**	**19,000**	**5,943**

[1] Upland runoff is the sum of surface water inflows to the Napa Valley Subbasin from the Napa River Watershed, an output of the California Basin Characterization Model, less the amounts withheld by municipal reservoirs in the Subbasin watershed

[2] Upland Subsurface Inflow is the BCM calculated groundwater recharge for areas within 500 meters outside of the Subbasin border that correspond to surficial Quaternary geologic formations.

[3] Imported surface water deliveries are the sum of surface water imported to the Subbasin by municipalities, including water from reservoirs in the Subbasin watershed and State Water Project deliveries.

[4] Groundwater recharge represents the fraction of infiltration that reaches the Napa Valley Subbasin from the overlying soils as calculated by the Root Zone Model.

[5] Total consumptive surface water use is calculated by the root zone model as the application of water to meet demands due to evapotranspiration for irrigated land uses.

[6] Total consumptive groundwater use is calculated by a combination of root zone model calculated values, pumping reported by municipal purveyors, and estimated pumping for use by wineries and residences not supplied by municipal purveyors in the unincorporated parts of the Subbasin. The root zone model calculates the application of water to meet demands due to evapotranspiration for irrigated land uses, irrigation applications are assumed to be efficiently applied such that return flows to the Subbasin are not produced. Total non-irrigation related groundwater pumping is assumed to include a minor return flow component of 15% based on published values.

[7] Urban wastewater outflow is the volume of municipal wastewater conveyed by pipeline out of the Subbasin to the Napa Sanitation District.

[8] Surface water outflow and Baseflow is the sum of measured streamflow discharge at the USGS Napa River near Napa gage and runoff calculated by the USGS Basin Characterization Model (BCM) for Upland areas that are not within the watershed gaged by the USGS gage.

[9] Groundwater outflow is the flow of groundwater from the unconsolidated formations of the Napa Valley Subbasin to the Napa-Sonoma Lowlands Subbasin calculated based on measured groundwater level gradients and a geologic cross section of the Napa Valley Subbasin.

Table 6-13. Napa Valley Subbasin Calculated Annual Groundwater Pumping, 1988 – 2015 Hydrologic Base Period

		Groundwater Pumping, All Demands								
	Water Year (10/1 - 9/30)	Unincorporated Area Residential Indoor Uses [1] [AF]	Unincorporated Area Wineries, Indoor Uses [2] [AF]	Municipal Non-irrigation [3] [AF]	Municipal Irrigation [4] [AF]	Semi-Ag, Residential, and Commercial Unincorporated Areas, Irrigation [4] [AF]	Vineyard Irrigation [4] [AF]	Other Ag Irrigation [4] [AF]	Total Consumptive GW Use [5] [AF]	Total GW Pumping [AF]
Drier than Average	1988	420	1,222	52	39	2,083	5,824	611	8,811	10,251
	1989	416	1,222	52	39	2,016	6,166	605	9,079	10,516
	1990	412	1,222	20	36	1,989	5,606	551	8,430	9,836
	1991	411	1,222	51	43	2,225	6,960	616	10,097	11,528
	1992	411	1,222	365	42	2,202	7,497	592	10,632	12,331
	1993	409	1,222	165	39	2,056	6,167	524	9,055	10,582
	1994	408	1,222	374	45	2,295	7,709	573	10,922	12,626
Wetter than Average	1995	407	1,222	279	39	2,106	5,969	507	8,907	10,529
	1996	408	1,222	238	43	2,218	5,871	533	8,945	10,533
	1997	406	1,222	300	49	2,541	9,202	578	12,659	14,297
	1998	405	1,222	221	40	2,060	5,908	454	8,739	10,310
	1999	404	1,222	129	135	2,359	8,728	515	12,000	13,492
	2000	404	1,222	203	142	2,385	8,132	497	11,430	12,985
Variable, Dry to Wet	2001	400	1,222	323	145	2,492	10,753	515	14,196	15,850
	2002	398	1,222	197	152	2,618	10,814	524	14,381	15,925
	2003	396	1,222	324	139	2,419	8,788	481	12,119	13,770
	2004	394	1,222	317	163	2,911	12,389	550	16,303	17,946
	2005	391	1,222	262	120	2,253	7,219	403	10,276	11,870
	2006	388	1,222	271	139	2,548	10,653	465	14,087	15,685
	2007	386	1,222	359	162	2,973	12,744	512	16,686	18,358
	2008	385	1,222	316	163	3,047	15,631	519	19,648	21,283
	2009	381	1,222	363	145	2,819	11,693	457	15,409	17,081
	2010	379	1,222	203	122	2,442	10,217	392	13,443	14,976
	2011	377	1,222	122	105	2,155	5,810	308	8,637	10,099
Drier than Average	2012	375	1,222	52	130	2,605	11,695	408	15,086	16,487
	2013	372	1,222	379	147	2,928	12,447	445	16,263	17,940
	2014	369	1,222	162	155	2,958	11,499	474	15,349	16,839
	2015	367	1,222	89	155	3,047	13,412	465	17,331	18,757

1 Calculated based on a daily demand of 60.3 gallons per person for indoor uses (Aquacraft, 2011) and unincorporated Subbasin population based on U.S. Census data for 1980, 1990, 2000, 2010.

2 Groundwater pumping by wineries in the unincorporated is based on a Napa County dataset of permitted wineries as of 2015 and includes estimates of water use for winemaking, wine tasting, visitation, and events. Data for prior years were not available, so the 2015 value is applied across the base period.

3 Municipal groundwater pumping reflects values reported by Calistoga, St. Helena, and Yountville and includes pumping for all non-irrigation water uses served by those municipalities.

4 Irrigation related groundwater pumping demands outside of the Subbasin municipalities is calculated by the Root Zone Model.

5 Total consumptive groundwater use is calculated by the root zone model as the application of water to meet demands due to evapotranspiration for irrigated land uses.

6.7.1 Qualitative Consideration of the Napa-Sonoma Lowlands Subbasin

Outflows from the Napa Valley Subbasin enter the Napa-Sonoma Lowlands Subbasin through Napa River flow (including stormflows and groundwater baseflow) and subsurface flow of groundwater. Subsurface groundwater outflows are likely between ten thousand and twenty thousand acre-feet per year, based on the outflow analysis conducted with groundwater level data collected from 2005 through 2013 (see **Section 6.5.2**). Surface water outflows vary seasonally with the largest discharges occurring during winter and spring storm flows.

6.7.2 Projected Subbasin Water Budget Results

The projected baseline Subbasin water budget utilizes the "warm and moderate rainfall" future climate scenario from the BCM that includes projections for precipitation and reference evapotranspiration. Amongst the suite of climate scenarios addressed by the BCM, the "warm and moderate rainfall" scenario is most similar to recent conditions. This approach is interpreted to be most consistent with the regulations for projected future water budgets described in the DWR Groundwater Sustainability Plan Regulations.

Projected baseline water demand is based on the most recent municipal demands and the most recent land use survey data (DWR, 2011). Projected baseline water demands also incorporate increases associated with the expansion of vineyards and wineries in the Subbasin. Potential demand increases were developed based on a review of proposed vineyard development projects, new or modified winery permit applications pending through 2016, and permits for wineries in the unincorporated portion of the Subbasin approved between 2011 and 2015.

Permit applications for new or modified winery operations through September 2016 indicate potential additional demand for 47.7 AFY, based on 21 permit applications for sites within the Subbasin; however, there is uncertainty as to whether all proposed projects will be approved. Winery permits can take several years to receive permitting approval, and even then, not all permitted projects are carried through to construction in a timely manner. A review of winery permits approved from 2011 to 2015 finds that 9 winery permits were approved during that time with a total calculated water demand of 19.55 AFY over that five-year period.[24] Considering the pending winery permit applications and recently approved winery permit applications, total winery water demand in the Napa Valley Subbasin is increased by 12 AFY for each year of the projected water budget.

As of September 2016, vineyard development permit applications indicated the potential for 8.67 acres of additional vineyard in the Napa Valley Subbasin. The future water demand associated with these and other potential vineyard development projects within the Subbasin are accounted for through the addition of 2 AFY of groundwater demand for each year of the future scenario, based on a conservative annual water demand factor of 1 AF per acre and up to a 5-year period between the initial proposal and eventual vineyard planting. All other water demands for irrigation water for the future water budget, as well as groundwater recharge due to percolation through Subbasin soils, are calculated by the Root Zone Model consistent with the methods applied for the base period.

[24] Total water demand was calculated based on the permitted winery production and marketing details and the County's suggested water use factors presented in the Water Availability Analysis Guidance Document for activities ranging including winemaking, tasting room operations, and events.

Projected municipal demands for surface water and groundwater reflect the average of reported uses from 2011 through 2015. This is a conservative projection given legislatively mandated conservation targets for municipal water use, including SBx 7-7 which sets a goal of 20% per capita reduction in urban water demand by 2020. Projected demand for domestic use by residences in the unincorporated portion of the Subbasin are also conservatively projected to remain stable based on the 2011 to 2015 average estimated use, despite a trend of declining population in the unincorporated Subbasin.

Projected baseline surface water supply is based on the 2011 to 2015 average of imported surface water deliveries. Upland Runoff and Upland Subsurface Inflow for the projected baseline water budget are derived from the BCM “warm and moderate rainfall” scenario consistent with the approach used for the base period water budget. Streamflow is projected based on regression of historical upland precipitation and streamflow recorded at USGS Napa River near Napa gage.

The projected baseline Subbasin water budget results for years 2016 to 2025 are presented in **Table 6-14**. The projected average net annual Subbasin storage change over this 10 year period is 8,000 AF. As with the water budget results over the base period, the projected accrual of water within the Subbasin is likely in part explained by inflows being overstated, outflows being understated, or some combination of the two.

In addition to the “warm and moderate rainfall” baseline condition, an alternative “hot and low rainfall” future climate scenario (BayArea_MIROC_esm_rcp85) from the BCM was applied to the Subbasin water budget, resulting in a projected average net annual Subbasin storage change from 2016 to 2025 of -14,300 AF. The difference of 22,300 AF in projected average net annual Subbasin storage change between the baseline condition and the “hot and low rainfall” future climate indicates the level of uncertainty in projected water budgets due to uncertainties associated with projections of climate change. The monthly time scale climate scenario data that the future Subbasin water budget analyses utilize do not constitute “predictions of precisely when climatic events will occur” instead they represent simulated future conditions considered “physically possible given the state of the science.” (Micheli et al. 2016). In particular, the “hot and low rainfall” scenario represents the most severe future climate scenario analyzed by the BCM, with mid-century (i.e., 2040 to 2069) average hydrologic indicators showing the greatest change relative to the 1981 to 2010 average. For the “hot and low rainfall” scenario mid-century averages include a 21% reduction in average annual precipitation, an 11% increase in minimum monthly winter temperatures, and an 8% increase in the maximum monthly summer temperatures.

The projected baseline Subbasin water budget utilizes the “warm and moderate rainfall” future climate scenario and the most recent water demands with allowances for increased water demands in future years due to vineyard expansion and additional winery development. The projected baseline estimate for average total groundwater pumping over the 10-year period is 18,000 AFY, with 12,600 AFY pumping for vineyard irrigation. To reflect ongoing improvements in vineyard irrigation management, a soil moisture retention parameter value of 30% (down from 40% in the baseline condition) was applied to the root zone model of the water budget, lowering projected pumping for vineyard irrigation to 12,000 AFY and total annual pumping to 17,000 AFY. Future development in the larger Subbasin watershed is not explicitly considered as part of the projected Subbasin water budget; however, any reductions in runoff or subsurface inflow to the Subbasin as a result of future development are believed to be minor relative to the overall inflow volumes.

Table 6-14. Projected Baseline Subbasin Water Budget Results

		Subbasin Inflows				Subbasin Outflows					
	Water Year (10/1 - 9/30)	Upland Runoff [1] [AF]	Upland Subsurface Inflow [2] [AF]	Imported Surface Water Deliveries [3] [AF]	GW Recharge [4] [AF]	Total Consumptive SW Use [5] [AF]	Total Consumptive GW Use [6] [AF]	Urban Wastewater Outflow [7] [AF]	Surface Water Outflow and Baseflow [8] [AF]	Groundwater Outflow [9] [AF]	Net Annual Subbasin Storage Change (Subbasin Inflows - Subbasin Outflows) [AF]
Future Scenario (Warm and Moderate Rainfall)	2016	136,117	4,335	15,797	59,127	12,426	17,621	7,365	124,973	19,000	33,989
	2017	149,018	6,251	15,797	74,169	12,622	18,108	7,365	167,374	19,000	20,765
	2018	230,816	7,916	15,797	97,699	11,394	15,804	7,365	300,264	19,000	-1,598
	2019	236,682	7,202	15,797	101,129	10,552	13,696	7,365	295,623	19,000	14,572
	2020	115,229	4,983	15,797	57,347	11,982	16,756	7,365	161,257	19,000	-23,005
	2021	185,483	6,760	15,797	82,915	12,461	17,875	7,365	206,183	19,000	28,071
	2022	55,068	488	15,797	11,219	12,374	16,702	7,365	58,516	19,000	-31,386
	2023	289,311	7,438	15,797	112,766	11,467	15,331	7,365	305,794	19,000	66,354
	2024	93,779	3,368	15,797	43,472	12,532	17,700	7,365	110,760	19,000	-10,941
	2025	82,055	4,607	15,797	55,940	11,399	15,179	7,365	122,537	19,000	-17,084
	Average:	**157,356**	**5,335**	**15,797**	**69,578**	**11,921**	**16,477**	**7,365**	**185,328**	**19,000**	**7,974**

[1] Upland runoff is the sum of surface water inflows to the Napa Valley Subbasin from the Napa River Watershed, an output of the California Basin Characterization Model, less the amounts withheld by municipal reservoirs in the Subbasin watershed

[2] Upland Subsurface Inflow is the BCM calculated groundwater recharge for areas within 500 meters outside of the Subbasin border that correspond to surficial Quaternary geologic formations.

[3] Imported surface water deliveries are the sum of surface water imported to the Subbasin by municipalities, including water from reservoirs in the Subbasin watershed and State Water Project deliveries.

[4] Groundwater recharge represents the fraction of infiltration that reaches the Napa Valley Subbasin from the overlying soils as calculated by the Root Zone Model.

[5] Total consumptive surface water use is calculated by the root zone model as the application of water to meet demands due to evapotranspiration for irrigated land uses.

[6] Total consumptive groundwater use is calculated by a combination of root zone model calculated values, pumping reported by municipal purveyors, and estimated pumping for use by wineries and residences not supplied by municipal purveyors in the unincorporated parts of the Subbasin. The root zone model calculates the application of water to meet demands due to evapotranspiration for irrigated land uses, irrigation applications are assumed to be efficiently applied such that return flows to the Subbasin are not produced. Total non-irrigation related groundwater pumping is assumed to include a minor return flow component of 15% based on published values.

[7] Urban wastewater outflow is the volume of municipal wastewater conveyed by pipeline out of the Subbasin to the Napa Sanitation District.

[8] Surface water outflow and Baseflow is the sum of measured streamflow discharge at the USGS Napa River near Napa gage and runoff calculated by the USGS California Basin Characterization Model (BCM) for Upland areas that are not within the watershed gaged by the USGS gage.

[9] Groundwater outflow is the flow of groundwater from the unconsolidated formations of the Napa Valley Subbasin to the Napa-Sonoma Lowlands Subbasin calculated based on measured groundwater level gradients and a geologic cross section of the Napa Valley Subbasin.

6.8 Groundwater Level Change in Storage Analysis

The water budget analysis presented in this **Section 6.2** is complemented by an analysis of changes in groundwater storage computed separately through observed changes in groundwater levels over the base period. Results from the groundwater level change in storage analysis provide a means to check the results of the water budget analysis by comparison with the average annual changes in storage computed by the water budget.

6.8.1 Groundwater Contours and Potentiometric Surfaces for Key Base Period Years

Available groundwater level data from wells completed in the alluvium were extracted from the Napa DMS and plotted spatially on a map to assess coverage. To achieve satisfactory coverage, it was necessary to interpolate over the extent of the alluvial basin by creating auxiliary points just beyond the extent of the basin. Additionally, some wells near the basin boundary did not have water level data present for each year of the base period. Therefore, an estimated measurement of depth to water was developed using regression analysis. The groundwater level data used for this analysis are summarized in **Table 6-15**. The locations of the data points are shown in **Figure 6-25**.

A depth to the base of the aquifer grid was developed (**Figure 6-26**) from mapped alluvium isopach contours and geologic cross sections (LSCE and MBK, 2013), and a depth to water grid was developed for each year of the base period (2015 shown in **Figure 6-27**). By raster algebra within GIS, a difference grid between the base of the alluvium and the top of the water table was calculated for each year to determine a volumetric change in saturated aquifer volume for each year. Groundwater storage was calculated by multiplying the saturated aquifer volume with an estimated specific yield of 6% (Kunkel and Upson, 1960).

The resulting annual changes in storage are shown along with annual total precipitation in **Figure 6-28a**. The cumulative change in storage is shown in Figure 6-28b. The calculated net change in storage over the base period of 1988 to 2015 is 3,398 AF, with an average annual change in storage of 126 AFY. The largest decrease in storage of 18,919 acre-feet was calculated for 1991. The largest increase in storage of 25,509 AF was calculated for 1992. Large year-to-year changes in calculated groundwater storage are likely in part related to the sparsity of available groundwater level data and the uncertainty of the interpolated depth to water grids. However, groundwater level storage change calculated with this method appears to follow trends in precipitation records for the base period.

Figure 6-28a. Groundwater Level Change in Storage

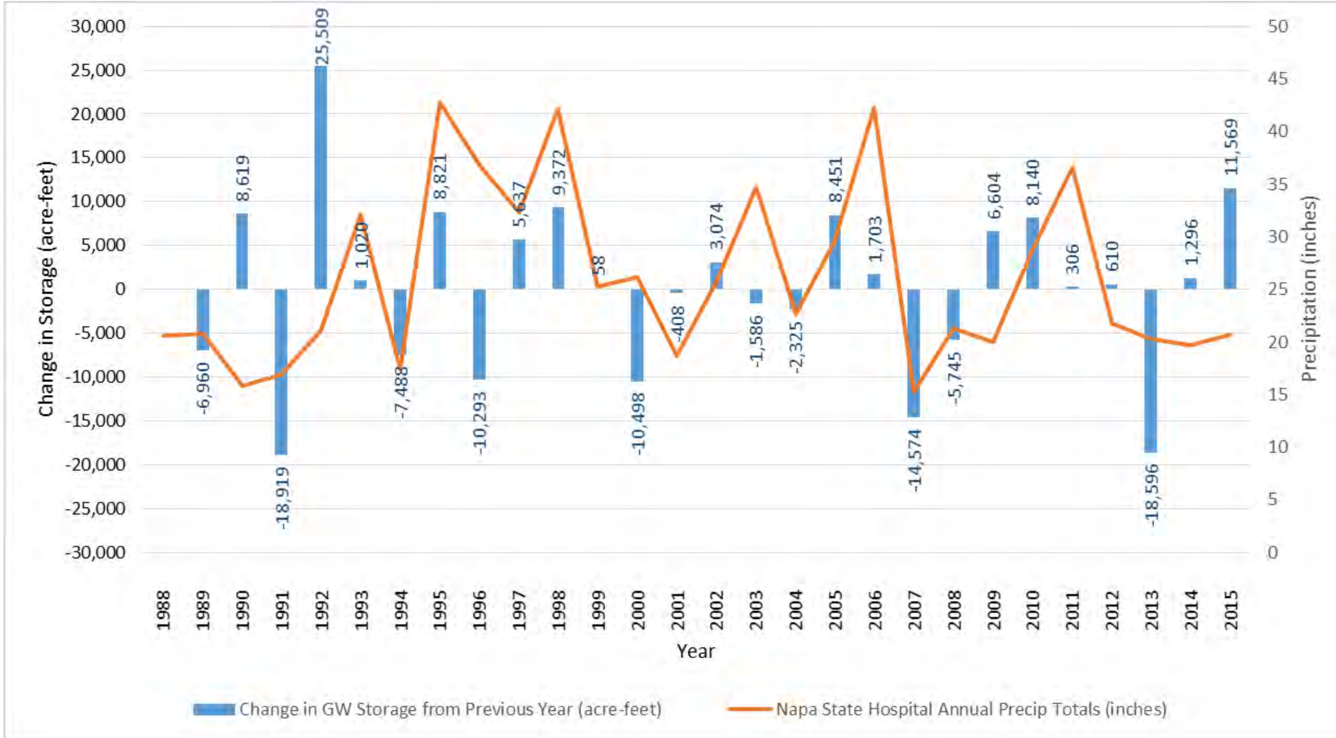


Figure 6-28b. Cumulative Groundwater Level Change in Storage

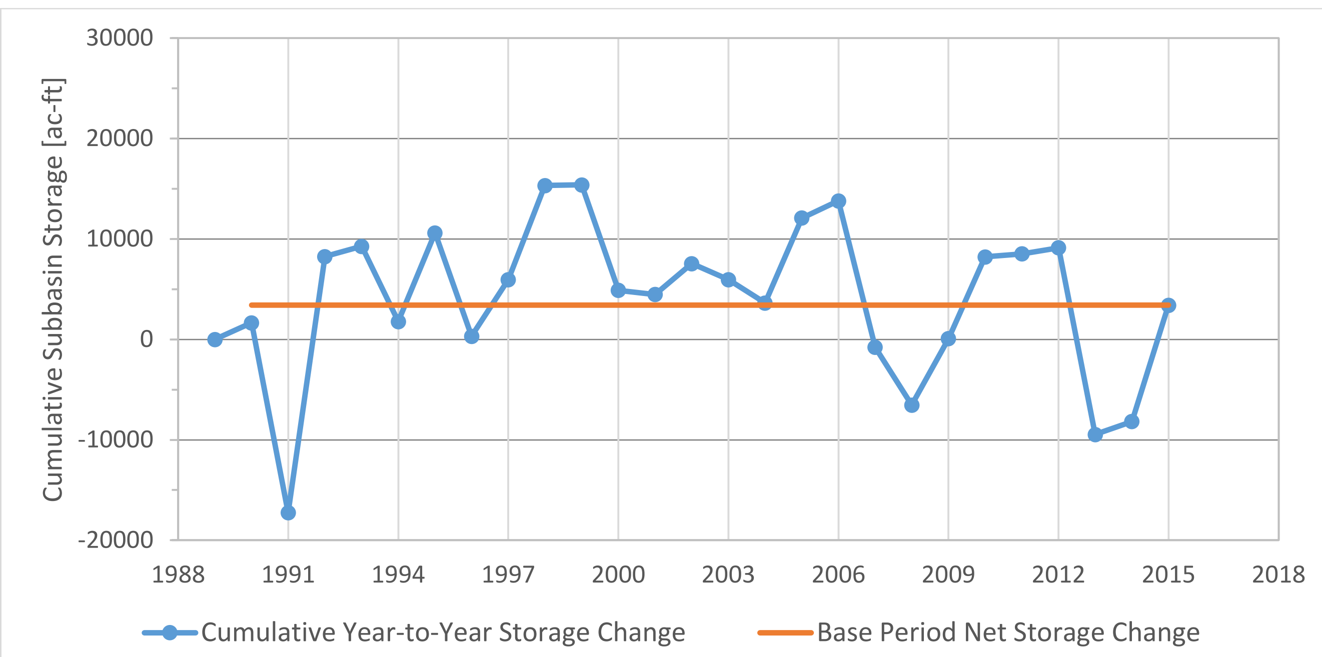


Table 6-15. Spring Water Levels (Depth, feet)

Well ID	RPE[7]	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
NapaCounty127AUX[6]	392.5	10.9	8.5[1]	13.9	7.8	7.9	11.2[1]	12.0	7.4[1]	7.5	7.6[1]	5.0[1]	5.0[1]	6.6	7.7	8.6	15.2	33.8	6.7	5.5	8.6	7.1	7.2	7.1	7.6	7.2	10.4	11.1	14.3	13.4
NapaCounty127	392.5	10.9	8.5[2]	13.9	7.8	7.9	11.2[2]	12.0	7.4[2]	7.5	7.6[2]	5.0[2]	5.0[2]	6.6	7.7	8.6	15.2	33.8	6.7	5.5	8.6	7.1	7.2	7.1	7.6	7.2	10.4	11.1	14.3	13.4
NapaCounty128	343.7	9.5		7.5	12.5		7.6	7.9		6.0				6.7	7.2	6.8	6.0	7.5	5.6	4.5	7.9	8.4	7.2	5.2	6.3	4.9	9.1	6.0	6.5	6.3
NapaCounty129	338.7	27.6		10.5	14.7	9.8	8.8	10.0		11.1				9.5	11.4	9.6	8.2	10.4	7.0	6.2	10.5	14.0	10.0	6.0	8.3	9.2	9.6	13.8	8.7	7.0
NapaCounty203	304.0																											24.9		
08N06W10Q001M	293.4	7.7	6.9	6.7	9.1	5.9	8.8	7.0	6.2	3.8	6.3	4.5	4.5	6.0	6.5	8.7	7.3	7.2	6.2	6.0	7.4	7.4	7.2	6.7	7.2	7.2	6.9	11.2	7.5	
NapaCounty222sswgw5	218.5																												25.1	22.8
07N05W09Q002M	158.2	13.1	15.4	16.0	20.8	11.3	10.0	14.6	13.7	10.0	11.9	9.4	10.2	12.0	16.3	11.7	12.9	11.8	10.4	9.5	18.2	13.5	16.3	14.0	12.7	19.0	14.9	31.9	15.5	
NapaCounty132	142.7	11.6		14.4	21.8	9.2	9.3	13.6		8.5	42.2			10.1	22.8	11.8	11.7	10.8	9.2	8.2	19.6		19.4	12.3	10.1	12.2	14.7	25.7	16.1	13.0
NapaCounty131	173.5	25.4		19.1	48.5	12.5	13.7	14.2		11.9				11.5	15.7	16.8	15.0	14.5	9.4	7.3	34.0	19.5	15.8	12.2	9.4	13.1	31.5	21.2	17.7	10.0
NapaCounty138	195.1	16.4		8.0	71.1	9.0	7.0	13.5		7.3				16.4	12.4	9.9	8.1	12.6	6.7	7.8	12.6	41.0	11.8	6.4	8.6	6.5	79.2	6.3	9.3	6.9
NapaCounty204	141.7																												20.0	18.2
NapaCounty177	149.3																											9.7	9.7	8.7
NapaCounty220sswgw4	99.7																												15.4	10.2
NapaCounty133	94.7	14.0		16.6	22.5	8.9	8.9	13.0		8.2	11.3			8.5	11.4	9.2	8.8	9.2	7.4	8.0	14.6	17.7	10.1	7.0	8.4	7.5	11.3	18.0	10.5	8.4
NapaCounty179	74.3																											20.2	14.4	10.0
NapaCounty180	76.9																											22.3	15.1	
06N04W17A001M	70.3	18.9	36.3	28.1	24.0	9.0	5.5	15.8	5.9	1.3	6.6	4.2	3.8	5.0		6.5	6.8	6.3	4.3	2.0	22.4	27.7	16.0	10.9	4.6	8.2	13.7	23.3	12.6	
NapaCounty218sswgw3	52.8																												20.9	13.9
NapaCounty216sswgw2	105.8																												21.4	15.0
NapaCounty139	85.8	13.4		16.5	28.2	9.8	8.8	15.0		7.5	10.0			9.0	11.9	8.9	8.7	9.4	8.2	7.3	14.8	11.9	11.4	8.0	7.9	9.5	11.3	19.0	12.2	9.3
NapaCounty135	129.2	21.0		18.8	21.0	21.2	21.0	22.0		34.5				41.5	16.7	23.2	30.8	23.5	23.5	18.8	25.4	29.0	33.8	29.0	28.0	29.8	44.5	77.8		30.8
NapaCounty185	83.0																											22.6		16.5
NapaCounty183	48.9																											15.2	11.1	10.7
NapaCounty190	73.8																												25.0	
NapaCounty75	41.2	27.6		47.9	30.3	26.3	8.5	28.5		24.2				27.8	28.8	32.7	49.3	45.0	35.2		41.9	55.1	46.9	46.1	38.7	44.2	45.7	53.2		
06N04W27L002M	53.6	30.9	32.9	30.6	34.5	36.1	32.5	29.9	24.0	21.2	25.7	23.0	22.2	27.0	27.3	25.1	22.2	25.8	25.8	21.7	34.9	27.5	29.3	27.7	24.5	31.8	28.3	41.0	29.7	
NapaCounty152	78.3																									6.8	14.8	10.8	11.0	9.0
NapaCounty136	53.2	27.5	28.4[3]	23.9	36.5	22.0	21.0	28.0	20.0[3]	48.8	21.6[3]	19.1[3]	18.3[3]	22.9	23.8	21.0	20.7	23.6	15.0	17.8[3]	24.2	32.6	27.0	18.6	19.6	17.4	29.9	23.5	24.5	19.5
NapaCounty214sswgw1	22.1																												16.9	16.3
NapaCounty18	124.3	22.3[4]	22.7[4]	20.9[4]	26.0[4]	20.1[4]	19.7[4]	22.5[4]	19.3[4]	31.0[4]	19.9[4]	18.9[4]	18.6[4]	17.1	18.0	19.2	19.1	20.5	19.0	18.4[4]	20.0	23.2	22.5	18.5	19.3	17.2	21.8	21.8	23.5	23.5
NapaCounty18AUX[6]	124.3	22.3[5]	22.7[5]	20.9[5]	26.0[5]	20.1[5]	19.7[5]	22.5[5]	19.3[5]	31.0[5]	19.9[5]	18.9[5]	18.6[5]	17.1	18.0	19.2	19.1	20.5	19.0	18.4[5]	20.0	23.2	22.5	18.5	19.3	17.2	21.8	21.8	23.5	23.5

[1] Constant depth to water was assumed northward/downstream from NapaCounty127

[2] Estimated using linear regression between NapaCounty127 and 08N06W10Q001M

[3] Estimated using linear regression between NapaCounty136 and 06N04W27L002M

[4] Estimated using linear regression between NapaCounty18 and NapaCounty136

[5] Constant depth to water was assumed southward/downstream from NapaCounty18

[6] Auxiliary data point to achieve water level interpolation covering entire Subbasin

[7] Reference Point Elevation

6.9 Sensitivity Analysis

Root Zone Model

The Root Zone Model estimates recharge and pumping as functions of input data including land use, soil, precipitation, and ET, as well as model parameters for crop coefficients, effective root zone depth, and soil moisture retention for irrigated land use units. The uncertainties in each of these input data and parameters translate into uncertainties in model results. The Root Zone Model results presented in this report are based on typical (relative precipitation year) ITRC crop coefficients listed above in **Table 6-8**, root zone depths listed in **Table 6-6**, and soil moisture retention (SMR) of 40%. Root Zone Model results are sensitive to changes of each parameter. Model parameters can be calibrated to improve model results (e.g., to minimize the difference between estimates of groundwater pumping and measured pumping data when they are available).

Table 6-16, **Table 6-17**, and **Table 6-18** show the model sensitivity for estimated average annual vineyard irrigation (sum of groundwater, surface water, and reclaimed water) in the Subbasin from 2005 to 2014 to changes to crop coefficients, effective root depths, and minimum maintained soil moisture.

Table 6-16. Crop Coefficient Sensitivity Analysis Results (with 3 ft grape root depth, and 40% SMR)

Crop Coefficients	Average Annual Vineyard Irrigation WY 20052014 (ac-ft/ac)	Kc											
		January	February	March	April	May	June	July	August	September	October	November	December
ITRC, Dry Year, Grape Vines with 40% canopy	0.60	0.76	1.06	0.90	0.51	0.39	0.38	0.34	0.27	0.19	0.10	0.76	0.71
ITRC, Typical Year, Grape Vines with 40% canopy	0.70	1.03	0.40	0.38	0.47	0.51	0.42	0.36	0.39	0.18	0.26	0.48	0.85
ITRC, Wet Year, Grape Vines with 40% canopy	0.90	0.98	1.00	0.80	0.80	0.75	0.44	0.35	0.27	0.20	0.17	0.84	0.89
Williams VSP (Oakville 2000)	0.73	1.03	0.40	0.38	0.14	0.21	0.33	0.45	0.51	0.55	0.26	0.48	0.85
Williams Wye (Oakville 2000)	1.55	1.03	0.40	0.38	0.20	0.47	0.69	0.79	0.83	0.83	0.26	0.48	0.85

Table 6-17. Grape Root Depth Sensitivity Analysis Results (with ITRC Typical Year Crop Coefficients, and 40% SMR)

Grape Root Depth (ft)	Average Annual Vineyard Irrigation WY 2005 - 2014 (ac-ft/ac)
1	0.91
2	0.79
3	0.70
4	0.61
5	0.53

Table 6-18. Soil Moisture Retention Sensitivity Analysis Results (with ITRC Typical Year Crop Coefficients, and 3 ft grape root depth)

Minimum Maintained Soil Moisture	Average Annual Total Vineyard Irrigation WY 2005 - 2014 (ac-ft/ac)
60%	0.79
50%	0.74
40%	0.70
30%	0.66
20%	0.61

Groundwater Level Change in Storage Analysis

The groundwater level change in storage analysis estimates fluctuations in groundwater storage based on changes in measured groundwater levels. The relationship of uncertainties in groundwater levels and uncertainties in groundwater storage estimates is:

$$\pm\text{Groundwater Level} \times \text{Subbasin Area} \times \text{Specific Yield} = \pm\text{Groundwater Storage}$$

For example, an uncertainty in groundwater levels of 1 foot across the Subbasin would result in:

$$\pm 1 \text{ foot} \times 45{,}900 \text{ acres} \times 6\% = \pm 2{,}754 \text{ acre feet}$$

The uncertainty in applied groundwater levels are due to errors in recorded values at monitoring locations, and to a larger degree due to uncertainty in interpolated levels for areas in between monitoring locations. Available groundwater levels from 30 monitoring locations were interpolated over the extent of the alluvial basin. An increase in the number of monitoring locations would improve accuracy of future groundwater level change in storage analysis estimates.

The uncertainty in the applied value for specific yield across the Subbasin affects groundwater storage change estimates as follows:

$$\pm\text{Specific Yield} \times \text{Groundwater Level Change} \times \text{Subbasin Area} = \pm\text{Groundwater Storage Change}$$

For example, an uncertainty of ±1% in the applied value for specific yield at a change in groundwater levels of 1 foot across the Subbasin would result in an uncertainty in storage change estimates of ±459 AF:

$$\pm 1\ \% \ \times 1 \text{ foot } \times 45{,}900 \text{ acres} = \ \pm 459 \text{ acre feet}$$

6.10 Napa Valley Subbasin Sustainable Yield

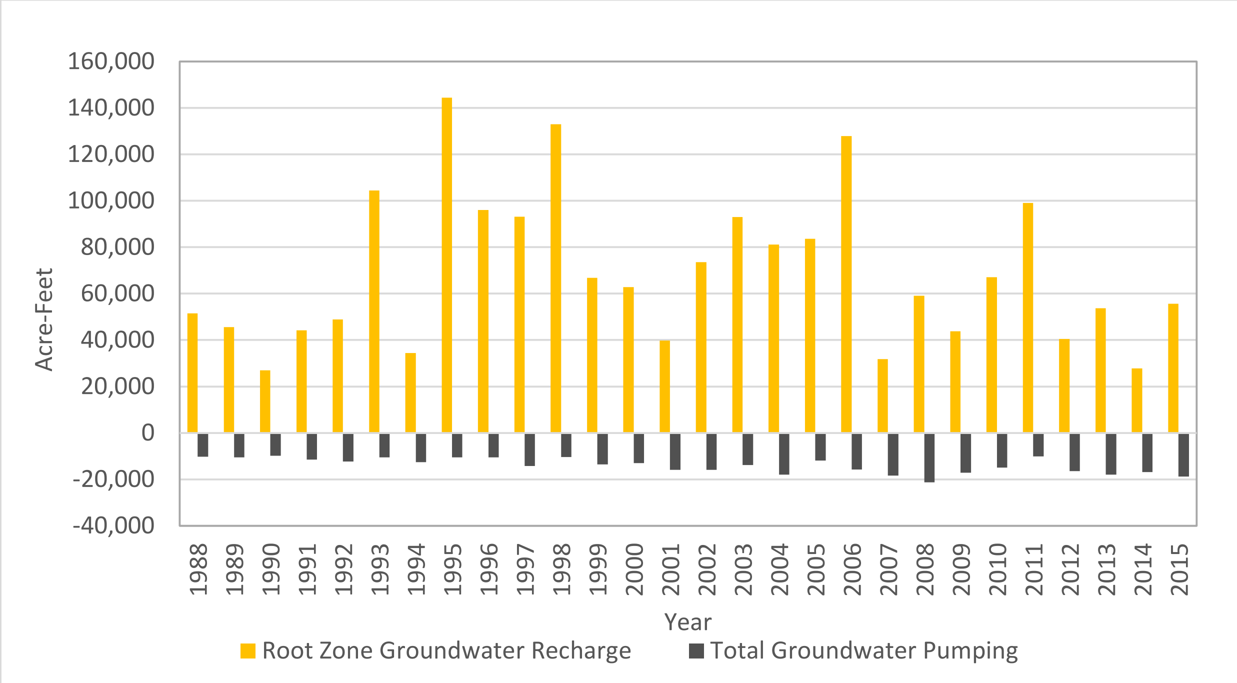
Long-term conditions in the Napa Valley Subbasin, during the 1988 to 2015 base period, have been marked by stable land uses and stable supplies of imported surface water (**Chapter 5**). Consumptive uses of surface water and groundwater in the Subbasin have also remained stable at about 27,000 AFY, though varying somewhat in response to water year types (**Table 6-12**). Total groundwater utilization has increased over that time from approximately 11,000 AFY to 18,000 AFY, with consumptive uses of groundwater increasing from approximately 10,000 AFY to 16,000 AFY. Consumptive use of surface water has decreased from approximately 19,000 AFY to 12,000 AFY (**Tables 6-12 and 6-13**). Projected water use in the Subbasin from 2016 through 2025 shows stable levels of groundwater pumping at an average rate of 18,000 AFY. Total consumptive uses of surface water and groundwater are projected to increase slightly to approximately 28,000 AFY (**Table 6-14**).

Although the annual level of groundwater pumping has increased over the base period, results from the Root Zone Model and water budget analyses (**Section 6.7**) as well as the groundwater level change in storage analysis (**Section 6.8**) show positive average annual changes in Subbasin water storage over this period. **Figure 6-29** shows the average annual inflows and outflows for the base period with the resulting positive average annual change in storage. While Subbasin inflows and outflows beyond the Subbasin land use driven processes represented in the Root Zone Model are subject to greater uncertainties, groundwater recharge resulting from precipitation across the Subbasin has consistently been much greater than outflows due to groundwater pumping (F**igure 6-30**). Over the entire base period root zone groundwater recharge averaged 69,000 AFY. During the 2012 – 2015 drought period, average root zone groundwater recharge decreased to 44,000 AFY and yet was still more than twice the average rate of groundwater pumping of 18,000 AFY during that period.

The overall stability of groundwater and surface water conditions observed over the base period and during recent drought conditions, from 2012 through 2015, (**Chapter 4**) indicate that rates of groundwater pumping have not exceeded the sustainable yield of the Subbasin as it is currently managed. Groundwater levels and groundwater quality have remained stable across the Subbasin. There is no evidence of chronic lowering of groundwater levels affecting the Subbasin. Land subsidence and seawater intrusion are not affecting the Subbasin.

The number of days during summer and fall months with no flow recorded in the Napa River, while comparable to conditions observed in the 1930s, 1960s, and 1970s, do show an increase between the dry years at the start of the base period and dry years at the end of the base period (**Section 4.2**). However, total annual streamflow records show stable annual baseflow volumes between similar water year types across the base period. **Chapter 10** includes recommendations for improving the understanding of Napa River baseflow patterns and addressing the potential for augmented recharge in the Subbasin to avoid significant, prolonged reductions in baseflow conditions in the future.

Figure 6-30. Napa Valley Subbasin Groundwater Pumping and Root Zone Groundwater Recharge, 1988 – 2015



Based on the Subbasin conditions presented in **Chapter 4**, trends in land use and water use presented in **Chapter 5**, and the water budget and groundwater level change in storage analyses presented in **Chapter 6**, the sustainable yield for the Napa Valley Subbasin has been between 17,000 AFY and approximately 20,000 AFY. The upper end of this range accounts for the average level of pumping during the recent drought while allowing for an additional increment of yield based on the surplus shown by the average net change in Subbasin storage calculated by the water budget. Sustainable yield is not considered to be a constant value (DWR, 2003). It can change with variations in water budget components or as a result of management decisions. Those changes may lead to increased or decreased sustainable yields in the future. Regularly updated evaluations of Subbasin conditions and sustainable yield will continue to account for the sustainability goal and sustainability indicators. Given the potential sensitivity of Napa River baseflow to the timing and location of groundwater pumping in the Subbasin, despite the primary influence of precipitation noted above, it is recommended that Subbasin management seek to keep rates of groundwater use in the Subbasin at levels consistent with those that occurred over the base period in order to be protective of Napa River baseflow conditions, while allowing for changes in the sustainable yield due to climate change or the implementation of augmented recharge projects in the future.

7 NAPA VALLEY SUBBASIN SUSTAINABILITY GOALS (SECTION 354.24)

As part of Napa County's General Plan update in 2008, and within the Plan's Conservation Element, six goals are set forth relating to the county's water resources, including to "Conserve, enhance and manage water resources on a sustainable basis to attempt to ensure that sufficient amounts of water will be available for the uses allowed by this General Plan, for the natural environment, and for future generations" (Goal CON-10; LSCE, 2016).

Additionally, based on the Groundwater Resources Advisory Council (GRAC's)[25] charge from the Napa County Board of Supervisors in 2011 and a review of many definitions in published literature, the GRAC (2014) defined "groundwater sustainability[26]" as:

Groundwater sustainability depends on the development and use of groundwater in a manner that can be maintained indefinitely without causing unacceptable economic, environmental, or social consequences, while protecting economic, environmental, and social benefits.

The GRAC concluded that groundwater sustainability is both a goal and a process; most importantly, it is a shared responsibility. Everyone living and working in the county has a stake in protecting groundwater resources, including groundwater supplies, quality, and associated watersheds (GRAC, 2014). The GRAC further found that healthy communities, healthy agriculture and healthy environments exist together and not in isolation. Without sustainable groundwater resources, the character of the county would be significantly different in terms of its economy, communities, rural character, ecology, housing, and lifestyles.

The sustainability goal and groundwater sustainability objectives[27] developed by the GRAC included (GRAC, 2014; **Appendix A**):

GRAC Sustainability Goal: To protect and enhance groundwater quantity and quality for all the people who live and work in Napa County, regardless of the source of their water supply.

GRAC Sustainability Objectives:

1. Initiate and carry out outreach and education efforts.
    a. Develop public outreach programs and materials to make everyone who lives and works in the County aware that the protection of water supplies is a shared responsibility and everyone needs to participate.
    b. Through education, enable people to take action.
2. Optimize existing water supplies and systems.
    a. Support landowners in implementing best sustainable practices.

[25] GRAC formation and charge are described in Chapter 1.
[26] The definition for Groundwater Sustainability developed by the GRAC is separate from the definition of Sustainable Groundwater Management applied in the 2014 Sustainable Groundwater Management Act.
[27] These are overarching groundwater sustainability objectives; "measurable objectives", per SGMA requirements, are discussed in Section 7.5.

   b. Enhance the water supply system and infrastructure – including but not limited to system efficiencies, reservoir dredging, recycled water, groundwater storage and recharge, conjunctive use – to improve water supply reliability.

3. Continue long-term monitoring and evaluation.

   a. Collect groundwater and surface water data and maintain a usable database that can provide information about the status of the county's groundwater and surface water resources and help forecast future supplies.

   b. Evaluate data using best analytical methods in order to better understand characteristics of the county's groundwater and water resources systems.

   c. Share data and results of related analytical efforts while following appropriate confidentiality standards.

4. Improve our scientific understanding of groundwater recharge and groundwater-surface water interactions.

5. Improve preparedness to address groundwater issues that might emerge.

   a. Improve preparedness for responding to long-term trends and evolving issues, such as adverse groundwater trends (including levels and quality), changes in precipitation and temperature patterns, and saltwater intrusion.

   b. Improve preparedness for responding to acute crises, such as water supply disruptions and multi-year drought conditions.

The GRAC's sustainability goal and groundwater sustainability objectives were presented to and accepted by the Napa County Board of Supervisors on April 8, 2014. The Board of Supervisors and public commended the GRAC for their multi-year commitment and work in assisting the County and its consulting team with the development of groundwater sustainability objectives, completion of a groundwater monitoring plan, expansion of the County's groundwater monitoring network, assessment of technical and procedural updates to the County's Water Availability Analysis (WAA) document and groundwater ordinances, and development of community education and outreach materials. Upon receiving the GRAC's conclusions and recommendations, the Napa County Board of Supervisors directed County staff to propose updates and amendments to the WAA for the Board's consideration and to continue implementation and expansion of the County's groundwater monitoring program to better assess and monitor the sustainability of the County's groundwater resources.

7.1 SGMA Requirement to Develop a Sustainability Goal (Section 354.24)

SGMA requires that each agency shall establish a sustainability goal (Section 354.24); specifically:

Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be *achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.*

This Basin Analysis Report[28] provides a functionally equivalent definition of a sustainability goal. This Report is based on an understanding of hydrogeologic conditions and management measures that demonstrate the basin has already been operated within the sustainable yield for at least 10 years. Chapter 6 summarizes the water budget details that show the Napa Valley Subbasin, on a subbasin scale, has been operated within the sustainable yield. The Napa County Board of Supervisors establishment of the GRAC, acceptance of the GRAC's sustainability goal and objectives for all of Napa County, and implementation of key GRAC recommendations demonstrates the County's intent to maintain sustainable conditions indefinitely. The corresponding groundwater sustainability objectives recognized by the Board of Supervisors serve as the "measures that will be implemented to ensure that the basin will be operated within its sustainable yield" and are memorialized in this Report adopted by the Napa County Board of Supervisors (**Appendix A)**.

The GRAC also provided supplemental recommendations:

1. *Support the WICC[29] and RCD[30] in implementing the objectives.*
2. *If a County or sub-regional groundwater stewardship and sustainability plan is developed in the future, these should be the foundational objectives.*

These supplemental recommendations, developed by the GRAC in February 2014 well before SGMA was adopted, emphasize the County's intent to integrate groundwater stewardship and sustainability planning in future planning and resource management.

In conformance with SGMA and the intent of the GRAC (February 2014) and the County Board of Supervisors (April 2014), the GRAC sustainability goal is expanded to:

Napa Valley Subbasin SGMA Sustainability Goal: To protect and enhance groundwater quantity and quality for all the people who live and work in Napa County, regardless of the source of their water supply. The County and everyone living and working in the county will integrate stewardship principles and measures in groundwater development, use, and management to protect economic, environmental, and social benefits and maintain groundwater sustainability indefinitely without causing undesirable results, including unacceptable economic, environmental, or social consequences.

7.2 Sustainability Indicators and Undesirable Results (Section 354.26)

SGMA establishes undesirable results for applicable sustainability indicators, including a description of the process and criteria used to define undesirable results for the Napa Valley Subbasin. A "sustainability indicator" (SGMA Article 2) refers to any of the effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, cause undesirable results, as described in Water Code Section 10721(x). Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are "caused by groundwater conditions occurring *throughout* the

[28] SGMA Section 10733.6 (b)(3), Alternative Submittal
[29] Watershed Information & Conservation Council
[30] Napa County Resource Conservation District

basin" (Section 354.26; emphasis added). Undesirable results include one or more of the following (SGMA Definitions[31]):

1. Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.
2. Significant and unreasonable reduction of groundwater storage.
3. Significant and unreasonable seawater intrusion.
4. Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.
5. Significant and unreasonable land subsidence that substantially interferes with surface land uses.
6. Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

California has a long-history of groundwater development, which in many basins in the state has resulted in evidence of undesirable results.[32] The Napa Valley Subbasin, an elongated alluvial river valley, has benefited from high precipitation and the corresponding potential for a substantial amount of recharge, as discussed in Chapter 6. Overall, the groundwater table in the alluvial aquifer of the Napa Valley Subbasin is quite shallow; the depth to groundwater in the main part of the Valley Floor in the spring is approximately 5 to 35 feet. While agricultural land use, especially vineyards, have covered much of the Valley Floor for decades, the water requirements for this type of agricultural land use are significantly lower than agricultural commodities grown elsewhere in California, such as the Central Valley. As a result, due to high recharge potential in most years, low water requirements and a hydrogeologic setting conducive to recharge, the Napa Valley Subbasin remains full overall. However, because Napa Valley also enjoys a relatively flat valley landscape and a river system that is seasonally and temporally connected spatially to the underlying groundwater system, there is an interplay between factors that affect both the surface water and groundwater systems of the Subbasin. When groundwater levels have temporarily declined during drier years or seasonal dry periods during the year, the river system can also be more sensitive during drier years and also drier periods of the year when baseflow (i.e., groundwater discharge to surface water) is diminished. As discussed further below, the Napa River has experienced these effects over many decades, particularly during the summer to fall period.

As described in **Chapter 4**, groundwater levels in the Napa Valley have been stable over the hydrologic base period (1988-2015), and the prior historical period where data are available, with recognition that groundwater levels in some areas have been lower during dry water year types. Stable groundwater

[31] **http://water.ca.gov/groundwater/sgm/definitions.cfm**
[32] 21 basins/subbasins have been designated by DWR to be critically overdrafted;
http://www.water.ca.gov/groundwater/sgm/cod.cfm

levels, on average, over the 28-year base period indicate that there have been *no significant and unreasonable effects* occurring throughout the basin related to:

- Chronic lowering of groundwater levels
- Reduction of groundwater storage
- Seawater intrusion
- Degraded water quality
- Land subsidence

At some locations during the summer to fall period, the historical occurrence of diminished baseflow could be considered an undesirable result. SGMA provides that a plan[33] or alternative submittal are not required to address undesirable results that occurred before and have not been corrected by, January 1, 2015. However, the Groundwater Sustainability Agency or local agency have the discretion to set measurable objectives and the timeframes for achieving them.[34] (Section 10727.2).

The Napa Valley Subbasin has been operated in a sustainable manner for more than 10 years, where overall groundwater conditions have been stable, and baseflow is lower and/or not present at some locations during the summer to fall period, pending the water year type (Grossinger, 2012; Faye, 1973). Since the river system is considered the most sensitive sustainability indicator in the Napa Valley Subbasin, the measurable objectives and minimum thresholds discussed below are recommended to ensure groundwater sustainability or improve groundwater conditions, and provide ongoing monitoring targets devised to address potential future effects on surface water.

7.3 Representative Monitoring Sites

SGMA defines “representative monitoring” as “a monitoring site within a broader network of sites that typifies one or more conditions within the basin or an area of the basin” (Section 351). This subset of monitoring sites is for the purpose of monitoring groundwater conditions that are representative of the basin or an area of the basin (Section 354.36). For SGMA purposes for the Napa Valley Subbasin, these sites are where sustainability indicators are monitored, and minimum thresholds and measurable objectives are defined. Many sites are monitored for more than one sustainability indicator.

Groundwater elevations are used at many sites for monitoring a number of sustainability indicators. As discussed in Chapter 4, there are strong relationships between surface water flow measured at gages along the Napa River system and groundwater level trends. Since the river system is the most sensitive sustainability indicator in the Napa Valley Subbasin, minimum thresholds and measurable objectives that are set to be protective of the river system (i.e., established to prevent the occurrence of further depletion of surface water that has significant and unreasonable adverse impacts on beneficial uses of the surface water, including avoidance of longer durations of no flow days in summer to fall at some

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[33] Plan refers to the development of a Groundwater Sustainability Plan. The Basin Analysis Report is related in that it is an Alternative to a GSP, but it is required to be functionally equivalent to the elements of a Plan required in Articles 5 and 7 for GSPs (Section 358.2).

[34] An Alternative to a GSP does not require the formation of a Groundwater Sustainability Agency. The governing body that prepares and approves the Alternative could establish measurable objectives for achieving any objectives for undesirable results that exceed the express requirements of the Act.

locations) *and ensure groundwater sustainability* necessarily preclude the occurrence of undesirable results. By maintaining groundwater elevations at the selected representative monitoring sites at levels comparable to the hydrologic base period, this precludes the occurrence of significant and unreasonable chronic groundwater level declines, reduction of groundwater storage, land subsidence, and seawater intrusion.

Napa County has used the term "representative" in reference to hydrographs presented in previous reports (LSCE, 2011; 2015; 2016). In this Basin Analysis Report, the term representative is refined to align with SGMA. Specific representative monitoring sites are designated that typify conditions in the subbasin. Eighteen selected wells are summarized in **Table 7-1** and shown in **Figure 7-1**. Seven of the SGMA representative wells were selected because of their long historical groundwater level record and their prior use in Napa County groundwater-related reports as "representative" wells with hydrographs that typify groundwater conditions and trends in the Napa Valley Subbasin. Ten relatively new wells were selected because of their construction (as part of DWR's Local Groundwater Assistance Grant that was awarded to Napa County) for the specific purpose of assessing surface water and groundwater interaction. One other well was selected because of its location in the southern part of the subbasin, moderate historical groundwater level record, likely construction in unconfined part of the groundwater system, and purpose for tracking groundwater trends and gradients near the adjoining subbasin.

Table 7-1. Representative Monitoring Sites, Napa Valley Subbasin

Well ID	Data Source	Aquifer Designation	Subarea	Well Depth (ft)	Basis for Selection
06N04W17A001M	DWR	Qa	NVF_Yount	250	Long record
06N04W27L002M	DWR	Qa	NVF_Napa	120	Long record
07N05W09Q002M	DWR	NA	NVF_SH	232	Long record
08N06W10Q001M	DWR	NA	NVF_Calis	200	Long record
NapaCounty-128	Napa County	Qa	NVF_Calis	50	Long record
NapaCounty-133	Napa County	Qa	NVF_Yount	120	Long record
NapaCounty-135	Napa County	Qa	NVF_Yount	125	Long record
5N/4W-15E1	DWR	Qa	NVF_Napa	158	Moderate record
Napa County 214s-swgw1	Napa County	Qa	NVF_Napa	53	Designated SW/GW[35] facility
Napa County 215d-swgw1	Napa County	Qa	NVF_Napa	98	Designated SW/GW facility
Napa County 216s-swgw2	Napa County	Qa	NVF_Yount	50	Designated SW/GW facility
Napa County 217d-swgw2	Napa County	Qa	NVF_Yount	86	Designated SW/GW facility
Napa County 218s-swgw3	Napa County	Qa	NVF_Napa	40	Designated SW/GW facility
Napa County 219d-swgw3	Napa County	Qa	NVF_Napa	93	Designated SW/GW facility
Napa County 220s-swgw4	Napa County	Qa	NVF_Yount	45	Designated SW/GW facility
Napa County 221d-swgw4	Napa County	Qa	NVF_Yount	85	Designated SW/GW facility
Napa County 222s-swgw5	Napa County	Qa	NVF_SH	40	Designated SW/GW facility
Napa County 223d-swgw5	Napa County	Qa	NVF_SH	100	Designated SW/GW facility

7.4 Minimum Thresholds (Section 354.28)

SGMA defines a “minimum threshold” as “a numeric value for each sustainability indicator used to define undesirable results” (Section 351). This section discusses the preliminary minimum thresholds established to quantify groundwater conditions for each applicable sustainability indicator at representative monitoring sites. Justification is provided for the thresholds based on best available data,

[35] Designated SW/GW facility: refers to surface water and groundwater monitoring facilities installed as part of the DWR Local Groundwater Assistance Program grant awarded to Napa County for purposes of evaluating the connectivity between groundwater and surface water.

including groundwater levels, groundwater quality, and surface water flows. As noted above, groundwater level thresholds are used as a proxy for multiple sustainability indicators. **Table 7-2** shows the relationship between representative monitoring sites, the sustainability indicators applicable to those sites, the data category for the measurable objective and minimum threshold (e.g., groundwater level, groundwater quality or other), and which sustainability indicators use groundwater elevations as a proxy. For representative monitoring sites where long term periods of record are not available, as in the case of the dedicated monitoring wells constructed in 2014 to monitor groundwater-surface water interactions, minimum thresholds established here will be reviewed and reevaluated in future years as the collection of available data for each sites expands to better reflect true long term variability at those sites.

7.4.1 Minimum Threshold: Streamflow Depletion and Other Sustainability Indicators

Based on the analyses of surface water and groundwater interconnections, including the relationship of this connection to seasonal and annual groundwater elevation fluctuations (Chapter 4), minimum thresholds are set at 16 wells in the subbasin (**Table 7-3**). These thresholds represent the lowest static groundwater level elevation that has occurred historically in the fall and an elevation below which additional streamflow depletion is likely to occur, i.e., expand the duration of annual no flow days in some reaches of the Napa River. These thresholds represent the lowest static groundwater elevation to which groundwater levels may reasonably be lowered at the end of a dry season without exacerbating streamflow depletion. These levels are not acceptable on a continuous basis as this would contribute to a worsening of existing conditions. These groundwater elevation thresholds also serve as proxies for many other sustainability indicators, as shown in **Table 7-2.**

Table 7-2. Representative Monitoring Sites and Sustainability Indicators

Well ID	Sustainability Indicators[3]					
	Chronic Lowering of GWLs	Reduced GW Storage	Seawater Intrusion	Degraded GW Quality	Land Subsidence	Streamflow Depletion
06N04W17A001M	GWE	GWE		GWQ[2]	GWE	GWE[1]
06N04W27L002M	GWE	GWE		GWQ	GWE	GWE
07N05W09Q002M	GWE	GWE		GWQ	GWE	GWE
08N06W10Q001M	GWE	GWE		GWQ	GWE	GWE
NapaCounty-128	GWE	GWE		GWQ	GWE	GWE
NapaCounty-133	GWE	GWE		GWQ	GWE	GWE
NapaCounty-135	GWE	GWE		GWQ	GWE	
5N/4W-15E1			GWQ	GWQ		
Napa County 214s-swgw1	GWE	GWE				GWE
Napa County 215d-swgw1	GWE	GWE				GWE
Napa County 216s-swgw2	GWE	GWE				GWE
Napa County 217d-swgw2	GWE	GWE				GWE
Napa County 218s-swgw3	GWE	GWE				GWE
Napa County 219d-swgw3	GWE	GWE				GWE
Napa County 220s-swgw4	GWE	GWE				GWE
Napa County 221d-swgw4	GWE	GWE				GWE
Napa County 222s-swgw5	GWE	GWE				GWE
Napa County 223d-swgw5	GWE	GWE				GWE

1. GWE: Groundwater Elevation; data category for establishing minimum thresholds and measurable objectives for avoiding the undesirable result of depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water (e.g., streamflow depletion). Since the river system in the Napa Valley Subbasin is considered sensitive to climate and groundwater condition variability, GWE's set for the streamflow depletion sustainability indicator serve as a proxy for many other sustainability indicators.

2. GWQ (green): Groundwater Quality

3. Where neither GWE nor GWQ is indicated, this does not mean that groundwater elevations and/or quality are not being measured, rather it means that groundwater elevations and/or groundwater quality are not being assessed for purposes of evaluating one or more sustainability indicators at this representative monitoring site.

Table 7-3. Minimum Thresholds to Avoid Streamflow Depletion

Well ID	Minimum Threshold: Minimum Fall Groundwater Elevation (Feet AMSL)
NapaCounty-128	320
08N06W10Q001M	269
07N05W09Q002M	127
NapaCounty-133	72
06N04W17A001M	37
06N04W27L002M	-2
NapaCounty-214s-swgw1	2[1]
NapaCounty-215d-swgw1	2
Napa County 216s-swgw2	61
Napa County 217d-swgw2	61
NapaCounty-218s-swgw3	29
NapaCounty-219d-swgw3	29
NapaCounty-220s-swgw4	75
NapaCounty-221d-swgw4	75
NapaCounty-222s-swgw5	185
NapaCounty-223d-swgw5	164

1. The Napa County surface water/groundwater monitoring facilities are relatively new with limited data; minimum thresholds will be re-evaluated with additional data.

7.4.2 Minimum Threshold: Avoid Degraded Groundwater Quality

The minimum threshold for avoidance of degraded groundwater quality is based on groundwater quality concentrations remaining above water quality objectives. The focus for SGMA purposes is on constituents contributed due to activities at the land surface rather than on the presence of naturally occurring constituents. An example is shown in **Table 7-4** for nitrate as nitrogen.

Table 7-4. Minimum Threshold to Avoid Degraded Groundwater Quality

Well ID	Minimum Threshold: GW Quality Objective (example Nitrate-N mg/L[1])
06N04W17A001M	10 mg/L
06N04W27L002M	10 mg/L
07N05W09Q002M	10 mg/L
08N06W10Q001M	10 mg/L
NapaCounty-128	10 mg/L
NapaCounty-133	10 mg/L
NapaCounty-135	10 mg/L

1. The Maximum Contaminant Level (MCL) for Nitrate as Nitrogen is 10 mg/L.

7.4.3 Minimum Threshold: Seawater Intrusion

The minimum threshold for avoidance of seawater intrusion is based on groundwater quality concentrations remaining stable in the representative well designated for this sustainability indicator (**Table 7-5**). Well 5N/4W-15E1 is located in the southern part of the Napa Valley Subbasin and has a long historical record.

Table 7-5. Minimum Threshold to Avoid Seawater Intrusion

Well ID	Minimum Threshold: Maintain TDS At or Below Historically Observed TDS Concentration[1] (mg/L)
5N/4W-15E1	450

1. Secondary Recommended Maximum Contaminant Level for TDS is 500 mg/L.

7.4.4 Minimum Threshold: Chronic Lowering of Groundwater Levels, Land Subsidence and Reduced Groundwater Storage

The minimum thresholds for avoidance of chronic groundwater level decline, land subsidence, and a reduction in groundwater storage are based on groundwater levels set at minimum fall level observed over the historical period. Most representative wells use the groundwater elevations for avoidance of streamflow depletion as the proxy (**Table 7-3**). One other representative well, Napa County 135 located away from the Napa River, is also used for these sustainability indicators (**Table 7-6**). The minimum threshold is the lowest fall level observed over the entire historical period.

Table 7-6. Minimum Threshold to Avoid Chronic Lowering of Groundwater Levels and Reduced Groundwater Storage

Well ID	Minimum Threshold: Avoid Groundwater Level Decline over Successive Years and Land Subsidence (Fall GWE, Feet AMSL)	Minimum Threshold: Avoid Reduced Groundwater Storage (Avoidance of Chronic GWE Decline is Proxy; Fall GWE, Feet AMSL)
NapaCounty-135	20	20

7.5 Measurable Objectives (Section 354.30)

SGMA defines "measurable objectives" as "specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions" (Section 351). This section establishes measurable objectives for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites that are used to define the minimum thresholds. These objectives provide a reasonable margin of operational flexibility under adverse conditions where applicable and utilizes components such as historical water budgets, seasonal and long-term trends, and periods of drought. Similar to the minimum thresholds discussed in Section 7.4, groundwater elevations serve as the proxy for multiple sustainability indicators where reasonable. For representative monitoring sites where long term periods of record are not available, as in the case of the dedicated monitoring wells constructed in 2014 to monitor groundwater-surface water interactions, measurable objectives established here will be reviewed and reevaluated in future years as the collection of available data for each sites expands to better reflect true long term variability at those sites.

7.5.1 Measurable Objective: Streamflow Depletion and Other Sustainability Indicators

Based on the analyses of surface water and groundwater interconnections, including the relationship of this connection to seasonal and annual groundwater elevation fluctuations (Chapter 4), measurable objectives for streamflow depletion are set at 16 wells in the subbasin (**Table 7-7**). These objectives represent the mean fall groundwater level elevations that occurred historically. These objectives represent the fall groundwater elevations within which groundwater elevations are reasonably likely to fluctuate during fall without exacerbating streamflow depletion. These measureable groundwater elevation objectives also serve as proxies for many other sustainability indicators, as shown in **Table 7-2.** (Measurable objectives and minimum thresholds are shown together in **Table 7-11**.)

Table 7-7. Measurable Objectives for Streamflow

Well ID	Measurable Objective for Streamflow: Fall Groundwater Elevation (Feet AMSL)
NapaCounty-128	331
08N06W10Q001M	281
07N05W09Q002M	135
NapaCounty-133	76
06N04W17A001M	50
06N04W27L002M	12
NapaCounty-214s-swgw1	4
NapaCounty-215d-swgw1	4
Napa County 216s-swgw2	76
Napa County 217d-swgw2	76
NapaCounty-218s-swgw3	32
NapaCounty-219d-swgw3	32
NapaCounty-220s-swgw4	77
NapaCounty-221d-swgw4	77
NapaCounty-222s-swgw5	190
NapaCounty-223d-swgw5	175

7.5.2 Measurable Objective: Maintain or Improve Groundwater Quality

The measurable objective for maintaining or improving groundwater quality is based on groundwater sample concentrations remaining above water quality objectives and groundwater quality at concentrations similar to and/or improved compared to historical observations in the groundwater basin. One representative well (06N04W27L002M, also referred to as 6N/4W-27L2) has a historical groundwater quality record. Other wells in **Table 7-8** that have long groundwater level monitoring records are proposed to be added to track groundwater quality trends at locations representative of basin conditions. Beginning in spring 2017, groundwater quality sampling on an annual basis will incorporate these wells in the ongoing monitoring program. Measurable objectives for the newly designated representative wells will be re-evaluated after baseline water quality conditions are established (approximately three years of sampling and analysis of conditions). An example of measurable objectives for nitrate-nitrogen is shown in **Table 7-8**.

Table 7-8. Measurable Objective: Groundwater Quality

Well ID	Measurable Objective: GW Quality Objective (example Nitrate-N mg/L)[1]
06N04W17A001M	8 mg/L
06N04W27L002M	8 mg/L
07N05W09Q002M	8 mg/L
08N06W10Q001M	8 mg/L
NapaCounty-128	8 mg/L
NapaCounty-133	8 mg/L
NapaCounty-135	8 mg/L

1. The Maximum Contaminant Level for Nitrate as Nitrogen is 10 mg/L.

7.5.3 Measurable Objective: Avoid Seawater Intrusion

The measurable objective for avoidance of seawater intrusion is based on groundwater quality concentrations remaining stable in the representative well designated for this sustainability indicator (**Table 7-9**). Well 5N/4W-15E1 is located in the southern part of the Napa Valley Subbasin and has a long historical record.

Table 7-9. Measurable Objective to Avoid Seawater Intrusion

Well ID	Measurable Objective: Maintain TDS At or Below Historically Observed TDS Concentration (mg/L)
5N/4W-15E1	300

1. Secondary Recommended Maximum Contaminant Level for TDS is 500 mg/L.

7.5.4 Measurable Objective: Avoid Chronic Lowering of Groundwater Levels, Reduced Groundwater Storage, and Land Subsidence

This measurable objective for avoidance of chronic groundwater level decline, land subsidence, and a reduction in groundwater storage is based on fall groundwater levels at representative wells that use the fall groundwater elevations for avoidance of streamflow depletion as the proxy (**Table 7-3**). Napa County 135, located away from the Napa River, is one other representative well used for these sustainability indicators (**Table 7-10**). The measurable objective is the fall level observed prior to the recent drought period. As described above, for the selected representative sites for this indicator, the minimum threshold is the fall groundwater elevation above which groundwater elevations are to be maintained in order to avoid undesirable results. Similarly, for these sites, the measurable objective is the fall groundwater elevation, at or above which, to maintain groundwater sustainability or improve groundwater conditions.

Table 7-10. Measurable Objective to Avoid Chronic Lowering of Groundwater Levels and Reduced Groundwater Storage

Well ID	Measurable Objective: Avoid GWL Decline over Successive Years and Land Subsidence (Fall GWE, Feet AMSL)	Measurable Objective: Avoid Reduced Groundwater Storage (Avoidance of Chronic GWE Decline is Proxy; Fall GWE, Feet AMSL)
NapaCounty-135	60	60

Table 7-11 summarizes the minimum thresholds and measurable objectives (respectively) for all representative sites and sustainability indicators.

Table 7-11. Representative Monitoring Sites: Minimum Thresholds and Measurable Objectives for Sustainability Indicators

Well ID	Sustainability Indicators and Minimum Thresholds and Measurable Objectives											
	Min Threshold	Measur-able Objective	Min Threshold	Measur-able Objective	Min Threshold	Measur-able Objective	Min Threshold	Measur-able Objective	Min Threshold	Measur-able Objective	Min Threshold	Measurable Objective
	Chronic Lowering of GWLs (Fall GWE, Feet AMSL)	Chronic Lowering of GWLs (Fall GWE, Feet AMSL)	Reduced GW Storage (Fall GWE, Feet	Reduced GW Storage (Fall GWE, Feet AMSL	Seawater Intrusion (TDS, mg/L)	Seawater Intrusion (TDS, mg/L)	Degraded GW Quality (NO3-N mg/L)	Degraded GW Quality (NO3-N mg/L)	Land Subsid-ence (Fall GWE, Feet	Land Subsid-ence (Fall GWE, Feet	Streamflo w Depletion (Fall GWE, Feet	Streamflow Depletion (Fall GWE, Feet AMSL)
06N04W17A001	37	50	37	50			10	8	37	50	37	50
06N04W27L002	-2	12	-2	12			10	8	-2	12	-2	12
07N05W09Q002	127	135	127	135			10	8	127	135	127	135
08N06W10Q001	269	281	269	281			10	8	269	281	269	281
NapaCounty-128	320	331	320	331			10	8	320	331	320	331
NapaCounty-133	72	76	72	76			10	8	72	76	72	76
NapaCounty-135	20	60	20	60			10	8	20	60		
5N/4W-15E1					450	300	10	8				
Napa County 214s-swgw1	2	4	2	4							2	4
Napa County 215d-swgw1	2	4	2	4							2	4
Napa County 216s-swgw2	61	76	61	76							61	76
Napa County 217d-swgw2	61	76	61	76							61	76
Napa County 218s-swgw3	29	32	29	32							29	32
Napa County 219d-swgw3	29	32	29	32							29	32
Napa County 220s-swgw4	75	77	75	77							75	77
Napa County 221d-swgw4	75	77	75	77							75	77

Well ID	Sustainability Indicators and Minimum Thresholds and Measurable Objectives											
	Min Threshold	Measur-able Objective	Min Threshold	Measur-able Objective	Min Threshold	Measur-able Objective	Min Threshold	Measur-able Objective	Min Threshold	Measur-able Objective	Min Threshold	Measurable Objective
	Chronic Lowering of GWLs (Fall GWE, Feet AMSL)	Chronic Lowering of GWLs (Fall GWE, Feet AMSL)	Reduced GW Storage (Fall GWE, Feet	Reduced GW Storage (Fall GWE, Feet AMSL	Seawater Intrusion (TDS, mg/L)	Seawater Intrusion (TDS, mg/L)	Degraded GW Quality (NO3-N mg/L)	Degraded GW Quality (NO3-N mg/L)	Land Subsid-ence (Fall GWE, Feet	Land Subsid-ence (Fall GWE, Feet	Streamflo w Depletion (Fall GWE, Feet	Streamflow Depletion (Fall GWE, Feet AMSL)
Napa County 222s-swgw5	185	190	185	190							185	190
Napa County 223d-swgw5	164	175	164	175							164	175

7.6 Management Area

SGMA defines a "management area" as an area within a basin for which the Plan (in this case, the Basin Analysis Report) may identify different minimum thresholds, measurable objectives, monitoring, or projects and management actions based on differences in water use sector, water source type, geology, aquifer characteristics, or other factors (GSP Regulations Article 21, Section 351). Within the Napa Valley Subbasin, there is an area where groundwater level trends are different than those that are typical of groundwater level trends for the overall groundwater basin. This area, referred to below as the Study Area, is not considered to be representative of the overall Napa Valley Subbasin. At this time, there are no Management Areas that have been defined in the Napa Valley Subbasin. However, the investigation described below will determine whether a Management Area is warranted.

As described in Chapter 4, groundwater level trends in the Napa Valley Subbasin of the Napa-Sonoma Valley Groundwater Basin are stable in the majority of wells with long-term groundwater level records. While many wells have shown at least some degree of response to recent drought conditions, the water levels observed in recent years are generally higher than groundwater levels in the same wells during the 1976 to 1977 drought. Elsewhere in the County long-term groundwater level records are limited, with the exception of the MST Subarea.

Although designated as a groundwater subarea for local planning purposes, the majority of the MST is not part of a groundwater basin as mapped by DWR[36]. Groundwater level declines observed in the MST Subarea as early as the 1960s and 1970s have stabilized since about 2008. Groundwater level responses differ within the MST Subarea and even within the north, central, and southern sections of this subarea, indicating that localized conditions, whether geologic or anthropogenic in nature, might be the primary influence on groundwater conditions in the MST Subarea.

While the majority of wells with long-term groundwater level records exhibit stable trends, periods of year-to-year declines in groundwater levels have been observed in some wells. These wells are located near the Napa Valley margin, east of the Napa River, in an area where the East Napa Fault follows the Napa River and the Soda Creek Fault follows the eastern basin margin. This area (**Figure 7-2**) is characterized in part by relatively thin alluvial deposits, which may contribute to more groundwater being withdrawn from underlying semi-consolidated deposits.

Water levels in northeastern Napa Subarea wells monitored by the County (NapaCounty-75 and Napa County-76) east of the Napa River have stabilized since 2009, though declines were observed over approximately the prior decade. To ensure continuation of the current stable groundwater levels, further study in this area was recommended in the *Napa County Groundwater Monitoring Program 2015 Annual Report and CASGEM Update* (LSCE, 2016). The study was recommended given the potential for a hydraulic connection between the aquifer units in the vicinity of these wells and those of the MST Subarea and an apparent increase in new well permits over the past 10 years. The Napa County Board of Supervisors discussed the recommended Study Area and provided direction to staff at their April 5, 2016 meeting, with approved of the contract for the study on July 19, 2016. The study is designed to examine existing and future water use in the area, sources of groundwater recharge, and the geologic setting to address questions regarding the potential for long-term effects. The study will also investigate the

[36] **http://www.water.ca.gov/groundwater/bulletin118/gwbasins.cfm**

potential influence of previously documented groundwater cones of depression in the MST subarea on the Study Area both east and west of the Napa River.

The study, planned to begin in fall 2016, involves the following tasks:

1. Obtain and review existing information pertaining to Study Area data, including Petra Drive well locations, drillers' reports, water use information (if known), etc.;
2. Evaluate the geologic and hydrogeologic setting and historical groundwater conditions and trends for the Study Area, including previously mapped faults, the thickness of the alluvium in the Study Area, especially near the Napa River and Soda Creek;
3. Tabulate and evaluate existing well performance data (to the extent available) including yield, specific capacity, and pump test data (if any);
4. Estimate potential recharge to the Study Area;
5. Conduct well interference analysis, including an analysis of potential effects from the wells located in the Petra Drive area and also within the overall Study Area. A simplified numerical model will be used to assess mutual well interference and also to assess potential streamflow effects from current use and known proposed projects;
6. Estimate water demands for the overall Study Area along with sources of supply used to meet Study Area water demands. Water demands and supplies will be tabulated for the overall Study Area for variable water year types; and
7. Estimate groundwater supply sufficiency to meet the current and potential future groundwater demands for the overall Study Area and other potential considerations with respect to proposed future groundwater use.

The County will evaluate the study results to determine if potential groundwater management measures or controls (similar to those that have been successfully implemented in the MST) or a Management Area designation are warranted.

The County's current monitoring network includes several wells in the Study Area. Napa County-76 will continue to be monitored and will be used to establish minimum thresholds and measurable objectives related to the chronic groundwater level declines sustainability indicator until the investigation is completed in winter/spring 2017 (**Table 7-12**).

Table 7-12. Study Area Minimum Threshold and Measurable Objective

Well ID	Minimum Threshold: Avoid Chronic GWL Decline (Feet AMSL)	Measurable Objective: Stabilize GWLs (Feet AMSL)
NapaCounty-76	-30	20

8 MONITORING DATA MANAGEMENT AND REPORTING

8.1 Groundwater Data Management

This section describes how groundwater data obtained by the County are managed, used, and shared. Specifically, this section discusses the County's Data Management System, data that may be shared with the State (e.g., DWR or other entities) and/or reported to the public, previously recommended reporting, and new report types and frequency for reporting in accordance with SGMA.

8.2 Data Management Overview

An overview of the County's data management approach is provided in **Figure 8-1** and described in Napa County's Voluntary Groundwater Level Monitoring, Data Management and Disclosure (Napa County, 2016; see also **Appendix H**). Data are collected from a variety of sources and programs. The groundwater monitoring program includes public and volunteered wells and also permit-required monitoring. Guidelines have been established to ensure that data are managed according to the well owner's permission and/or as it relates to applicable permit conditions (Napa County, 2013).

8.3 Data Management System (DMS)

The Napa County DMS has been constructed to incorporate existing and new data about groundwater resources in Napa County (LSCE, 2010a). The data incorporated in the DMS are used on an ongoing basis by the County to evaluate countywide groundwater supply and quality conditions and functions as a secure central data storage location.

In order to ensure security and user flexibility, the database was initially designed using Microsoft Access 2000 and the .mdb database format. The DMS now resides in a SQL server to provide expanded capacity and flexibility for central archival of many interrelated County datasets.

8.4 Data Use and Disclosure

Napa County uses a tiered participation approach in the volunteer groundwater monitoring program which allows property owners to choose their level of participation, including what data can be shared versus what data are to be kept confidential as required by State law (Water Code §13751, §13752). Well owners that volunteer their well for inclusion in the County's monitoring program receive the groundwater information collected from their well. This is provided on an annual basis and/or in periodic reports produced by the County.

8.4.1 Protected Data

The DMS contains certain protected information that will not be made publicly available. For example, the owner name and address on well completion reports are confidential. Per State law this data will be held as confidential unless permission is received from the well owner.

8.4.2 Data Sharing and Disclosure

The County has implemented an education and outreach program that includes communication to the public about opportunities to volunteer to have their well monitored as part of the County's groundwater monitoring program. More information is included in Chapter 9 on education and outreach efforts. The various data collection programs are summarized below.

8.4.2.1 Napa County Program

Property owners interested in participating in the County groundwater monitoring program but who wish to keep their information confidential may elect to not have their well data (e.g., groundwater levels) reported to DWR's Water Data Library or as part of the CASGEM program. This means the County would only use the collected groundwater data (levels and/or quality) for public education and information and would display the data in publically distributed reports in a manner which ensures the owner's privacy.

8.4.2.2 Water Data Library

DWR maintains groundwater information in a database called the Water Data Library (WDL). Napa County reports groundwater level elevation data from its voluntary and CASGEM wells to DWR for inclusion in the WDL. Although well location information is included in the WDL, well construction information is not reported. This level of participation is offered to property owner's volunteering their well for the County groundwater monitoring program. This authorizes the County to release water level information, but State mandated protected information will continue to be held as confidential.

8.4.2.3 CASGEM Program

Property owners interested in participating in the County's groundwater monitoring program and who are willing to provide the information required by the CASGEM program could also become participants in that program. Particularly, owners would recognize that if the County elects to include their well in the CASGEM program, the construction information for their well would be available online on DWR's site.

8.4.3 Data from Other Sources

In addition to the groundwater level and quality data directly collected by the County, other groundwater data are available for the County to download and include in the evaluation of countywide groundwater conditions. Several different public agencies collect and maintain groundwater data, including DWR, the USGS, the CDPH, and the SWRCB (GeoTracker; GeoTracker-GAMA) (LSCE, 2010a). These sources can be accessed through the SWRCB website that summarizes the current data and databases available on the web at www.waterboards.ca.gov/resources/data_databases/. These programs and publicly available databases are continually evolving to expand and merge to create a more useful and powerful network of information. During the development of the County DMS, these data sources were combined with Napa County's own records in order to populate the Napa County DMS (LSCE, 2010a).

For gathering data that are collected by external agencies, a timeframe of about 2 to 3 years is a reasonable span between obtaining updates. This can be a sizeable effort to integrate multiple datasets, and planning should be done to avoid inconsistencies, gaps or duplications of data over a historical record.

8.5 Data Submittals

The County has historically and continues to routinely reported groundwater level data to DWR for inclusion in the WDL. Beginning in 2012, the County is also now reporting a subset of the groundwater level data collected by the County to DWR as part of the CASGEM program.

Any maps prepared from data in the DMS should represent generalized well locations with large symbols. Names and addresses of well owners would be kept confidential.

8.5.1 Data Submitted to DWR

Groundwater data collected by the County (including data collected as part of the CASGEM program and other County programs) are input into the DMS in a systematic way through a centralized person/department to ensure data accuracy and consistency (Napa County, 2013; LSCE, 2014). It is expected that there will be regular updates from internal County sources and external agencies of new data for new and existing wells/sites tracked in the DMS. Consistent quality control of the data and data entry are described in the documentation for the DMS (LSCE, 2010b).

Per DWR's CASGEM program reporting requirements, the following information related to each of the designated wells monitored will be submitted online at the end of each calendar year:

- Well identification number (DWR state well number in online format)
- Measurement dates
- Reference point elevation of the well (feet) using NAVD88 vertical datum
- Elevation of land surface datum at the well (feet) using NAVD88 vertical datum
- Depth to water below reference point (feet) (unless no measurement was taken)
- Method of measuring water depth
- Measurement quality codes
- Measuring agency identification (Napa County as the Monitoring Entity)
- Measurement time (PST/PDT with military time/24 hour format)
- Comments about measurement, if applicable

8.5.2 Data Submitted for SGMA Purposes

Monitoring data stored in the County's DMS will be submitted to DWR electronically[37,38] (GSP Sections 354.40, 356.2). A copy of the monitoring data included in the Annual Report (see Section 8.6.4) will be submitted electronically on forms provided by DWR.

[37] The County understands that DWR is working on guidance that will describe the formatting requirements needed to submit data to DWR.
[38] All submittals to DWR will be made subject to the terms and conditions of any monitoring agreements between well owners and Napa County.

8.6 Reporting

To facilitate community understanding of Napa County groundwater and surface water systems, the County prescribed reports that would be published in a manner that gives full and easy access to the public (LSCE, 2013).

8.6.1 Annual Groundwater Monitoring Progress and Data Report

In 2013, it was recommended that an Annual Groundwater Monitoring Progress and Data Report be prepared that includes a review of the groundwater monitoring program and network (LSCE, 2013). This has since been implemented by the County. Based on the data gathered from the current monitoring year, review of the historical record, water level and quality trend analyses, and consideration of issues of interest to the County and collaborating entities, the monitoring program would be evaluated and adjusted as needed to accomplish the countywide groundwater resources goals and monitoring objectives. The Annual Progress Report considers the stated goals and objectives of the groundwater monitoring program and includes recommended modifications to the program and network, as needed. The Annual Progress Report also includes a summary of the groundwater level and quality data collected by Napa County staff, including attachments containing tables that summarize the data and figures showing the measurement locations. Two such Annual Groundwater Monitoring Reports have been prepared, including for 2014 and 2015.

Since SGMA was adopted, the Annual Report contents will be augmented as described below in Section 8.6.4.

8.6.2 Annual CASGEM Reporting

In 2013, it was recommended that the County prepare an annual report summarizing the results and findings of the countywide CASGEM program (LSCE, 2013). This has since been implemented by the County. The CASGEM-related reporting has been integrated into the County's Annual Progress Report, including the 2014 and 2015 Annual Reports.

8.6.3 Triennial Countywide Reporting on Groundwater Conditions

In 2013, it was also recommended that the County prepare on a regular basis, approximately triennially, a report on countywide groundwater level and quality conditions and any other monitoring network modifications (LSCE, 2013).

It was recommended that the Triennial Groundwater Conditions Report include the following:

- A summary of the groundwater level and quality data collected in Napa County by Napa County staff and other entities, including attachments containing tables that summarize the data and provide a reference to applicable water quality standards; figures showing the measurement locations;
- Figures illustrating groundwater level trends at locations throughout the County, especially in high interest subareas;
- Figures showing contours of equal groundwater elevation for the 1) Napa Valley Floor subareas (including Calistoga, St. Helena, Yountville, and Napa Subareas); 2) MST Subarea; and 3) other subareas as the groundwater level monitoring program evolves;

- Figures illustrating groundwater quality trends at locations throughout the County, especially in high interest subareas (time series plots would include TDS, nitrate and chloride and other selected constituents, depending on specific interests in individual subareas;
- A summary of coordinated efforts with other local, state and federal agencies pertaining to County and regional groundwater conditions and reporting. Examples include summaries pertaining to interagency collaboration on Integrated Regional Water Management Planning and Implementation, Urban Water Management Plan updates, and Basin Plan updates.

Similar to the Annual Progress Report, it was recommended that, as part of the triennial review and update, the groundwater monitoring program and network be regularly reviewed and modifications to the groundwater monitoring network and program also included in the Triennial Report.

Interagency coordination is considered an important aspect of the ongoing monitoring program. Specifically, the local participants benefit from efforts made toward systematic data collection and analyses and maintaining the DMS in a standardized format.

Since SGMA was adopted, the Triennial Report will be replaced with a five-year update of the Basin Analysis Report (see Section 8.6.5).

8.6.4 SGMA Annual Report

With the adoption of SGMA, the County's Annual Report will be augmented with additional information. Specifically, the Annual Report, for the preceding water year, will include (GSP Section 356.2):

> *(a) General information, including an executive summary and a location map depicting the basin covered by the report.*
>
> *(b) A detailed description and graphical representation of the following conditions of the basin managed in the Plan:*
>
> > *(1) Groundwater elevation data from monitoring wells identified in the monitoring network will be analyzed and displayed as follows:*
> >
> > > *(A) Groundwater elevation contour maps for each principal aquifer in the basin illustrating, at a minimum, the seasonal high and seasonal low spring and fall groundwater conditions.*
> > >
> > > *(B) Hydrographs of groundwater elevations and water year type using historical data to the greatest extent available, including from January 1, 2015, to current reporting year. The relationship between groundwater level trends and water year type will be described in the Annual Report.*
> >
> > *(2) Groundwater extraction for the preceding water year. Data will be collected using the best available measurement methods and presented in a table that summarizes Groundwater extractions estimated by water use sector will be presented in a table and identifies the method of measurement (direct or estimate) and accuracy of measurements, and a map that illustrates the general location and volume of groundwater extractions.*

(3) Surface water supply used or available for use, for groundwater recharge or use will be reported based on quantitative data (as available) that describe the annual volume and sources for the preceding water year.

(4) Total water use will be collected using the best available measurement methods and reported in a table that summarizes total water use by water use sector, water source type, and identifies the method of measurement (direct or estimate) and accuracy of measurements. Existing water use data from the most recent Urban Water Management Plans or Agricultural Water Management Plans within the basin may be used, as long as the data are reported by water year.

(5) Change in groundwater in storage, including:

(A) Change in groundwater in storage maps for the unconfined alluvial aquifer in the basin.

(B) A graph depicting water year type, groundwater use, the annual change in groundwater in storage, and the cumulative change in groundwater in storage for the basin based on historical data to the greatest extent available, including from January 1, 2015, to the current reporting year.

(c) A description of monitoring, data evaluation and other actions in support of continued sustainability, including implementation of projects or management actions since the previous annual report.

The Annual Report will also include other information (such as presented in the 2014 and 2015 Annual Reports).

The County will submit an Annual Report to DWR by April 1 of each year following the adoption of this Basin Analysis Report.

8.6.5 SGMA Five-Year Update and Evaluation of Management Efforts

The County commits to preparing an updated Basin Analysis Report every five years. This report would assess whether the basin is in compliance with California Water Code Part 2.11 (commencing with Section 10920). The update would emphasize evaluation of sustainability based on the sustainability indicators and corresponding measurable objectives and minimum thresholds, as described in Chapter 7. The update will also assess the adequacy of data, including groundwater and surface water monitoring locations and their sufficiency to evaluate whether the basin has continued to be operated within its sustainable yield.

This section describes the process to be used by Napa County to evaluate its groundwater management efforts, including evaluation of the subbasin setting in light of any new information or changes in water use, consideration of changes in subbasin groundwater conditions, description of management actions implemented and their effect on subbasin conditions, and additional management tools or actions needed to maintain subbasin sustainability (GSP Section 356.4).

The update will describe how the subbasin is meeting the sustainability goal in the basin and include the following:

(a) A description of current groundwater conditions for each applicable sustainability indicator relative to measurable objectives and minimum thresholds.

(b) A description of the implementation of any projects or management actions, and the effect on groundwater conditions resulting from those projects or management actions.

(c) Elements of the Basin Analysis Report, including the basin setting, management areas, or the potential identification of undesirable results and the setting of minimum thresholds and measurable objectives, will be assessed and revisions proposed, if necessary.

(d) An evaluation of the basin setting in light of significant new information or changes in water use, and an explanation of any significant changes.

(e) A description of the monitoring network within the Subbasin, including whether data gaps exist, or any areas within the Subbasin are represented by data that do not satisfy the requirements of Sections 352.4 and 354.34(c). The description will include the following:

(1) An assessment of monitoring network function with an analysis of data collected to date, identification of data gaps, and the actions necessary to improve the monitoring network, consistent with the requirements of Section 354.38.

(2) If data gaps are identified, the Report will describe a program for the acquisition of additional data sources, including an estimate of the timing of that acquisition, and for incorporation of newly obtained information into the Report.

(3) The Report will prioritize the installation of new data collection facilities and analysis of new data based on the needs of the basin.

(f) A description of significant new information that has been made available since the initial Basin Analysis Report, Annual Reports, or the last five-year update. The description will also include whether new information warrants changes to any aspect of the Report, including the evaluation of the basin setting, measurable objectives, minimum thresholds, or the criteria defining undesirable results.

(g) A description of relevant actions implemented in the County, including a summary of regulations or ordinances related to the Report.

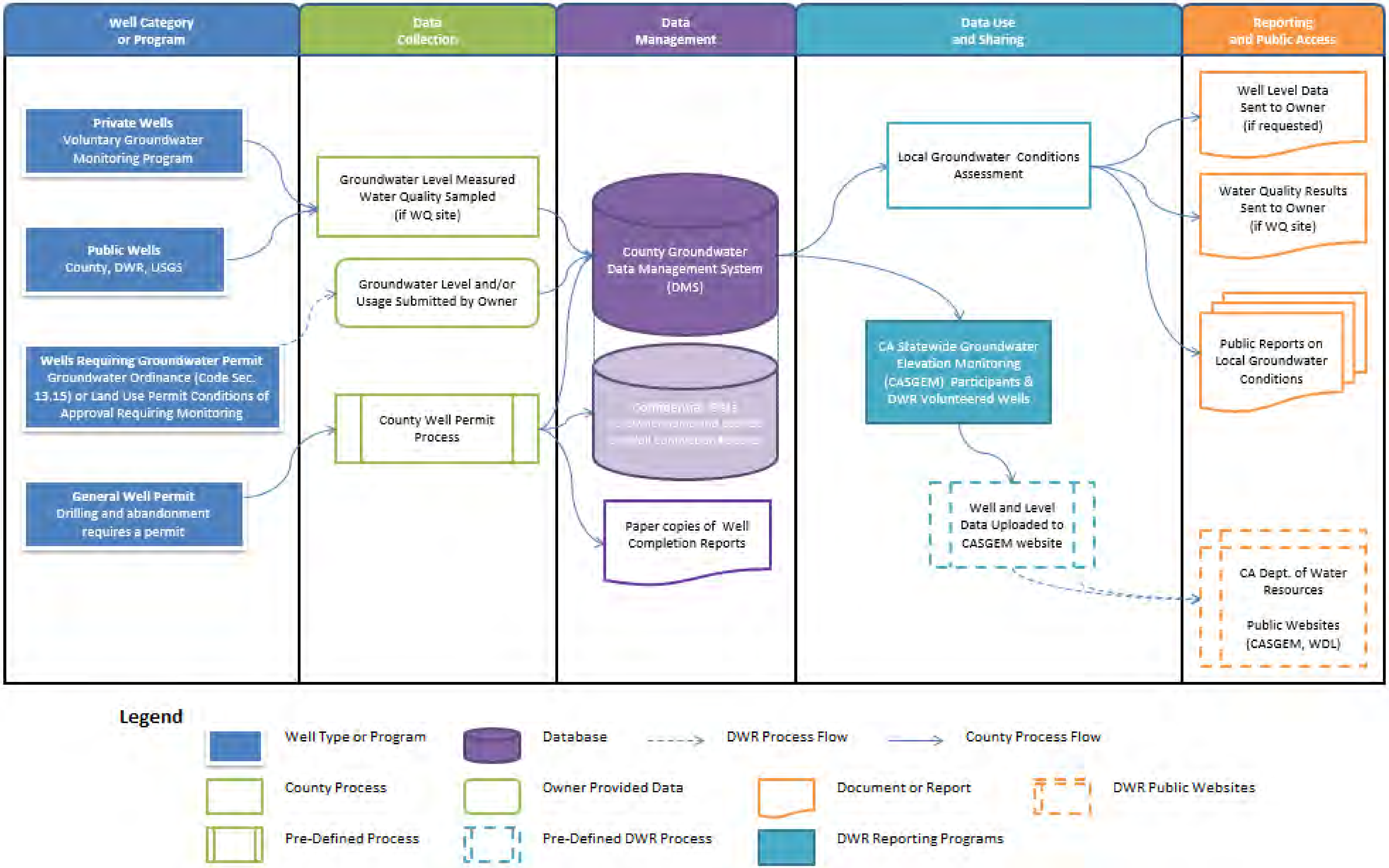
(h) Information describing any actions implemented in furtherance of the sustainability goal for the basin.

(i) A description of completed or proposed Report amendments, as applicable.

(j) Where appropriate, a summary of coordination that occurred between multiple agencies in the basin, agencies in hydrologically connected basins, and land use agencies.

(k) Other information the County determines is appropriate, along with any information required by DWR to conduct a periodic review as required by Water Code Section 10733.

Figure 8-1. Data Management Process



9 SUSTAINABLE GROUNDWATER MANAGEMENT

This section describes the management actions, education and outreach, and projects that the County has implemented and will continue to use, along with other potential future programs, to achieve the sustainability goal for the basin (GSP Section 354.42 and 354.44).

9.1 Napa County General Plan – Water Resources Goals and Policies

As recognized in the County's General Plan (2008, as amended), "water is one of the most complex issues related to land use planning, development, and conservation; it is governed and affected by hundreds of federal, state, regional, and local mandates pertaining to pollution, land use, mineral resources, flood protection, soil erosion, reclamation, etc. Every year, the state legislature considers hundreds of bills relating to water issues, and in Napa County, more than two dozen agencies have some say in decisions and regulations affecting water quality and water use." With the adoption of SGMA in 2014, the County is actively continuing outreach and education efforts that promote water resources sustainability.

As part of the General Plan update in 2008, and within the Conservation Element, six goals are set forth relating to the County's water resources, including surface water and groundwater. Complementing these goals are twenty-eight policies and ten water resources action items (one of which is "reserved" for later description). The County's six water resources goals are included below (the entire group of water resources goals, policies, and action items is included in the General Plan).

> **Goal CON-8**: Reduce or eliminate groundwater and surface water contamination from known sources (e.g., underground tanks, chemical spills, landfills, livestock grazing, and other dispersed sources such as septic systems).
>
> **Goal CON-9**: Control urban and rural storm water runoff and related non-point source pollutants, reducing to acceptable levels pollutant discharges from land-based activities throughout the county.
>
> **Goal CON-10**: Conserve, enhance and manage water resources on a sustainable basis to attempt to ensure that sufficient amounts of water will be available for the uses allowed by this General Plan, for the natural environment, and for future generations.
>
> **Goal CON-11**: Prioritize the use of available groundwater for agricultural and rural residential uses rather than for urbanized areas and ensure that land use decisions recognize the long-term availability and value of water resources in Napa County.
>
> **Goal CON-12**: Proactively collect information about the status of the County's surface and groundwater resources to provide for improved forecasting of future supplies and effective management of the resources in each of the County's watersheds.
>
> **Goal CON-13**: Promote the development of additional water resources to improve water supply reliability and sustainability in Napa County, including imported water supplies and recycled water projects.

Key General Plan Action Items related to the focus of this Basin Analysis Report include:

Action Item CON WR-1: Develop basin-level watershed management plans for each of the three major watersheds in Napa County (Napa River, Putah Creek, and Suisun Creek). Support each basin-level plan with focused sub-basin (drainage-level) or evaluation area-level implementation strategies, specifically adapted and scaled to address identified water resource problems and restoration opportunities. Plan development and implementation shall utilize a flexible watershed approach to manage surface water and groundwater quality and quantity. The watershed planning process should be an iterative, holistic, and collaborative approach, identifying specific drainage areas or watersheds, eliciting stakeholder involvement, and developing management actions supported by sound science that can be effectively implemented. [Implements Policies 42 and 44]

Action Item CON WR-4: Implement a countywide watershed monitoring program to assess the health of the County's watersheds and track the effectiveness of management activities and related restoration efforts. Information from the monitoring program should be used to inform the development of basin-level watershed management plans as well as focused sub-basin (drainage-level) implementation strategies intended to address targeted water resource problems and facilitate restoration opportunities. Over time, the monitoring data will be used to develop overall watershed health indicators and as a basis of employing adaptive watershed management planning. [Implements Policies 42, 44, 47, 49, 63, and 64]

Action Item CON WR-6: Establish and disseminate standards for well pump testing and reporting and include as a condition of discretionary projects that well owners provide to the County upon request information regarding the locations, depths, yields, drilling and well construction logs, soil data, water levels and general mineral quality of any new wells. [Implements Policy 52 and 55]

Action Item CON WR-7: The County, in cooperation with local municipalities and districts, shall perform surface water and groundwater resources studies and analyses and work toward the development and implementation of an integrated water resources management plan (IRWMP) that covers the entirety of Napa County and addresses local and state water resource goals, including the identification of surface water protection and restoration projects, establishment of countywide groundwater management objectives and programs for the purpose of meeting those objectives, funding, and implementation. [Implements Policy 42, 44, 61 and 63]

Action Item CON WR-8: The County shall monitor groundwater and interrelated surface water resources, using County-owned monitoring wells and stream and precipitation gauges, data obtained from private property owners on a voluntary basis, data obtained via conditions of approval associated with discretionary projects, data from the State Department of Water Resources, other agencies and organizations. Monitoring data shall be used to determine baseline water quality conditions, track groundwater levels, and identify where problems may exist. Where there is a demonstrated need for additional management actions to address groundwater problems, the County shall work collaboratively with property owners and other stakeholders to prepare a plan for managing groundwater supplies pursuant to State Water Code Sections 10750-10755.4 or other applicable legal authorities. [Implements Policy 57, 63 and 64]

Action Item CON WR-9.5: The County shall work with the SWRCB, DWR, CDPH, CalEPA, and applicable County and City agencies to seek and secure funding sources for the County to develop and expand its groundwater monitoring and assessment and undertake community-based planning efforts aimed at developing necessary management programs and enhancements.

As described in **Chapter 1** and subsequently illustrated throughout this Basin Analysis Report, the County in coordination with the GRAC, other stakeholders and the public, as elaborated below, have implemented programs to achieve the goals and action items contained in the County's General Plan update.

9.2 Napa County Groundwater Ordinance

9.2.1 Introduction

Napa County regulates groundwater usage and well development through its Code of Ordinances, Title 13 Water, Sewers, and Services. Those parts of Title 13 that are concerned with wells and groundwater usage were reviewed by County staff (LSCE, 2011) and the GRAC for consistency with the County's policies and goals with respect to resources and conservation as expressed in the 2008 General Plan Update. Specifically, the Plan prioritizes "available groundwater for agricultural and rural residential uses…" and seeks to ensure "that discretionary projects will be required to assess and mitigate their potential impacts…" The ordinances are a means to ensure that these General Plan objectives are managed effectively.

9.2.2 Consistency with County Policies and Goals

The Conservation Element of the 2008 General Plan Update is relevant to ordinances concerning groundwater and wells through the establishment of specific water resources goals:

Goal	Description
CON-8	"Reduce or eliminate groundwater and surface water contamination from known sources…"
CON-10	"Conserve, enhance and manage water resources on a sustainable basis…"
CON-11	"Prioritize the use of available groundwater for agricultural and rural residential uses rather than for urban areas…"
CON-12	"Proactively collect information about the status of the county's surface and groundwater resources to provide for improved forecasting of future supplies and effective management…"

Water resources policies that are relevant to the review of groundwater and well ordinances include:

Policy	Description
CON-52	"The County encourages responsible use and conservation of groundwater resources by way of its groundwater ordinances. "
CON-53	"The County shall ensure that the intensity and timing of new development are consistent with the capacity of water supplies and protect groundwater and

Policy	Description
	other water supplies by requiring all applicants for discretionary projects to demonstrate the availability of an adequate water supply prior to approval. May include "evidence or calculation of groundwater availability…"
CON-53.5	"Before authorizing any new exportation of water from the County, the County shall ensure an adequate, long term supply of ground and surface water…"
CON-54	"The County shall maintain or enhance infiltration and recharge of groundwater aquifers…" This policy applies to deficient areas and requires that projects maintain predevelopment recharge potential to the extent possible.
CON-55	County shall curtail new or expanded water uses under discretionary projects where they will cause significant well interference or reduce groundwater discharge to surface waters. Seeks to protect riparian habitats and fisheries, and avoid overdraft.
CON-56	"The County shall discourage the drilling or operation of any new wells in known areas of saltwater intrusion..."
CON-57	"The County shall work with appropriate agencies and districts to develop an understanding of potential groundwater deficiencies…"
CON-58	"…the County shall periodically review and update groundwater policies and ordinances as new studies and monitoring data become available…"
CON-59	States that County shall disseminate groundwater information.
CON-60	States that County shall promote water conservation and efficiency measures.

The County seeks to implement water resources goals and policies through various Water Resources Action Items stated in the General Plan Update. Several action items are addressed through the Comprehensive Groundwater Monitoring Program initiated by the County in 2009. Action Items that were implemented partially or wholly under the Comprehensive Groundwater Monitoring Program include CON-WR-1 and WR-4 through WR-9. Action Item CON-WR-6 states that the County will "Establish and disseminate standards for well pump testing and reporting and include as a condition of discretionary projects that well owners provide to the County upon request information regarding the location, depths, yields, drilling and well construction logs, soil data, water levels and general mineral quality of any new wells." Review comments on the County's well and groundwater ordinances were made (LSCE, 2011) that addressed Chapters 13.04, 13.12, and 13.15 of Title 13 of the municipal code. Subsequently, the GRAC discussed the review comments and changes were made to Title 13 of the municipal code and adopted by the Napa County Board of Supervisors (April 8, 2014).

9.2.3 Title 13, Chapter 13.15 Conservation

Napa County adopted a groundwater conservation ordinance that was most recently revised in 2003 and 2007 to address concerns and needs regarding conservation of groundwater resources. The ordinance is intended to regulate the extraction and use, and promote the preservation of the county's groundwater resources. Compliance with this ordinance applies to development of new water systems or improvements to an existing water system that may use groundwater and imposes conditions on that use if it exceeds pre-determined thresholds. Consistent with the 2008 General Plan Update Water Resources Action Item WR-9, the County is currently implementing the State's Water Efficient Landscape Ordinance (WELO) as a conservation measure. Incorporation of the most current efficiency standards is included in recommendations in this chapter.

The groundwater conservation ordinance makes a distinction with respect to permitting requirements within groundwater deficient areas of which one is currently recognized: the MST. The MST is located predominantly outside of the Napa Valley Subbasin; groundwater conditions in the MST are not representative of groundwater conditions typical of the overall Napa Valley Subbasin. Because the MST is considered a groundwater deficient area, additional regulations and review requirements under the CEQA have required application of "no net increase" and "fair share" principles in groundwater use associated with discretionary actions requiring county approval. The "no net increase" in groundwater use is required because there is no surplus water to support new projects without adverse environmental impacts. The County has established a water conservation program in the MST to disseminate information relevant to the unique needs of this area. The County has also recently completed a recycled water project pipeline and service program in the area.

The Conservation Chapter in Title 13 is consistent with prioritizing groundwater use for agricultural and rural residential uses as envisioned in the County's General Plan. It accomplishes this by limiting other uses when alternative sources of supply are available and by defining guidelines for acceptable usage rates.

9.3 Water Availability Analysis and Discretionary Use Permits

9.3.1 Background

At the height of the 1990 drought in Napa County, the Napa County Board of Supervisors and the Napa County Planning Commission became very concerned with the approval of use permits and parcel divisions that would cause an increased demand on groundwater supplies within Napa County. During several Commission hearings, conflicting testimony was entered as to the impact of such groundwater extraction on water levels in neighboring wells. The Commission asked the Department of Public Works to evaluate what potential impact an approval might have on neighboring wells and on the groundwater system as a whole. In order to simplify a very complex analysis, the Department developed a three phase Water Availability Analysis and process to provide a cost-effective answer to the question.

On March 6, 1991 an interim policy report, prepared by County staff, was presented to and approved by the Commission requiring use permit and parcel division applicants to submit a Water Availability Analysis with their application. The staff policy report provided a procedure by which applicants could achieve compliance with the Commission policy. Oversight of groundwater development within the County's jurisdiction was later refined by the Board of Supervisors approval of Napa County Ordinance No.1162 (Groundwater Conservation Ordinance) on August 3, 1999. A revised staff policy report was subsequently adopted by the Board of Supervisors in August 2007. The 2007 Policy Report updated the Water Availability Analysis procedure and restated the purpose and functionality of the analysis relative to the Groundwater Conservation Ordinance.

In January 2011, as part of the County's Comprehensive Groundwater Monitoring Program initiated in 2009, the County's technical consultant, Luhdorff & Scalmanini, Consulting Engineers, completed a review of the County's Groundwater Conservation Ordinance and procedures, and recommended updating the staff policy report and Water Availability Analysis procedure. The consultant's review found that the initial "phase one" analysis was valuable as a screening process, but that the pump test envisioned in "phase two" was not the best way to assess whether projects exceeding the screening criteria would have detrimental groundwater impacts.

On September 11, 2011, the Board of Supervisors appointed the GRAC to assist with development of a groundwater monitoring program, and to recommend updates to the Groundwater Conservation Ordinance, as needed. As part of their work, the GRAC also reviewed changes to the Water Availability Analysis report in late 2013. The Board of Supervisors adopted the updated Water Availability Analysis in May 2015
(**Appendix I**).

9.3.2 Water Availability Analysis (WAA) Purpose

The County is required by CEQA (Public Resources Code 21000–21177) and the CEQA Guidelines (California Code of Regulations, Title 14, Division 6, Chapter 3, Sections 15000–15387) to conduct an environmental analysis of all discretionary permits submitted for approval. CEQA requires analysis of literally dozens of environmental aspects, including:

"Would the project substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?"

The purpose of the WAA is to provide guidance and a procedure to assist county staff, decision makers, applicants, neighbors, and other interested parties to gather the information necessary to adequately answer that question. The WAA is not an ordinance, is not prescriptive, and project specific conditions may require more, less, or different analysis in order to meet the requirements of CEQA. However, the WAA is used procedurally as the baseline to commence analysis of any given discretionary project.

A WAA is required for any discretionary project that may utilize groundwater or will increase the intensity of groundwater use of any parcel through an existing, improved, or new water supply system. As such, it will most commonly be used for discretionary development applications using groundwater such as wineries and commercial uses. Since CEQA does not apply to non-discretionary ("ministerial") projects, it does not apply to projects such as building permits, single family homes, track II replants, etc. While discretionary vineyard projects are welcome to borrow from the WAA, such vineyard projects, due to their size and scope, generally receive a much more exhaustive analysis under longstanding processes managed by the Conservation Division of the Planning Building & Environmental Services (PBES) Department. The WAA may also apply when a discretionary Groundwater Permit is required by the Groundwater Conservation Ordinance, Section 13.15.010 of the Napa County Code.

9.3.3 WAA Procedure

The WAA uses a screening process for discretionary permit applications (both for new projects and for project modifications that change groundwater use) and determines if a proposal may have an adverse impact on the groundwater basin as a whole or on the water levels of neighboring non-project wells or on surface waters. The WAA also provides procedures for further analysis when screening criteria are exceeded (see **Appendix I**). An important sidelight to the process is public education and awareness. The WAA is based on an application which requires the applicant to gather information about existing non-project groundwater wells and water uses at the applicant's site, to describe planned project well operations, to document existing uses of groundwater on the property, and to estimate future water demands associated with the proposed project. In addition, other information relating to the geology, proximity to surface water bodies (e.g., river, creeks, etc.), and the location and construction of existing non-project wells located near the applicant's property or project well(s) will also be important to evaluate, as warranted, for the potential for well interference and effects on surface water.

9.3.4 Application of the WAA Process to Date

The Napa County Board of Supervisors has long been committed to the preservation of groundwater for agriculture and rural residential uses within the County. It is their belief that through proper management, the groundwater resources developed within the County can be sustained for future generations. Several conclusions can be drawn from application of the WAA process to date (**Appendix** I; Napa County, 2015):

- In the process of conducting the analysis, applicants develop a greater awareness of water use by their project, providing a higher level of awareness and potentially leading to more efficient use of the resource.
- Information submitted by applicants has led to a broader database for future study and management.
- Groundwater use can vary widely depending upon its availability, local hydrogeologic constraints, and periodic hydrologic constraints which may affect the recharge and replenishment of the aquifer system.
- On the Napa Valley Floor and in the MST, the practice of evaluating an applicant's WAA by using screening criteria is an accepted method for making groundwater determinations. Based on the significant information available on Napa County groundwater basins, the screening criteria present a reasonable approach to the process. Because of the variability in parcel conditions in "All Other Areas", these parcels warrant a site-specific analysis.
- The WAA is based upon the basic premise that each landowner has equal right to the groundwater resource below his or her property, so long as it doesn't significantly impact others. Furthermore, the WAA provides sufficient information and supporting documentation to enable the County to determine whether a proposed project may significantly affect groundwater resources and the reasonable and beneficial uses in the proposed area. By implementing policies to prevent wasteful or harmful use of groundwater, it is intended that sufficient groundwater will be available for both current and future property owners. Ensuring wells are located and constructed so as to avoid impacts on neighboring wells and surface water bodies will minimize neighbor disputes and avoid significant environmental impacts.

In summary, the WAA implements a process that recognizes:

- The current understanding of the occurrence and availability of the County's groundwater resources,

- The hydrogeologic constraints that can locally affect the utilization of those resources, and
- The periodic hydrologic constraints that may also affect the utilization of the resource and replenishment of the aquifer system.

9.4 Education and Collaboration

9.4.1 Watershed Information & Conservation Council (WICC)

The Napa County Board of Supervisors passed Resolution No. 02-103 on May 21, 2002, creating the Watershed Information & Conservation Council (WICC). The WICC was chosen to represent the diversity of Napa County's community[39]. The WICC's mission is:

> *To improve the health of Napa County's watersheds by informing, engaging and fostering partnerships within the community.*

The role of the WICC is to assist the County Board of Supervisors in their decision-making process and serve as a conduit for citizen input by gathering, analyzing and recommending options related to the management of watershed resources countywide. The WICC has a responsibility to publicly evaluate and discuss matters relating to watershed restoration and resource protection activities, coordination of land acquisition, development of long-term watershed resource management plans and programs. The WICC also serves to provide public outreach and education, monitoring and assessment coordination, and data management of Napa County's water and watershed resources.

As of October 1, 2016, the WICC includes 17 members and 7 alternates; the WICC members and alternates include representatives from the Cities of Yountville, Napa, American Canyon, St. Helena and Calistoga; representatives from the County Board of Supervisors; representatives from Napa County Regional Park and Open Space District, Conservation Development and Planning Commission, Napa County Resource Conservation District and Natural Resource Conservation Service; and members at large. The WICC holds regular public meetings every other month (odd numbered month) on the fourth Thursday. Meetings are open to the public.

Through collaboration and partnerships, the WICC supports and promotes the activities of watershed groups and organizations working within Napa County, and strives to facilitate cooperation among them. The WICC is intended to be part of the solution to watershed issues and concerns. The WICC collects and disseminates the best possible information to aid those involved in policy and decision-making. The WICC seeks monies and grants from foundations, private individuals, organizations, and local, state and federal government agencies to address the financial needs to further its mission and goals.

The WICC website includes interactive pages on groundwater including pages on groundwater monitoring in the county. Using the map at http://www.napawatersheds.org/groundwater viewers can click on specific areas to find more information and links to subarea groundwater monitoring results, levels, trends, and reports. Viewers can also enter an address, city or zip in the legend area to zoom to an area of specific interest. Summaries of groundwater conditions are provided by subarea, along with

[39] More information on the Watershed Information & Conservation Council is located here **http://www.napawatersheds.org/app_pages/view/4156**

representative groundwater hydrographs. Geological cross sections from (LSCE and MBK, 2013) are shown (see example at http://www.napawatersheds.org/app_pages/view/7249) along with an animation of conceptualized subsurface geology (click the icon for a "flyover" of the Napa Valley Subbasin at https://player.vimeo.com/video/131484843?title=1&byline=1&portrait=1).

9.4.2 Well Owner Outreach and Self-Directed Well Monitoring Education

9.4.2.1 Well Owner Outreach

The Napa County Groundwater Monitoring Plan 2013 (LSCE, 2013) recommended 18 Areas of Interest (AOIs) for additional monitoring to fill existing data gaps and to provide a better understanding of groundwater resources in the County. The AOIs indicated an area with wells that included potential candidates for the voluntary groundwater monitoring program. In each of the AOIs, at least one well was desired for groundwater level and groundwater quality monitoring.

With the Communication and Education Plan[40] as their guide, the GRAC created an educational/outreach brochure (**Appendix K**), a PowerPoint presentation, and related handouts. These were used as a part of their ongoing outreach efforts through various public and industry meetings in 2013-2014. This also included an annual joint public meeting with the WICC Board of Napa County on July 26, 2012 and July 25, 2013 in Yountville.

The GRAC also assigned themselves to each of the AOIs in teams of two and began contacting their friends, neighbors, and others through various meetings they attended. County staff then met with well owners that had expressed an interest to answer any questions and complete the sign-up. Other sign-ups came in from word of mouth from the GRAC's outreach efforts, as well as other public meetings and news articles.

As a result, the well owner outreach has been very successful thanks to the efforts of the GRAC members. Through their efforts, and continued public interest in the program, as of spring 2016 approximately 48 volunteered wells have been added to the monitoring program since 2103. Key criteria for volunteered participation in this program includes a well with known construction information**.** Candidate wells are vetted to assess the suitability of the volunteered well to meet the groundwater monitoring objectives, including those objectives now related to SGMA.

[40] The GRAC developed a Communication and Education Plan to serve as a strategic guide for their public communication and education activities. The communication goal of the plan was to ensure that interested parties and Napa County residents as a whole are well-informed of the deliberations and activities of the GRAC. The education goal of the plan was to increase the understanding of groundwater resources so these audiences also have a factual basis for discussion and decision making. The plan includes potential audiences and partners and other key elements. (see **Appendix J**).

9.4.2.2 Napa County's Do-It-Yourself Well-being Program

Napa County and the Resource Conservation District launched a "Do it Yourself" Well Monitoring Program in 2015[41]. This new service is for County residents interested in monitoring the status of their wells. RCD and County have acquired a Well Sounder Pro, a sonic well-depth measuring device, and it is now available for use by County residents on a short-term loan basis. This program provides a great opportunity for residents to learn how water depth changes and recharge occurs in their well over the course of a year. The hand held device is easy to use; RCD staff guide residents in operating the equipment during the first use.

Napa County also provides a video on the use of the sounder at Video on County DIY groundwater level monitoring program and tool.

9.4.2.3 Newsletters

In addition to Information distributed by the WICC, another vehicle that the County has utilized to distribute information on the county's groundwater resources is a groundwater list serve via MailChimp and the *Sustainable Napa County* E-News. The September 2016 E-News announced the September 22, 2016 (and also the November 3 Sustainable Groundwater Management Workshops):

> *The Watershed Information and Conservation Council (WICC) will host public workshops to learn how Napa County and its groundwater consultant are working to meet the requirements of the California Sustainable Groundwater Management Act (SGMA). There will be opportunity to comment on elements of the Napa Valley Groundwater Sustainability - Basin Analysis Report for the Napa Valley Subbasin.*

9.4.3 Napa County's Participation in San Francisco Bay Area and Westside IRWMPs

In 2005, the County formed the Napa County regional water management group (RWMG), a working group of local water agencies, where the Napa County Flood Control and Water Conservation District served as the lead agency. The County RWMG worked together to draft the Napa-Berryessa IRWMP Functional Equivalent (Napa-Berryessa Regional Water Management Group, 2005).

In 2009, DWR established IRWM regions that have been accepted through the Regional Acceptance Process (DWR, 2009). Currently, there are two formally accepted regions that include Napa County; these regions are: 1) the San Francisco Bay Area Region (which covers the generally southern part of Napa County and focuses on the Napa River and Suisun Creek watersheds), and 2) the Westside Sacramento Region (which covers the generally northern part of Napa County and focuses on the Putah Creek/Lake Berryessa watershed; the Westside Region also covers parts of Yolo, Solano, Lake, and Colusa Counties).

The County has contributed to two larger regional IRWMPs. The County actively collaborated with the San Francisco Bay and Westside RWMGs to update the IRWMP for the San Francisco Bay (Kennedy Jenks et al., 2013) and to develop a new IRWMP for the Westside Sacramento Region (Kennedy Jenks, 2013).

[41] See more information on the County and RCD DIY Well Monitoring Program **http://www.napawatersheds.org/app_pages/view/7819**

The County's representation and participation in the San Francisco Bay and Westside IRWMPs enables further coordination and sharing of information on water resources management planning programs and projects (particularly those that are a high priority for the County) and other information for IRWMP grant funding and implementation.

9.5 Other Groundwater Management Strategies

Implementation of the monitoring and reporting actions outlined in **Chapter 8** and elsewhere in this Report over time may require the incremental implementation of a variety of management strategies or actions to ensure the long-term sustainability of the Napa Valley Subbasin. Actions may include future changes to local land use controls, well permitting, groundwater metering and usage limits, changes to County ordinances, and direct coordination with other municipal agencies to effectively protect and sustain groundwater and surface water resources. Fortunately, as evident by results of this Report, the Napa Valley Subbasin has been operating within its sustainable yield for more than 20 years and far-reaching management actions are not necessary at this time.

9.5.1 Potential Changes in Land Use Controls to Consider

The revised WAA (Napa County, 2015) includes provisions for analysis of potential impacts on surface water when substantial evidence indicates the need to do so. At this time, the new WAA criteria together with the analyses conducted as part of this Report, indicate that the Subbasin has been operating within its sustainable yield. Therefore, no modifications to zoning, building codes, landscaping, or similar changes are considered necessary at this time.

It is recommended that the standard Conditions of Approval used by Napa County for discretionary projects be revised to include, for all future projects, groundwater monitoring and water use monitoring, reporting data to the County when requested, and use of project wells for monitoring when requested and needed to support this Report, and provisions for permit modification based on monitoring results.

9.5.2 Potential Changes to Well Regulations to Consider

In order to have the authority needed to obtain additional groundwater-related data when necessary, the above recommendation is also applicable in this section to discretionary projects involving new wells or modifications to existing wells. If future information indicates that areas in the Subbasin are potentially being impacted by groundwater pumping, the County would have the ability to obtain additional data when requested and needed to assess whether it is a very localized condition, or indicative of broader effects on the Subbasin.

Since the Subbasin has been operating within its sustainable yield, no taxes or fees are considered necessary at this time. Pending the results of the northeast Napa area study (as described in **Chapter 7**), restrictions on groundwater use may be developed if warranted.

9.5.3 Recycled Water

Currently, the Napa Sanitation District provides recycled water along two main pipelines to the southeast and north of the Soscol Water Recycling Facility[42]. The NSD is working with water users throughout Napa to identify areas where recycled water could replace the use of potable, surface or groundwater.

Recycled water finally made its way to the Coombsville/MST area (outside the Napa Valley Subbasin) after 10 years of planning and almost 2 years of construction. In mid-December 2015, the NSD tested the newly constructed MST Recycled Water Project, a 5-mile pipeline and booster pump station that brings irrigation water to vineyards, homes, an elementary school, and the Napa Valley Country Club. The project has been constructed through a partnership between Napa County, the NSD, and property owners that have joined the specially formed MST Community Facilities District to fund the project.

Napa Valley Country Club completed construction of a new pond to receive the recycled water for irrigation of its 182 acres of property. Through a partnership with the NSD, their new pond will be utilized to receive recycled water resulting from the performance-testing of the new MST pump station located over 5 miles away on Napa State Hospital property. Irrigation of the Napa Valley Country Club with recycled water will result in conservation of between 150 and 200 acre feet (over 50 million gallons) per year of groundwater that is pumped from the MST area.

During 2016, over 50 participating properties were anticipated to connect to the recycled water pipeline and begin to use recycled water. The pipeline is designed to initially deliver up to 700 acre-feet (230 million gallons) per year of recycled water to the area and is expandable to 2,000 acre-feet per year (650 million gallons). An extension to this new system is currently under consideration following the recent award of drought-relief grant funding and additional interested property owners.

The Los Carneros Water District (LCWD) Recycled Water Project will extend the District's recycled water pipeline from Stanly Ranch through the Los Carneros area, located outside the Napa Valley Subbasin. The pipeline will primarily be in public roads. The project will provide recycled water for agricultural and landscaping uses.

9.5.4 Groundwater Ordinances/WAA Updates

The County recently updated its WAA (Napa County, 2015). The WAA will be periodically reviewed in coordination with 5-year Basin Analysis updates for the Napa Valley Subbasin, or more often should Annual Reports on groundwater conditions indicate a need to do so.

9.5.5 Other Actions in Cooperation with Cities and Other Stakeholders

In addition to the outreach and education activities described above, the WICC organizes a biennial conference on watersheds and groundwater-related issues in Napa County. Planning is underway for the next Watershed Summit in May 2017.

[42] Information from Napa Sanitation District web site at **http://www.napasan.com/**.

9.6 Ongoing Evaluation of Groundwater Management Efforts

As described in **Chapter 8**, the County will conduct ongoing assessments (annual and five-year updates) of groundwater conditions, new information or changes in water use, consideration of changes in subbasin groundwater conditions, management actions implemented and their effect on subbasin conditions, and additional management tools or actions needed to maintain subbasin sustainability. The annual and five-year assessments will also describe planned changes to the monitoring network to address data gaps relevant to future water budget calculations, track sustainability indicators, identify groundwater-dependent ecosystems, and/or other monitoring needs to maintain subbasin sustainability.

9.7 Best Management Practices (BMPs)

DWR released drafts of five BMP documents on October 28, 2016 and accepted public comment through November 28, 2016. A schedule posted on the DWR website shows that final BMPs are planned to be released in December 2016. The BMPs developed by DWR are to provide clarification, technical guidance, and examples to help with the development of a GSP; practices described in the BMPs do not replace or serve as a substitute for the GSP regulations, nor do they create new requirements or obligations.

Per SGMA (Section Water Code 10720 (d)), DWR is required to:

> *(1) By January 1, 2017, the department shall publish on its Internet Web site best management practices for the sustainable management of groundwater.*
>
> *(2) The department shall develop the best management practices through a public process involving one public meeting conducted at a location in northern California, one public meeting conducted at a location in the San Joaquin Valley, one public meeting conducted at a location in southern California, and one public meeting of the California Water Commission.*

The County has incorporated some elements of the draft BMPs and will consider the final BMPs that DWR posts on its website in upcoming future Reports (Annual Reports and five-year Basin Analysis Report updates). This Basin Analysis Report has included monitoring protocols and data/reporting standards where previously developed and readily available for incorporation in this Report. The five-year Basin Analysis Report update will also include additional BMPs which are in use but not yet formally documented.

10 FINDINGS AND RECOMMENDATIONS

In response to the 2014 Sustainable Groundwater Management Act, Napa County prepared this Basin Analysis Report, an Alternative Submittal per the requirements of Water Code Section 10733.6 (b)(3) which provides for an analysis of basin conditions demonstrates that the basin has operated within its sustainable yield over a period of at least 10 years. This Basin Analysis Report covers the entire Napa Valley Subbasin, a designated medium-priority basin that is subject to the Act. This chapter presents Findings and Recommendations from the analyses conducted as part of the Basin Analysis Report and in consideration of prior activities by Napa County, the GRAC, the WICC, and others.

Napa County's Comprehensive Groundwater Monitoring Program involved many tasks that led to the preparation of five technical memorandums and a key foundational report on *Napa County Groundwater Conditions and Groundwater Monitoring Recommendations* (LSCE, 2011a). This report and the other related documents can be found at: http://www.napawatersheds.org/. This program detailed eighteen recommended near- to long-term "implementation steps" (LSCE, 2011; Report Executive Summary) directed towards groundwater sustainability. The County has implemented most of the recommended steps since completion of that report and has also implemented many additional actions.

Napa County's long-term efforts have created a strong foundation for public outreach and participation in water resources understanding, planning, and management. These efforts included a Groundwater Public Outreach Project with the Center for Collaborative Policy (CCP, 2010/AB 303 related), creation of a new Groundwater Resources Advisory Committee (GRAC), and the long-term support of the Watershed Information & Conservation Council (WICC-2002). From this foundation, the County developed a Comprehensive Groundwater Monitoring Program, based upon numerous technical memorandums, and a key foundational report on *Napa County Groundwater Conditions and Groundwater Monitoring Recommendations* (LSCE, 2011a; http://www.napawatersheds.org/) While there was no formal groundwater management plan (under SB 1938), Napa County's efforts have been instrumental in the development and implementation of functionally equivalent groundwater management actions to better understand groundwater conditions, establish monitoring to track conditions, conduct education and outreach, and other programs to maintain groundwater sustainability.

10.1 Findings

The findings presented below are organized by Report Chapters 2 through 9.

Chapter 2: Physical Setting and Hydrogeology

- The Napa Valley Subbasin consists of a complex geologic and hydrogeologic setting
- The relatively narrow and flat Valley Floor contains three major geologic units
- The primary aquifer unit of the Napa Valley Subbasin is the Quaternary Alluvial Deposits
- A hydrogeologic conceptual model has been developed that consists of: Subbasin Inflows (recharge, runoff, subsurface inflow, and surface water deliveries), Subbasin Outflows (surface water outflow, subsurface groundwater outflow, groundwater pumping, and urban wastewater

outflow), and Subbasin Groundwater Storage (Quaternary Alluvial deposits groundwater storage).

- The Napa Valley Subbasin, an elongated alluvial river valley, has benefited from high precipitation and the corresponding potential for a substantial amount of recharge. Due to high recharge potential in most years, low water requirements for the dominant agricultural land use (wine grapes) and a hydrogeologic setting conducive to recharge, the Napa Valley Subbasin remains full overall.
- The groundwater table in the alluvial aquifer of the Napa Valley Subbasin is generally quite shallow; the depth to groundwater in the main part of the Valley Floor in the spring is approximately 5 to 35 feet.

Chapter 3: Monitoring Network and Program

- Napa County has designed a monitoring network to assess groundwater levels and groundwater quality in order to better understand groundwater conditions throughout the Napa Valley Subbasin.
- The groundwater level monitoring network currently consists of 113 wells; the groundwater quality monitoring network currently consists of 81 sites, all of which are distributed throughout the Subbasin considering factors such as data availability, current population, and groundwater utilization.
- Napa County has recently developed and incorporated a surface water-groundwater monitoring program that uses groundwater and surface water levels as well as temperature and electrical conductivity to assess the relationship between surface water and groundwater on a continuous basis.
- Napa County provides monitoring results and assessments of groundwater conditions in the form of Annual Groundwater Monitoring Progress and Data Reports and Annual CASGEM reporting of water levels.
- The monitoring program involves utilizing Best Management Practices including monitoring protocols, data collection, and reporting site information.

Chapter 4: Groundwater and Surface Water Conditions

- Groundwater conditions in the Napa Valley Subbasin are influenced by groundwater levels, groundwater quality, surface water flows, the seawater/freshwater interface, and the potential for recharge.
- Groundwater levels in the subbasin show generally stable conditions, with declines that are within the historical range associated with the recent drought.
- Groundwater quality in the subbasin is generally of good quality despite a lack of historical groundwater quality records. Areas of poor groundwater quality exist in the south (due to high levels of EC, TDS, and chloride) and the north-central parts of the County, and include concentrations of naturally occurring metals such as arsenic, iron, and manganese that exceed drinking water standards throughout Napa County.

- Surface water is dominated by the Napa River and its many tributaries, and is influenced by the contribution associated with groundwater (baseflow, or groundwater discharge), which is in turn influenced by precipitation, water year type, and the size of the watershed contribution area.
- Because Napa Valley also enjoys a relatively flat valley landscape and a river system that is seasonally and temporally connected spatially to the underlying groundwater system, there is an interplay between factors that affect both the surface water and groundwater systems of the Subbasin. The Napa River system is affected by a number of factors, groundwater being only one of them. It can also be more sensitive during dry (low rainfall) years and also drier periods within the year. The Napa River system has experienced these temporal and seasonal effects over many decades (since the 1930s), particularly during the summer to fall period. More recently, new groundwater monitoring wells and surface water monitoring facilities have been constructed under a California Department of Water Resources grant. These new monitoring wells provide for the collection of continuous groundwater level and stream data to better assess the spatial and temporal interconnection of surface water and groundwater resources. The timing and occurrence/amount of precipitation and natural groundwater recharge events affect the amount of groundwater baseflow discharged to the Napa River system.
- Understanding the role of natural recharge events in replenishing the Napa Valley Subbasin will be increasingly important as the effects of future climate variability are also considered as part of long-term surface water and groundwater resource management and planning to ensure sustainability.
- The seawater/freshwater interface occurs in the southern portion of the Napa Valley subbasin, as the San Pablo Bay provides tidal influences on surface water features in that area. Elevated chloride concentrations occur in the vicinity of the City of Napa, but disappear to the north farther away from the Bay.
- A recent analysis in 2015 of the potential for soils to recharge was conducted (O'Geen et al., 2015) that indicated areas of greatest recharge potential in areas of exposed Napa Valley Alluvium, most notably in the vicinity of an alluvial fan-head area where Sulphur Creek flows over and into the Napa Valley Subbasin.

Chapter 5: Historical, Current, and Projected Water Supply

- Water demands are influenced by population trends and land uses. In the Napa Valley Subbasin, the U.S. Census Bureau indicates that the population is increasing, growing across all four of the incorporated municipalities in the Subbasin (City of Napa, City of St. Helena, City of Calistoga, and the Town of Yountville).
- DWR land use surveys indicate that irrigated agricultural lands include wine grape production (vineyards), orchards, pasture, grain, and truck/field crops. The water demand associated with irrigated agriculture (based on a root zone model) in the Subbasin has decreased slightly from approximately 18,000 AFY to approximately 16,000 AFY, and relies on groundwater pumped from the Subbasin, recycled water, surface water diverted from the Napa River System within the Subbasin, and surface water diverted from the Subbasin watershed.

- Two cultural practices that affect the water demand include: 1. Water for frost protection (which increased water demand), and 2. Drain tiles (decreased water demand by through reuse of water).
- Municipal water use data is available by municipality and averages 17,300 AFY over the base period 1988-2015 for:
    - City of Napa
        - Uses imported State Water Project water, local surface waters from Lake Hennessey and the Milliken Reservoir, as well as a growing contribution from recycled water
    - City of St. Helena
        - Uses imported surface water from the State Water Project, as well as local surface water from Bell Canyon, and groundwater
    - City of Calistoga
        - Uses imported surface water from the State Water Project, local surface water from the Kimball Reservoir, groundwater, and a relatively constant amount of recycled water
    - Town of Yountville
        - Uses surface water from the State Water Project and locally from the Rector Reservoir
- Water use for the unincorporated parts of the Subbasin has increased over time from about 4,000 AFY in 1988 to about 5,000 AFY in 2015, and are mostly supplied by groundwater.
- Total water use in the Subbasin has remained stable from 1988 through 2015 despite the observed population growth and despite some fluctuations over time, ranging from a low of about 21,000 AFY to as much as 40,000 AFY.
- Driven largely by a transition in agricultural water sources, groundwater has increased as a proportion of the overall sources of supply during the base period, while diversions of local surface water (particularly from the Napa River System within the Subbasin itself) have declined by about half of initial levels.

Chapter 6: Sustainable Yield Analysis

- Water budget analyses are performed to estimate sustainable yield for the Napa Valley Subbasin, and are based on the selection of a representative study period, or base period. The selected base period for the Subbasin is WY 1988-2015. This is based on long-term annual water supply, inclusion of both wet and dry stress periods, antecedent dry conditions, adequate data availability, and inclusion of current cultural conditions and water management conditions.
- Water budget results are estimated for the base period, WY 2015, and Projection for the future, based on a quantitative approach that provides estimates of different hydrologic processes that affect the surface water and groundwater in the subbasin, including:

  - Surface Water Inflows (as streamflow from the Napa River Watershed Uplands, conveyed from municipal reservoirs located in the Napa River Watershed Uplands, and from outside the Watershed through State Water Project facilities)
  - Surface Water Outflows (as runoff and groundwater discharge to the Napa River)
  - Groundwater Inflows (from groundwater recharge and subsurface inflows from the bedrock of the Napa River Watershed Uplands adjacent to the Subbasin)
  - Groundwater Outflows (to the Napa-Sonoma Lowlands Subbasin, and due to evapotranspiration and groundwater pumping)
  - Changes in Annual Groundwater Storage
- A root zone model was used to assist in the estimation of the water budget components above, and results indicated that during the base period, groundwater recharge always exceeds groundwater pumping within the Subbasin on a year-to-year basis.
- The watershed-scale water budget results for the Subbasin indicate that there is a net positive contribution to groundwater storage, and that the variations in Net Subbasin Storage from year to year are largely influenced by fluctuations in the Uplands Runoff and Streamflow components. The magnitude of the surface water components demonstrate that large quantities of water move through the Subbasin in most years compared to the amounts of water pumped from the Subbasin or that is flowing out of the Subbasin via subsurface outflow.
- To complement the water budget analysis, a groundwater storage change analysis is also performed that uses groundwater contours and the geometry and properties of the groundwater aquifer to estimate the amount of water volume is present in storage on a year-to-year basis within the base period (WY 1988-2015).
- A sensitivity analysis was performed to assess the uncertainty of various components used in each approach for determining sustainable yield.
- The sustainable yield analysis established that the maximum amount of water that can be withdrawn annually from the Subbasin groundwater supply without causing an undesirable result is within 17,000 AFY to approximately 20,000 AFY. The sustainable yield is not a constant value and could change with variations in water budget components or as a result of management decisions that could lead to increased or decreased sustainable yields in the future.
  - It is recommended that Subbasin management seek to keep rates of groundwater use in the Subbasin at levels consistent with those that occurred over the base period in order to be protective of Napa River baseflow conditions, while allowing for changes in the sustainable yield due to climate change or the implementation of augmented recharge projects in the future.

Chapter 7: Napa Valley Subbasin Sustainability Goals

- The GRAC (February 2014) developed the following sustainability goal:

    - Sustainability Goal: To protect and enhance groundwater quantity and quality for all the people who live and work in Napa County, regardless of the source of their water supply.

- The GRAC developed five major Sustainability Objectives that include: initiating and carrying out outreach and education efforts; optimizing existing water supplies and systems; continuing long-term monitoring and evaluation; improving the scientific understanding of groundwater recharge and groundwater-surface water interactions; and improving preparedness to address groundwater issues that might emerge.
- In conformance with SGMA and the intent of the GRAC (February 2014) and the County Board of Supervisors (April 2014), the GRAC sustainability goal is expanded to:
    - Napa Valley Subbasin SGMA Sustainability Goal: To protect and enhance groundwater quantity and quality for all the people who live and work in Napa County, regardless of the source of their water supply. The County and everyone living and working in the county will integrate stewardship principles and measures in groundwater development, use, and management to protect economic, environmental, and social benefits and maintain groundwater sustainability indefinitely without causing undesirable results, including unacceptable economic, environmental, or social consequences.
- The Napa Valley Subbasin has been operated within the sustainable yield for at least 10 years based on the current understanding of hydrogeologic conditions and management measures.
- The Napa Valley Subbasin is generally a full basin, benefitting from high precipitation, corresponding high potential for substantial amounts of recharge, and land use dominated by vineyards that have a comparatively low water requirement
- The river system is considered to be the most sensitive sustainability indicator in the Napa Valley Subbasin, so the measurable objectives and minimum thresholds are recommended to ensure groundwater sustainability or improve groundwater conditions, and provide ongoing monitoring targets devised to address potential future effects on surface water.
- 18 Representative Monitoring Sites are selected to monitor sustainability indicators and to set minimum thresholds and measurable objectives to avoid chronic lowering of groundwater levels, land subsidence, reduced groundwater storage, streamflow depletion, degraded groundwater quality, and seawater intrusion.

Chapter 8: Monitoring Data Management and Reporting

- Napa County already has many data management and reporting processes for collecting, analyzing, and reporting data related to groundwater conditions in the Napa Valley Subbasin
- Napa County's DMS is the data house that stores all of the monitoring data including groundwater levels, groundwater quality, and surface water data.
- There are already several outlets for monitoring data collected and stored in the DMS, including data submittals to DWR's WDL, CASGEM, and reports publicly available via Napa County
- Reporting of groundwater conditions include five channels of documents available for the public: 1. Napa County's Annual Groundwater Monitoring Progress and Data Report, 2. Napa

County's Annual CASGEM Reporting, 3. Triennial Countywide Reporting on Groundwater Conditions, 4. SGMA's Annual Report; and 5. SGMA's Five-Year Update

Chapter 9: Sustainable Groundwater Management

- Napa County has already established several management actions, education and outreach programs, and projects whose purpose helps achieve the sustainability goal for the basin.
- The County has developed six (6) goals, twenty-eight (28) policies, and ten (10) water resources action items within the Conservation Element of the Napa County 2008 General Plan related to water resources.
- Groundwater Ordinances are in place to regulate groundwater usage and well development in the County
- The County has a required WAA and developed new guidelines that help applicants for discretionary projects submitted to the County comply with CEQA guidelines. The WAA promotes better understanding of local groundwater conditions to determine whether a proposal may have an adverse impact on: the groundwater basin as a whole, on the water levels of neighboring non-project wells, or on surface waters.
- Napa County promotes education and collaboration with regards to water resources sustainability through several methods including:
    - The WICC, created in 2002, to support the County's Board of Supervisors by providing recommendations related to the management of watershed and groundwater resources countywide. It is a 17 member board comprised of a diverse group of community representatives and elected officials that serve as a conduit for citizen input.
    - Well owner outreach, which has been successfully implemented in helping educate and encourage participation in groundwater monitoring, resulting in approximately 48 new volunteered wells being added to the County's monitoring program (as of spring 2016).
    - A new service for Self-Directed Well Monitoring Education that helps residents monitor the status of their own well by borrowing a county-owned water-depth measuring device to learn how water depth changes and recharge occurs in their own well.
    - Actively collaborating with the San Francisco Bay and Westside Regional Water Management Groups to update the IRWMP for the San Francisco Bay and to develop a new IRWMP for the Westside Sacramento Region, leading to further coordination and sharing of information.
- Other groundwater management strategies may be developed to achieve sustainability goals, including potential changes in land use controls that consider zoning, building codes, landscaping, and limits on new or major changes to existing projects; potential changes to well regulations to consider (including possible metering, withdrawal limits, etc.); recycled water; groundwater ordinances; and other actions in cooperation with cities and other stakeholders.

- Ongoing assessments of groundwater conditions in the subbasin on an annual and every five-year basis will include management actions implemented and discuss their effect on subbasin conditions, as well as include additional management tools or actions needed to maintain subbasin sustainability.
- BMPs are already in place for several aspects of the County's existing monitoring and reporting programs, including protocols and data/reporting standards, and the five-year Basin Analysis Report update will include additional BMPs which are either in use but not yet formally documented, or not yet released by DWR.
- Implementation of the monitoring and reporting actions outlined in this Report over time may require the incremental implementation of a variety of management strategies or actions to ensure the long-term sustainability of the Napa Valley Subbasin. Actions may include future changes to local land use controls, well permitting, groundwater metering and usage limits, changes to County ordinances, and direct coordination with other municipal agencies to effectively protect and sustain groundwater and surface water resources. As evident by results of this Report, the Napa Valley Subbasin has been operating within its sustainable yield for more than 20 years and far-reaching management actions are not necessary at this time.
    - It is recommended that the standard Conditions of Approval used by Napa County for discretionary projects be revised to include, for all future projects, groundwater monitoring and water use monitoring, reporting data to the County when requested, and use of project wells for monitoring when requested and needed to support this Report, and provisions for permit modification based on monitoring results.

10.2 Recommendations

This section describes recommended implementation steps to maintain groundwater sustainability. As discussed above, Napa County has made considerable progress towards implementing recommendations made in 2011 as part of the Comprehensive Groundwater Monitoring Program. The recommendations and the status of actions are summarized in **Table 10-1** included at the end of this section. The GRAC provided groundwater sustainability objectives and metrics to accomplish those objectives in February 2014 (**Appendix A**). These objectives/recommendations are also summarized in **Table 10-1,** where not duplicative of earlier recommendations.

As an outcome of this Basin Analysis Report, additional recommendations are provided below and summarized in **Table 10-1**.

Sustainable yield is not considered to be a constant value (DWR, 2003). It can change with variations in water budget components or as a result of management decisions. Those changes may lead to increased or decreased sustainable yields in the future. Regularly updated evaluations of Subbasin conditions and sustainable yield will continue to account for the sustainability goal and sustainability indicators. Given the potential sensitivity of Napa River baseflow to the timing and location of groundwater pumping in the Subbasin (**Section 4.2**), despite the primary influence of precipitation, it is recommended that Subbasin management seek to keep rates of groundwater use in the Subbasin at levels consistent with those that occurred over the base period in order to be protective of Napa River baseflow conditions, while allowing for changes in the sustainable yield due to climate change or the implementation of augmented recharge projects in the future.

A. Refine Spatial Distribution of Groundwater Monitoring Network

Four recommendations involve refining the spatial distribution of the groundwater monitoring network, including:

- Address groundwater monitoring data gaps to improve spatial distribution of water level measurements in the alluvial aquifer
- Evaluate and address groundwater monitoring data gaps to improve spatial distribution of water level measurements in the semi-confined to confined portions of the aquifer system
- Implement Napa County groundwater quality monitoring program; includes water quality monitoring in a subset of current monitoring network wells
- Coordinate with existing discretionary permit applicants (e.g., wineries and others) regarding existing groundwater level and/or water quality information)

The County successfully implemented a program to recruit volunteered wells for inclusion in the County's groundwater monitoring program. Based on very specific groundwater monitoring objectives to meet SGMA purposes, some additional wells remain of interest to fill data gaps. Specifically, with respect to monitoring in the alluvial aquifer system, additional wells are of interest in the St. Helena Subarea, northern part of the Yountville Subarea, and the southern part of the Napa Subarea. Figure 10-1 shows the current distribution of monitoring wells, including monitoring wells used to compute groundwater levels and the change in groundwater storage in the alluvial aquifer system and the distribution of other currently monitored wells. Additional wells are also of interest to monitor conditions in older formations underlying the alluvial aquifer system. The County has the opportunity, through Conditions of Approval on new and modified discretionary permits, to obtain additional wells and monitoring data by requiring new permittees to monitor and record water level and extraction data, and provide the County access to project wells and data when it is needed to maintain or expand the monitoring network.

The County has already planned for groundwater quality sampling of a subset of its currently monitored wells. This sampling will be implemented in 2017. The additional water quality information would expand the understanding of background water quality, particularly with respect to salinity and nutrients.

B. Expand Stream Gaging and Nearby Shallow Groundwater Monitoring

The implementation of the DWR LGA program to construct and implement coupled surface water and groundwater monitoring in and near the Napa River system has been very valuable for improving the understanding of surface water and groundwater interaction. Similar facilities at additional locations would help further this understanding, are important for the County's SGMA sustainability goal, and would be key to the objective of maintaining or improving streamflow during drier years and/or seasons. It is recommended that the County:

- Coordinate with RCD and others regarding current stream gaging and supplemental needs for SGMA purposes; consider areas that may also benefit from nearby shallow nested groundwater monitoring wells (similar to LGA SW/GW facilities)

C. Hydrogeology and Freshwater/Saltwater Interface Southern Part of Napa Sonoma Valley Groundwater Basin

The Jameson/American Canyons and Napa River Marshes Subareas, which make up the southern County area, have limited available data. These are very low priority basins located outside of the Napa Valley Subbasin. The two main issues facing this area are potential saltwater intrusion and the possibility that current water resources will not be sufficient to meet future demand. To establish current conditions and obtain information necessary for future development planning, further analysis is recommended that includes:

- Monitoring groundwater levels;
- Monitoring groundwater quality;
- Collection and interpretation of geologic data (primarily from well drillers' reports);
- Analysis of streamflow and precipitation;
- Estimation of recharge and discharge using both mass balance and streamflow infiltration methods; and
- Determination of the extent and properties of aquifer materials.

The current lack of groundwater data makes it difficult to determine the source and distribution of salinity in the southern County area with any certainty. A series of multi-level monitoring well clusters installed stepping south from the City of Napa toward San Pablo Bay would help in determining the geology of the Napa River Marsh Subarea and distribution of high salinity groundwater. This further subsurface exploration and characterization of the aquifer system, in conjunction with efforts to estimate subsurface outflow from the Napa Valley, would also help determine if freshwater within the Napa River Marshes Subarea could possibly be used to sustain increasing demand in the Jameson/American Canyon Subarea.

D. Distribution of Groundwater Dependent Ecosystems and Relationship with Groundwater Conditions

During planning for the preparation of this Basin Analysis Report, Napa County met with DWR staff on several occasions to discuss questions and the potential report content. Groundwater dependent ecosystems and their relationship to SGMA sustainability indicator for surface water and potential streamflow depletion was among the topics discussed. DWR staff indicated that studies are underway by the Nature Conservancy and the California Fish and Wildlife Service (CFWS). Subsequent communications occurred with these entities. The Nature Conservancy and CFWS are working to prepare guidance related to GDEs; however, this guidance is in progress and not available at the time of preparation of this Basin Analysis Report. It is recommended that the County:

- Evaluate distribution of Groundwater Dependent Ecosystems and relationships to depth to groundwater; coordinate evaluation with BMPs or guidance developed by DWR, Nature Conservancy or others; and include in the next update to this Report

E. Review and Coordination with DWR BMPs

Following DWR's preparation of GSP regulations, DWR staff began in earnest to work on many other SGMA efforts, especially the development of BMPs. DWR is to publish BMPs on its web site by January 1, 2017. The due date for the Alternative submittal to DWR, this Basin Analysis Report, is the same as the BMPs – January 1, 2017. While some County BMPs have been included in this Report, it is recommended that additional BMPs be incorporated in future updates. This may include use of BMPs for the preparation of Annual Reports and the 5-year update and/or inclusion of detailed BMPs as appendices to one or both types of reports.

F. Reduce Uncertainties of Water Budget Components and Projected Future Water Budgets

The Subbasin water budget results for the base period from 1988 through 2015 show a positive average net storage change of 5,900 AFY. Groundwater levels and groundwater storage have been stable over the base period, however, indicating some degree of water budget component uncertainties. Further calibration of model components based on ongoing data collection will reduce uncertainties of previously estimated water budget components and projected future water budgets.

G. Improve Linkages between Land Use Decision-Making and Groundwater Management

SGMA recognizes the inherent connections between land use decision-making and other, more traditional groundwater sustainability efforts. Through its 2015 update to the Water Availability Analysis guidance document, the County has continued its record of informing land use permitting with best available data. As a compliment to that Water Availability Analysis update, it is recommended that the County revise the standard Conditions of Approval applied to permitted discretionary projects in order to facilitate the transfer of information about groundwater conditions and usage by all approved projects back to the County in support of its on-going groundwater monitoring program. Formalizing the data collection and reporting standards in the Conditions of Approval, including groundwater level monitoring and water use monitoring, will also enable the County to review approved projects and, if necessary, modify permits based on the best available data.

H. Develop Capacity to Empower Local Areas to Monitor Their Own Communities

Napa County residents have demonstrated a great ability in the past to get involved and solve problems on their own. In many areas, this is in fact preferred over government intervention. Neighborhood watch, community clean ups, and creek stewardship groups are just a few examples of neighborhood empowerment to work together to fix problems. Voluntary groundwater stewardship groups could likewise be very valuable in gathering data, understanding a small area, and encouraging cooperation and conservation. The County could be a catalyst in helping these groups to form, by providing education, facilitation, and some amount of monitoring equipment to assist nascent community efforts. This would be particularly helpful for residents in the hillside areas that are outside of the SGMA area. In these areas, the County has already started a voluntary well self-monitoring program with free loaner monitoring equipment and free training to help residents develop a better understanding of their well and local groundwater conditions (**Appendix K**).

I. Improved Understanding of Groundwater Uses

The water budget analyses involved the compilation and synthesis of various water source and use datasets, many of which are not routinely tracked and recorded. It is recommended that approaches to improved understanding of water source and use data be identified and implemented. This will provide greater accuracy of these data, which affect both inflow and outflow components of the water budget analysis. Improved tracking of these data (including surface water and groundwater usage) will also provide a better understanding of trends.

Table 10-1 summarizes the steps necessary to implement the above-described recommendations. The summary table includes the following:

- **Implementation time frames**: near-term, mid-term and long-term (approximately 3, 5, and 10-year periods, respectively); and
- **Relative priorities for implementation**: the priority ranking is on a scale of 1 to 3, with 1 being the highest priority and 3 being the lowest priority.

Table 10-1. Summary of Recommended Implementation Steps

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
Napa County Groundwater Conditions and Groundwater Monitoring Recommendations (2011)				
1.1a	Entry of archived data not previously available, link WellMA table information, add well construction data from wells the County monitors, add recent surface water delivery information, add municipal pumping data, and other information along with development and implementation of quality control protocols for inputting new data and reviewing existing data discrepancies	**Near to Long Term**	**1**	**Complete**
1.1b	Establishment of a map-interface with the DMS to enhance the use of the database by non-database users	**Near Term to Mid Term**	**1**	**2018**
2.1a	Input CASGEM groundwater level data into the DMS	**Ongoing**	**1**	**Complete**
2.1b	Establish data format to meet DWR guidelines for electronic data transfer	**Near Term**	**1**	**Complete**
2.1c	Optimize CASGEM monitoring well network per DWR guidelines by filling in data gaps where identified	**Mid to Long Term**	**3**	**Complete**
3.1a	Update County field procedures for measuring groundwater levels	**Near Term**	**1**	**Complete**

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
3.1b	Develop and/or expand aquifer-specific groundwater monitoring network in Napa Valley Floor, Pope Valley and Carneros Subareas by identifying existing wells with well construction data and constructing new aquifer-specific monitoring wells as needed where data gaps may exist	**Near to Mid Term**	**2**	**Ongoing**
3.1c	Develop aquifer-specific groundwater monitoring network in other Subareas by identifying existing monitored wells with well construction data and constructing new wells where data gaps may exist	**Mid to Long Term**	**3**	**Ongoing**
4.1a	Update geologic cross sections for the Napa Valley Floor and Carneros Subareas (previous ones were 50 years old)	**Near to Mid Term**	**2**	**Complete**
4.1b	Develop new geologic cross sections in those areas with the greatest short- and long-term growth and/or land use potential	**Near to Long Term**	**2**	**2019**
4.1c	Investigate groundwater/surface water interactions and the effect of recharge and pumping on groundwater levels in the Napa Valley Floor Subareas, along with the Carneros Subarea to assess the sustainability of groundwater resources. May include groundwater modeling, as needed.	**Near to Mid Term**	**1**	**Complete/ Ongoing**

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
5.1a	Prepare workplan for the purposes of preparing a Groundwater Sustainability Plan; workplan includes steps to implement County Monitoring Program and CASGEM Program	**Near Term**	**1**	**Complete (Basin Analysis Report; Monitoring Program and CASGEM Plan)**
5.1b	Utilize the Watershed Information & Conservation Council (WICC) Board for various public outreach components related to groundwater sustainability planning	**Near Term**	**2**	**Ongoing**
5.1c	Develop objectives for public outreach, including information sharing and education about the County's groundwater resources	**Near to Mid Term**	**2**	**Complete**
5.1d	Preparation of a Groundwater Sustainability Plan for Napa County	**Near to Mid Term**	**2**	**Complete (Basin Analysis Report)**
5.2a	Public outreach, including information sharing and education about the County's groundwater resources	**Ongoing**	**3**	**Ongoing**
6.1a	Updating of Ordinances 13.04, 13.12, and 13.15	**Mid Term**	**2**	**Complete**
6.1b	Update Groundwater Permitting Process	**Mid Term**	**3**	**Complete**

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
Groundwater Resources Advisory Committee (February 2014)				
7	Develop and widely distribute public outreach programs and materials; educate people about opportunities for taking action	**Near Term/ Ongoing**	**1**	**Ongoing**
8	Support landowners in implementing best sustainable practices; Solicit information on, and widely share best practices with regard to water use in vineyards, wineries, and other agricultural/commercial applications	**Near Term/ Ongoing**	**1**	**Ongoing**
9	Enhance the water supply system and infrastructure to improve water supply reliability (regional and local)	**Near Term (evaluate and rank opportunities); Long Term – seek funding for high value projects**	**2**	**Ongoing**
10	Share groundwater conditions data and results; updates through BOS/WICC/Other	**Near Term/ Ongoing**	**1**	**Ongoing**
11	Continue to improve scientific understanding of groundwater recharge and groundwater- surface water interactions	**Near Term/ Ongoing**	**1**	**Ongoing**

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
12	Improve preparedness for responding to long- term trends and evolving issues; improve preparedness for responding to acute crises, such as water supply disruptions and multiyear drought conditions	**Long Term**	**3**	**2020**
Basin Analysis Report for the Napa Valley Subbasin (2016)				
13	Address groundwater monitoring data gaps to improve spatial distribution of water level measurements in the alluvial aquifer	**Near Term**	**1**	**Ongoing**
14	Evaluate and address groundwater monitoring data gaps to improve spatial distribution of water level measurements in the semi-confined to confined portions of the aquifer system	**Near Term**	**1**	**Ongoing**
15	Implement Napa County groundwater quality monitoring program; includes water quality monitoring in a subset of current monitoring network wells	**Near Term**	**1**	**Ongoing**
16	Coordinate with existing discretionary permit applicants (e.g., wineries and others) regarding existing groundwater level and/or water quality information)	**Near Term**	**1**	**2018**

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
17	Coordinate with RCD and others regarding current stream gaging and supplemental needs for SGMA purposes; consider areas that may also benefit from nearby shallow nested groundwater monitoring wells (similar to LGA SW/GW facilities)	**Near- to Mid Term**	**2**	**2019**
18	Install test hole(s) and multiple completion monitoring wells at south end of Napa Valley Subbasin/Napa Sonoma Lowlands Subbasin for improved understanding of freshwater/salt water interface	**Mid Term**	**2**	**2020**
19	Evaluate strategic recharge opportunities, particularly along Subbasin margin and in consideration of hydrogeologic factors and O'Geen (2015) mapping	**Near- to Mid Term**	**2**	**2019**
20	Evaluate distribution of Groundwater Dependent Ecosystems and relationships to depth to groundwater; coordinate evaluation with BMPs or guidance developed by DWR, Nature Conservancy, California Native Plant Society or others	**Near Term**	**1**	**2019**
21	Review of and coordination with BMPs published on DWR's web site (DWR is due to post BMPS by January 1, 2017)	**Near Term**	**1**	**2018**

Item	Summary Description	Implementation Time Frame[1]	Relative Priority Ranking [2]	Status/ Anticipated Completion
22	Evaluate and address uncertainties in historical water budgets to improve calibration of budget components and reduce uncertainty of projected future water budgets.	**Near- to Mid Term**	**1-2**	**2020**
23	Revise the standard Conditions of Approval used by Napa County for discretionary projects to include, for all future projects, groundwater monitoring and water use monitoring, reporting data to the County when requested, and use of project wells for monitoring when requested and needed to support this plan, and provisions for permit modification based on monitoring results	**Near Term**	**2**	**2017**
24	Expand the capacity to encourage groundwater stewardship/groups through education, facilitation, and equipment	**Near term**	**2**	**2018**
25	Develop an improved understanding of surface water and groundwater uses in unincorporated areas in the County and trends in those uses	**Near Term**	**1**	**2019**

[1] Implementation schedule reflects relative multi-year time frames for completing or conducting the task. Near, Mid, and Long Terms are reflective of 3, 5, and 10 year periods.

[2] Priority ranking is on a scale of 1 to 3 with 1 being the highest priority and 3 being the lowest.

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FIGURES

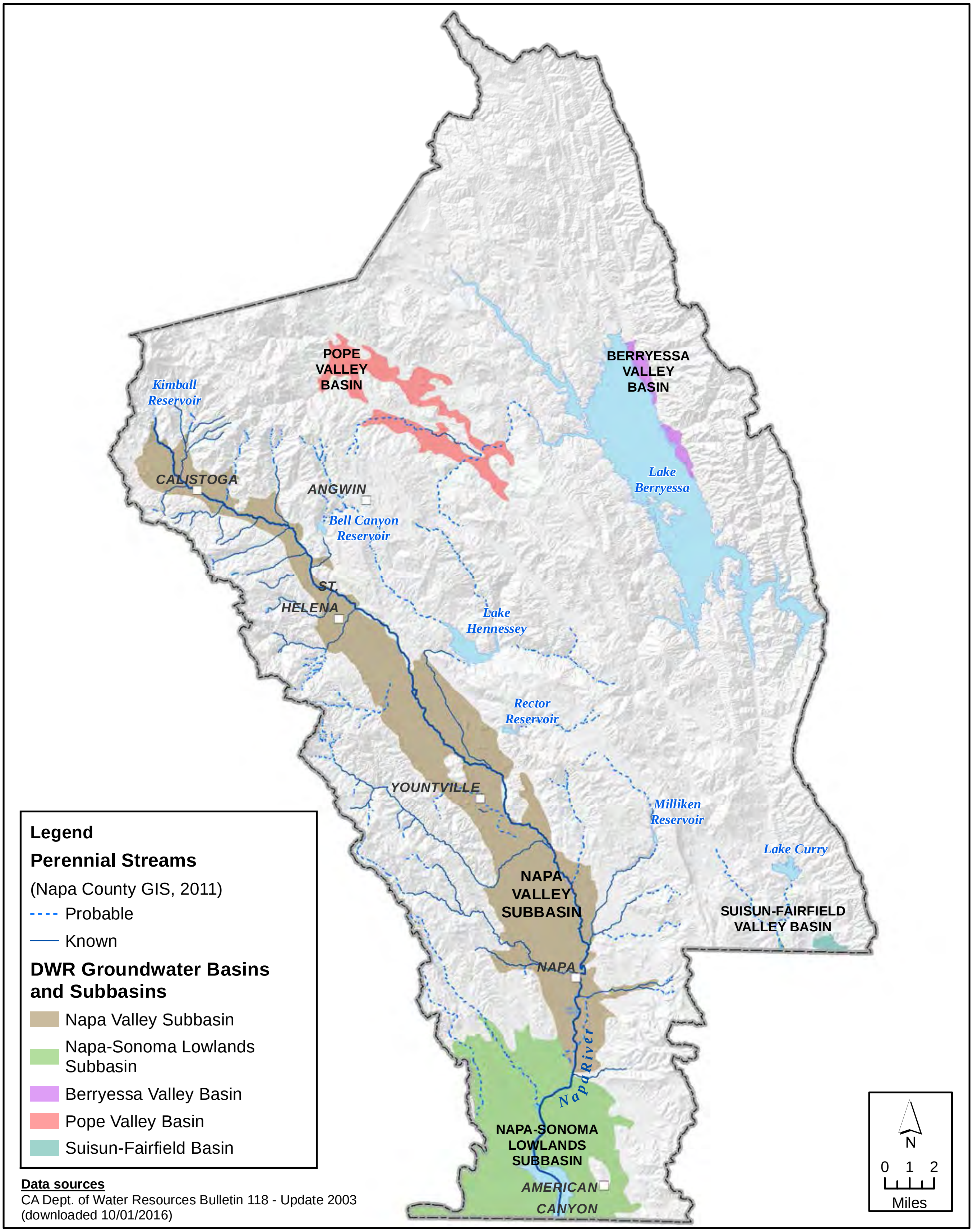

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FIGURE 1-1
Groundwater Basins and Subbasins in Napa County, CA

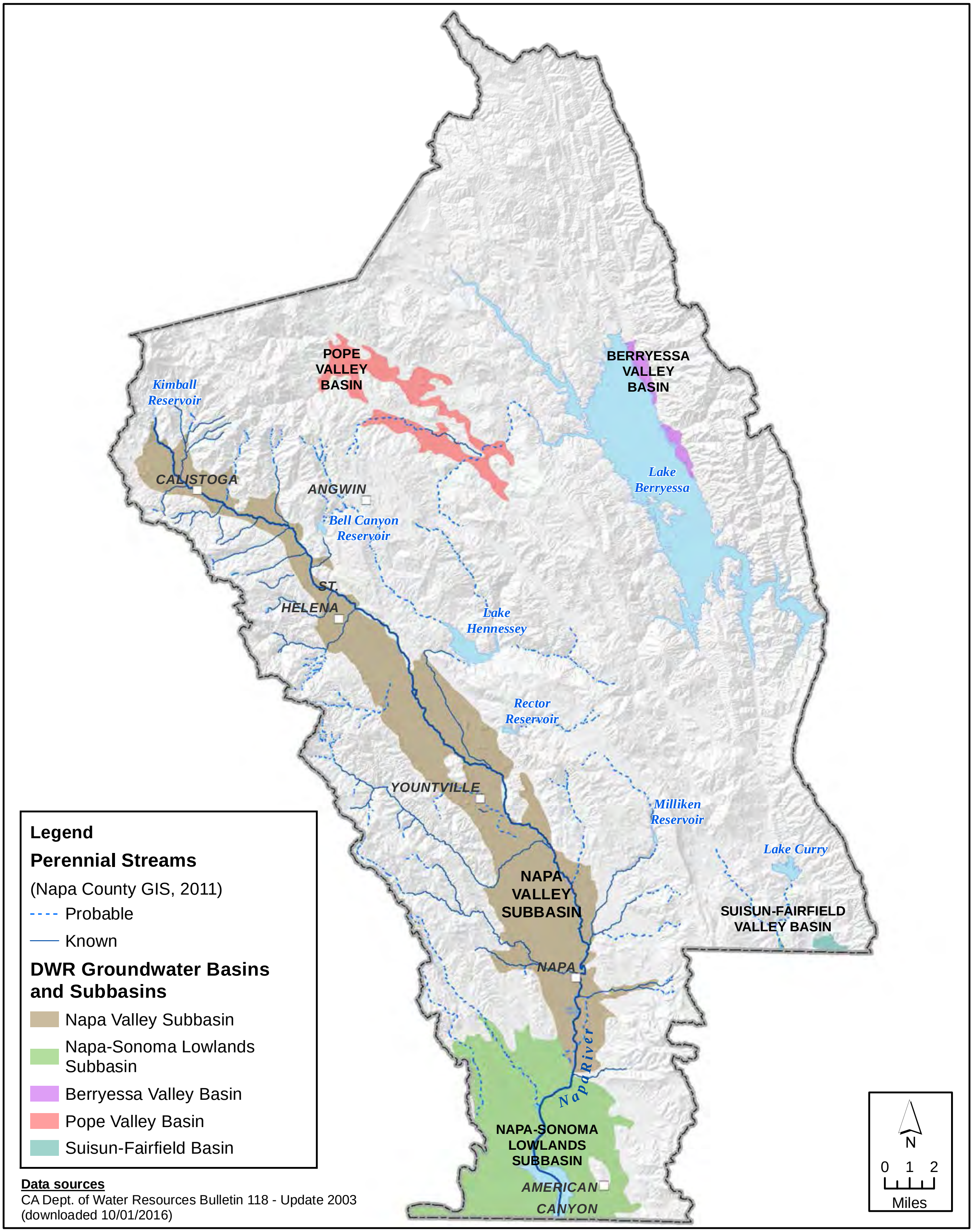

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FIGURE 2-1
Groundwater Basins and Subbasins in Napa County, CA

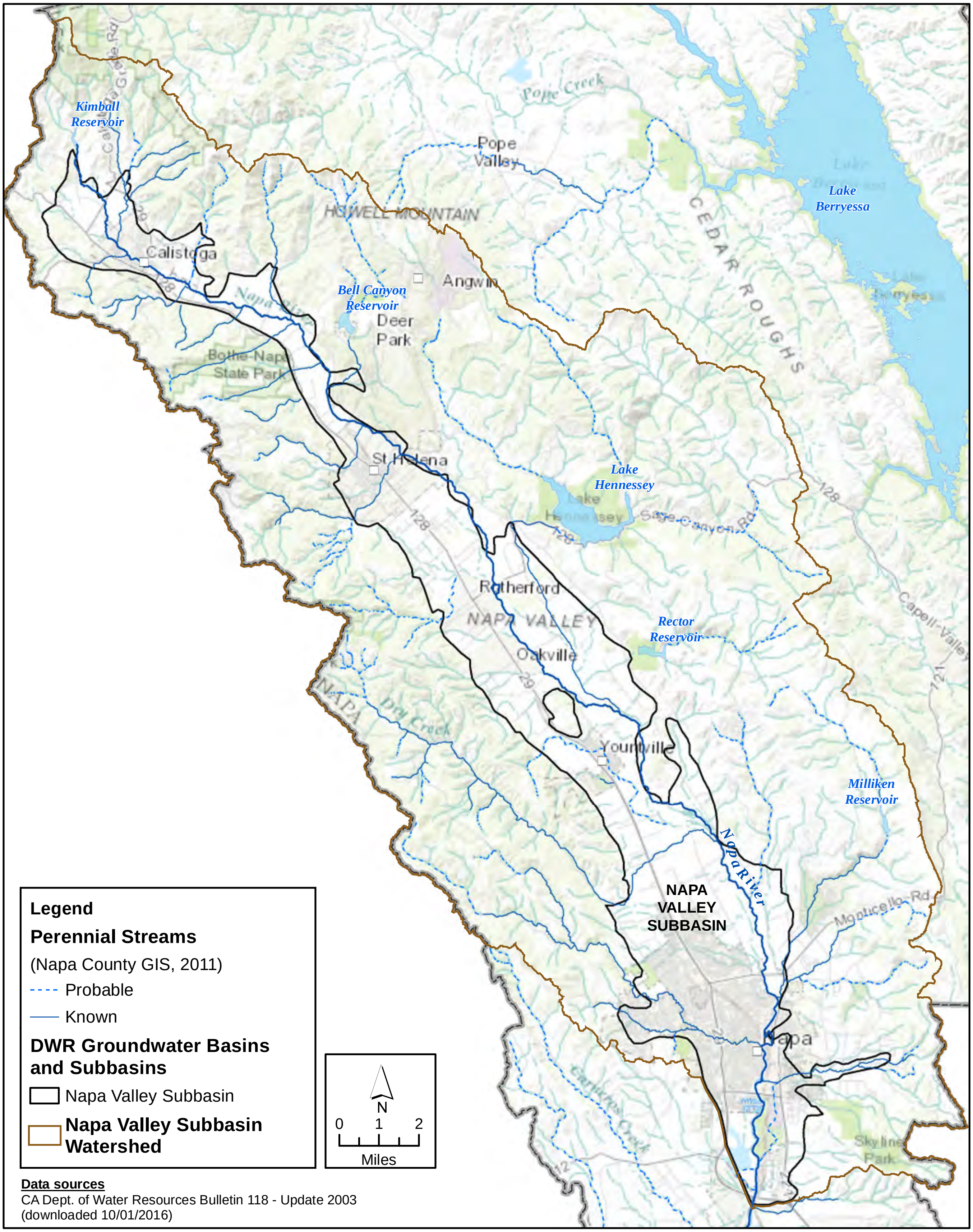

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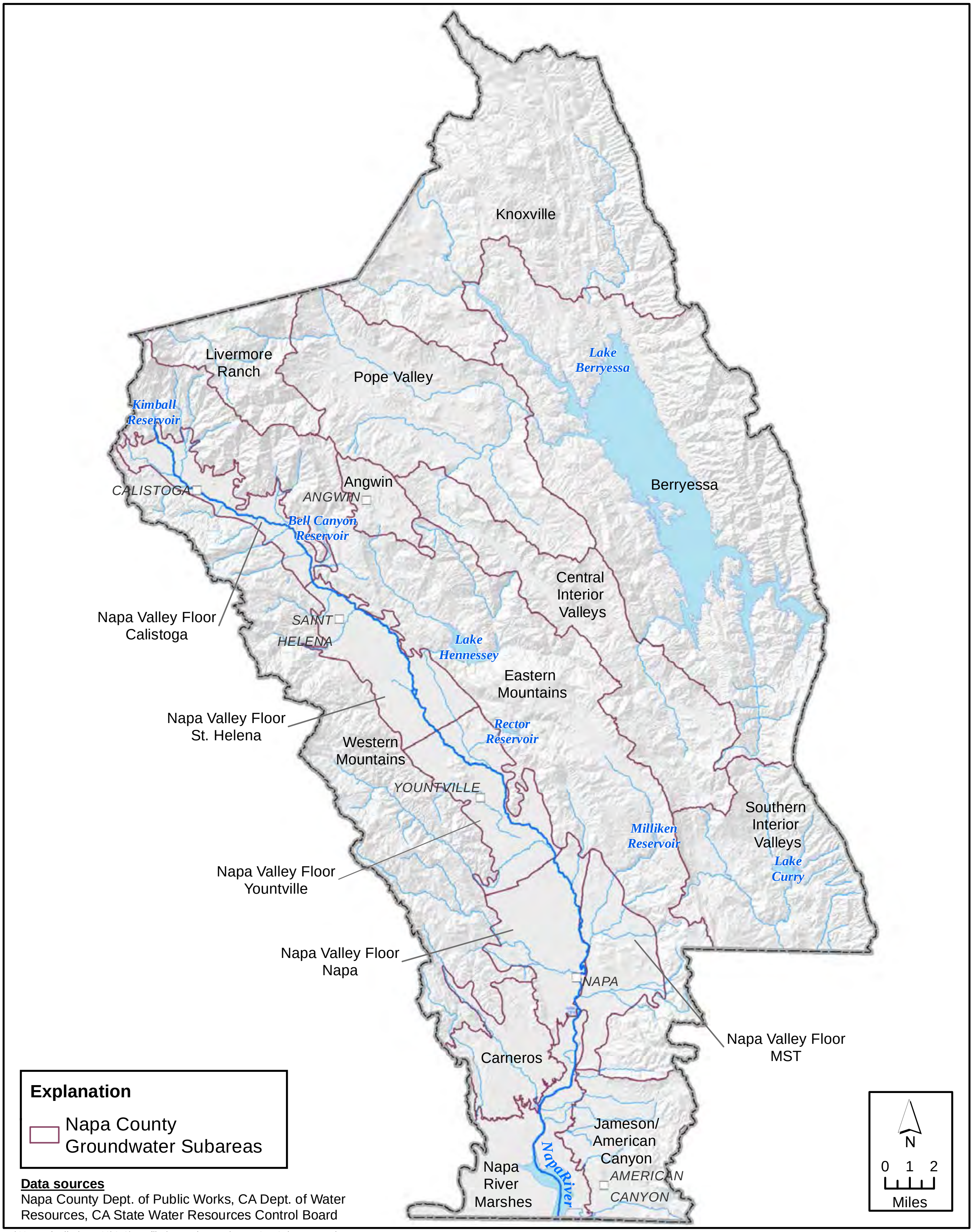
FIGURE 2-2a
Napa Valley Subbasin Topography



Data sources
Napa County Dept. of Public Works, CA Dept. of Water Resources, CA State Water Resources Control Board

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FIGURE 2-2b
Napa County Groundwater Subareas

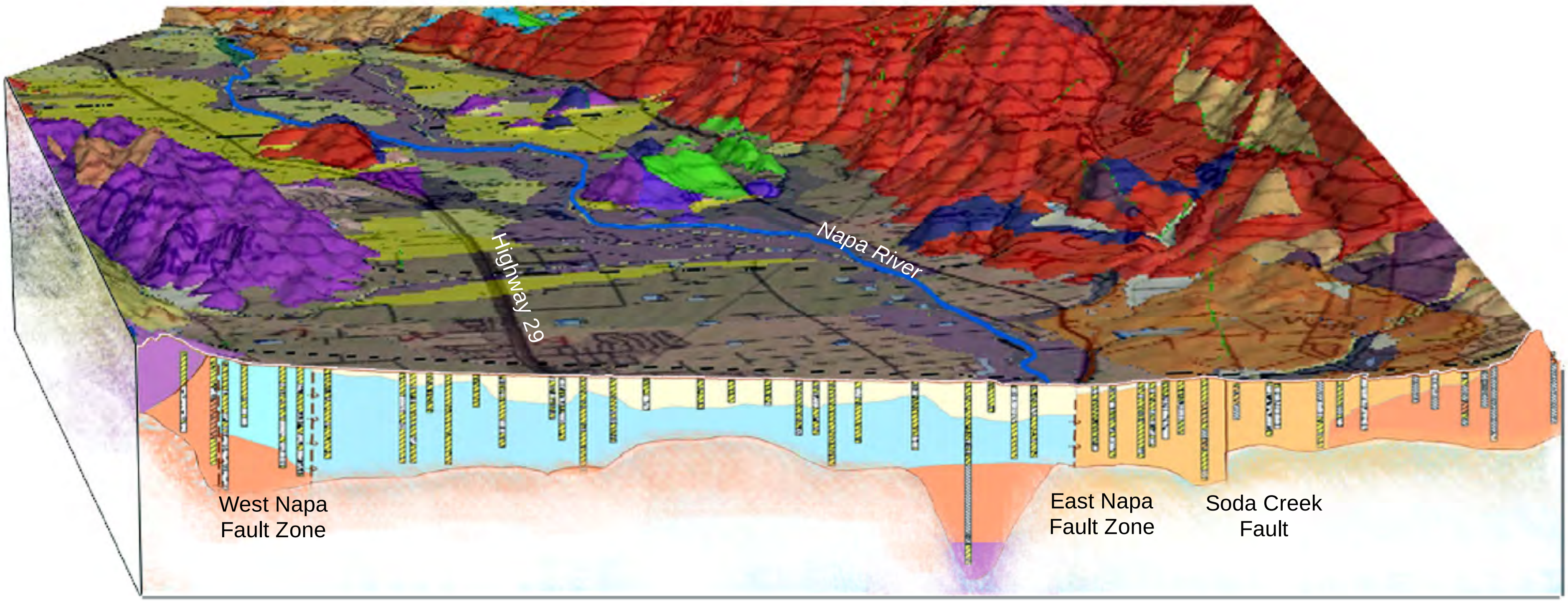

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Figure 2-3
Three-Dimensional Visualization of the Geology in the Napa Valley Area

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin

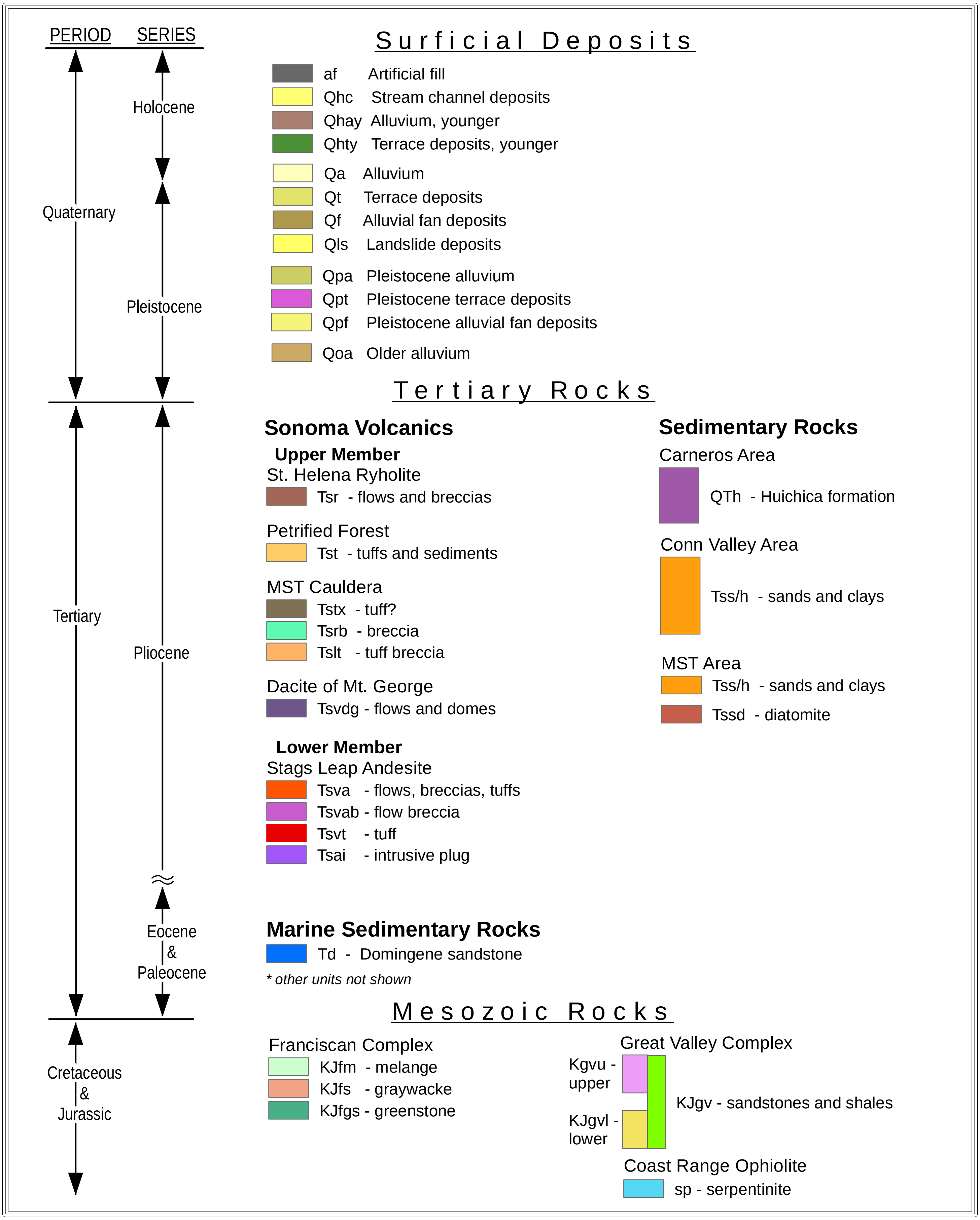

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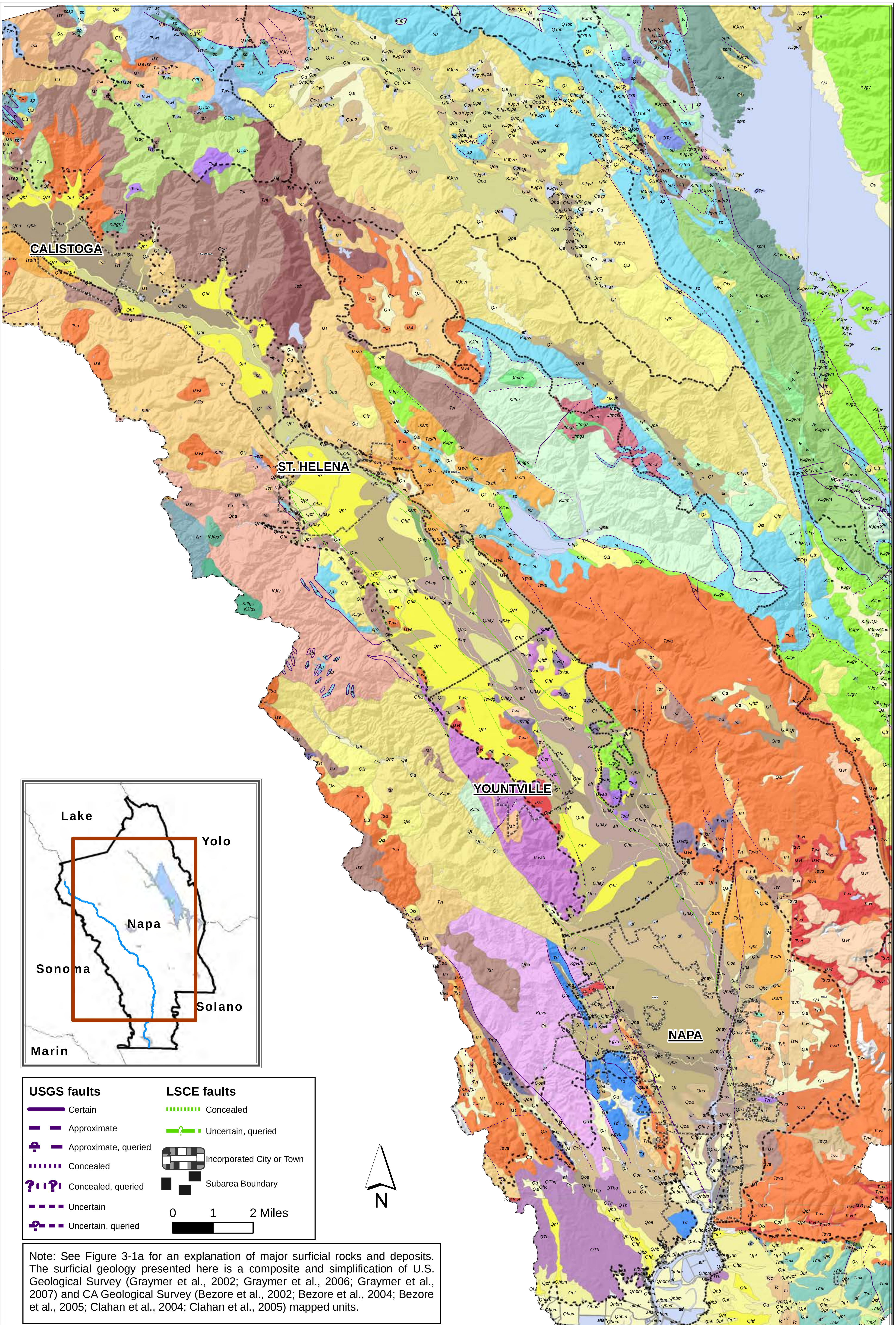
Figure 2-4a
Major Surficial Rocks and Deposits of Napa Valley



Note: See Figure 3-1a for an explanation of major surficial rocks and deposits. The surficial geology presented here is a composite and simplification of U.S. Geological Survey (Graymer et al., 2002; Graymer et al., 2006; Graymer et al., 2007) and CA Geological Survey (Bezore et al., 2002; Bezore et al., 2004; Bezore et al., 2005; Clahan et al., 2004; Clahan et al., 2005) mapped units.

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Figure 2-4b

Napa Valley Surficial Geology

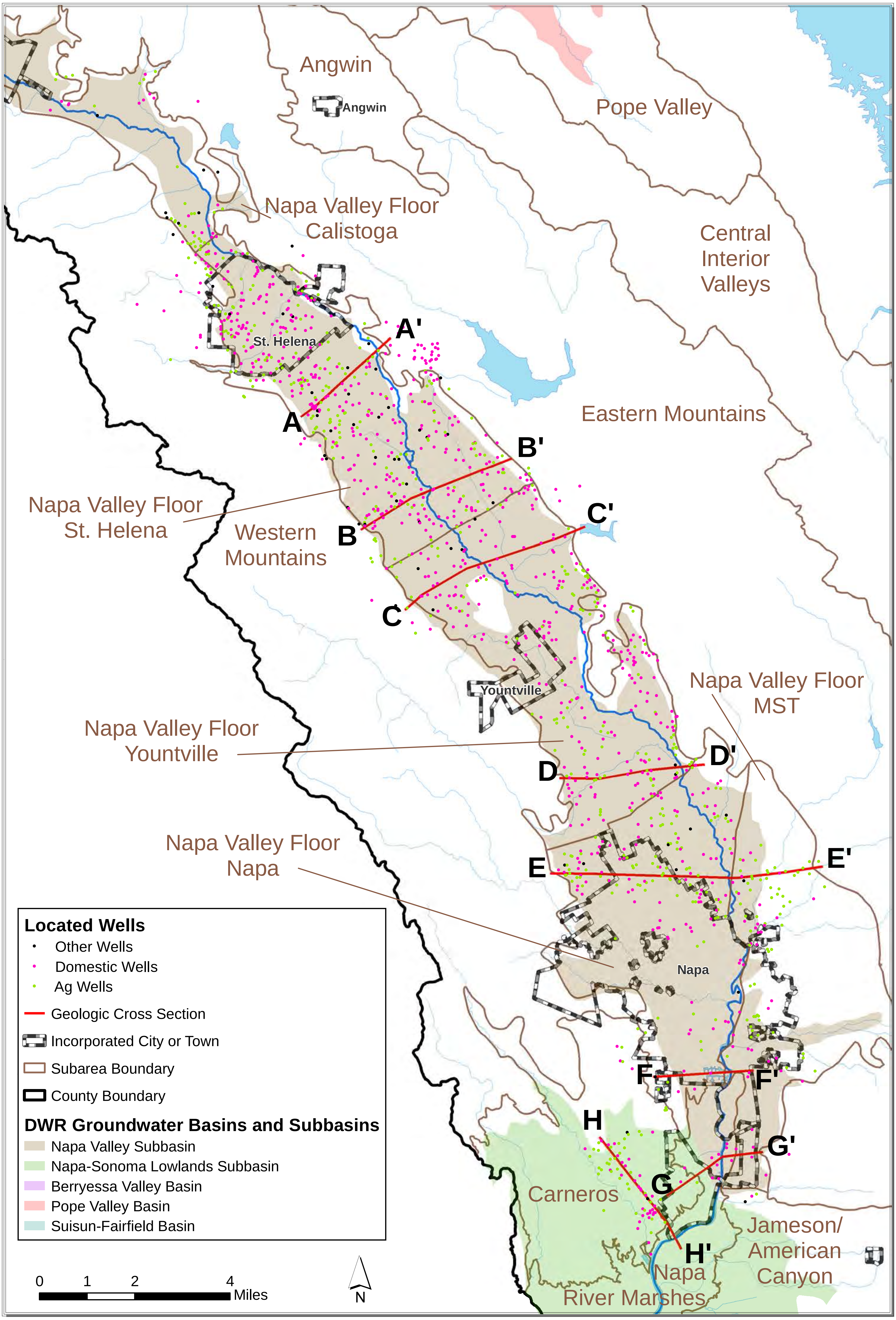

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Figure 2-5a
Geologic Cross Section Location Map

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin

Stratigraphy

- QTh: Quaternary Tertiary Huichica formation
- Qsb: Quaternary sedimentary basin deposits
- Tst/s: Tertiary Sonoma Volcanic tuff and sediments
- TQsu: Tertiary Quaternary sedimentary deposits, undifferentiated
- KJgv: Mesozoic Great Valley Complex
- Qa: Quaternary alluvium
- Qa/sb: Quaternary alluvium/sedimentary basin deposits
- TQsb: Tertiary Quaternary sedimentary basin deposits
- Tcg/ab: Tertiary Sonoma Volcanic conglomerate/breccia
- Tcg/ab?: Tertiary Sonoma Volcanic conglomerate/breccia
- Td: Tertiary marine rock
- Tsr: Tertiary Sonoma Volcanic rhyolite
- Tss/h: Tertiary sedimentary rock
- Tss/h?: Tertiary sedimentary rock
- Tst: Tertiary Sonoma Volcanic tuff
- Tsva: Tertiary Sonoma Volcanic andesite flow
- Tsvat: Tertiary Sonoma Volcanic andesite and tuff
- Tsva?: Tertiary Sonoma Volcanic andesite flow
- Tsvab: Tertiary Sonoma Volcanic andesite flow or breccia
- Tsvt: Tertiary Sonoma Volcanic tuff
- Tsvt?: Tertiary Sonoma Volcanic tuff
- Tst?: Tertiary Sonoma Volcanic tuff

Well Lithology

- Basalt
- Clay
- Clay and Basalt
- Clay and Gravel
- Clay and Sand (or Sandstone)
- Clay and Tuff
- Clay, Sand, and Gravel
- Gravel
- Rock
- Sand
- Sand (or Sandstone) and Gravel
- Sand and Clay
- Faults
- Sandstone
- Tuff or Ash
- Unknown
- Possible Faults

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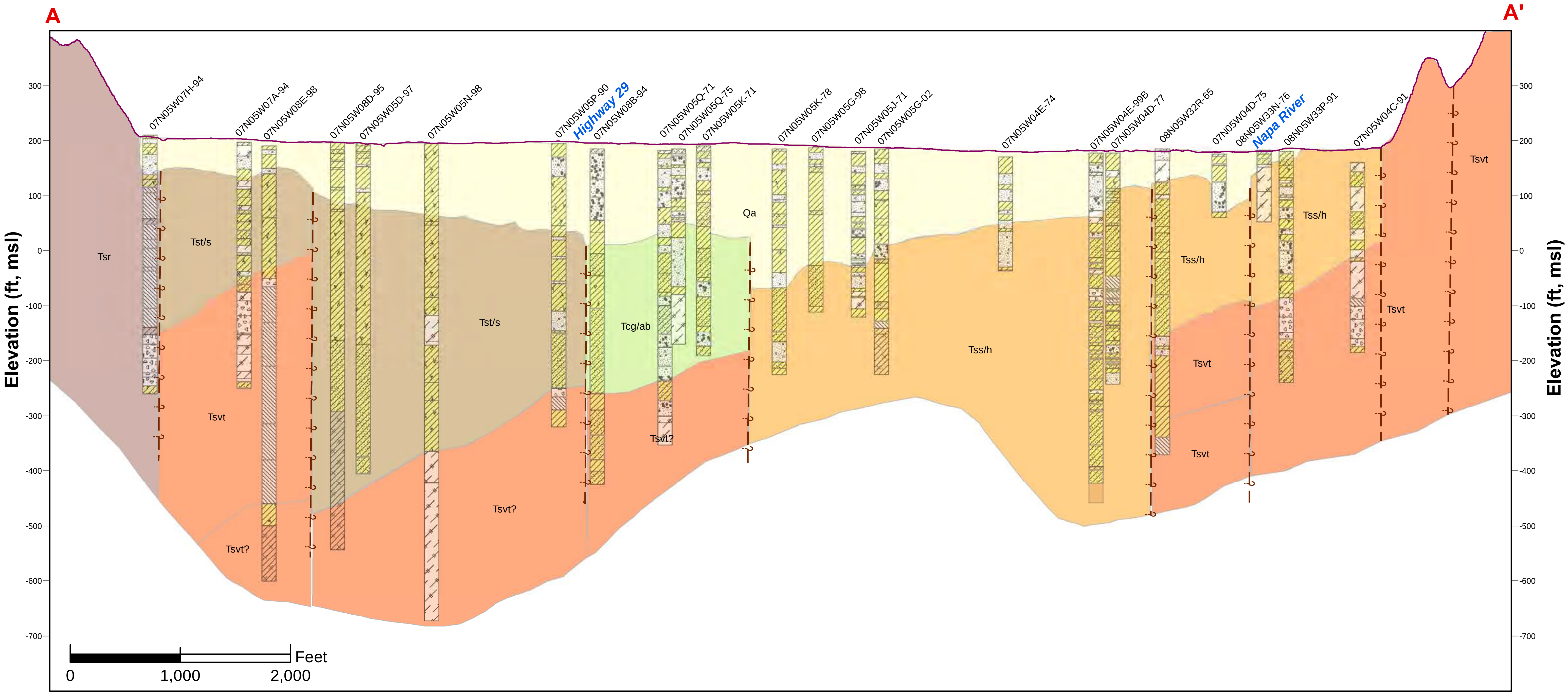
FIGURE 2-5b

Cross-Section Stratigraphy and Well Lithology

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



Legend

Basalt	Clay and Basalt	Clay and Sand (or Sandstone)	Clay, Sand, and Gravel	Rock	Sand (or Sandstone) and Gravel	Sandstone	Unknown
Clay	Clay and Gravel	Clay and Tuff	Gravel	Sand	Sand and Clay	Tuff or Ash	Faults

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Figure 2-6
Cross Section A-A'
Northern NVF-St Helena Subarea, Napa County, CA

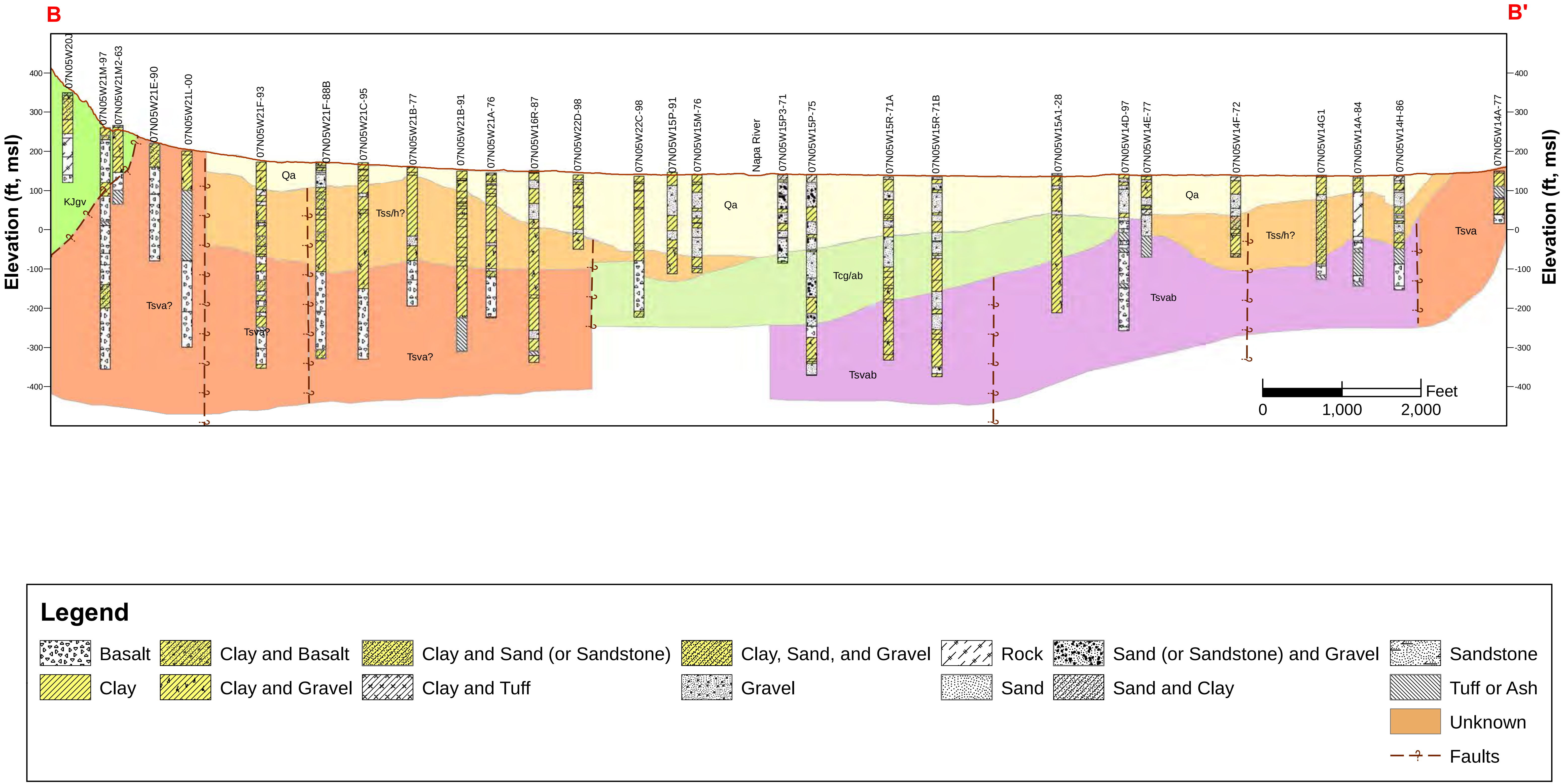

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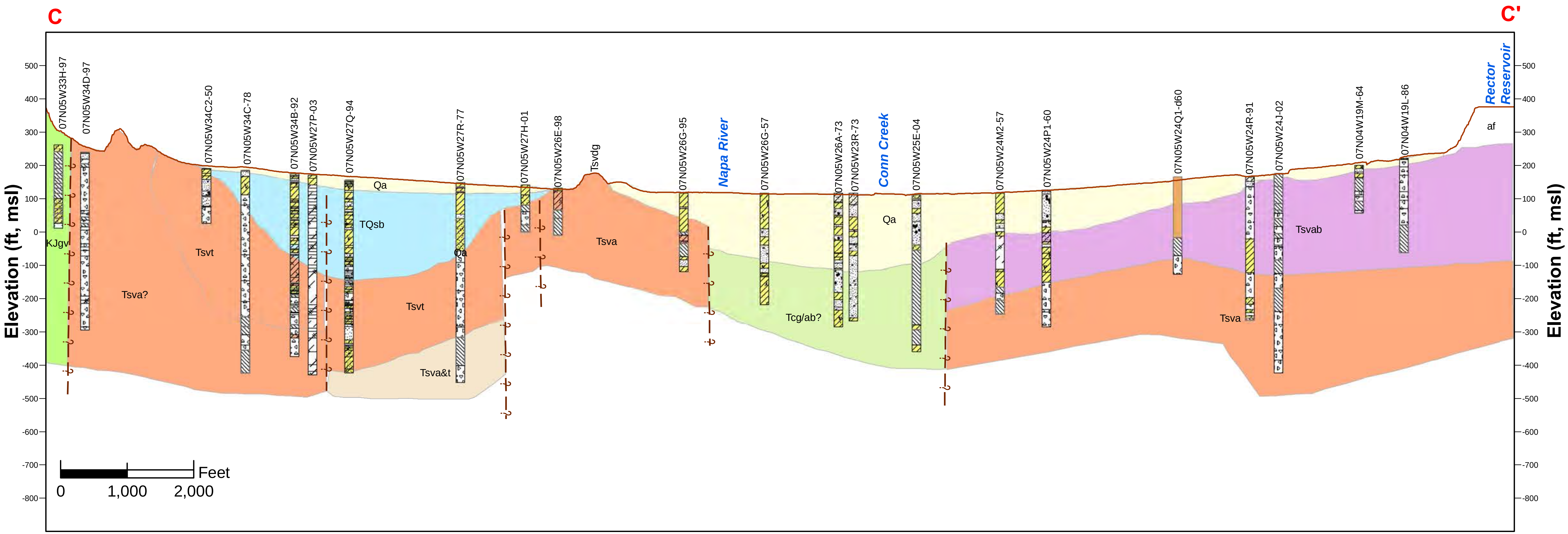
Figure 2-7
Cross Section B-B'
Southern NVF-St Helena Subarea, Napa County, CA



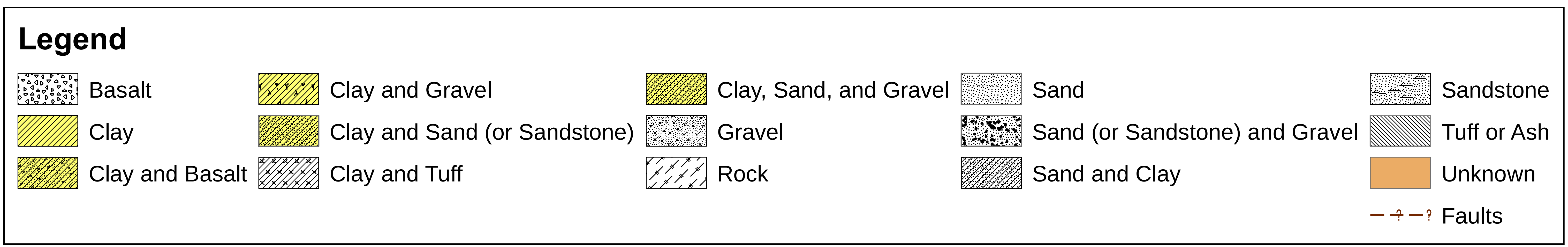


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Figure 2-8
Cross Section C-C'
Northern NVF-Yountville Subarea, Napa County, CA

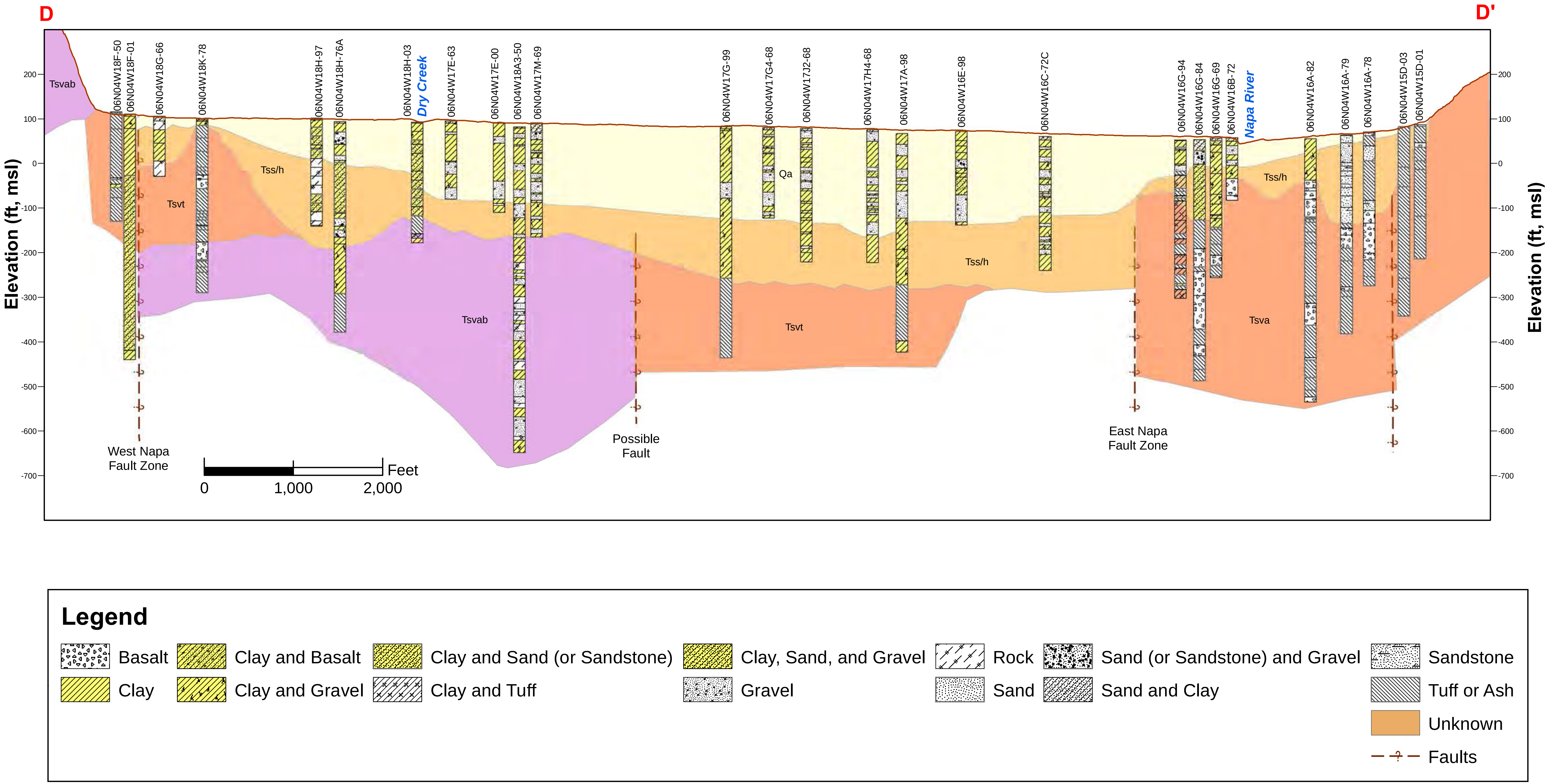

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Figure 2-9
Cross Section D-D'
Southern NVF-Yountville Subarea, Napa County, CA

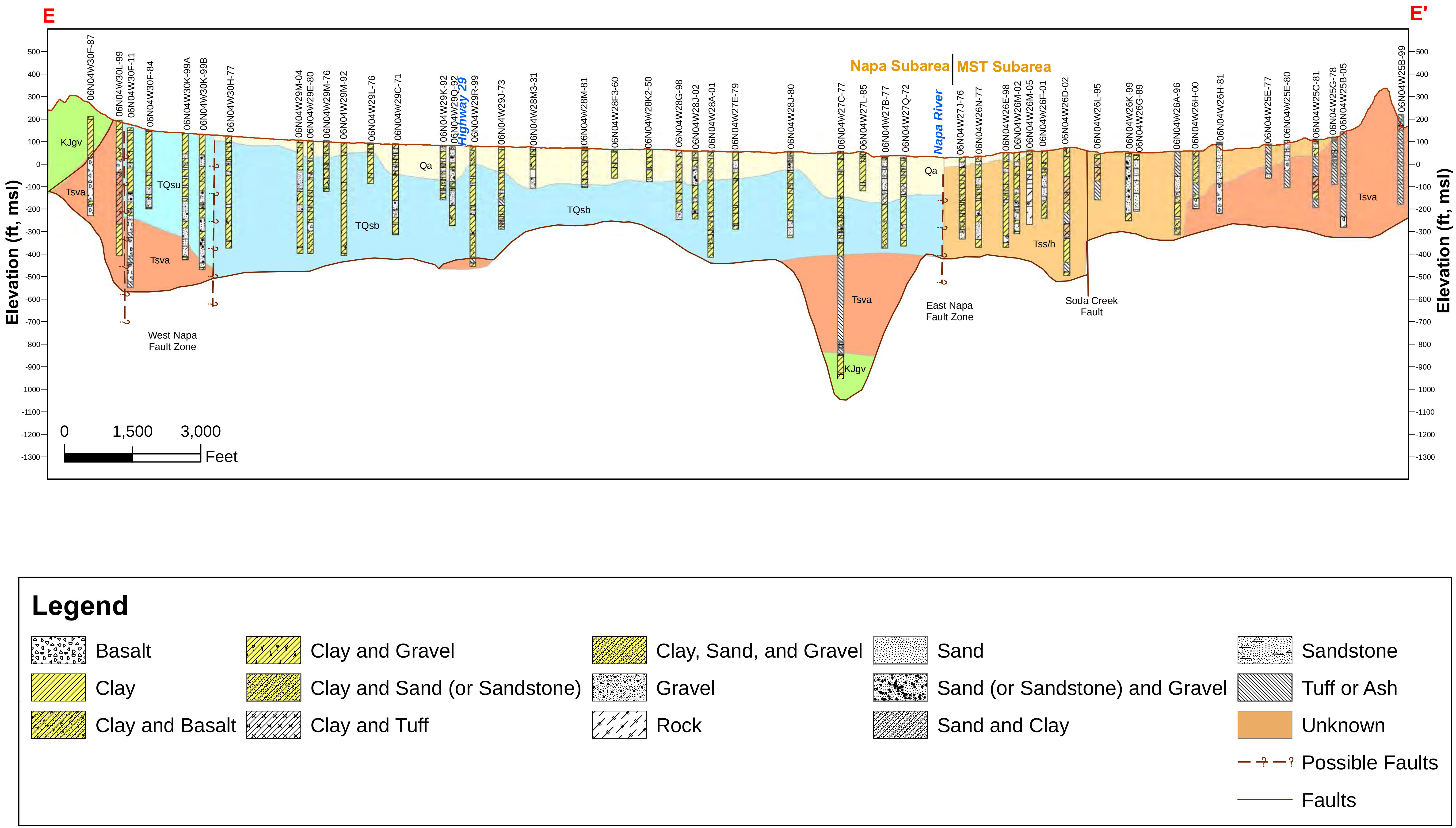

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Figure 2-10
Cross Section E-E'
Norhtern NVF-Napa Subarea, Napa County, CA

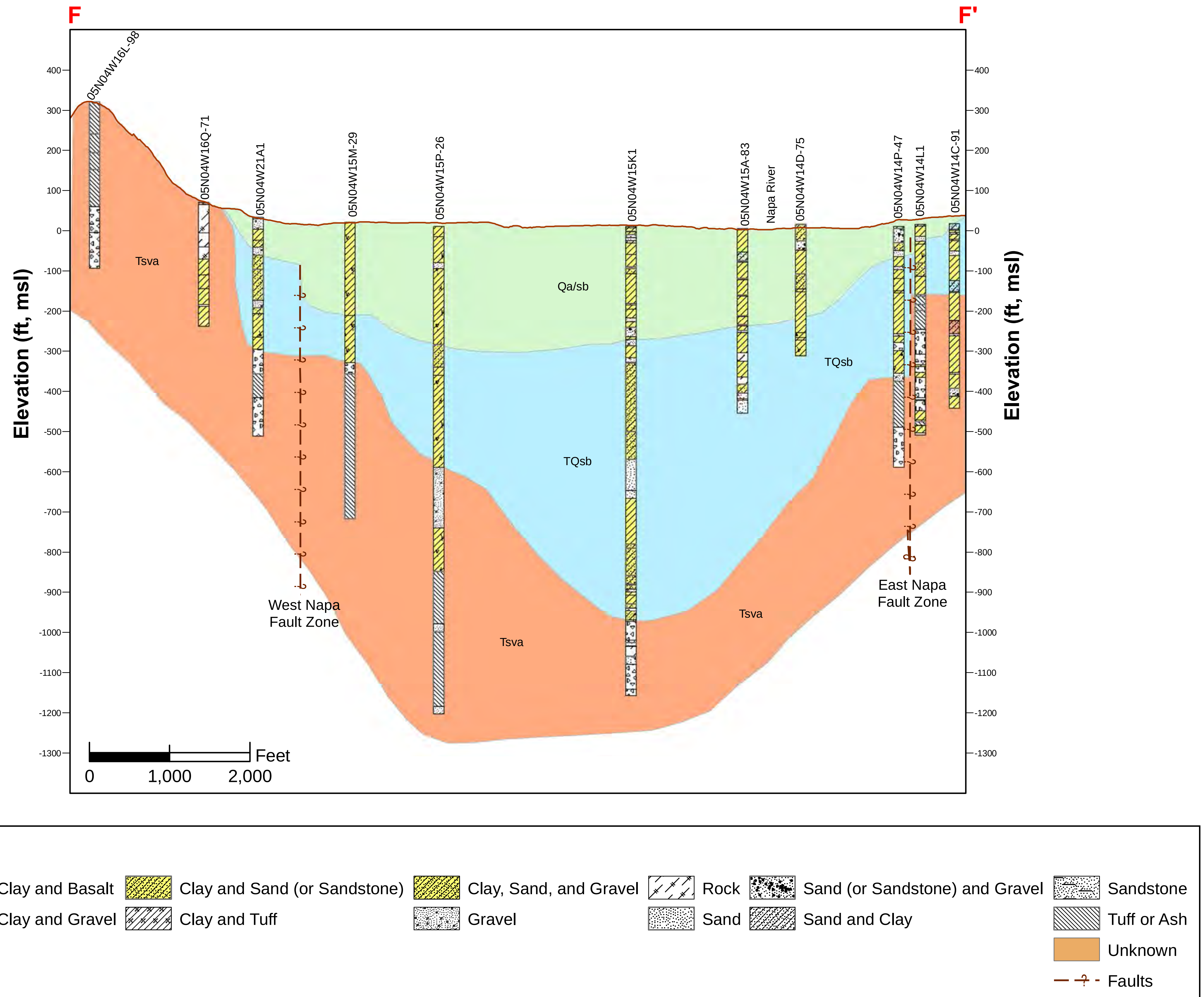

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Figure 2-11
Cross Section F-F'
Southern NVF-Napa Subarea, Napa County, CA

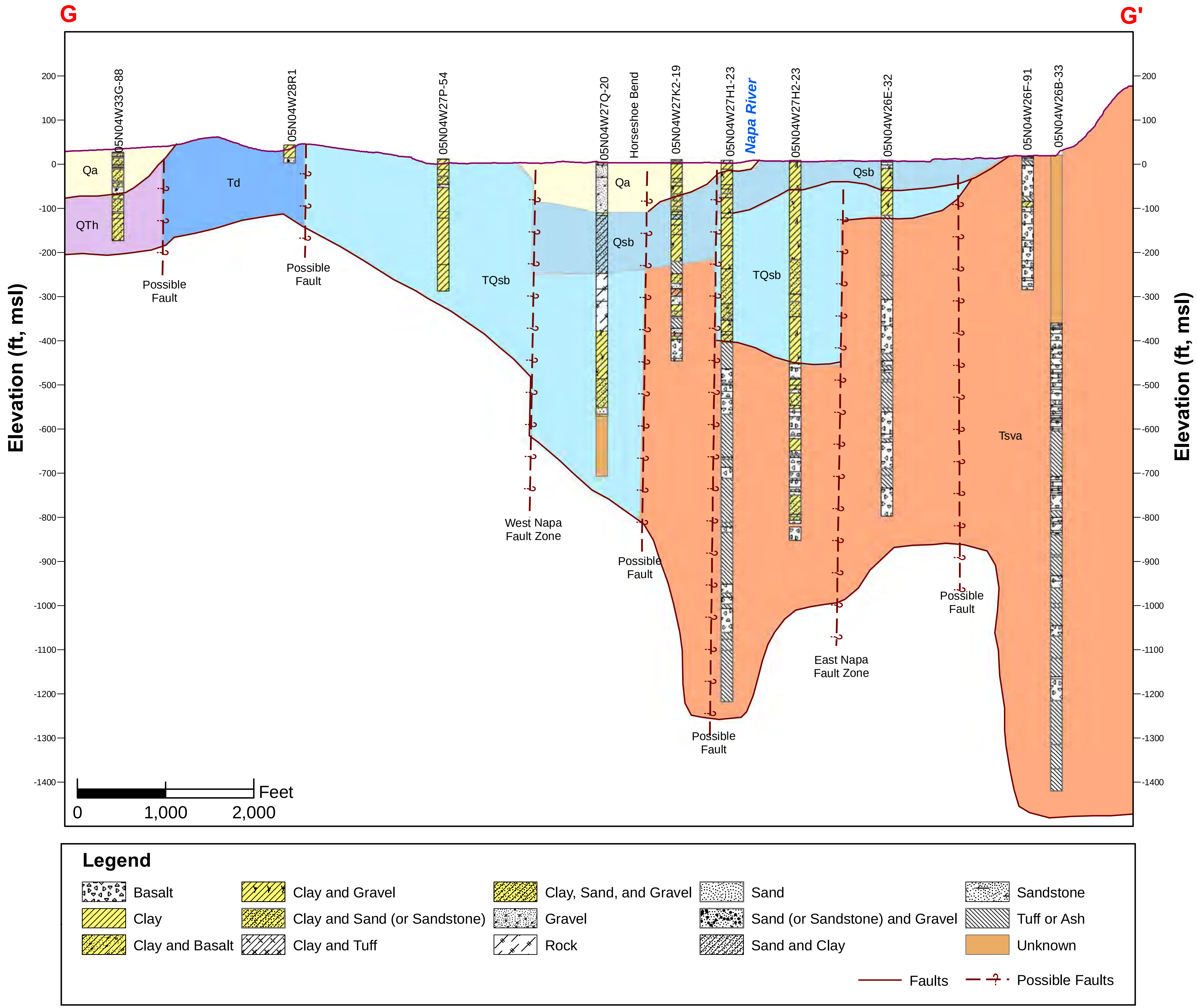

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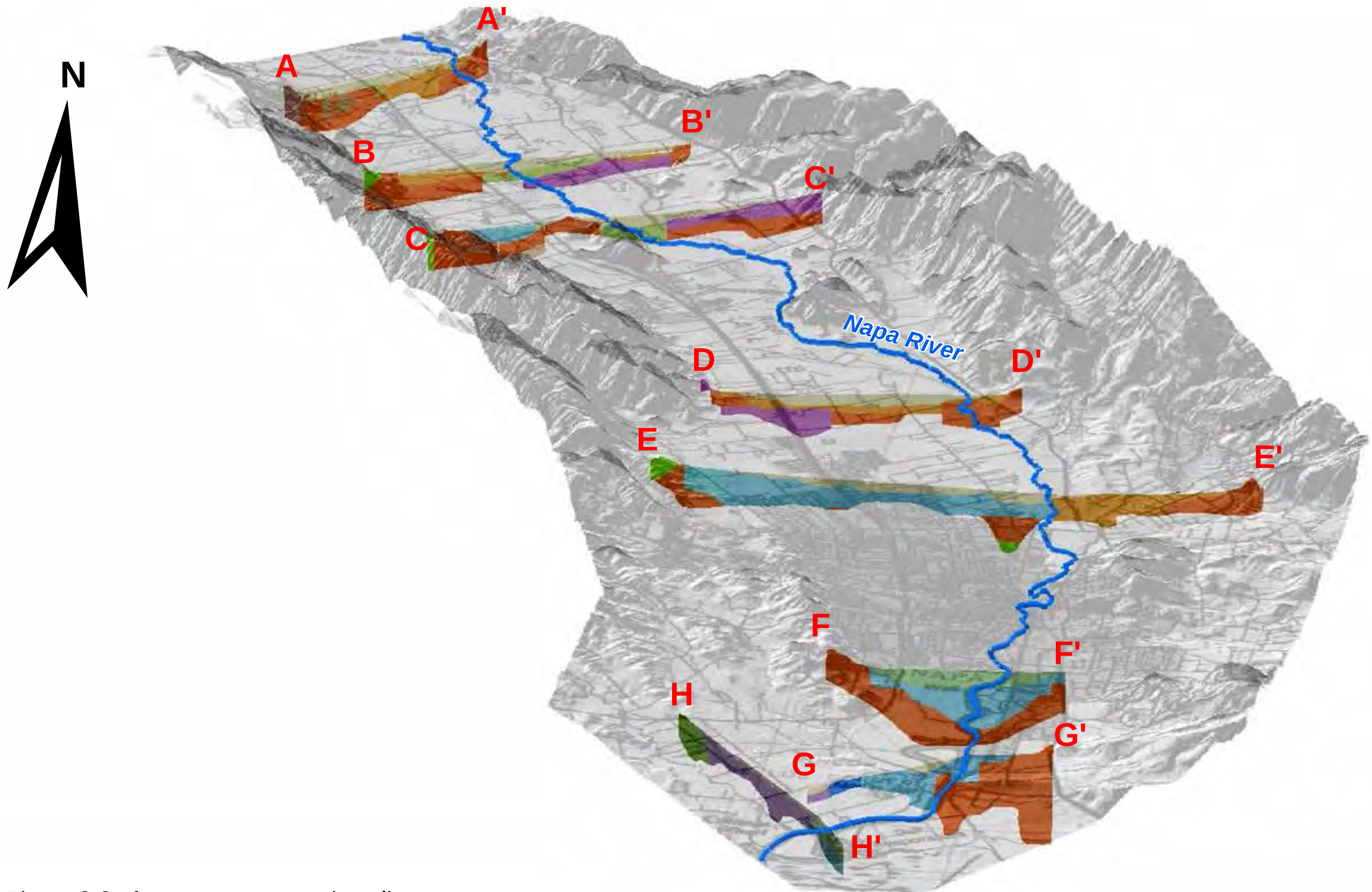
Figure 2-12
Cross Section G-G'
Carneros/Napa River Marshes/NVM-MST Subareas, Napa County, CA



See Figure 2-8a for exact cross section alignments.
See Figures 2-9 through 2-16 for individual cross sections.
Vertical Exaggeration = 3x

C:\Users\tnguyen.LSCEDOMAIN\Desktop\000\Job files\Napa County\gis\map files\2013\02\Napa Cross Section 3D.mxd

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Figure 2-13
Napa Valley Geologic Cross Section Fence Diagram

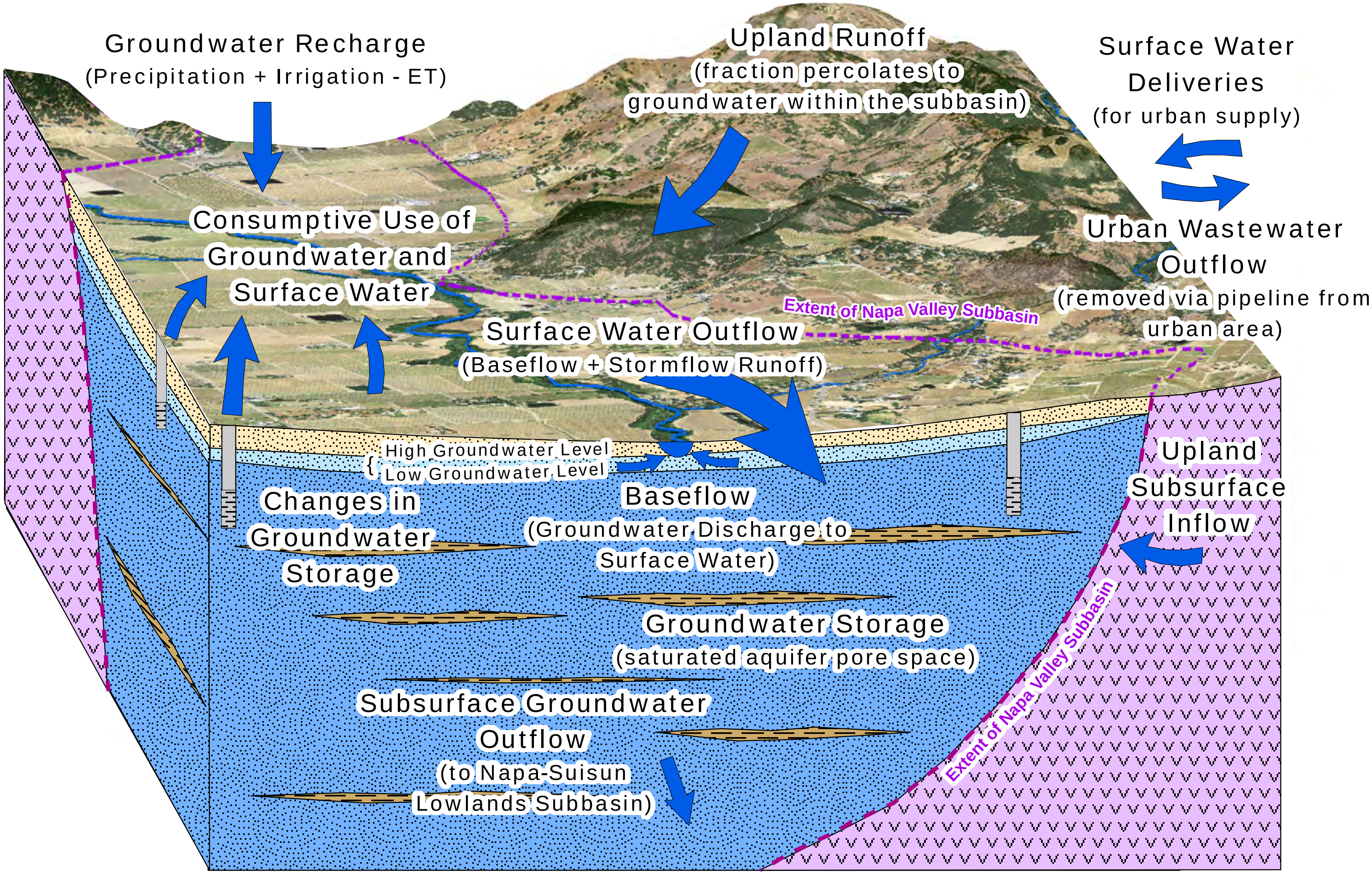

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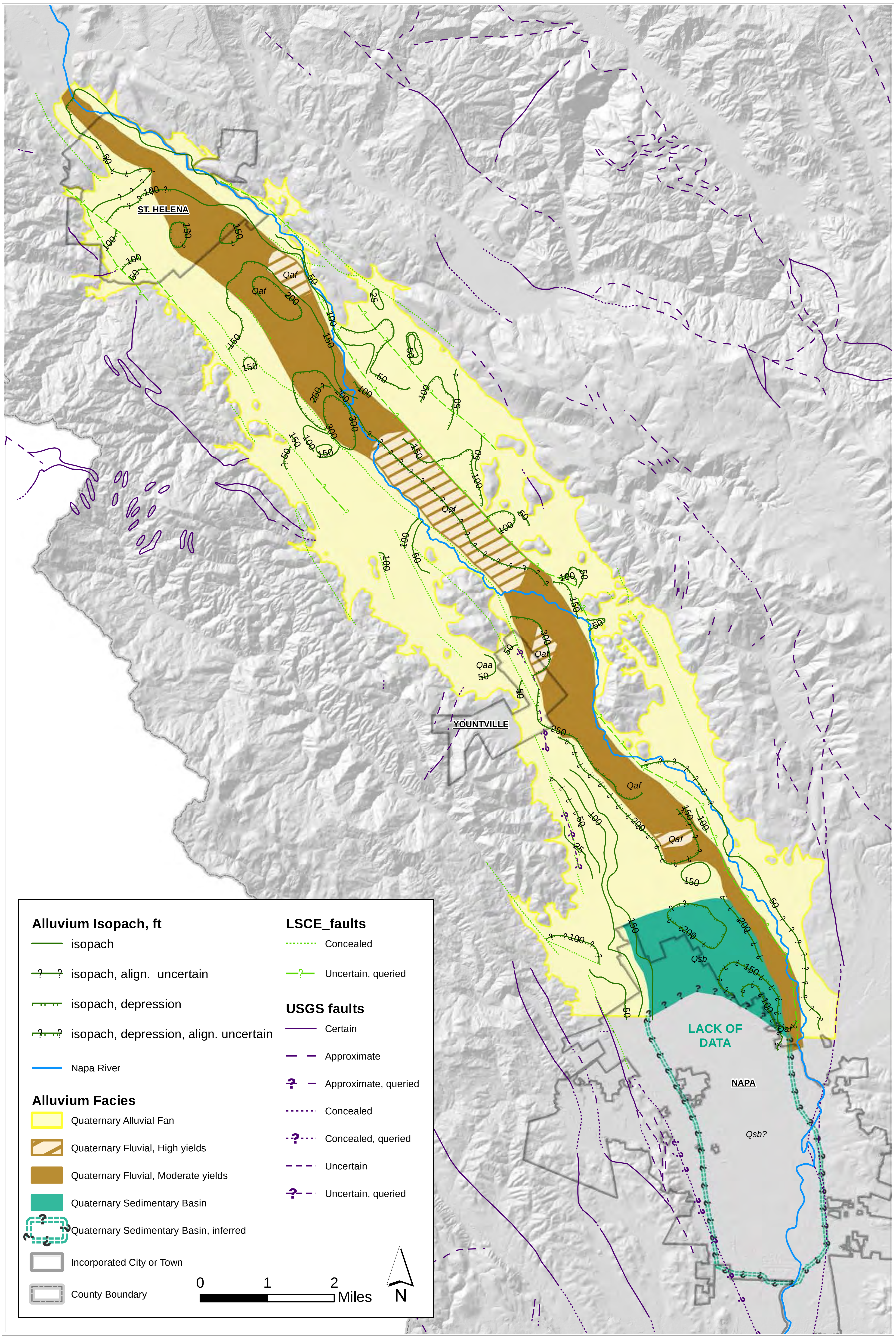
FIGURE 2-14
Schematic of Hydrogeologic Conceptual Model Components in the Napa Valley Subbasin

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



Document Path: X:\2011 Job Files\11-090\GIS\SubCrop Geology and Contours\isopach map.mxd

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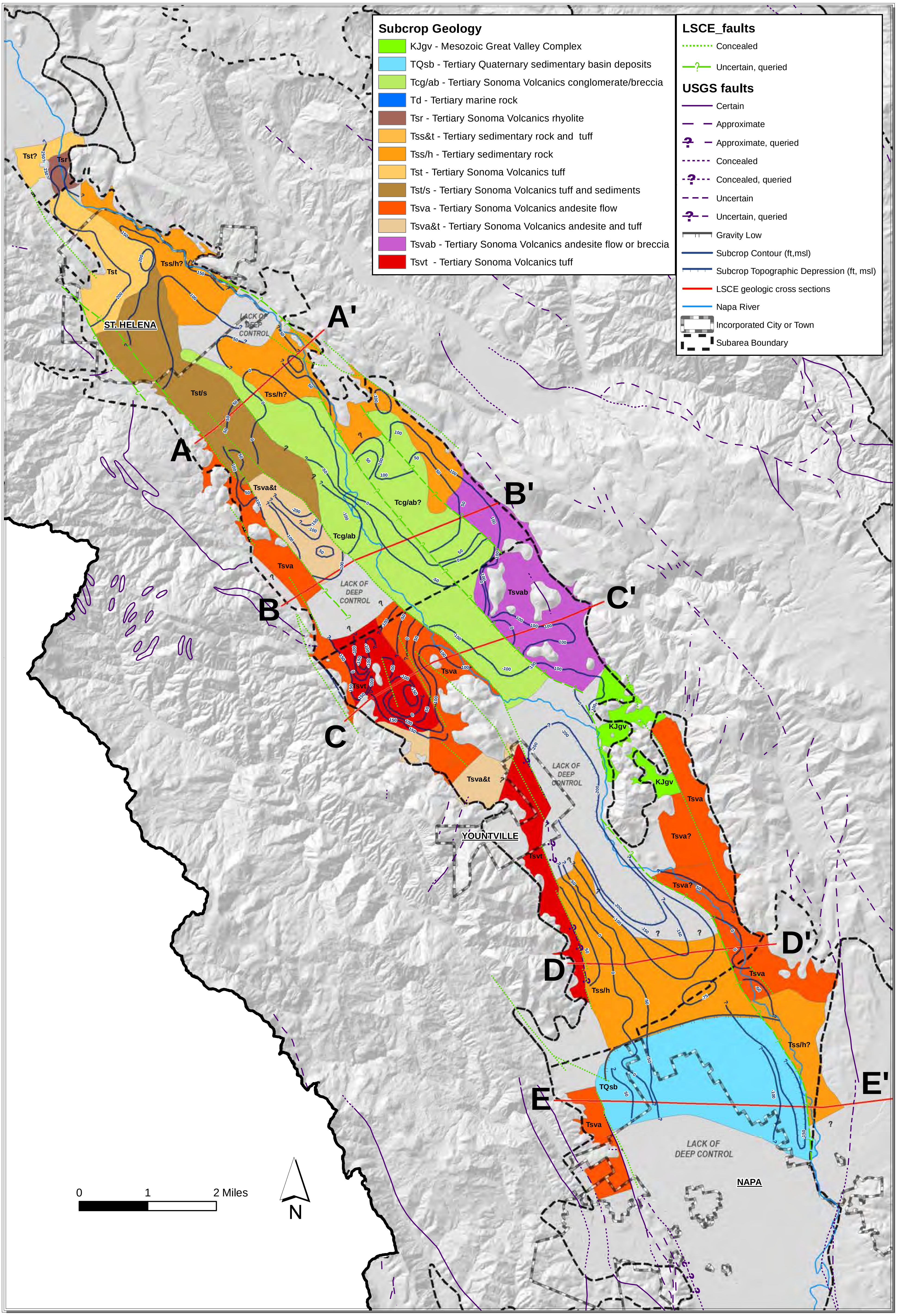
Figure 2-15
Napa Valley Floor Isopach and Facies Map of Alluvium

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



Document Path: X:\2011 Job Files\11-090\GIS\SubCrop Geology and Contours\structure contour map.mxd

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Figure 2-16
Napa Valley Floor Structure Contours and Pre-Alluvium Subcrop Geology

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin

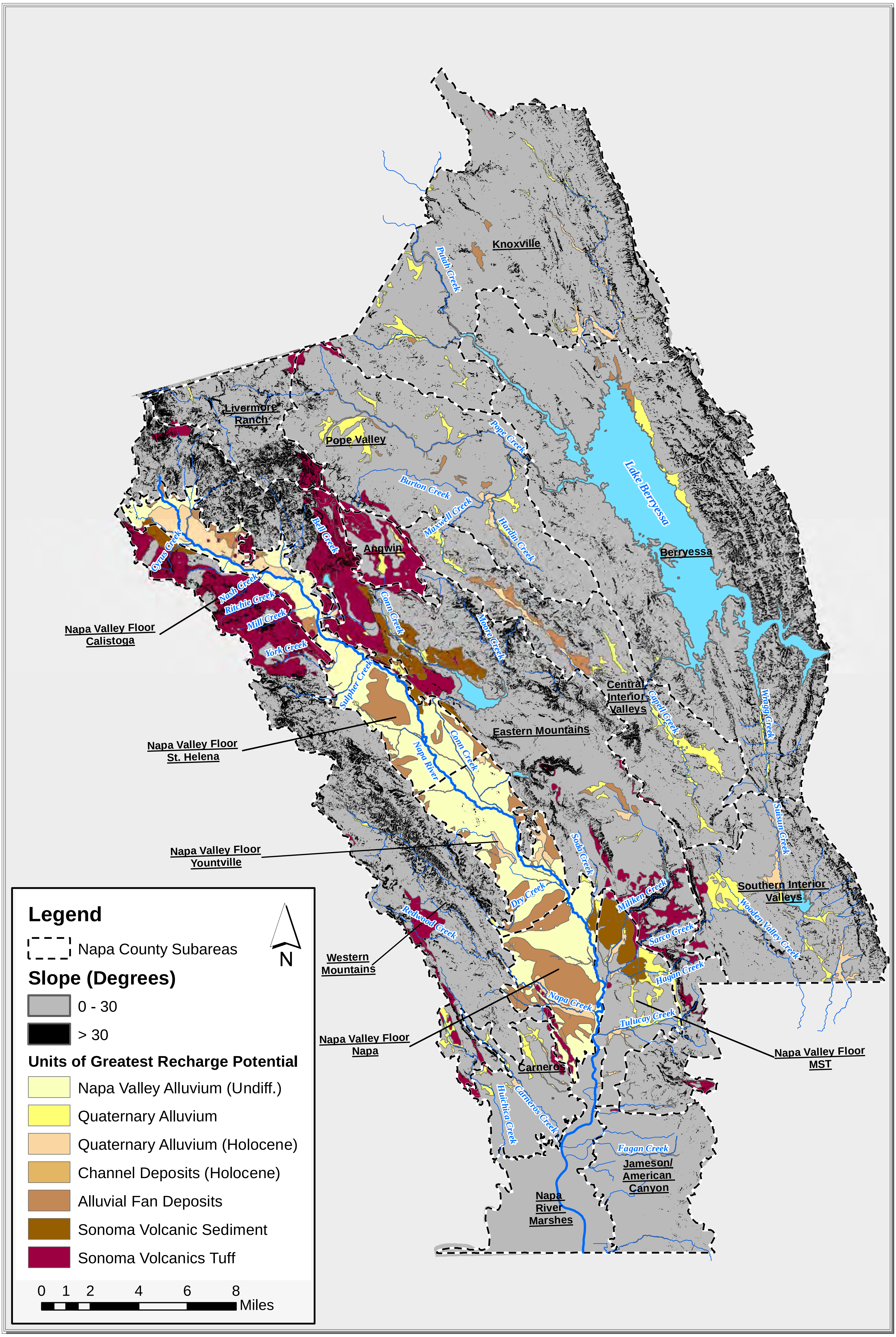

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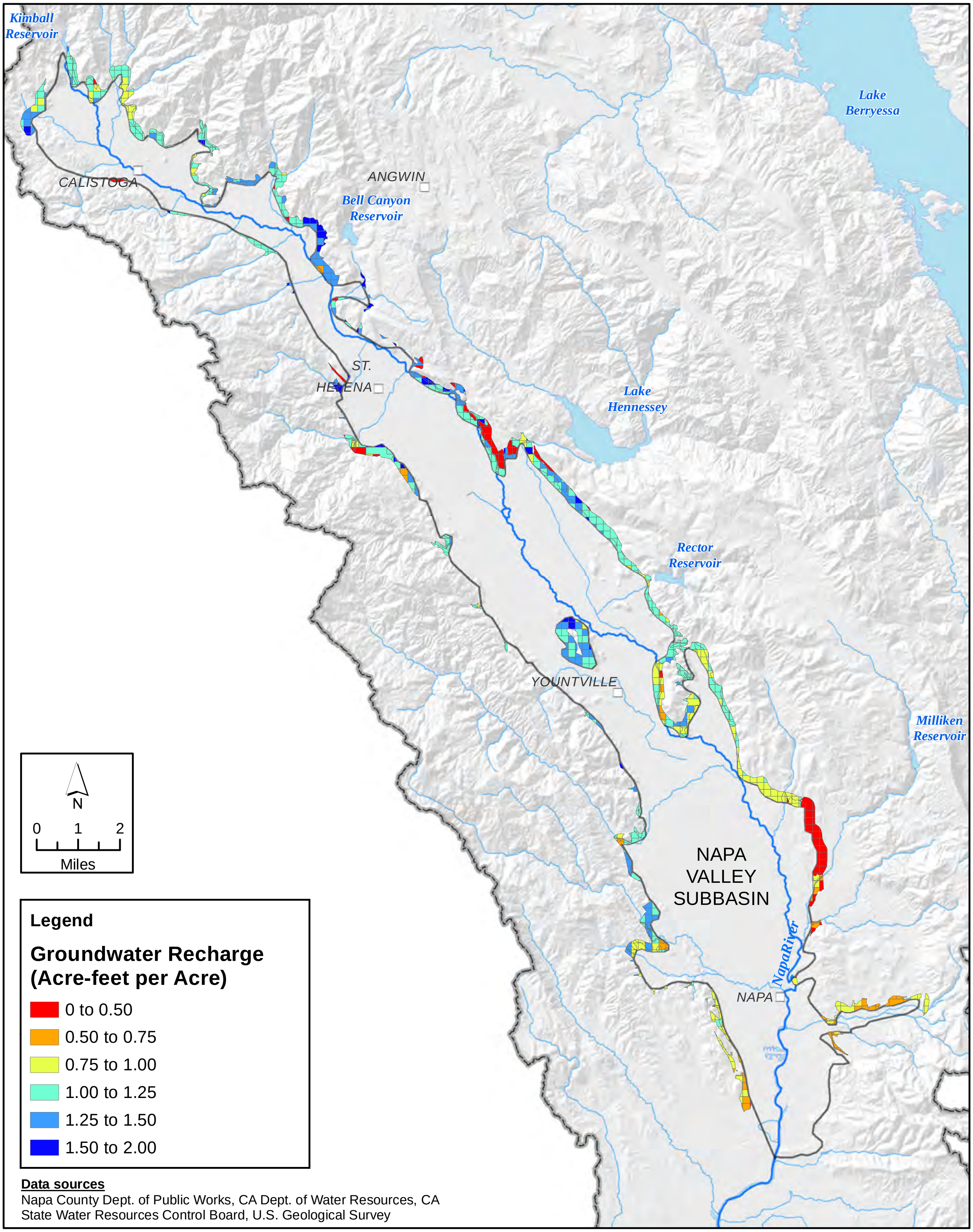
Figure 2-17
Geologic Units of Greatest Recharge Potential

Napa County, CA

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



Data sources
Napa County Dept. of Public Works, CA Dept. of Water Resources, CA State Water Resources Control Board, U.S. Geological Survey

X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 2-18 Uplands Subsurface Inflow.mxd

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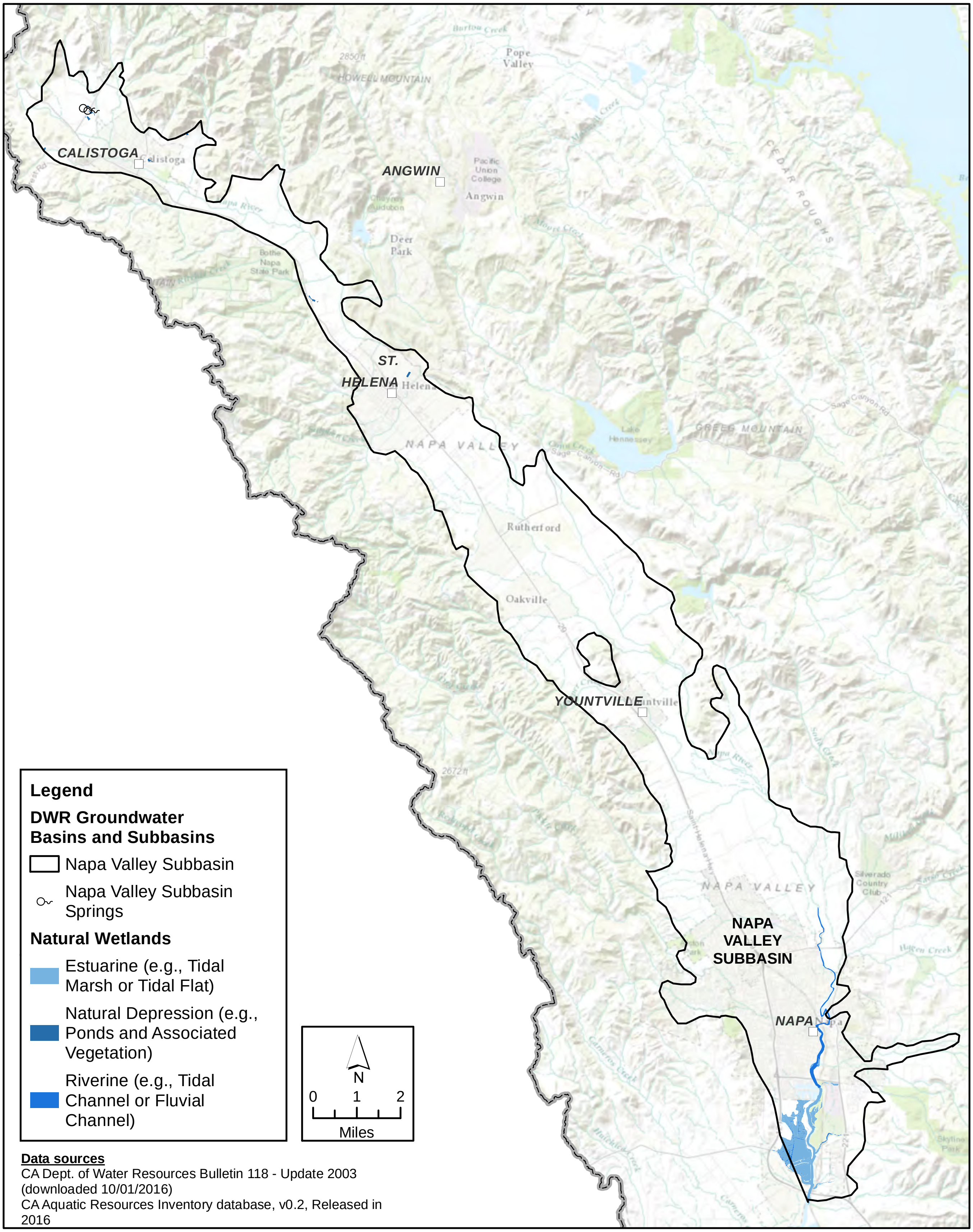
FIGURE 2-18
Upland Subsurface Inflow Example
Water Year 2005



Data sources
CA Dept. of Water Resources Bulletin 118 - Update 2003 (downloaded 10/01/2016)
CA Aquatic Resources Inventory database, v0.2, Released in 2016

X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 2-19 Napa Valley Subbasin Groundwater Discharge Areas.mxd

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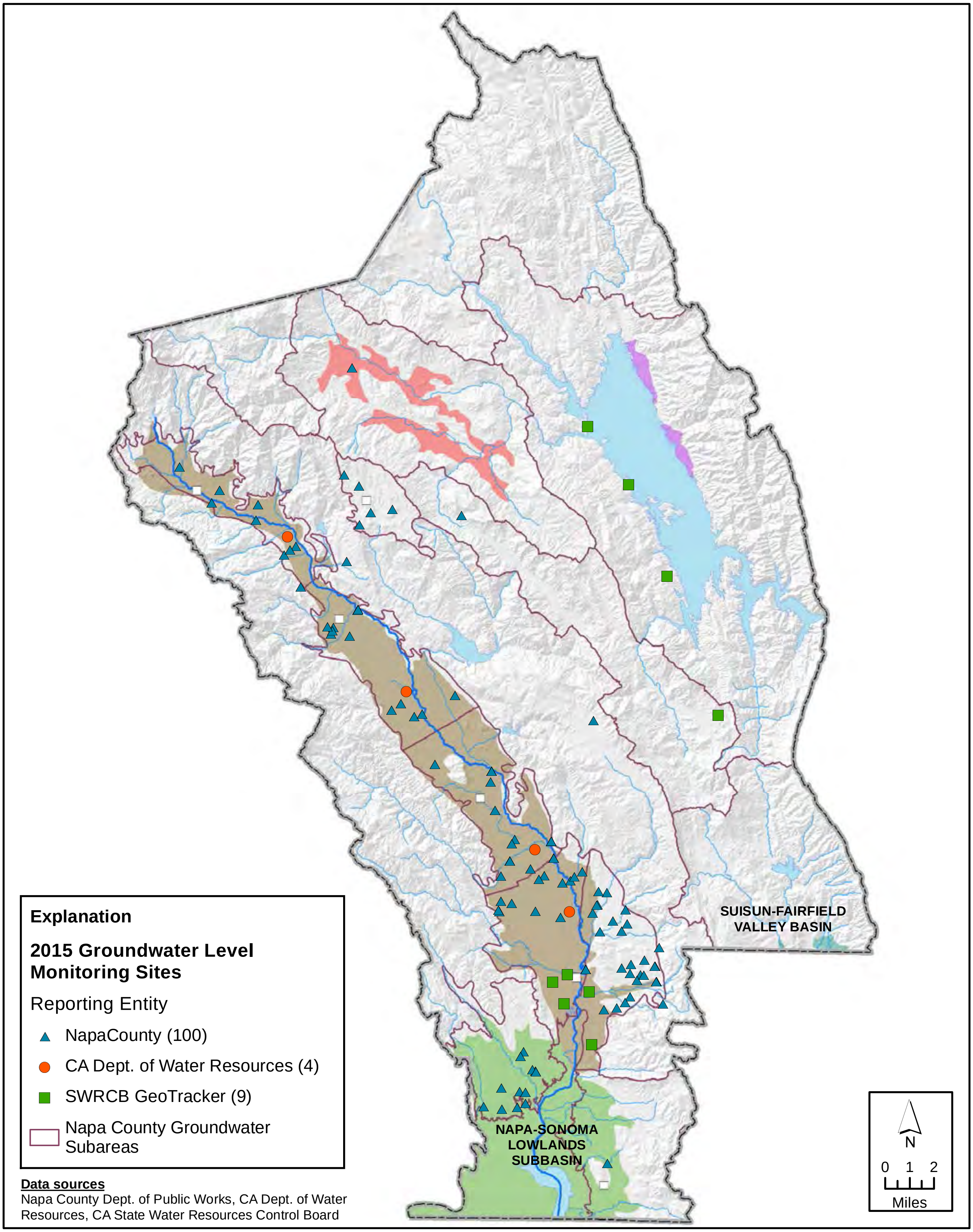
FIGURE 2-19
Napa Valley Subbasin Groundwater Discharge Areas



X:\2014 Job Files\14-108\GIS\Mapfiles\Annual Report\2015 Current GWL Monitoring Sites by Entity.mxd

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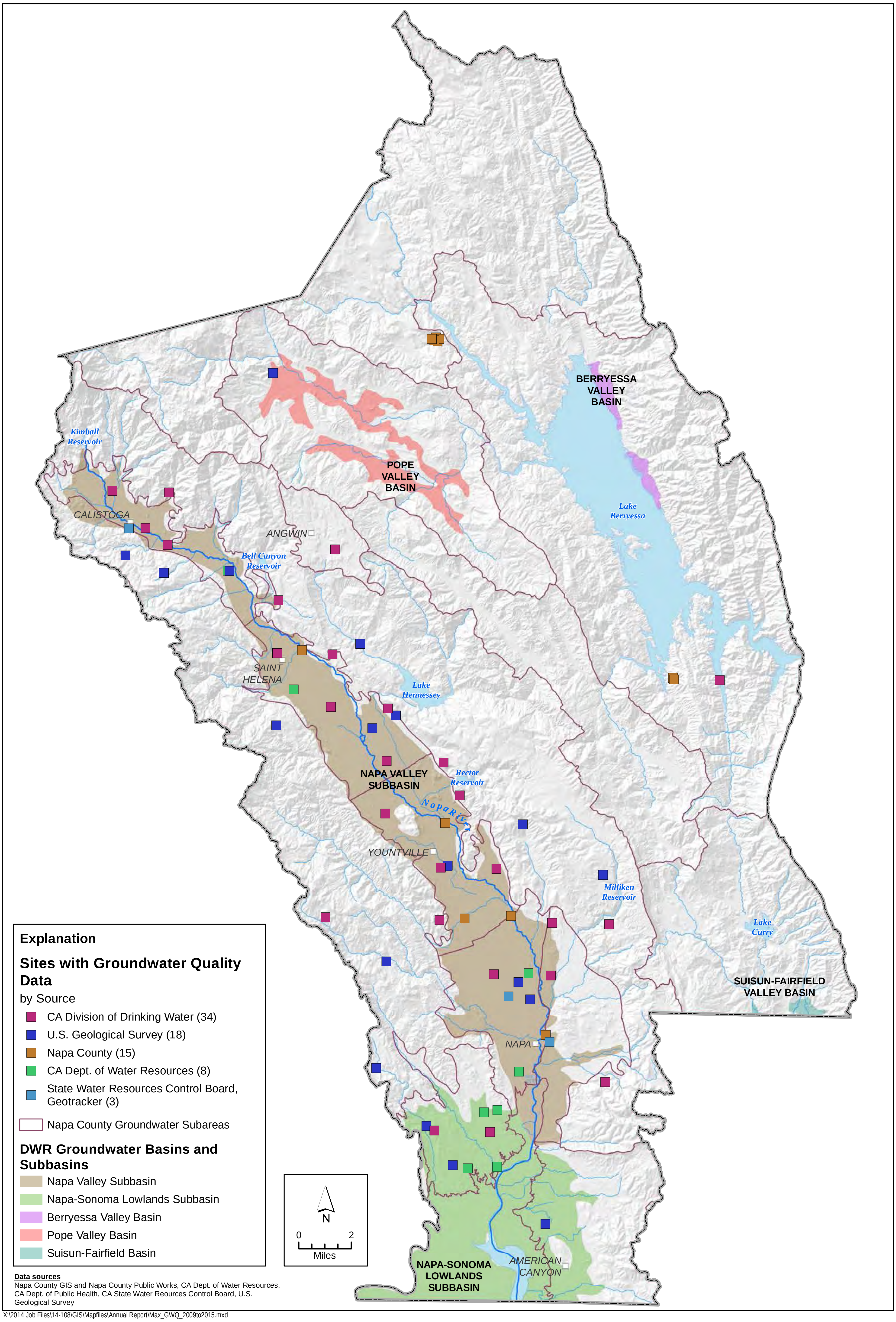
FIGURE 3-1

Current Groundwater Level Monitoring Sites by Reporting Entity

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Annual Report\Max_GWQ_2009to2015.mxd

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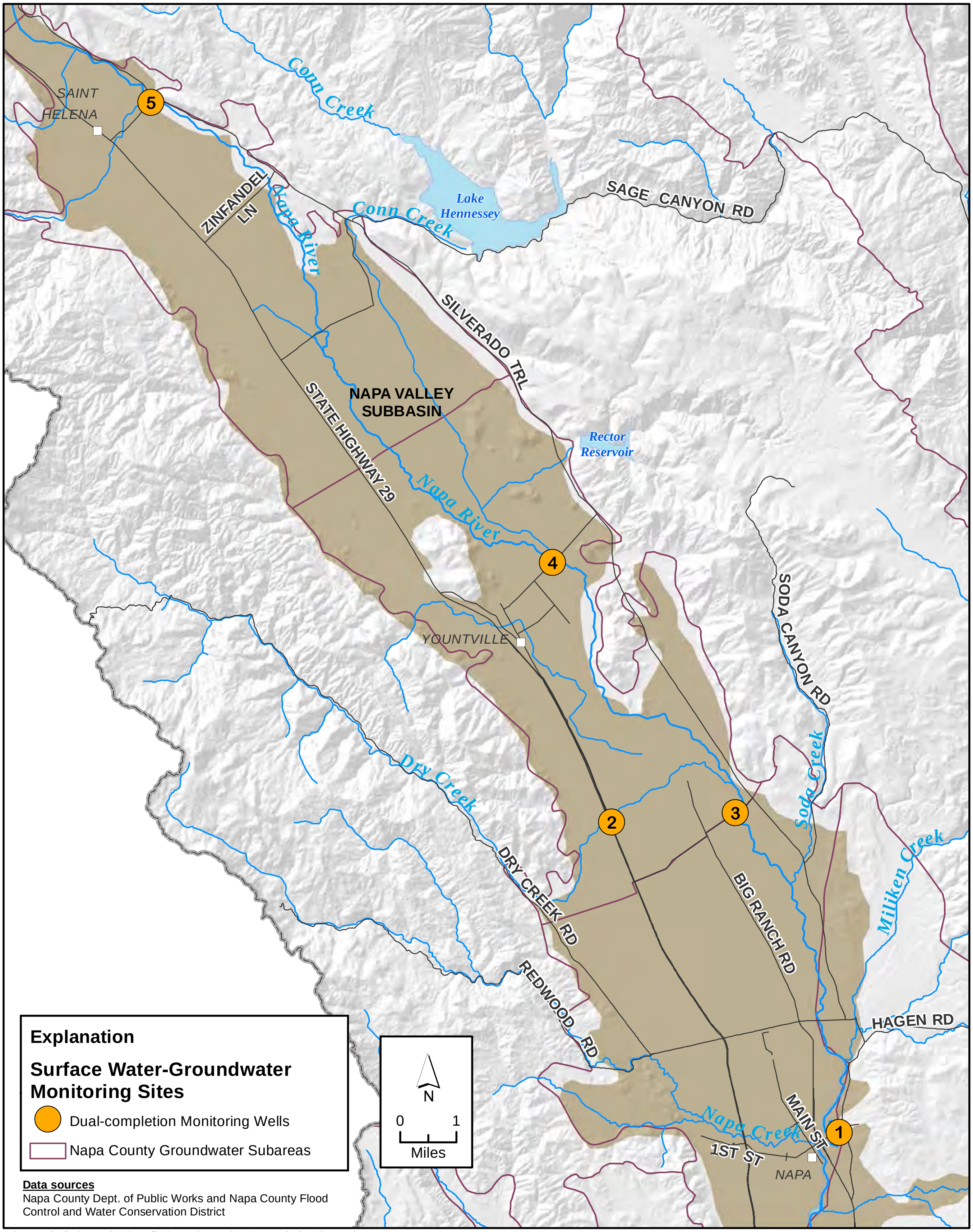
FIGURE 3-2
Groundwater Quality Sites, 2009 - 2015
Napa County, CA

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Annual Report\SWGW Monitoring Sites.mxd

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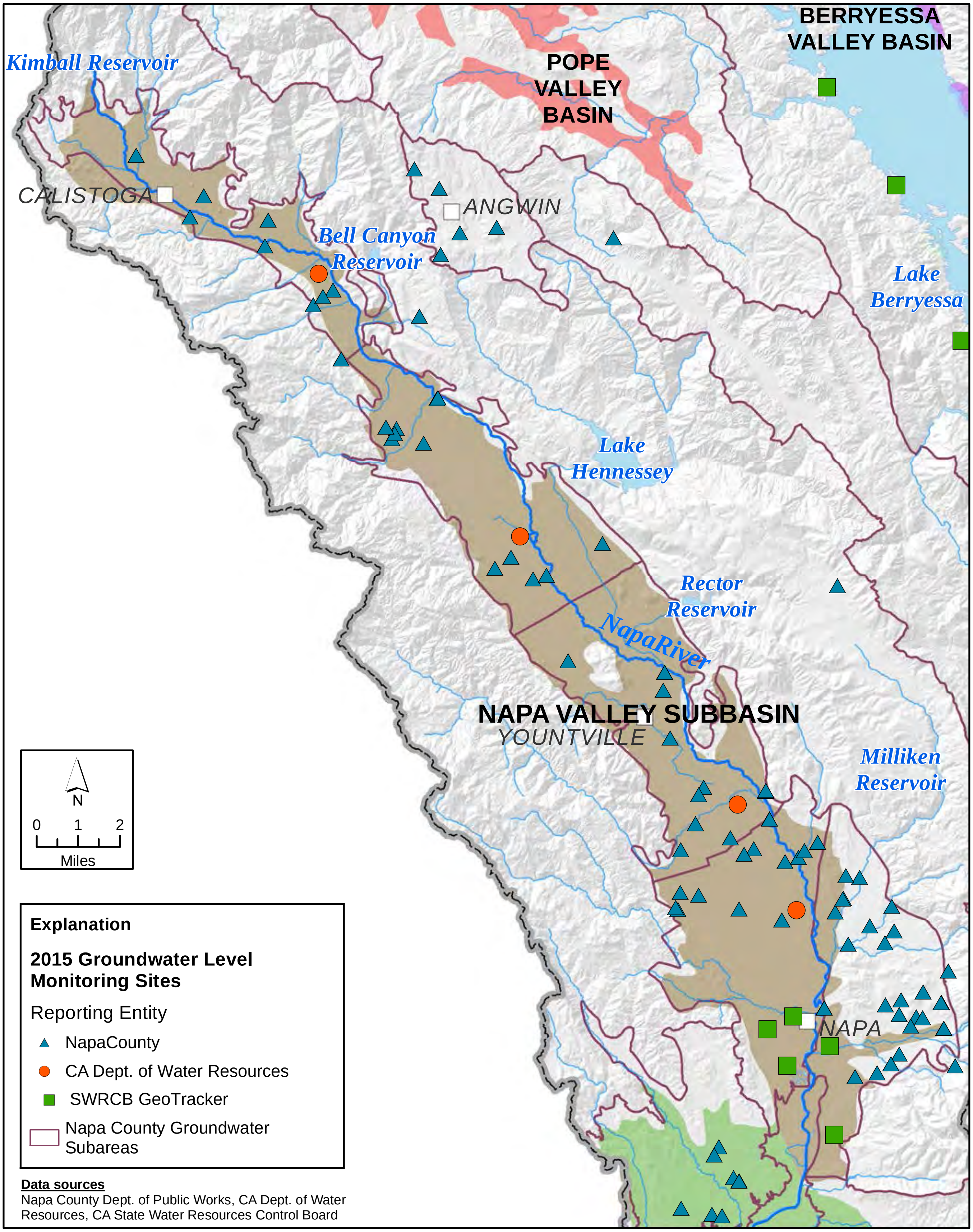
FIGURE 3-3
Napa County Surface Water-Groundwater Monitoring Sites



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 4-1 2015 GWL Monitoring Sites by Entity.mxd

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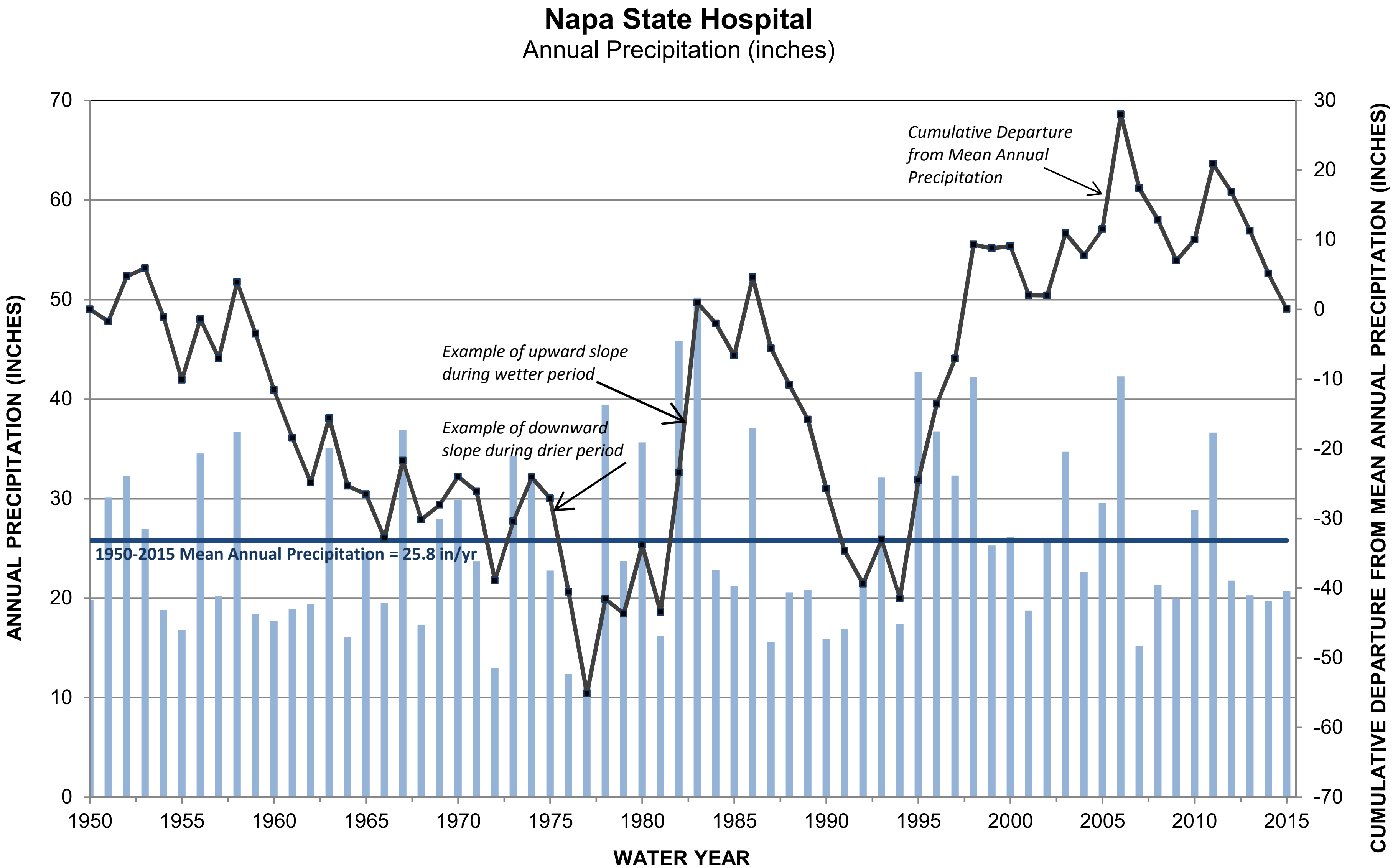
FIGURE 4-1
2015 Groundwater Level Monitoring Sites by Reporting Entity

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



NOTE: Gaps in this data record have been reconstructed using data from the Oakville CIMIS station (77) and NOAA Saint Helena, CA US station (GHCND:USC0004764).

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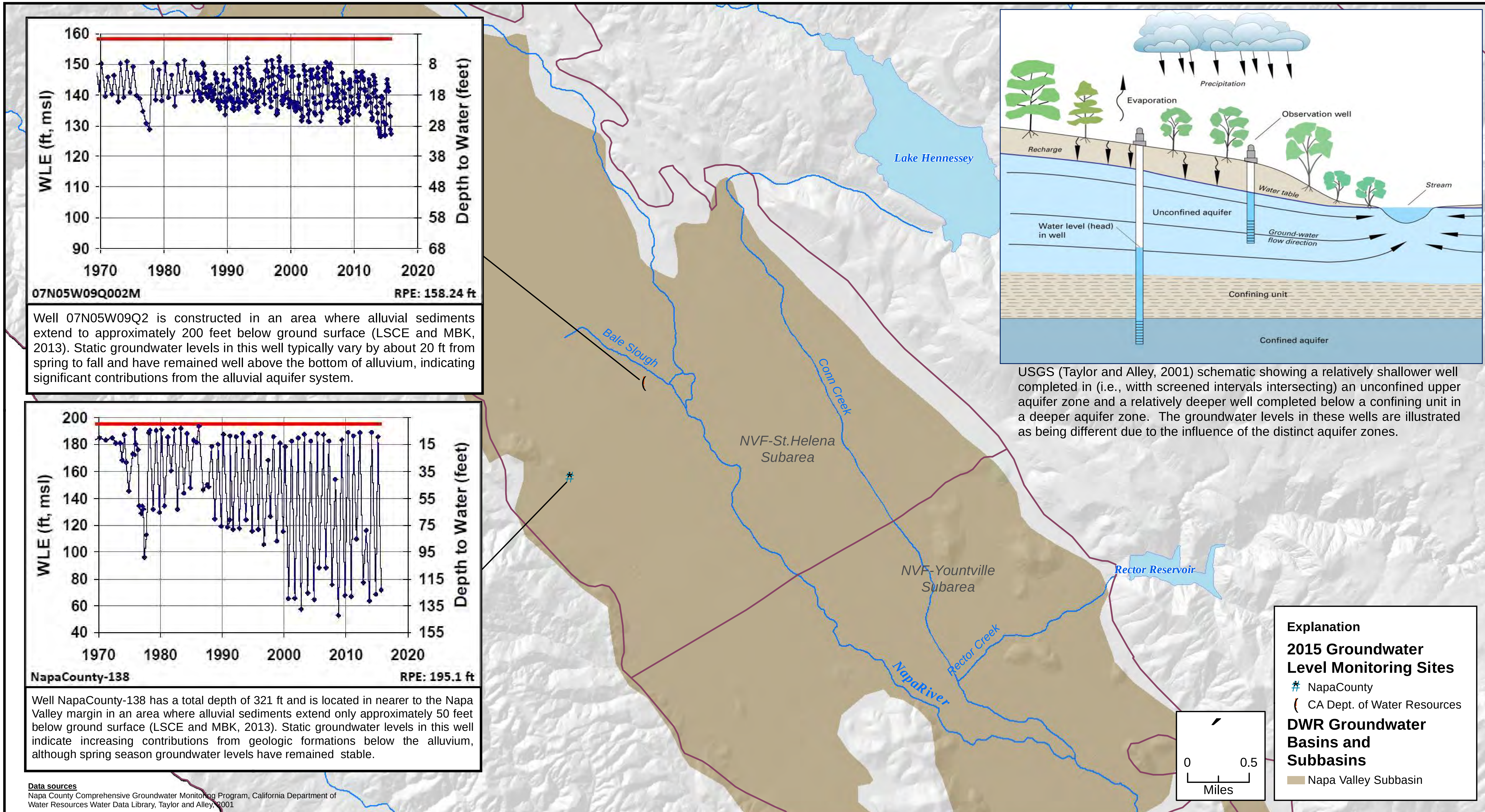
Figure 4-2
Napa State Hospital Water Year Precipitation and Cumulative Departure , Water Years 1950 - 2015



Path: X:\2014 Job Files\14-108\GIS\Mapfiles\Figure 5-2_Aq_zone_schematic 11_17_20160315.mxd

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FIGURE 4-3a

Southern St. Helena Subarea Aquifer Zone Schematic and Representative Hydrographs

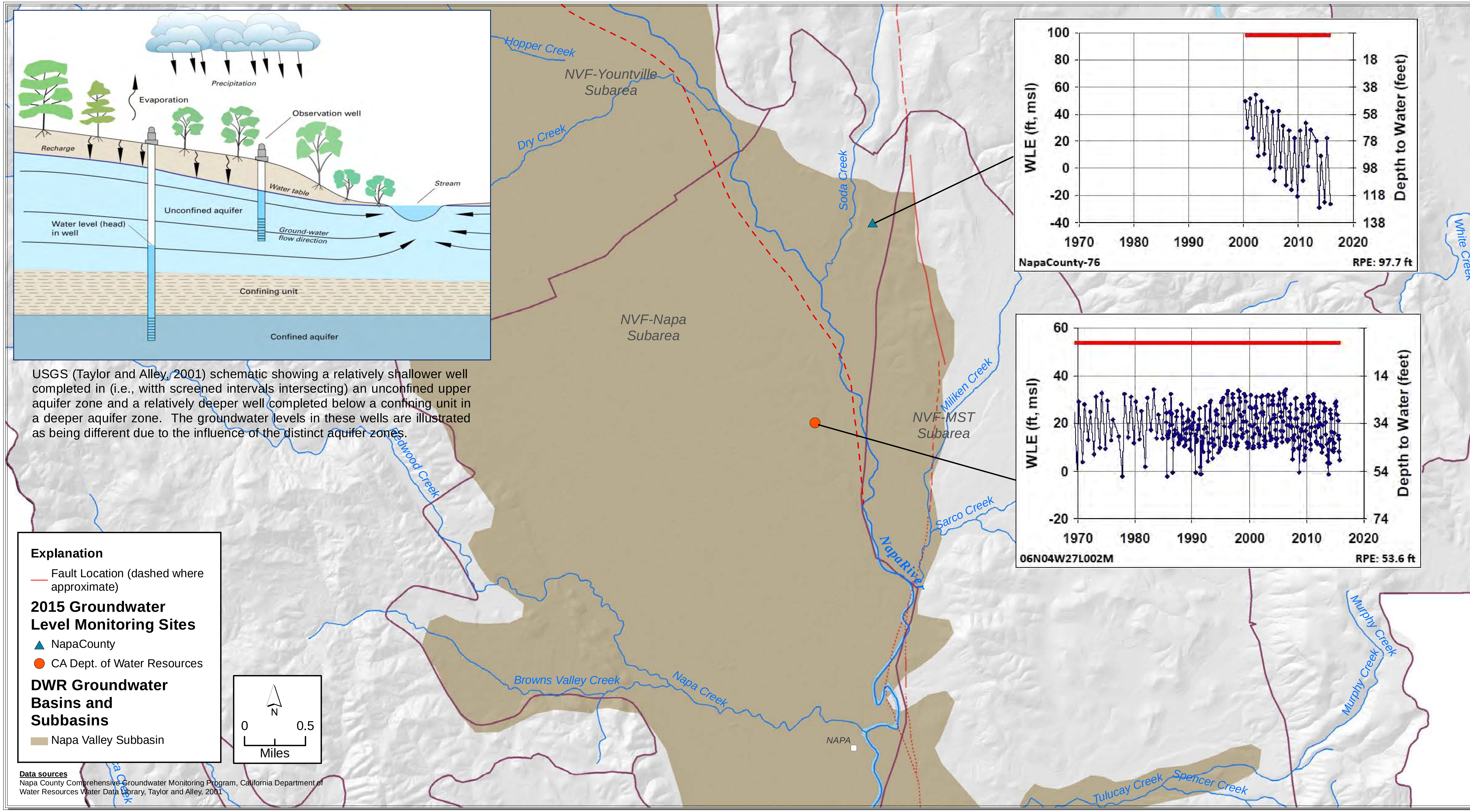

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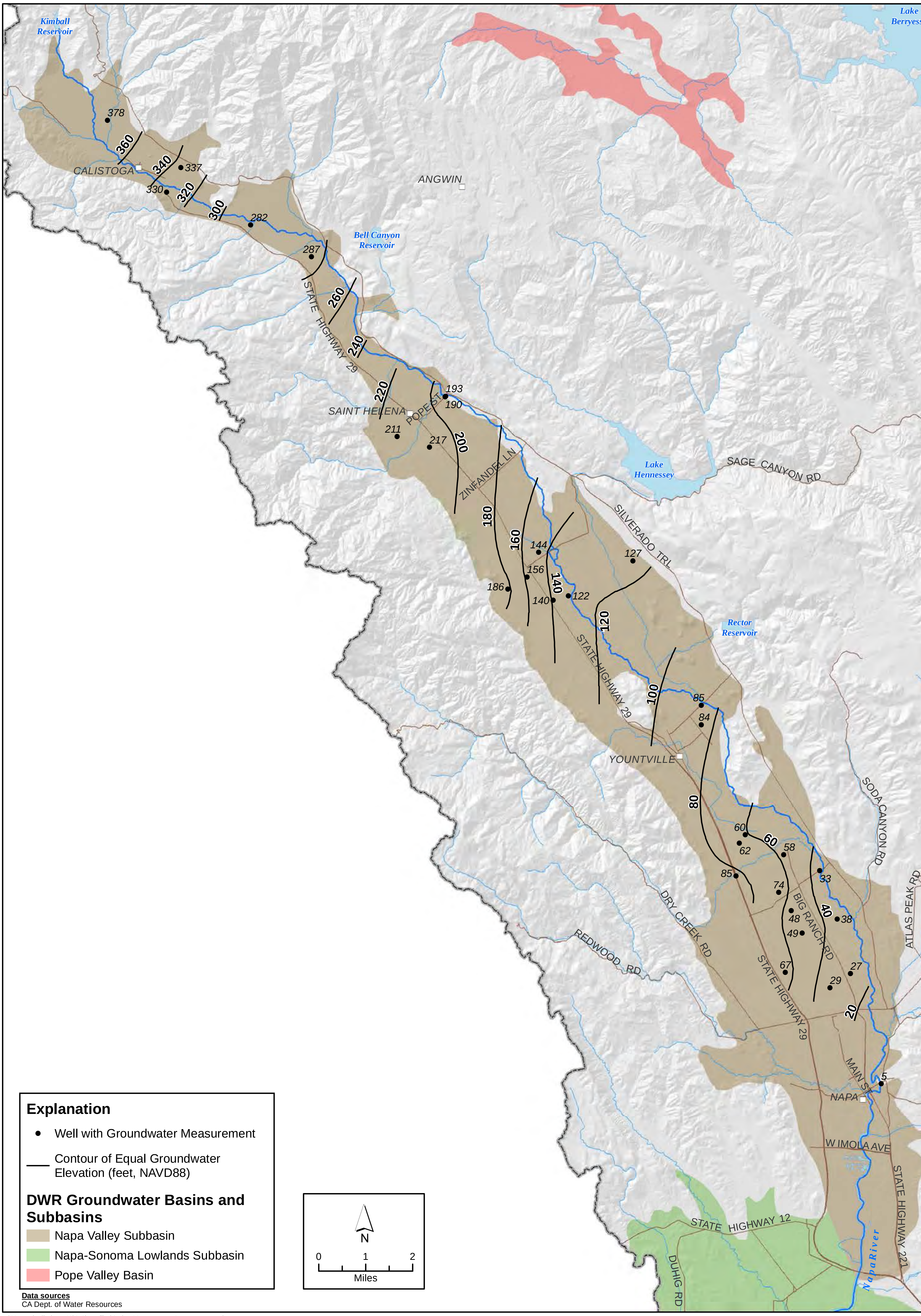
FIGURE 4-3b

Northeast Napa Subarea Aquifer Zone Schematic and Representative Hydrographs

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Spring 2015 NVF WL Contour Map.mxd

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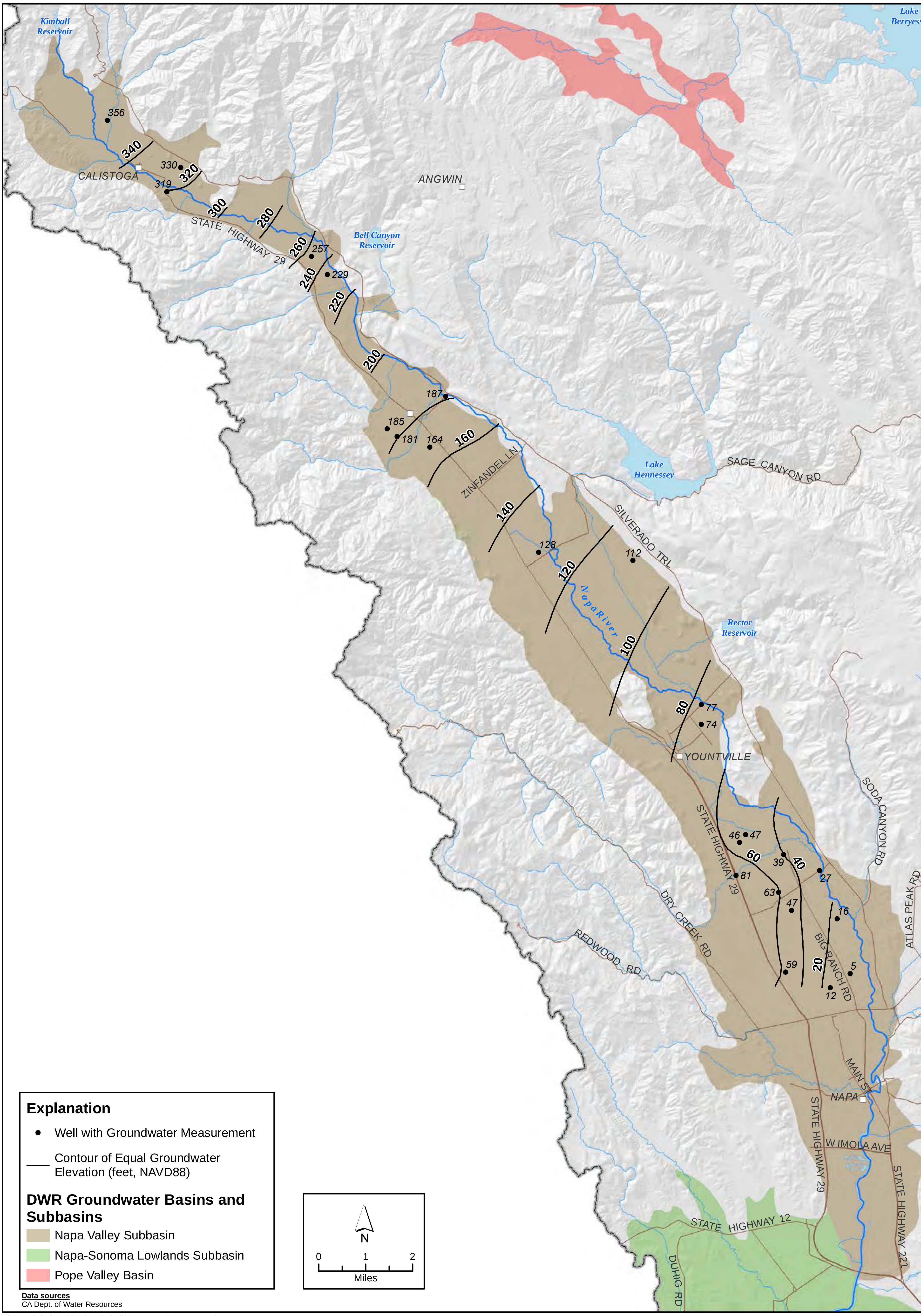
FIGURE 4-4

Contours of Equal Groundwater Elevation, Spring 2015
Napa Valley Subbasin, Napa County, CA

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Fall 2015 NVF WL Contour Map.mxd

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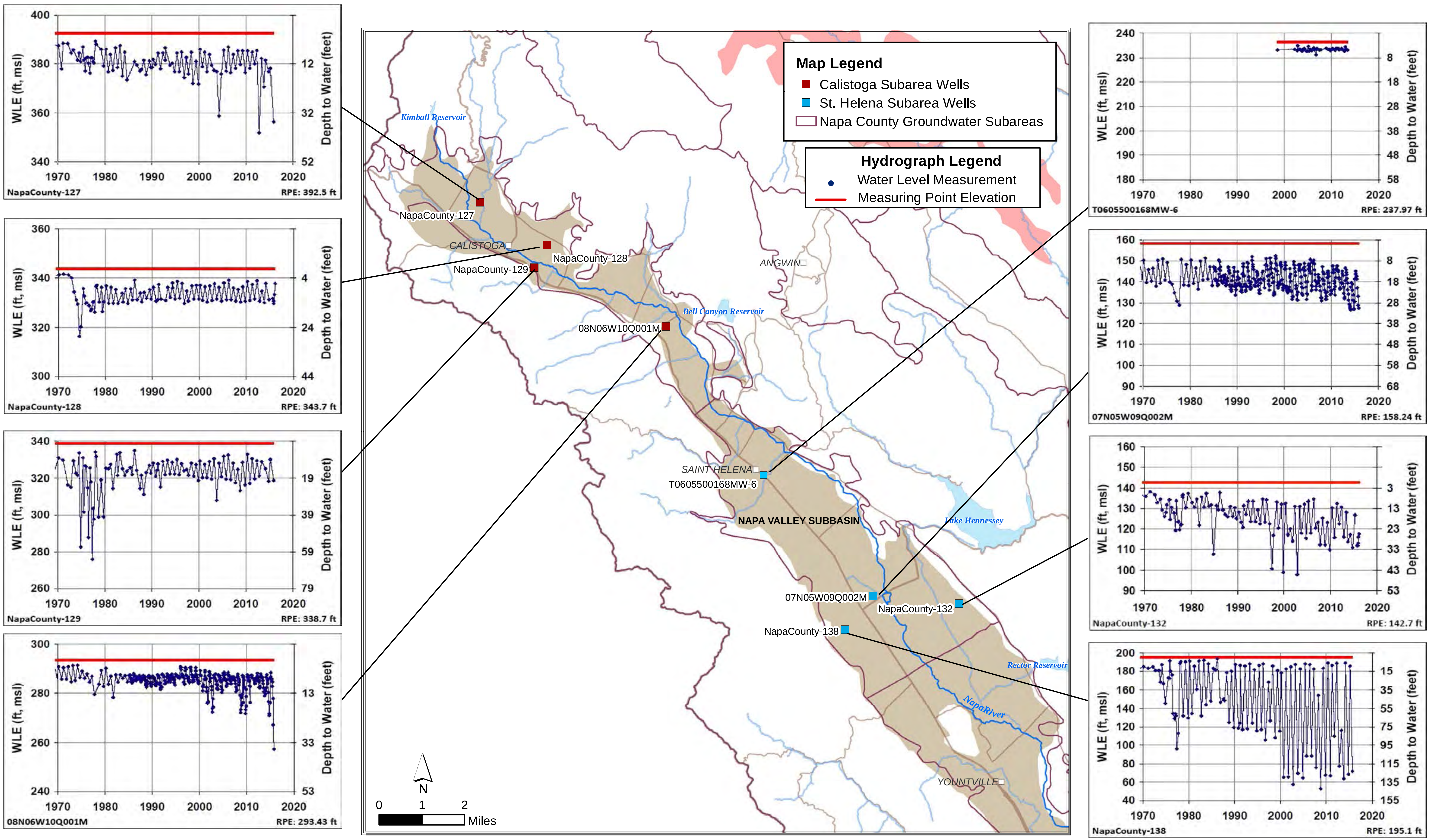
FIGURE 4-5
Contours of Equal Groundwater Elevation, Fall 2015
Napa Valley Floor, Napa County, CA

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



Path: X:\2014 Job Files\14-108\GIS\Mapfiles\Annual Report\HydrographNorthernNapaValley_thru2015.mxd

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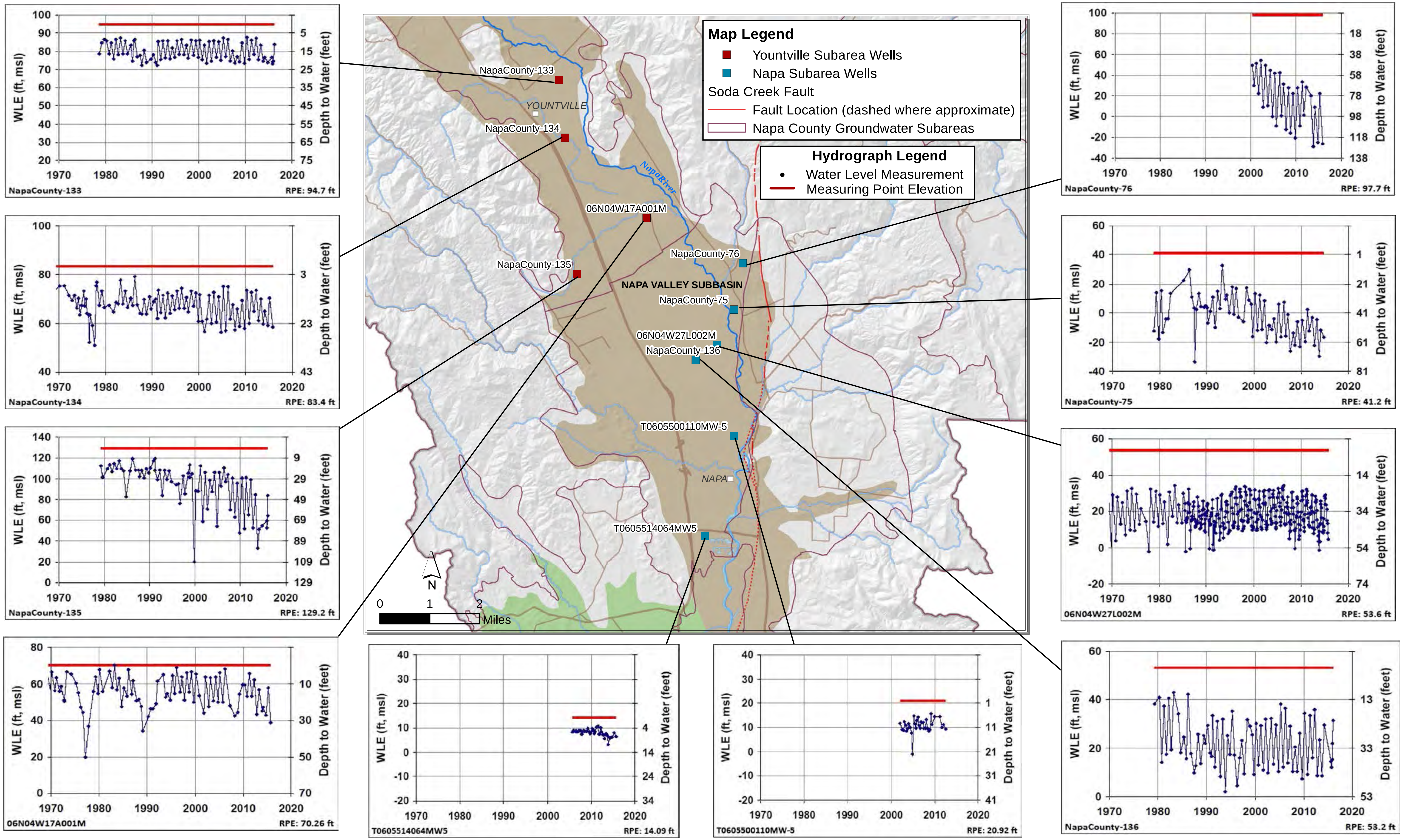
FIGURE 4-6
Representative Groundwater Hydrographs Northern Napa Valley

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin



Path: X:\2014 Job Files\14-108\GIS\Mapfiles\Annual Report\Hydrograph_SouthernNapaValley.mxd

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FIGURE 4-7
Representative Groundwater Hydrographs Southern Napa Valley

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

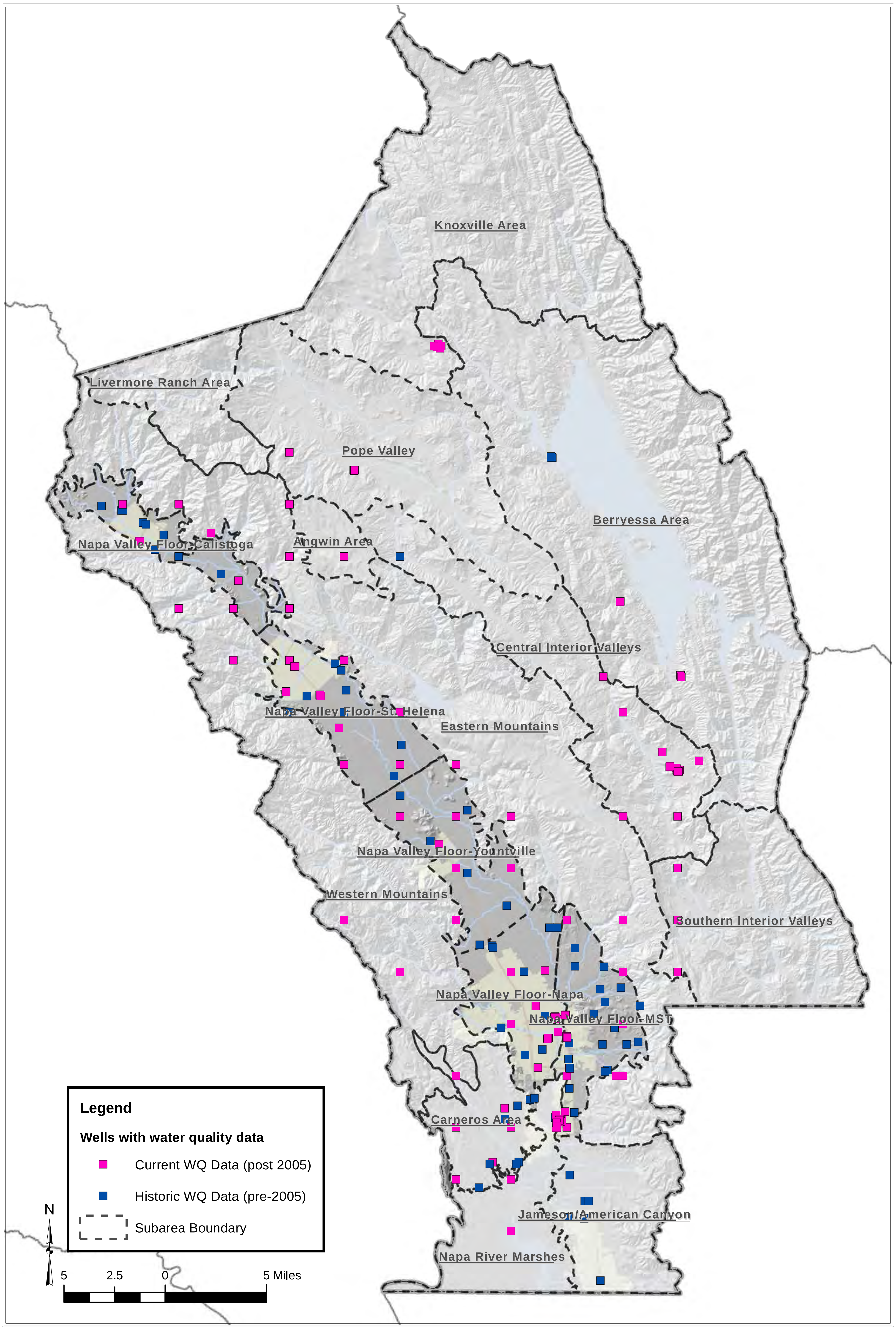

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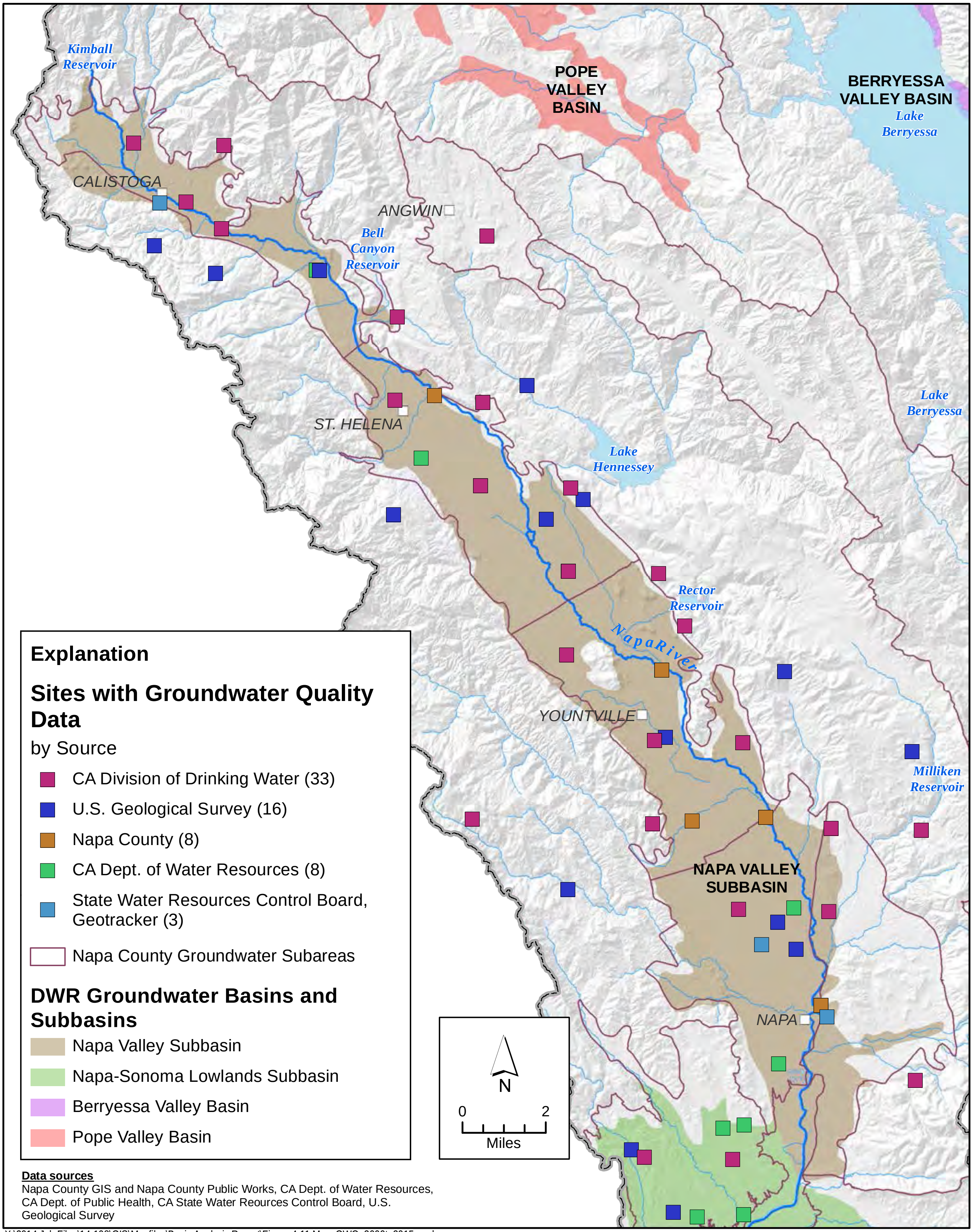
Figure 4-8
Well Location Map of Wells with Water Quality Data in Napa County

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 4-11 Max_GWQ_2009to2015.mxd

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FIGURE 4-9
Groundwater Quality Sites, 2009 - 2015
Napa County, CA

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin

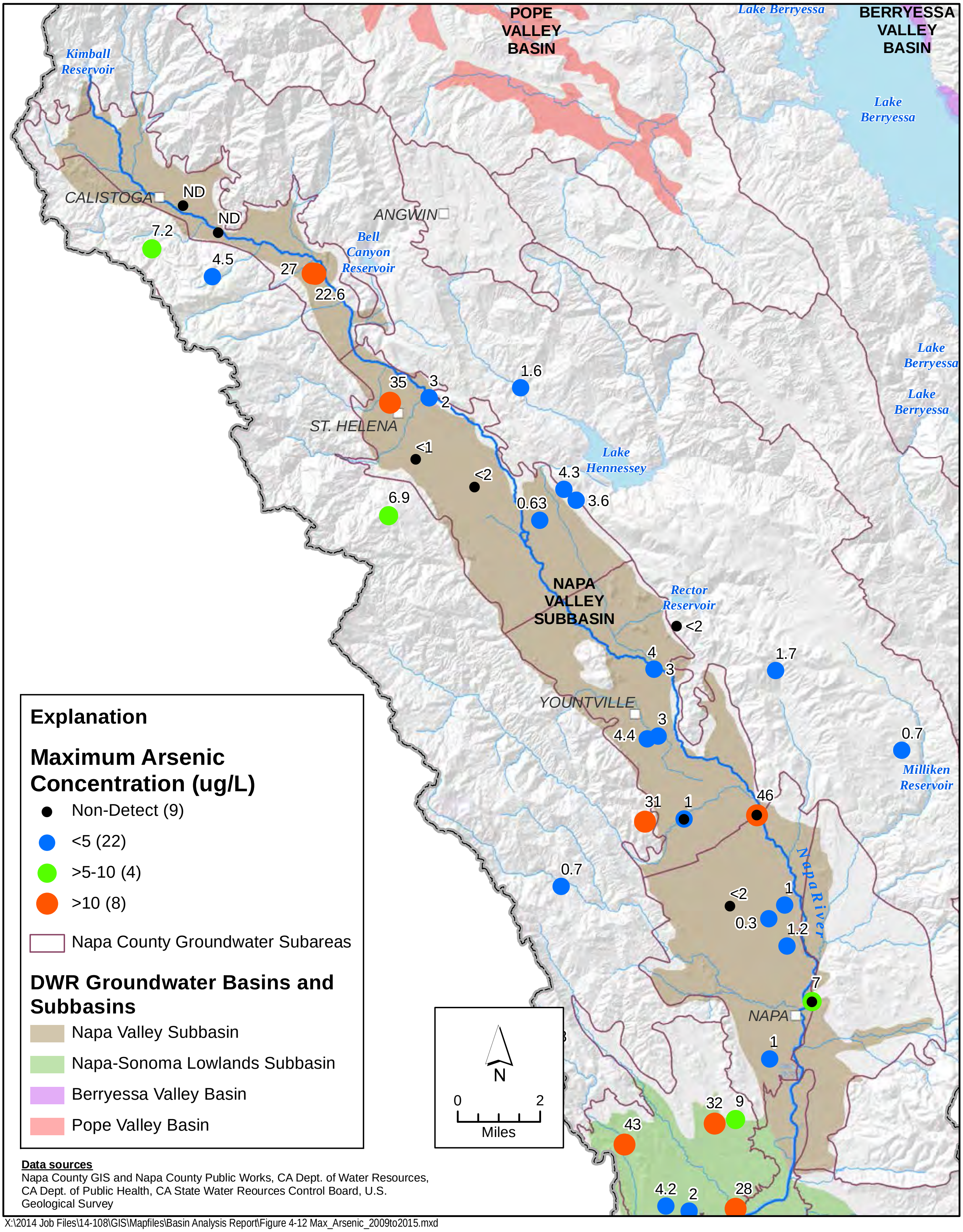

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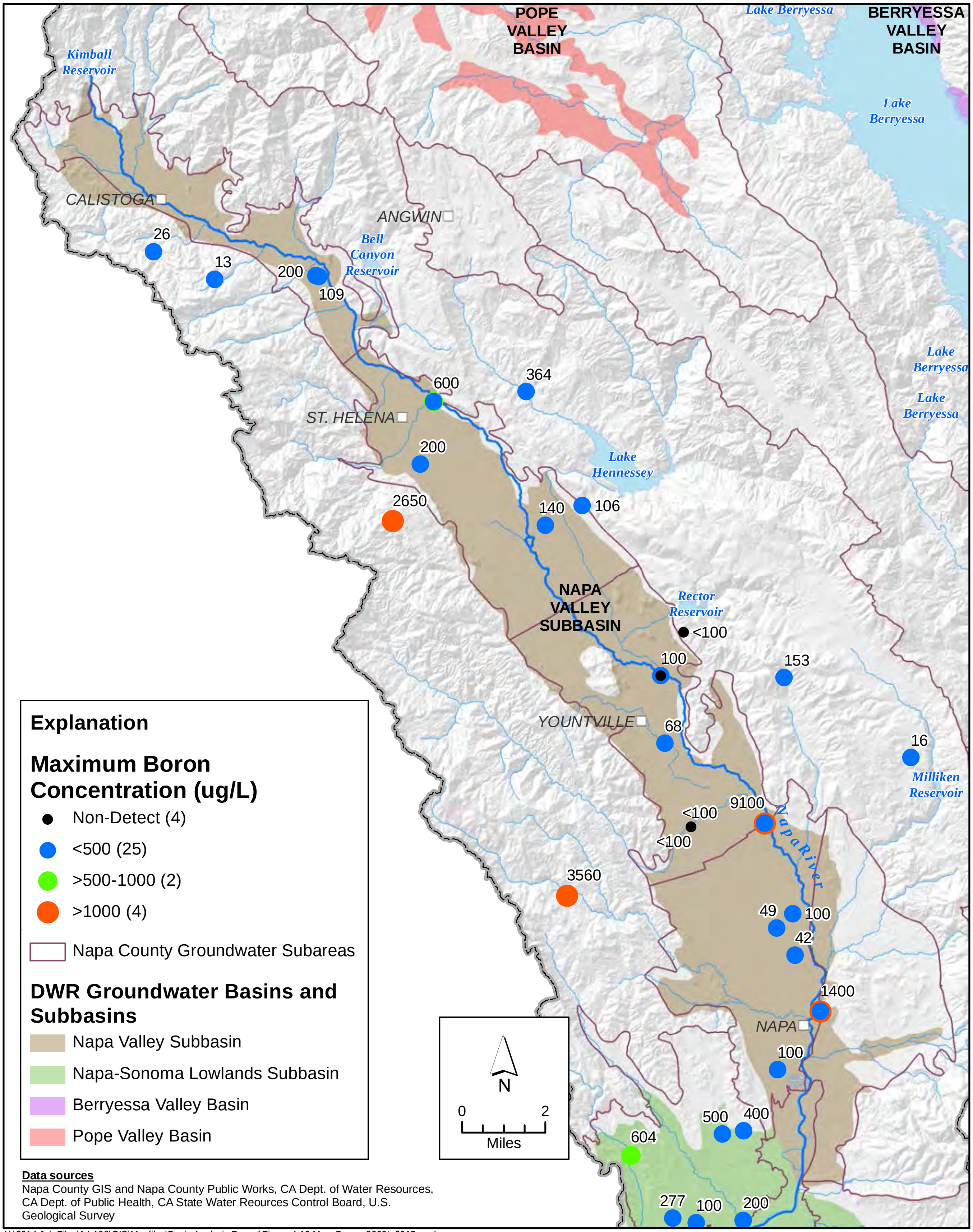
FIGURE 4-10

Maximum Arsenic Concentrations in GW, 2009 - 2015
Napa County, CA



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 4-13 Max_Boron_2009to2015.mxd

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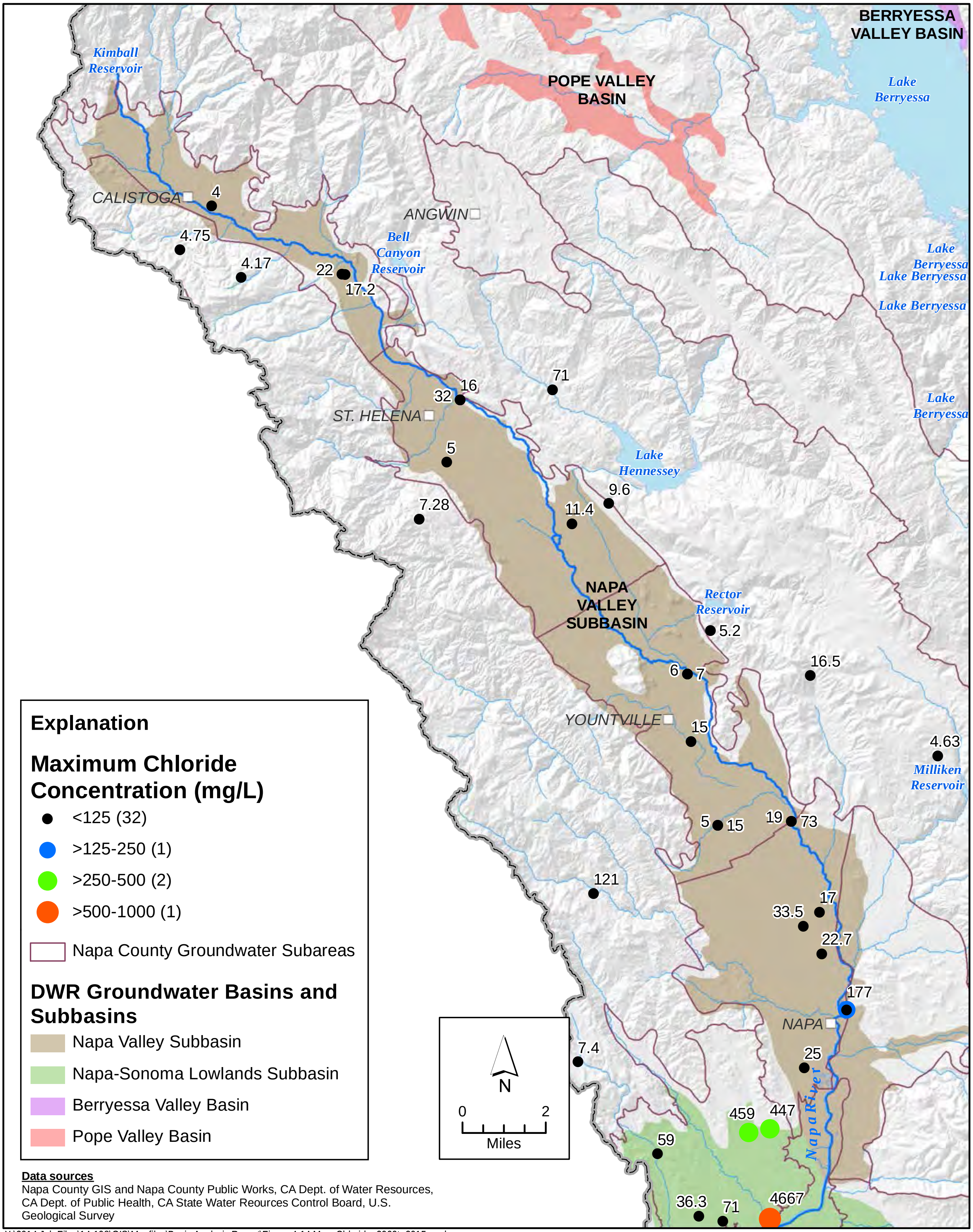
FIGURE 4-11

Maximum Boron Concentrations in GW, 2009 - 2015
Napa County, CA

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 4-14 Max_Chloride_2009to2015.mxd

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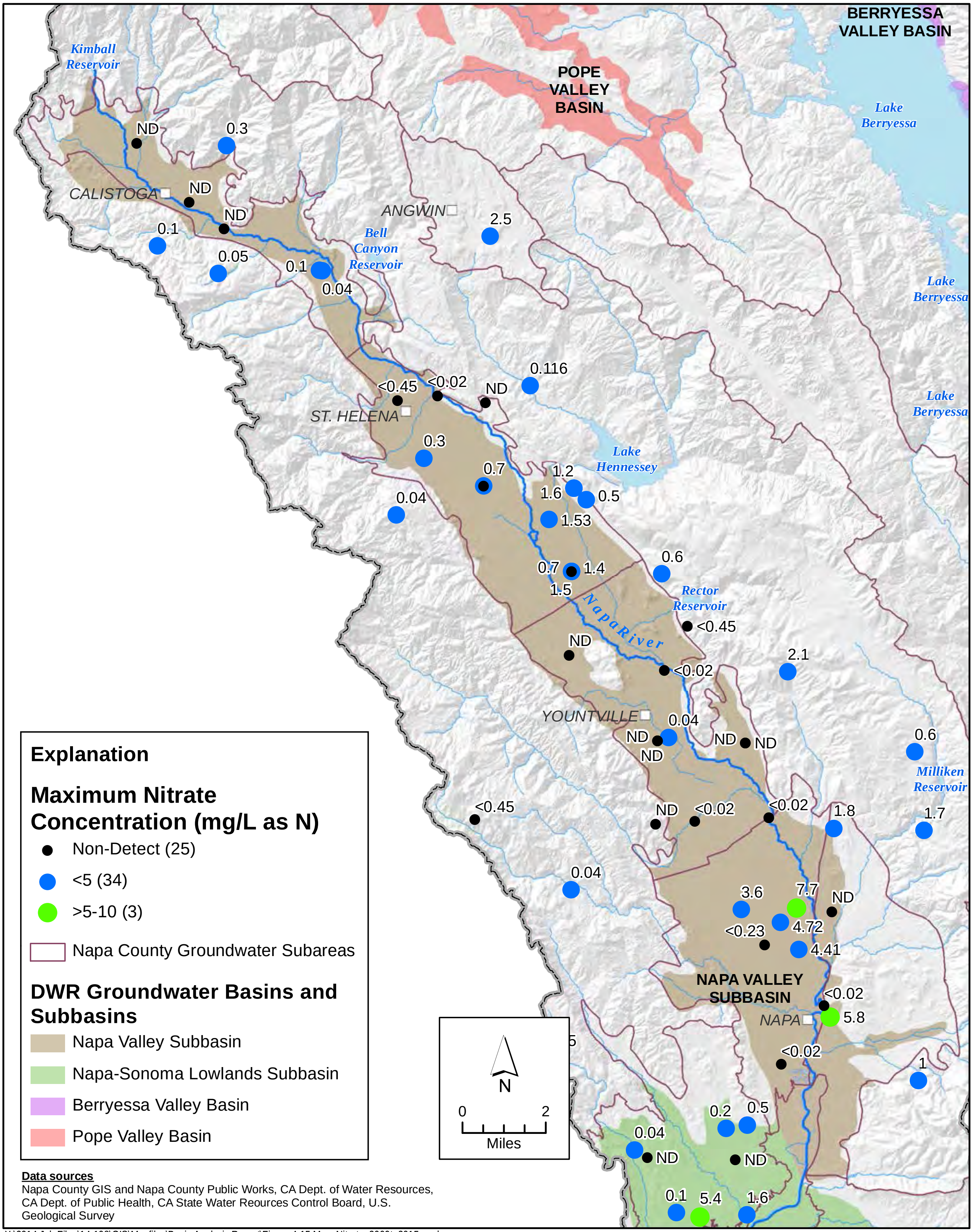
FIGURE 4-12
Maximum Chloride Concentrations in GW, 2009 - 2015
Napa County, CA

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



Data sources
Napa County GIS and Napa County Public Works, CA Dept. of Water Resources, CA Dept. of Public Health, CA State Water Reources Control Board, U.S. Geological Survey

X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 4-15 Max_Nitrate_2009to2015.mxd

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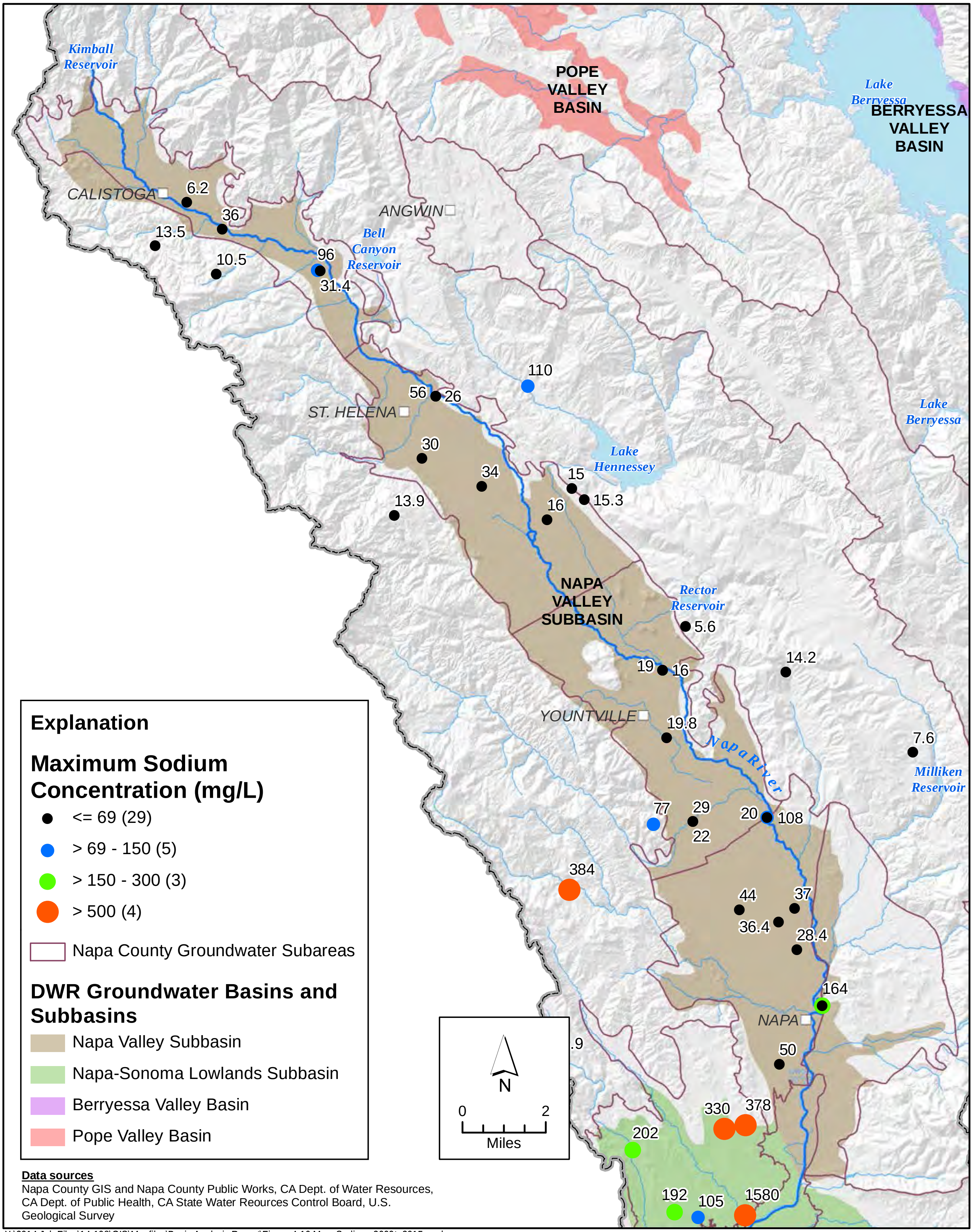
FIGURE 4-13

Maximum Nitrate Concentrations in GW, 2009 - 2015
Napa County, CA

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 4-16 Max_Sodium_2009to2015.mxd

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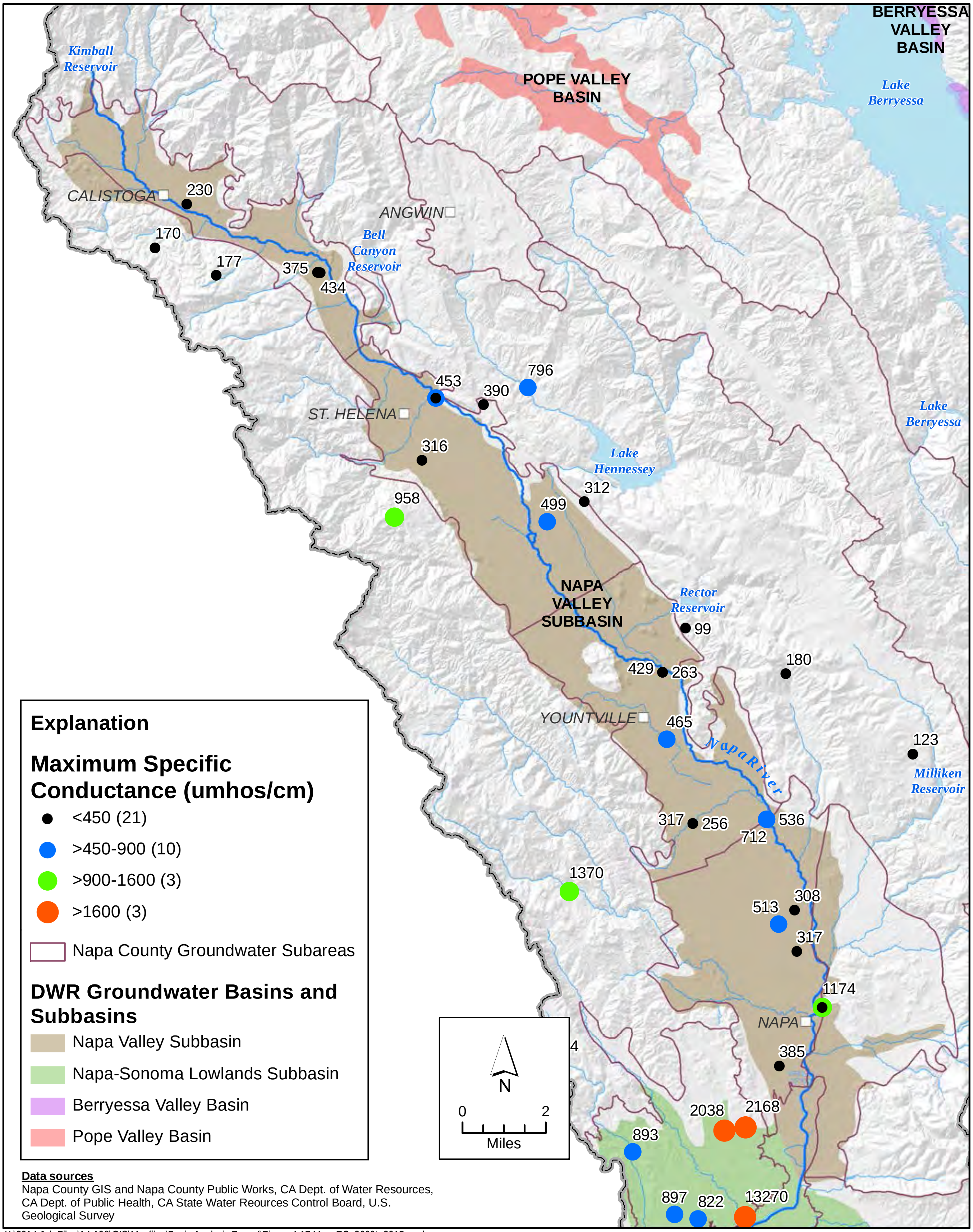
FIGURE 4-14
Maximum Sodium Concentrations in GW, 2009 - 2015
Napa County, CA

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 4-17 Max_EC_2009to2015.mxd

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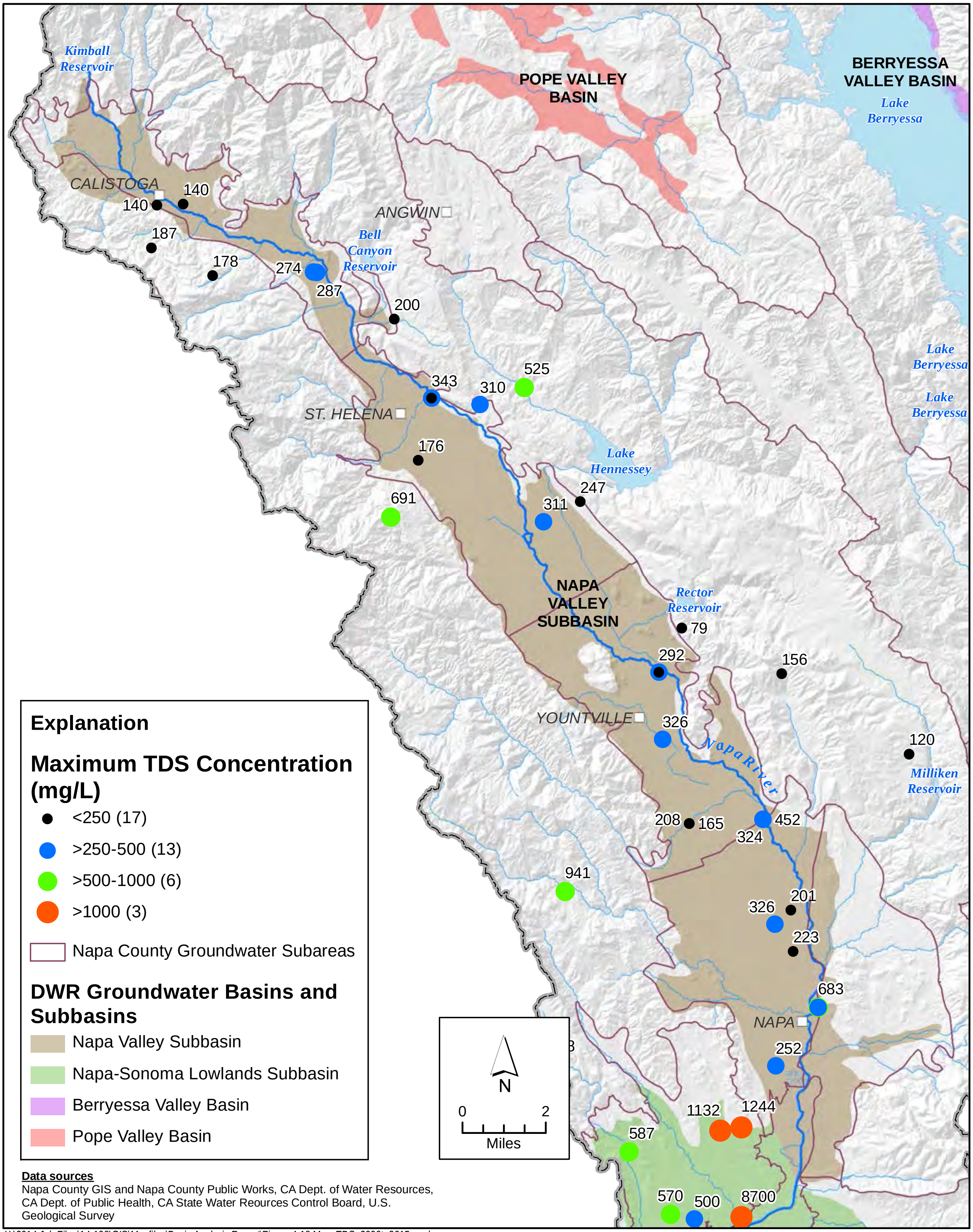
FIGURE 4-15

Maximum Specific Conductance in GW, 2009 - 2015
Napa County, CA

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 4-18 Max_TDS_2009to2015.mxd

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FIGURE 4-16
Maximum TDS Concentrations in GW, 2009 - 2015
Napa County, CA

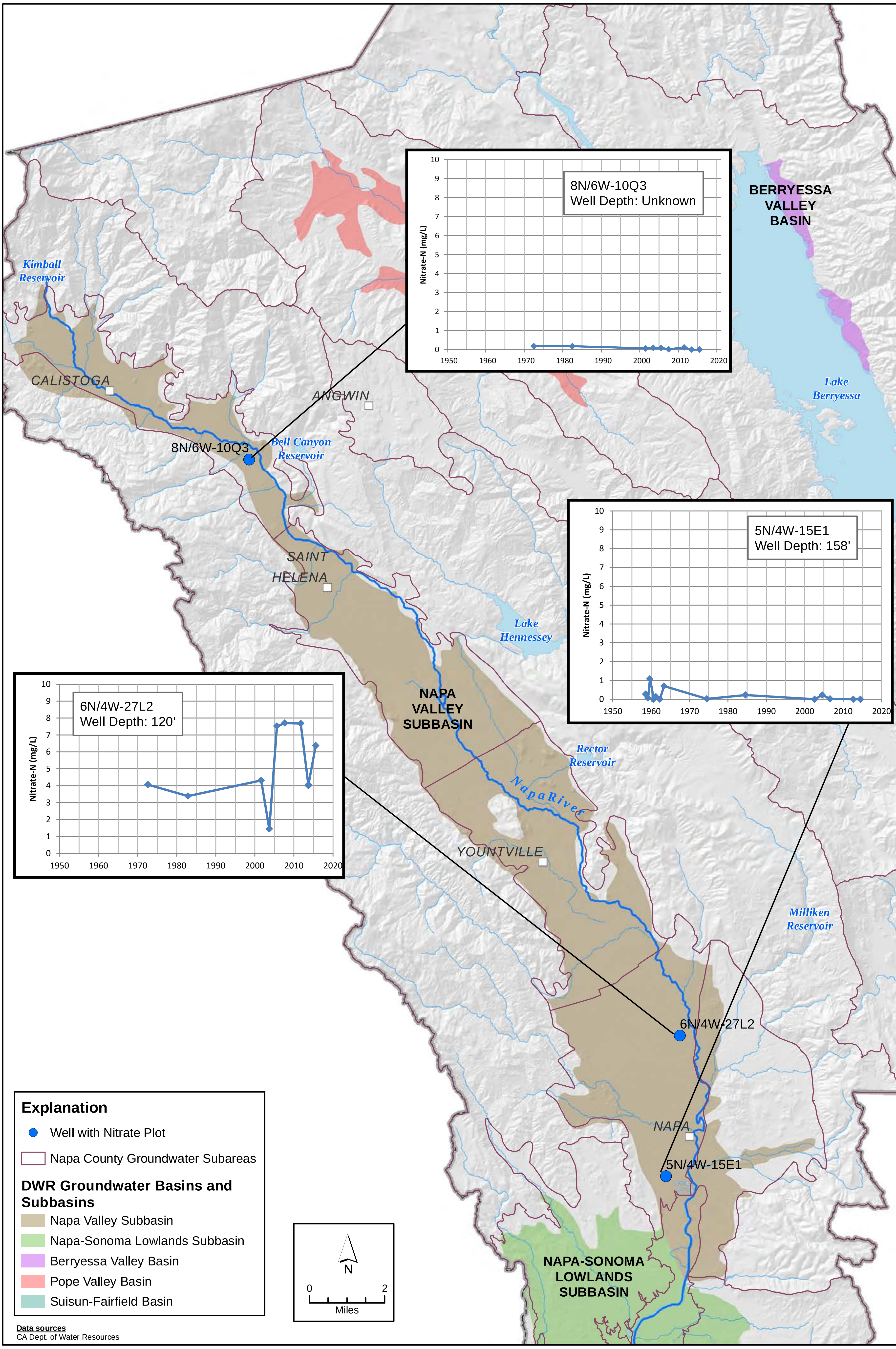

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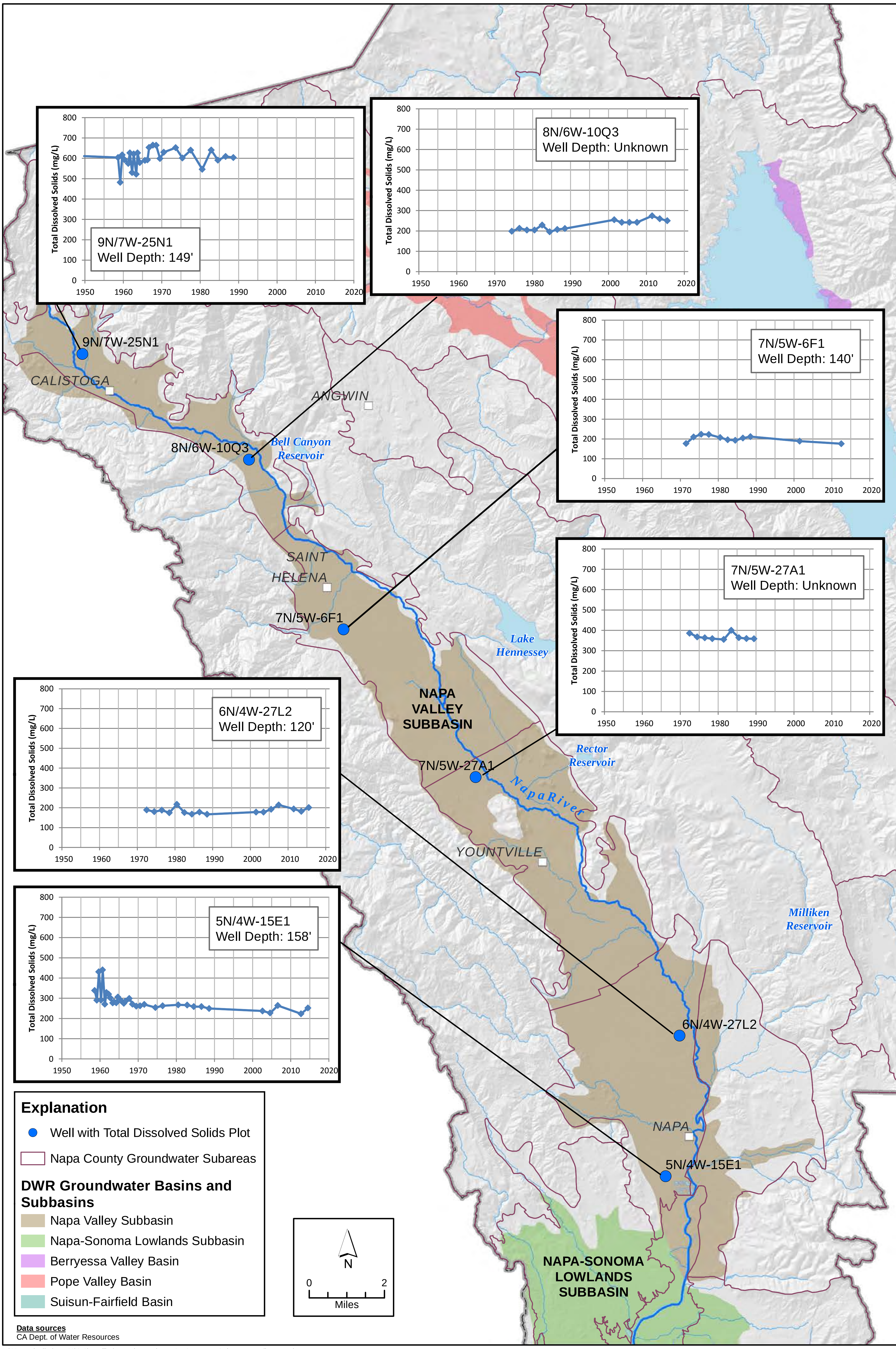
FIGURE 4-17
Nitrate Concentrations Time-Series Plots
Napa Valley Groundwater Subbasin, Napa County, CA



X:\2014 Job Files\14-108\GIS\Mapfiles\Annual Report\NapaGWQ_Map_TDSPlots_NapaValley__.mxd

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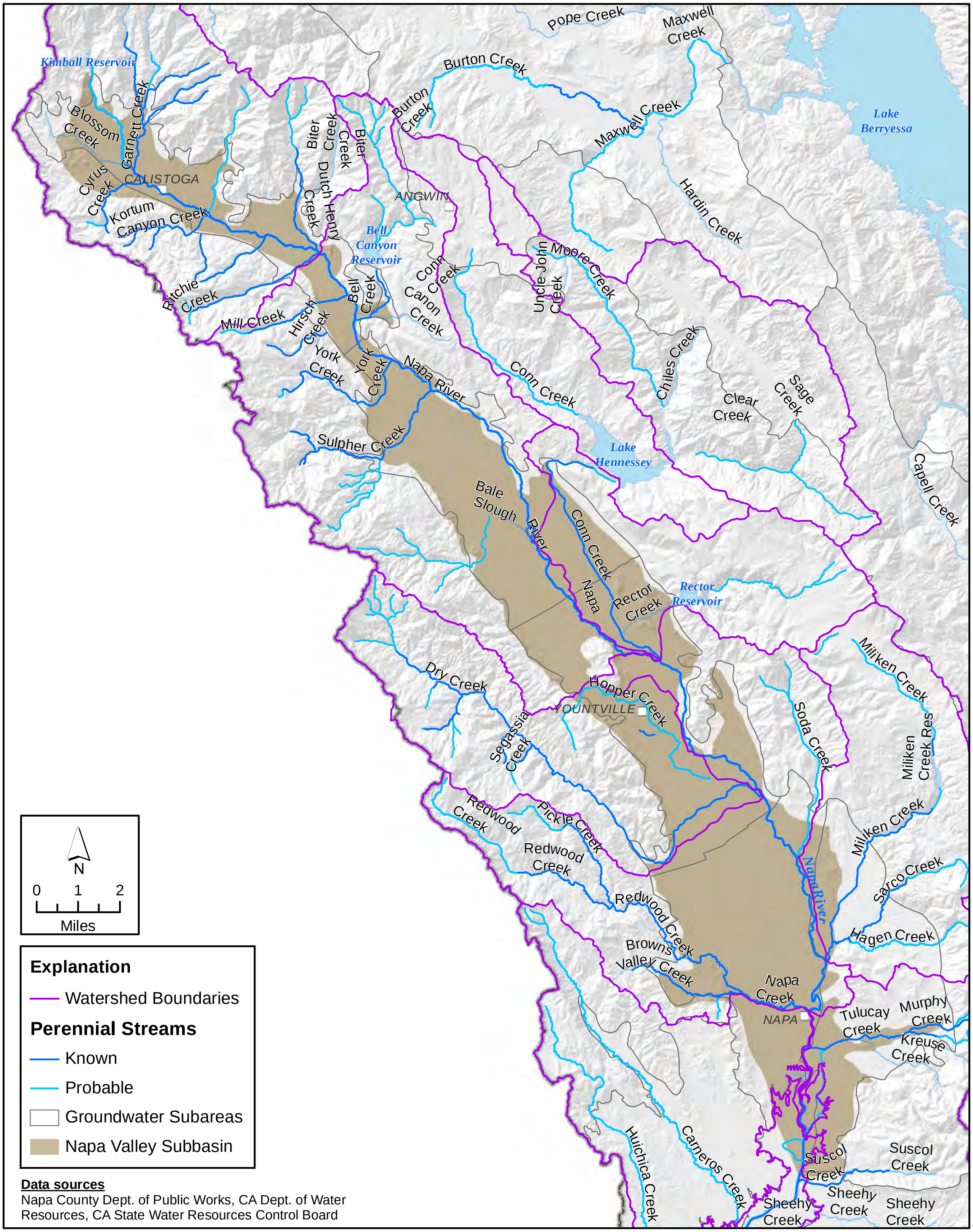
FIGURE 4-18
TDS Concentrations Time-Series Plots
Napa Valley Groundwater Subbasin, Napa County, CA



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 4-23 Perennial Streams and Watersheds.mxd

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FIGURE 4-19
Perennial Streams and Watershed Boundaries of the Napa Valley Subbasin

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin

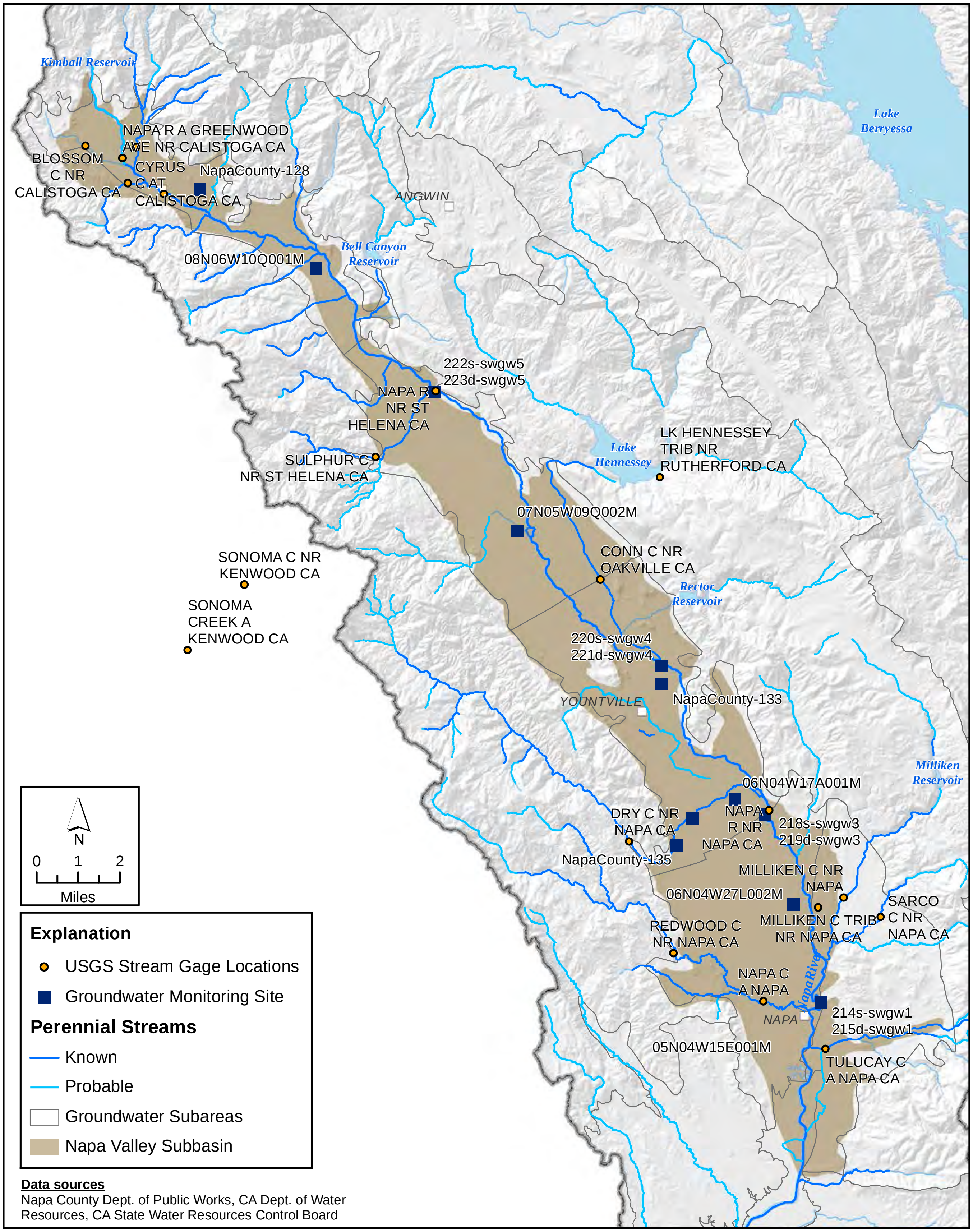

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FIGURE 4-20

USGS Surface Water and DWR Groundwater Monitoring Sites

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin

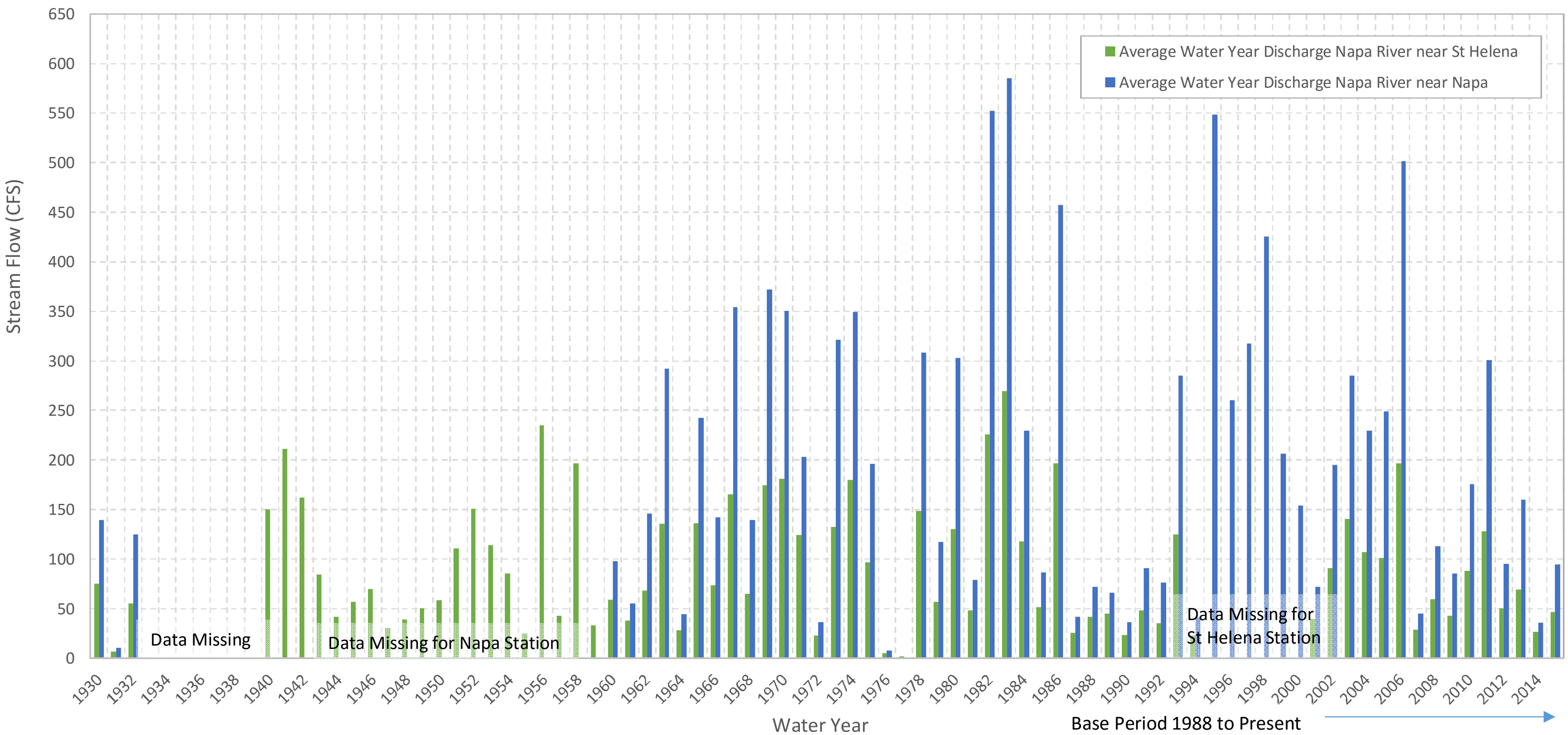

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Figure 4-21
Historical Napa River Annual Average Streamflow by Water Year

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

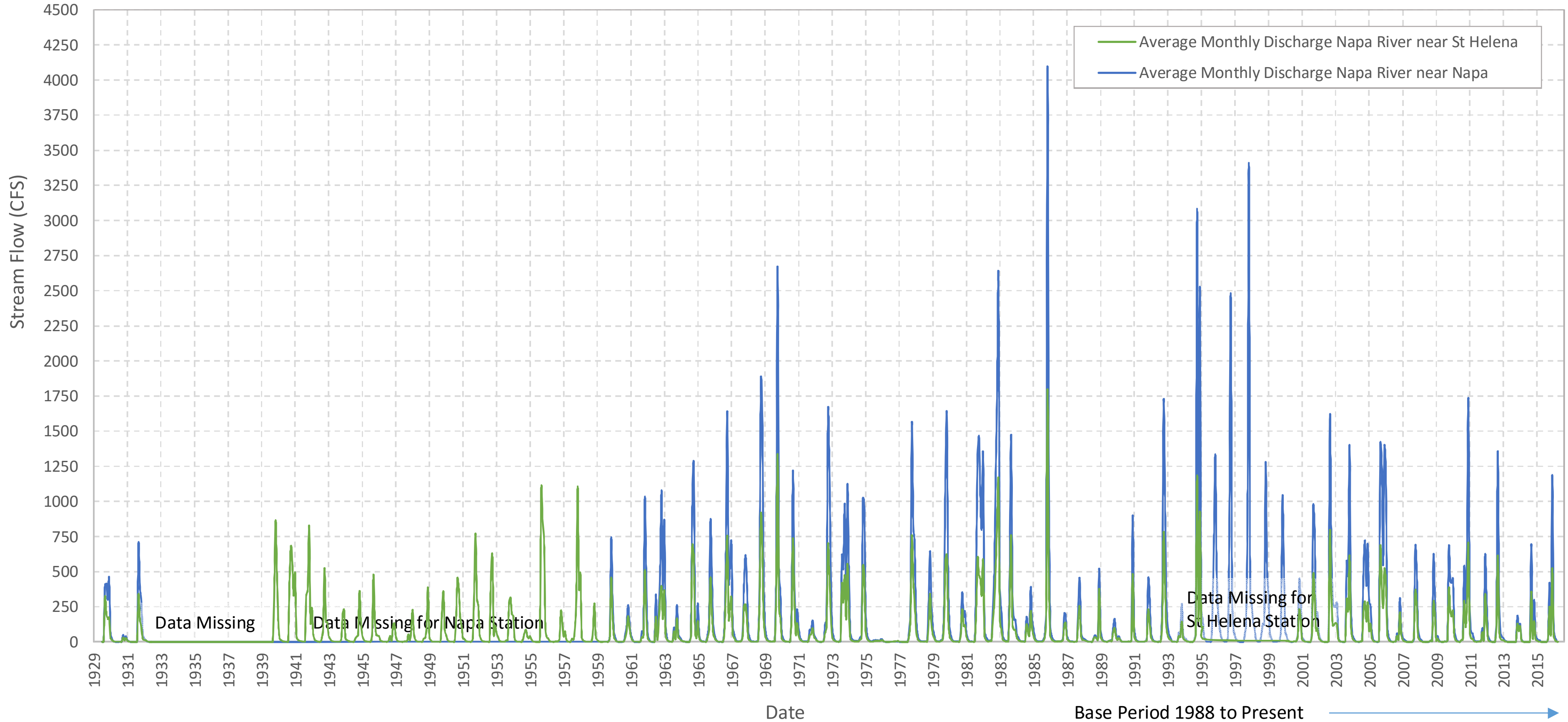

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Figure 4-22
Historical Napa River Monthly Average Streamflow

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

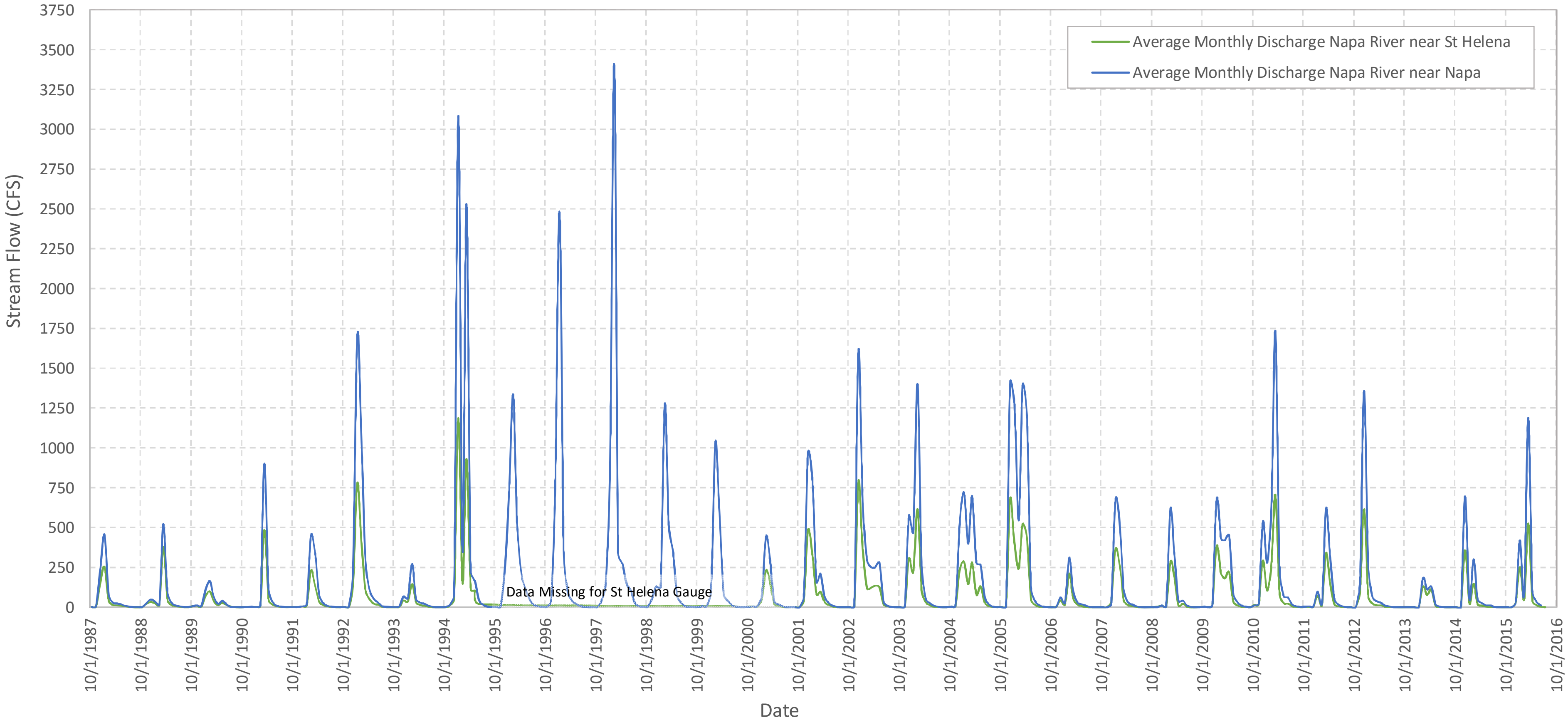

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Figure 4-23
Base Period Napa River Monthly Average Streamflow

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

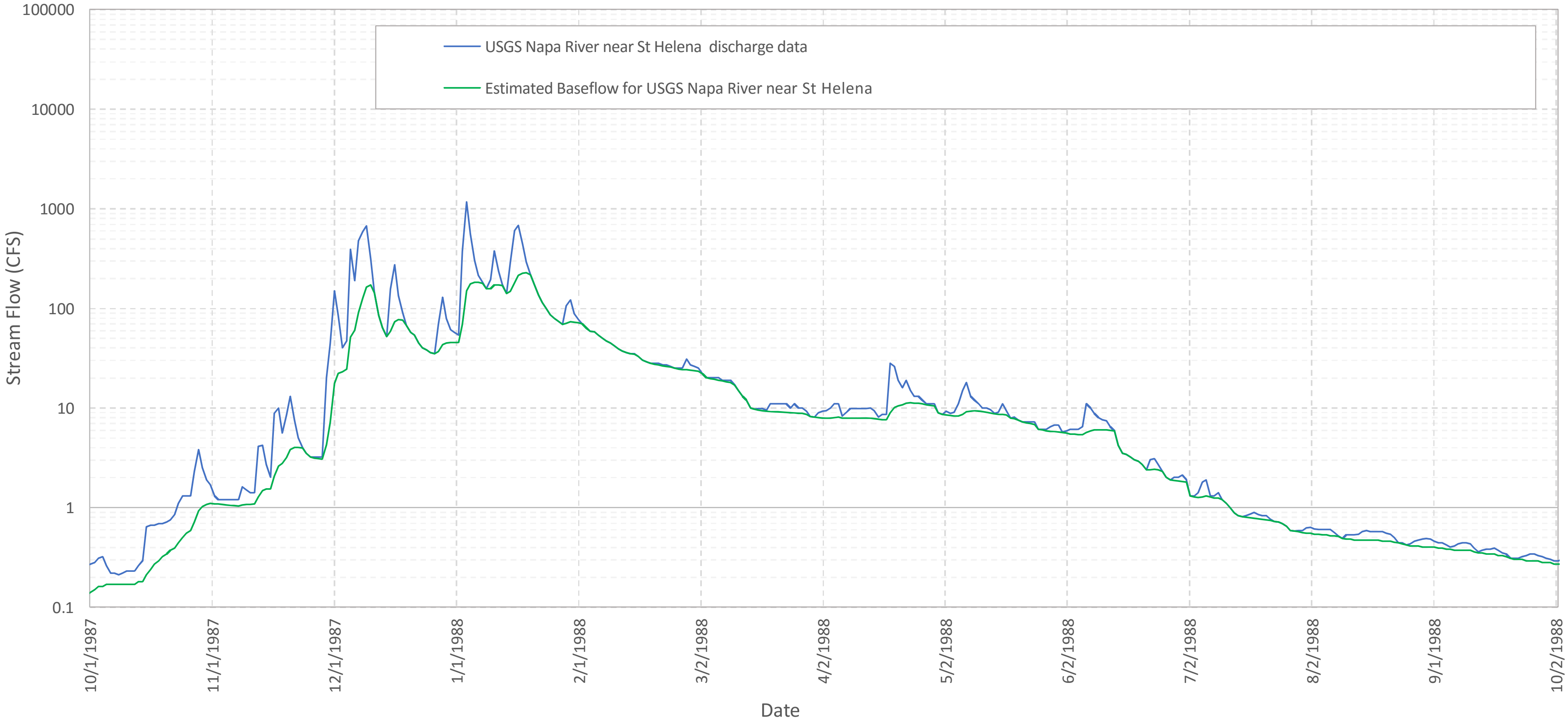

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Figure 4-24
First Water Year Base Period Baseflow Analysis Results for the Napa River Near St Helena

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

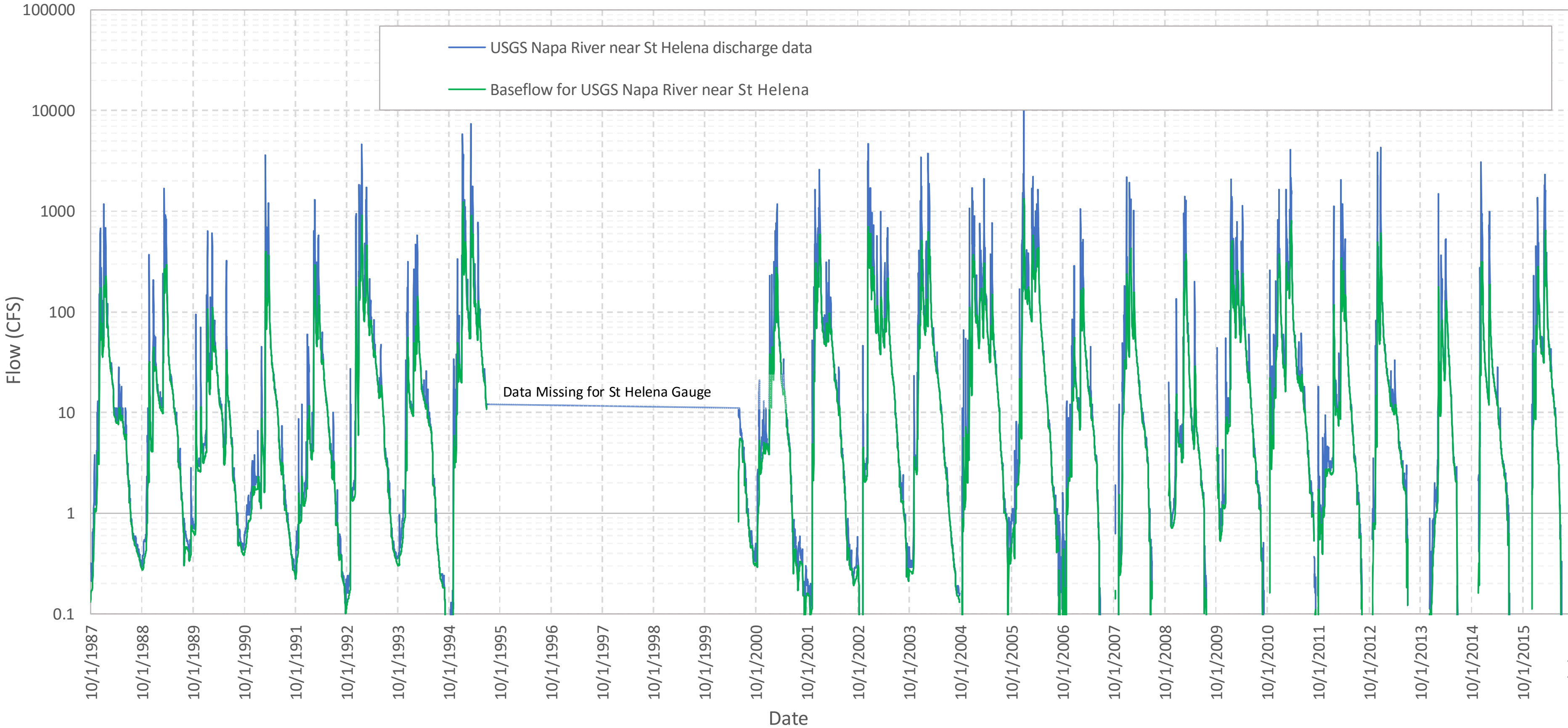

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Figure 4-25
Baseflow Analysis Results for the Napa River Near St Helena Base Period

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

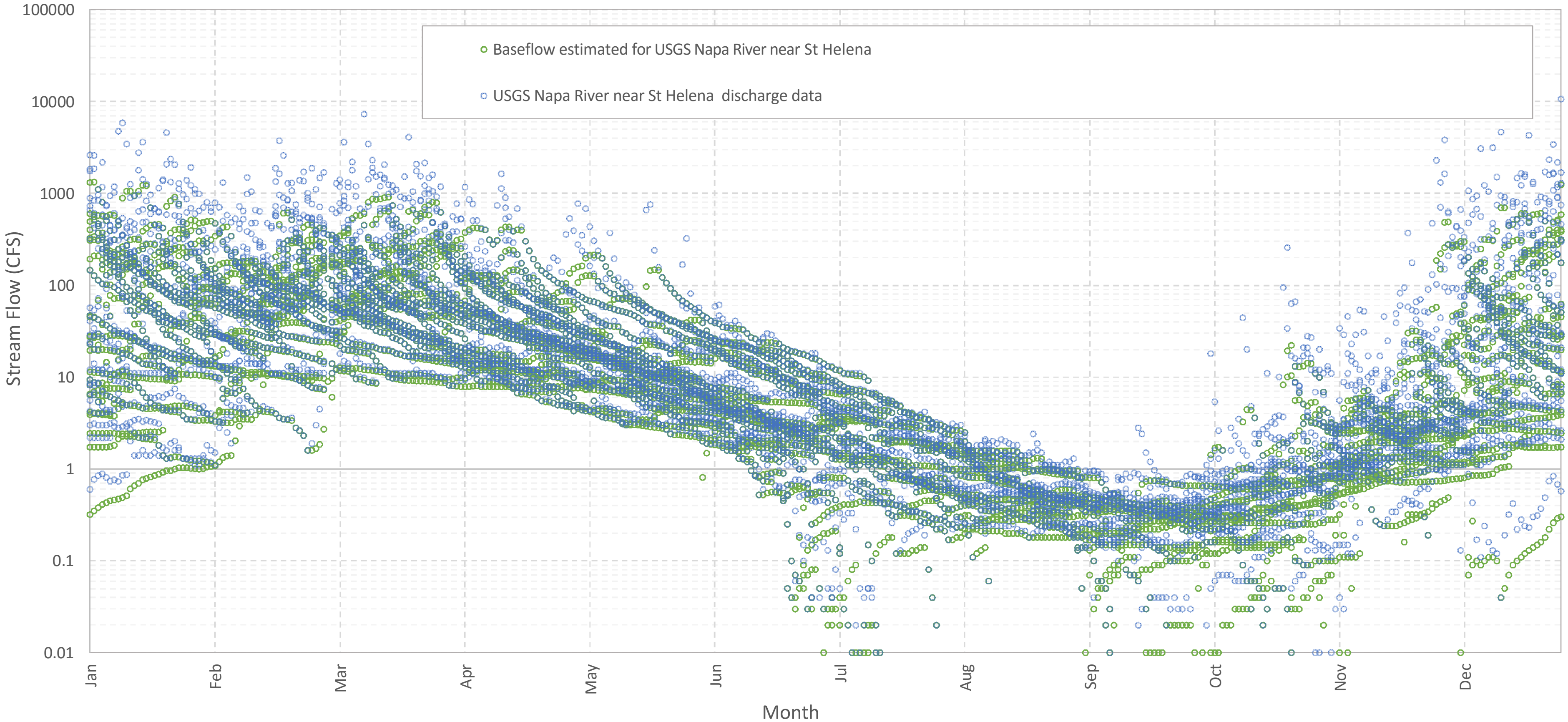

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Figure 4-26
Base Period Baseflow Analysis Results for the Napa River Near St Helena Point Cloud

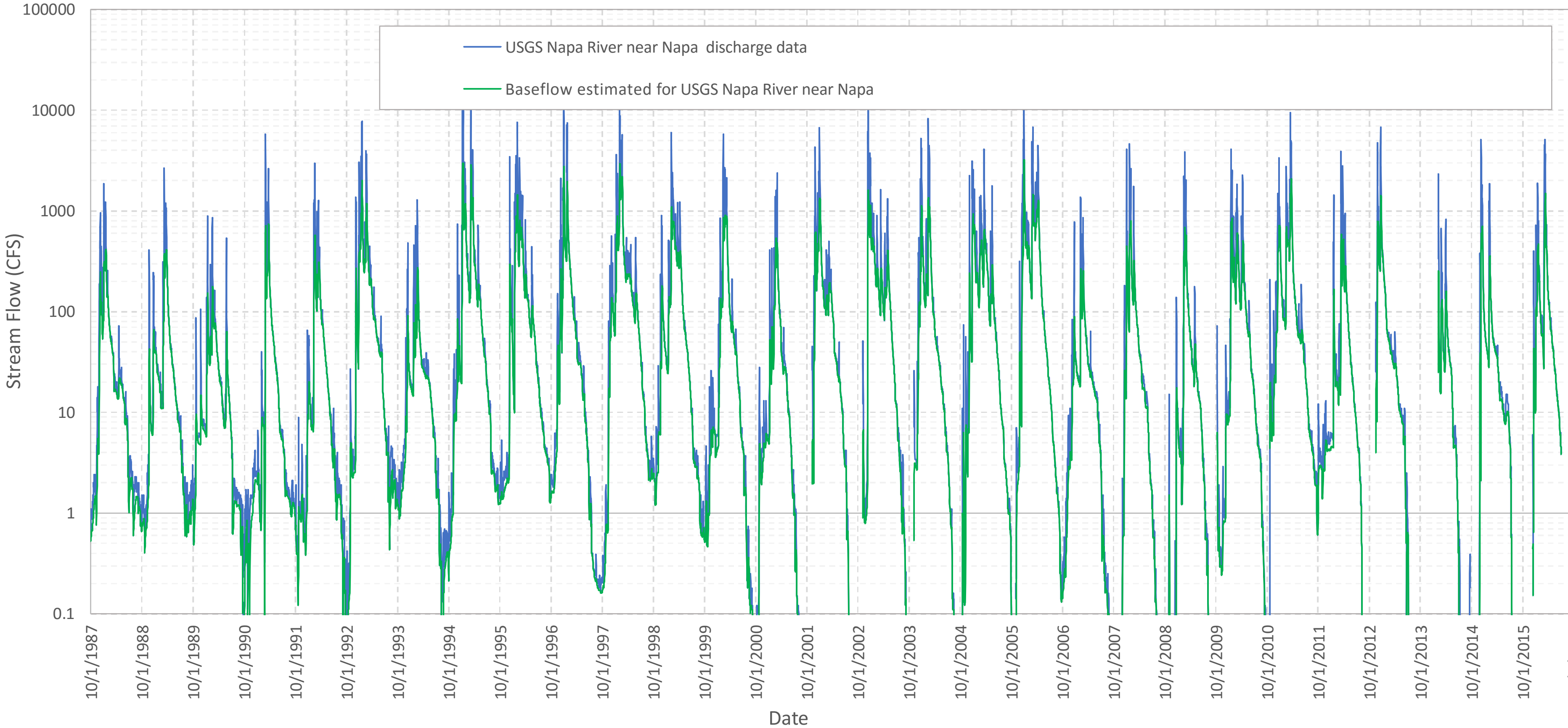

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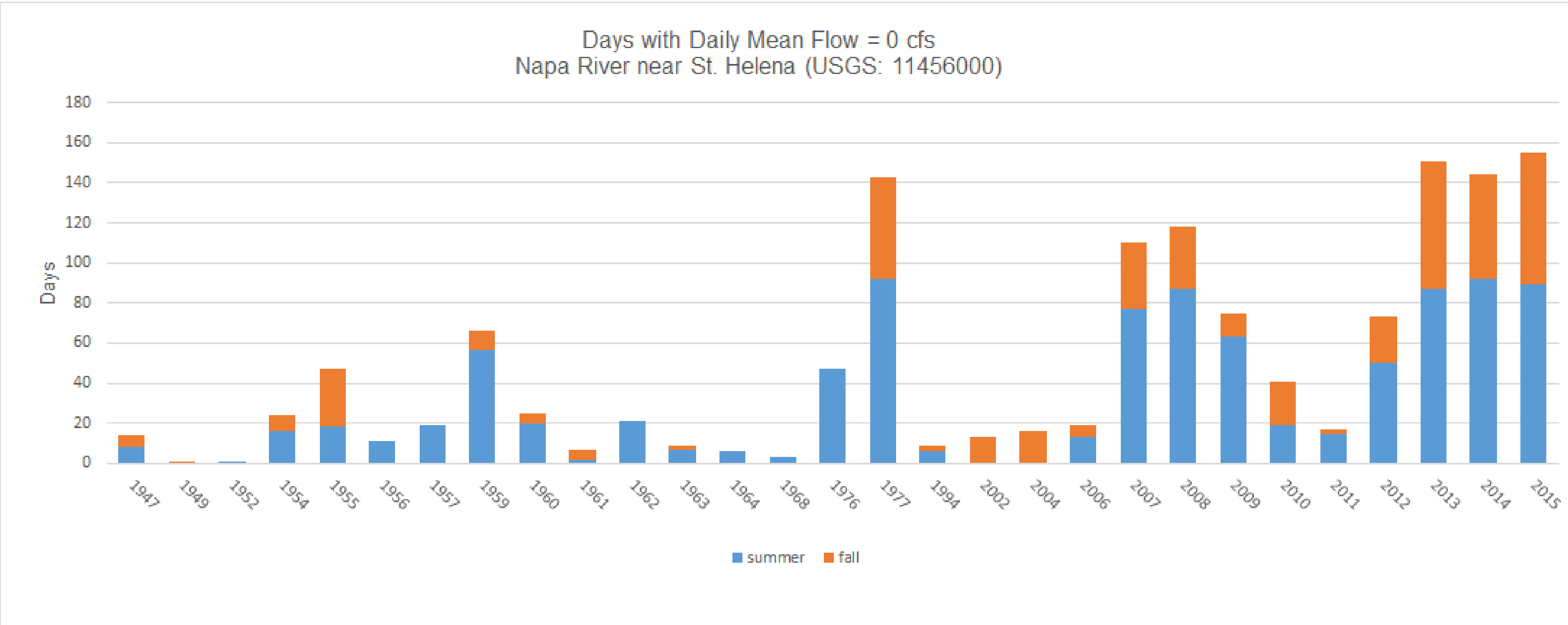
Figure 4-27
Base Period Baseflow Analysis Results for the Napa River Near Napa

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin



Period of Record: 10/01/1929 to 10/29/2015. Summer is July through September. Fall is October through December.

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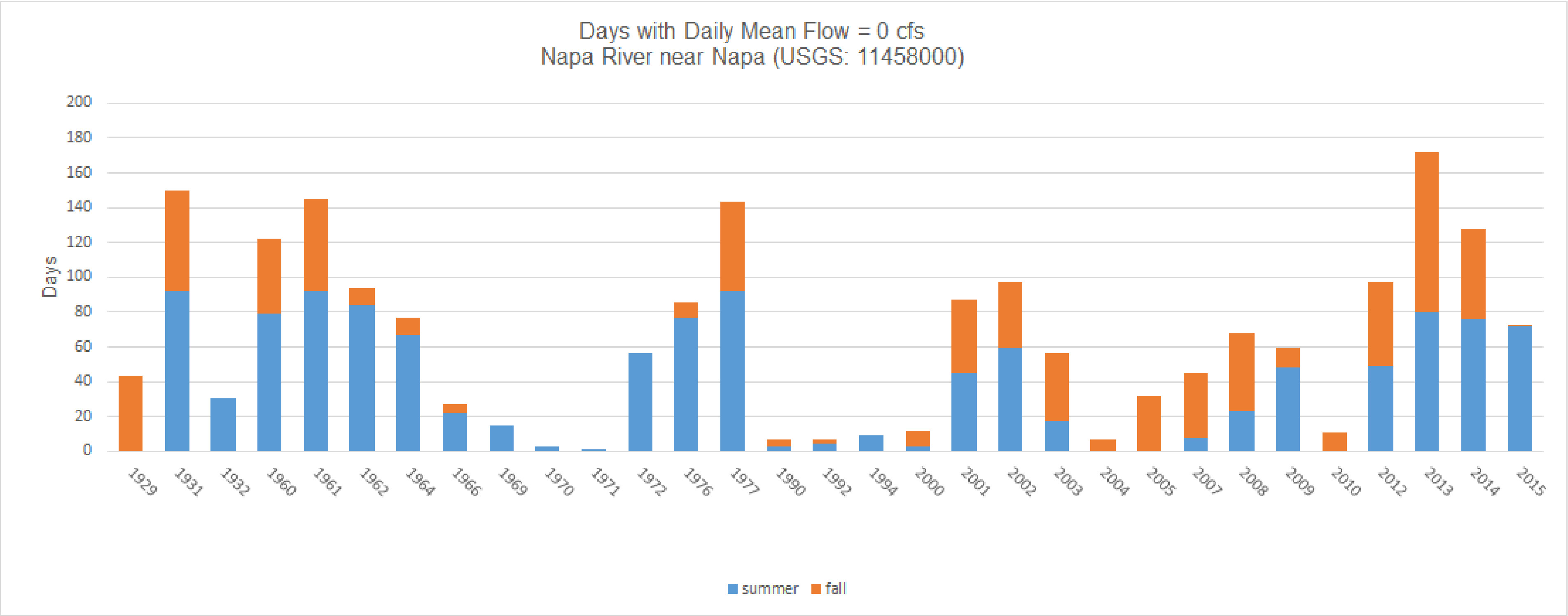
Figure 4-28a
Historical Annual Number of Days With Stream Flow Less Than 0.1 CFS
USGS Napa River Near St. Helena



Period of Record: 10/01/1929 to 10/01/2015. Summer is July through September. Fall is October through December.

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Figure 4-28b
Historical Annual Number of Days With Stream Flow Less Than 0.1 CFS
USGS Napa River Near St. Helena

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

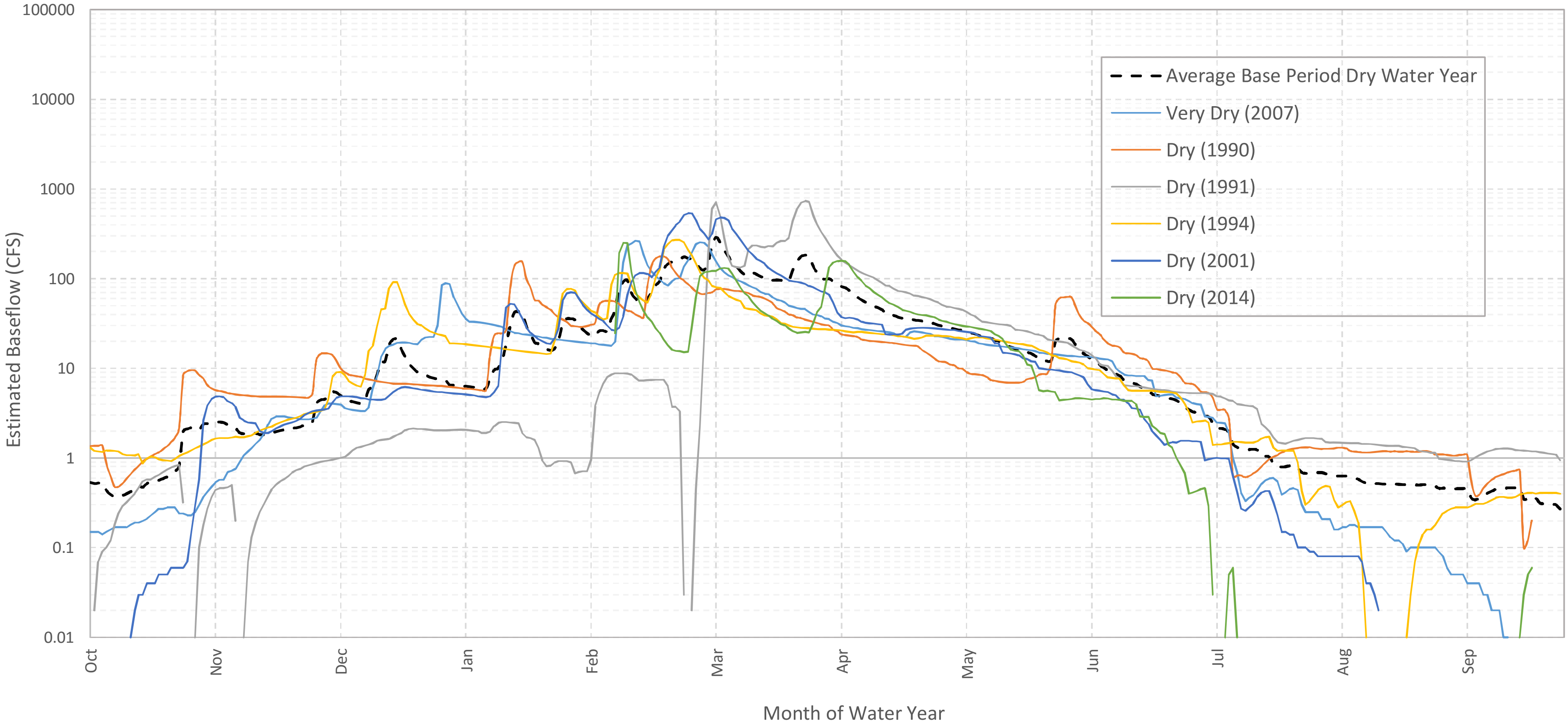

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Figure 4-29
Base Period Baseflow Analysis Results for the Napa River Near Napa
Very Dry and Dry Water Years

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

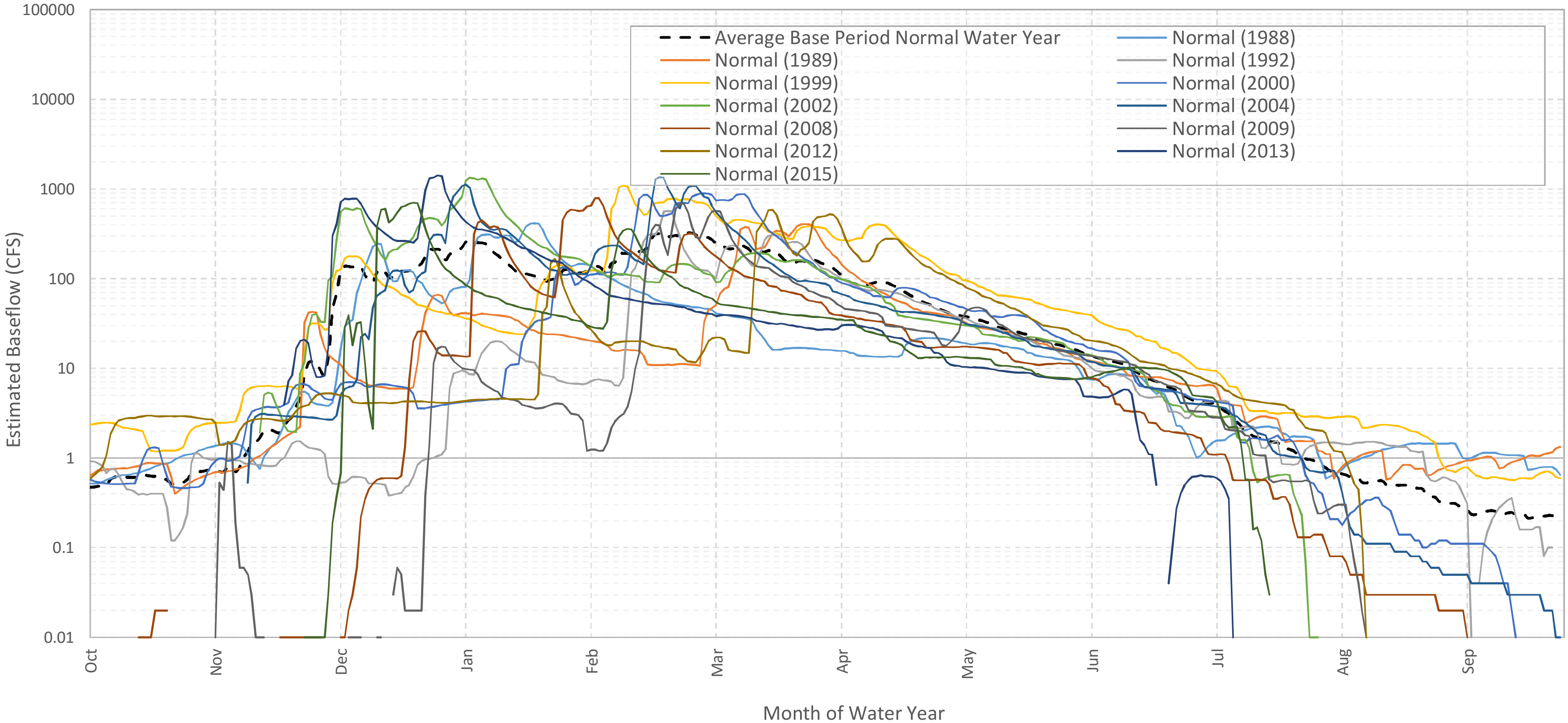

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Figure 4-30

Base Period Baseflow Analyses Results for the Napa River Near Napa

Normal Water Years

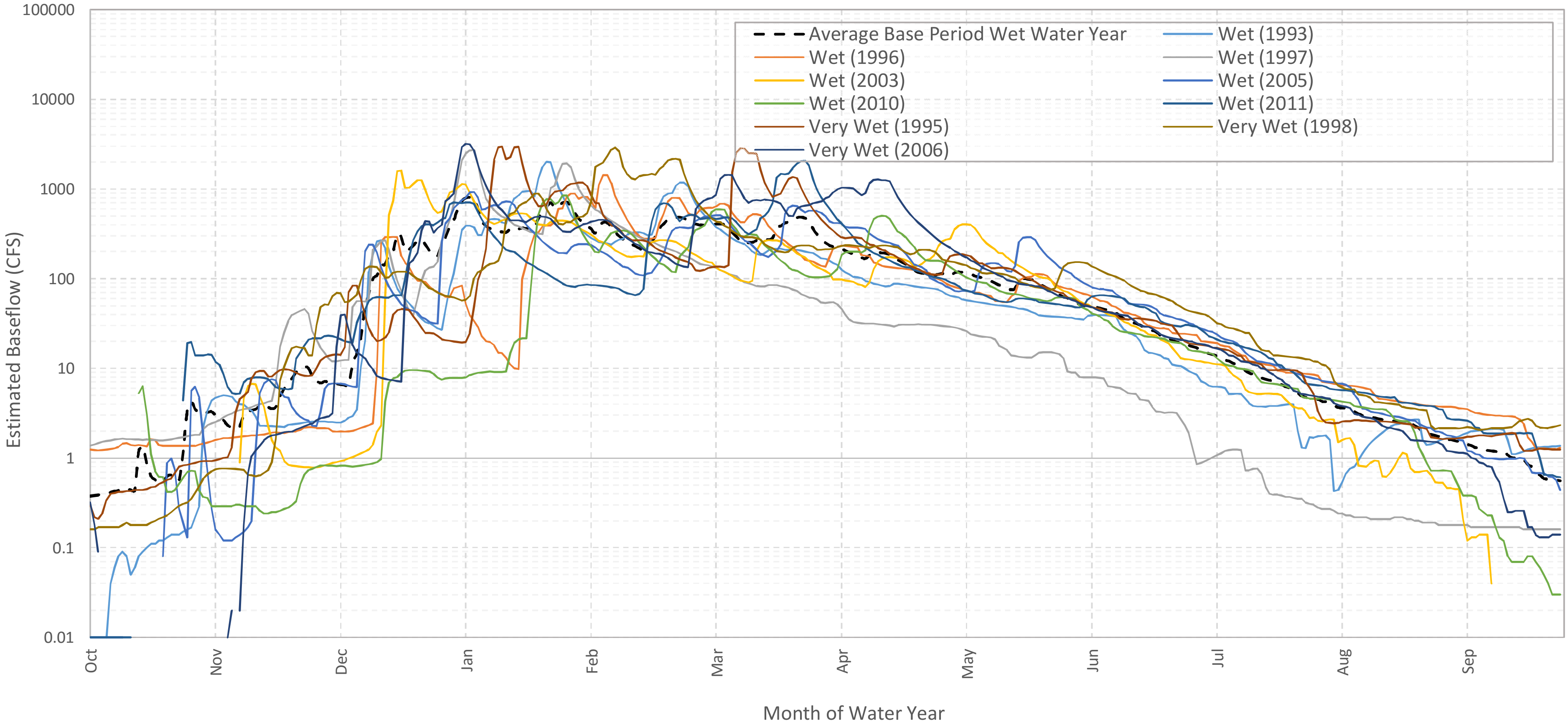

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Figure 4-31
Base Period Baseflow Analyses Results for the Napa River Near Napa
Wet and Very Wet Water Years

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

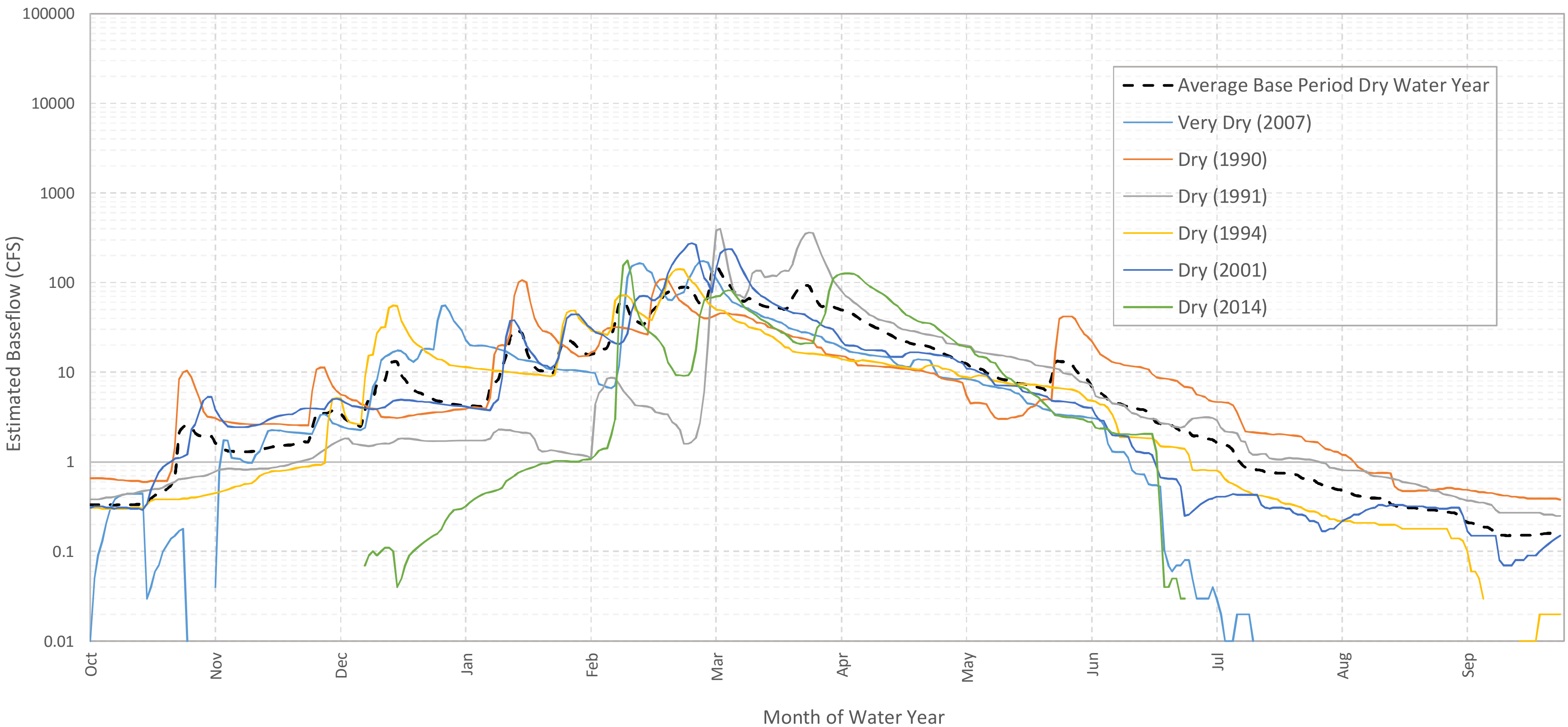

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Figure 4-32
Base Period Baseflow Analyses Results for the Napa River Near St Helena
Very Dry and Dry Water Years

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

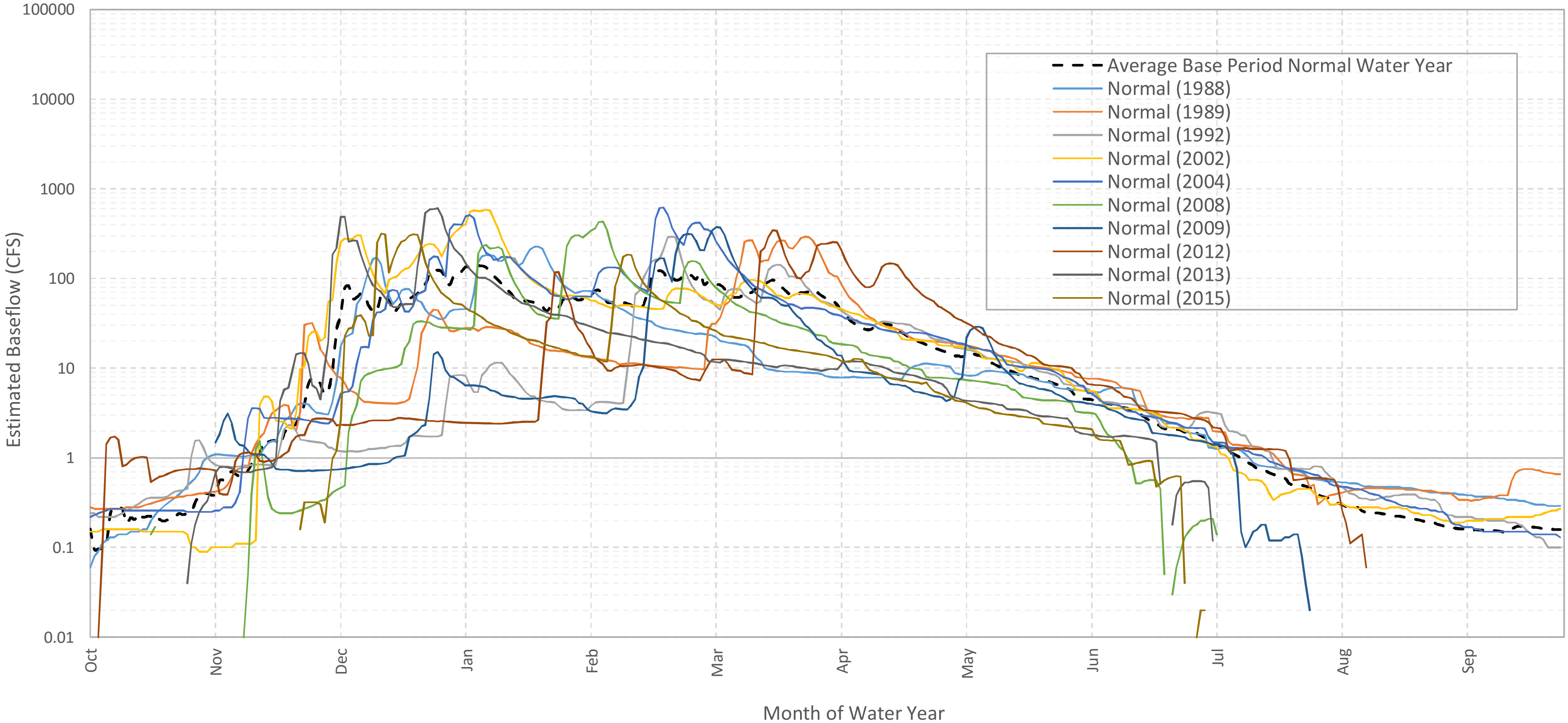

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Figure 4-33
Base Period Baseflow Analyses Results for the Napa River Near St Helena
Normal Water Years

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

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Figure 4-34
Base Period Baseflow Analyses Results for the Napa River Near St Helena
Wet and Very Wet Water Years

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

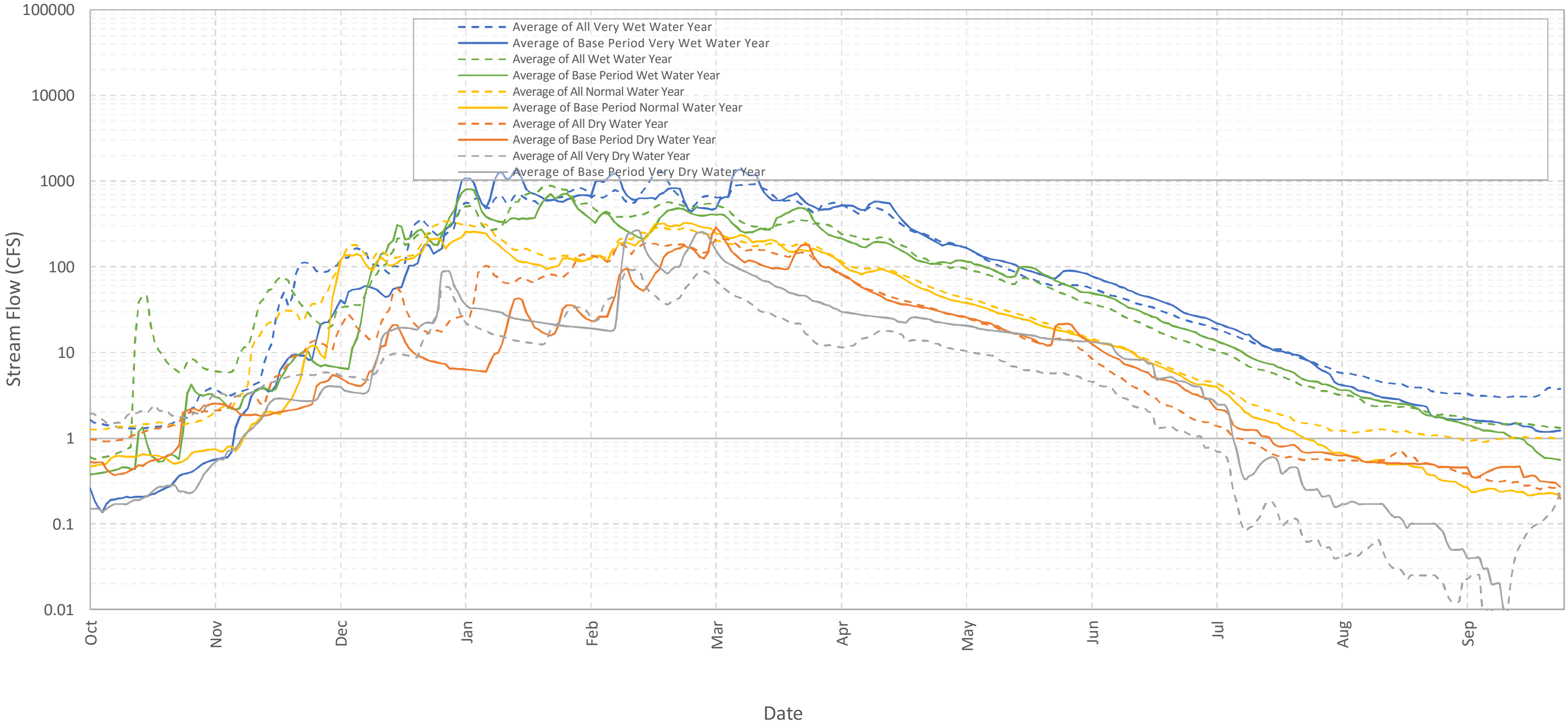

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Figure 4-35

Average Water Year Type Baseflow Analysis Results for the Napa River Near Napa

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

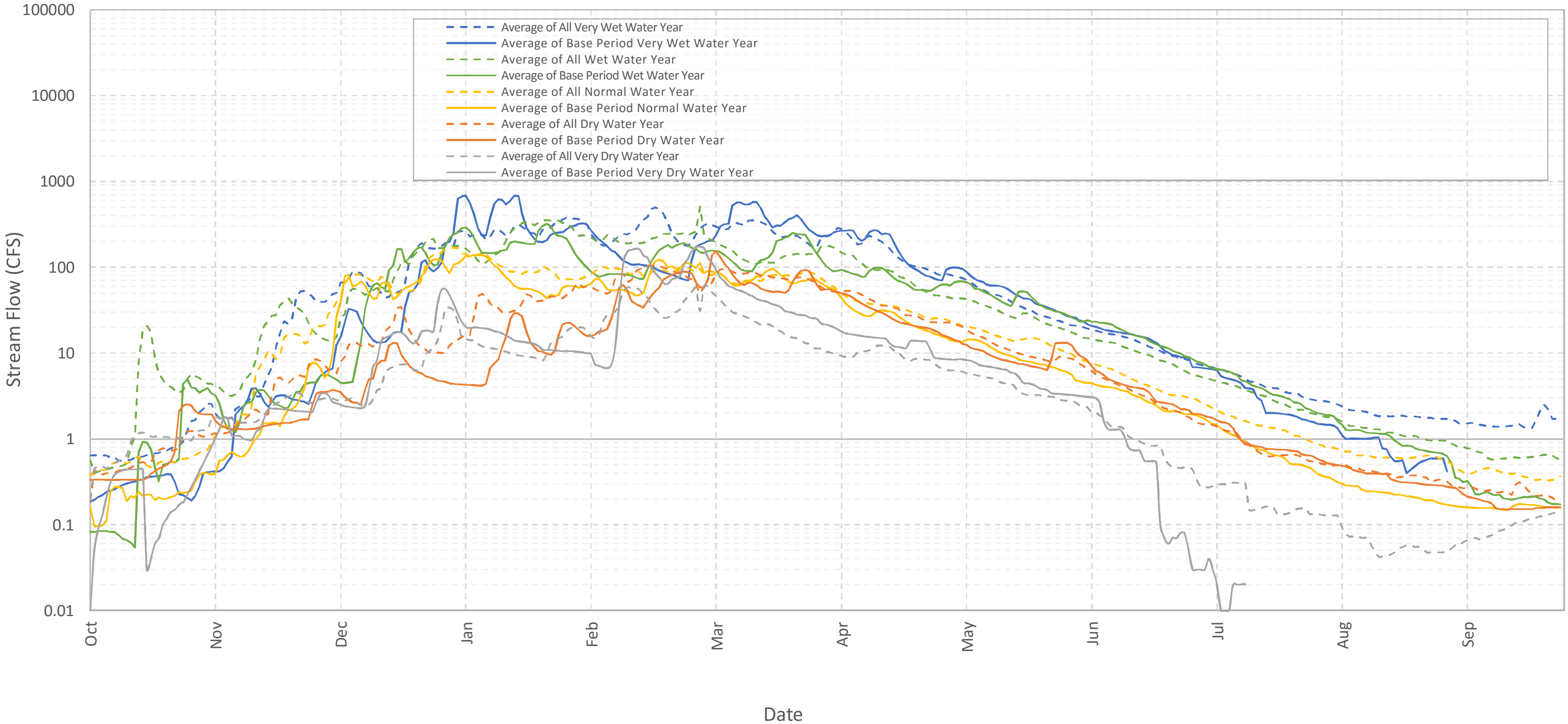

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Figure 4-36

Average Water Year Type Baseflow Analysis Results for the Napa River Near St Helena

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

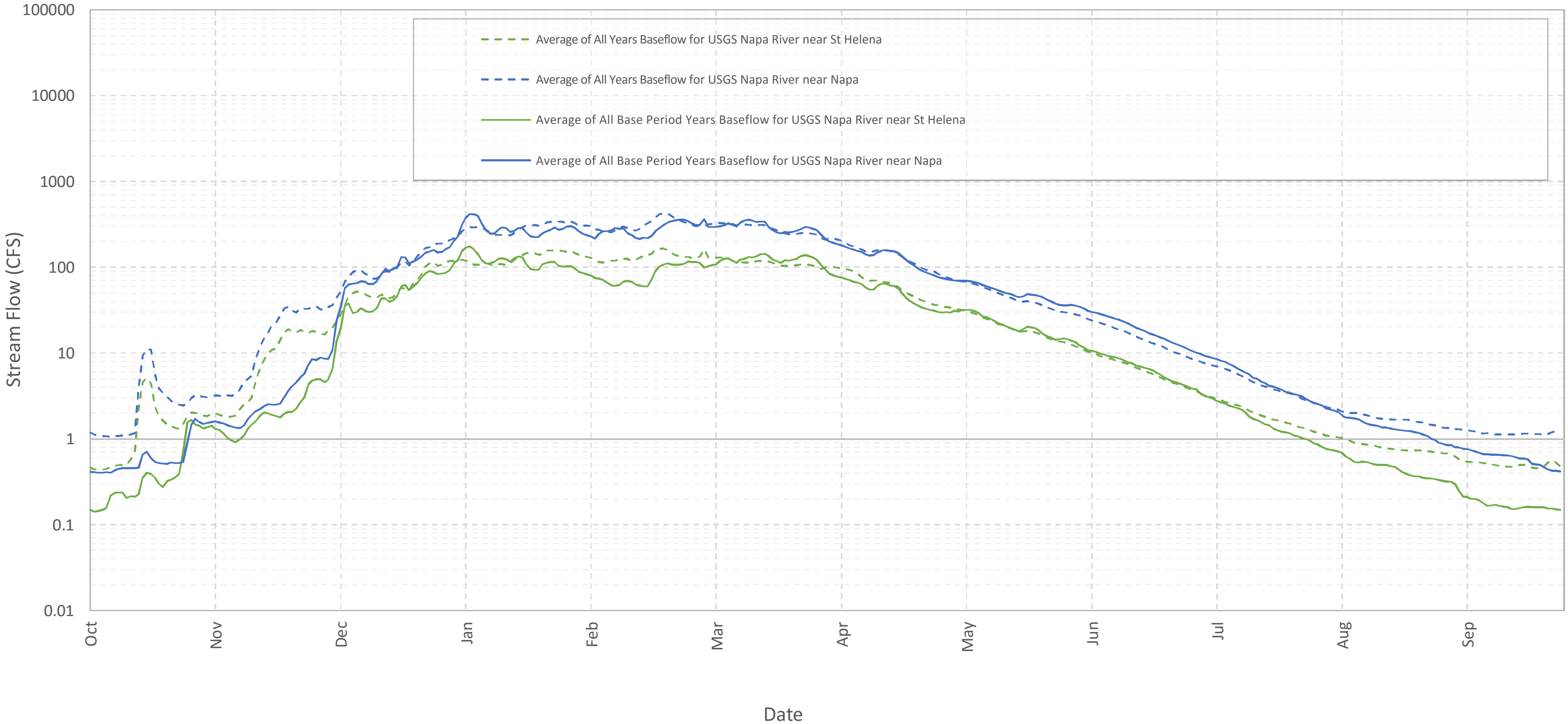

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Figure 4-37
All Years Average Baseflow Analysis Results for the Napa River Near St Helena and Napa

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

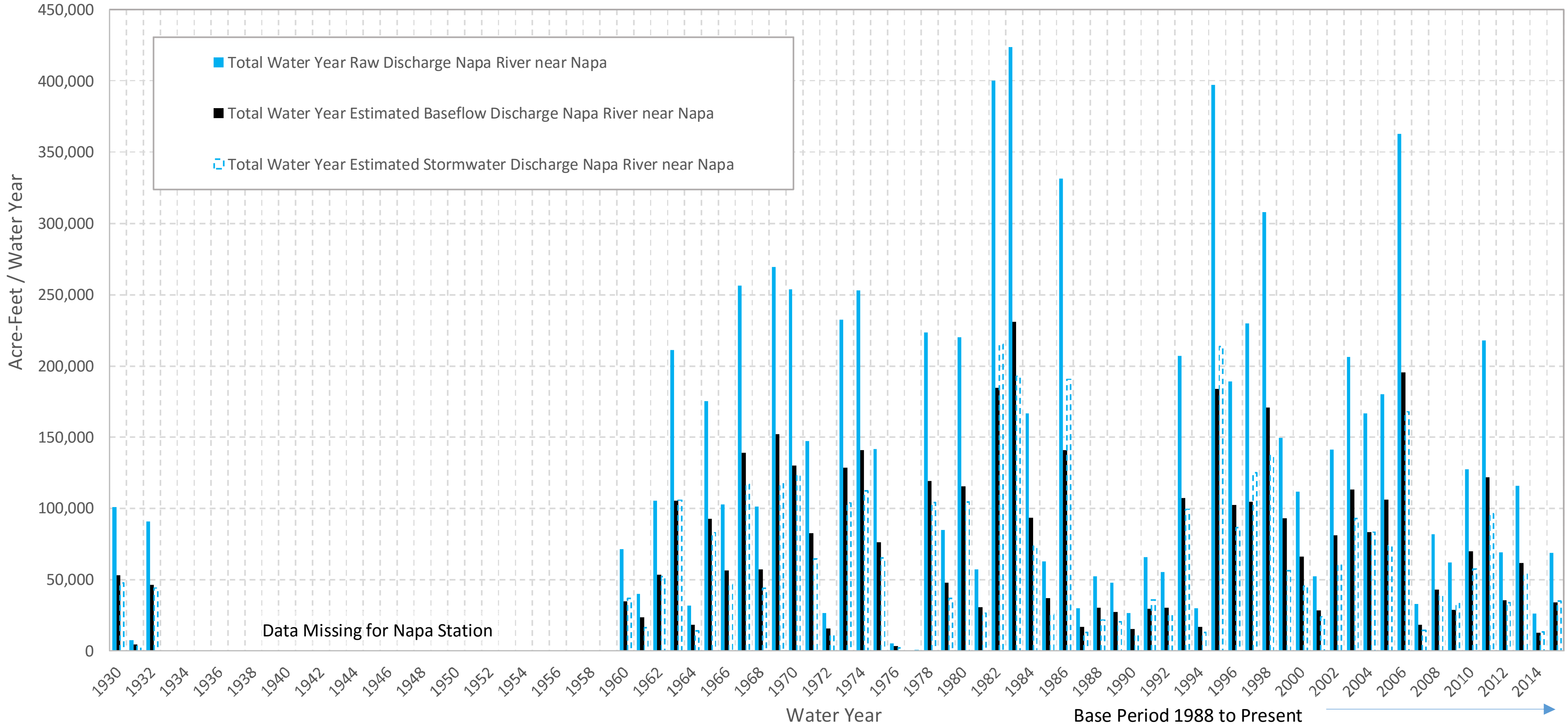

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Figure 4-38
Total Napa River near Napa Discharge, Baseflow Discharge, and Stormwater Discharge

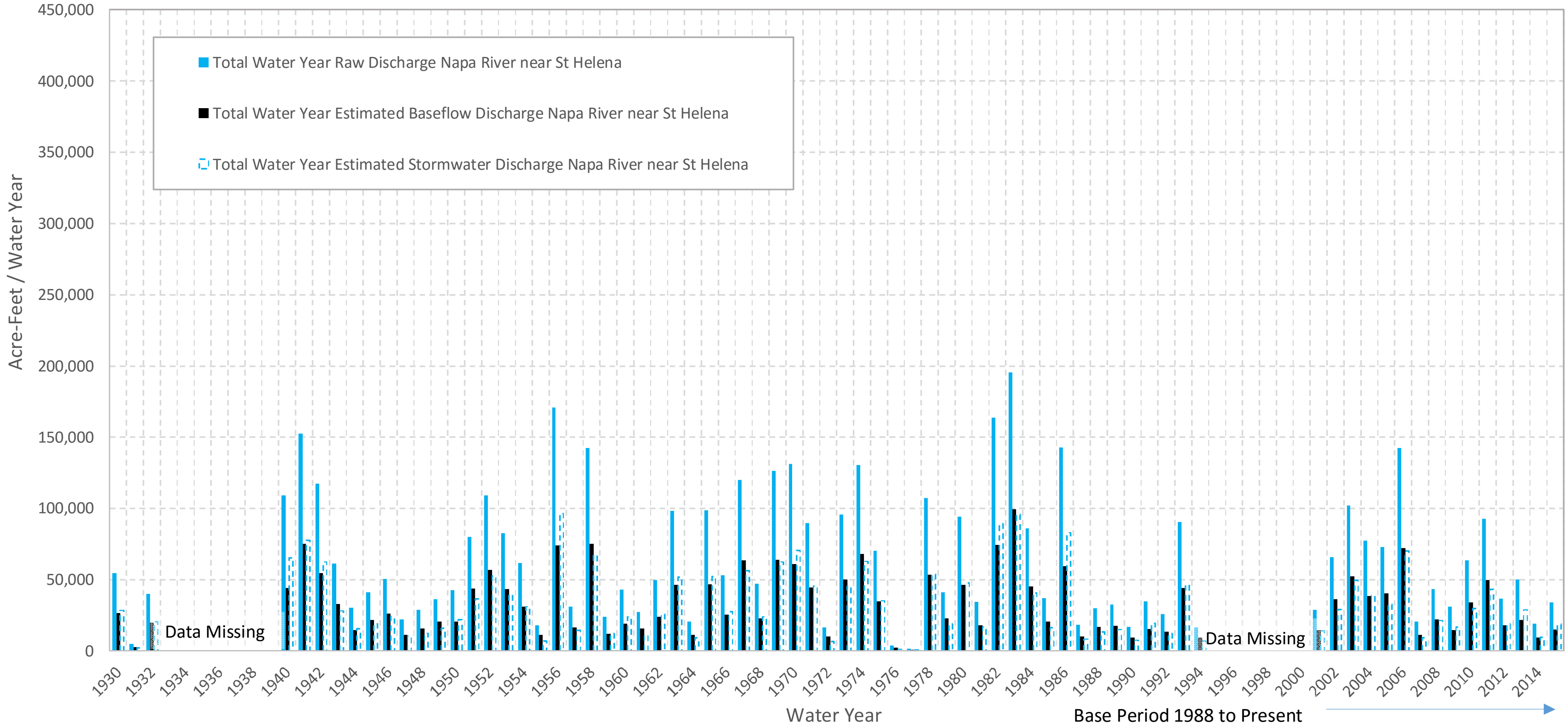

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Figure 4-39
Total Napa River near St Helena Discharge, Baseflow Discharge, and Stormwater Discharge

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

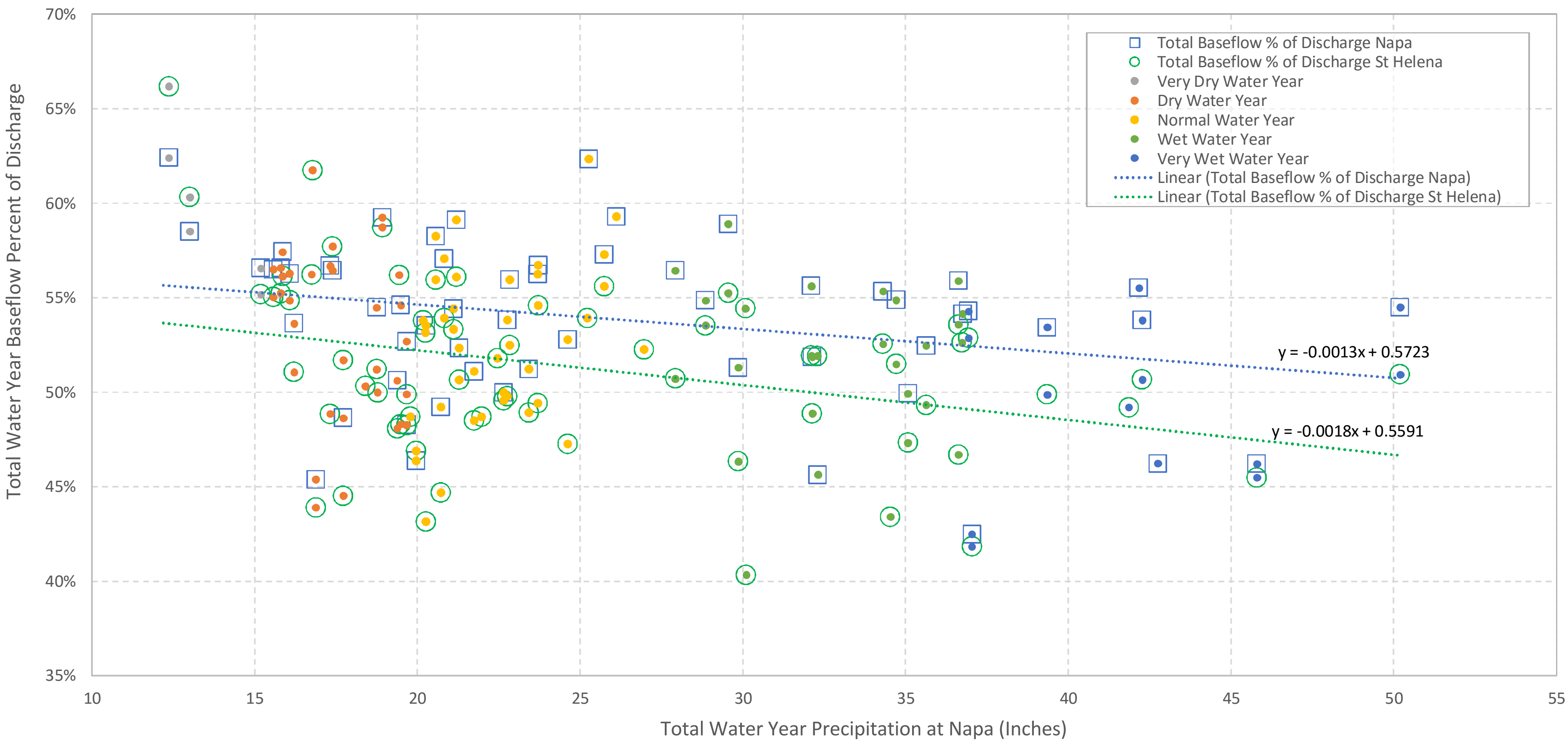

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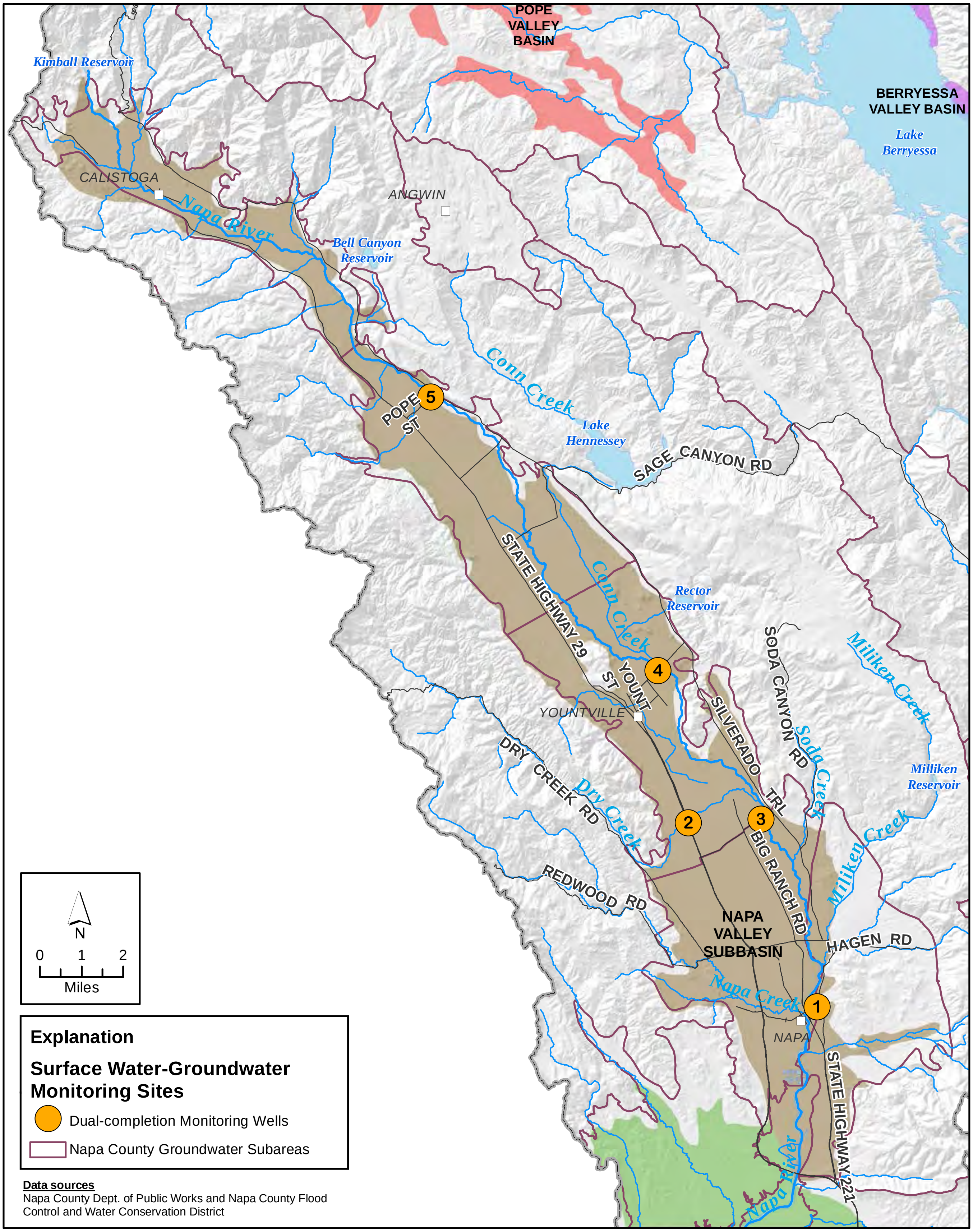
Figure 4-40

Baseflow Percent of Total Water Year Discharge Compared to Precipitation

All Years Napa River Near Napa and St Helena



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 4-3 SWGW Monitoring Sites.mxd

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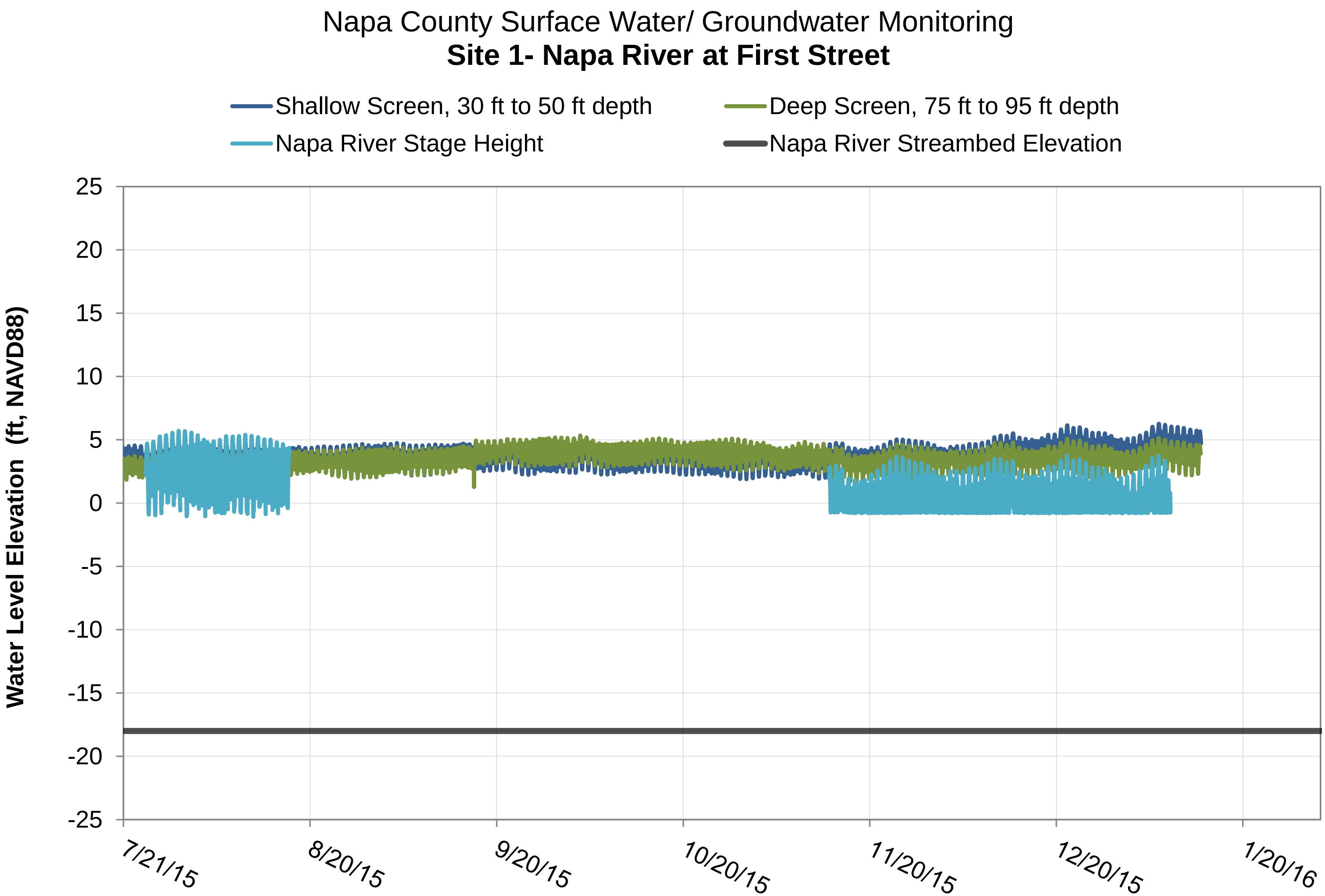
FIGURE 4-41
Napa County Surface Water-Groundwater Monitoring Sites

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



X:\2012 Job Files\12-071\Data__Current Project Data Charts\DatabaseCharts.xlsm\WL Site 1

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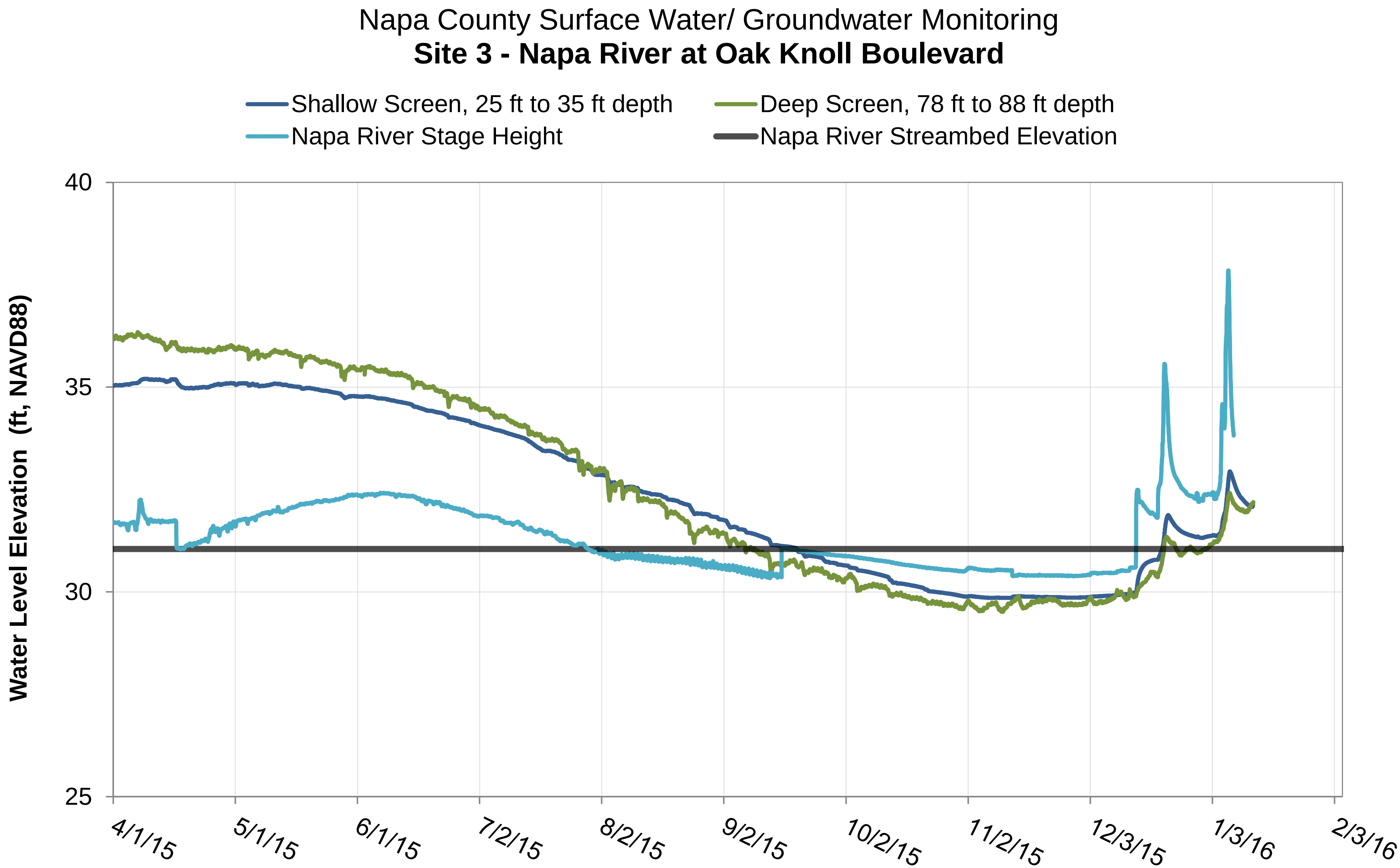
Figure 4-42

Surface Water-Groundwater Hydrograph
Site 1: Napa River at First Street

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin



X:\2012 Job Files\12-071\Data__Current Project Data Charts\DatabaseCharts.xlsm\WL Site 3

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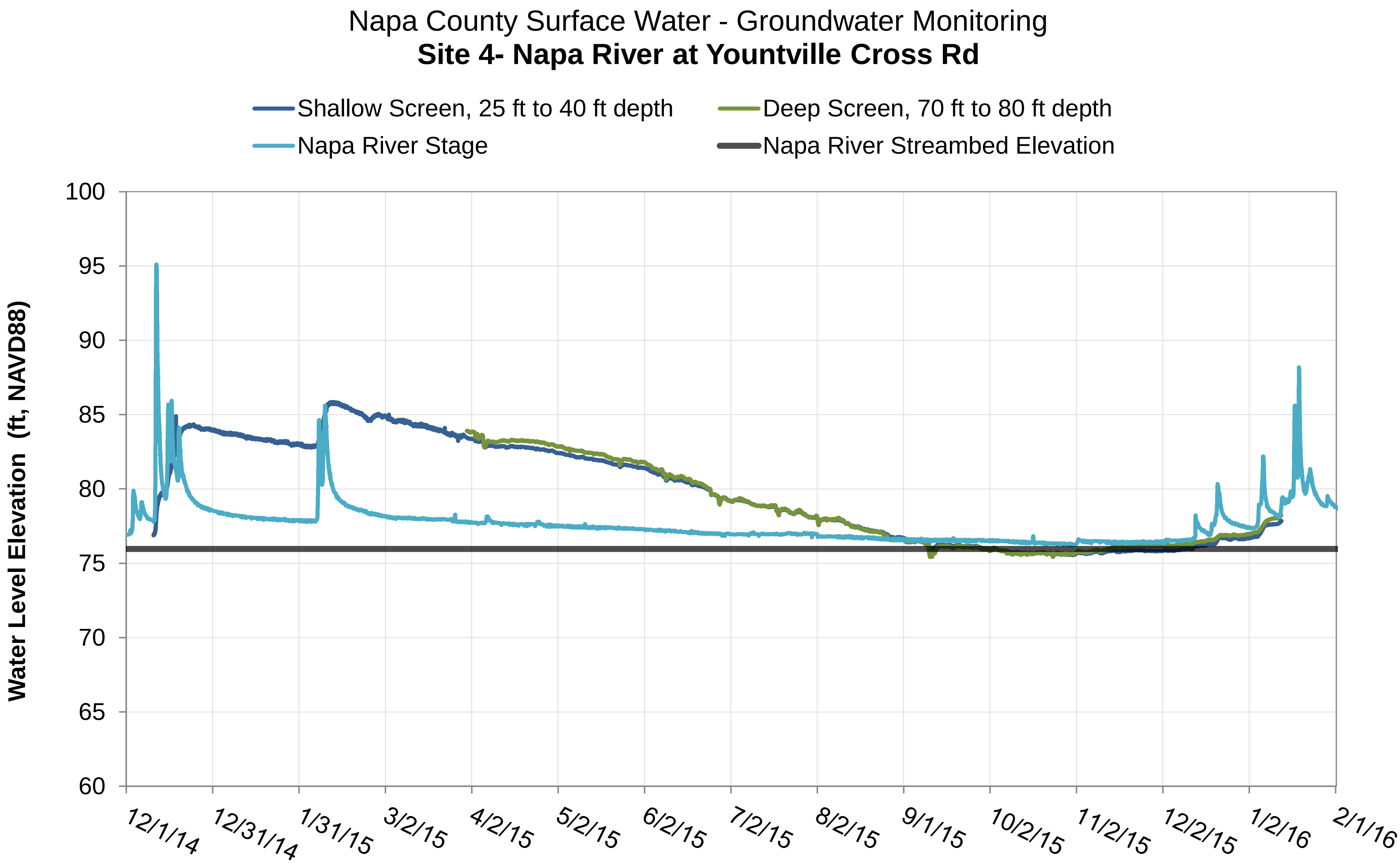
CONSULTING ENGINEERS

Figure 4-43

Surface Water-Groundwater Hydrograph
Site 3: Napa River at Oak Knoll Avenue



X:\2012 Job Files\12-071\Data__Current Project Data Charts\DatabaseCharts.xlsm\WL Site 4

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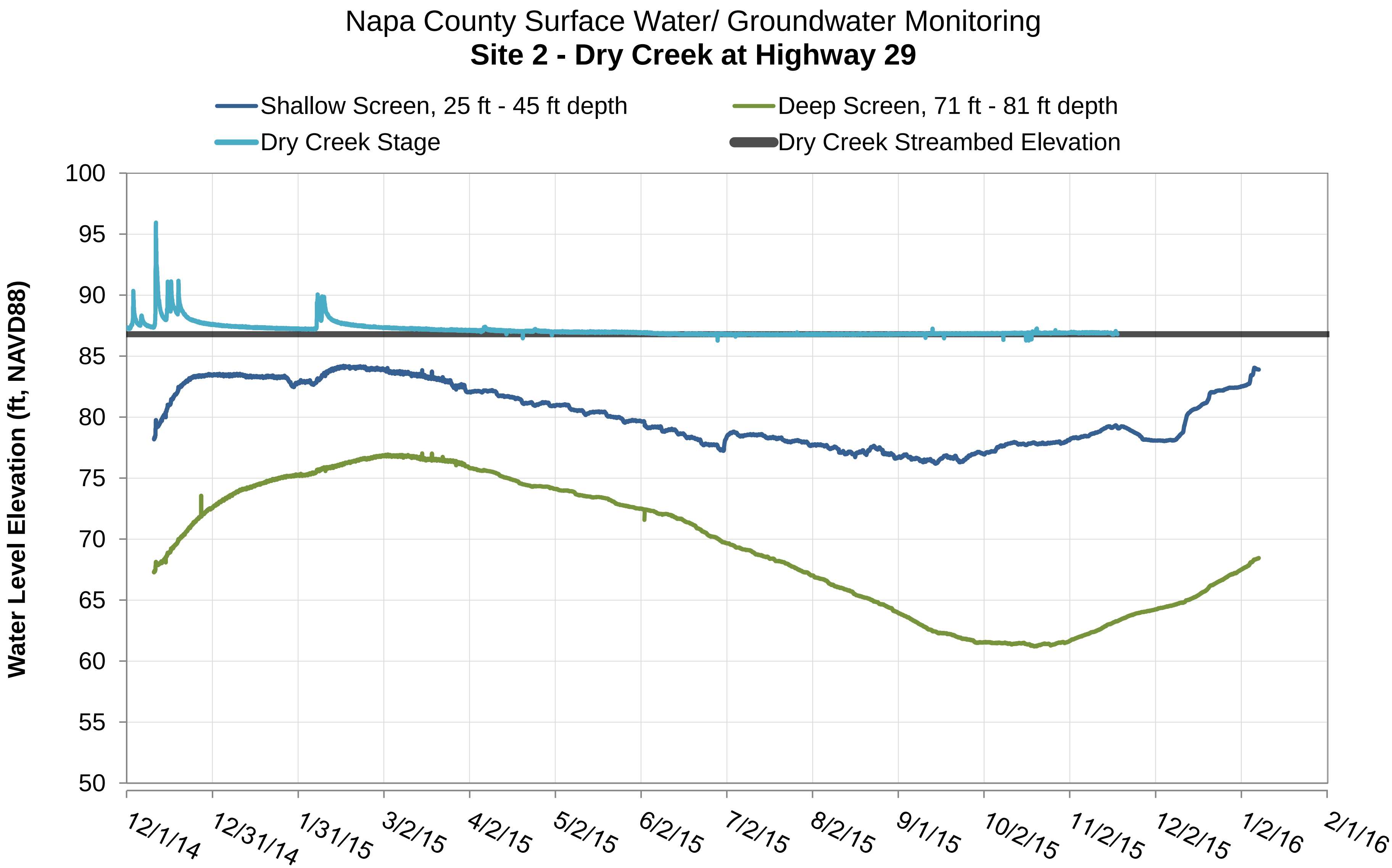
Figure 4-44
Surface Water-Groundwater Hydrograph
Site 4: Napa River at Yountville Cross Road



X:\2012 Job Files\12-071\Data__Current Project Data Charts\DatabaseCharts.xlsm\WL Site 2

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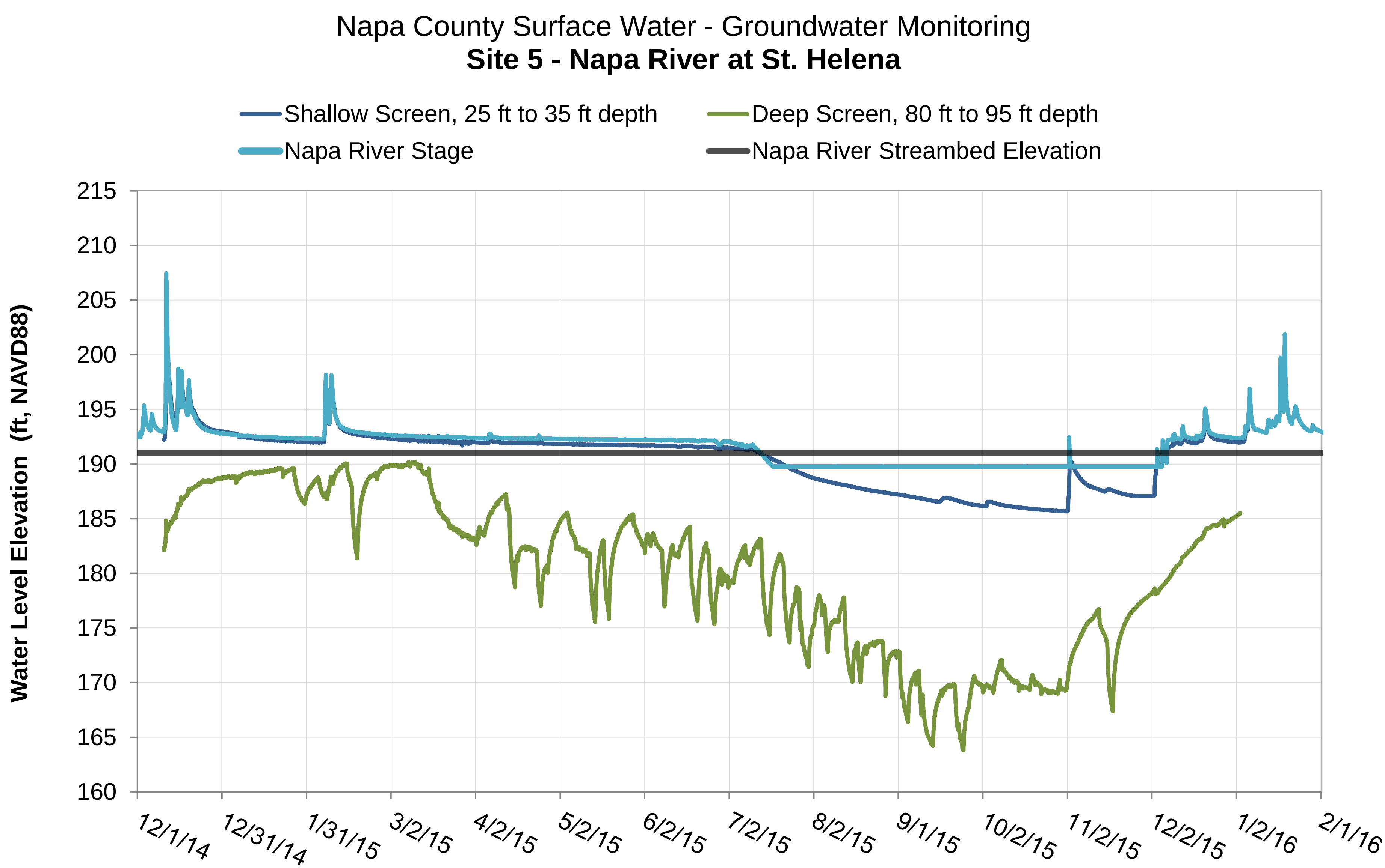
Figure 4-45
Surface Water-Groundwater Hydrograph
Site 2: Dry Creek at Highway 29



X:\2012 Job Files\12-071\Data__Current Project Data Charts\DatabaseCharts.xlsm\WL Site5

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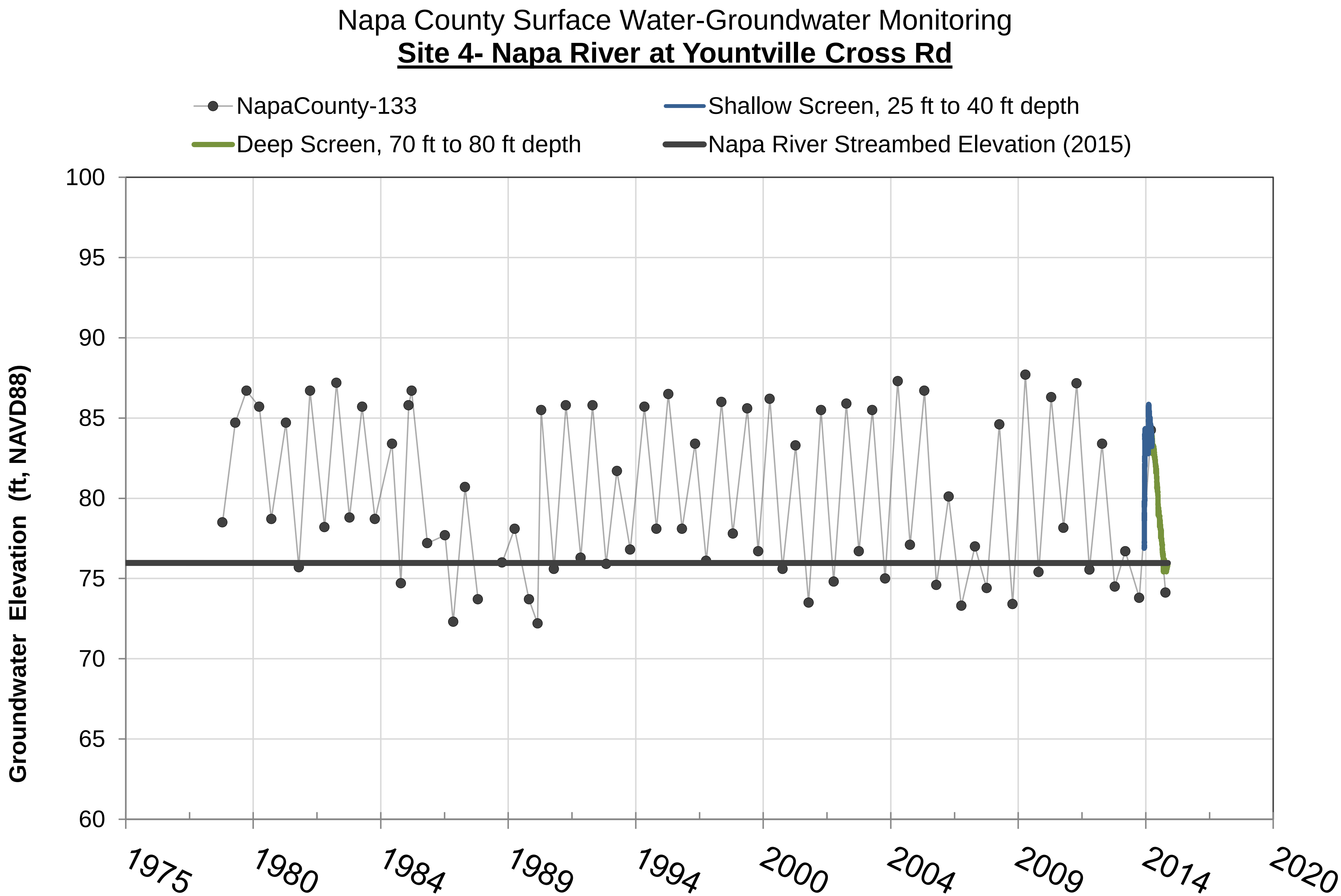
Figure 4-46
Surface Water-Groundwater Hydrograph
Site 5: Napa River at Pope Street

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin



X:\2012 Job Files\12-071\Data__Current Project Data Charts\Site_4_Surface-GW_Chart.xlsx\Chart_GWL_historical

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Figure 4-47

Surface Water-Groundwater Network Site Historical Comparison
Site 4: Napa River at Yountville Cross Road

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

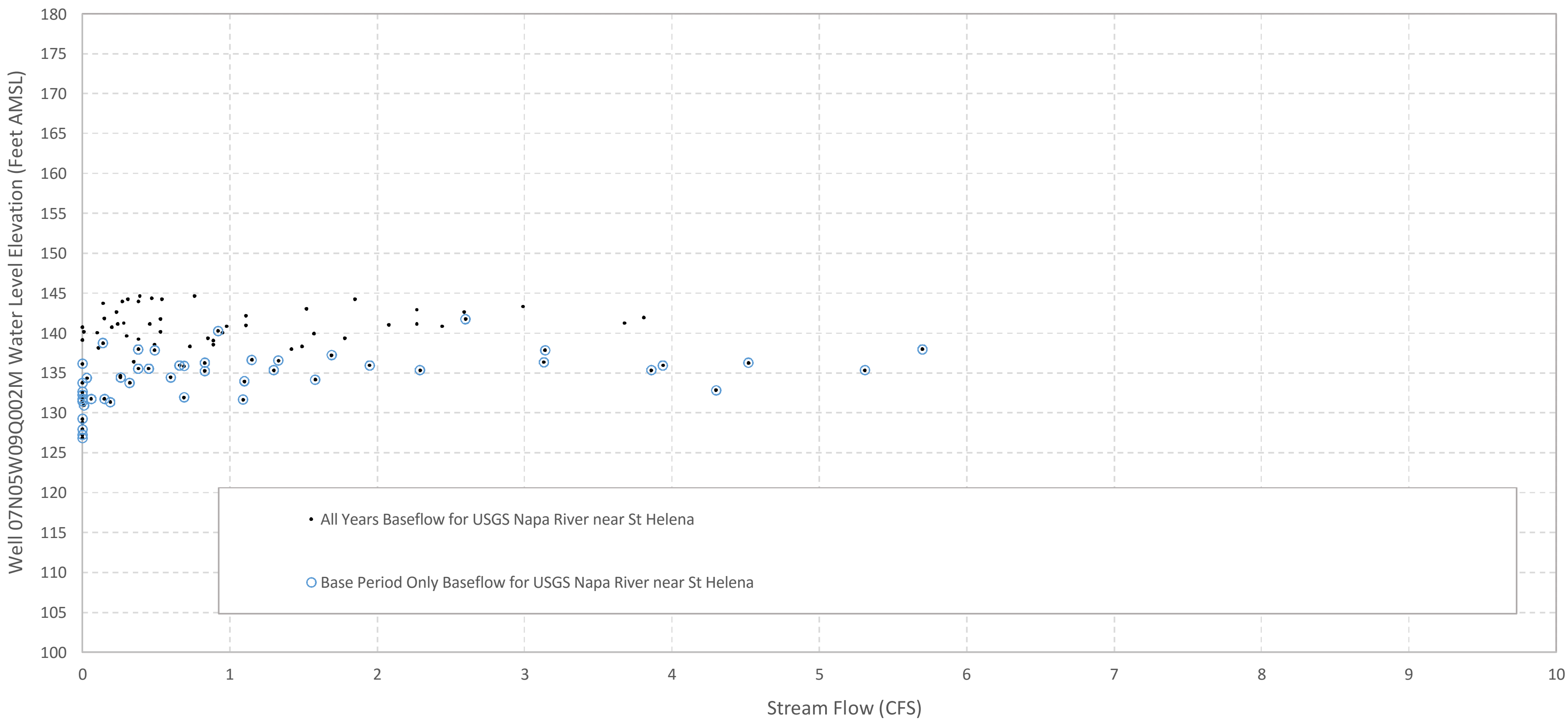

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Figure 4-48
Baseflow Napa River Near St Helena and Well 07N05W09Q002M Groundwater Elevation (All Years and Base Period, Fall)

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

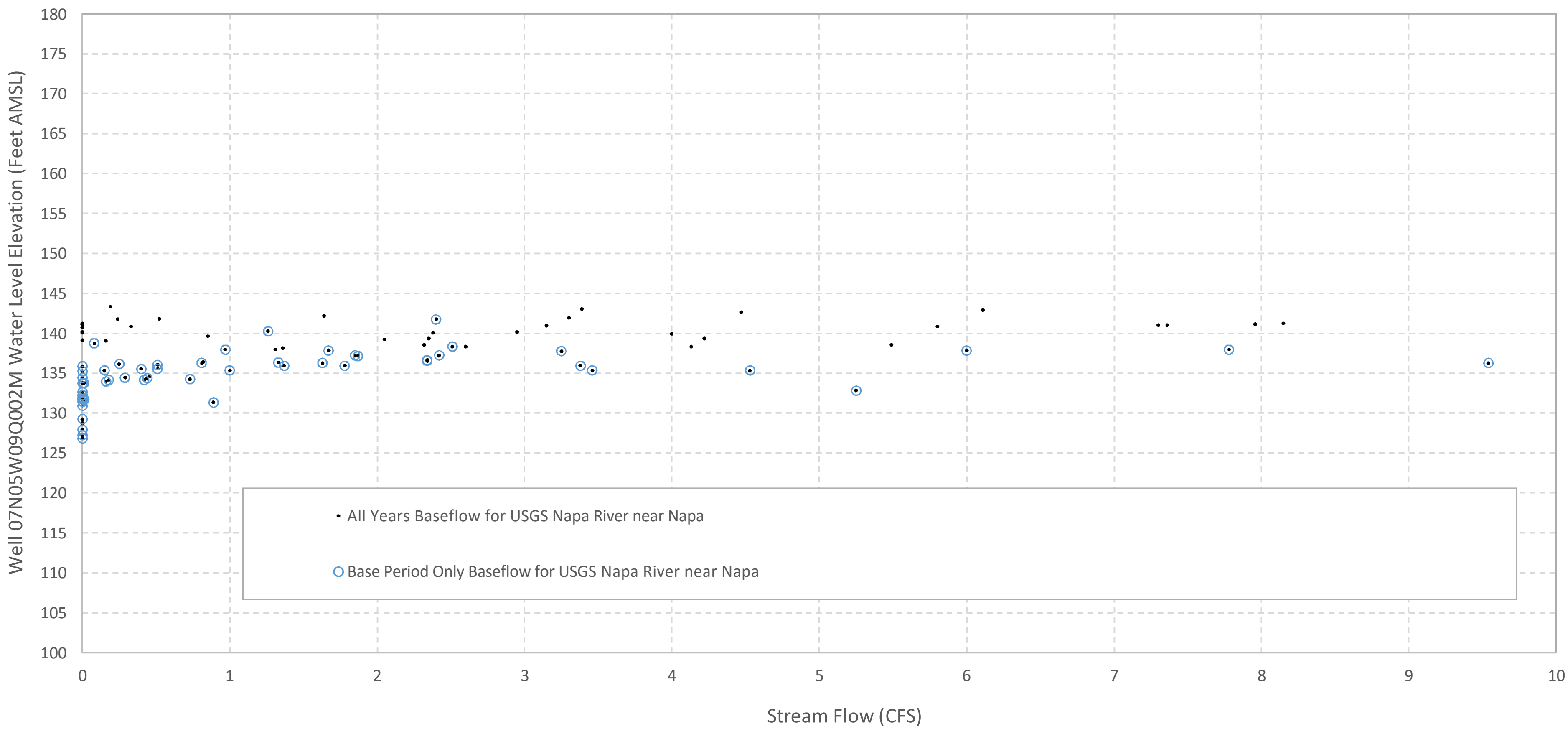

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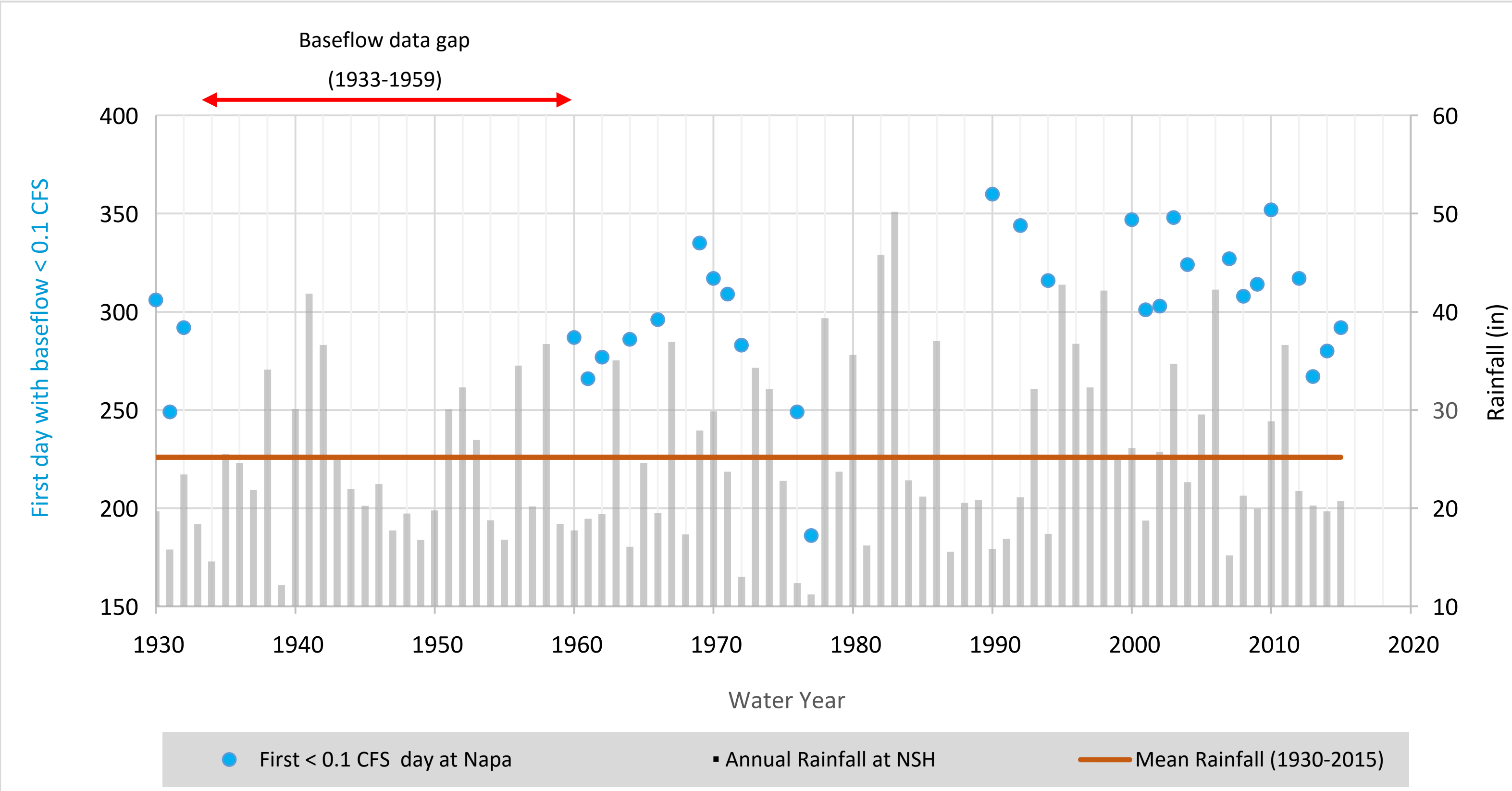
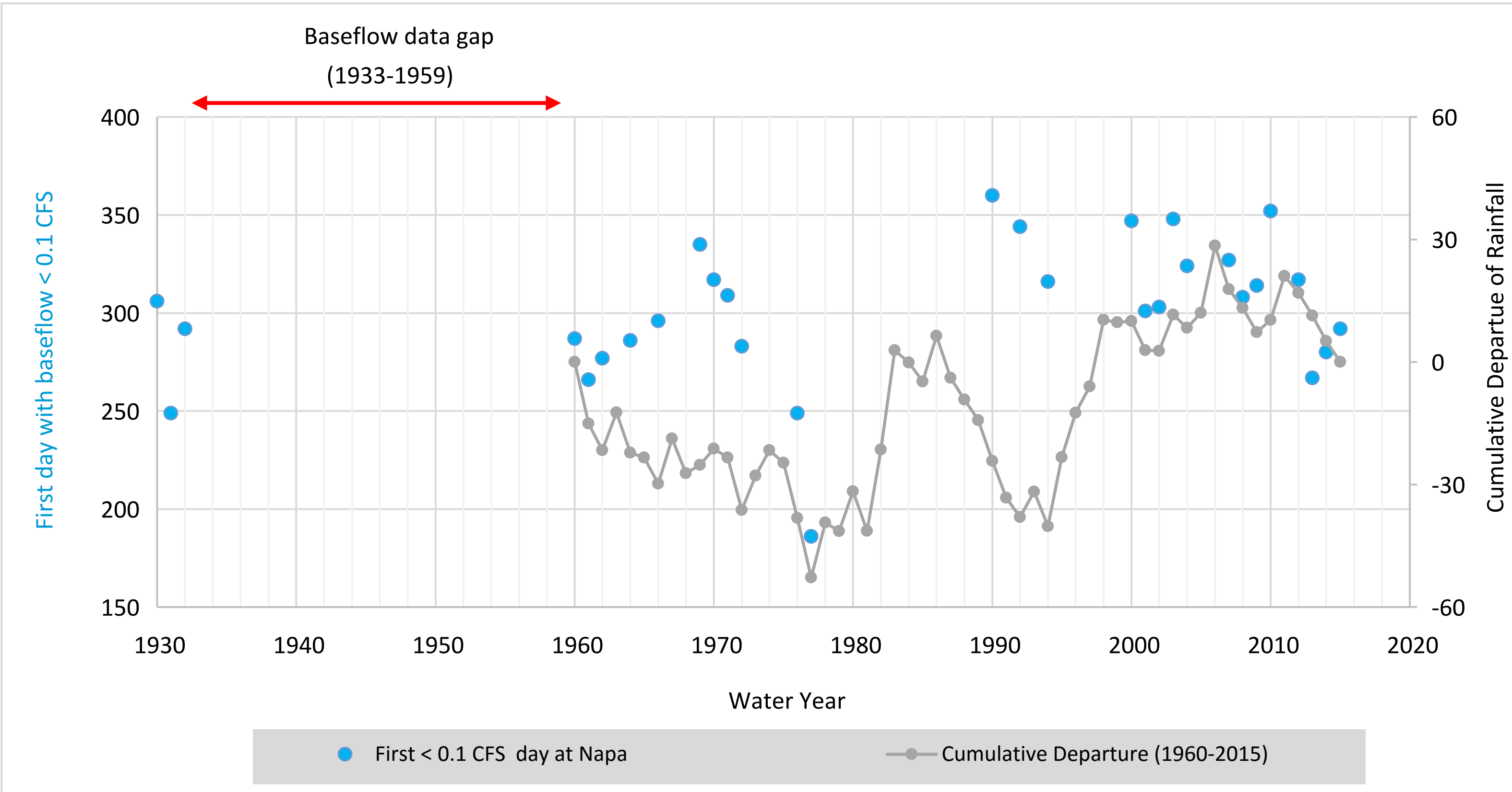
Figure 4-49
Baseflow Napa River Near Napa and Well 07N05W09Q002M Groundwater Elevation (All Years and Base Period, Fall)



NOTE: First day with baseflow < 0.1 CFS is relative to the start of each water year, October 1.

Figure 4-50
First Day of Baseflow < 0.1 CFS at Napa River near Napa and Annual Rainfall



NOTE: First day with baseflow < 0.1 CFS is relative to the start of each water year, October 1.

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Figure 4-51

First Day of Baseflow < 0.1 CFS at Napa River near Napa and Cumulative Departure of Rainfall

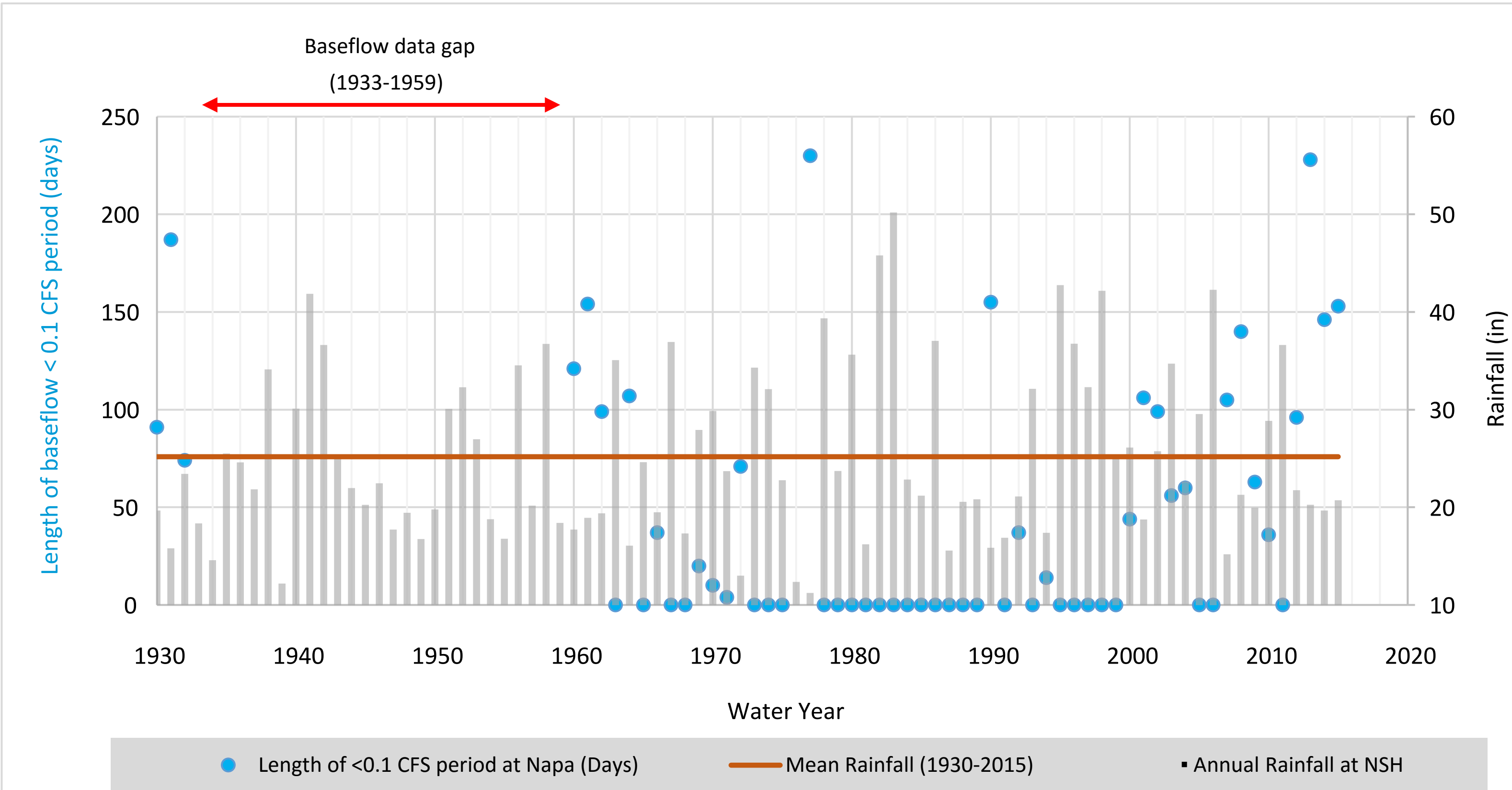

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Figure 4-52
Length of Baseflow < 0.1 CFS Period at Napa River near Napa and Annual Rainfall

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin

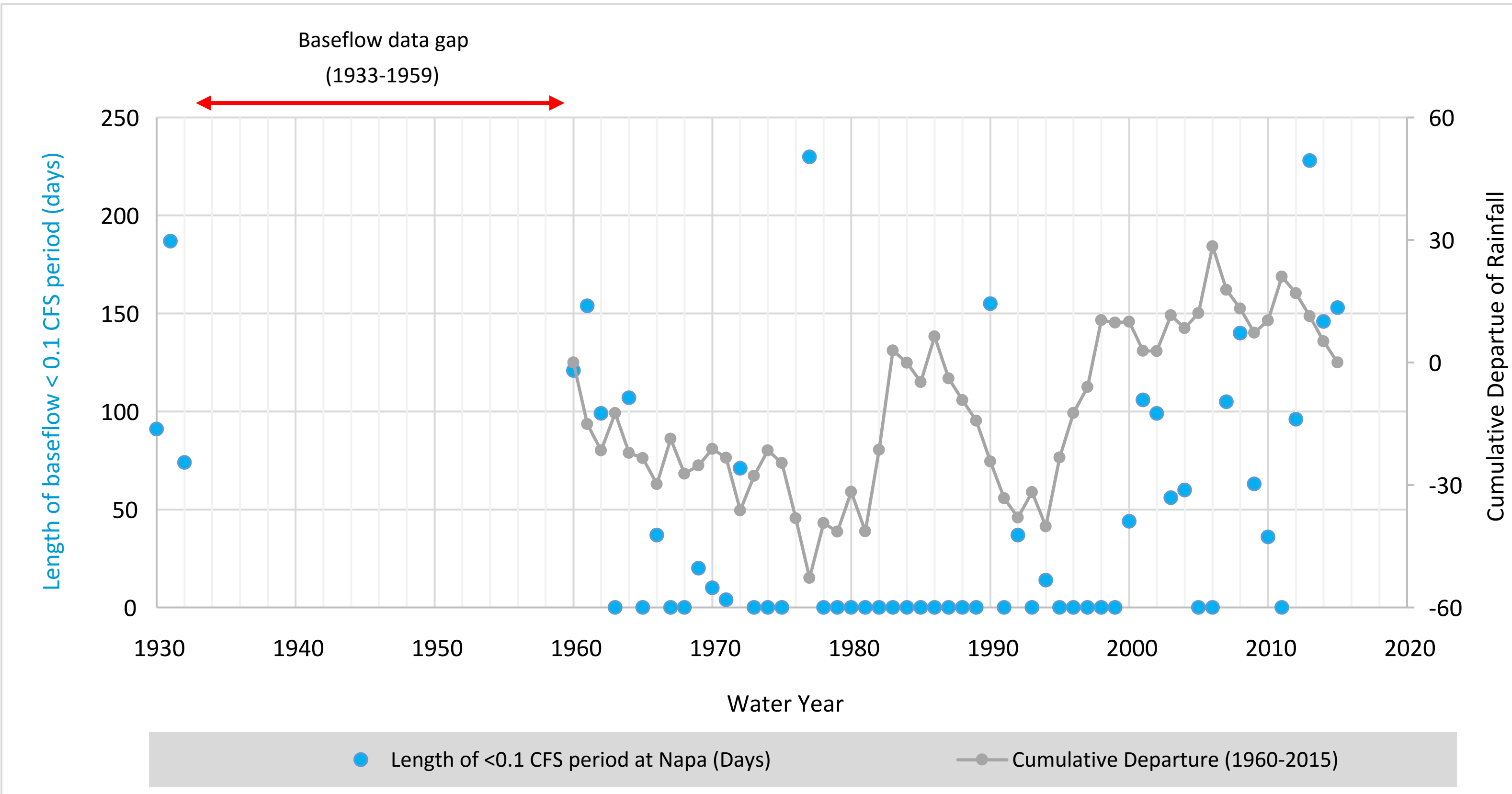

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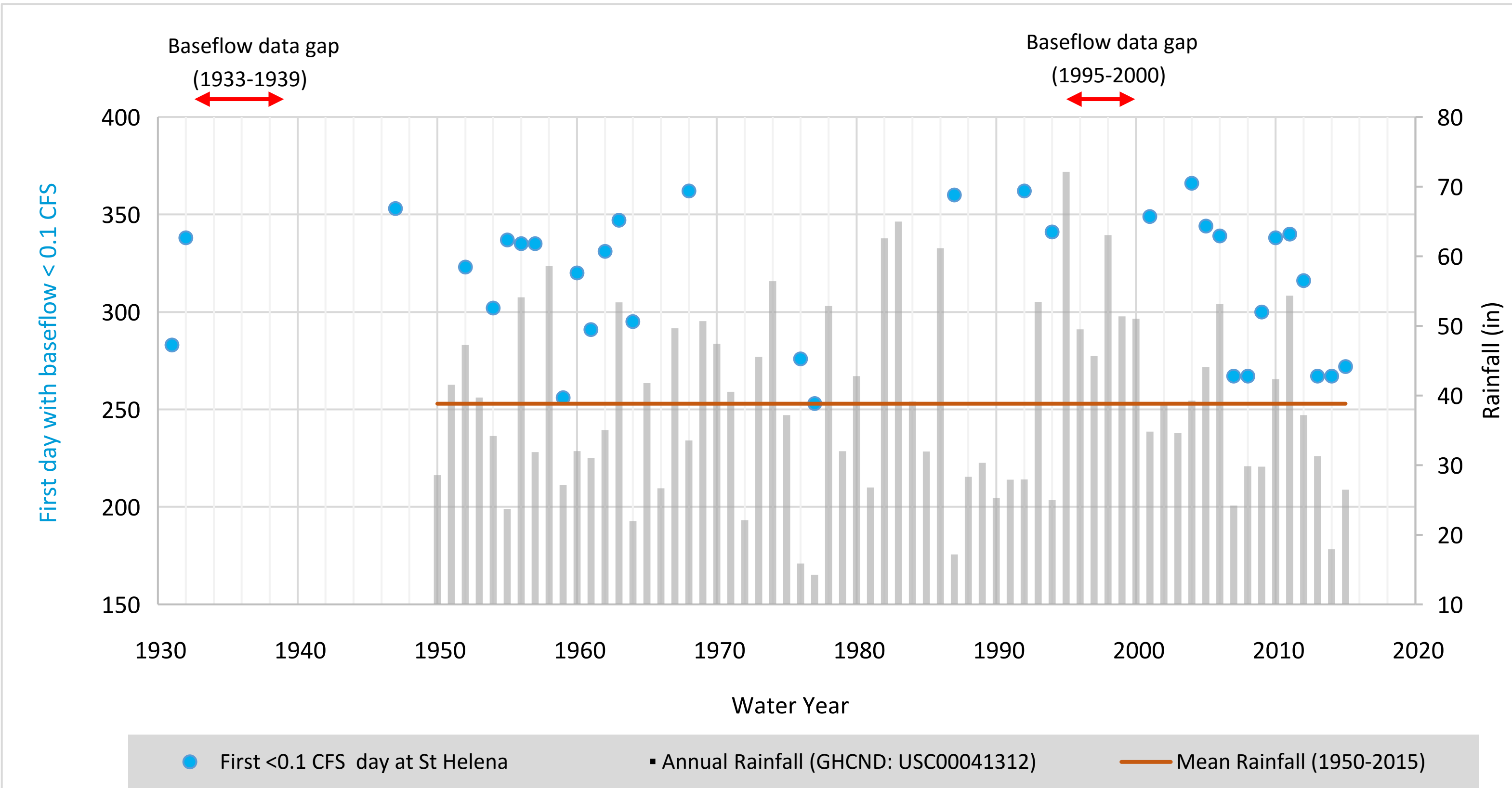
Figure 4-53
Length of Baseflow < 0.1 CFS Period at Napa River near Napa and Cumulative Departure of Rainfall



NOTE: First day with baseflow < 0.1 CFS is relative to the start of each water year, October 1.

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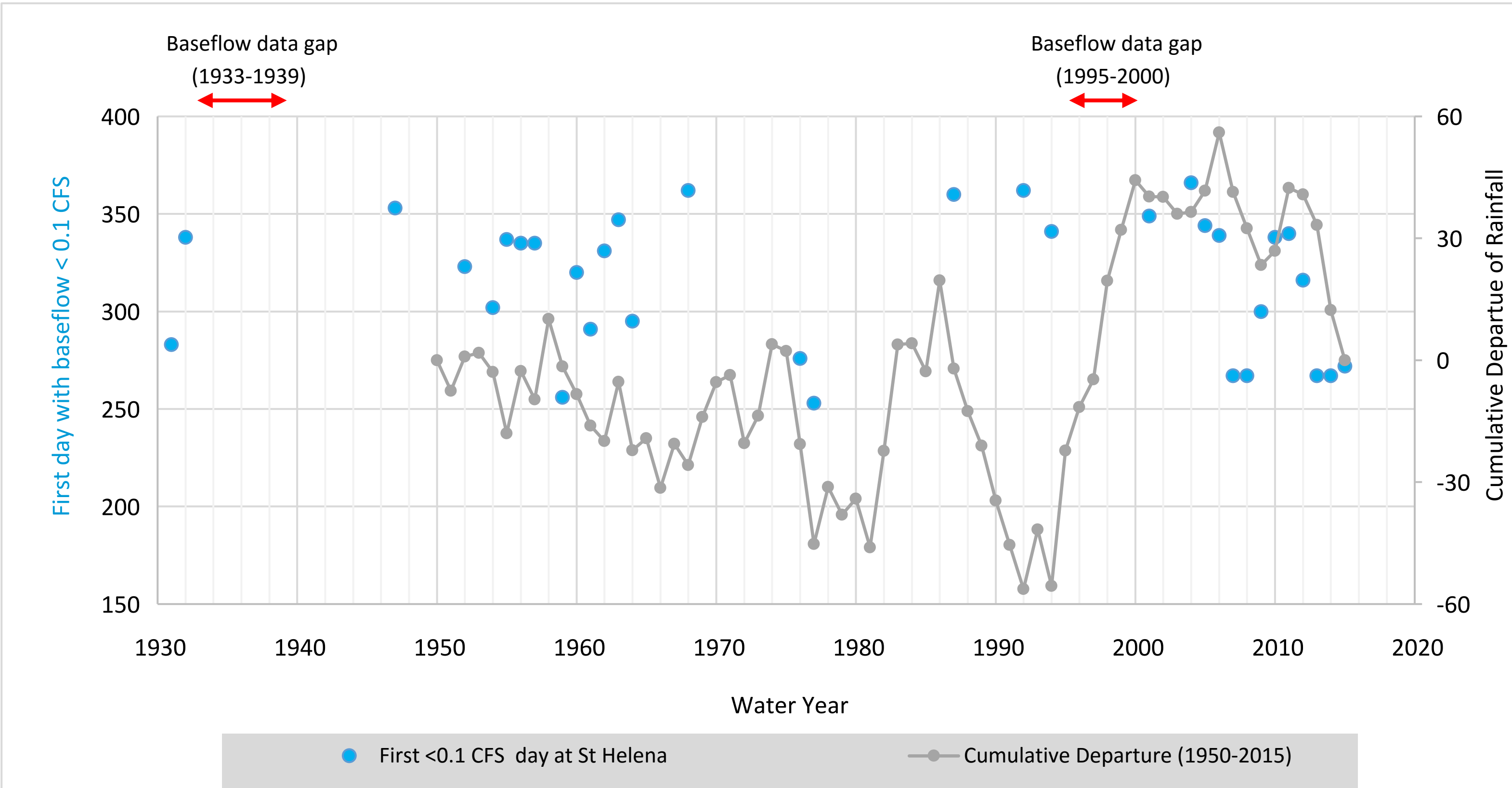
Figure 4-54
First Day of Baseflow < 0.1 CFS at Napa River near St. Helena and Annual Rainfall



NOTE: First day with baseflow < 0.1 CFS is relative to the start of each water year, October 1.

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Figure 4-55
First Day of Baseflow < 0.1 CFS at Napa River near St. Helena and Cumulative Departure of Rainfall

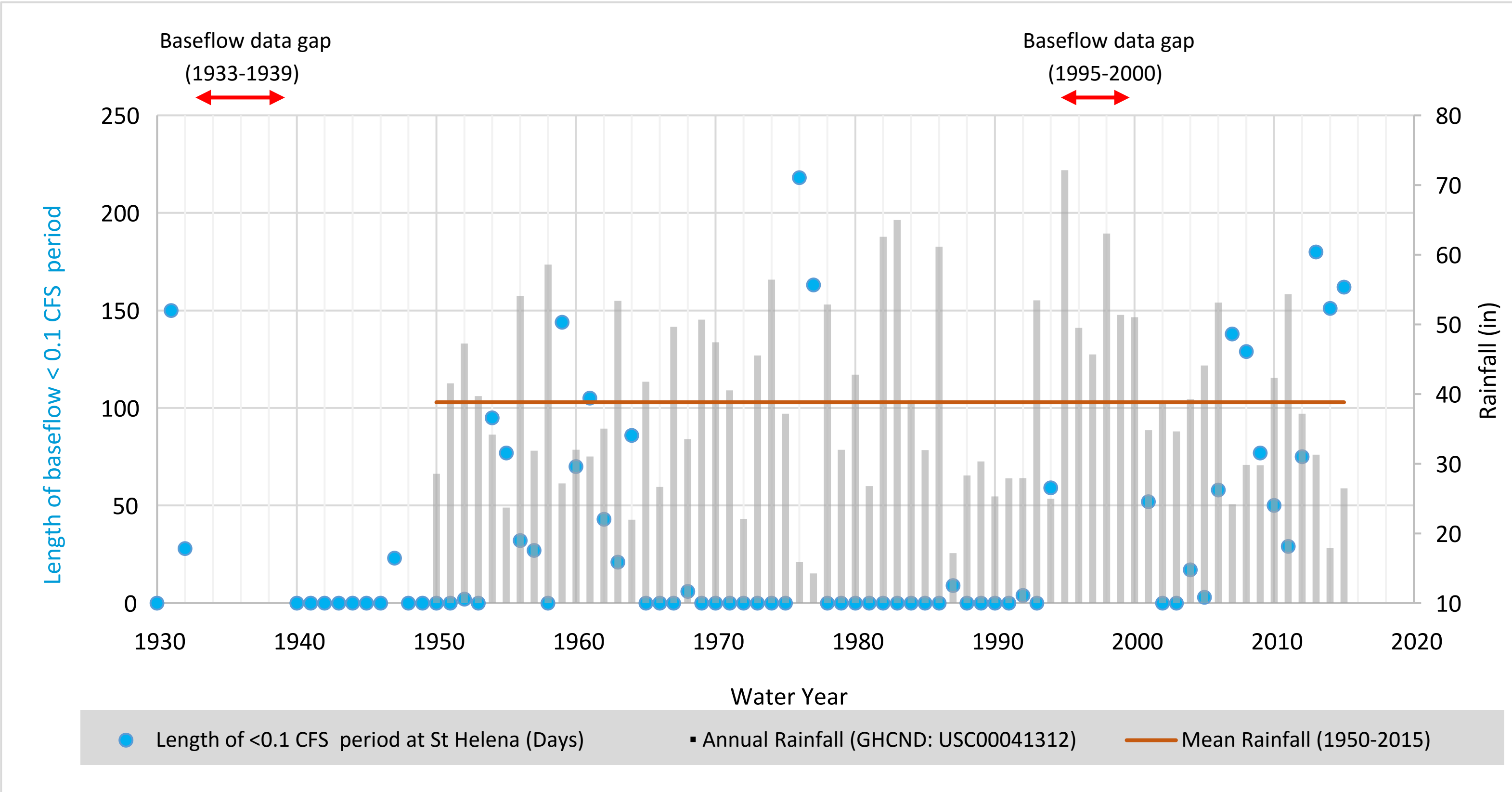

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Figure 4-56
Length of Baseflow < 0.1 CFS Period at Napa River near St. Helena and Annual Rainfall

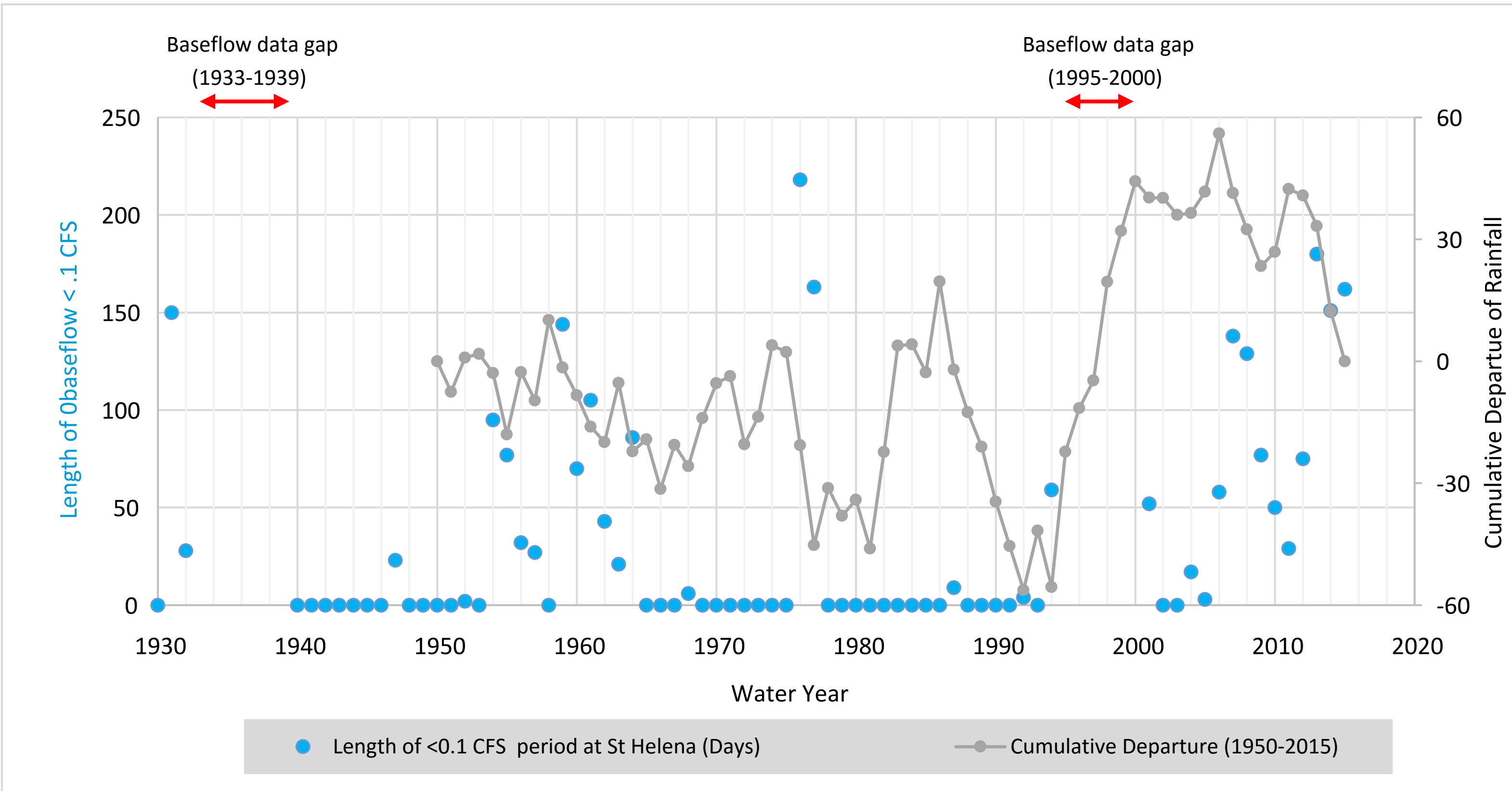

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Figure 4-57
Length of Baseflow < 0.1 CFS Period at Napa River near St. Helena and Cumulative Departure of Rainfall

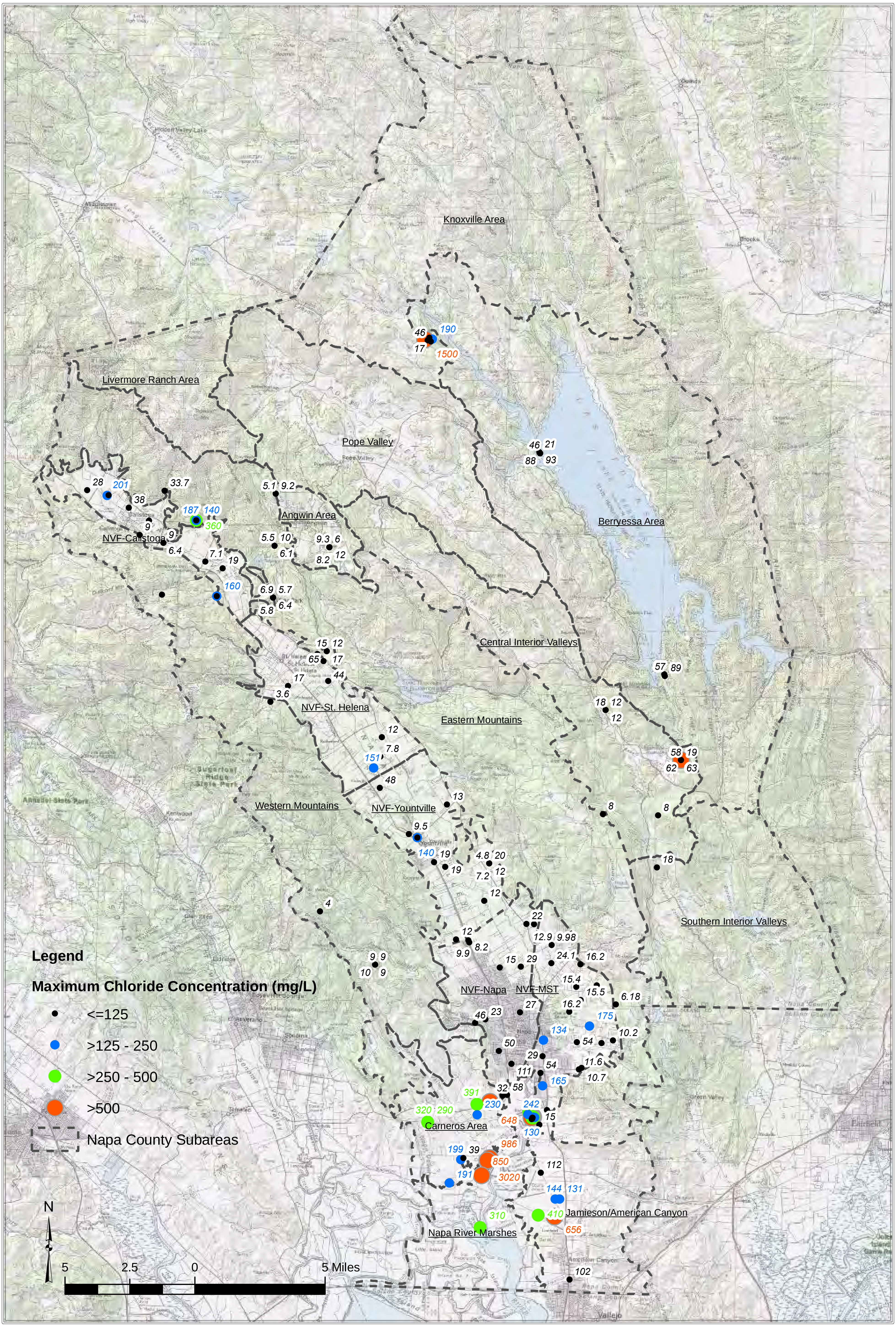

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Figure 4-58
Maximum Historical Chloride Concentrations in Groundwater

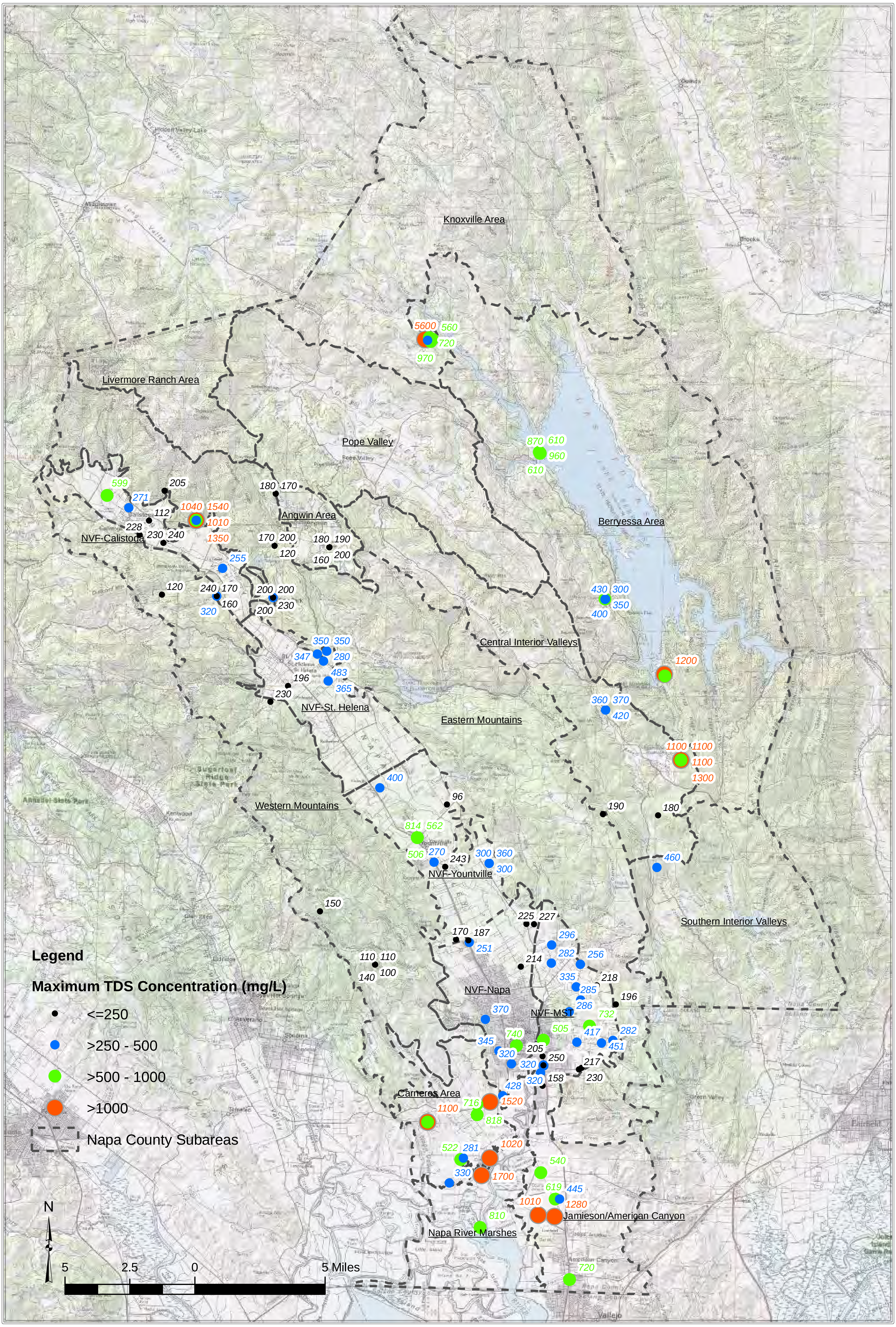

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Figure 4-59
Maximum Historical TDS Concentrations in Groundwater

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin

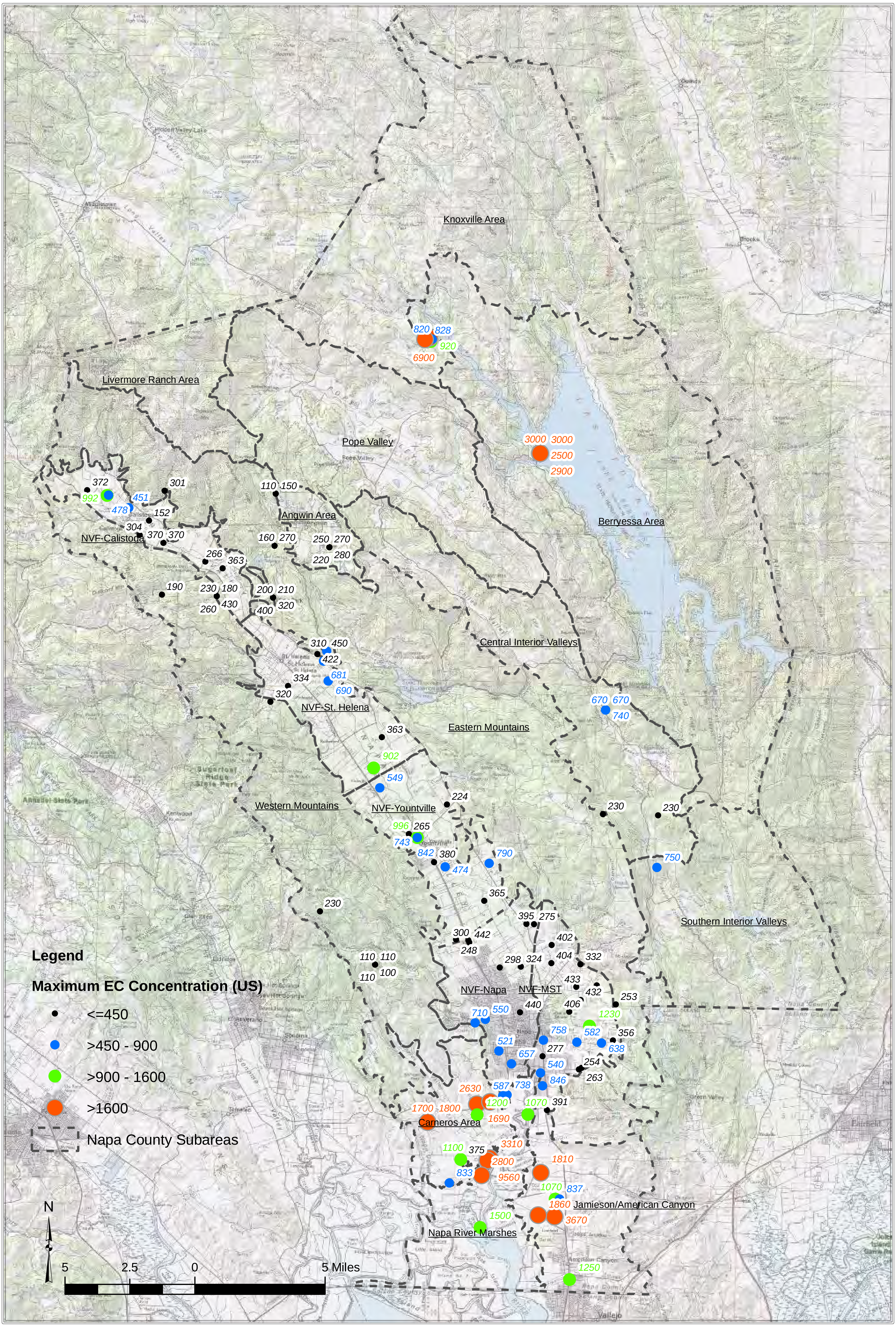

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Figure 4-60
Maximum Historical EC Concentrations in Groundwater

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin

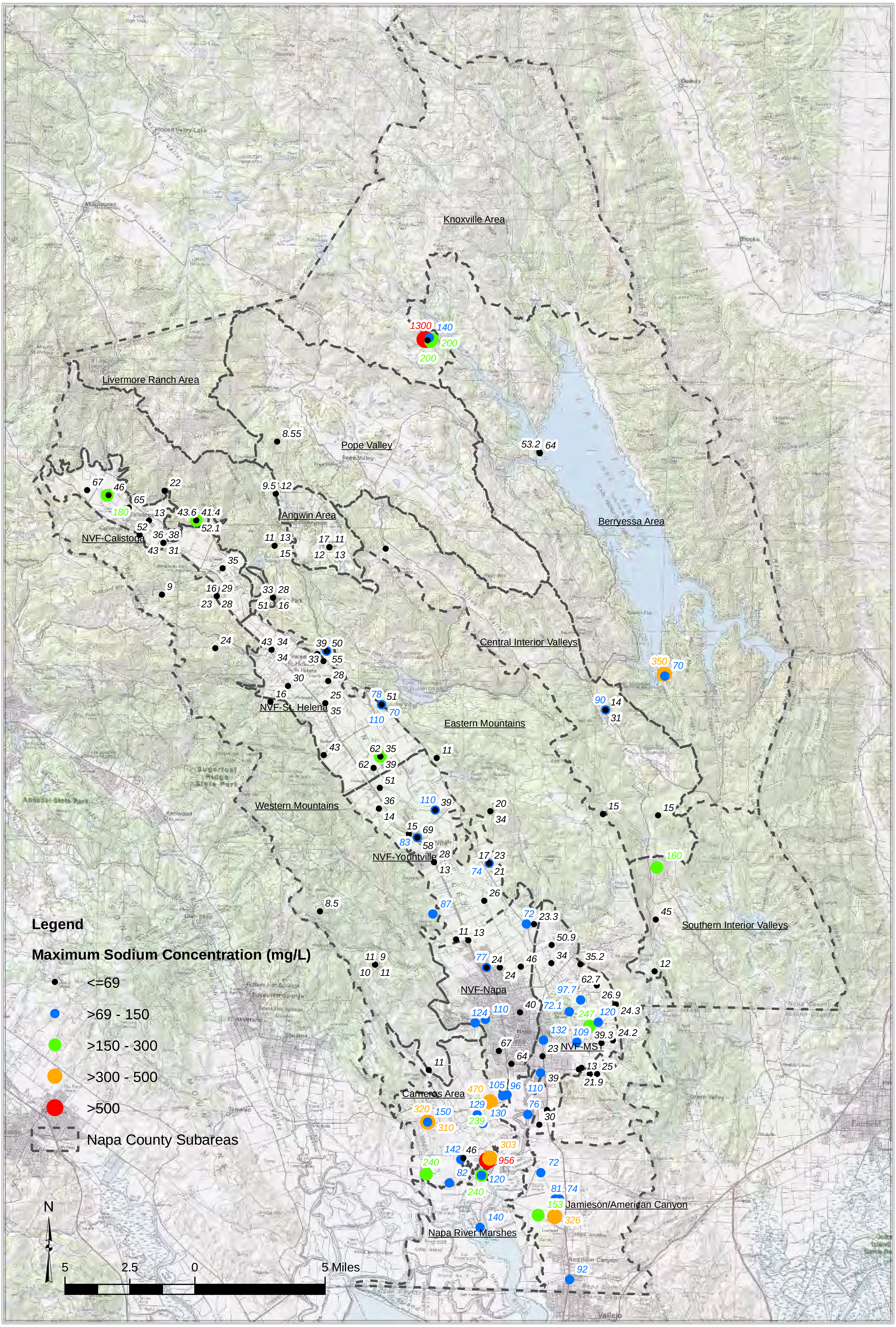

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Figure 4-61
Maximum Historical Sodium Concentrations in Groundwater

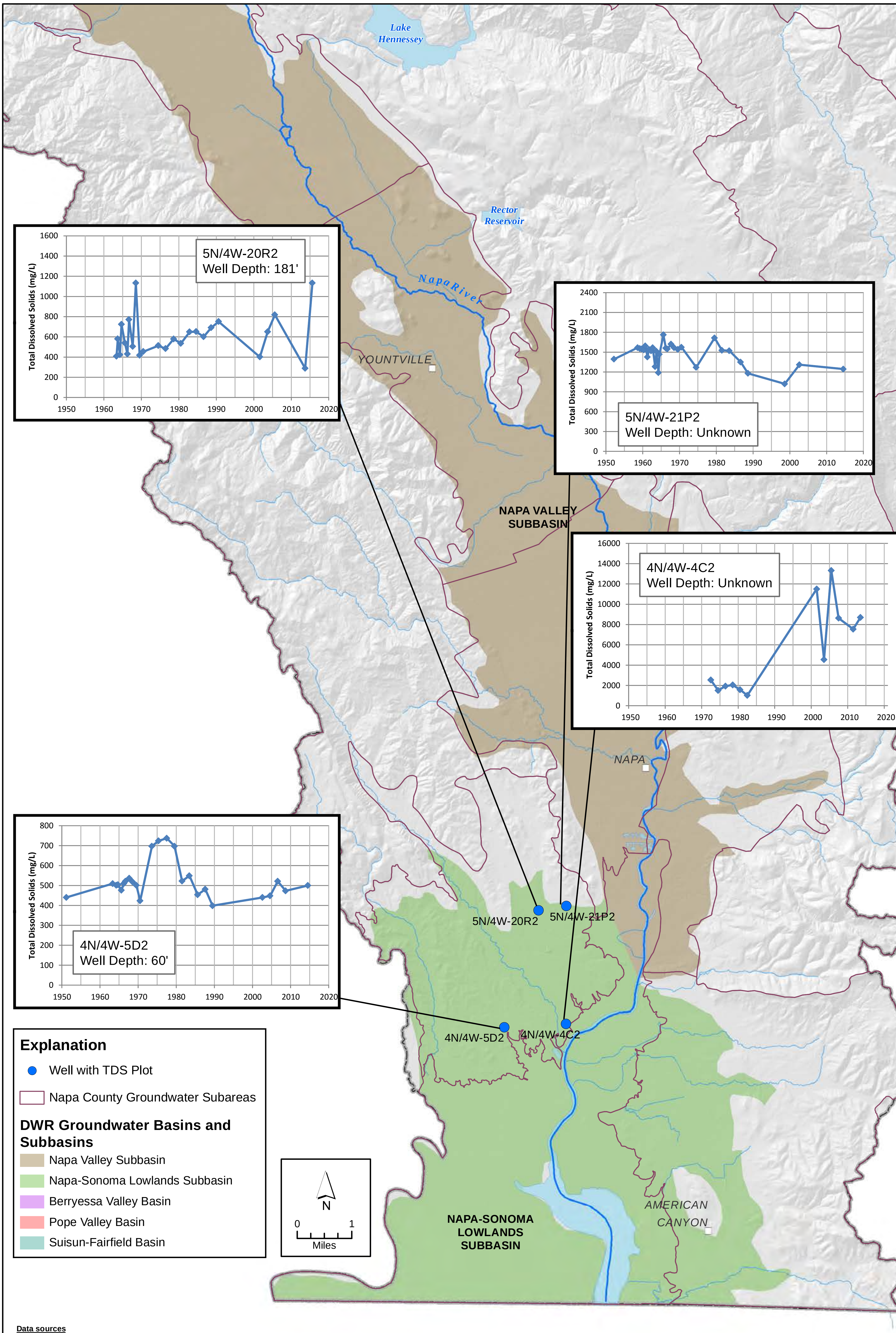

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FIGURE 4-62
TDS Concentrations Time-Series Plots
Napa-Sonoma Lowlands Groundwater Subbasin, Napa County, CA

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin

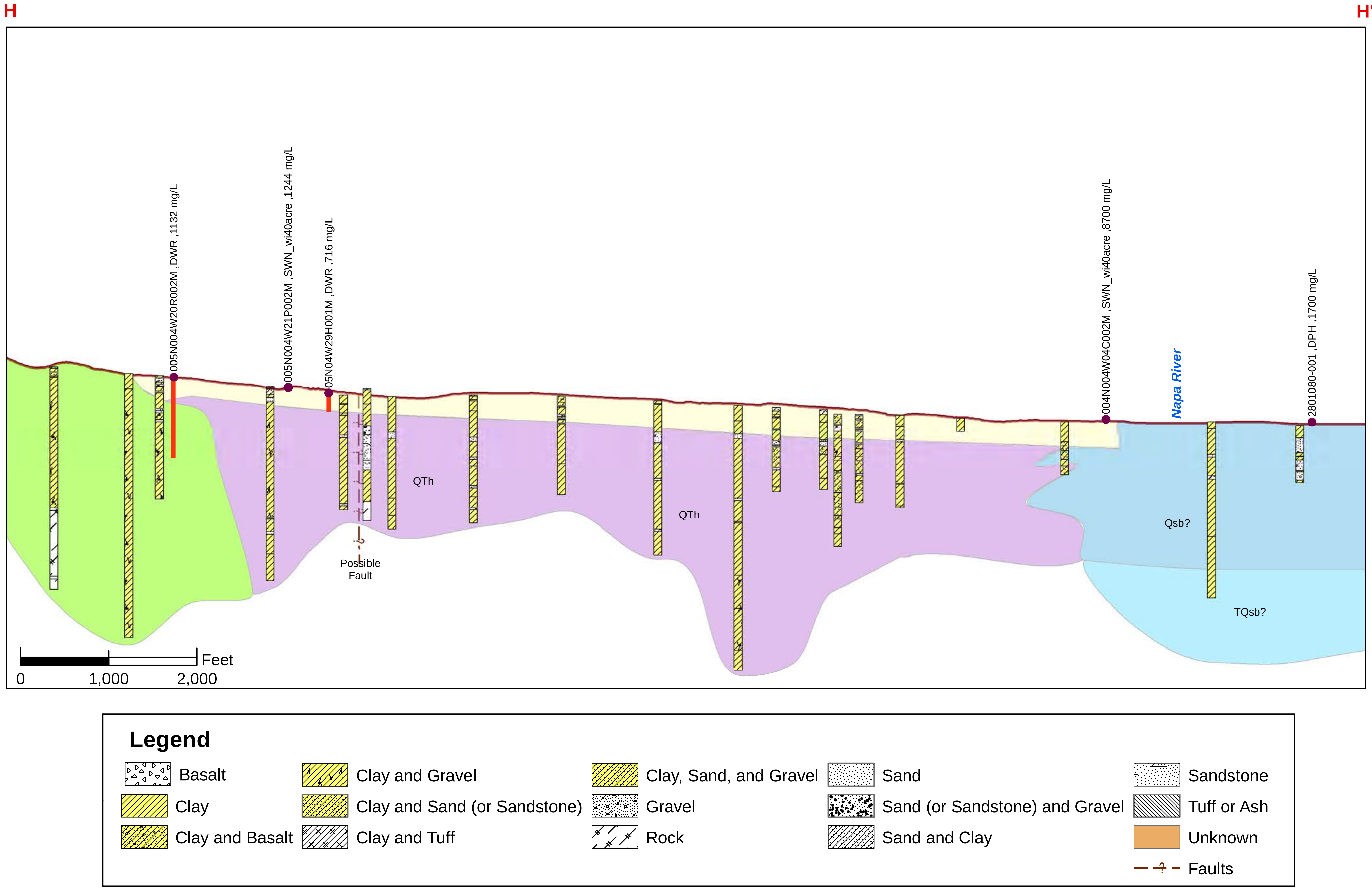

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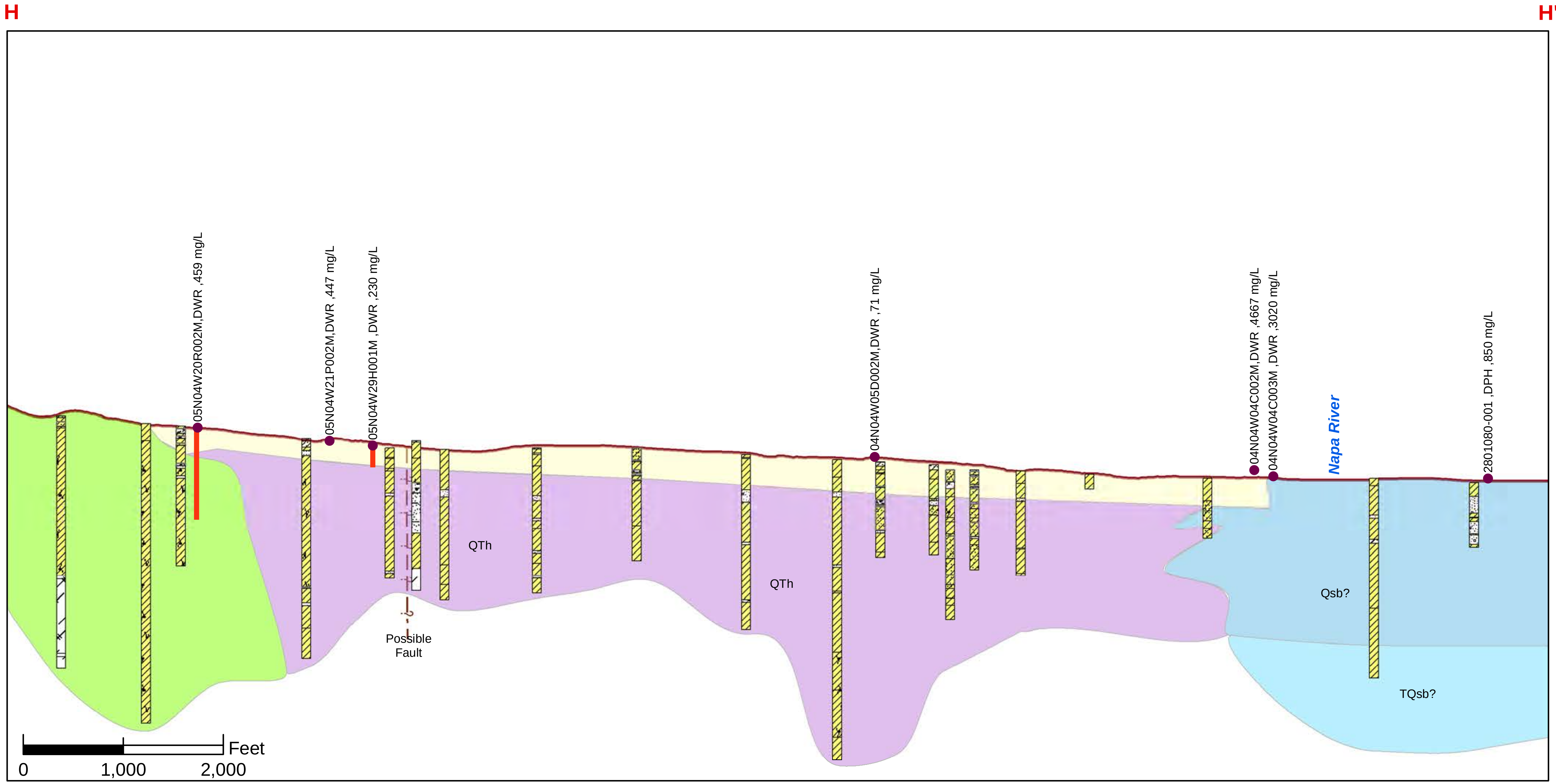
Figure 4-63
Cross Section H-H' with Proximal Maximum Historical TDS in Groundwater
Carneros Subarea, Napa County, CA



Legend

Basalt
Clay
Clay and Basalt
Clay and Gravel
Clay and Sand (or Sandstone)
Clay and Tuff
Clay, Sand, and Gravel
Gravel
Rock
Sand
Sand (or Sandstone) and Gravel
Sand and Clay
Sandstone
Tuff or Ash
Unknown
Faults

X:\2011 Job Files\11-090\GIS\xsections\102014\hh_xsection_cl.mxd

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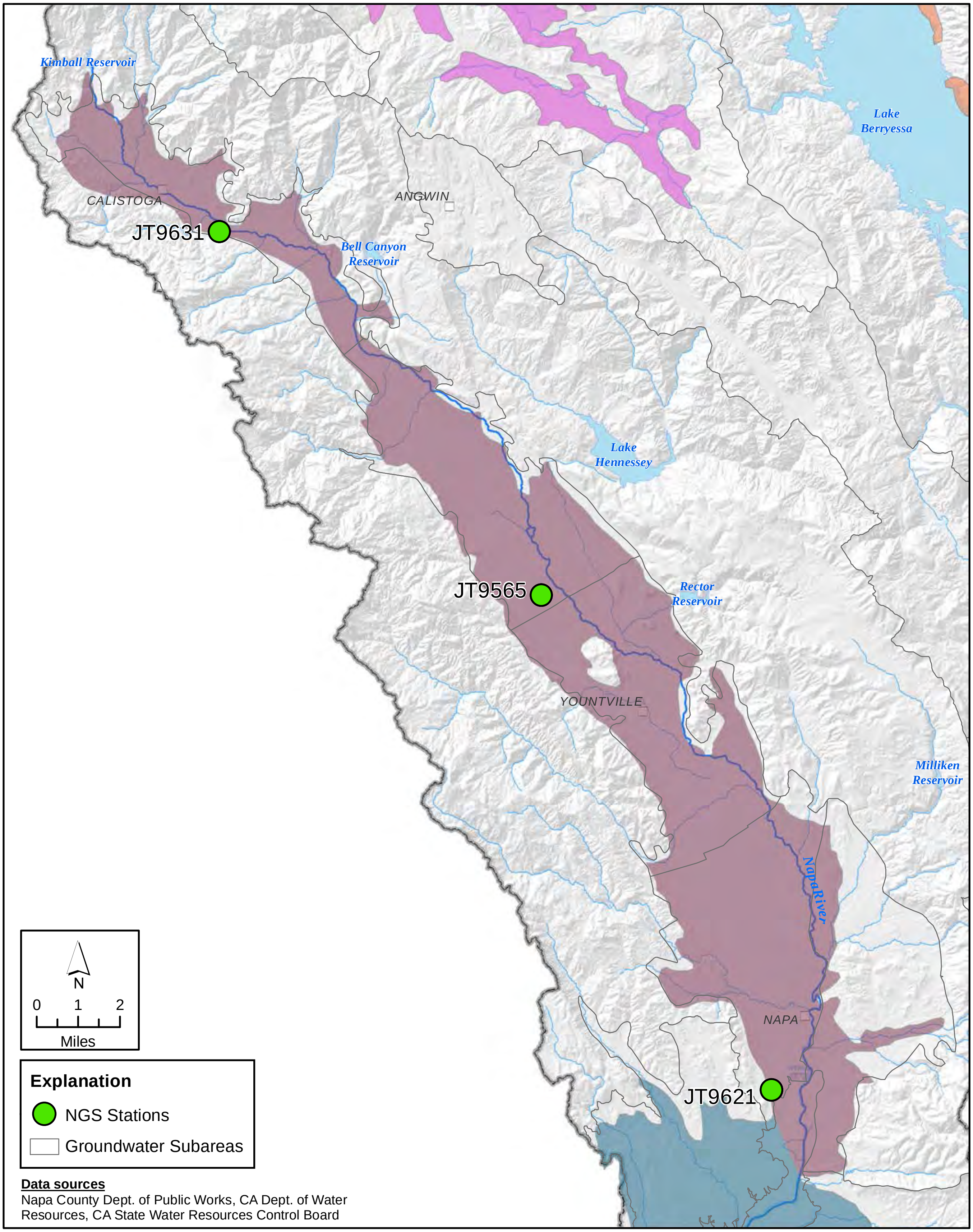
Figure 4-64
Cross Section H-H' with Proximal Maximum Historical Chloride in Groundwater

Carneros Subarea, Napa County, CA



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 4-51.mxd

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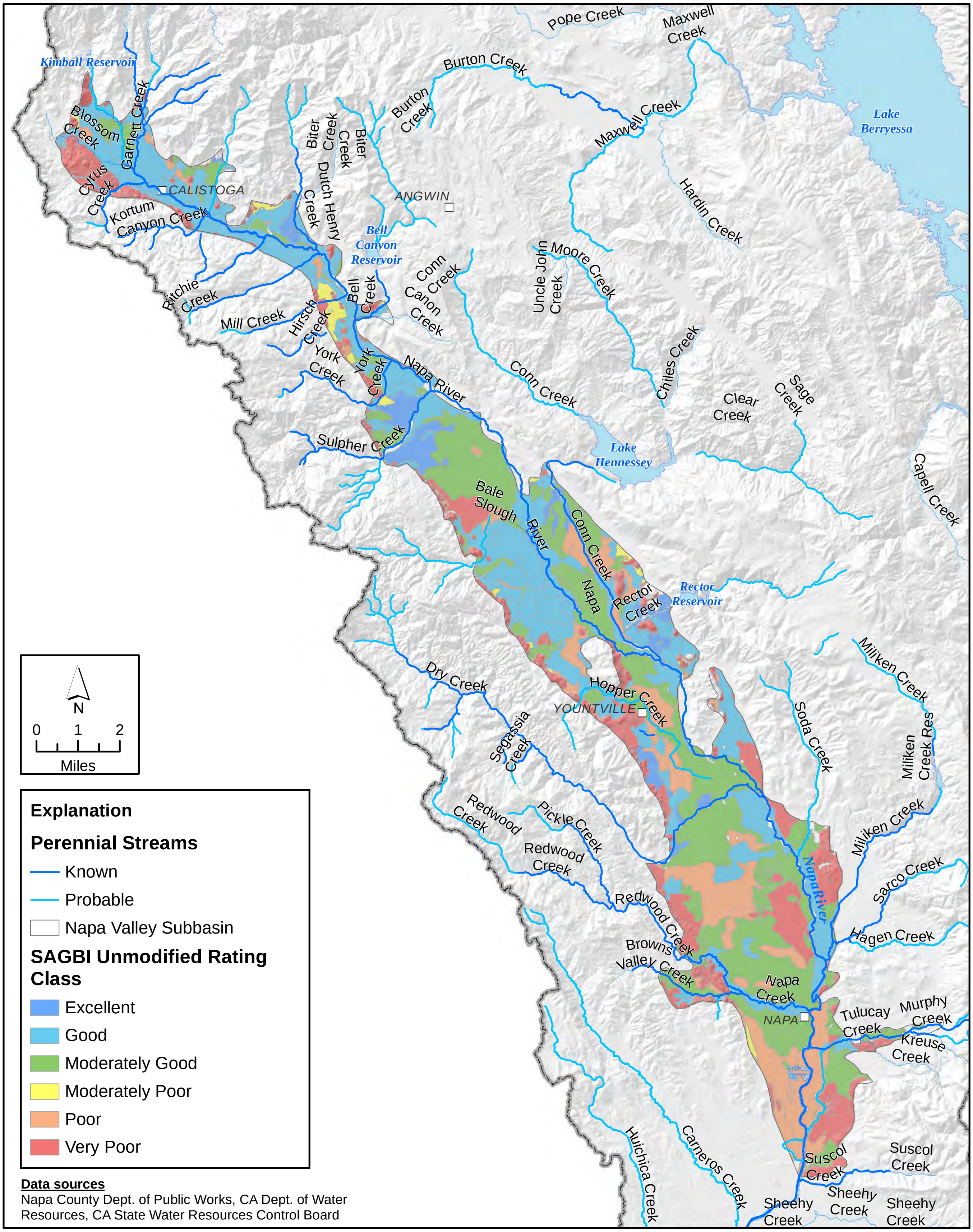
FIGURE 4-65
National Geodetic Elevation Benchmarks



Data sources
Napa County Dept. of Public Works, CA Dept. of Water Resources, CA State Water Resources Control Board

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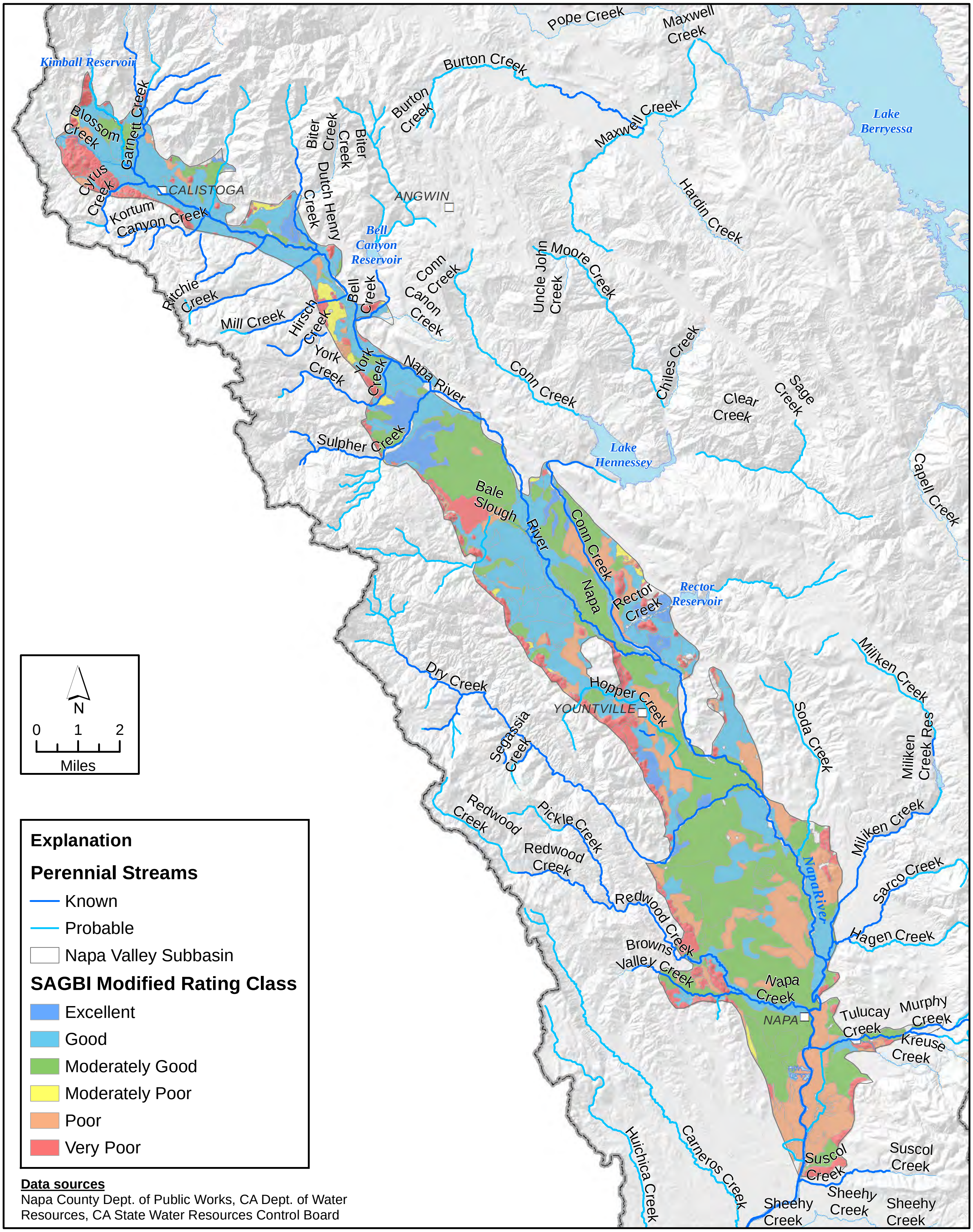
FIGURE 4-66a
Artificial Recharge Potential
Unmodified Soil Agricultural Groundwater Banking Index



\\LSCEEXSER\Clerical\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 4-55b.mxd

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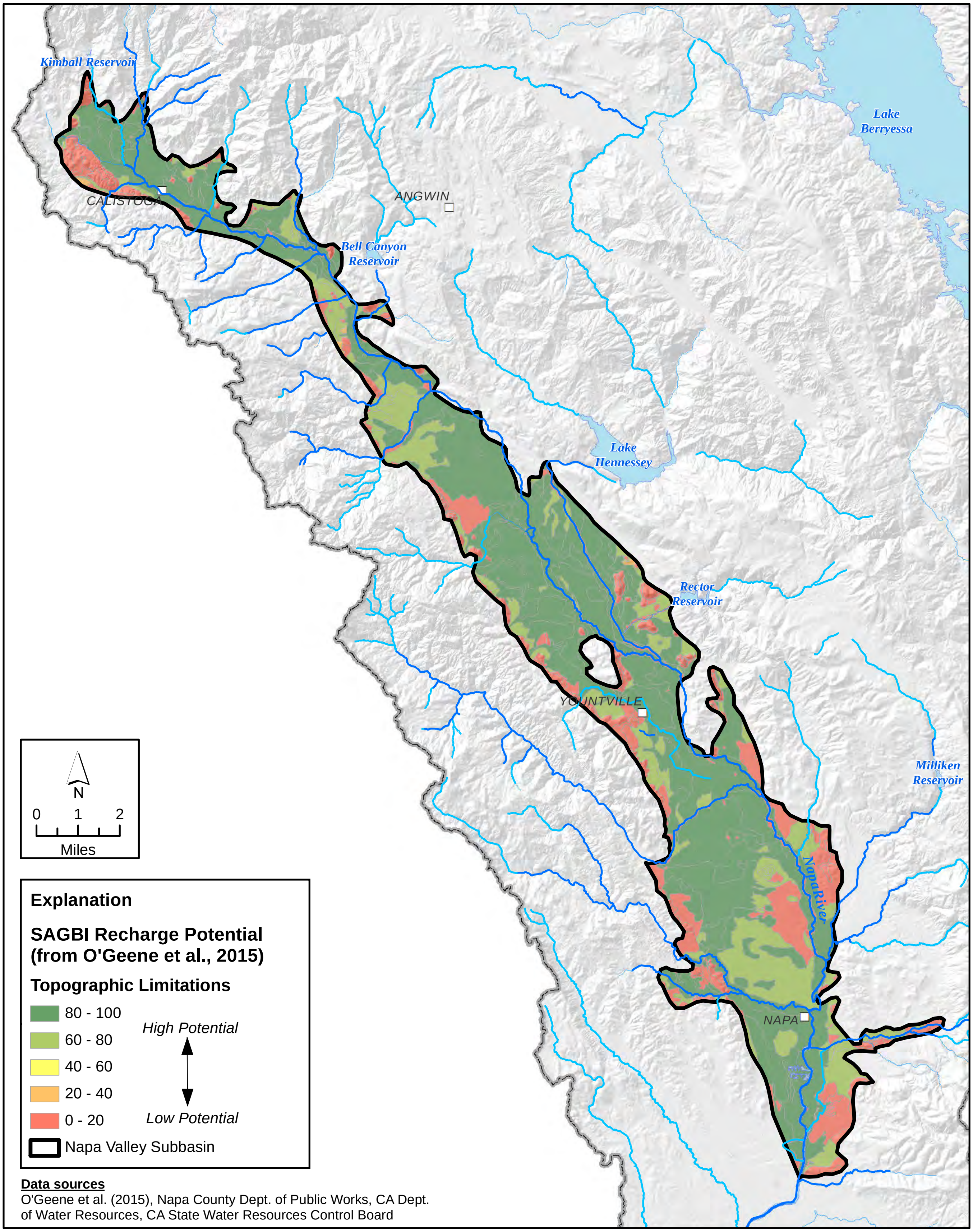
FIGURE 4-66b
Artificial Recharge Potential
Soil Agricultural Groundwater Banking Index Modified for Deep Ripping



\\LSCEEXSER\Clerical\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 4-53 SAGBI Recharge Potential Topographic Limitations.mxd

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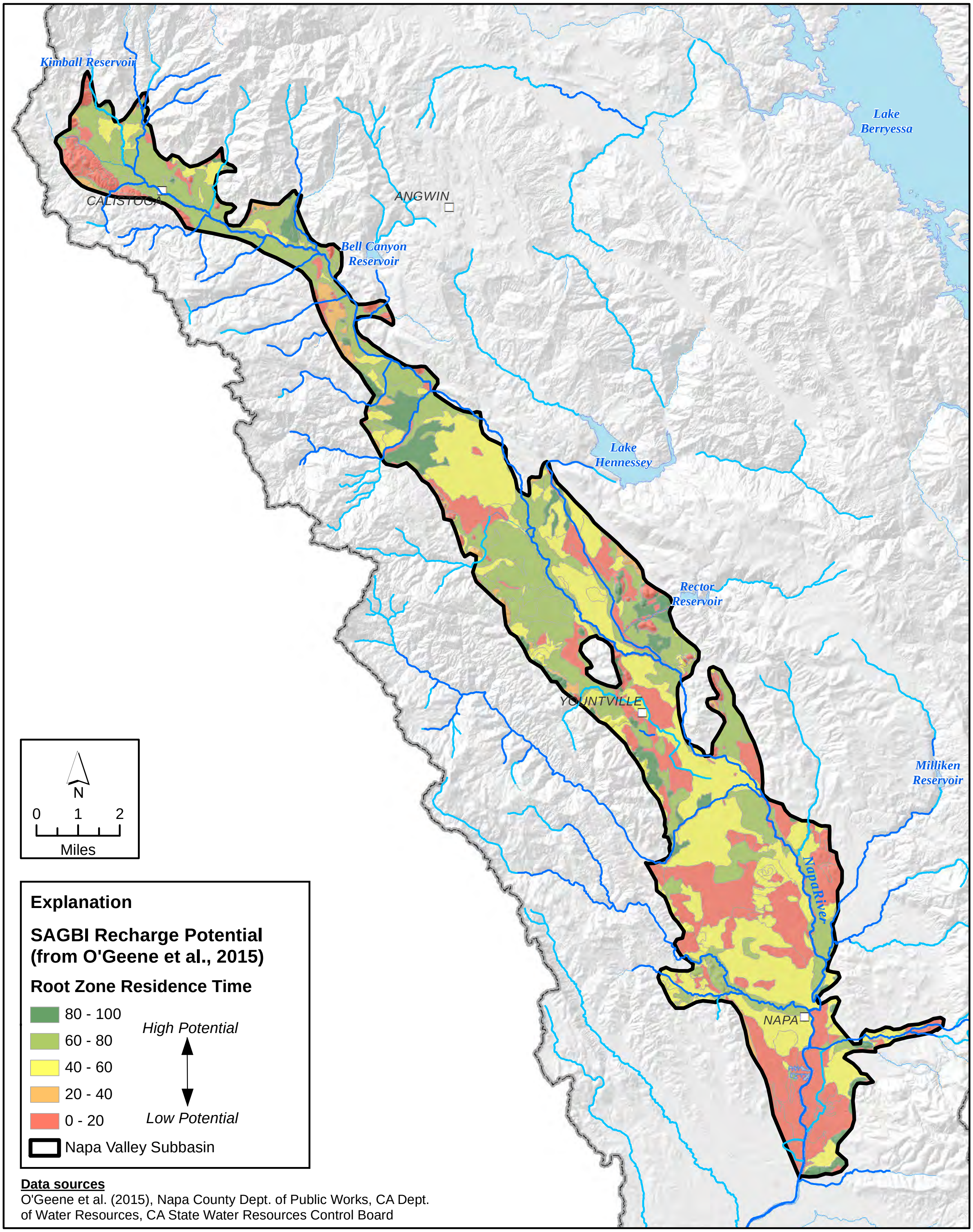
FIGURE 4-67
SAGBI Groundwater Recharge Potential Topographic Limitations Rating



\\LSCEEXSER\Clerical\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 4-54.mxd

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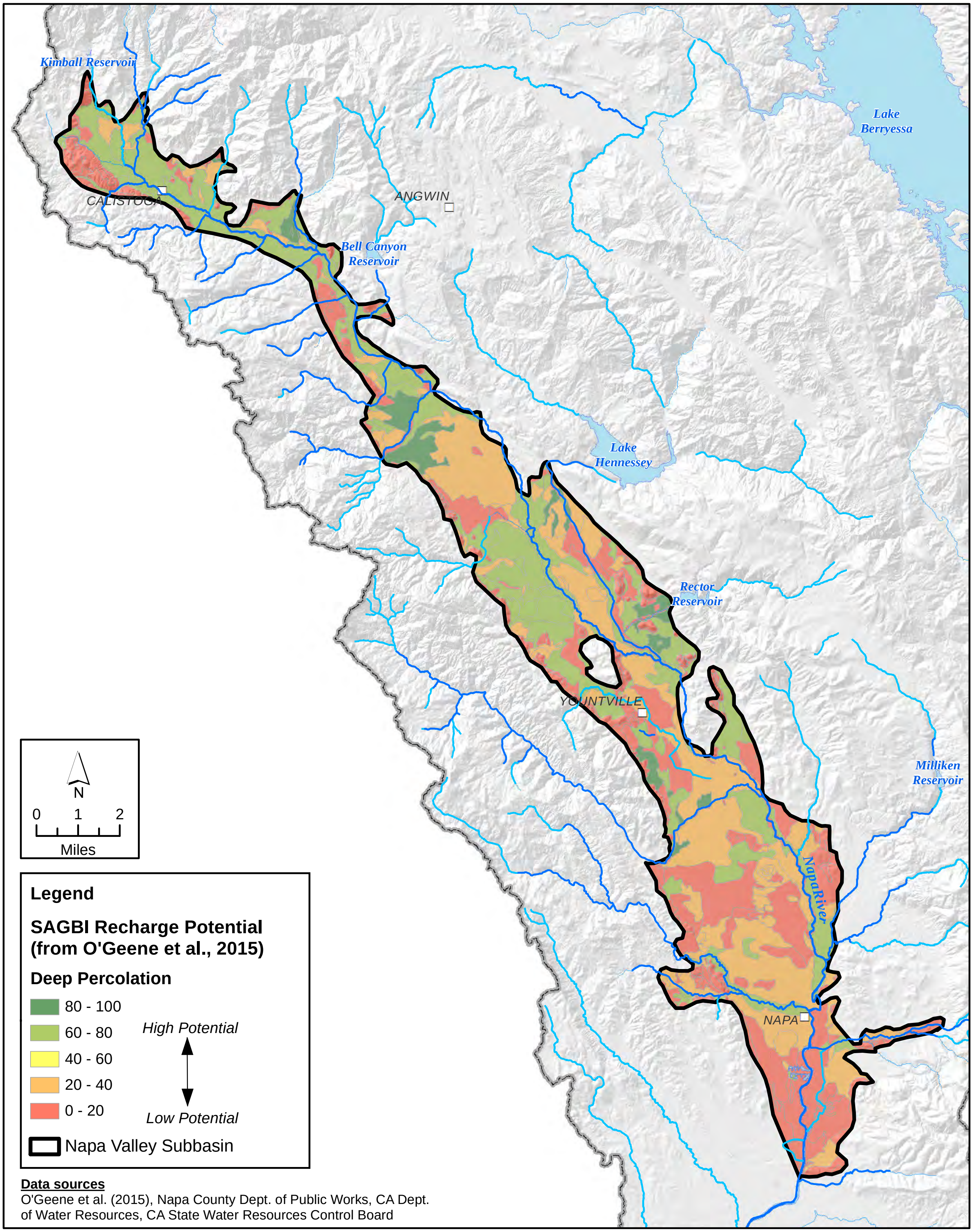
FIGURE 4-68
SAGBI Groundwater Recharge Potential Root Zone Residence Time Rating



\\LSCEEXSER\Clerical\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 4-55 SAGBI Recharge Potential Deep Percolation.mxd

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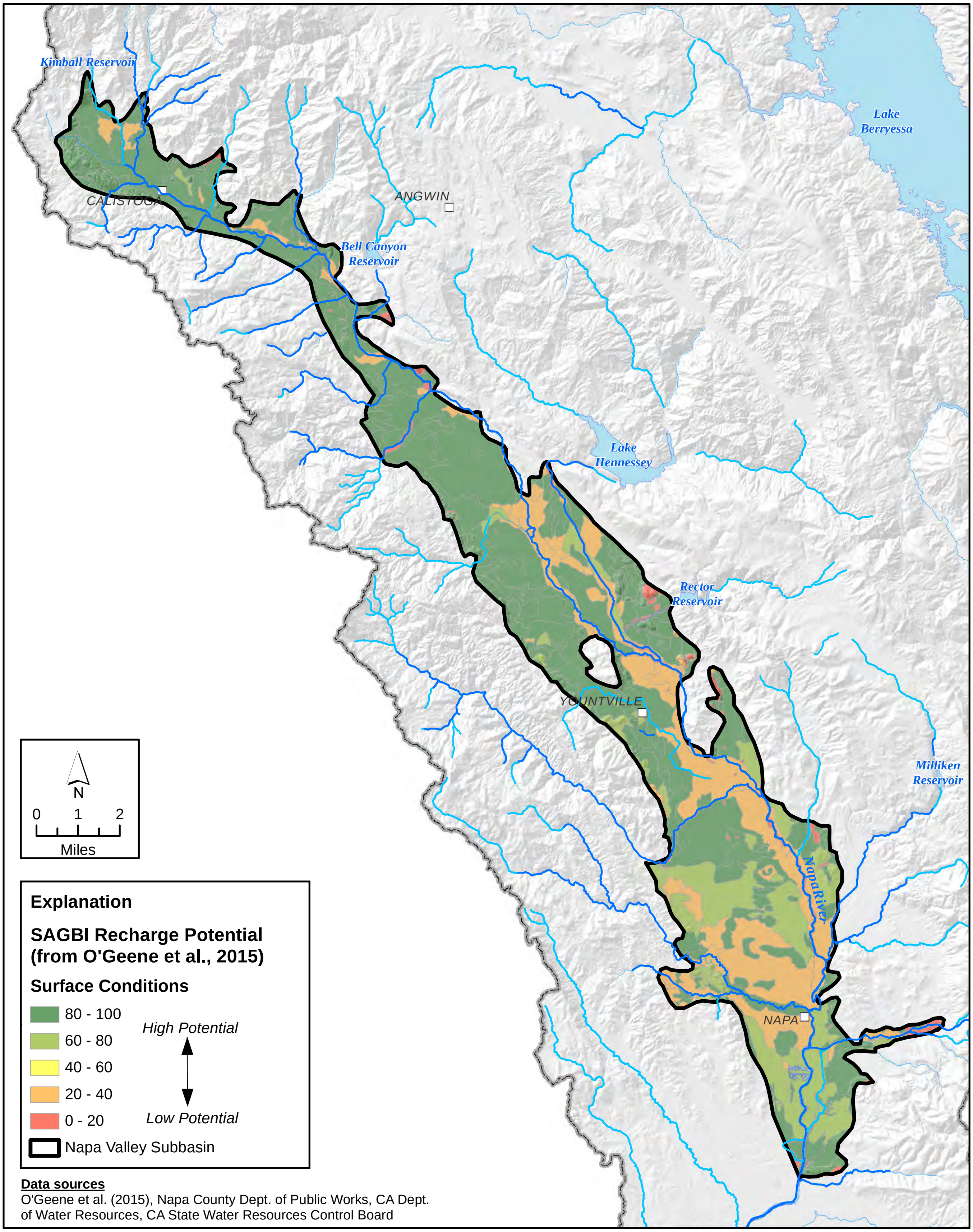
FIGURE 4-69
SAGBI Groundwater Recharge Potential Deep Percolation Rating

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



\\LSCEEXSER\Clerical\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 4-56 SAGBI Recharge Potential Surface Conditions.mxd

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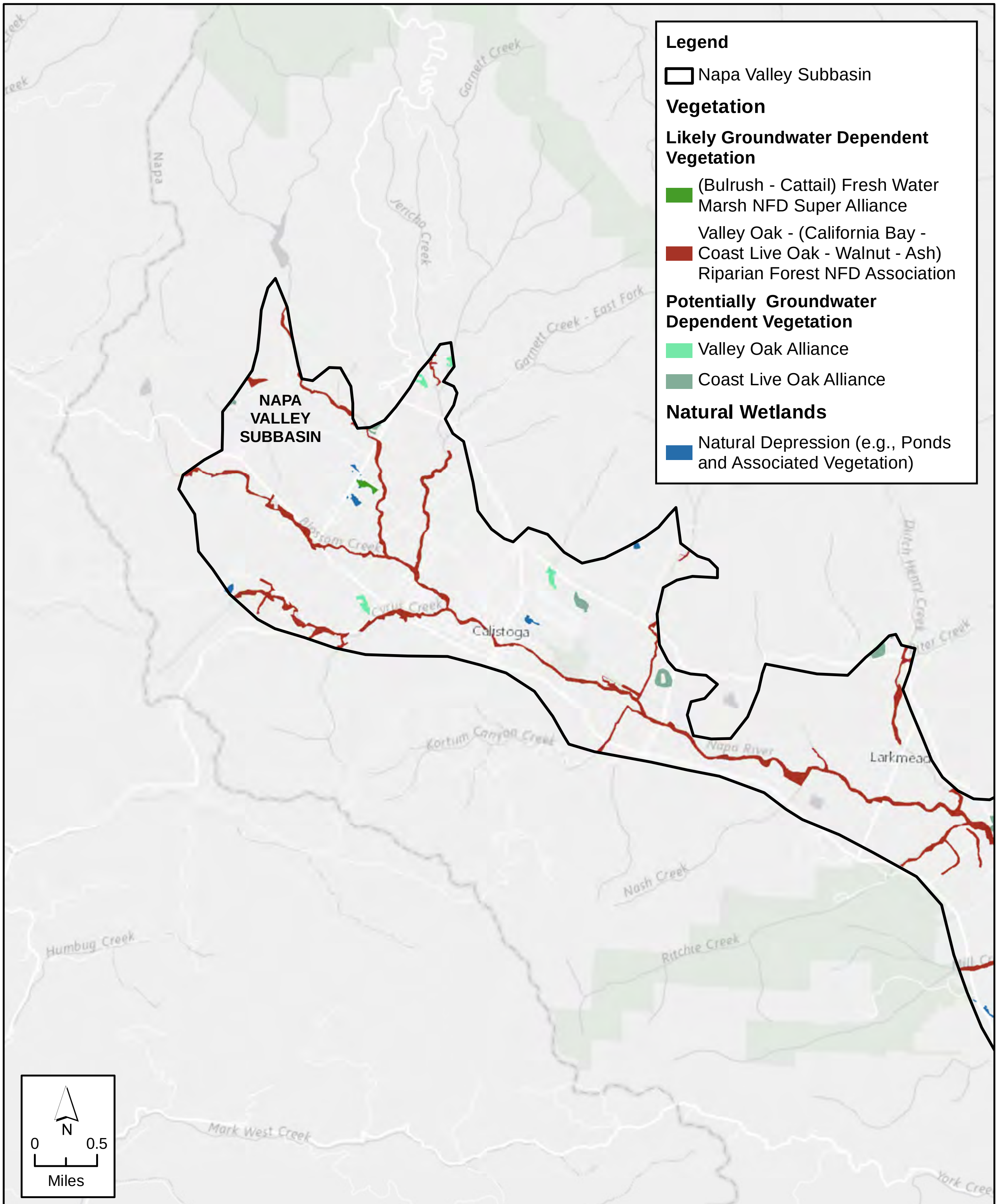
FIGURE 4-70
SAGBI Groundwater Recharge Potential Surface Conditions Rating



Data sources
CA Aquatic Resources Inventory database, v0.2, Released in 2016
Napa County vegetation community dataset, Updated in 2013

X:\2014 Job Files\14-108\GIS\Mapfiles\GW Dependent Ecosystems.mxd

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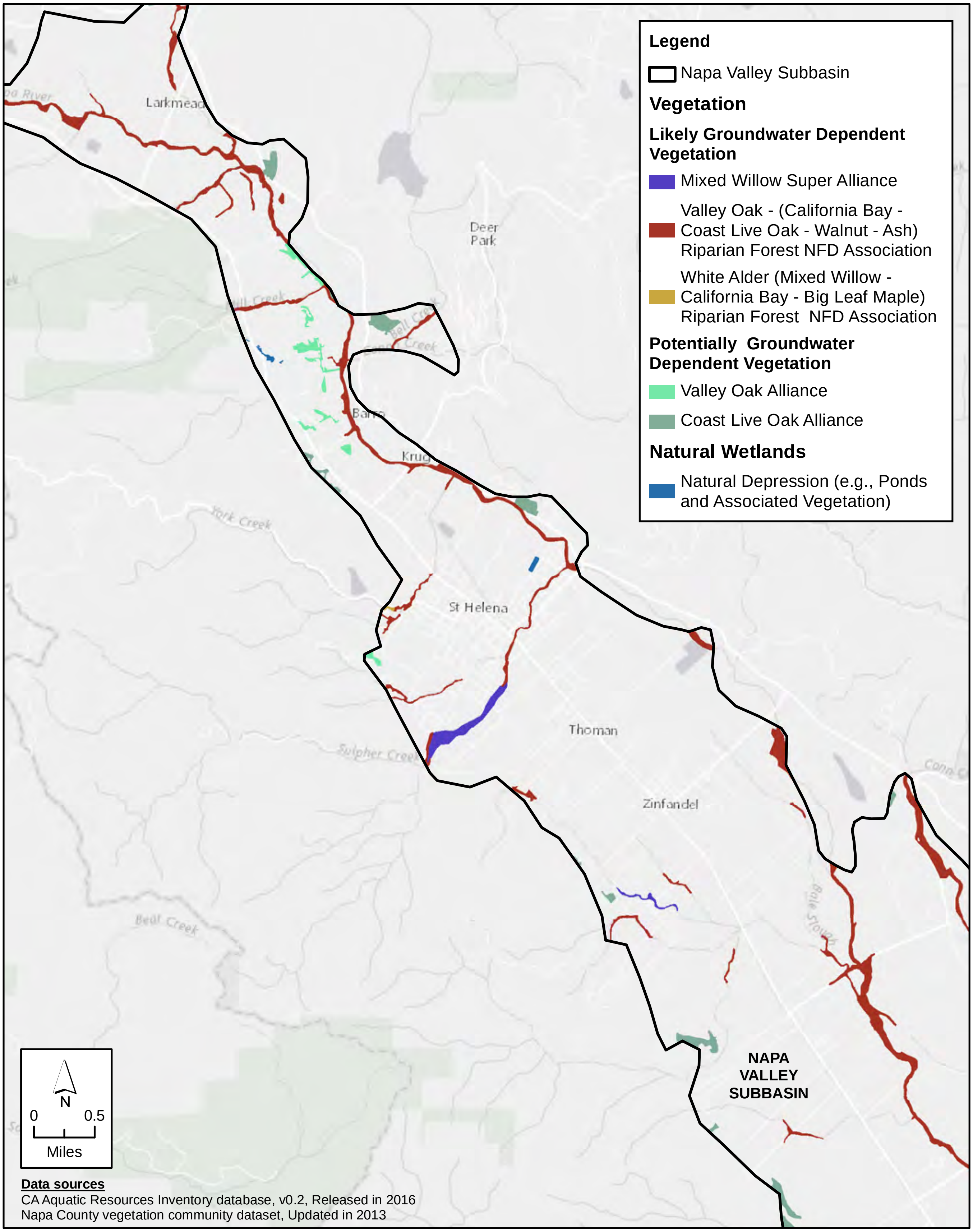
FIGURE 4-71
Likely and Potential Groundwater Dependent Ecosystems Napa Valley Subbasin

Napa Valley Groundwater Sustainability
A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\GW Dependent Ecosystems.mxd

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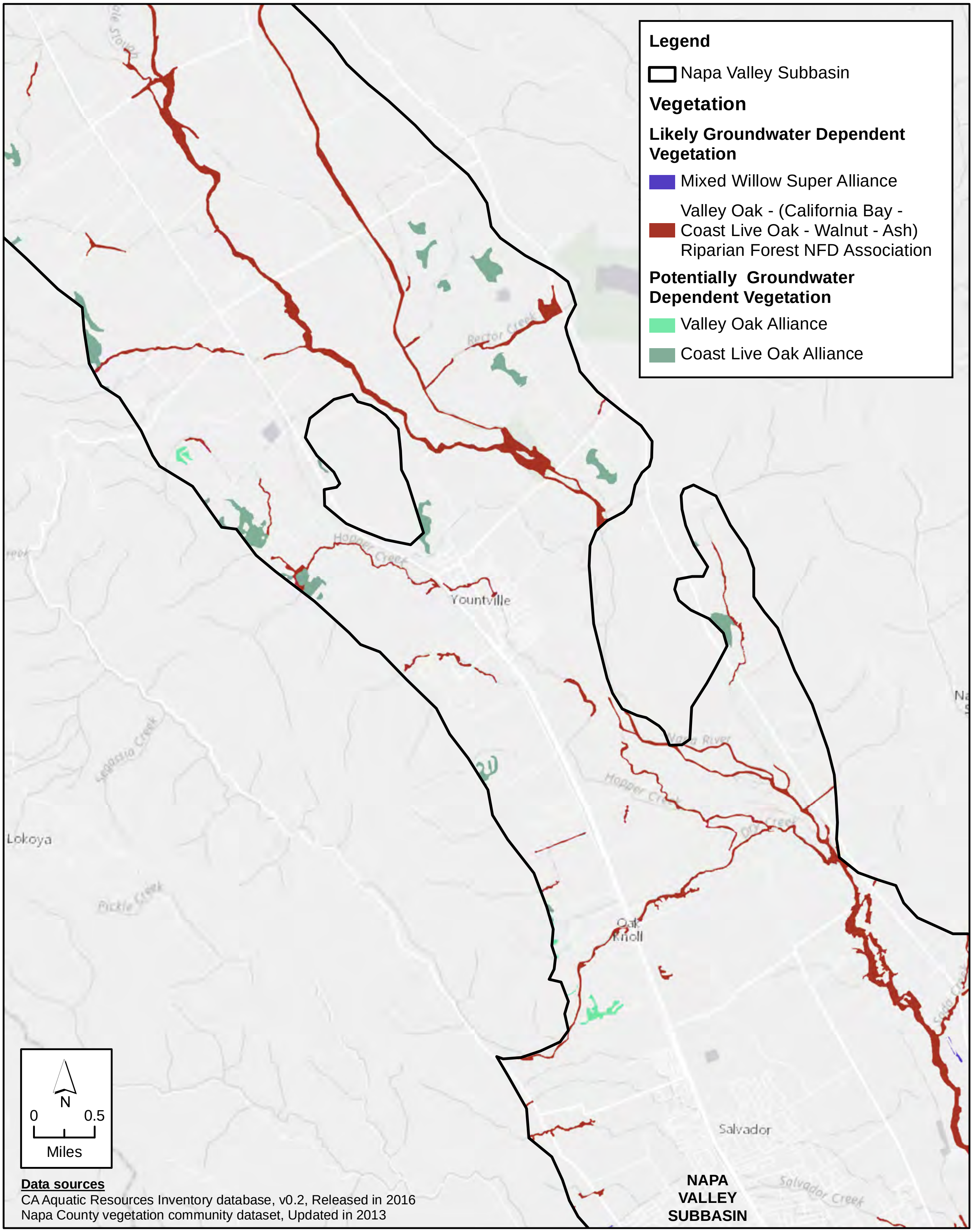
FIGURE 4-72
Likely and Potential Groundwater Dependent Ecosystems Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\GW Dependent Ecosystems.mxd

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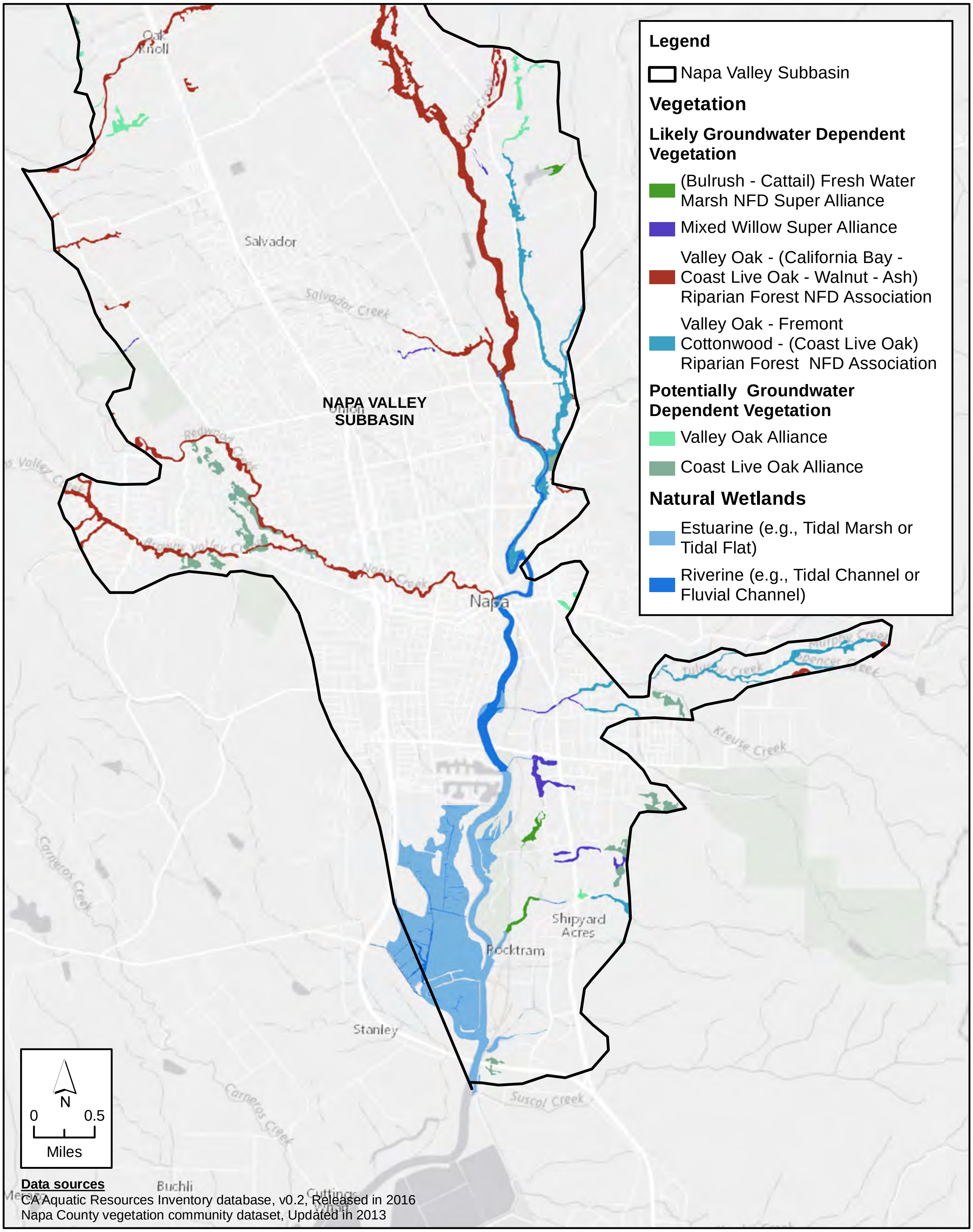
FIGURE 4-73
Likely and Potential Groundwater Dependent Ecosystems Napa Valley Subbasin

Napa Valley Groundwater Sustainability

A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\GW Dependent Ecosystems.mxd

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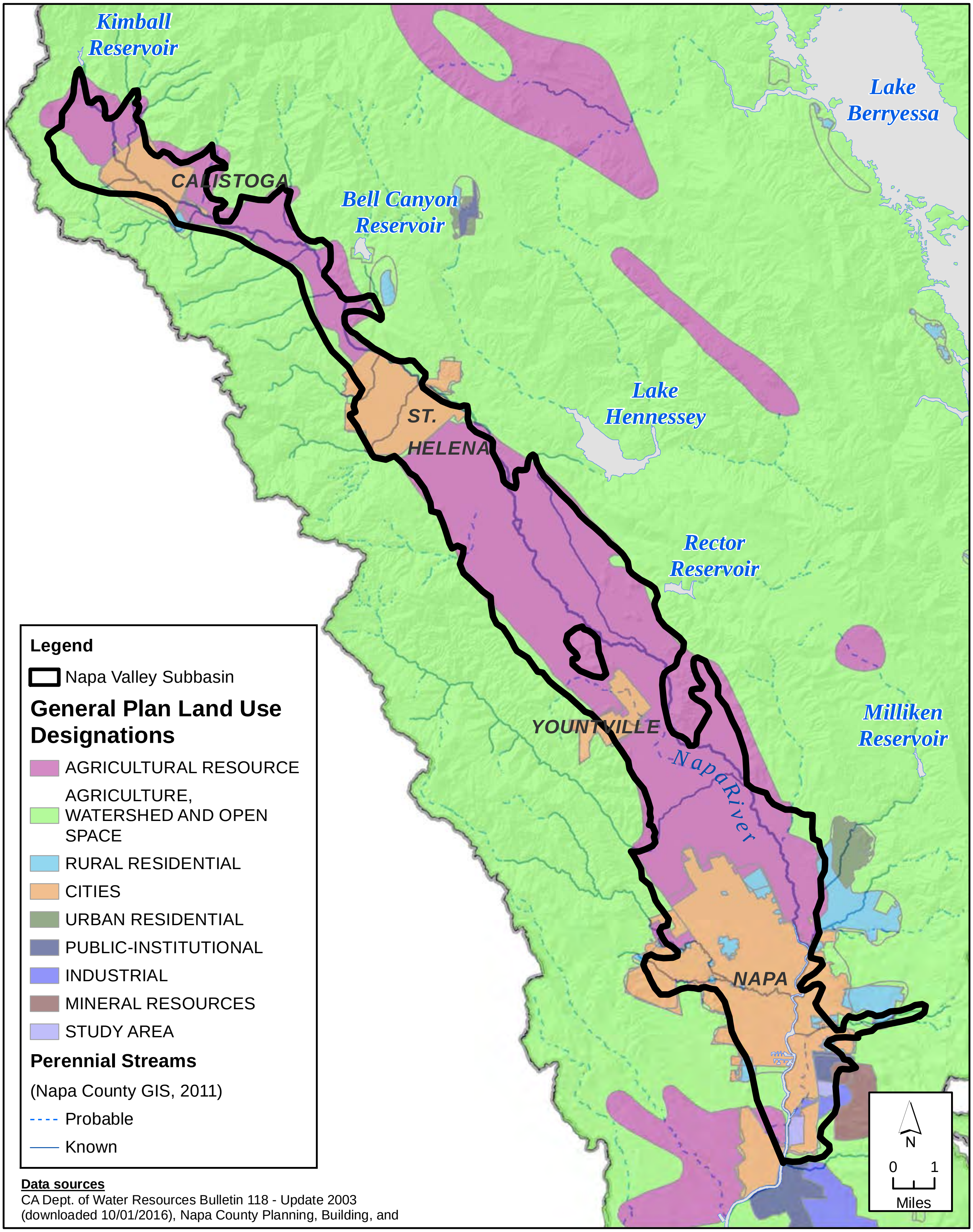
FIGURE 4-74
Likely and Potential Groundwater Dependent Ecosystems
Napa Valley Subbasin



Data sources
CA Dept. of Water Resources Bulletin 118 - Update 2003 (downloaded 10/01/2016), Napa County Planning, Building, and

X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 5-1 General Plan Land Use 2008 2030.mxd

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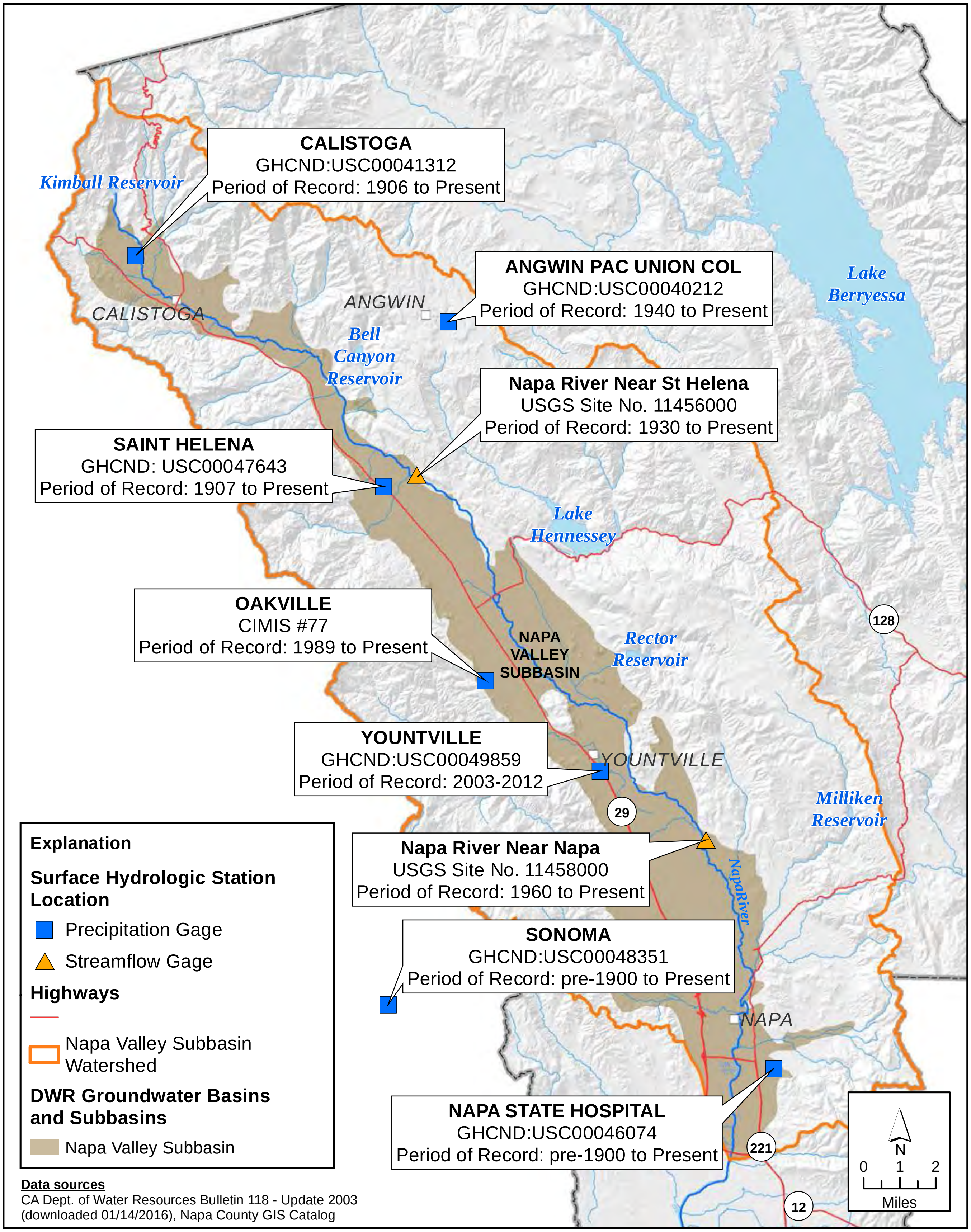
FIGURE 5-1

Napa County Land Use Plan 2008 - 2030



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 6-1 Sfc Hydro Station Location Map.mxd

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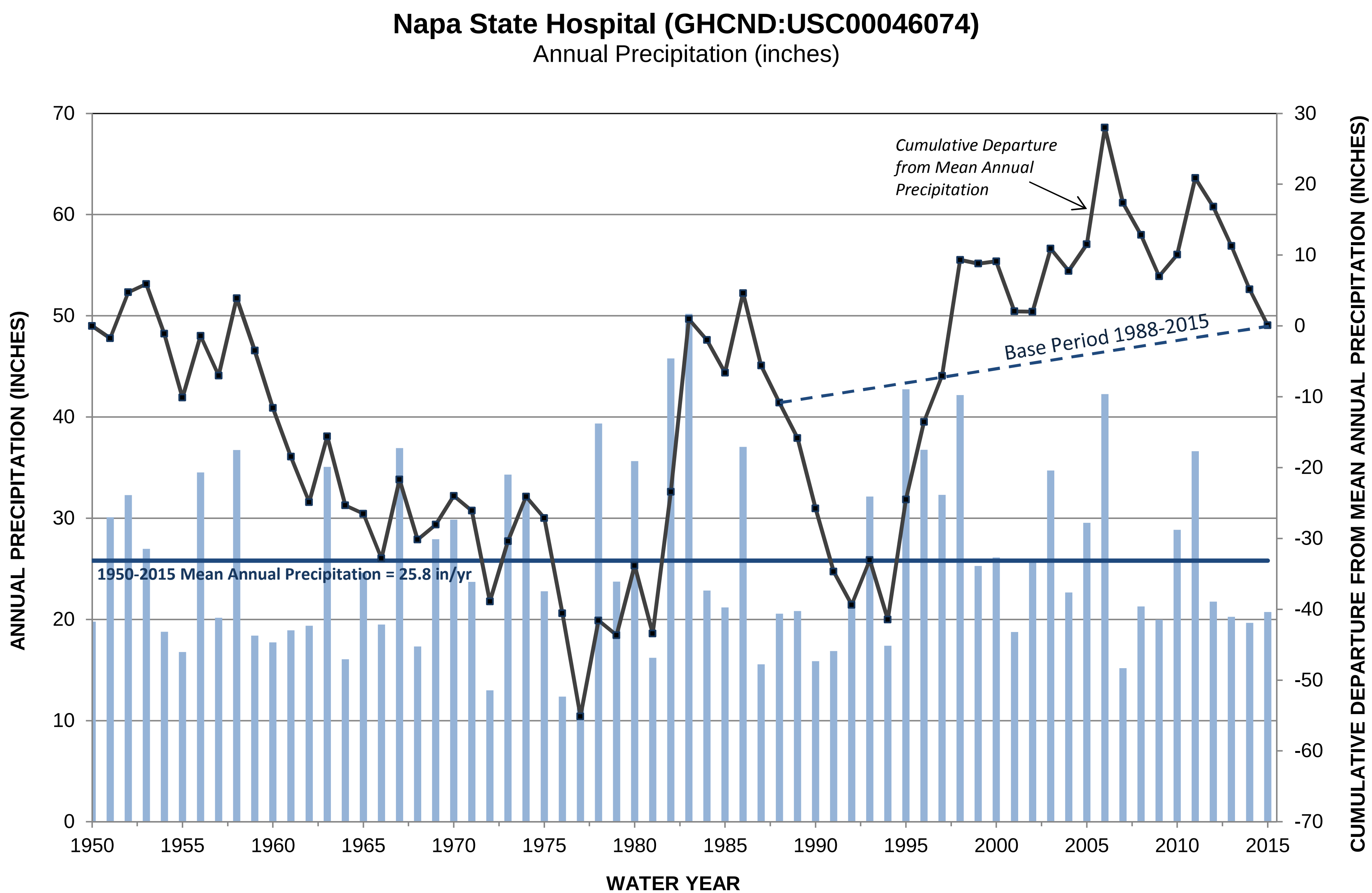
FIGURE 6-1

Napa Valley Precipitation and Streamflow Gage Locations



NOTE: Gaps in this data record have been reconstructed using data from the Oakville CIMIS station (77) and NOAA Saint Helena, CA US station (GHCND:USC00047643).

X:\2014 Job Files\14-054\Data\Precip\NCDC Data Summary UPDATED Feb2016.xlsx\NSH_CD_50-15plot Annual Rep (2

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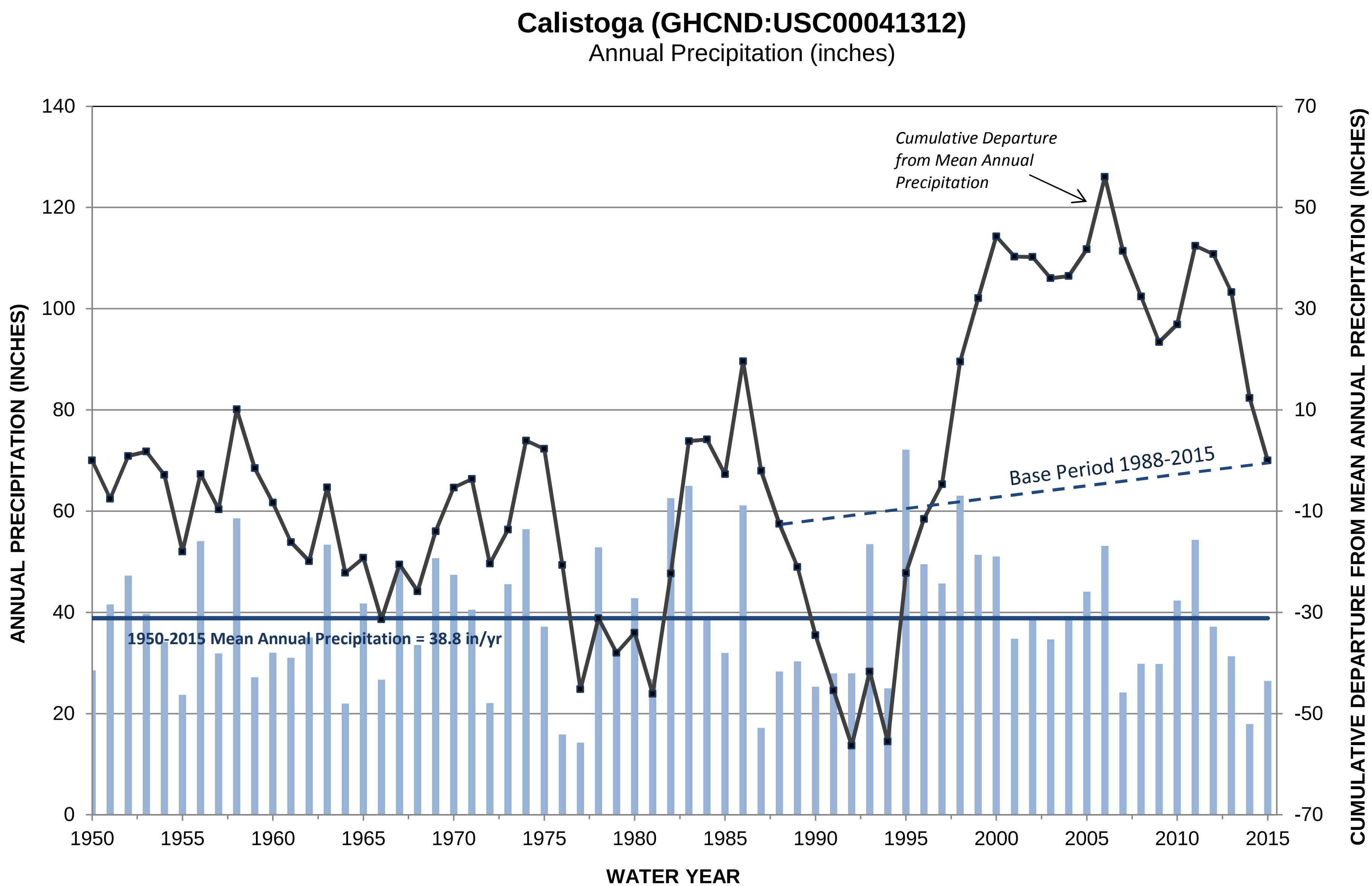
Figure 6-2
Napa State Hospital Gage Water Year Precipitation (1950-2015) and Cumulative Departure

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



NOTE: Gaps in this data record have been reconstructed using data from the NOAA Napa State Hospital, CA US Station (GHCND:USC00046074).

X:\2014 Job Files\14-054\Data\Precip\NCDC Data Summary UPDATED Feb2016.xlsx\NSH_CD_50-15plot Annual Rep (2

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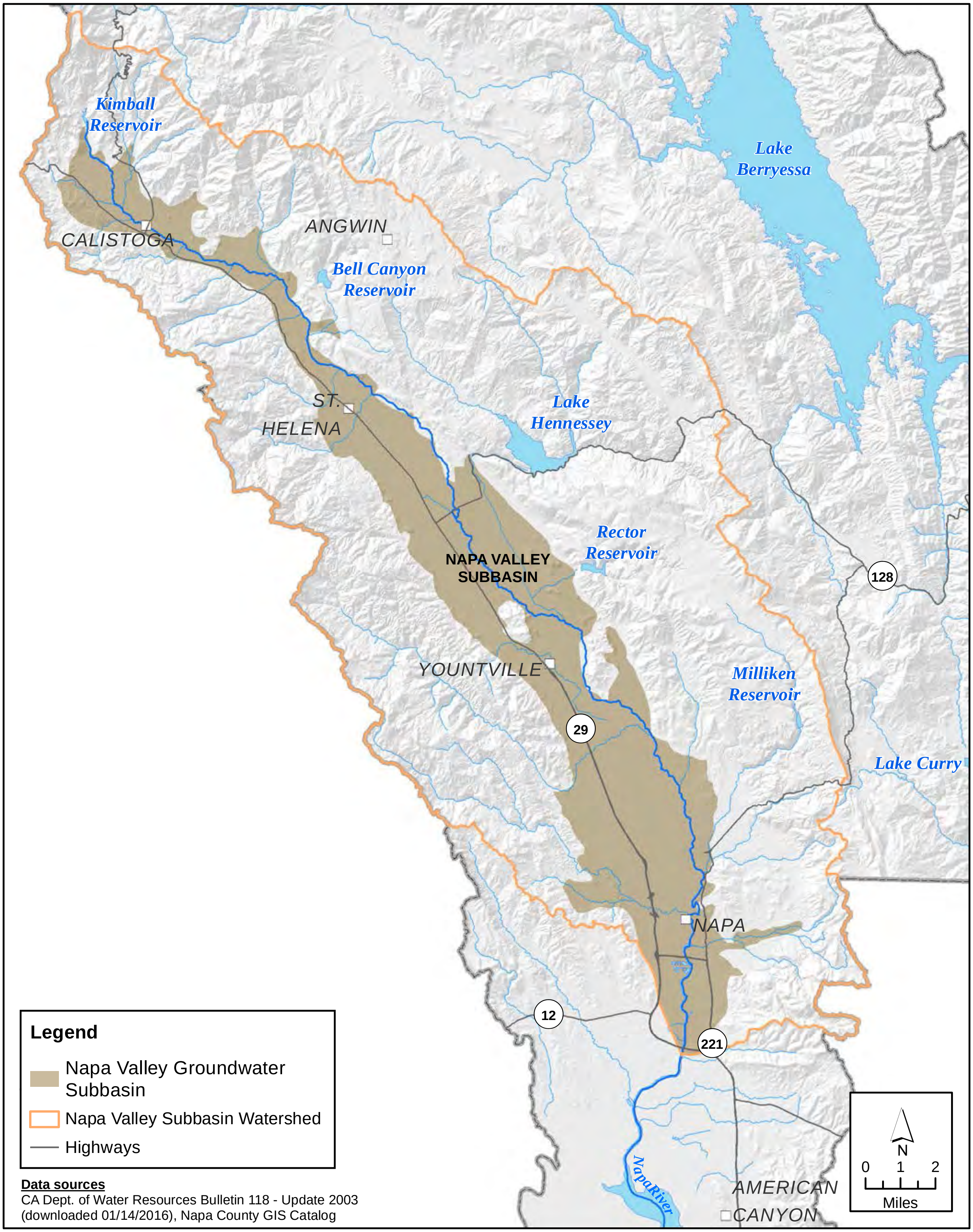
Figure 6-3
Calistoga Gage Water Year Precipitation (1950-2015) and Cumulative Departure

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 6-7 Napa Valley Subbasin and Watershed.mxd

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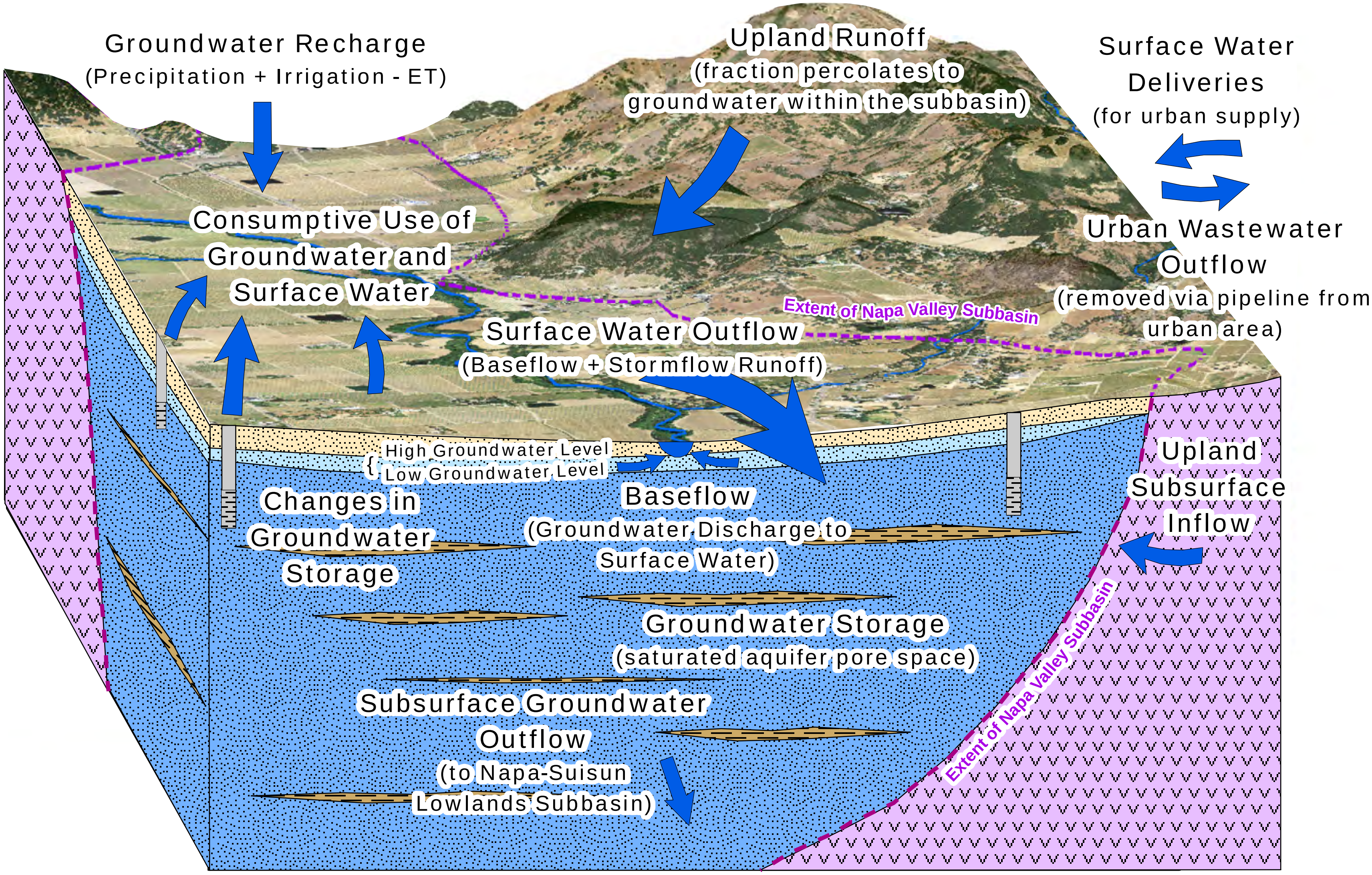
FIGURE 6-7

Napa Valley Groundwater Subbasin and Watershed

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Conceptual Diagram\Figure 6-8 3D_WaterBudgetConceptualDiagram_wSWcomponents_20161005.mxd

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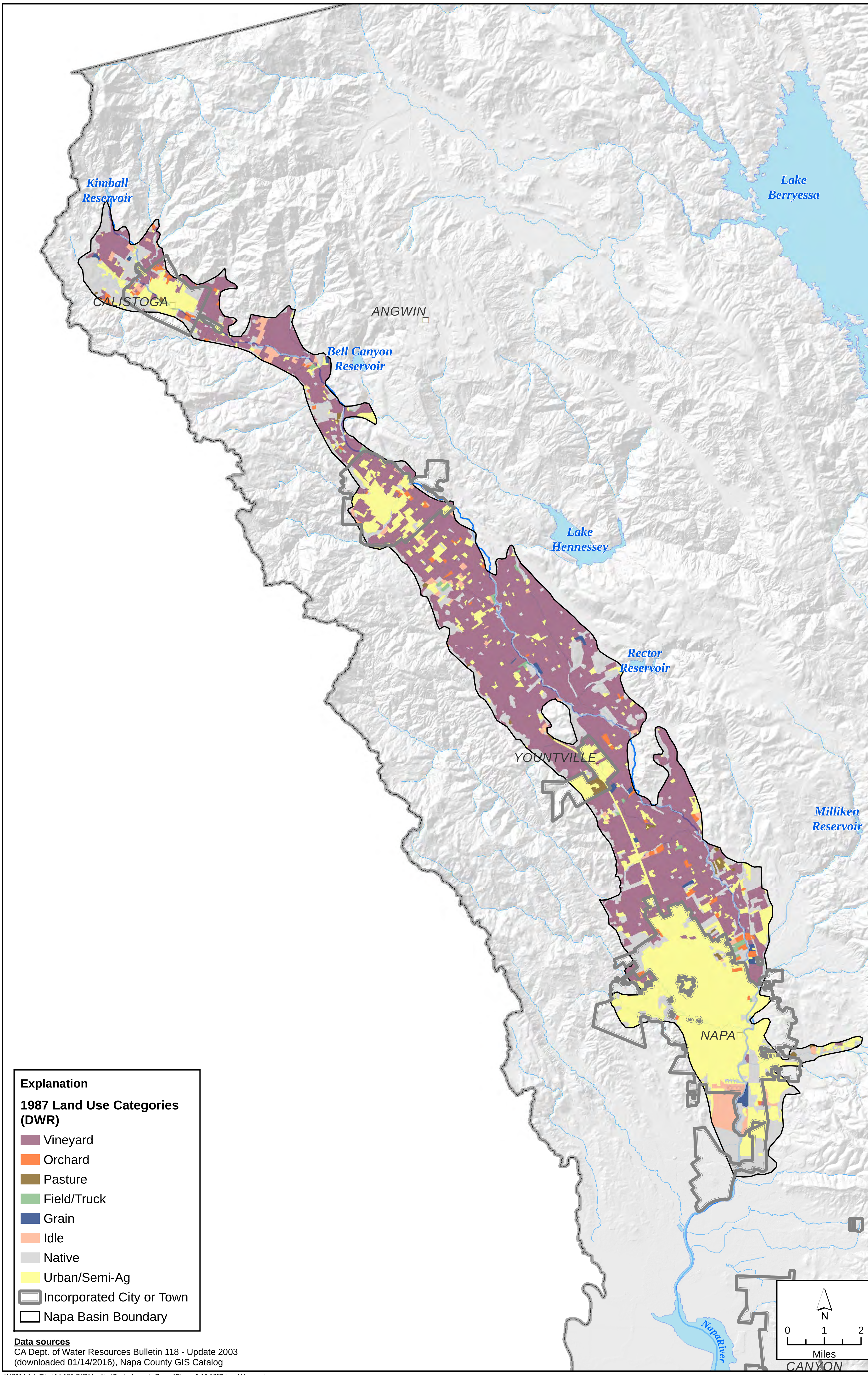
FIGURE 6-8
Schematic of Water Budget Components in the Napa Valley Subbasin

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 6-10 1987 Land Use.mxd

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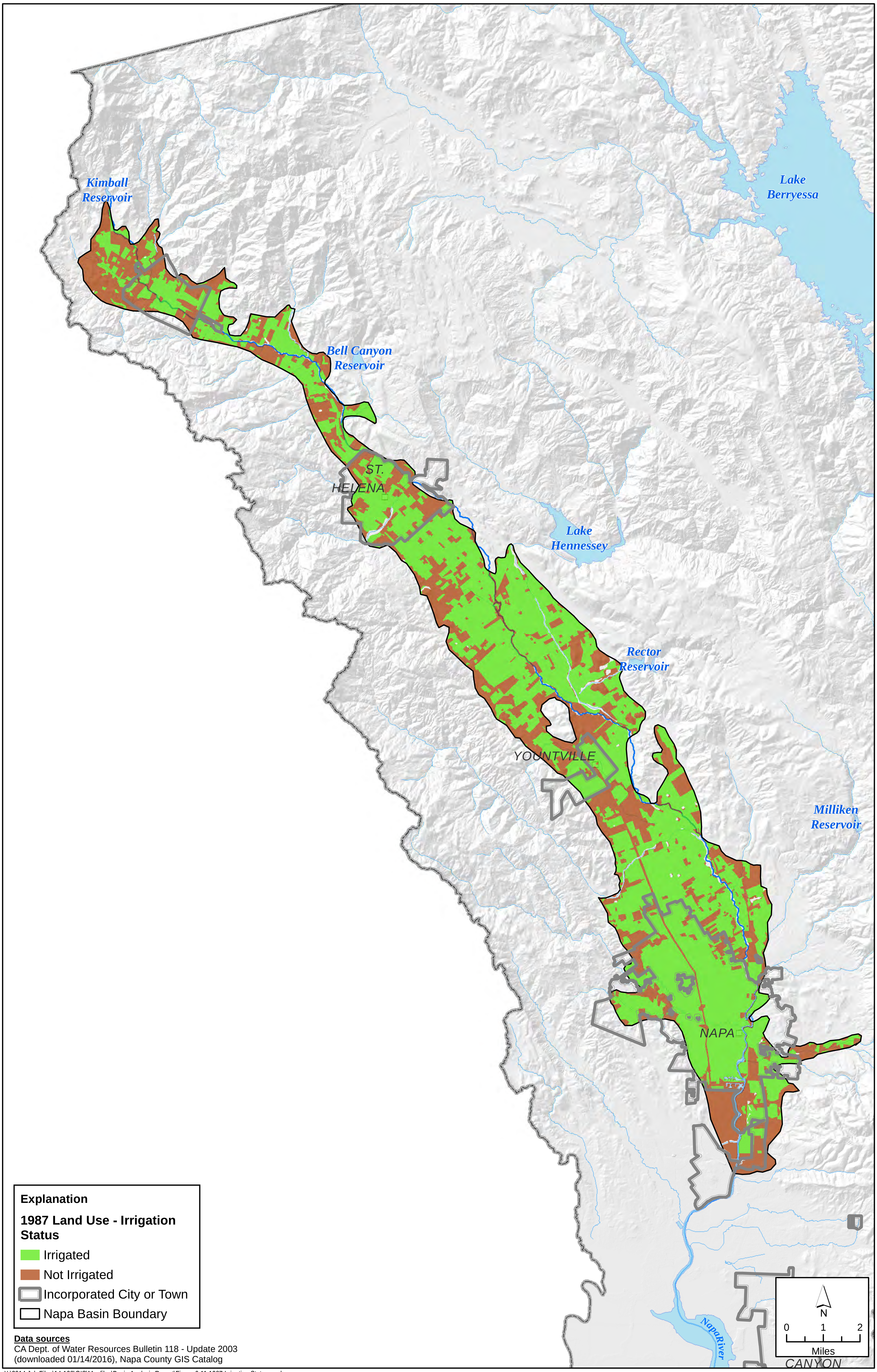
FIGURE 6-10

1987 Land Use Categories

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



Data sources
CA Dept. of Water Resources Bulletin 118 - Update 2003 (downloaded 01/14/2016), Napa County GIS Catalog

X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 6-11 1987 Irrigation Status.mxd

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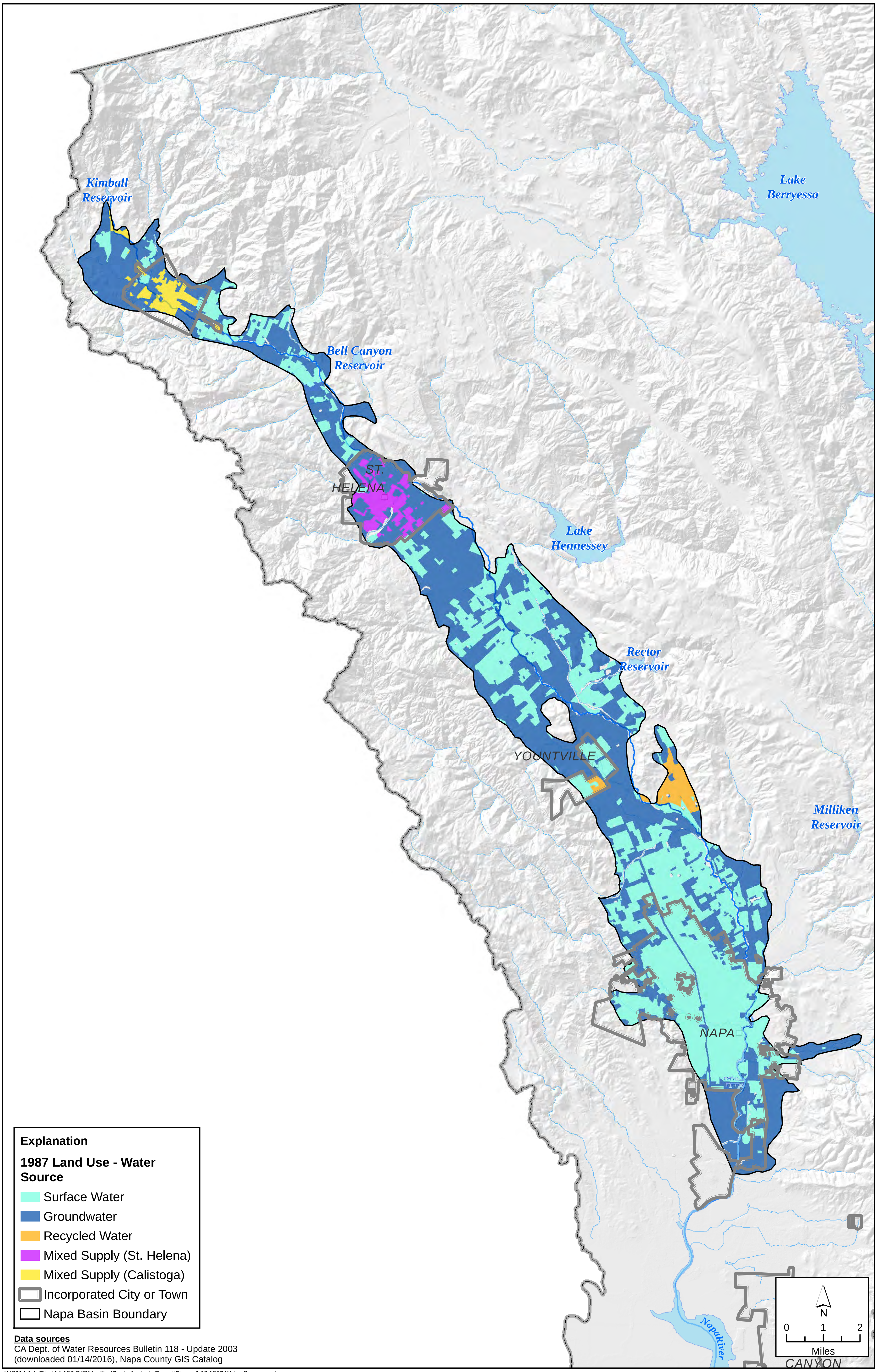
FIGURE 6-11

1987 Land Use - Irrigation Status

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



Data sources
CA Dept. of Water Resources Bulletin 118 - Update 2003 (downloaded 01/14/2016), Napa County GIS Catalog

X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 6-12 1987 Water Source.mxd

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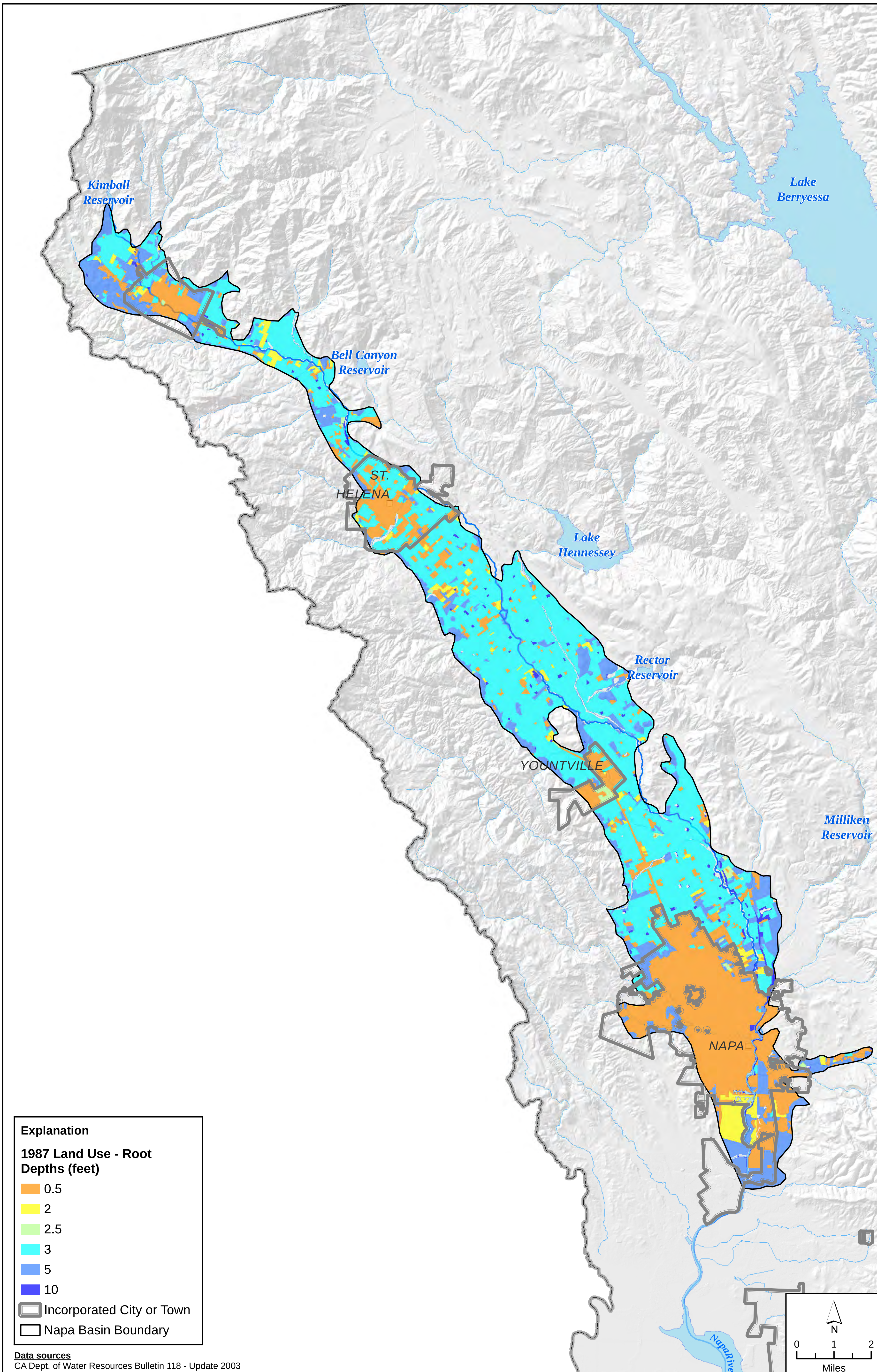
FIGURE 6-12

1987 Land Use - Water Source

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 6-13 1987 Root Depths.mxd

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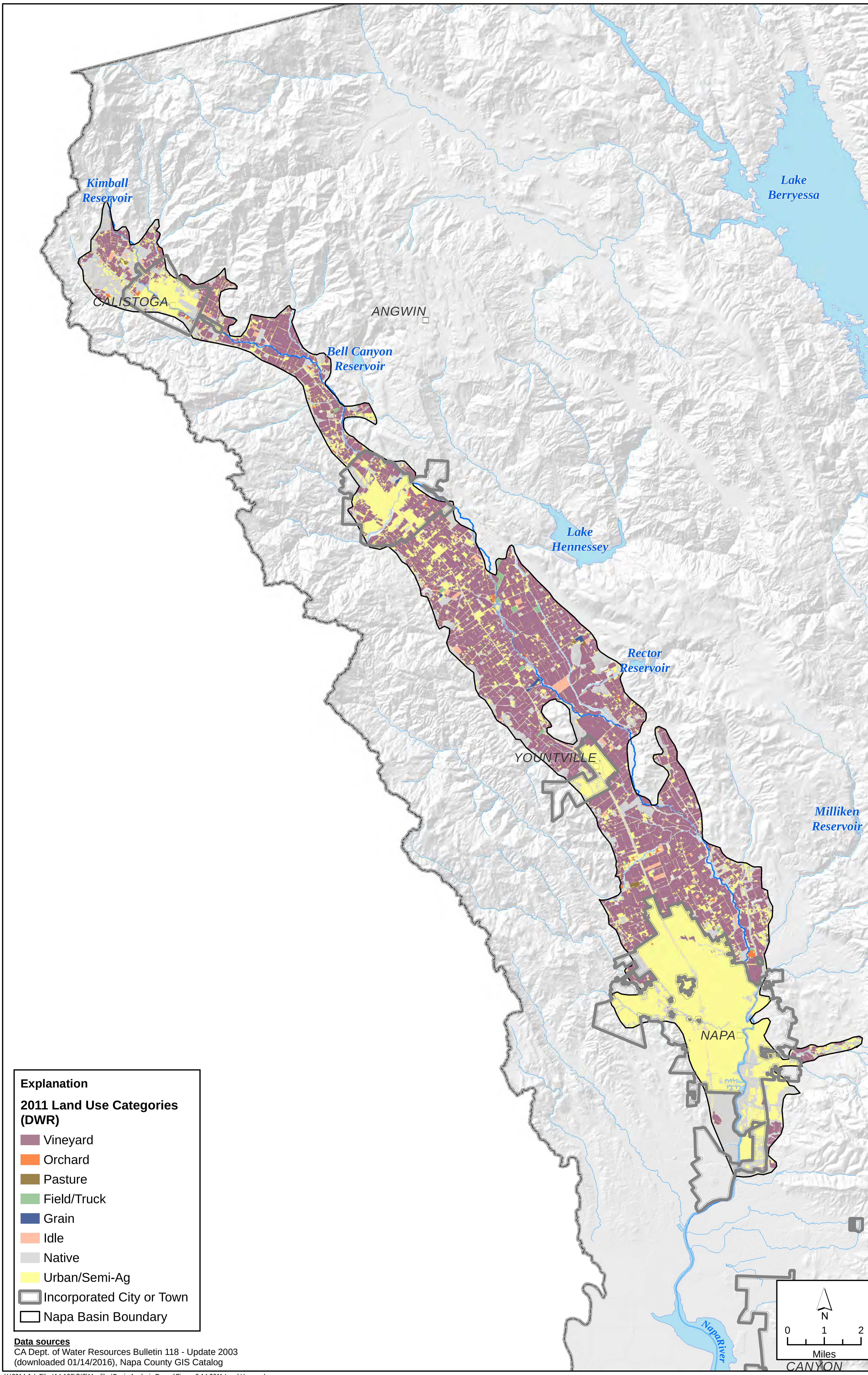
FIGURE 6-13

1987 Land Use - Root Depths

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



Data sources
CA Dept. of Water Resources Bulletin 118 - Update 2003
(downloaded 01/14/2016), Napa County GIS Catalog

X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 6-14 2011 Land Use.mxd

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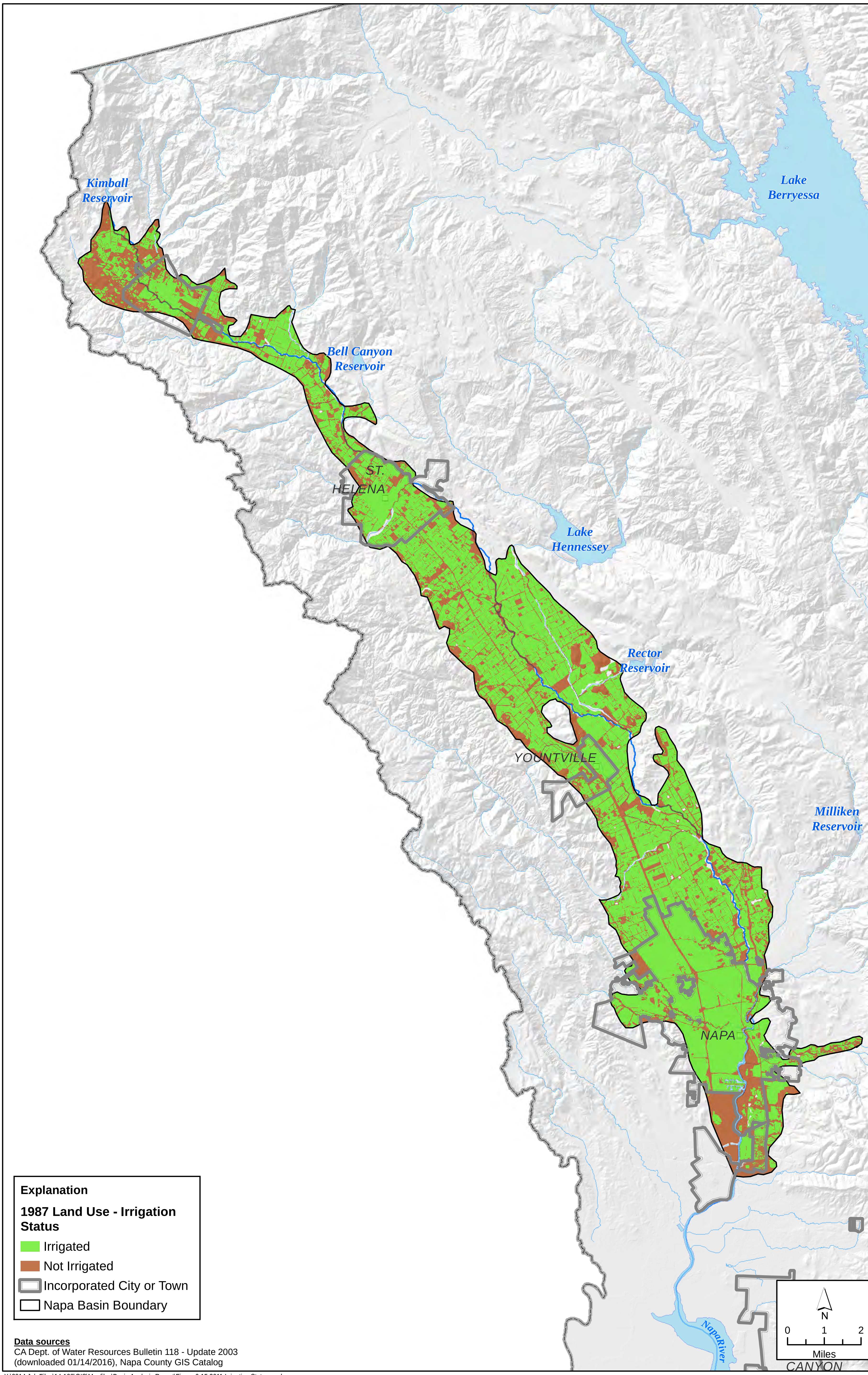
FIGURE 6-14

2011 Land Use Categories

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 6-15 2011 Irrigation Status.mxd

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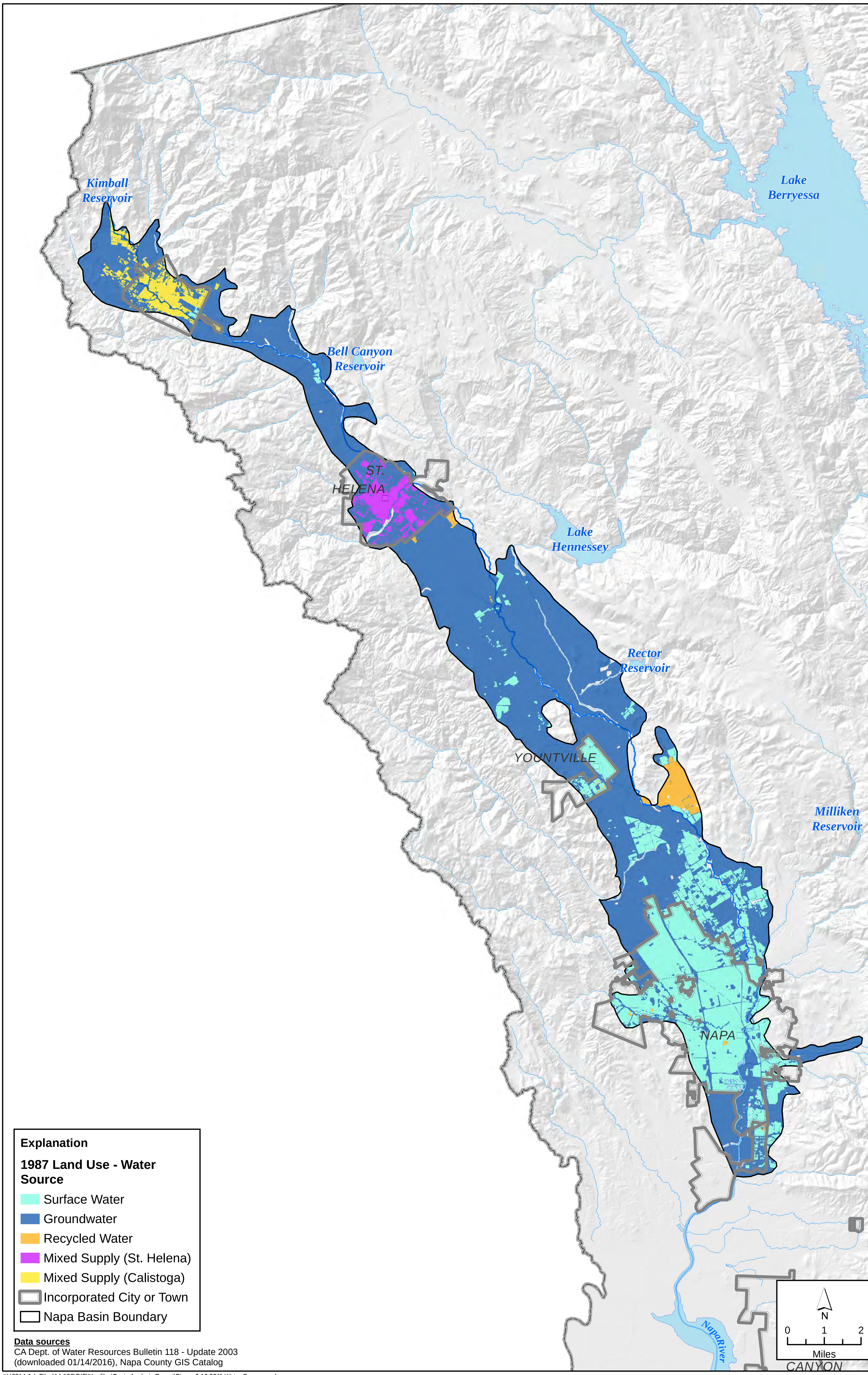
FIGURE 6-15

2011 Land Use - Irrigation Status

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 6-16 2011 Water Source.mxd

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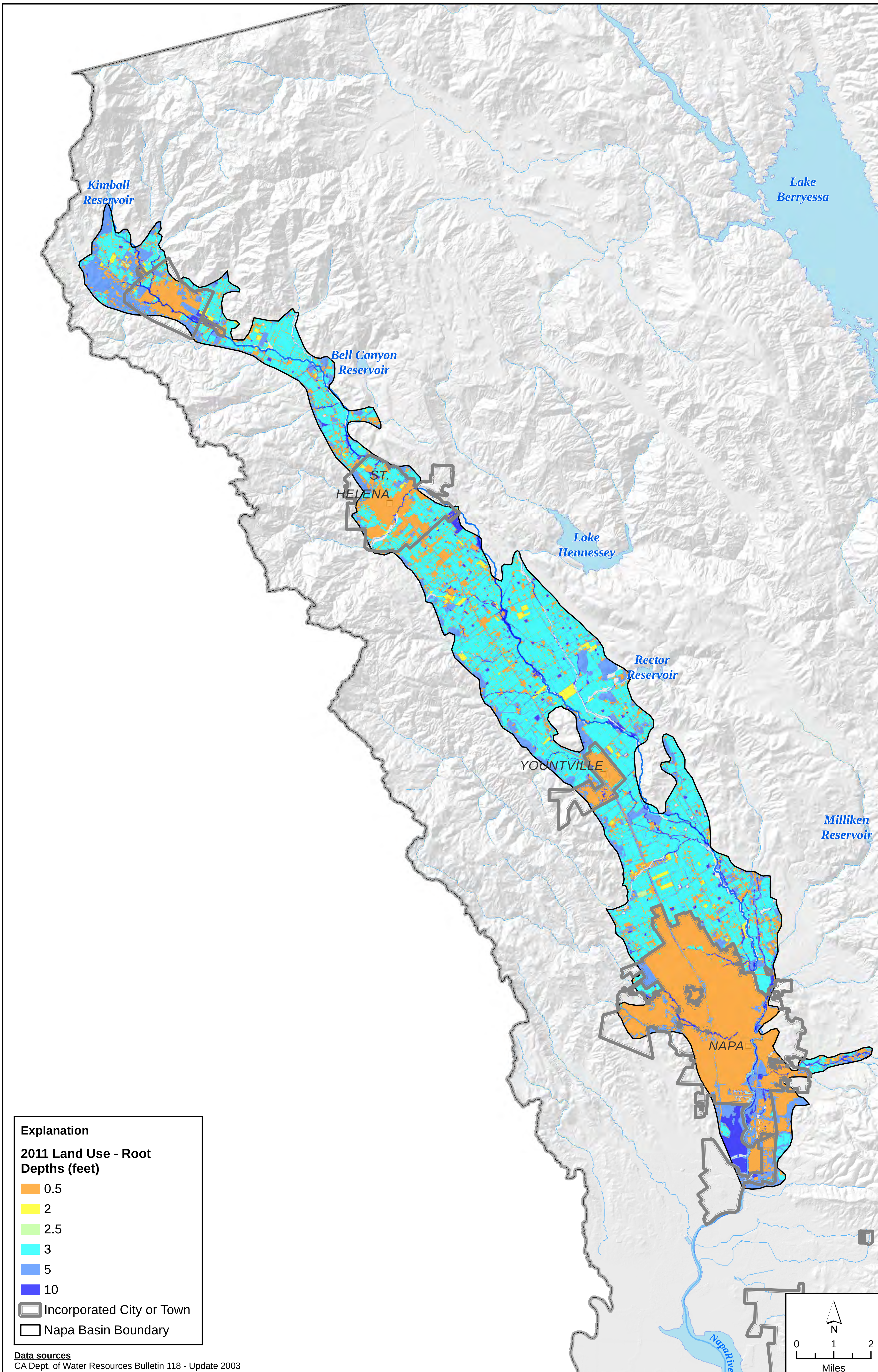
FIGURE 6-16

2011 Land Use - Water Source

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



Data sources
CA Dept. of Water Resources Bulletin 118 - Update 2003 (downloaded 01/14/2016), Napa County GIS Catalog

X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 6-17 2011 Root Depths.mxd

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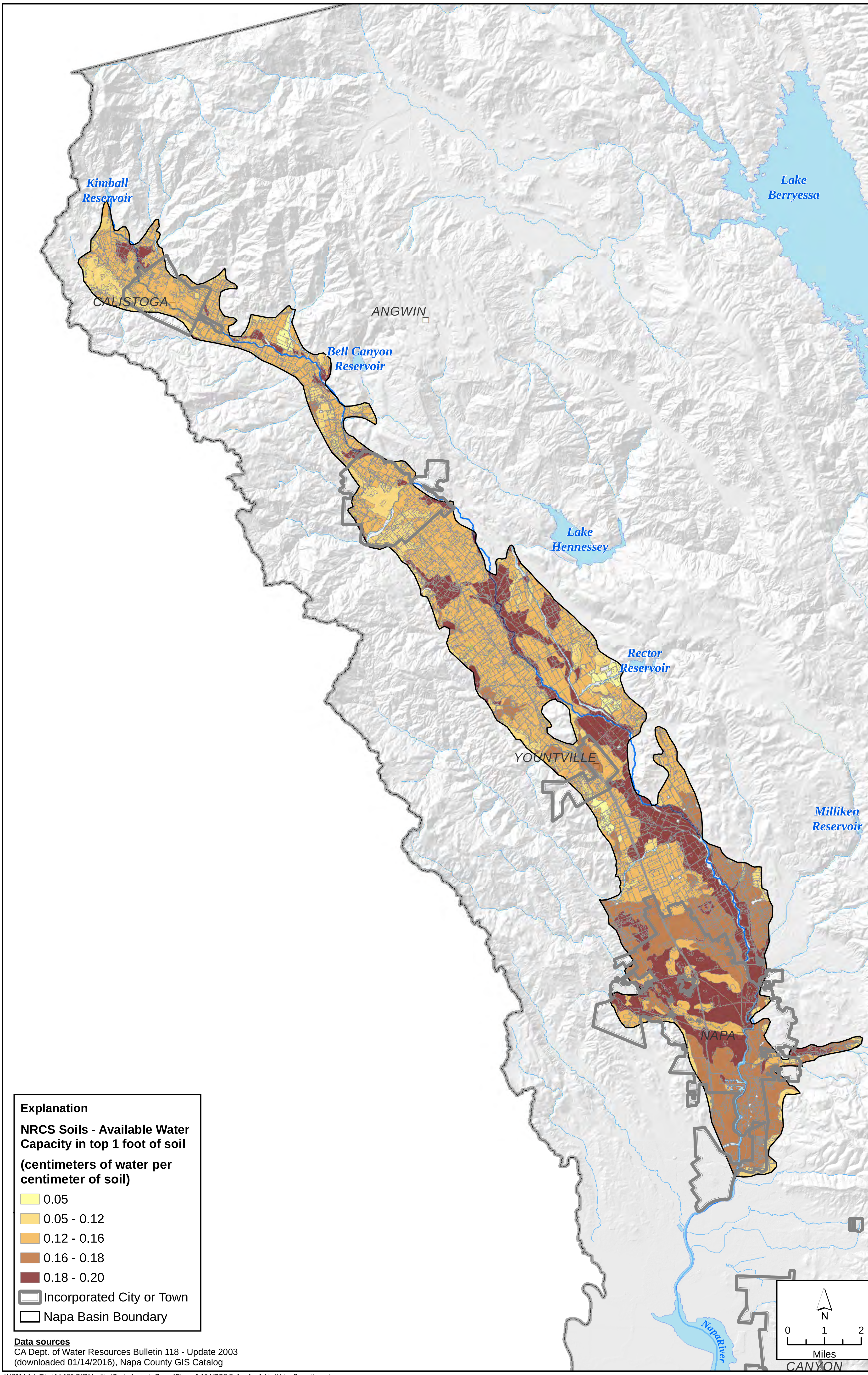
FIGURE 6-17

2011 Land Use - Root Depths

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 6-18 NRCS Soils - Available Water Capacity.mxd

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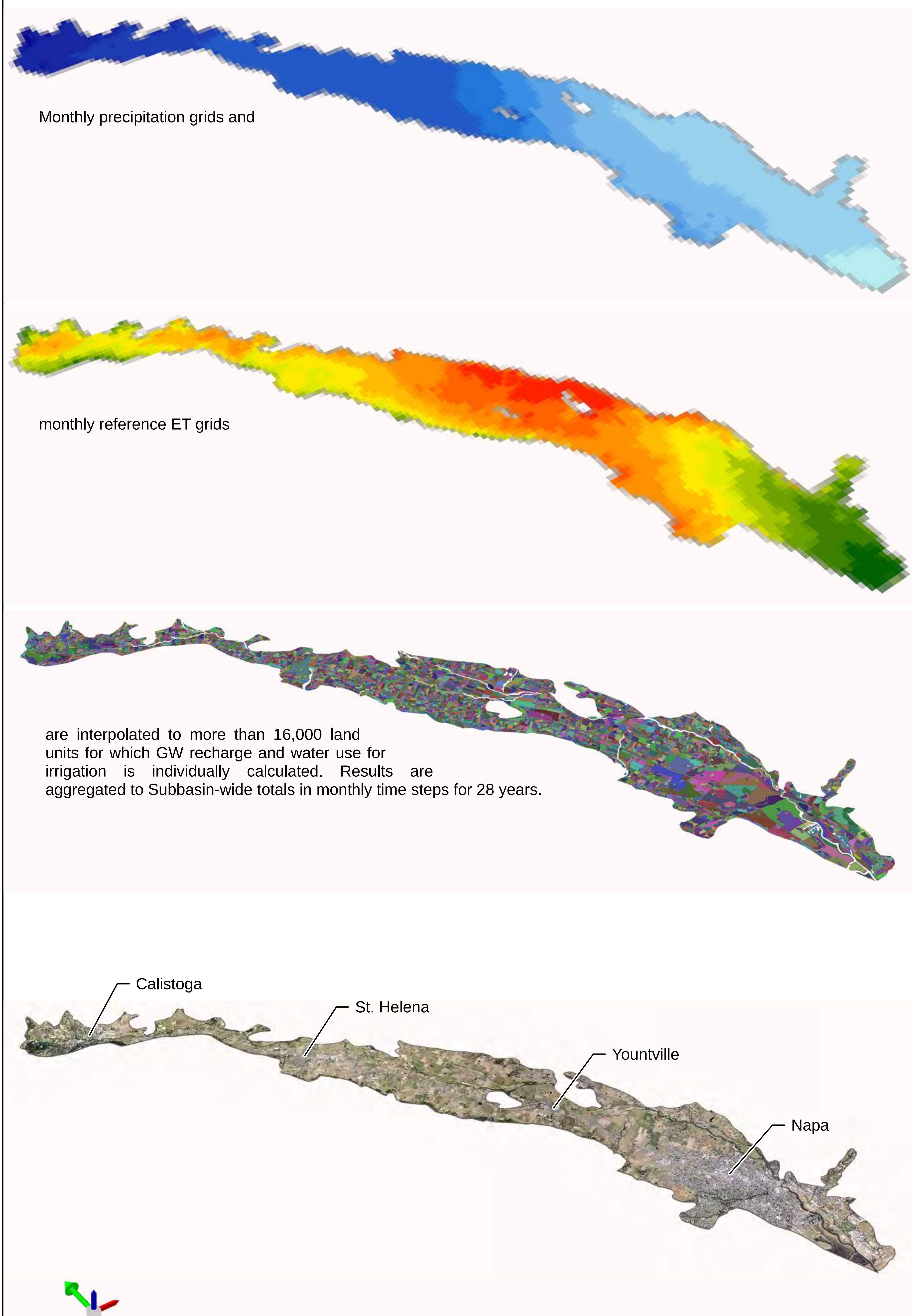
FIGURE 6-18

NRCS Soils - Available Water Capacity

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 6-19 Hydrologic Inputs.mxd

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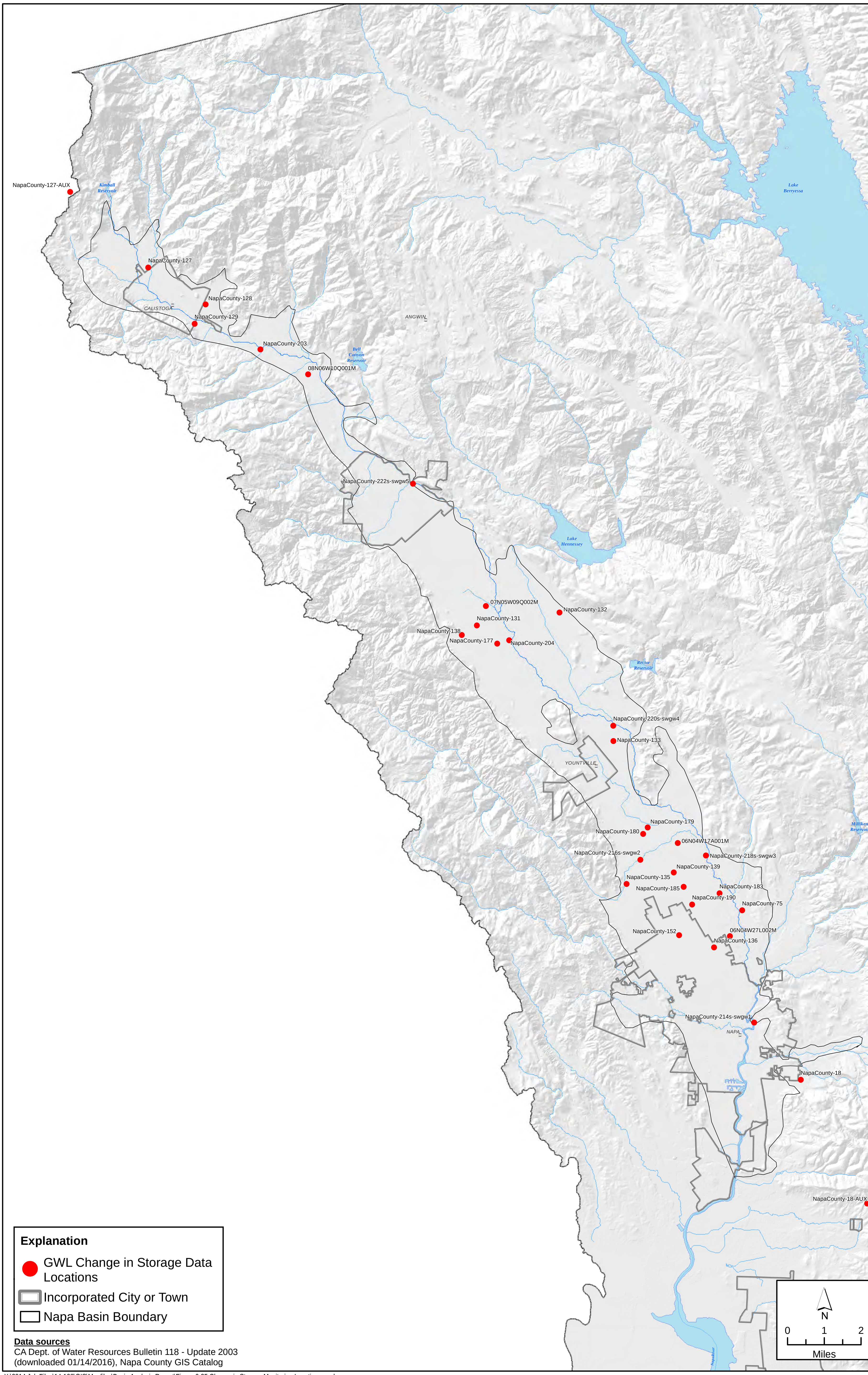
FIGURE 6-19

Hydrologic Root Zone Model Inputs

Napa Valley Groundwater Sustainability:
A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 6-25 Change in Storage Monitoring Locations.mxd

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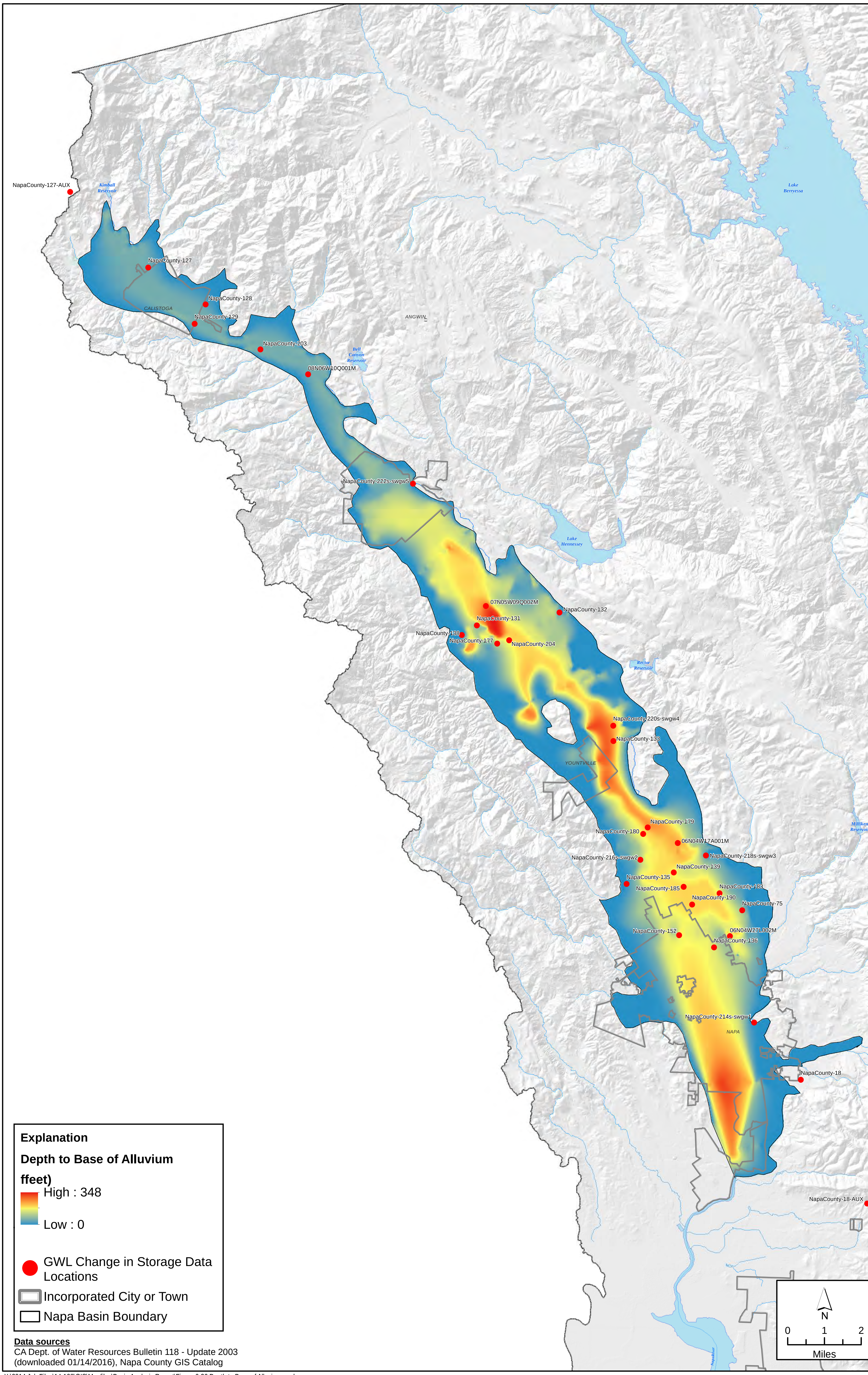
FIGURE 6-25

Groundwater Level Change in Storage - Data Locations

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



Data sources
CA Dept. of Water Resources Bulletin 118 - Update 2003 (downloaded 01/14/2016), Napa County GIS Catalog

X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 6-26 Depth to Base of Alluvium.mxd

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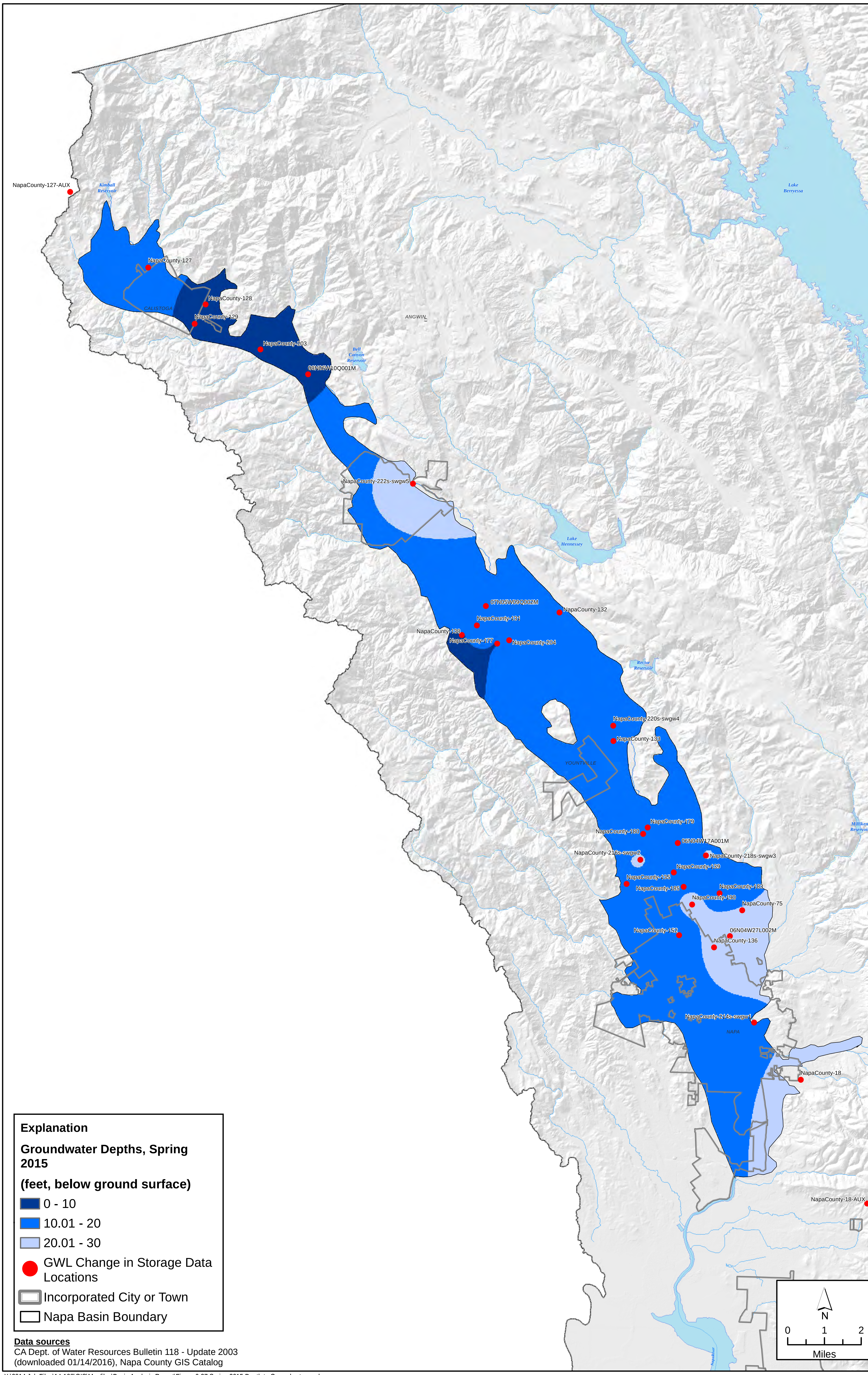
FIGURE 6-26

Depth to Base of Aquifer

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 6-27 Spring 2015 Depth to Groundwater.mxd

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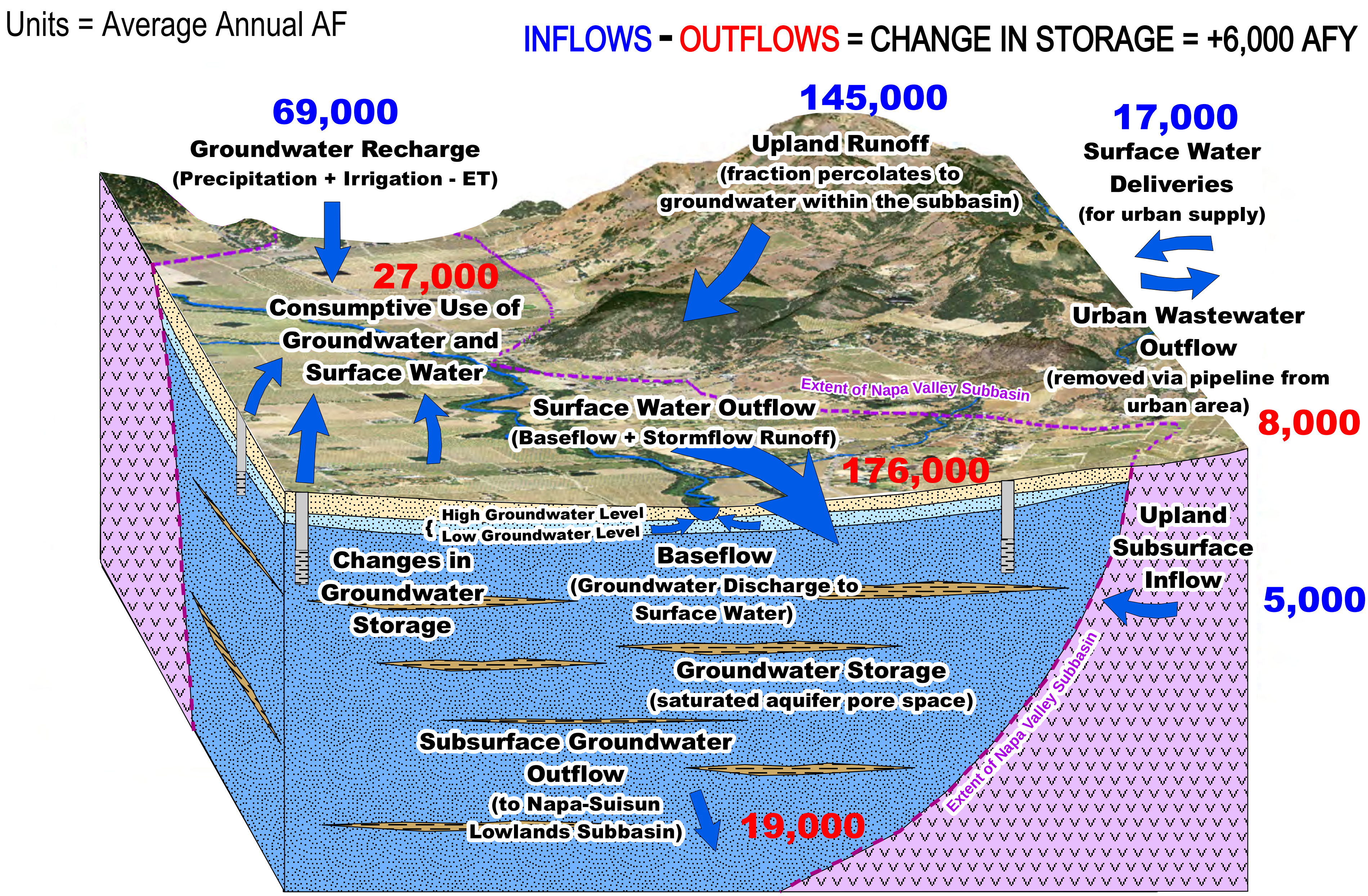
FIGURE 6-27

Depth to Groundwater - Spring 2015

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Conceptual Diagram\Figure 6-8 3D_WaterBudgetConceptualDiagram_wSWcomponents_20161005.mxd

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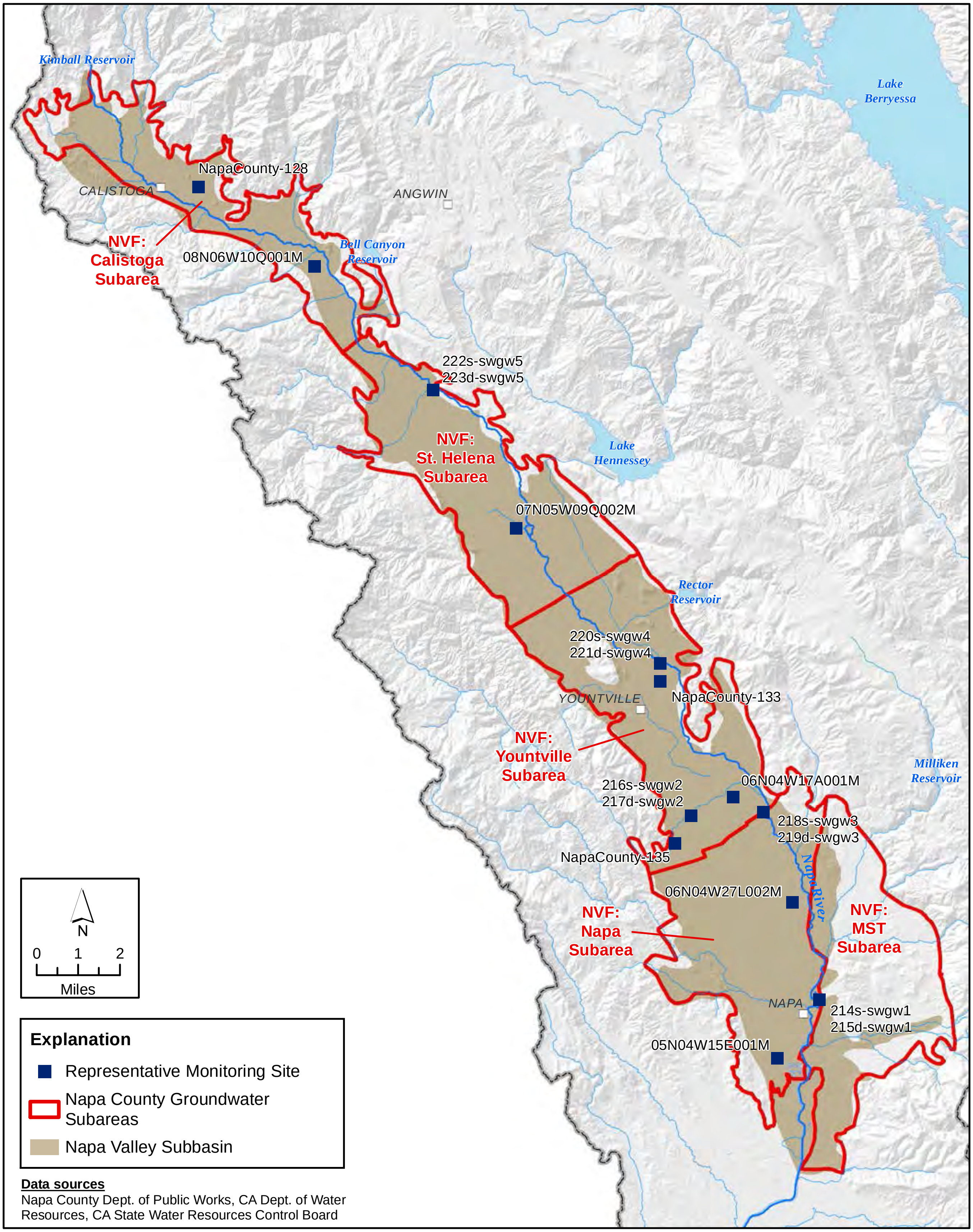
FIGURE 6-29
Schematic of Hydrogeologic Conceptual Model Components in the Napa Valley Subbasin with Average Annual Inflows and Outflows

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 7-1 NV Subbasin Representative Monitoring Sites_revised.mxd

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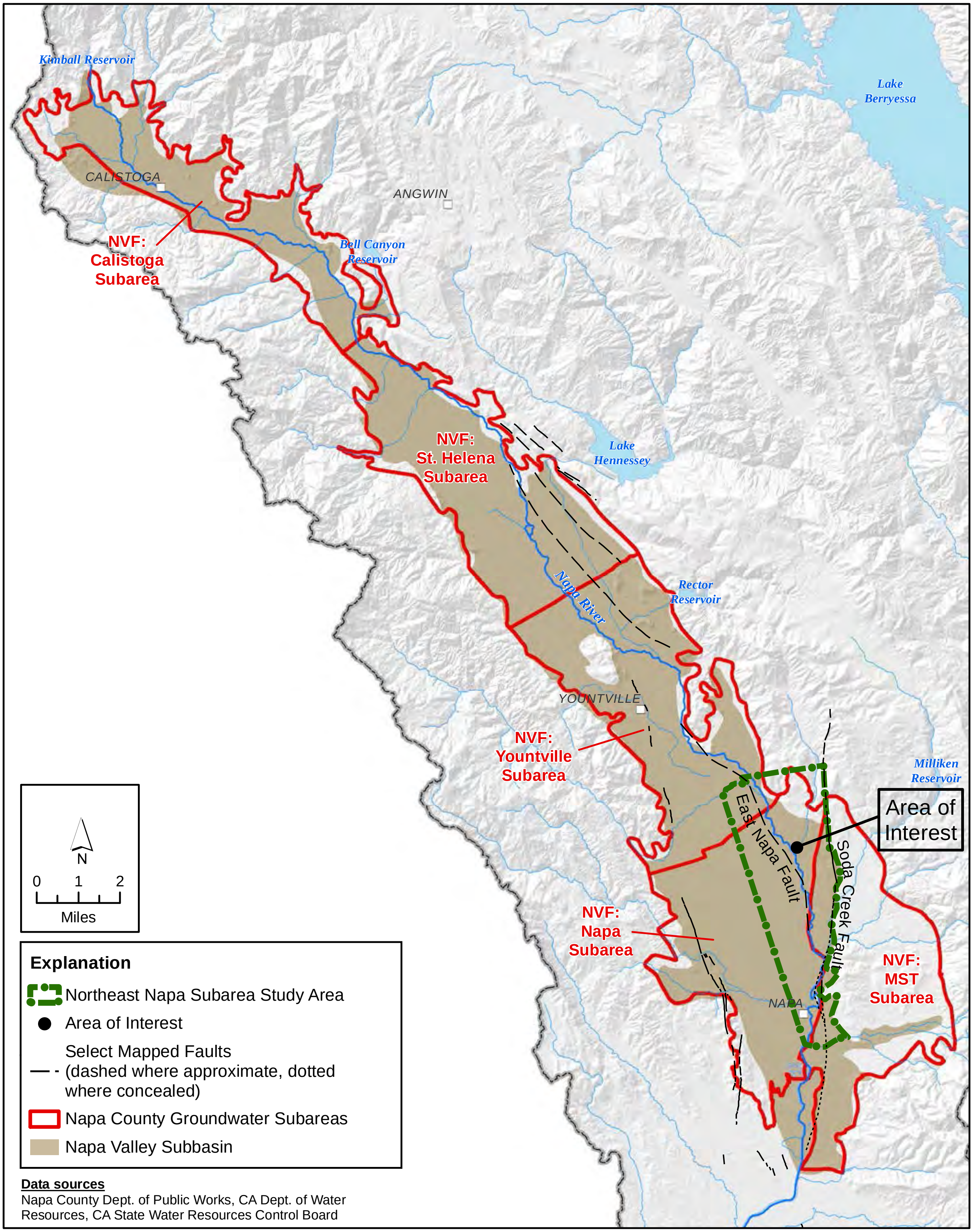
FIGURE 7-1
Napa Valley Subbasin Representative Monitoring Sites

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 7-2 Napa County Northeast Study Area.mxd

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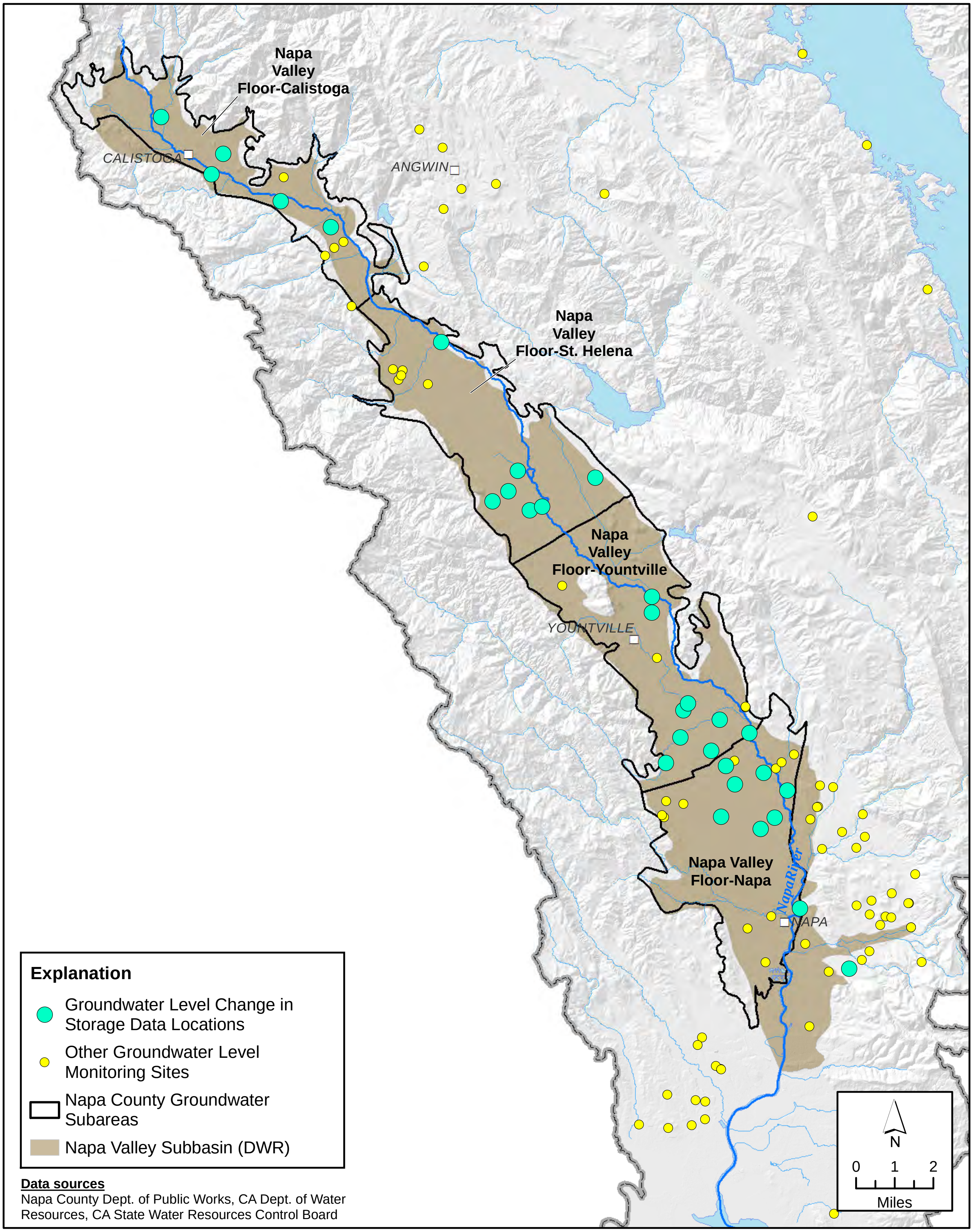
FIGURE 7-2
Northeast Napa Subarea Study Area

Napa Valley Groundwater Sustainability: A Basin Analysis Report for the Napa Valley Subbasin



Data sources
Napa County Dept. of Public Works, CA Dept. of Water Resources, CA State Water Resources Control Board

X:\2014 Job Files\14-108\GIS\Mapfiles\Basin Analysis Report\Figure 10-1 Change in Storage and Other Monitoring Locations.mxd

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FIGURE 10-1
Change in Storage and Other Monitoring Locations

APPENDICES

(See Separate Files)