Potter Valley Water Supply Reliability Study

Prepared for Sonoma County Water Agency

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Executive Summary

Study Overview

For more than 100 years, Potter Valley has received imports of water from the Pacific Gas & Electric Company's (PG&E's) Potter Valley Project (PVP), which transfers water from the Eel River watershed into the Russian River Watershed. As part of the ongoing water supply agreement with PG&E and its own water rights license, the Potter Valley Irrigation District (PVID) uses a portion of imported PVP water for agricultural purposes in Potter Valley.

In 2019, PG&E announced that it would not proceed with relicensing the PVP and would instead enter into a license surrender and decommissioning process, with the intention to remove the Scott and Cape Horn dams and end water diversion operations to the Russian River. In response, the Mendocino County Inland Water and Power Commission, the Round Valley Indian Tribes, and Sonoma County Water Agency (Sonoma Water) formed a new entity, the Eel-Russian Project Authority, and they submitted a proposal to PG&E to preserve water diversions into the Russian River, while also prioritizing upstream and downstream fish migration in the Eel River. The proposed New Eel-Russian Facility (NERF) would facilitate ongoing water diversions from the Eel River to the Russian River through the PVP's tunnel, while providing for fish migration on the Eel River by removing Scott and Cape Horn dams. Unlike the PVP, which historically has maintained year-round water diversions, the proposed facility would use run-of-river operations, where diversions from the Eel River would occur only when its flows meet defined thresholds for fish passage. As a result, the magnitude and timing of diversions are uncertain, but would change markedly from previous PVP operations, with water transfers likely only occurring when flow thresholds are met during the wet season and ceasing during the dry season.

Given the uncertainties surrounding the magnitude and timing of future water availability, Sonoma Water acquired funding from the California Department of Water Resources to support water resource investigations in the Potter Valley. This Potter Valley Water Supply Reliability Study was developed to evaluate potential water management strategies in the Potter Valley Groundwater Basin.

Summary of Findings

The key findings of this study are summarized as follows:

- Decommissioning of the PVP will result in substantial loss of water supply for users in Potter Valley during the late spring and summer. Estimated water supply shortfalls are approximately 9,000 acre-feet per year (AFY) under current demand assumptions and projected run-of-the-river diversion capability.
- Water supply reliability for uses in Potter Valley will require strategic management of seasonal NERF flows and pond storage within the valley.
- Water supply reliability likely will require combined actions, including new supply, new storage, and demand management.
- Long-term water supply reliability for uses in the Potter Valley may be achievable with a combination of seasonally available run-of-river Eel River diversions, local water resources, and demand management.
- Potter Valley water users will need to determine which balance of these actions (such as new supply, storage, and demand management) is most desired, but each of these actions will be required.

- New supply through groundwater, new storage as ponds, and demand management through irrigation and delivery system improvements are the most promising actions.
- Further field investigations are needed to reduce uncertainty related to the quantity of groundwater development evaluated in this study.

Recommendations

Based on the potential magnitude and seasonality of future water supply shortfalls to Potter Valley water users with PVP decommissioning the following recommendations are provided:

- **Recommendation 1: Pursue an Integrated Water Supply Strategy**

  Pursue a future water supply strategy that (1) integrates with run-of-river operations of the NERF to maximize storage of diverted water with expanded in-valley pond storage, (2) develops local groundwater supply, and (3) incentivizes demand management. Figure 6-1 demonstrates the combination of storage and supplemental supply needs with different levels of demand reductions.

- **Recommendation 2: Accelerate Efforts to Reduce Water Demand in Potter Valley**

  Reduce Potter Valley water demands by 20 to 30% through irrigation delivery system improvements and on-farm irrigation demand management.

- **Recommendation 3: Develop New In-Valley Pond Storage**

  Develop at least 2,500 acre-feet (AF) of new in-valley pond storage. These new storage ponds may be dispersed throughout the valley but should be capable of being filled with irrigation canal water or pumped groundwater during the early winter and spring. These new in-valley ponds would cover approximately 313 acres, in addition to the current pond area of 125 acres.

- **Recommendation 4: Develop New Groundwater Supply in Potter Valley**

  Develop a new groundwater supply of at least 3,500 AFY by constructing agricultural production wells to provide supplemental supply during June through September. A well drilling program will be required to establish yields for these fit-for-purpose production wells.

- **Recommendation 5: Incentivize Storage and Well Development throughout Potter Valley**

  Due to the large number of new small ponds and new wells that will be required, it is likely that a decentralized approach toward reliability will be most effective. In such an approach, each major landholding or group of landholdings would develop new ponds and wells for use on their lands. To provide an incentive to develop ponds and production wells as soon as possible, a Potter Valley water fund could be established to offer reduced costs (or rebates) to individuals who develop such projects.

- **Recommendation 6: Consider a New Governance Structure to Manage the Program**

  A program that implements Recommendations 1 through 5 likely will manage capital projects of up to $60 million and annual operations and maintenance costs of up to $2 million. Consideration should be given to substantially increasing the staffing and resources of PVID or developing an independent authority, such as a joint powers authority to manage the program and water fund.

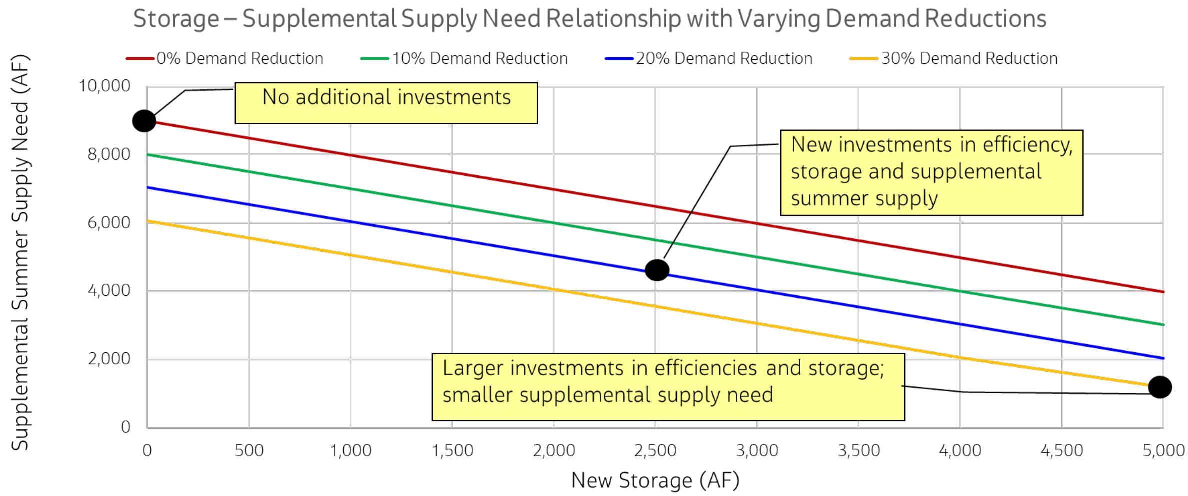

Figure ES-1. Relationship between Storage and Supplemental Summer Supply Need with Varying Demand Reductions

Next Steps

This current study has evaluated the existing and future conditions of water supply for Potter Valley and identified a series of recommendations that can achieve reliability in the mid to long term. The need to reduce the uncertainty of the new groundwater supply and for immediate action of other elements leads to the following next steps that should be considered in the near term.

Implement Production Well Drilling Program to Validate Groundwater Supply

This study identified the potential to produce 3,500 to 5,000 AFY of new groundwater supply through the construction of agricultural production wells throughout Potter Valley. However, most existing wells and the monitoring wells constructed for this current study are shallow and designed for domestic purposes. In addition, the geophysics investigations and groundwater modeling approaches employed in this study are indirect methods that have considerable uncertainty in estimating available groundwater storage. An appropriate next step would be to implement a production well drilling and aquifer testing program to validate these supply estimates and ascertain groundwater quality conditions within the basin. The program would include up to 12 test wells constructed to maximize production. The results from this program would reduce uncertainty of aquifer properties and potential well yields in the Basin, provide information on potential impacts to existing domestic wells, and identify potential areas of concern for groundwater quality.

Initiate District Scale Water Use Efficiency Program

PVID has been providing periodic investments to increase the efficiency of the district's delivery system. Lining of some canal sections and piping has occurred in areas where seepage losses were estimated to be high. An expansion and acceleration of these efforts will provide significant value and reduce diversion requirements in the canal systems. This action is a no-regret action (an action that provides benefits regardless of future conditions) that can be implemented in the near term and will continue the trajectory toward greater water reliability.

Incentivize Expanded Pond Storage throughout the Valley

Several landowners are expanding, or considering expanding, pond storage for their agricultural operations. Greater seasonal storage in Potter Valley is another no-regret action for water supply reliability. At present, incentives provided for landowners would likely increase the rate of in-valley pond storage development. An early incentive, in the form of rebate or cost reductions, likely would lead to a greater number of landowners involved in pond storage expansion. An incentive could be provided through state or locally derived funds even prior to establishing a Potter Valley water fund or considering new governance.

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Acronyms and Abbreviations

Acronym	Definition
$/AF	dollars per acre-foot
$M	million dollars
>	greater than or equal to
≥	greater than or equal to
<	less than
AF	acre-foot or acre-feet
AFY	acre-foot per year or acre-feet per year
ASR	aquifer storage and recovery
Basin	Potter Valley Groundwater Basin
bgs	belowground surface
DBEM	drone-based frequency-domain electromagnetic
DWR	California Department of Water Resources
EFRR	East Fork Russian River
EIR	Environmental Impact Report
ER	electrical resistivity
ET	evapotranspiration
ETa	actual evapotranspiration
gpm	gallon(s) per minute
gpm/foot	gallon(s) per minute per foot of drawdown
MAR	managed aquifer recharge
N/A	not applicable
NERF	New Eel-Russian Facility
O&M	operations and maintenance
PG&E	Pacific Gas & Electric Company
PVID	Potter Valley Irrigation District
PVIFM	Potter Valley Integrated Flow Model
PVP	Potter Valley Project
PW	private well
Reliability Study	Potter Valley Water Supply Reliability Study
SCADA	Supervisory Control and Data Acquisition
Sonoma Water	Sonoma County Water Agency
USGS	US Geological Survey
WY	water year

1. Introduction

Sonoma County Water Agency (Sonoma Water) contracted Jacobs Engineering Group (Jacobs) to support the Potter Valley Water Supply Reliability Study (Reliability Study) by evaluating potential water management strategies in the Potter Valley Groundwater Basin (Basin). Jacobs prepared this report, which documents the background, approach, and results of the Reliability Study.

Sonoma Water serves a population of approximately 600,000 people, providing wholesale water supply to cities and water districts in Sonoma and Marin counties in Northern California. The reliability of Sonoma Water supplies and other partners on the Russian River is impacted by the outcomes of changes to the Potter Valley Project (PVP) operation and water transfers from the East Fork of the Russian River.

For more than 100 years, the Potter Valley has received imports of water from the Pacific Gas & Electric Company's (PG&E's) PVP, which transfers water from the Eel River watershed into the Russian River Watershed. Features of the PVP include Scott Dam, which impounds Lake Pillsbury, and Cape Horn Dam, which impounds the Van Arsdale Reservoir. From just upstream of the Cape Horn Dam, a diversion system has been operated to supply water through a tunnel to the Potter Valley Powerhouse located at the northern end of the study area for the Reliability Study (Figure 1-1). As part of the ongoing water supply agreement with PG&E and its own water rights license, the Potter Valley Irrigation District (PVID) uses a portion of imported PVP water for agricultural purposes in Potter Valley. The remaining water not used by PVID flows down the East Fork Russian River (EFRR) into Lake Mendocino, providing a critical source of water for beneficial users in Mendocino, Sonoma, and Marin Counties and for ecosystems along the Russian River.

In 2019, PG&E announced that it would not proceed with relicensing the PVP and would instead enter into a license surrender and decommissioning process, with the intent to remove the Scott and Cape Horn dams, and end water diversion operations to the Russian River. In response, the Mendocino County Inland Water and Power Commission, the Round Valley Indian Tribes, and Sonoma Water formed a new entity, the Eel-Russian Project Authority, and submitted a proposal to PG&E to preserve water diversions into the Russian River, while also prioritizing upstream and downstream fish migration in the Eel River. The proposed New Eel-Russian Facility (NERF) would facilitate ongoing water diversions from the Eel River to the Russian River through the PVP's tunnel, while providing for Eel River fish migration by removing Scott and Cape Horn dams. Unlike the PVP, which historically has maintained year-round water diversions, the proposed facility would use run-of-river operations, where diversions would occur only when Eel River flows meet defined thresholds for fish passage. As a result, the magnitude and timing of diversions are uncertain, but would change markedly from previous PVP operations, with water transfers likely only occurring when Eel River flow thresholds are met during the wet season and ceasing during the dry season.

Given the uncertainties surrounding the magnitude and timing of future water availability, the Reliability Study aims to support water supply reliability planning for the Potter Valley through the evaluation of hydrogeologic conditions, historical and current agricultural water use and irrigation practices, potential future agricultural water supply, storage, and demand management strategies within Potter Valley.

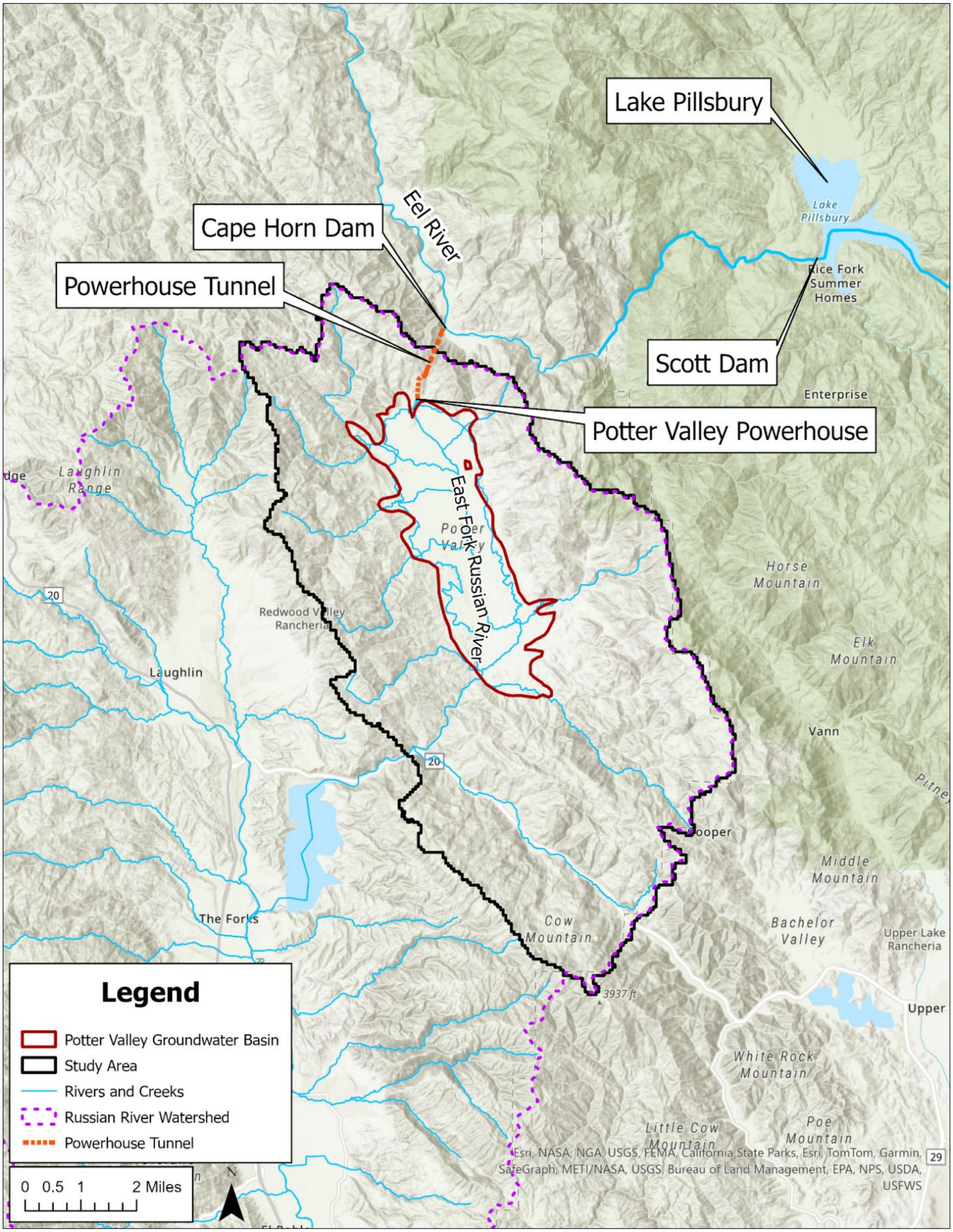


Figure 1-1. Study Area

1.1 Project Motivations

The following project motivations are identified for the Reliability Study:

- Year-round PVP water transfers have fostered plentiful and reliable water supply for Potter Valley for over 100 years, with the PVP providing almost all of Potter Valley's water supply needs.
- The Russian River watershed has also benefited from the PVP providing a critical supplemental source of water for over 600,000 people in Mendocino, Sonoma, and Marin counties and for threatened and endangered fish in the in the Russian River.
- Historically, PG&E released water from Lake Pillsbury to meet minimum instream flow requirements on the Eel River and to divert water through the PVP to generate electricity and maintain minimum instream flow requirements in the EFRR. The average annual transfer through the PVP between 1922 and 2006 was approximately 150,000 acre-feet. Following an amendment to PG&E's operating license in 2007, the average annual transfer volume was approximately 60,000 acre-feet. A 2021 mechanical failure of PVP power generation equipment has further reduced annual transfers to around 39,000 acre-feet in recent years. With the April 2022 expiration of PG&E's project license for the PVP, the future of the PVP is unclear, and it is uncertain if the transfer of water from the Eel River to the Russian River will continue.
- Regardless of whether future changes to PVP results in seasonal trans-basin water transfers under run-of-river operations or cessation of transfers entirely, either result will have pronounced impacts on water supply, agriculture, and community in Potter Valley and the greater Russian River watershed. As such, additional water supply planning must be undertaken in the Russian River watershed to ensure water supply resiliency under this uncertainty.
- Developing a detailed understanding of the water resources of Potter Valley and quantifying the potential impacts of future change is critical. To achieve this, hydrogeological investigations, geophysical analyses, and evaluation of existing and future demands must be conducted.
- Identifying solutions that must adapt to future changes to achieve sustainability for the Russian River watershed.

1.2 Critical Success Factors

The following factors are identified to gauge the success of the Reliability Study:

- Accurate characterization of Potter Valley water resources for historical and future conditions.
- In-depth understanding of the perspectives of local Potter Valley stakeholders, Sonoma Water, Mendocino County Inland Water and Power Commission, and greater Russian River watershed users of impacts, risks, and opportunities associated with changes to the PVP.
- Evaluate and determine strategies to address uncertainty in future water supply reliability.

Recommend feasible and robust water supply solutions and support effective decision making.

2. Potter Valley Water System Description

To support the Reliability Study, a field reconnaissance and irrigation system data collection effort was conducted to characterize water management in Potter Valley. The following section provides an overview of the findings from this reconnaissance effort. Additional details of the reconnaissance are provided in Appendix A.

PVID operates a system of canals and lateral ditches within Potter Valley and provides irrigation water to local users. PVID receives imported water from the PVP diversion tunnel that routes from Lake Van Arsdale on the Eel River to the PG&E Powerhouse in Potter Valley (Figure 1-1). From the PG&E Powerhouse, water is diverted at the East and West Weir into PVID's East and West Canals, which convey water to PVID customers. Additional diversions into the East and West Canal occur further downstream of the East and West Weir from the Powerhouse Canal at the West Pump, West Diversion, and East Pump. Flows not diverted into the East and West Canals remain in the Powerhouse Canal and eventually flow into the EFRR. Figure 2-1 is a map of PVID conveyance infrastructure, canal inflow and diversion locations associated with importing water from the PVP to Potter Valley, and locations of canal diversions and lateral ditches used to convey water to customers.

Figure 2-2 presents historical annual PVID deliveries, diversions, and June through September PVID deliveries and actual evapotranspiration (ETa) representing conditions during the irrigation season. Annual PVID diversions averaged approximately 15,000 AF while annual PVID deliveries averaged approximately 11,000 AF. The difference in PVID diversions and PVID deliveries represents the volume of water required to adequately convey water throughout PVID and to cover potential losses due to ET and seepage. Water remaining in the East and West Canals that is not delivered eventually flows to the EFRR or infiltrates via canal losses. The majority of annual PVID deliveries are delivered during June through September months when irrigation demands are highest, averaging approximately 8,500 AF. OpenET estimates of ETa throughout PVID were summarized for 2016 through 2021 based on data publicly available (OpenET 2023).[1] The June through September average ETa is approximately 5,500 AF per month.

Table 2-1 presents an annual summary of measured canal surface water inflows and deliveries for water years (WYs) 2011 through 2022. Total water diverted to PVID, representing the total water diverted into the East and West Canals ranges from 7,768 to 19,693 AFY, and the total PVID deliveries ranged from 8,620 to 13,562 AFY. In general, differences between the total water delivered to PVID and PVID deliveries results from PVID needing to maintain certain flows and stages along the canals to convey water throughout the system. Water conveyed through the East and West Canals that is not diverted eventually flows to the EFRR or infiltrates via canal losses.

Water diverted into PVID's East and West Canals is conveyed to customers throughout Potter Valley to support agricultural operations. Table 2-2 shows annual PVID irrigated area by crop type for WYs 2011 through 2022. The primary crop types in Potter Valley are grapes and pasture/hay. In general, no significant changes in crop types have occurred throughout PVID over the 12-year period listed in Table 2-2.

[1] OpenET is an online platform for mapping evapotranspiration (ET) at the scale of individual fields.

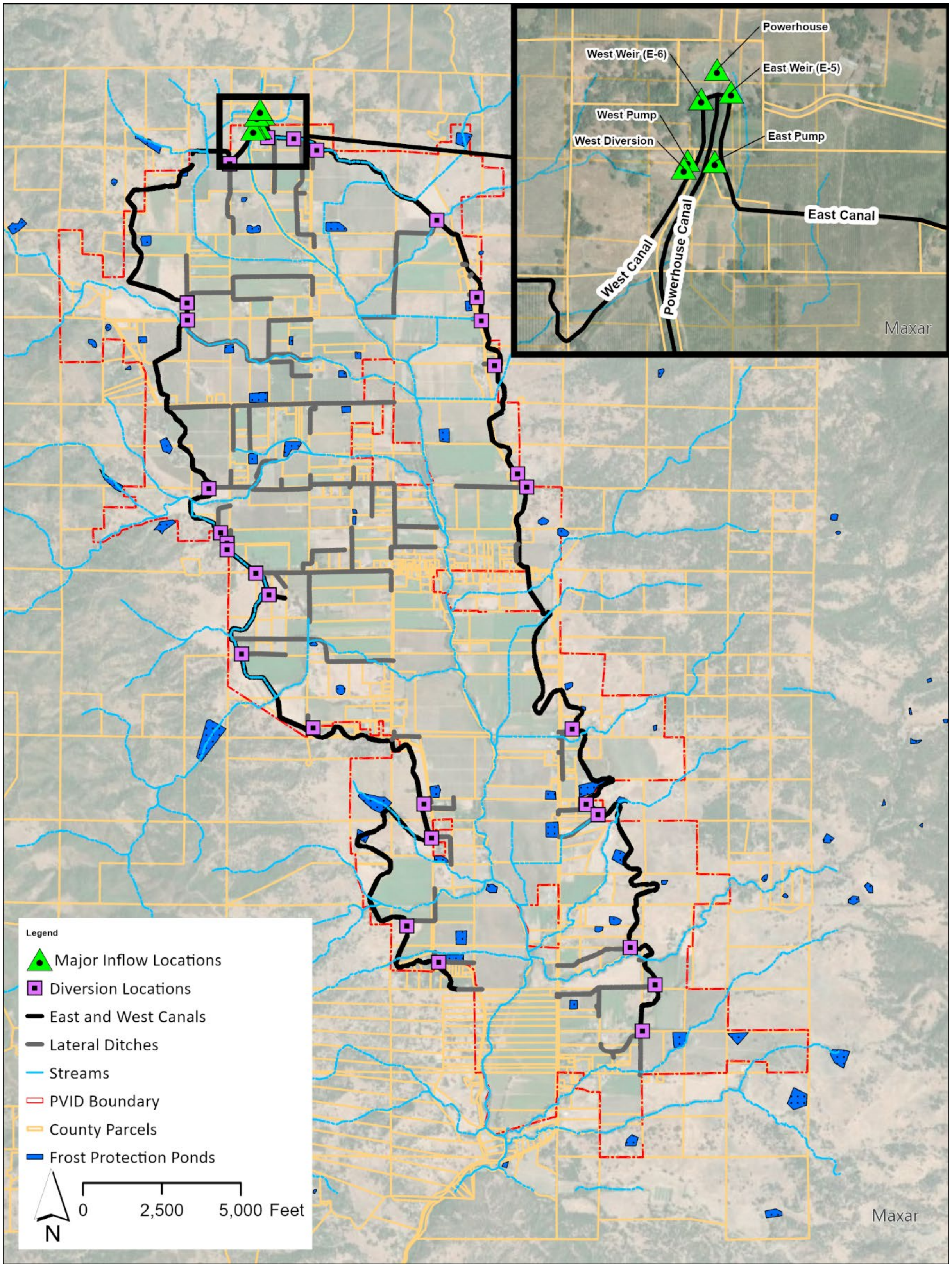


Figure 2-1. Potter Valley Irrigation District Conveyance Infrastructure

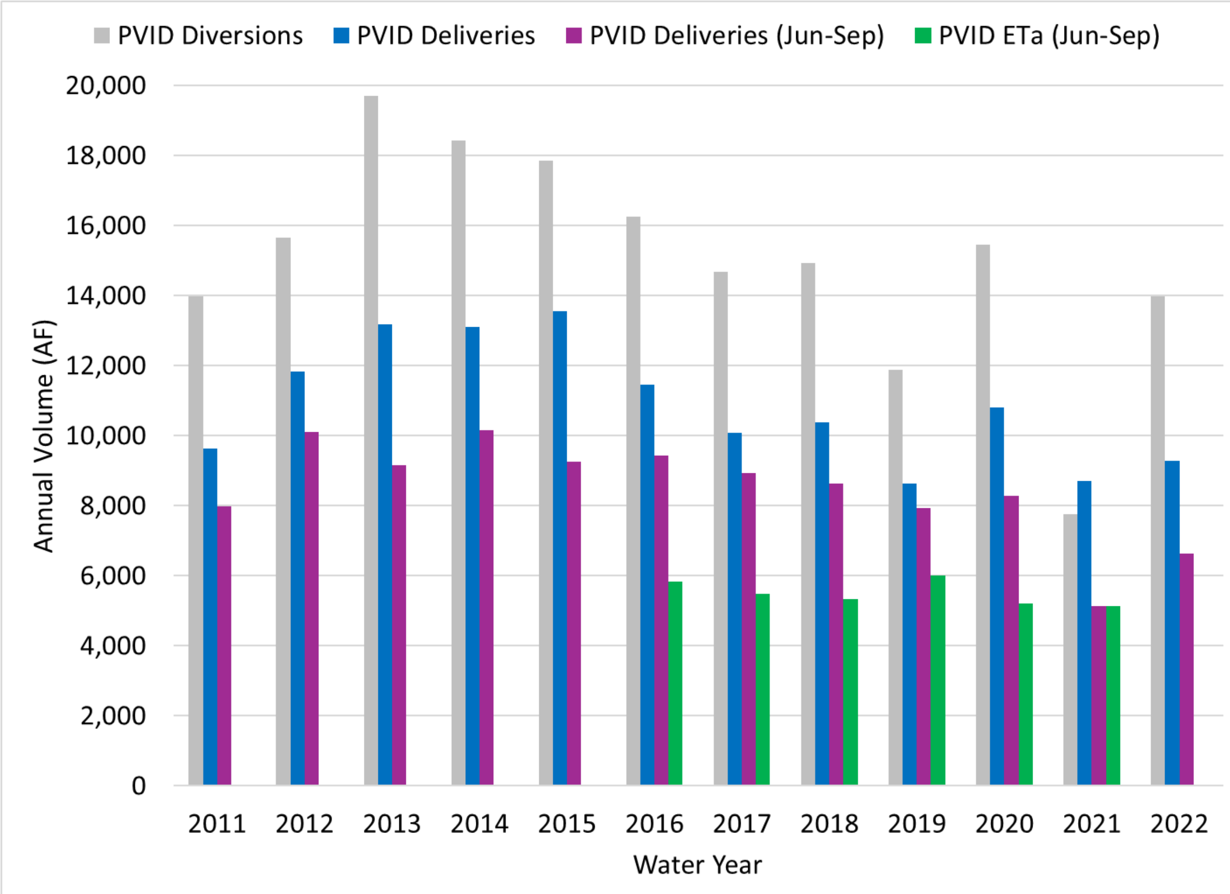


Figure 2-2. Historical Annual Potter Valley Irrigation District Diversions, Deliveries, and Evapotranspiration

Note: Data used to compile PVID ETa were only available for Water Years 2016 through 2023.

Table 2-1. Summary of Measured Canal Surface Water Inflows and Deliveries

Water Year	Measured Water Entering Diversion Tunnel to Powerhouse (AF)	Measured Water Diverted into PVID East & West Canals [a] (AF)	Measured Water Removed from Powerhouse Canal at East Pump, West Pump, and West Diversion [b] (AF)	Measured Total Water Delivered to PVID [c] (AF)	Measured East Canal Deliveries (AF)	Measured West Canal Deliveries (AF)	Measured Total PVID Deliveries (AF)
2011	100,590	11,982	1,991	13,973	4,433	5,200	9,633
2012	69,007	12,275	3,384	15,659	4,974	6,859	11,833
2013	67,640	15,290	4,403	19,693	5,413	7,774	13,187
2014	38,940	11,702	6,722	18,424	5,492	7,619	13,111
2015	37,055	8,246	9,615	17,861	5,762	7,800	13,562
2016	46,253	6,832	9,414	16,246	4,894	6,557	11,451
2017	67,035	6,596	8,091	14,687	4,381	5,688	10,069
2018	48,696	6,778	8,145	14,923	4,596	5,789	10,385
2019	65,641	5,495	6,386	11,881	4,044	4,576	8,620
2020	58,457	6,909	8,540	15,449	4,697	6,099	10,796
2021	31,805	6,090	1,678	7,768	3,787	4,925	8,712
2022	42,605	12,335	1,634	13,969	3,972	5,300	9,272

[a] Term is based on values reported in PVID's water use reports called "PG&E CEDC FOR E-5 & E-6".

[b] Term is based on values reported in PVID's water use reports called "Lic. 5246 USE AT DIVERSION" and represents additional PVID diversions into the East and West Canals.

Table 2-2. Potter Valley Irrigation District Irrigated Area in Acres by Crop Type

Water Year	Fallow	Grazing	Grapes	Pears	Pasture/Hay	Farm Crops	Cannabis	Total Area
2011	N/A	N/A	2,018	209	2,525	72	N/A	4,824
2012	N/A	N/A	2,018	209	2,525	72	N/A	4,824
2013	N/A	N/A	1,966	208	2,571	67	N/A	4,812
2014	N/A	N/A	1,966	208	2,571	67	N/A	4,812
2015	N/A	N/A	1,966	208	2,571	67	N/A	4,812
2016	190	449	1,979	205	2,658	84	N/A	5,565
2017	171	549	2,140	195	2,406	80	N/A	5,541
2018	171	549	2,140	195	2,398	80	N/A	5,533
2019	107	663	2,157	195	2,323	77	37	5,559
2020	107	693	2,137	195	2,327	77	37	5,573
2021	100	966	2,198	143	2,159	51	37	5,654
2022	91	926	2,198	143	2,161	74	27	5,620

N/A = not applicable

3. Field Investigations

Three types of field investigations were executed in support of the Reliability Study, including the following:

- Geophysical investigations
- Monitoring of selected existing wells
- Exploratory drilling and monitoring well construction

The following sections provide an overview of these investigations. Additional details regarding the geophysical investigation are provided in Appendix B, and monitoring well construction details are provided in Appendix C.

3.1 Geophysical Investigations

Jacobs' staff members conducted geophysical investigations during the weeks of July 17 and November 6, 2023 to help refine the Basin hydrogeologic conceptual model. More specifically, the objectives of the geophysical investigation were to improve delineation of the lateral extent and continuity of subsurface materials and hydrogeologic structures, and improve understanding of the Basin aquifer system depth and geometry. Jacobs addressed these objectives as follows:

- Reviewing gravity data collected by the US Geological Survey (USGS) (USGS 2007, 2022a)
- Reviewing existing stratigraphic information from available California Department of Water Resources (DWR) well completion reports
- Conducting additional geophysical surveys

The geophysical surveys conducted by Jacobs included drone-based frequency-domain electromagnetic (DBEM) surveys and two-dimensional electrical resistivity (ER) surveys. The purpose of the DBEM survey was to map subsurface geologic and hydrogeologic structures at a basin scale and identify potential areas for conducting more focused ground-based geophysical investigations. The planned layout of the DBEM survey included collecting data along five longitudinal transects and six latitudinal transects across Potter Valley. However, the DBEM survey was only conducted along two flight paths in the northwest portion of the Basin because of windy conditions, which limited access to landing/takeoff locations and hampered initial attempts at safely flying the drone system above trees and powerlines. As a result, the number of ground-based ER transects performed was increased to 16 ER transects, which improved geophysical data coverage across Potter Valley (Figure 3-1).

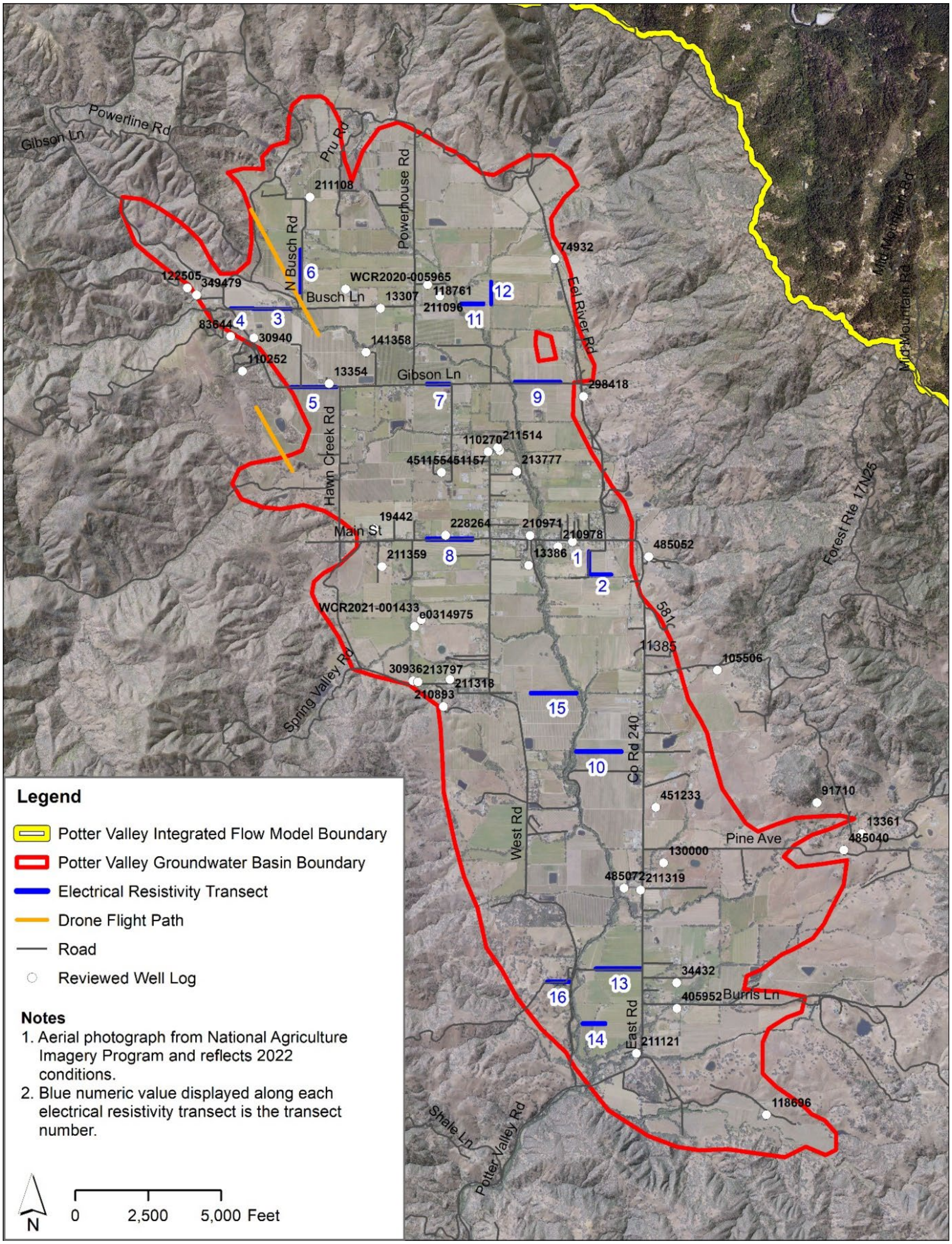


Figure 3-1. Flight Paths and Electrical Resistivity Transects

The DBEM and ER surveys provided information about subsurface materials to a maximum depth of approximately 250 feet below ground surface (bgs). Previous USGS estimated depths to basement rock exceeded a depth 250 feet in the west-southwest portion of the Basin. Therefore, it was not possible to refine initial USGS estimates of depth to bedrock in the west-southwest portion of the Basin based on the DBEM and ER survey models. Estimates of depth to bedrock could be refined in the future throughout the Basin if borings are drilled to bedrock and paired with information from the DBEM and ER surveys.

Although distinguishing between subtle changes in soil textures generally is not possible with the DBEM or ER methods directly, these methods provide information about lateral and vertical distributions of fine- and coarse-texture unconsolidated deposits, or consolidated rocks below the ER transects. Most of the ER interpretations generally show low-resistivity distributions that likely represent fine-texture unconsolidated deposits, such as clay. Some higher-resistivity anomalies were indicated by the ER models at scattered locations; these anomalies likely represent coarser-texture deposits or consolidated rock. In terms of general spatial trends across the Basin, the DBEM and ER models in the northwestern portion of the valley show a greater proportion of higher-resistivity zones as compared with ER models in the rest of the valley. These higher-resistivity zones likely represent coarser-texture deposits indicative of more productive aquifer material. This is supported by well log WCR2020-005965; this well is along Busch Lane near ER Transect 6 (Figure 3-2). The log indicates the following:

- Soil and gravel from 0 to 20 feet bgs
- Gravels from 20 to 75 feet bgs
- Gray clay from 75 to 90 feet bgs

Thus, according to this well log, a higher proportion of gravel to a depth of 75 feet bgs is in this northwestern portion of the Basin. Most of the ER transects across the rest of the Basin indicate a greater proportion of fine-texture soils (Figure 3-2). This information along with other information provided by PVID, USGS, and others helped guide the development of an integrated surface water-groundwater model, which is described in Section 4 and Appendix D.

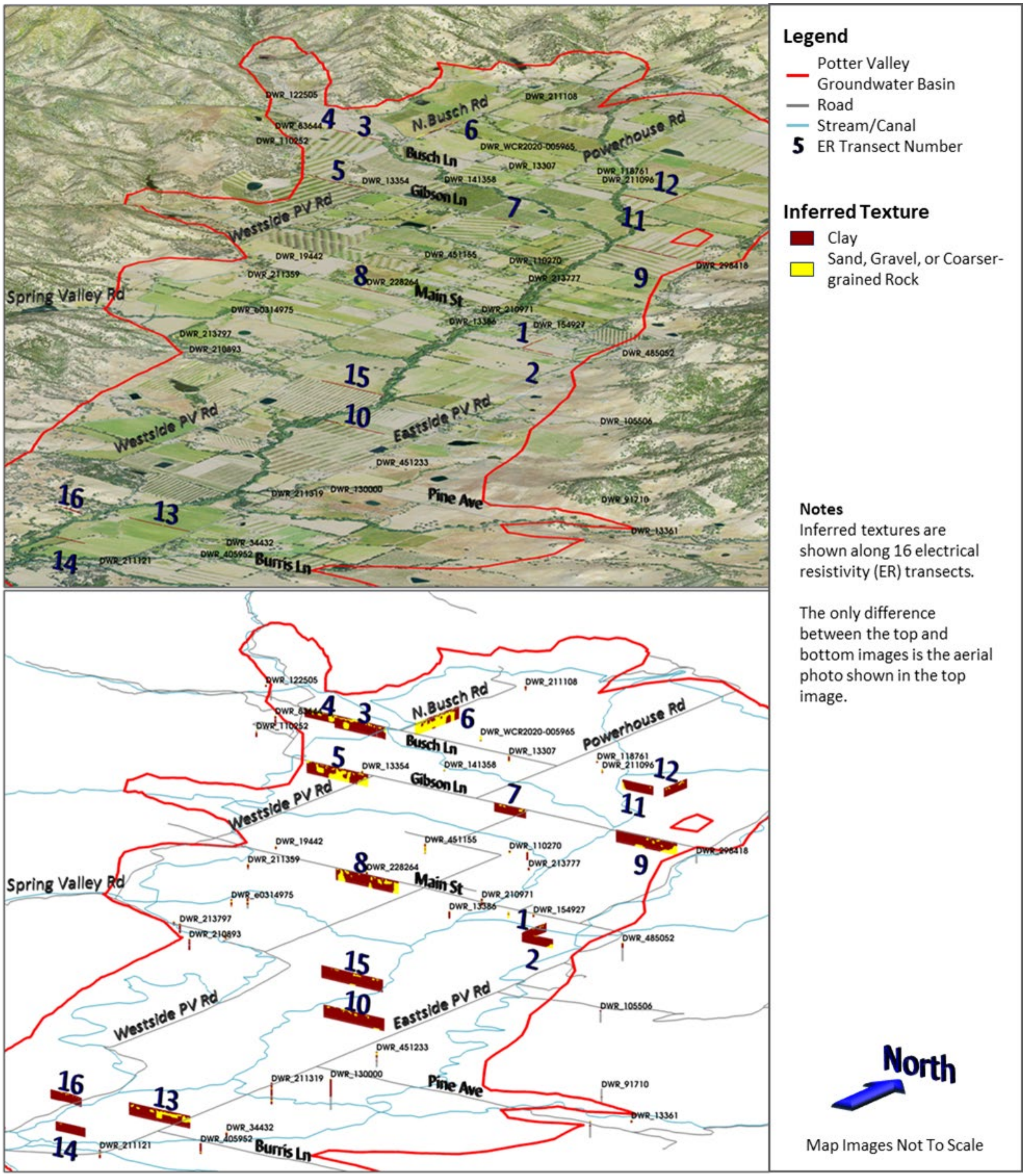


Figure 3-2. Electrical Resistivity Transect Locations and Results

3.2 Monitoring of Selected Existing Wells

In early 2024, eight existing private wells (PWs) were identified for water level instrumentation to expand the monitoring well network within Potter Valley. Figure 3-3 shows the location of the eight existing wells labeled PW-01 through PW-08. Five of the eight wells are actively operated (i.e., actively pumped) domestic or small irrigation wells (PW-01, PW-02, PW-04, PW-05, PW-06, PW-07), and the remaining three are currently not being operated (PW-03, PW-07, PW-08). Water level instrumentation was installed at these wells during a period between January and March, 2024 and were used to measure depth to water continuously for a period up to 12 months. Table 3-1 presents depth to water statistics for May through June 2024 for all eight existing monitoring wells that were instrumented. In addition, Figure 3-4 shows a graphic version of the depth to water statistics at the eight existing monitoring wells. In general, depth to water measured at existing monitoring wells are shallow with a maximum measured depth to water observed at PW-08 of 17 feet. All of the wells show small seasonal fluctuations in depth-to-water, with the largest fluctuations in an individual well observed at PW-08 (16.6 feet). General shallow and stable groundwater levels exhibited in the existing well network indicate that the groundwater storage of the Basin is near full capacity.

Continued monitoring and collection of depth to water data at these existing monitoring wells will help to improve the conceptual understanding of groundwater conditions throughout the Basin. The data will support future evaluations of groundwater conditions and water supply reliability in the Basin.

Table 3-1. Depth to Water Statistics at Existing Monitoring Wells

Location	Minimum (feet btoc)	Maximum (feet btoc)	Average (feet btoc)	Range (feet)	Time Period
PW-01	2.5	13.1	3.1	10.6	Jan 2024 through May 2024
PW-02	2.4	11.3	6.3	8.9	Feb 2024 through Jan 2025
PW-03	1.7	6.9	4.9	5.2	Mar 2024 through Jan 2025
PW-04	2.4	15.0	12.6	8.8	Feb 2024 through Jan 2025
PW-05	2.5	14.9	4.5	12.5	Jan 2024 through July 2024
PW-06	2.9	9.5	5.3	6.6	Feb 2024 through Jan 2025
PW-07	5.5	10.0	8.1	4.5	Mar 2024 through Jan 2025
PW-08	11.1	20.7	16.6	9.7	Mar 2024 through Jan 2025

btoc = below top of casing

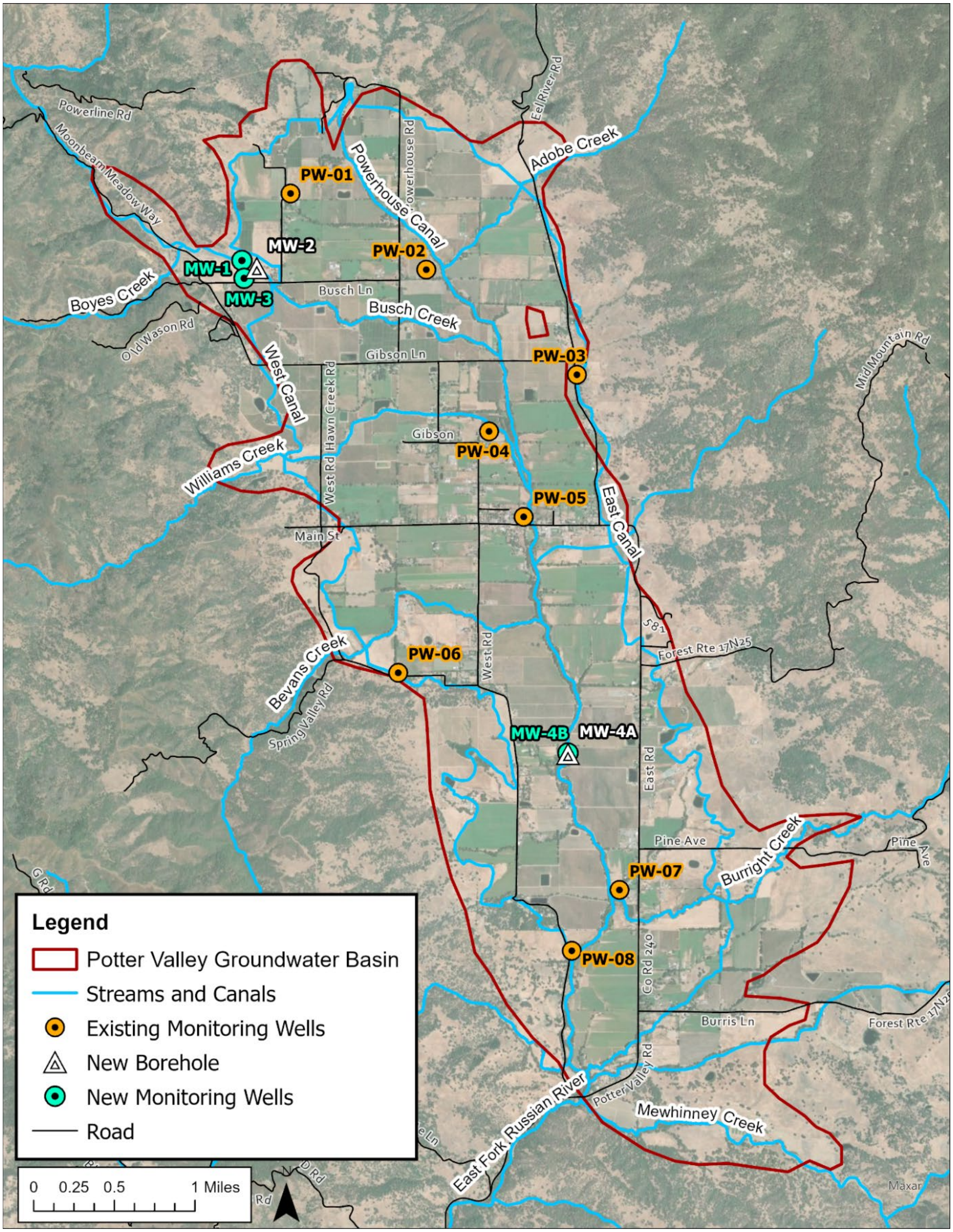


Figure 3-3. Existing Well, New Monitoring Well, and New Boring Locations

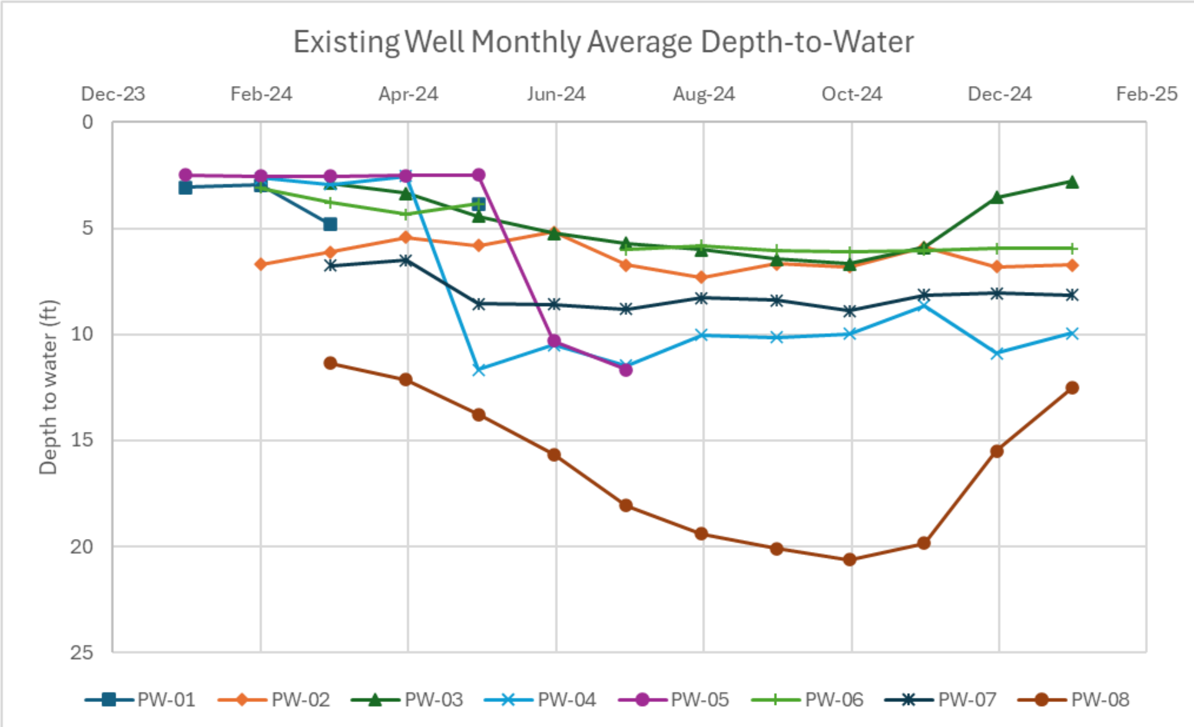


Figure 3-4. Monthly Average Depth to Water for Existing Monitoring Wells

3.3 Exploratory Drilling and Monitoring Well Construction

Jacobs retained Gregg Drilling to drill exploratory boreholes and construct new monitoring wells in Potter Valley. Drilling and construction activities occurred between October 23 and November 13, 2024. The primary objectives of the drilling and well construction were to provide data to assist in developing and refining the hydrogeologic conceptual model of the Potter Valley. Jacobs prepared a monitoring well construction report (Appendix C) that documents the objectives of the field activities, selection of locations for new monitoring wells, permitting, drilling, construction, and development of new monitoring wells.

3.3.1 Objectives and Approach to Monitoring Well Construction

Specific objectives of the exploratory drilling and well construction were as follows:

- Collect lithologic information to assess the nature of the shallow (less than 100 feet bgs) aquifer.
- Facilitate future collection of groundwater-level data to evaluate the spatial and temporal variability of groundwater levels in the Potter Valley by locating new monitoring wells in areas where existing subsurface data are lacking.
- Facilitate future assessment of the horizontal and vertical hydraulic properties of the shallow aquifer by installing and evaluating pumping from adjacent wells at a monitoring well cluster.
- Facilitate future evaluation of groundwater-surface water interaction by locating new monitoring wells along major surface water drainages.
- Locate a new well near geophysical transects completed previously to provide an additional data set for future geophysical interpretation.

To achieve these objectives, Jacobs worked with Sonoma Water, with the assistance of PVID staff members, to identify Potter Valley landowners that agreed to allow drilling and construction of new monitoring wells on their properties. Jacobs and Sonoma Water reviewed the potential new well locations, and then finalized the well sites to best align with the above objectives, which resulted in a proposed plan to construct five new monitoring wells at three different locations as follows:

- A two-well cluster (shallow/deep pair) on the north side of Busch Creek in northwest Potter Valley (MW-1 and MW-2 location).
- One shallow well on the south side of Busch Creek in northwest Potter Valley (MW-3 location).
- A two-well cluster (shallow/deep pair) on the east side of EFRR in central Potter Valley (MW-4A/B location).

Figure 3-3 shows the locations of new monitoring wells and borings installed for the project.

3.3.2 Drilling, Well Construction, and Well Development

Jacobs' subcontractor, Gregg Drilling, advanced borings at each location by the hollow-stem auger drilling method and collected soil samples using a 2-inch diameter by 2-foot-long California modified split-spoon sampler. Soil samples were collected continuously or at intervals of approximately 5 feet. The lithology was described by a Jacobs field geologist under the direction of a State of California Licensed Professional Geologist. Pilot borings were advanced to the planned total depth or refusal, which is evident when drilling is met with substantial resistance from consolidated subsurface materials (for example, bedrock). A summary of borehole details for each location is provided in Table 3-2. Borings logs and photographs of soil core samples from each borehole are included in monitoring well construction report in Appendix C.

Shallow and deep monitoring wells were planned to be up to 50 feet and 80 feet deep, respectively. Modifications to the well construction plan were required based on the lithology encountered during borehole drilling resulting in construction of three new monitoring wells at MW-1, MW-3, and MW-4B and abandonment of two boreholes at MW-2 and MW-4A. Cluster monitoring wells were not constructed at either planned location because of the shallow depth to bedrock along Busch Creek (at MW-1 through MW-3) and the presence of a continuous clay sequence and lack of permeable materials across the water table along EFRR at MW-4A/B.

The new monitoring wells at MW-1, MW-3, and MW-4B were constructed with 4-inch-diameter, Schedule 80 polyvinyl chloride (PVC) casing and 20-foot-long, 0.01-inch slot PVC screens. Boreholes at MW-2 and MW-4A were abandoned by backfilling with neat cement grout. Groundwater monitoring wells were constructed, and boreholes were abandoned in accordance with State of California requirements outlined in the California Well Standards, Bulletins 74-81 and 74-90 (DWR 1981, 1991). The monitoring wells were developed by a combination of bailing, swabbing, and purging with an electric submersible pump. Field parameters were measured periodically using calibrated field instruments, and development continued until the field parameters were stabilized.

Table 3-2. Borehole and Well Construction Details

Location	Borehole Depth (feet bgs)	Lithologic and Borehole Observations
MW-1	42	▪ Lithology consisted primarily of brown clayey to silty gravel 0 to 24 feet bgs, brown clayey to silty sand 24 to 32 feet bgs, and weathered bedrock (sandstone) 32 to 42 feet bgs. ▪ Refusal encountered at 42 feet bgs. ▪ Groundwater recovered to 18 feet bgs in borehole overnight prior to well construction.
MW-2 [a]	24	▪ Lithology consisted primarily of brown clayey to silty gravel 0 to 22 feet bgs, brown silty sand 22 to 24 feet bgs, and a fragment of schist recovered at 24 feet bgs. ▪ Refusal encountered at 24 feet bgs.
MW-3	70	▪ Lithology consisted primarily of brown clayey to silty gravel 0 to 28 feet bgs, brown clayey to silty sand 28 to 32 feet bgs, and bluish gray/black weathered bedrock (sandstone/schist) 32 to 70 feet bgs. ▪ Refusal encountered at 70 feet bgs. ▪ Groundwater recovered to 24 feet bgs in borehole overnight prior to well construction.
MW-4A [a]	30	▪ Not sampled 0 to 15 feet bgs. ▪ Predominantly clay 15 to 30 feet bgs. Color change from brown to bluish gray 18 feet bgs.
MW-4B	80	▪ Lithology consisted primarily of brownish clayey to silty sand and gravel 0 to 19 feet bgs, gray/bluish gray clay 19 to 30 feet bgs, and bluish gray clayey and silty gravel 30 to 80 feet bgs. ▪ Refusal encountered at 80 feet bgs. ▪ Groundwater recovered to 21 feet bgs in borehole overnight prior to well construction.

[a] Boreholes at MW-2 and MW-4A were not completed as monitoring wells.

Table 3-3 summarizes the well construction details, static groundwater levels, and key parameters measured during well development. A complete discussion of the well construction and development, including well completion diagrams, well completion reports filed with DWR, and copies of the well development logs are included the well completion report in Appendix C.

Table 3-3. Summary of Well Construction and Development

Parameter	MW-1	MW-3	MW-4B
Well depth (feet bgs)	32	38	80
Screened interval (feet bgs)	12 to 32	18 to 38	60 to 80
Groundwater level (feet btoc) [a]	20.80	14.05	20.18
Drawdown (feet)	2	0.85	▪ 33 (at 0.5 gpm) ▪ 23.5 (at 0.25 gpm)
Specific capacity (gpm/foot)	0.25	1.2	0.01 to 0.02

[a] Top of well casings are approximately 2.5 feet above ground at MW-1 and MW-4B and 0.5 feet above ground at MW-3.

btoc = below top of casing

gpm = gallons per minute

gpm/foot = gallons per minute per foot of drawdown

4. Integrated Flow and Water Budget Model

On behalf of Sonoma Water, Jacobs developed the Potter Valley Integrated Flow Model (PVIFM) of a study area encompassing the Basin (Figure 1-1). PVIFM was developed to support the Reliability Study in evaluating potential water management strategies in the Basin. Appendix D documents the objectives, development, and calibration of PVIFM, which was developed leveraging the data collected and evaluated during the field reconnaissance and geophysical investigation work conducted by Jacobs (Jacobs 2023). Details on the field reconnaissance and geophysical investigation are provided in Appendixes A and B, respectively.

4.1 Modeling Objectives and Development Approach

PVIFM modeling objectives are as follows:

- Help to identify and prioritize groundwater data gaps, and reduce uncertainty in groundwater supply in Potter Valley.
- Develop surface water and groundwater budgets for the Basin.
- Support decision making associated with water management in Potter Valley.

To achieve the modeling objectives, PVIFM was developed and calibrated using available data and professional judgment. PVIFM is a three-dimensional model that was constructed and calibrated to simulate monthly stress periods used to represent monthly average surface water and groundwater flow conditions for the time period from October 2010 through September 2022 (that is, WYs 2011 through 2022) in a 94-square-mile study area (domain) encompassing the Basin (Figure 1-1). The following modeling software was used for this effort:

- US Geological Survey (USGS) code MODFLOW-NWT (USGS 2011), which is a Newton formulation for MODFLOW-2005 (USGS 2005)
- Groundwater Vistas version 8, which is a graphical user interface used to help manage input and output files and inspect spatial distributions of parameters of interest (Environmental Simulations Incorporated [ESI] 2020)
- FloPy, which is a Python package used to create, run, and post-process MODFLOW models (Bakker et al. 2016)

The PVIFM domain is subdivided in the horizontal direction into 73,212 cells each with dimensions of 328 feet by 328 feet. The PVIFM domain is subdivided in the vertical direction into three layers that represent different combinations of channel alluvium (24 to 335 feet thick), unconsolidated sediments (3 to 722 feet thick), and bedrock (164 to 4,216 feet thick).

PVIFM is set up to simulate the following processes on a monthly basis:

- Precipitation
- Stream and canal flows
- Canal diversions and deliveries
- Groundwater recharge from precipitation and irrigation
- Groundwater flow
- Runoff
- ET
- Groundwater pumping
- Surface water-groundwater interaction
- Groundwater discharge to land surface

PVIFM was calibrated in accordance with the ASTM International (ASTM) Standard D5981, *Standard Guide for Calibrating a Groundwater Flow Model Application* (ASTM 2018). Calibration is a process of adjusting model input parameters within reasonable ranges to adequately replicate measured groundwater levels, streamflows, deliveries, and estimates of ET over the 12-year simulation period, including WYs 2011 through 2022. Appendix D includes additional details regarding the development and calibration of PVIFM.

4.2 Modeled Water Levels

Figure 4-1 illustrates the modeled water table during March 2013. WY 2013 had an annual rainfall of approximately 41 inches, which is close to the annual average of 43 inches. Additionally, PVID diversions were approximately 19,000 AFY and PVID deliveries were approximately 13,500 AFY in WY 2013.Thus, the modeled water table shown on Figure 4-1 is intended to be representative of typical groundwater conditions. The intent of Figure 4-1 is to illustrate general groundwater flow through the Basin. Given the sharp contrast in groundwater levels between the Basin and the surrounding bedrock area, two contour intervals are shown on Figure 4-1 with a 10-foot contour interval within the Basin where the water table is less steep and a 100-foot contour interval outside of the Basin where the water table is steeper. In general, groundwater flows toward the EFRR (EFRR is a gaining stream), which drains Potter Valley. Groundwater pumping depressions are not noted in the groundwater contours because of the minimal groundwater pumping that has occurred in the Basin. Overall groundwater flow patterns shown on Figure 4-1 are consistent with the conceptual understanding of groundwater flow through the Basin.

4.3 Modeled Water Budgets

Surface water and groundwater budgets were developed based on output from PVIFM to characterize the volumetric rate of water entering and leaving the surface water and groundwater flow systems. This section describes the historical water budgets for Potter Valley for the water budget area shown on Figure 4-2. The Potter Valley water budget area was defined to cover the extents of the Basin and PVID's boundary to account for the areas in which surface water and groundwater are actively managed in Potter Valley.

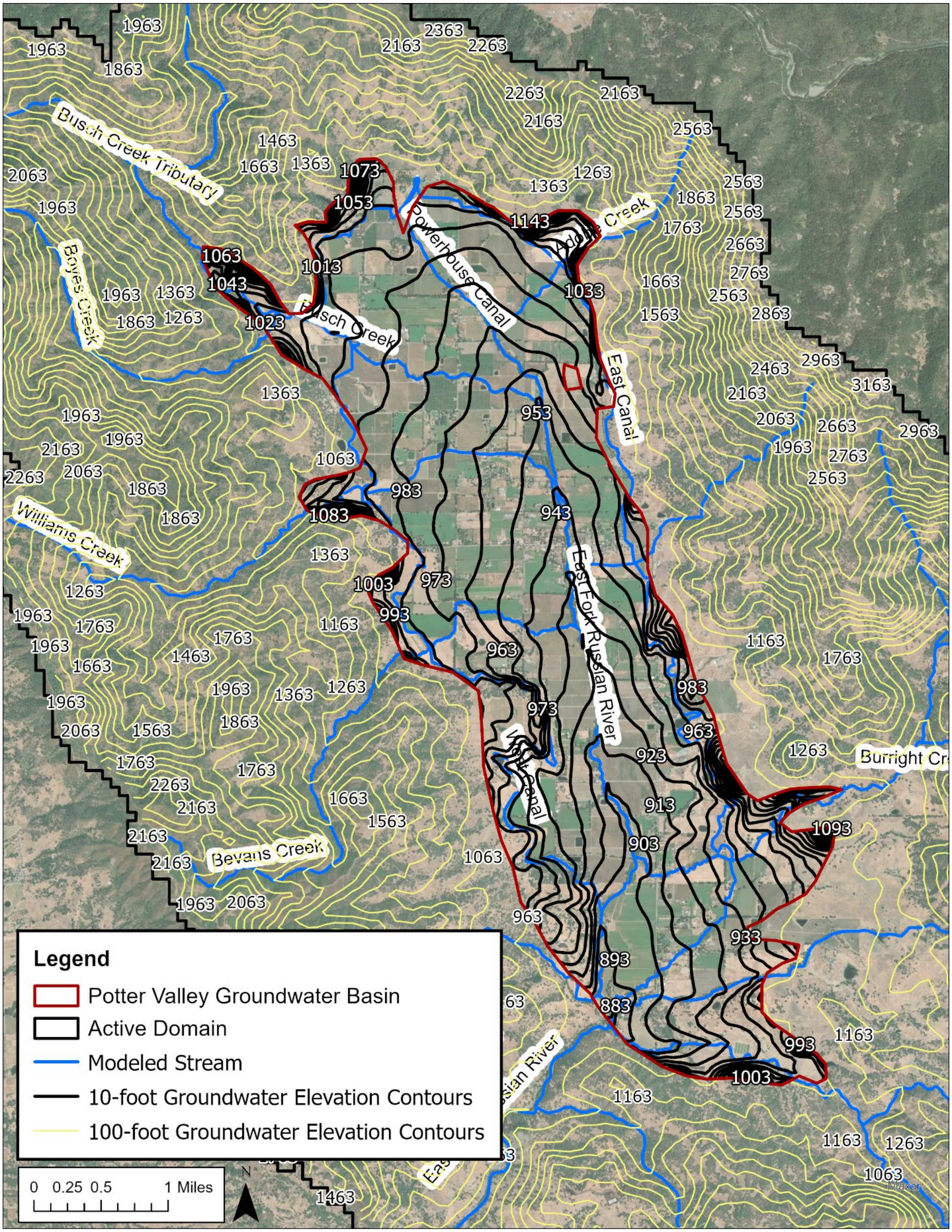


Figure 4-1. Modeled Water Table in March 2013

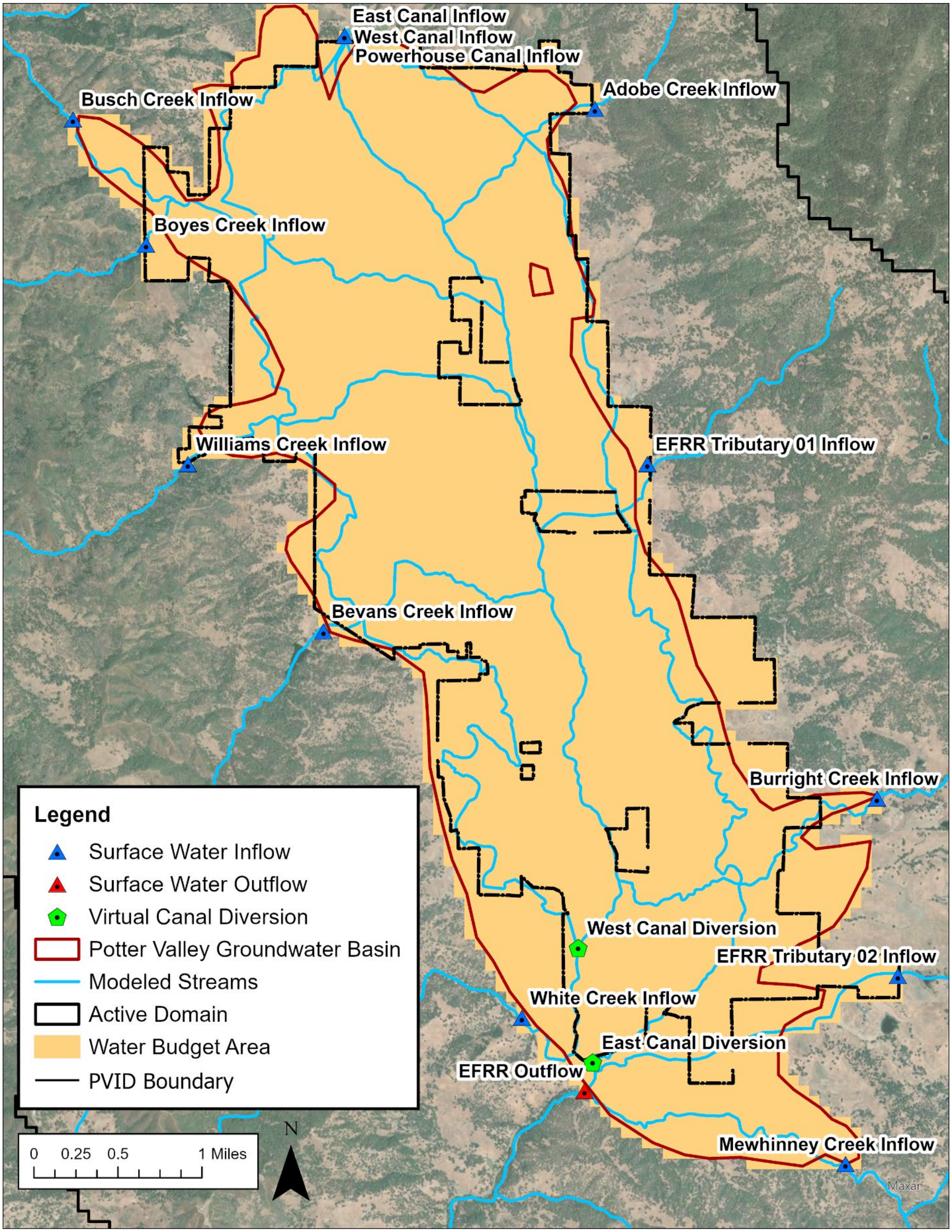


Figure 4-2. Water Budget Area

4.3.1 Surface Water Budget

Table 4-1 presents a summary of the simulated average annual surface water budget for the water budget area shown on Figure 4-2 over the 12-year simulation period. A table including monthly values for the surface water budget is included in Attachment 3 of Appendix D. According to PVIFM, the major surface water inflow to Potter Valley occurs through the Powerhouse Canal (41,102 AFY) and other streams (23,427 AFY), where "Other Streams" represent inflows from tributary creeks other than Busch Creek (Figure 4-2). The next largest surface water inflow term is the East Canal Inflow (8,462 AFY). These three surface water inflow terms make up 80% of the total surface water inflows. The largest surface water outflow term from Potter Valley is the stream outflow to Lake Mendocino at approximately 91,258 AFY (86% of the surface water outflows).

Table 4-1. Summary of Modeled Potter Valley Surface Water Budget

Surface Water Component	Inflow or Outflow	Average Annual Flow Volume (AF) for WYs 2011 through 2022
East Canal Inflow	Inflow	8,462
West Canal Inflow	Inflow	6,438
Powerhouse Canal Inflow	Inflow	41,102
Busch Creek Inflow	Inflow	4,635
Other Streams Inflow	Inflow	23,427
Runoff from Precipitation [a]	Inflow	7,712
Runoff from Applied Water [a]	Inflow	941
Groundwater Discharge to East Canal	Inflow	547
Groundwater Discharge to West Canal	Inflow	599
Groundwater Discharge to Powerhouse Canal	Inflow	358
Groundwater Discharge to EFRR	Inflow	964
Groundwater Discharge to Other Streams	Inflow	1,629
Total Surface Water Inflow	**Inflow**	**96,814**
Stream Outflow to Lake Mendocino	Outflow	91,258
East Canal Diversion	Outflow	4,550
West Canal Diversion	Outflow	5,929
Groundwater Recharge from East Canal	Outflow	640
Groundwater Recharge from West Canal	Outflow	1,306
Groundwater Recharge from Powerhouse Canal	Outflow	633
Groundwater Recharge from EFRR	Outflow	621
Groundwater Recharge from Other Streams	Outflow	888
Total Surface Water Outflow	**Outflow**	**105,825**

[a] PVIFM outputs a single monthly runoff term that represents runoff from all potential sources. To differentiate between runoff from precipitation and runoff from applied water, the lumped runoff term was summed for October through May months to represent runoff from precipitation, and for June through September months to represent runoff from applied water.

Notes: Values are representative of the water budget area shown on Figure 4-2.

4.3.2 Groundwater Budget

Table 4-2 presents a summary of the simulated average annual groundwater budget for the water budget area shown on Figure 4-2 over the 12-year simulation period. A table including monthly values for the groundwater budget is included in Attachment 4 of Appendix D. According to PVIFM, the major groundwater inflows to the Basin are the groundwater recharge from precipitation (18,187 AFY) and groundwater recharge from applied water (8,157 AFY). The groundwater recharge term simulated in PVIFM is a lumped term and does not explicitly simulate groundwater recharge attributed to different sources of water (for example, precipitation versus applied water). Thus, these separate values have been reported by summarizing the monthly lumped groundwater recharge term across different months of the year, assuming that there is a specific seasonality to rainfall and application of water for irrigation purposes. These two groundwater inflow terms make up 80% of the total groundwater inflows. The largest groundwater outflow term from the Basin is shallow groundwater ET (23,690 AFY). The next largest groundwater outflow is groundwater discharge to land surface (2,765 AFY) and is nearly an order-of-magnitude less than shallow groundwater ET. These two groundwater outflow terms make up 80% of the total groundwater outflows.

Table 4-2. Summary of Modeled Potter Valley Groundwater Budget

Groundwater Component	Inflow or Outflow	Average Annual Flow (AF) WYs 2011 through 2022
Groundwater Recharge from Precipitation [a]	Inflow	18,187
Groundwater Recharge from Applied Water [a]	Inflow	8,157
Groundwater Recharge from East Canal	Inflow	640
Groundwater Recharge from West Canal	Inflow	1,306
Groundwater Recharge from Powerhouse Canal	Inflow	633
Groundwater Recharge from EFRR	Inflow	621
Groundwater Recharge from Other Streams	Inflow	888
Subsurface Inflow from Surrounding Areas	Inflow	2,526
Total Groundwater Inflow	**Inflow**	**32,958**
Shallow Groundwater ET	Outflow	23,690
Domestic Pumping	Outflow	2,158
Agricultural Pumping	Outflow	0
Groundwater Discharge to East Canal	Outflow	547
Groundwater Discharge to West Canal	Outflow	599
Groundwater Discharge to Powerhouse Canal	Outflow	358
Groundwater Discharge to EFRR	Outflow	964
Groundwater Discharge to Other Streams	Outflow	1,629
Groundwater Discharge to Land Surface	Outflow	2,765
Subsurface Outflow to Surrounding Areas	Outflow	353
Total Groundwater Outflow	**Outflow**	**33,063**
Change in Groundwater Storage		-105

[a] PVIFM outputs a single monthly groundwater recharge term that represents recharge from all potential sources. To differentiate between recharge from precipitation and recharge from applied water, the lumped recharge term was summed for October through May months to represent recharge from precipitation, and for June through September months to represent recharge from applied water.

Notes: Values are representative of the water budget area shown on Figure 4-2.

An average change in groundwater storage of -105 AFY indicates a slight reduction (deficit) in overall groundwater storage over the 12-year simulation period. Most of this reduction in groundwater storage is attributed to the last 2 to 3 years of the simulation period, which were drier years. Thus, this magnitude of deficit in groundwater storage is not alarming given the reduction in precipitation near the end of the simulation period. For context, a deficit of 105 AFY represents 0.3% of the total groundwater inflows and outflows. Additional assessment of longer-term groundwater storage trends would require groundwater-level measurements over longer timeframes.

5. Water Management Alternatives

This section provides a comprehensive overview of the various strategies evaluated to increase the reliability of water supply in Potter Valley. These alternatives encompass a range of approaches, including surface storage solutions, conjunctive use practices, operational improvements, and demand management techniques. This section also details the evaluation process undertaken to assess each alternative, offering insights to help inform water management decisions. In addition, it outlines the methodology used to develop cost estimates for each alternative for a thorough understanding of the financial implications involved.

5.1 Alternative Options

5.1.1 Surface Storage Alternatives

This section explores various strategies for enhancing water storage capacity through different types of surface storage solutions. It delves into options (such as tributary storage, which involves capturing and storing water from smaller streams in the Potter Valley); lower valley on-stream storage, which focuses on creating a small reservoir along the EFRR in the southern end of the valley; and in-valley pond storage, which entails constructing ponds within the valley to store water. Each alternative is examined in detail, providing insights into their potential benefits, challenges, and suitability for increasing Potter Valley’s reliability of water supply.

5.1.1.1 Tributary Storage

Opportunities for surface storage in Potter Valley were evaluated to identify potential for and benefits of developing dams in local watersheds. Seven watersheds with notable storage capacity, as shown on Figure 5-1, were selected for evaluation by analyzing 1-meter resolution elevation data in GIS. The elevation data were compiled based on available 1-meter light detection and ranging data accessed through The National Map Viewer from the USGS (USGS 2022b). These include the three watersheds previously evaluated in the McMillen Jacobs Associates (2021) investigation (in the steep, unnamed valley immediately east of the existing powerhouse, Boyes Creek watershed, and Busch Creek watershed), plus four additional watersheds more south and east. Figure 5-2, shows the storage potential for all watersheds, with the largest three indicated by the black circles at 100-, 150-, and 200-foot dam heights that were screened for further evaluation.

The three selected watersheds (Busch, Williams/Hawn, and Mewhinney Creek) were further examined for technical complexity in connecting to the Potter Valley supply system consisting of a network of irrigation canals. Table 5-1 summarizes the dam length, storage volume, and inundation area for dam heights ranging from 100 to 200 feet. In addition, the distance to the powerhouse and estimated annual natural runoff for each watershed are provided. Based on these characteristics, Busch Creek was identified as the most beneficial option with the least technical complexity, offering sufficient storage capacity and the shortest distance to the powerhouse. This option was selected for further evaluation (Section 5.2). Williams/Hawn Creek, while not much farther from the powerhouse, has lower storage capacity potential. Mewhinney Creek, despite having adequate storage capacity and the highest estimated runoff, is significantly farther from the powerhouse and would require a pump-back system, adding considerable costs to the project. A key challenge identified would be the financial and logistical aspects of constructing and maintaining the necessary infrastructure, which must be considered carefully to ensure the long-term viability of a large dam solution.

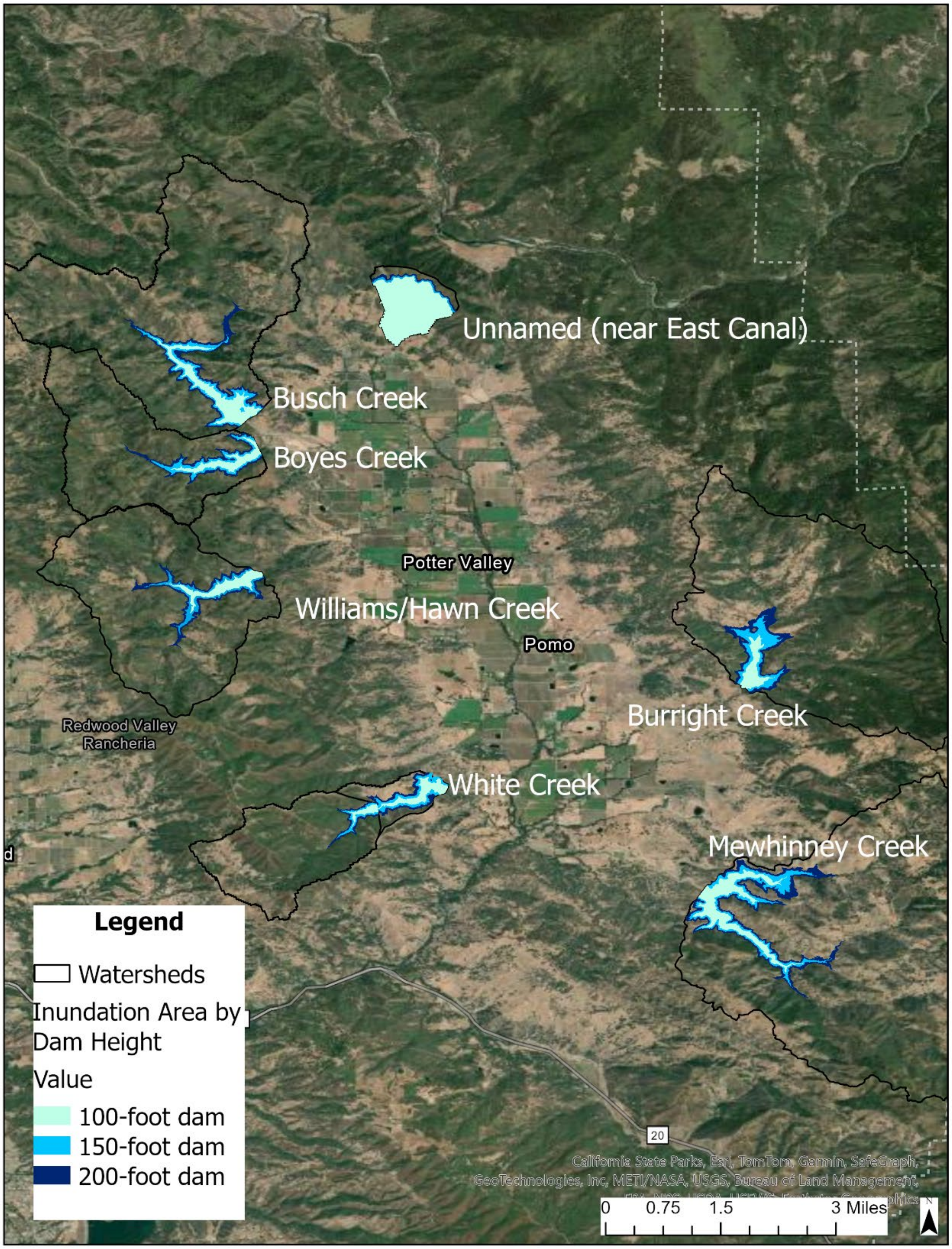


Figure 5-1. Tributary Storage Locations Evaluated

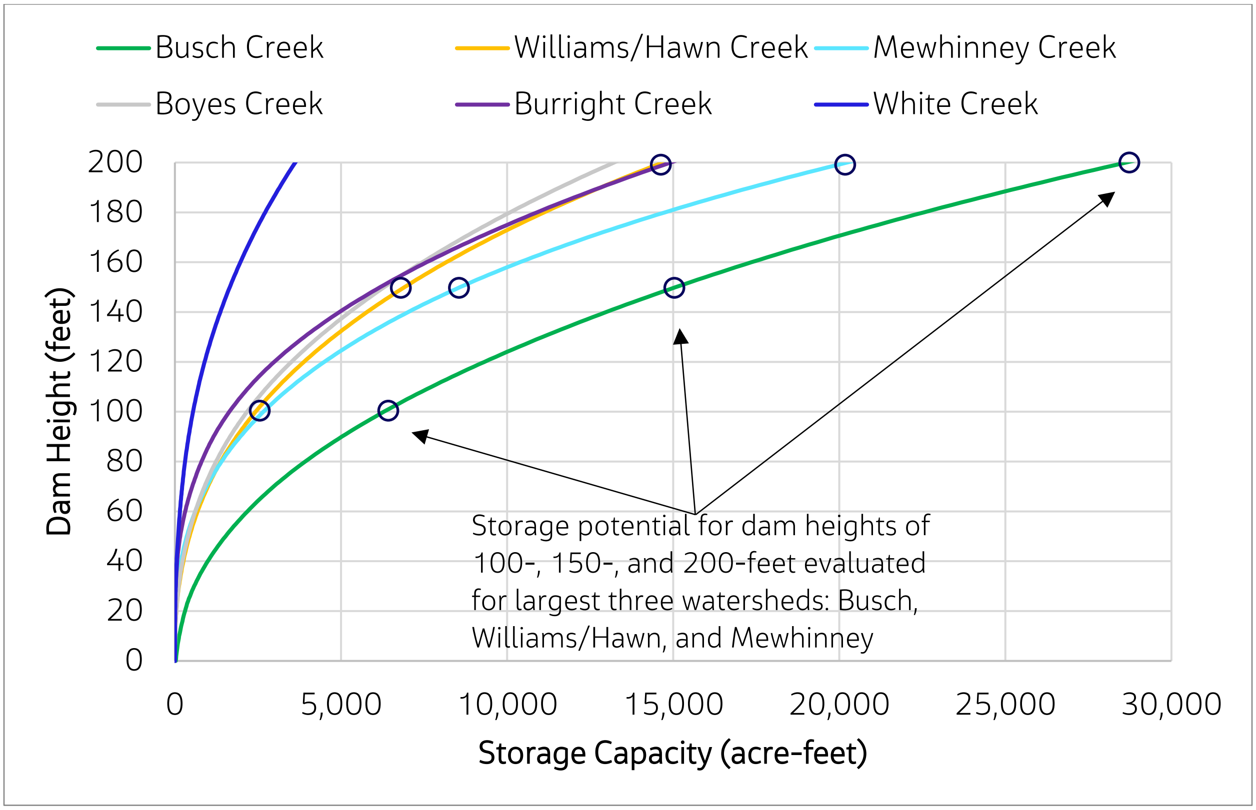


Figure 5-2. Storage Capacity by Dam Height for Each Watershed

Table 5-1. Tributary Storage Options Characteristics

Name	Dam Height (feet)	Dam Length (feet)	Storage Capacity (AF)	Inundation Area (acres)	Distance to Powerhouse (miles)	Natural Runoff (AFY) [a]
Busch	100 to 200	1,400 to 2,100	4,900 to 25,200	117 to 302	1.6	6,100
Williams/Hawn	100 to 200	850 to 1,500	2,400 to 14,700	62 to 195	1.7	5,400
Mewhinney [b]	100 to 200	800 to 2,200	2,700 to 20,200	76 to 304	7.7	10,900

[a] 1910 to 2022 average based on PVIFM model results

[b] Requires a pump-back system and saddle dam

Each of these watersheds were simulated using Sonoma Water's GoldSim Decision Support Model to evaluate their potential for enhancing water supply reliability in Potter Valley. Three scenarios were considered: full decommissioning of the PVP, where reservoirs would be filled only with local runoff; a scenario with the NERF that would fill reservoirs solely with imported Eel River supply; and another NERF scenario that would fill reservoirs with both local runoff and Eel River supply. Each simulation utilized historical hydrologic conditions between 1911 and 2022 and annual water supply demands on the order of 6,000 acre-feet in Potter Valley typically occurring between March through October each year.

In the PVP Decommission scenario, it was found that filling reservoirs with only local runoff could fully mitigate supply deficiencies in wetter years but would offer limited reliability during years with drier conditions. Specifically, shortages were mitigated in approximately 20%, 41%, and 88% of the simulated years for the Williams/Hawn, Busch, and Mewhinney Creek watersheds, respectively, with a 200-foot high dam. When shortages did occur, they ranged from approximately 100 to 8,000 acre-feet in the Williams/Hawn Creek watershed storage scenario, 190 to 8,100 acre-feet in Busch Creek watershed storage scenario, and 150 acre-feet to 4,800 acre-feet in Mewhinney Creek watershed storage scenario.

In both scenarios with the NERF implemented, all shortages were fully mitigated regardless of local hydrologic conditions.

The Busch Creek watershed option with the 150-foot dam height and the assumption that NERF would also be implemented was carried forward into the evaluation described in Section 5.2.

5.1.1.2 Lower Valley On-Stream Storage

The exploration of lower valley on-stream storage alternative aimed to identify potential for and benefits of developing a dam on-stream rather than a tributary. A key benefit would be the requirement of a smaller dam on the order of 20 to 40 feet, potentially leading to lower construction and maintenance costs than a 100- to 200-foot dam. In addition, it provides the ability to capture local runoff and/or Eel River imports through the EFRR without the need to develop conveyance to or from a tributary watershed. A site was first identified in the lower valley with sufficiently high valley walls to support the 20- to 40-foot dam. One-meter resolution elevation data (USGS 2022b) were then processed to determine the inundation areas for 20-, 30-, and 40-foot dam heights at this location. The selected dam site and corresponding inundation area for each dam height are illustrated on Figure 5-3.

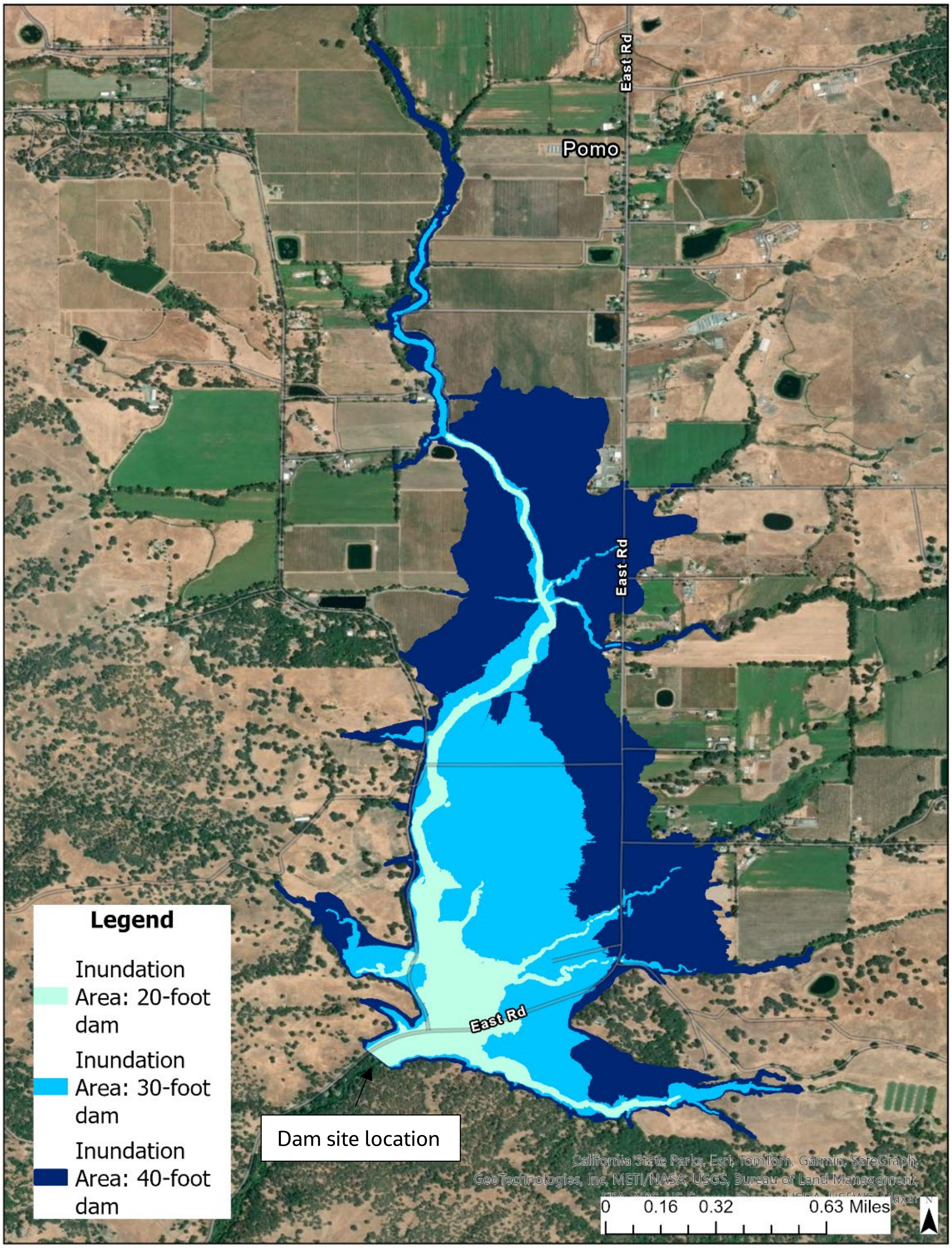


Figure 5-3. Inundation Areas for Lower Valley On-stream Storage for 20-, 30-, and 40-foot Dam Heights

The reservoirs for the three dam heights were further assessed for their technical complexity in connecting to the Potter Valley supply system. Table 5-2 summarizes the dam length, potential storage volume, and inundation area for each dam height option. In addition, the distance to the powerhouse is provided to estimate the length of pipeline required to connect to the PVID system. Based on these characteristics, the 30- and 40-foot dam options were selected for further evaluation because the 20-foot option did not offer sufficient storage capacity. The challenge with these options is the need for a more expensive pump-back system, which Busch Creek tributary storage does not require. In addition, they would inundate part of Eastside Potter Valley Road, as well as part of the lower valley, necessitating relocation. Furthermore, the resulting water body would be shallower, leading to higher evaporation rates and potential water quality issues.

Table 5-2. Lower Valley On-Stream Storage Options Characteristics

Dam Height (feet)	Dam Length (feet)	Storage Capacity (AF)	Inundation Area (acres)	Distance to Powerhouse (miles)
20	360	620	62	6.5
30	420	5,600	280	6.5
40	480	19,300	640	6.5

The 30- and 40-foot options were simulated using Sonoma Water's Goldsim Decision Support Model to evaluate their potential for enhancing water supply reliability in Potter Valley. Two scenarios were considered: full decommissioning of the PVP, where the reservoir would only be filled with local runoff to the EFRR, and a scenario with the NERF that would fill the reservoir with Eel River as well.

In the PVP Decommission scenario, it was found that the 30-foot dam option in the lower valley on-stream reservoir could mitigate approximately half or more of the estimated supply deficiencies simulated without the reservoir. In this scenario, shortages still occurred every year of the simulation but were generally halved in comparison to the PVP Decommission scenario without the dam option implemented. The 40-foot dam option resulted in no shortages in all years, providing sufficient storage to fill during the winter and meet the spring to early fall irrigation demands. In the scenario with NERF, all shortages were fully mitigated with both 30- and 40-foot dam options which were able to store a sufficient volume of imported Eel River supply in the wet season to meet summer irrigation demands. The option with NERF implemented was decided to be carried forward into the evaluation process described in Section 5.2.

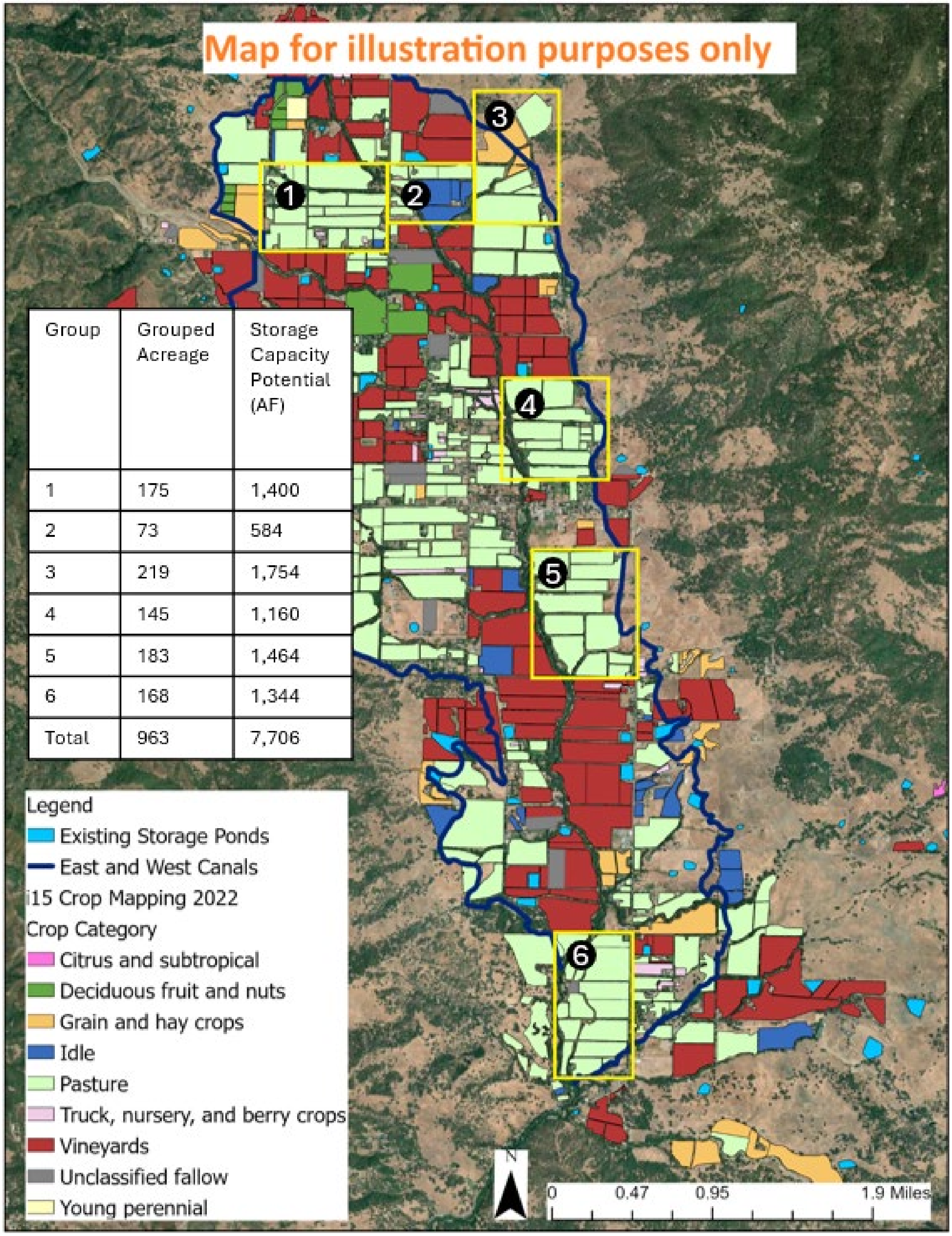
5.1.1.3 In-Valley Pond Storage

The evaluation of in-valley pond storage aimed to identify the potential for, and benefits of, using 10-foot berms to develop ponds in Potter Valley. These ponds would store water from the Eel River imported during wet seasons, making it available for irrigation during the spring to early fall irrigation season. Smaller ponds with berm heights lower than the dam options provide additional investment flexibility, as additional ponds could be constructed and phased over time. In addition, if ponds are co-located close to the canal system, conveyance costs would be less than the options that require miles of pipeline. Furthermore, environmental impacts would be less than the tributary storage options in the watersheds.

The evaluation began by collecting crop data to identify large areas of fallowed, idle, hay, and pasture lands that could be converted to at least 5,000 AF of pond storage. Assuming a berm height of 10 feet filled to 8 feet with water, meeting a 5,000-AF storage target would require 625 acres of pond area. This would expand current pond storage by five times because the ponds currently amount to approximately 125 acres.

Two potential pond configuration options were identified: smaller, dispersed ponds throughout the valley, or larger, centralized ponds. Based on the crop type analysis, the valley has sufficient area to develop either dispersed or centralized ponds on areas with the crop types mentioned herein. An example of the dispersed ponds is shown on Figure 5-4. For the centralized pond configuration, a slight expansion of groups one through three could provide sufficient storage. These groups are closest to the powerhouse and canal system and would require the least conveyance infrastructure.

The primary challenges of this alternative include limited topographic relief, which may cause hydraulic constraints when conveying water to and from the ponds. In addition, it requires repurposing some farmland. Furthermore, the shallower ponds result in higher evaporation rates and a greater potential for water quality issues. Successful implementation of pond storage is dependent on the scenario in which NERF transfers are available to fill the ponds seasonally.



Group	Grouped Acreage	Storage Capacity Potential (AF)
1	175	1,400
2	73	584
3	219	1,754
4	145	1,160
5	183	1,464
6	168	1,344
Total	963	7,706

Figure 5-4. Crop Types and Potential In-Valley Storage Pond Sites

5.1.2 Conjunctive Use Alternatives

This section explores various strategies for enhancing water supply in Potter Valley through alternatives intended to actively manage surface water and groundwater resources, herein referred to as conjunctive use alternatives. Conjunctive use alternatives, include pumping groundwater from the Basin to supplement surface water supplies, herein referred to as supplemental groundwater pumping, managed aquifer recharge (MAR) by enhancing streambed recharge and flooding pasture fields, and aquifer storage and recovery (ASR) strategies using injection wells. MAR and ASR alternatives involve using Eel River surface water imports to increase groundwater storage in the Basin when supply is available. Each alternative is examined in detail, providing insights into their potential benefits, challenges, and suitability for increasing reliability of Potter Valley's water supply.

5.1.2.1 Supplemental Groundwater Pumping

Potential benefits and limitations of supplemental groundwater pumping were evaluated under the condition that PVP is fully decommissioned in the future, herein referred to as No PVP conditions. Evaluating a No PVP conditions helped assess how groundwater levels in the Basin could respond to no imports of surface water from the Eel River, to evaluate potential groundwater pumping yields, and evaluate the impact of groundwater pumping on the Basin's groundwater levels.

PVIFM was configured to assess potential groundwater pumping yields, assuming supplemental pumping wells were operated throughout the Basin. For this assessment, 124 hypothetical supplemental pumping wells were simulated in PVIFM with wells spaced approximately every one-quarter to one-third of a mile. Supplemental pumping wells were assumed to be screened within alluvial material with well depths ranging from 85 to 100 feet bgs.

Figure 5-5 shows the locations of the hypothetical 124 supplemental pumping wells simulated in PVIFM. Each supplemental pumping well was assumed to be operated 24 hours per day during June through September when agricultural water use demands are highest. The supplemental pumping well configuration shown in Figure 5-5 is meant to serve as a hypothetical test case to evaluate the extent to which groundwater could be utilized as a source of supply in Potter Valley. Wells would be sited according to favorable hydrogeologic conditions, proximity to existing conveyance infrastructure and places of use, and other considerations regarding access and well ownership. A constructed well field may include fewer wells and would likely not be placed uniformly throughout Potter Valley as the hypothetical supplemental pumping configuration simulated in PVIFM suggests.

The PVIFM simulation representing No PVP conditions with 124 supplemental pumping wells resulted in an annual average groundwater pumping yield of approximately 3,500 AF over the simulation period from WYs 2010 through 2022. This volume represents about 30% of the entire annual average PVID deliveries during the simulation period. Individual well yields ranged from 0 to 264 gpm across the valley, with a basin-wide average of 53 gpm (Figure 5-5). Within PVIFM, well yields were constrained to a rate of 300 gpm; however, modeled pumping rates are determined during the simulation based on hydrogeologic conditions at each well and the well's ability to pump groundwater. Thus, if groundwater levels within a pumping well drop below the screening interval, the well pumping rate is reduced to reflect rates that the well was able to simulate. Because of the limited characterization of subsurface basin materials, substantial uncertainty remains in groundwater pumping yields that may be sustainable from future agricultural wells. For reference, the DWR Bulletin 118 description indicates that typical well yields across the Basin range from 50 to 75 gpm, with a maximum of approximately 100 gpm (DWR 2004). PVIFM groundwater pumping rates, on average, appear plausible; however, additional investigations are needed to determine if agricultural production wells could sustain favorable pumping rates.

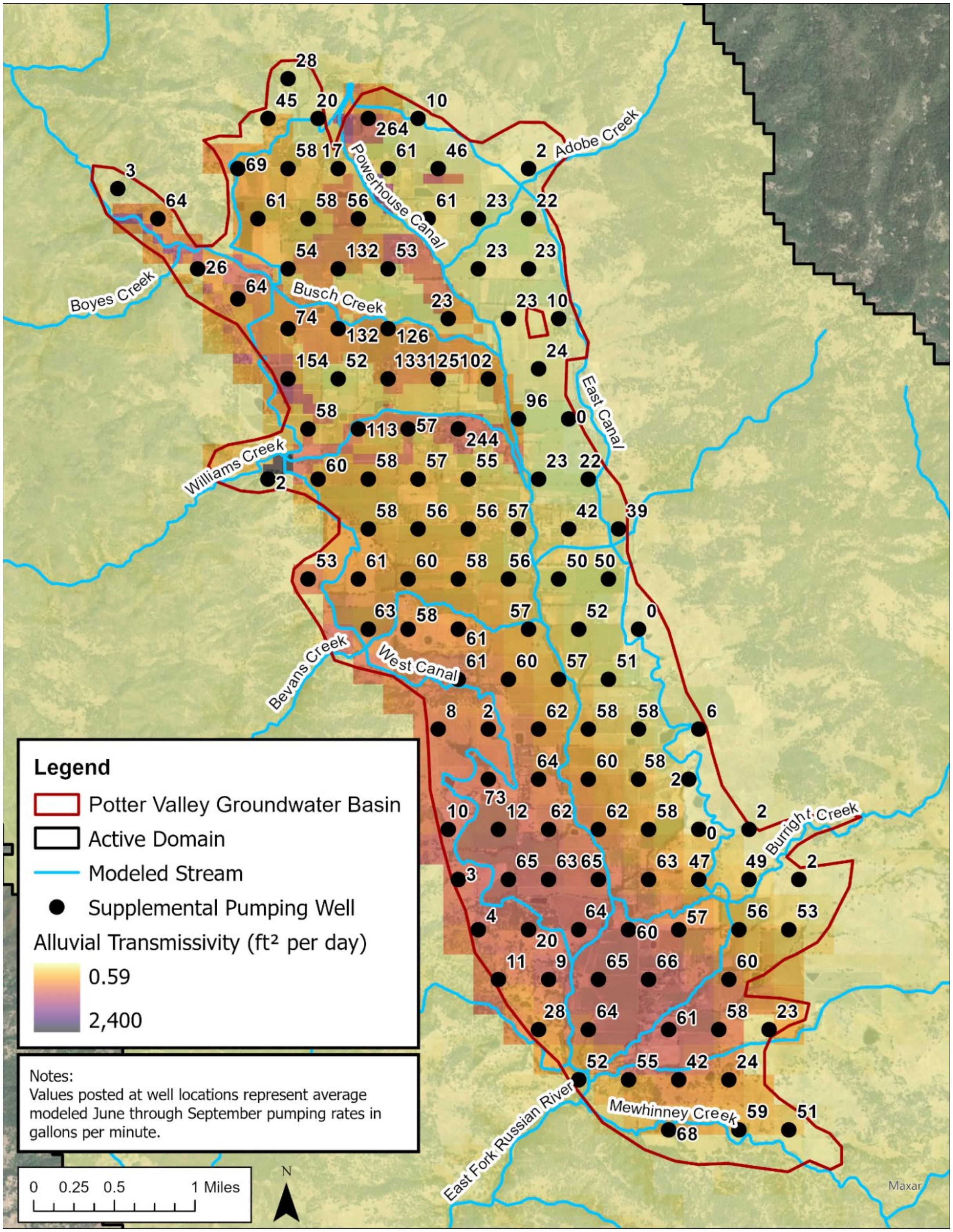


Figure 5-5. Simulated Supplemental Groundwater Pumping Configuration

To evaluate the influence of No PVP conditions and supplemental groundwater pumping on groundwater-level conditions, these simulations were compared to the calibrated version of PVIFM, herein referred to as Baseline. Figure 5-6 shows average basin depth to water for the Baseline, No PVP, and No PVP with 124 supplemental pumping well simulations. Simulated basin average depth to water typically ranged from 5 to 10 feet lower than No PVP conditions with the addition of supplemental pumping wells, and up to 40 feet lower than Baseline conditions in areas near agricultural pumping. Potential impacts on existing domestic well users due to the seasonal reduction in groundwater levels caused by supplemental groundwater pumping should be further evaluated. In addition, uncertainty regarding the magnitude of drawdown associated with supplemental pumping wells and the resulting extent of water level lowering throughout the valley warrants further evaluation.

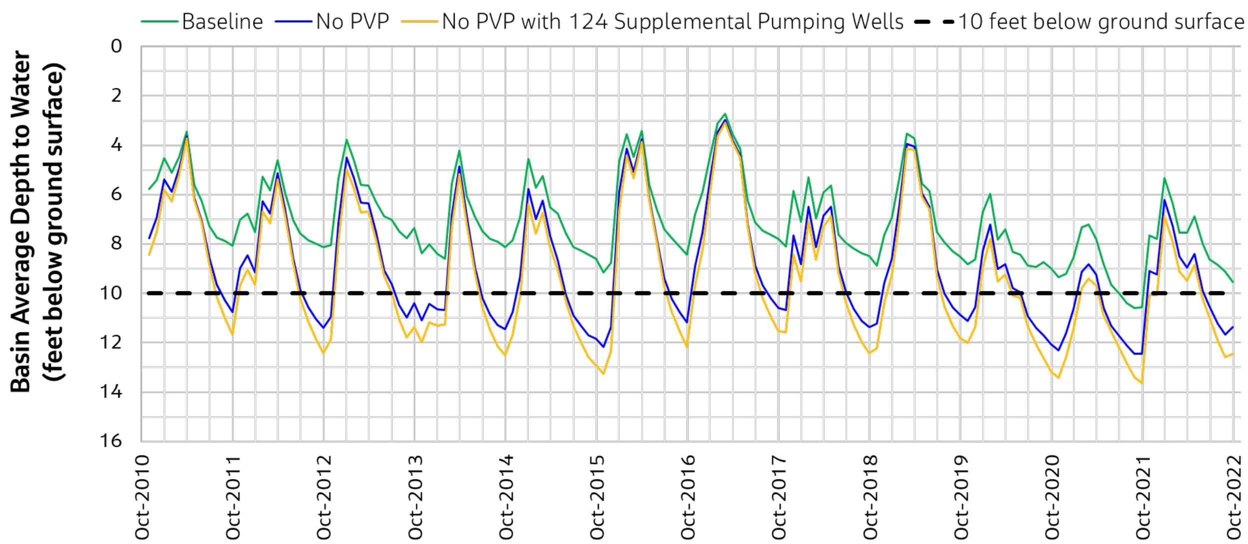


Figure 5-6. Simulated Basin Average Depth to Water for Baseline, No Potter Valley Project, and No Potter Valley Project with 124 Supplemental Pumping Wells Scenarios

Table 5-3 presents a comparison of the simulated average annual surface water budget for Baseline, No PVP, and No PVP with 124 Supplemental Pumping Wells for the water budget area shown on Figure 4-2. The largest changes in the surface water budget occur when imported water from the Eel River stops under No PVP conditions and the East Canal, West Canal, and Powerhouse Canal area assumed to no longer receive water from the Eel River. As a result, the total surface water inflows and outflows are reduced by approximately 61,000 AFY under No PVP conditions as compared to Baseline conditions. An additional reduction of approximately 700 AFY in total surface water inflows and outflows occurs under No PVP with 124 supplemental pumping wells operating. This happens from reductions in runoff from precipitation (480 AFY reduction) and groundwater discharge to streams and canals (230 AFY reduction). The reduction in runoff from precipitation occurs due to increased recharge during winter months from larger reductions in groundwater levels from supplemental pumping. Similarly, less discharge to streams and canals occurs due to lower groundwater levels from supplemental groundwater pumping.

Table 5-3. Summary of Average Annual Flow for Water Years 2011 through 2022 from the Simulated Potter Valley Surface Water Budget

Surface Water Component	Inflow or Outflow	Baseline (AF)	No PVP (AF)	No PVP with 124 Supplemental Pumping Wells (AF)	Supplemental Pumping Change from Baseline (AF)	Supplemental Pumping Change from No PVP (AF)
East Canal Inflow	Inflow	8,462	0	0	-8,462	0
West Canal Inflow	Inflow	6,438	0	0	-6,438	0
Powerhouse Canal Inflow	Inflow	41,102	0	0	-41,102	0
Busch Creek Inflow	Inflow	4,635	4,635	4,628	-7	-7
Other Streams Inflow	Inflow	23,427	23,225	23,196	-231	-29
Runoff from Precipitation [a]	Inflow	7,712	5,265	4,785	-2,927	-480
Runoff from Applied Water [a]	Inflow	941	136	120	-821	-16
Groundwater Discharge to East Canal	Inflow	547	356	349	-198	-7
Groundwater Discharge to West Canal	Inflow	599	250	208	-391	-42
Groundwater Discharge to Powerhouse Canal	Inflow	358	81	67	-291	-14
Groundwater Discharge to EFRR	Inflow	964	690	626	-338	-64
Groundwater Discharge to Other Streams	Inflow	1,629	1,419	1,314	-315	-105
Total Surface Water Inflow	**Inflow**	**96,814**	**36,057**	**35,293**	**-61,520**	**-764**
Stream Outflow to Lake Mendocino	Outflow	91,258	43,459	42,631	-48,627	-828
East Canal Diversion	Outflow	4,550	23	22	-4,528	-1
West Canal Diversion	Outflow	5,929	27	24	-5,905	-3
Groundwater Recharge from East Canal	Outflow	640	197	205	-435	8
Groundwater Recharge from West Canal	Outflow	1,306	228	202	-1,104	-26
Groundwater Recharge from Powerhouse Canal	Outflow	633	34	36	-597	2
Groundwater Recharge from EFRR	Outflow	621	215	236	-385	21
Groundwater Recharge from Other Streams	Outflow	888	1,050	1,154	266	104
Total Surface Water Outflow	**Outflow**	**105,825**	**45,233**	**44,510**	**-61,315**	**-723**

[a] PVIFM outputs a single monthly runoff term that represents runoff from all potential sources. To differentiate between runoff from precipitation and runoff from applied water, the lumped runoff term was summed for October through May months to represent runoff from precipitation, and for June through September months to represent runoff from applied water.

Note: Values are representative of the water budget area shown on Figure 4-2.

Table 5-4 presents a comparison of the simulated average annual groundwater budget for Baseline, No PVP, and No PVP with 124 supplemental pumping wells for the water budget area shown on Figure 4-2. When comparing the 124 supplemental pumping well scenario to Baseline and No PVP conditions, the largest change in the groundwater inflow terms is the groundwater recharge from applied water. Compared to Baseline, groundwater recharge from applied water decreases by approximately 6,400 AFY due to the loss of Eel River imports. Supplemental groundwater pumping is only able to replace approximately 30% of historical annual PVID deliveries; therefore, any loss to groundwater associated with agricultural water use is reduced substantially. Groundwater recharge from applied water increased by approximately 1,000 AFY as compared to No PVP conditions due to losses associated with the use of water supplied by supplemental pumping wells.

When comparing the 124 supplemental pumping wells scenario to Baseline and No PVP conditions, the largest change in the groundwater outflow terms is the shallow groundwater ET term. As compared to Baseline, shallow groundwater ET is reduced by approximately 9,600 AFY under the 124 supplemental pumping well condition. The change in shallow groundwater ET results from the overall reduction in groundwater levels in the Basin resulting from No PVP and the additional of supplemental groundwater pumping. Most of the reduction in shallow groundwater ET occurs when the imports of surface water from the Eel River cease. Additional lowering of shallow groundwater ET occurs with supplemental groundwater pumping due to increased lowering of groundwater levels (Figure 5-6). In addition, total groundwater inflow and outflows are reduced overall under the No PVP and No PVP with 124 supplemental pumping wells as compared to Baseline conditions.

In general, uncertainty remains regarding aquifer properties, groundwater quality, and potential supplemental groundwater pumping yields from future agricultural production wells across Potter Valley. Collection and analysis of these additional data will be necessary to evaluate potential supplemental pumping well yields and to further refine aquifer properties in PVIFM to support planning efforts and decisions around future water management strategies. Recommendations to address these uncertainties are provided in Section 6.

Table 5-4. Summary of Average Annual Flow for Water Years 2011 through 2022 from the Simulated Potter Valley Groundwater Budget

Groundwater Component	Inflow or Outflow	Baseline (AF)	No PVP (AF)	No PVP with 124 Supplemental Pumping Wells (AF)	Supplemental Pumping Change from Baseline (AF)	Supplemental Pumping Change from No PVP (AF)
Groundwater Recharge from Precipitation [a]	Inflow	18,187	17,484	17,829	-358	345
Groundwater Recharge from Applied Water [a]	Inflow	8,157	615	1,759	-6,398	1,144
Groundwater Recharge from East Canal	Inflow	640	197	205	-435	8
Groundwater Recharge from West Canal	Inflow	1,306	228	202	-1,104	-26
Groundwater Recharge from Powerhouse Canal	Inflow	633	34	36	-597	2
Groundwater Recharge from EFRR	Inflow	621	215	236	-385	21
Groundwater Recharge from Other Streams	Inflow	888	1,050	1,154	266	104
Subsurface Inflow from Surrounding Areas	Inflow	2,526	2,565	2,580	54	15
Total Groundwater Inflow	**Inflow**	**32,958**	**22,388**	**24,001**	**-8,957**	**1,613**
Shallow Groundwater ET	Outflow	23,690	15,591	14,111	-9,579	-1,480
Domestic Pumping	Outflow	2,158	2,157	2,157	-1	0
Agricultural Pumping	Outflow	0	0	3,502	3,502	3,502
Groundwater Discharge to East Canal	Outflow	547	356	349	-198	-7
Groundwater Discharge to West Canal	Outflow	599	250	208	-391	-42
Groundwater Discharge to Powerhouse Canal	Outflow	358	81	67	-291	-14
Groundwater Discharge to EFRR	Outflow	964	690	626	-338	-64
Groundwater Discharge to Other Streams	Outflow	1,629	1,419	1,314	-315	-105
Groundwater Discharge to Land Surface	Outflow	2,765	1,580	1,435	-1,330	-145
Subsurface Outflow to Surrounding Areas	Outflow	353	313	311	-42	-2
Total Groundwater Outflow	**Outflow**	**33,063**	**22,437**	**24,080**	**-8,983**	**1,643**
Change in Groundwater Storage		-105	-49	-79	26	-30

[a] PVIFM outputs a single monthly groundwater recharge term that represents recharge from all potential sources. To differentiate between recharge from precipitation and recharge from applied water, the lumped recharge term was summed for October through May months to represent recharge from precipitation, and for June through September months to represent recharge from applied water.

Notes: Values are representative of the water budget area shown on Figure 4-2.

5.1.2.2 Managed Aquifer Recharge and Aquifer Storage and Recovery

For evaluation of MAR and ASR alternatives, the Basin conditions were evaluated assuming Potter Valley receives imports of water from the Eel River under the run-of-river flow regime. With run-of-river operations, diversions would occur only when Eel River flows meet defined thresholds for fish passage. As a result, the magnitude and timing of diversions are uncertain, with water transfers likely only occurring when flow thresholds are met during the wet season and ceasing during the dry season. Given the timing of available run-of-river flows, these flows would need to be managed conjunctively with groundwater due to agricultural demands peaking in summer months, which is misaligned in time with the availability of run-of-river flows. This evaluation used PVIFM simulations to project how much imported run-of-river water could increase groundwater storage when surface water is available, while using supplemental groundwater pumping to meet agricultural water use demands in Potter Valley.

Two approaches were explored for MAR using run-of-river supplies:

1. **Releasing run-of-river flows into Busch Creek**: This alternative aimed to increase streambed recharge along Busch Creek by supplementing streamflow with run-of-river water.
2. **Delivering run-of-river flows to flood pasture areas**: This alternative involved flooding pasture areas within the Basin with run-of-river water.

For ASR, the evaluation assumed direct injection of run-of-river water into 21 injection wells in the northwest portion of the Basin. MAR and ASR approaches also include supplemental groundwater pumping using the same 124 supplemental well configuration operated June through September, as described herein. Figure 5-7 shows a map of the 124 supplemental pumping wells, as well as the locations of Busch Creek, pasture fields, and injection wells assumed in the MAR and ASR simulations.

The PVIFM simulations indicate that these MAR and ASR alternatives would likely not be beneficial in Potter Valley. The primary reason is because the Basin's groundwater levels typically rebound each spring from groundwater recharge of precipitation (Figure 5-6). Consequently, the available capacity to recharge run-of-river supplies during the winter through spring seasons would likely be limited. Thus, these scenarios were not carried forward into the evaluation process described in Section 5.2.

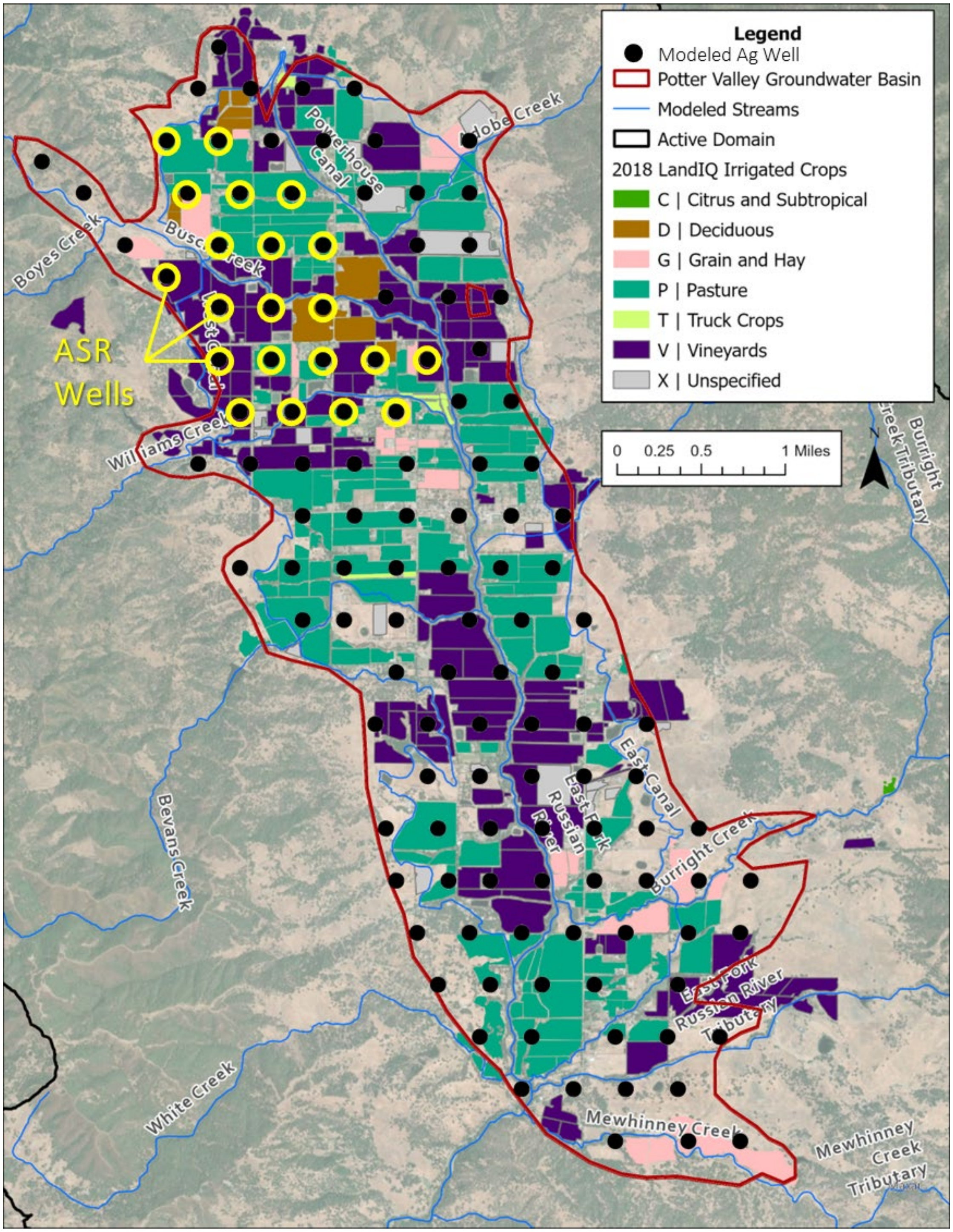


Figure 5-7. Simulated Pumping Configuration for Managed Aquifer Recharge and Aquifer Storage and Recovery Scenarios

5.1.3 Operational Improvements and Demand Management Alternatives

This section examines various strategies for enhancing water management through operational improvements and demand management solutions. It covers options, such as irrigation delivery system improvements, on-farm system efficiency improvements, and the development of a Lake Mendocino pump-back system. Each alternative is examined in detail, providing insights into their potential benefits, challenges, and suitability for increasing Potter Valley's reliability of water supply.

5.1.3.1 Irrigation Delivery System Improvements

Opportunities for improving efficiencies and reducing water losses through the irrigation delivery system were identified and evaluated for the following solutions:

- **Minimize system water losses**: Losses through PVID's canal system primarily occur from the following:
  - Infiltration into the ground (up to 22% of demand)
  - Evaporation into the atmosphere (approximately 5% of demand)
  - Excess "carrier water" bypassing farms and continuing on to the EFRR (volume lost currently unknown)
- Piping, fluid-applied geomembrane, concrete lining, exposed geomembrane, and/or concrete with geomembrane underliner are possible options to minimize these losses (McMillen Jacobs 2021).
- **Modernize canal operations**: Modernization efforts could lead to increased delivery efficiencies as well. These include upgrades to water level control structures, flow measurement, and/or implementation of SCADA to automate flow control at canal headings and main laterals (McMillen Jacobs 2021). [2]

Projects of these types have been estimated to reduce system demand by 20 to 25% (McMillen Jacobs 2021). Historical PVID deliveries in WYs 2011 through 2022 range from 7,800 to 19,700 AFY. A 20 to 25% reduction on these deliveries would equate to approximately 1,600 to 4,900 AFY.

5.1.3.2 On-Farm System Efficiency Improvements

Opportunities for the reduction of on-farm water demands were identified and evaluated for the following solutions:

- **Tailwater recovery systems**: On-farm water demands can be reduced significantly through the implementation of tailwater recovery systems. These systems capture runoff water from irrigation, known as tailwater, and store it for reuse. By collecting and reusing this water, farmers can reduce their reliance on other water sources. Tailwater recovery systems typically include a network of ditches or pipes to collect runoff, a storage reservoir, and a pump to redistribute the water back to the fields. This not only conserves water but also reduces the potential for nutrient runoff into nearby water bodies, promoting more sustainable farming practices.
- **Irrigation efficiency measures**: Irrigation efficiency measures are another effective way to reduce on-farm water demands. Techniques, such as drip irrigation and sprinkler systems deliver water directly to the plant roots, minimizing evaporation and runoff. Drip irrigation, in particular, uses a network of tubes and emitters to provide a slow, steady supply of water to plants, which can significantly reduce water usage compared to traditional flood irrigation. In addition, using soil moisture sensors and automated irrigation systems can optimize watering schedules based on real-time data, ensuring that crops receive the right amount of water at the right time, further enhancing water use efficiency.

[2] SCADA = Supervisory Control and Data Acquisition

- **Crop management**: Crop management practices also play a crucial role in reducing water demands. Selecting drought-resistant crop varieties and adjusting planting schedules to align with periods of higher rainfall can help minimize the need for supplemental irrigation. Crop rotation and cover cropping can improve soil health and water retention, reducing the overall water requirements of the farm. In addition, implementing conservation tillage practices can enhance soil structure and organic matter content, which improves the soil's ability to retain moisture and reduces the need for frequent irrigation.

Previous estimates indicate that PVID irrigation demands could potentially be reduced by 1,000 to 3,000 AFY with the implementation of these strategies (McMillen Jacobs 2021).

5.1.3.3 Pump-Back System

The evaluation of a pump-back solution from Lake Mendocino was the final strategy evaluated for enhancing water supply in Potter Valley. One significant benefit of this approach is its ability to capture Eel River imported water that cannot be diverted and used at the time of availability in Potter Valley. By storing the surplus water in Lake Mendocino, it can be pumped back and used during the irrigation season, ensuring a more reliable water supply for agricultural needs. This method not only maximizes the use of available water resources but also provides a buffer against periods of low water availability, enhancing the overall resilience of the water management system.

Implementing this solution would involve developing an intake at Lake Mendocino, along with the necessary pumping and conveyance infrastructure to deliver water to the head of Potter Valley, approximately 13 miles away. The feasibility of this approach was evaluated previously in the McMillen Jacobs Associates study from 2021, which sized the system for a recovery of 10,000 AFY during the irrigation season. This capacity was deemed sufficient to meet a significant portion of the valley's water demands, thereby reducing the reliance on direct diversions from the Eel River.

However, one of the challenges associated with the pump-back solution is the complex ownership and management of water in Lake Mendocino. Multiple agencies have jurisdiction over the water stored in the lake, which can complicate the coordination and implementation of the pump-back system. Negotiating agreements, addressing complex water rights issues, and ensuring compliance with regulatory requirements will be essential to the success of this project. In addition, the financial and logistical aspects of constructing and maintaining the necessary infrastructure must be considered carefully to ensure the long-term viability of the pump-back solution.

5.2 Evaluation and Cost of Alternatives

After compiling and evaluating the potential water management alternative options, an evaluation was performed on each to provide a characterization with respect to criteria, such as cost, feasibility, implementation timing and complexity, permitting, legal, environmental, and jurisdiction. The complete list of evaluation criteria is shown in Table 5-5. For each criterion, a rating scale of low to high was used to characterize the concept related to the specific measure. The characterization of water management alternatives in this fashion is designed to allow regional water resource managers and the Potter Valley retail customers to begin to evaluate promising options for further study or implementation.

Table 5-5. Evaluation Criteria and Rating Scale to Characterize Water Management Alternatives

Criteria	Description	Low Rating	Low/Medium Rating	Medium Rating	Medium/High Rating	High Rating
Annual yield	Supplemental annual supply volume alternative could produce for PVID	< 2,000 AF	< 4,000 AF	< 6,000 AF	< 8,000 AF	≥ 10,000 AF
Cost per yield	Estimate of capital and annual costs, annualized per acre-foot	N/A	N/A	N/A	N/A	N/A
Timing	Estimate of time required before project could be implemented considering planning, design, permitting, and implementation	< 2 years	< 5 years	< 7 years	< 10 years	> 10 years
Flexibility	Degree to which the alternative could be operated (or implemented) across a wide range of hydrologic conditions by having ability to adjust the magnitude of operation each year to meet required conditions	Alternative does not have the flexibility to be operated or idled from year to year or has significant financial implications	N/A	Alternative can be operated/idled in any year with moderate financial implications.	N/A	Alternative can be operated/idled in any year with little to no financial implications.
Environmental impacts	Anticipated positive or negative impacts on the natural environment	Significantly positive impacts are likely to exist, and negative impacts are not readily apparent	Moderately positive impacts are anticipated at some locations while other locations may or may not have negative impacts of a lesser degree	No impacts or impacts are expected to be neutral.	Moderately negative impacts are anticipated at some locations while other locations may or may not have positive impacts of a lesser degree.	Significant negative impacts are likely to exist, and positive impacts are not readily apparent.
Permitting/legal	List of permits required and status if option has begun permitting process	Does not require an EIR or other major permits	Requires an EIR or other major permits, but similar projects of this scale have been approved in the past 20 years	Requires an EIR or other major permits, but similar projects of smaller scale have been approved in the past 20 years.	Requires an EIR, and no precedent exists for the option.	Requires an EIR, and similar options have been declined during the permit process.
Jurisdiction complexity	Primary jurisdiction for implementation	Primarily involves PVID facilities and control	Requires PVID and other Sonoma County department actions	Requires PVID customer actions.	Requires utility or state agency/ federal actions.	Requires private citizens and landholder actions.
Phasing potential	Ability to phase project and scale up as needed over time	Alternative has no ability to phase	N/A	Alternative has potential to phase.	N/A	Certain alternative has ability to phase.

> = greater than or equal to
≥ = greater than or equal to
< = less than
EIR = Environmental Impact Report

Table 5-6 shows the results of the criteria ratings score for each water management alternative. The anticipated reliability benefit of supplemental annual supply volume is shown in the first row. Timing for implementation was estimated based on discussions with team members or from available documentation. Costs are estimated as the annualized (over a 30-year period) capital and operations and maintenance (O&M) costs for the particular option divided by the expected supply increase or demand reduction. The remaining rows characterize the feasibility of each alternative in terms of flexibility, environmental impacts, permitting/legal requirements, jurisdiction, and phasing potential based on information from similar projects that have been implemented in California.

Table 5-6. Evaluation Criteria and Ratings to Characterize Water Management Alternatives

Criteria	Tributary Storage	EFRR Dam	In-Valley Ponds	Groundwater Supply	Irrigation Delivery System Efficiency	On-Farm Demand Management	Lake Mendocino Pump-Back System
Annual yield (AF)	7,000	7,000	5,000	3,500	1,600 to 4,900	1,000 to 3,000	10,000
Capital cost ($M)	$125 to 250M	$110 to 220M	$15 to 28M	$19 to 22M	$8 to 10M	$0.1 to $0.3M	$100M
Annual O&M cost ($)	$1.2 to 2.5M	$1.1 to 2.3M	$0.2 to 0.3M	$0.3 to 0.8M	$0.25 to 0.5M	$0.2 to $0.6M	$0.7M
Cost ($/AF)	$1,200 to 2,400	$1,100 to 2,200	$201 to 381	$210 to 370	$259 to 386	$206 – 212	$466 to 919
Timing (years)	15 years	15 years	5 years	5 years	5 years	5 years	8 years
Flexibility	Low	Low	Moderate	Moderate	Moderate	Moderate/High	Moderate
Environmental impacts	High	High	Low/ Moderate	Low/Moderate	Low/ Moderate	Low/Moderate	Low/Moderate
Permitting/ legal	High	High	Low/ Moderate	Low/Moderate	Low/ Moderate	Low	High
Jurisdiction complexity	High	High	Low	Low	Low	Moderate/High	Moderate/ High
Phasing potential	Low	Low	Moderate	Moderate	Moderate/ High	High	Low

$/AF = dollars per acre-foot
$M = million dollars

6. Recommendations and Next Steps

6.1 Key Findings

The key findings of this study are summarized as follows:

- Decommissioning of the PVP will result in substantial loss of water supply for users in Potter Valley during the late spring and summer. Estimated water supply shortfalls are approximately 9,000 AFY under current demand assumptions and projected run-of-the-river diversion capability.
- Water supply reliability for uses in Potter Valley will require strategic management of seasonal NERF flows and pond storage within the valley.
- Water supply reliability likely will require combined actions, including new supply, new storage, and demand management.
- Long-term water supply reliability for uses in the Potter Valley may be achievable with a combination of seasonally available run-of-river Eel River diversions and local water resources, and demand management.
- Potter Valley water users will need to determine which balance of these actions (such as new supply, storage, and demand management) is most desired, but each of these actions will be required.
- New supply through groundwater, new storage as ponds, and demand management through irrigation and delivery system improvements are the most promising actions.

6.2 Recommendations

Based on the potential magnitude and seasonality of future water supply shortfalls to Potter Valley water users with PVP decommissioning, the following recommendations are provided:

- **Recommendation 1: Pursue and Integrated Water Supply Strategy**

  Pursue a future water supply strategy that (1) integrates with run-of-river operations of the NERF to maximize storage of diverted water with expanded in-valley pond storage, (2) develops local groundwater supply, and (3) incentivizes demand management. Figure 6-1 demonstrates the combination of storage and supplemental supply needs with different levels of demand reductions.

- **Recommendation 2: Accelerate Efforts to Reduce Water Demand in Potter Valley**

  Reduce Potter Valley water demands by 20% to 30% through irrigation delivery system improvements and on-farm irrigation demand management.

- **Recommendation 3: Develop New In-Valley Pond Storage**

  Develop at least 2,500 AF of new in-valley pond storage. These new storage ponds may be dispersed throughout the valley but should be capable of being filled with irrigation canal water or pumped groundwater during the early winter and spring. These new in-valley ponds would cover approximately 313 acres, in addition to the current pond area of 125 acres.

- **Recommendation 4: Develop New Groundwater Supply in Potter Valley**

  Develop a new groundwater supply of at least 3,500 AFY by constructing agricultural production wells to provide supplemental supply during June through September. A well drilling program will be required to establish yields for these fit-for-purpose production wells.

- **Recommendation 5: Incentivize Storage and Well Development throughout Potter Valley**

  Due to the large number of new small ponds and new wells that will be required, it is likely that a decentralized approach toward reliability will be most effective. In such an approach, each major landholding or group of landholdings would develop new ponds and wells for use on their lands. To provide an incentive to develop ponds and production wells as soon as possible, a Potter Valley water fund could be established to offer reduced costs (or rebates) to individuals who develop such projects.

- **Recommendation 6: Consider New Governance Structure to Manage the Program**

  A program that implements Recommendations 1 through 5 will likely manage capital projects of up to $60 million and annual operation and maintenance costs of up to $2 million. Consideration should be given to substantially increasing the staffing and resources of PVID or developing an independent authority, such as a joint powers authority, to manage the program and water fund.

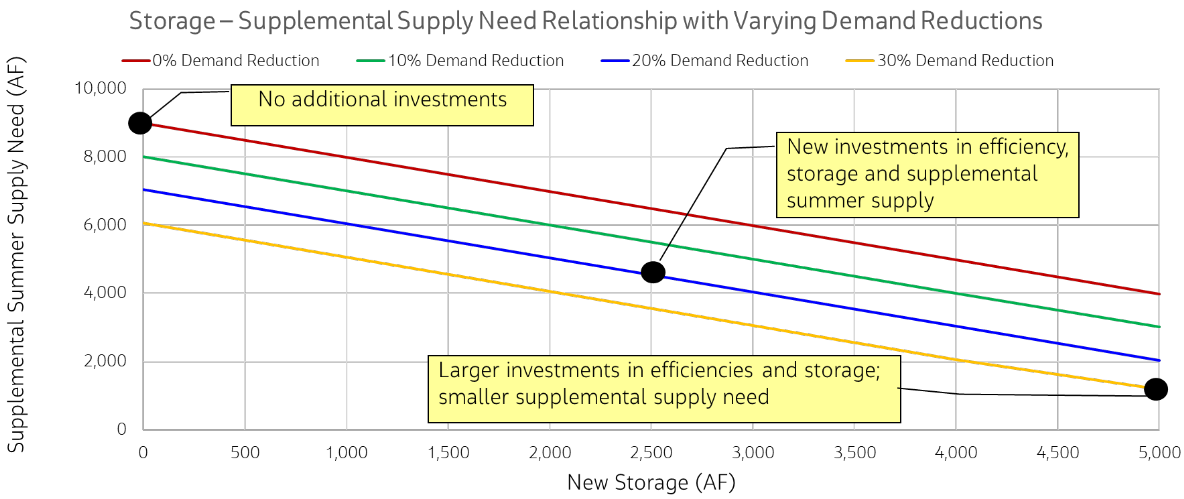


Figure 6-1. Relationship between Storage and Supplemental Summer Supply Need with Varying Demand Reductions

6.3 Next Steps

This current study evaluated the existing and future conditions of water supply for Potter Valley and identified a series of recommendations that can achieve reliability in the mid- to long-term. The need to reduce the uncertainty of a new groundwater supply and for immediate action of other elements leads to the following next steps that should be considered in the near term.

6.3.1 Implement Production Well Drilling Program to Validate Groundwater Supply

This study identified the potential to produce 3,500 to 5,000 AFY of new groundwater supply through the construction of agricultural production wells throughout Potter Valley. However, most existing wells and the monitoring wells constructed for this current study are shallow and designed for domestic purposes. An appropriate next step would be to implement a production well drilling and aquifer testing program to validate these supply estimates. The program would include up to 12 test wells constructed to maximize production. The results from this program would reduce uncertainty of aquifer properties and potential well yields in the Basin, provide information on potential impacts to existing domestic wells, and identify potential areas of concern for groundwater quality.

6.3.2 Initiate District Scale Water Use Efficiency Program

PVID has been providing periodic investments to increase the efficiency of the district's delivery system. Lining of some canal sections and piping has occurred in areas where seepage losses were estimated to be high. An expansion and acceleration of these efforts will provide significant value and reduce diversion requirements in the canal systems. This action is a no-regret action (an action that provides benefits regardless of future conditions) that can be implemented in the near term and will continue the trajectory toward greater water reliability.

6.3.3 Incentivize Expanded Pond Storage throughout the Valley

Several landowners are expanding, or considering expanding, pond storage for their agricultural operations. Greater seasonal storage in Potter Valley is another no-regret action for water supply reliability. At present, incentives provided for landowners would likely increase the rate of in-valley pond storage development. An early incentive, in the form of rebate or cost reductions, would likely lead to a greater number of landowners involved in pond storage expansion. An incentive could be provided through state or locally derived funds, even prior to establishing a Potter Valley water fund or considering new governance.

7. References

ASTM International (ASTM). 2018. Standard D5981, Standard Guide for Calibrating a Groundwater Flow Model Application. February. https://www.astm.org/d5981_d5981m-18.html

Bakker, M., V. Post, C.D. Langevin, J.D. Hughes, J.T. White, J.J. Starn, and M.N. Fienen. 2016. "Scripting MODFLOW Model Development Using Python and FloPy." Groundwater 54:733–739. DOI:10.1111/gwat.12413

California Department of Water Resources (DWR). 1981. *Water Well Standards: State of California*. Bulletin 74-81. December. https://water.ca.gov/Programs/Groundwater-Management/Wells/Well-Standards/Combined-Well-Standards.

California Department of Water Resources (DWR). 1991. *California Well Standards. Bulletin 74-90*. Supplement to Bulletin 74-81. June. https://water.ca.gov/Programs/Groundwater-Management/Wells/Well-Standards/Combined-Well-Standards.

California Department of Water Resources (DWR). 2004. Basin Report 1-51, *Potter Valley Groundwater Basin* in *California's Groundwater: Bulletin 118 Update 2003*. February. https://data.cnra.ca.gov/dataset/bulletin-118-update-2003-basin-reports/resource/f43c73d5-781e-433a-b6ed-2b7abe2ad640

Environmental Simulations Inc. (ESI). 2020. Guide to Using Groundwater Vistas Version 8. https://www.groundwatermodels.com/Groundwater_Vistas.php

Jacobs. 2023. *Field Work Plan for Potter Valley Water Supply Reliability Study, Potter Valley Water Supply Reliability Study*. June 22.

McMillen Jacobs Associates (McMillen Jacobs). 2021. *Potter Valley Irrigation District Water Supply Alternatives*. Prepared for Two-Basin Solution Partners. Technical Memorandum. November.

OpenET. 2023. *OpenET—Filling the Biggest Data Gap in Water Management*. https://openetdata.org/.

US Geological Survey (USGS). 2005. MODFLOW-2005, the U.S. Geological Survey Modular Ground-water Model—the Ground-Water Flow Process. Techniques and Methods 6-A16 (Chapter 16 in Book 6, Modeling Techniques). Prepared by A.W. Harbaugh. https://pubs.usgs.gov/tm/2005/tm6A16/PDF/TM6A16.pdf

US Geological Survey (USGS). 2007. *Preliminary Gravity and Magnetic Data of the Lake Pillsbury Region, Northern California Coast Ranges, California.* US Geological Survey Open-File Report 2007–1368. Version 1.0. Prepared by V.E. Langenheim, R.C. Jachens, R.L. Morin, and C.A. McCabe. http://pubs.usgs.gov/of/2007/1368/.

US Geological Survey (USGS). 2011. MODFLOW-NWT, A Newton formulation for MODFLOW-2005. Techniques and Methods 6–A37 (Chapter 37 of Section A, Groundwater in Book 6, Modeling Techniques). Prepared by R.G. Niswonger, S. Panday, and M. Ibaraki. https://pubs.usgs.gov/tm/tm6a37/pdf/tm6a37.pdf

US Geological Survey (USGS). 2022a. Data set: *Hydrogeologic Data of the Russian River Watershed, Sonoma and Mendocino Counties, California.* Version 1.1. Prepared by N.C. Fenton, G. Cromwell, D.S. Sweetkind, V.E. Langenheim, C.P. Ely, A.J. Martin, C.A. Kohel, A.Y. Morita, M.F. Peterson, and M.A. Roberts. https://doi.org/10.5066/P9GPH5FW.

US Geological Survey (USGS). 2022b. The National Map Viewer. November 3. https://www.usgs.gov/tools/national-map-viewer.