- **Agricultural Water Demand** – Agricultural irrigation demands were estimated using C2VSimFG-Colusa and modified from the current conditions scenario as described below.
  - Future Conditions, No Climate Change – Agricultural water demand was assumed to be similar to the current conditions water budget scenario.
  - Future Conditions, 2030 Climate Change – Agricultural water demand was increased from current conditions based on 2030 central tendency climate change projections.
  - Future Conditions, 2070 Climate Change – Agricultural water demand was increased from current conditions based on 2070 central tendency climate change projections.
  - Besides these modifications, the same general assumptions used for simulating all crops (including rice and managed wetlands) in the historical water budget were also used in the future conditions water budgets.
- **Urban and Industrial Water Demand** – Urban and industrial demands were estimated based on projected urban demands. Specifically, future urban demands were estimated based on preliminary draft demands for 2050 provided as part of the 2020 Urban Water Management Plan (UWMP) for Willows. Estimates for other urban demand areas were based on population growth rates and per capita water use similar to Willows.
- **Surface Water Diversions** – Climate change estimates are based on current diversions with reduced diversions in some years to simulate drought periods. For both the 2030 and 2070 central tendency scenarios, reductions occurred in eight years within the 50-year simulation period: 2016, 2026, 2027, 2028, 2041, 2042, 2064, 2065. Diversions were on average about 25 percent less than full supply years.
- **Groundwater Pumping** – Pumping to meet urban demand was estimated based on draft projections from UWMPs currently under development, as described above. Pumping to meet agricultural and managed wetlands demand was estimated using C2VSimFG-Colusa as described previously for the historical water budget.

3.3.4 Water Budget Estimates

As described previously, water budget estimates were developed using the C2VSimFG-Colusa model. Primary components of the land and surface water system water budget include the following:

- **Inflows**
  - Surface Water Inflows – Inflows at the land surface through rivers, streams, canals, or other waterways, including Sacramento River diversions, Stony Creek diversions, Sacramento River inflows, and inflows from boundary streams. These inflows may also include overland flow from upslope areas outside of the Subbasin. Note that although interactions with streams along the boundary of the subbasin (i.e., diversions and stream-aquifer interaction) are accounted for, the flow in the stream is not considered an inflow to the Subbasin. Inflows from streams that traverse the Subbasin, primarily the Sacramento River near the eastern edge of the subbasin where the river is within the subbasin, are accounted for explicitly. All surface water that enters the Subbasin that does not flow out of the Subbasin or evaporate may be used or available for use for groundwater recharge or in-lieu use, whether through seepage or deep percolation to the groundwater system, or irrigation or other consumptive use that offsets groundwater demand.

- Precipitation – Rainfall on the land surface within the Subbasin boundary.
- Groundwater pumping – Extraction of groundwater to meet agricultural, urban and industrial, managed wetlands, or other beneficial uses.
- Stream Gains from Groundwater (Accretions) – Gains in streamflow from shallow groundwater occurring when the water level in the aquifer adjacent to the stream is greater than the water level in the stream.

- **Outflows**
  - Evapotranspiration – Consumptive use of water including both evaporation and transpiration components occurring on agricultural, urban, industrial, managed wetland, native vegetation lands, and evaporation from canals and other water surfaces. Native vegetation includes riparian corridors along streams and rivers.
  - Deep Percolation – Recharge of the groundwater system through the vertical movement of precipitation and applied irrigation water (surface water and groundwater) below the root zone.
  - Seepage (also referred to as losses or leakage) – Recharge of the groundwater system from streams, canals, drains or other water bodies.
  - Surface Water Outflows – Outflows at the land surface through rivers, streams, canals, or other waterways, including runoff or precipitation, runoff of surface water and groundwater applied for irrigation, and outflows from the Sacramento River, Colusa Drain, the Colusa Weir (to the Sutter Bypass) and other boundary streams. These outflows may also include overland flow to downslope areas outside of the subbasin.
- **Change in Storage** – Changes in soil moisture storage within the upper several feet of soil in the root zone, as well as changes in storage in surface water bodies within the subbasin, calculated as Total Inflow minus Total Outflow. These changes vary over the course of a year based on precipitation and irrigation patterns and other factors, but are generally negligible on an annual basis.

Primary components of the groundwater system water budget include the following:

- **Inflows**
  - Subsurface Water Inflows – Groundwater inflows from adjacent subbasins or from the Coast Range foothills on the west side of the subbasin.
  - Deep Percolation (from the overlying land surface and surface water system) – Described above.
  - Seepage (from streams, canals, and drains) – Described above.
- **Outflows**
  - Groundwater Pumping – Described above.
  - Subsurface Outflows – Groundwater outflows to adjacent basins.
  - Accretions – Described above.
- **Change in Storage** – Changes in water storage in the aquifer system, calculated as Total Inflow minus Total Outflow. These changes tend to be large compared to changes in root zone soil moisture storage and can vary substantially from year to year.

Many components of the water budget can be estimated based on measured data (e.g., precipitation, diversions, evapotranspiration, etc.) and are used to develop inputs to C2VSimFG-Colusa to support water budget development. Other components are more difficult to measure or do not have measured values readily available (e.g., deep percolation, subsurface flows, groundwater pumping, surface water-groundwater interaction, etc.) and are estimated using C2VSimFG-Colusa. Additional detail describing the C2VSimFG is available in DWR Technical Memorandum entitled Integrated Water Flow Model: IWFM-2015 Theoretical Documentation[6].

Average annual water budget estimates for the historical water budgets and for the current and projected water budget scenarios are summarized in Table 3-11 for the land and surface water system and in Table 3-12 for the groundwater system. Additional information and discussion regarding the water budgets is provided in the following subsections. It is anticipated that the water budgets will be refined and updated over time as part of GSP implementation in the subbasin.

Table 3-11. Average Annual Land and Surface Water System Inflows, Outflows, and Changes in Storage in taf/yr for the Water Budget Analysis Periods Listed in Table 3-9

Component	Historical Simulation	Current Conditions Baseline	Future Conditions, No Climate Change Baseline	Future Conditions, 2030 Climate Change Baseline[(a)]	Future Conditions, 2070 Climate Change Baseline[(a)]
Inflows					
Surface Water Inflows	11,747	12,556	12,556	12,597	12,715
Sacramento River Diversions[(b)]	1,076	1,192	1,196	1,196	1,196
Stony Creek Diversions[(b)]	92	95	91	91	91
Sacramento River Inflows[(c)]	10,500	11,188	11,188	11,228	11,335
Other Inflows from Boundary Streams	78	81	81	81	92
Precipitation	1,210	1,183	1,183	1,198	1,258
Groundwater Pumping	502	499	499	525	559
Agricultural	463	458	458	484	516
Urban and Industrial	11	11	10	10	10
Managed Wetlands	28	30	30	31	32
Stream Gains from Groundwater (Stream Accretions)	366	349	349	337	323
Total Inflow	**13,824**	**14,587**	**14,586**	**14,658**	**14,853**

[6] https://data.cnra.ca.gov/dataset/5c4b82c9-d219-4d71-a6cc-7ea6ccbaa54b/resource/a94dda67-4d90-418d-8c10-f403626b0f8d/download/iwfm-2015.0.1129_theoreticaldocumentation.pdf

Table 3-11. Average Annual Land and Surface Water System Inflows, Outflows, and Changes in Storage in taf/yr for the Water Budget Analysis Periods Listed in Table 3-9

Component	Historical Simulation	Current Conditions Baseline	Future Conditions, No Climate Change Baseline	Future Conditions, 2030 Climate Change Baseline[(a)]	Future Conditions, 2070 Climate Change Baseline[(a)]
Outflows					
Evapotranspiration	1,740	1,790	1,790	1,841	1,901
Agricultural	1,430	1,494	1,494	1,542	1,596
Urban and Industrial	22	28	28	28	28
Managed Wetlands	69	69	69	70	73
Native Vegetation	180	163	163	165	167
Canal Evaporation	40	36	36	36	36
Deep Percolation	441	416	415	415	411
Precipitation	174	162	162	160	156
Applied Surface Water	196	162	162	161	158
Applied Groundwater	72	92	91	94	97
Seepage	345	379	379	387	401
Streams	206	231	231	239	253
Canals and Drains	139	148	148	148	148
Surface Water Outflows	11,302	12,002	12,003	12,015	12,141
Precipitation Runoff	55	51	51	52	60
Applied Surface Water Return Flows	96	93	93	92	90
Applied Groundwater Return Flows	22	19	18	19	20
Sacramento River	9,371	11,049	11,050	11,086	11,187
Colusa Drain	709	759	759	742	774
Colusa Weir to Sutter Bypass	994	0	0	0	0
Other Outflows to Boundary Streams	56	32	32	23	10
Total Outflow	**13,828**	**14,587**	**14,587**	**14,658**	**14,853**
Change in Storage (Inflow - Outflow)	**-3**	**0**	**0**	**0**	**0**

(a) Central Tendency Climate Change Projections
(b) Sacramento River Diversions and Stony Creek Diversions are diversions from boundary streams outside the subbasin. About 20 percent of the total diversions come from streams within the subbasin and are included in the Sacramento River Inflow.
(c) Sacramento River Inflows include flows along the Sacramento River and the Colusa Drain that enter the Subbasin.

Table 3-12. Average Annual Groundwater System Inflows, Outflows, and Changes in Storage in taf/yr for the Water Budget Analysis Periods Listed in Table 3-9

Component	Historical Simulation	Current Conditions Baseline	Future Conditions, No Climate Change Baseline	Future Conditions, 2030 Climate Change Baseline[a]	Future Conditions, 2070 Climate Change Baseline[a]
Inflows[b]					
Subsurface Water Inflows	200	203	203	205	209
Deep Percolation	441	416	415	415	411
Precipitation	174	162	162	160	156
Applied Surface Water	196	162	162	161	158
Applied Groundwater	72	92	91	94	97
Seepage	345	379	379	387	401
Streams	206	231	231	239	253
Canals and Drains	139	148	148	148	148
Total Inflow	**986**	**997**	**997**	**1,008**	**1,021**
Outflows					
Subsurface Water Outflows	146	149	149	148	147
Groundwater Pumping	502	499	499	525	559
Agricultural	463	458	458	484	516
Urban and Industrial	11	11	10	10	10
Managed Wetlands	28	30	30	31	32
Stream Gains from Groundwater (Stream Accretions)	366	349	349	337	323
Total Outflow	**1,014**	**997**	**996**	**1,011**	**1,028**
Change in Storage (Inflow - Outflow)	**-28**	**1**	**1**	**-3**	**-7**

(a) Central Tendency Climate Change Projections
(b) Sacramento River Diversions and Stony Creek Diversions are diversions from boundary streams outside the Subbasin. About 20 percent of the total diversions come from streams within the Subbasin and are included in the Sacramento River Inflow.

3.3.4.1 Historical Simulation

The historical water budget provides a foundation for understanding how the subbasin has behaved, including insight into historical groundwater conditions (e.g., observed water levels). Also, in accordance with the GSP Emergency Regulations, the historical water budget covers a period of at least ten years (26-year period from 1990 to 2015). The historical water budget is used to evaluate the availability and reliability of historical surface water supplies and provides insight into the ability to operate the subbasin sustainably. Note that the historical analysis period experienced slightly more precipitation than the long-term average and included historic drought conditions from approximately 2007 to 2015.

Average annual inflows to and outflows from the Subbasin for the historical land and surface water system water budget were estimated to be 13,825 taf/yr (13.8 maf/yr). Average annual values were presented previously in Table 3-11 and are shown graphically in Figure 3-39.

Primary inflows to the land and surface water system include surface water inflows (11,747 taf/yr), precipitation (1,210 taf/yr), groundwater pumping (502 taf/yr), and stream gains from groundwater[7] (366 taf/yr). Surface water inflows include the Sacramento River, other inflows from boundary streams including Stony Creek, as well as overland runoff of precipitation and applied water from upslope lands. Additionally, diversions from the Sacramento River and from Stony Creek are major sources of surface water inflows.

Primary outflows from the land and surface water system include evapotranspiration (1,740 taf/yr), deep percolation (441 taf/yr), seepage (345 taf/yr), and surface water outflows (11,302 taf/yr). Evapotranspiration is primarily from agricultural lands but also from managed wetlands, canal evaporation, native vegetation, and urban and industrial lands. Deep percolation is primarily from precipitation, but also from applied water. Seepage includes a combination of stream seepage and seepage from canals and drains.

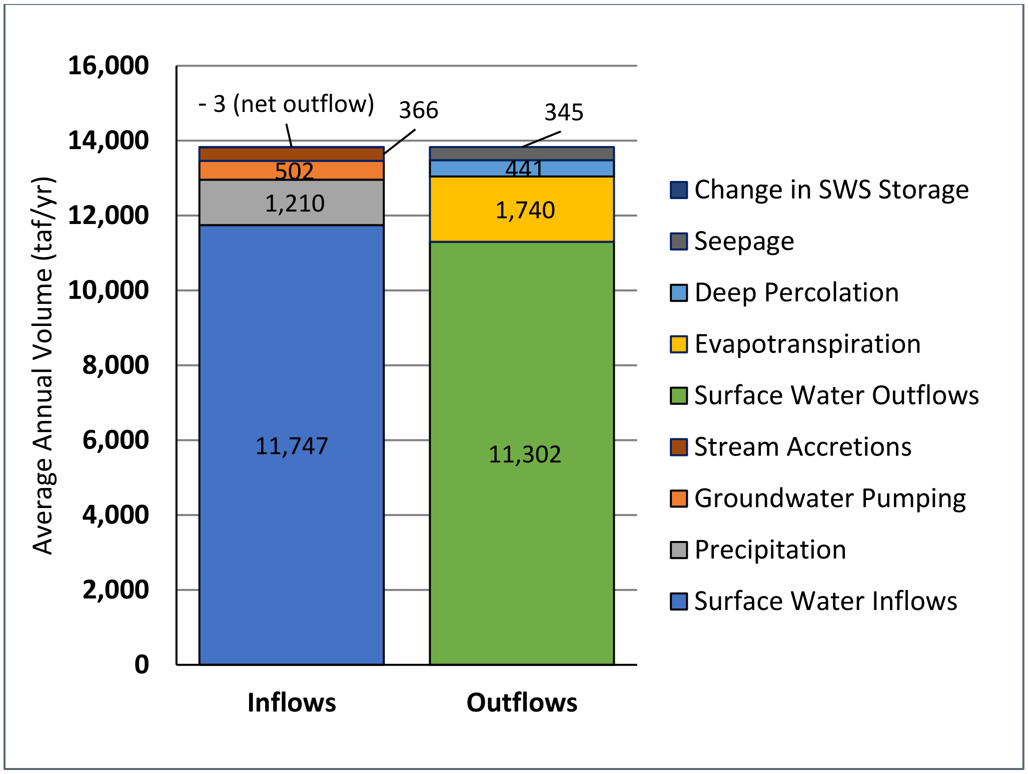


Figure 3-39. Average Annual Historical Land and Surface Water System Water Budget Summary (1990-2015, rounded to nearest taf/yr)

The average annual change in storage in the land and surface water system (3 taf/yr) is negligible due to similar soil moisture content in the root zone, on average, across water years.

Annual historical land and surface water system water budgets for 1990 to 2015 are provided in Table 3E-1 of Appendix 3E for the entire Subbasin.

[7] i.e., stream accretions

Average annual historical inflows to and outflows from the groundwater system were estimated to be 986 taf and 1,014 taf, respectively. Average annual values were presented previously in Table 3-12 are shown graphically in Figure 3-40 Inflows to the groundwater system include deep percolation (441 taf/yr), subsurface inflows from the Corning, Butte, Sutter, and Yolo Subbasins (200 taf/yr), seepage (345 taf/yr), and changes in groundwater storage (28 taf/yr). Outflows from the groundwater system include groundwater pumping (502 taf/yr), subsurface outflows to the Corning, Butte, Sutter, and Yolo Subbasins (146 taf/yr), and stream gains from groundwater (366 taf/yr).

Annual historical groundwater system water budgets for 1990 to 2015 are provided in Table 3E-2 of Appendix 3E for the entire Subbasin.

Historical water budget values are also presented in Appendix 3F for 32 distinct subareas defined within the Subbasin. Each subarea approximately represents a region of the Subbasin that shares a common water supplier (e.g., an irrigation or water district service area), a common governing agency (e.g., county or city), and a common primary water supply source (e.g., areas with access to surface water or areas with access to only groundwater, i.e., “groundwater” areas).

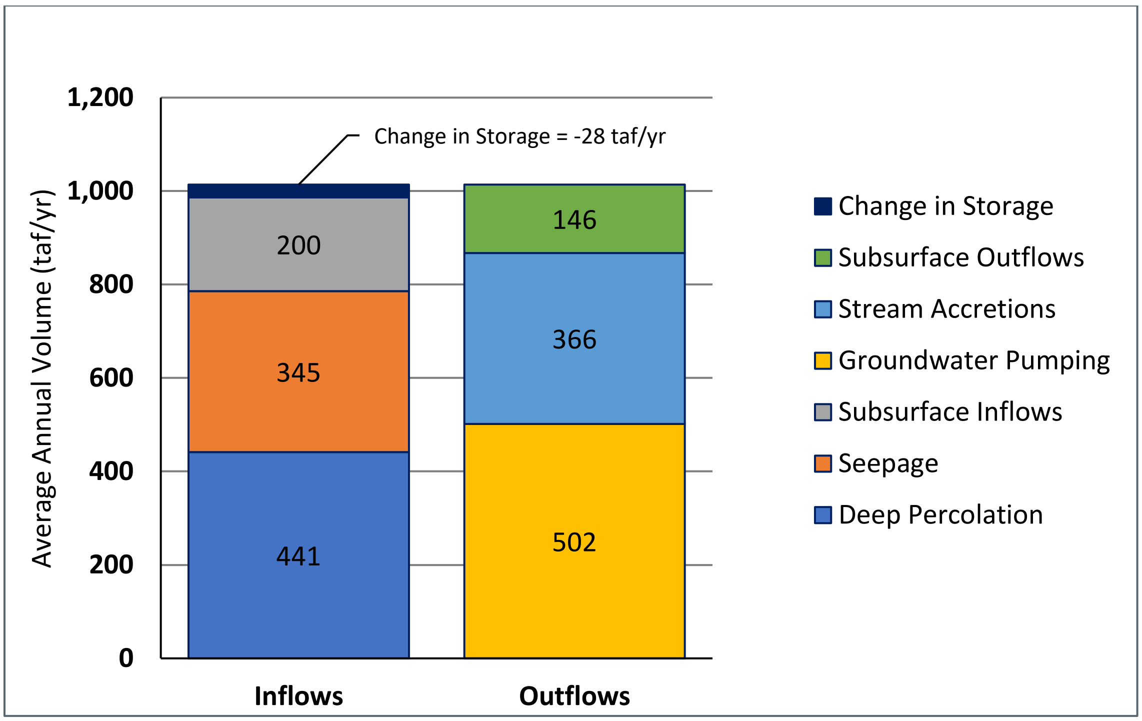


Figure 3-40. Average Annual Historical Groundwater System Water Budget Summary (1990-2015, rounded to nearest taf/yr)

Historical water supplies and change in groundwater storage are summarized by water year type in Table 3-13 based on the Sacramento Valley Water Year Index. Between 1990 and 2015, there were seven wet years, four above normal years, three below normal years, five dry years, and seven critical years. Historical surface water deliveries were greatest in dry years, when agricultural demands tend to be relatively high and surface water supplies tend to be available, and least in critical years, when surface water supplies tend to be constrained despite relatively high agricultural demands. Groundwater pumping was greatest in dry years and least in wet years. Historically, groundwater storage in the subbasin has tended to increase in wet and above normal years and to decrease in below normal, dry, and critical years, with reductions in storage in below normal years less than reductions in dry and critical years. The average annual change in storage over the 1990-2015 historical period was -28 taf.

Table 3-13. Historical Water Supplies and Change in Groundwater Storage by Hydrologic Water Year Type, taf/yr (1990-2015)

Water Year Type	Surface Water Deliveries[(a)]	Groundwater Pumping	Total Supply	Change in Groundwater Storage
Wet	1,381	435	1,814	99
Above Normal	1,474	435	1,909	101
Below Normal	1,592	546	2,138	-24
Dry	1,598	570	2,168	-116
Critical	1,228	540	1,768	-166
Average	**1,420**	**502**	**1,922**	**-28**

(a) Surface Water Deliveries represents the volume of water delivered to agricultural and urban lands. It is an internal flow path and is different than Surface Water Inflow in the Subbasin boundary balance summarized in Table 3-11.

3.3.4.1.1 Availability or Reliability of Historical Surface Water Supplies

As indicated in Table 3-13, historical surface water supplies for delivery to agricultural land vary based on water year type. The primary sources of surface water in the subbasin are the Sacramento River and Stony Creek Diversions. Surface water supplies are relatively reliable in the Subbasin and represent approximately 70-percent of the total water supplies (Sacramento River and Stony Creek diversions plus Groundwater Pumping). This average percentage reflects all of the supply curtailments or shortages experienced by the surface water suppliers in the subbasin over the 1990-2015 historical period, including the 25 percent curtailments to Sacramento River settlement contractors in Shasta Critical years, less than 100 percent allocations to Tehama-Colusa Canal CVP contractors in certain years, and Stony Creek water shortages experienced by the Orland Unit Water Users Association. Under 2030 and 2070 climate change conditions there may be an increase in the availability of surface water for irrigation in the Subbasin due to increased precipitation from climate change effects. Potential effects of these changes are evaluated as part of the projected water budgets in the following sections.

Under diversion agreements between Sacramento River Settlement Contractors and the State, Sacramento River diversions can be reduced under the following conditions:

- DWR forecasted annual inflow into Lake Shasta is less than 3,200 taf[8], or
- There is a cumulative deficit of inflows below 4,000 taf of greater than 800 taf for any year or consecutive series of years.

Another source of uncertainty in the availability or reliability of historical surface water supplies is Phase 2 of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary Water Quality Control Plan (Bay-Delta Water Quality Control Plan). Standards within the Bay-Delta Water Quality Control Plan are being updated by the State Water Resources Control Board in two phases. Phase 2 of this effort will include a

[8] The final, official forecast must be made by April 10 of each year.

comprehensive update to the plan, creating new inflow requirements for the Sacramento River and its tributaries. While Phase 2 is not yet complete, the requirements proposed in this phase have the potential to constrain the volume and/or timing of surface water diversions by water users along the Sacramento River and its tributaries. GSP annual reports and periodic evaluations will address specific impacts of the Bay-Delta Water Quality Control Plan, when known.

3.3.4.1.2 Suitability of Tools and Methods for Planning

The water budgets presented herein have been developed using the best available information and best available science and structured in a manner consistent with the hydrogeologic conceptual model of the Subbasin. The IWFM application C2VSimFG-Colusa, which is used to organize information for the water budgets, develop water budget scenarios, and perform water budget calculations, is currently the best available tool and is suitable for GSP development for the subbasin. The IWFM has been developed over the past several decades and updated over time to use updated model code, updated datasets, and updated input parameters through a series of efforts by DWR. Refinements to C2VSimFG specific to the Subbasin are described Appendix 3D.

The water budgets developed using C2VSimFG-Colusa support the development of sustainable management criteria, evaluation of the monitoring network, and development of projects and management actions as part of GSP development. It is anticipated that the C2VSimFG-Colusa will continue to be updated and refined in the future as part of GSP implementation. Additional information describing C2VSimFG is available in DWR's Theoretical Documentation and User's Manual[9].

3.3.4.1.3 Ability to Operate the Subbasin within the Sustainable Yield

Sustainable yield refers to the maximum quantity of water, calculated over a base period representative of long-term conditions in the Subbasin, and including any temporary surplus that can be withdrawn annually from a groundwater supply without causing an undesirable result. As a result, determination of sustainable yield requires consideration of SGMA's six sustainability indicators. Historical water budget estimates indicate an average annual decrease in storage of 28 taf/yr for the period from water year 1990 to 2015. Operation of the subbasin within the sustainable yield will likely require implementation of projects and management actions over the 20-year SGMA planning and implementation horizon. Projects and management actions are discussed in Chapter 6. The estimated sustainable yield of the subbasin is described in greater detail in Section 3.3.7.

3.3.4.2 Current Conditions Baseline

The current conditions baseline water budget provides a foundation to understand the behavior of the subbasin considering current land use and urban demands over a broad range of hydrologic conditions as well as a basis for evaluating how groundwater conditions may change in the future based on comparison of water budget results to projected water budgets presented in the following section. A 50-year hydrologic period was selected, rather than a single, recent year to improve the basis for estimation of sustainable yield under current conditions (along with consideration of other sustainability parameters).

[9] https://data.cnra.ca.gov/dataset/c2vsimfg_beta2

Average annual inflows to and outflows from the subbasin for the current conditions land and surface water system baseline water budget were estimated to be 14,587 taf/yr. Average annual values were presented previously in Table 3-11 and are shown graphically in Figure 3-41.

Primary inflows to the land and surface water system include surface water inflows (12,556 taf/yr), precipitation (1,183 taf/yr), groundwater pumping (499 taf/yr), and stream gains from groundwater (349 taf/yr). Surface water inflows include the Sacramento River, other inflows from boundary streams including Stony Creek, as well as overland runoff of precipitation and applied water from upslope lands. Additionally, diversions from the Sacramento River and from Stony Creek are primary sources of surface water inflows.

Primary outflows from the land and surface water system include surface water outflows (12,002 taf/yr), evapotranspiration (1,790 taf/yr), deep percolation (416 taf/yr), and seepage (379 taf/yr). Surface water outflows include outflows through Sacramento River, Colusa Drain, Colusa Weir to Sutter Slough, and outflows to boundary streams including Stony Creek, as well as overland runoff of precipitation and applied water to downslope lands. Evapotranspiration is primarily from agricultural lands but also from managed wetlands, canal evaporation, native vegetation, and urban and industrial lands. Deep percolation is primarily from precipitation, but also from applied water. Seepage includes a combination of stream seepage and seepage from canals and drains.

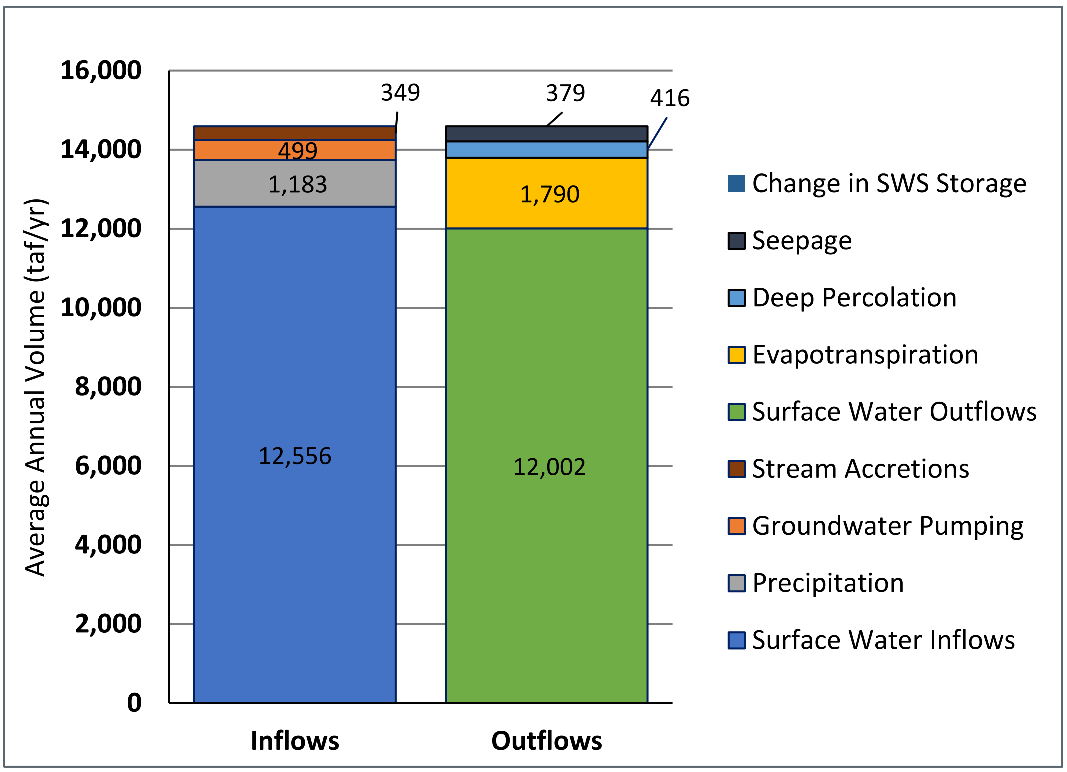


Figure 3-41. Average Annual Current Conditions Baseline Land and Surface Water System Water Budget Summary (2016-2065, rounded to nearest taf/yr)

The average annual change in storage in the land and surface water system (0.1 taf/yr) is negligible due to similar soil moisture content in the root zone, on average, across water years.

Average annual inflows to and outflows from the groundwater system were estimated to be 997 taf/yr during the current conditions baseline simulation period. Average annual values were presented previously in Table 3-12 and are shown graphically in Figure 3-42.

Inflows to the groundwater system include deep percolation (416 taf/yr), seepage (379 taf/yr), and subsurface inflows from the Corning, Butte, Sutter, and Yolo Subbasins (203 taf/yr). Outflows from the groundwater system include groundwater pumping (499 taf/yr), stream gains from groundwater (349 taf/yr), subsurface outflows to Corning, Butte, Sutter, and Yolo Subbasins (149 taf/yr), and change in groundwater storage (1 taf/yr).

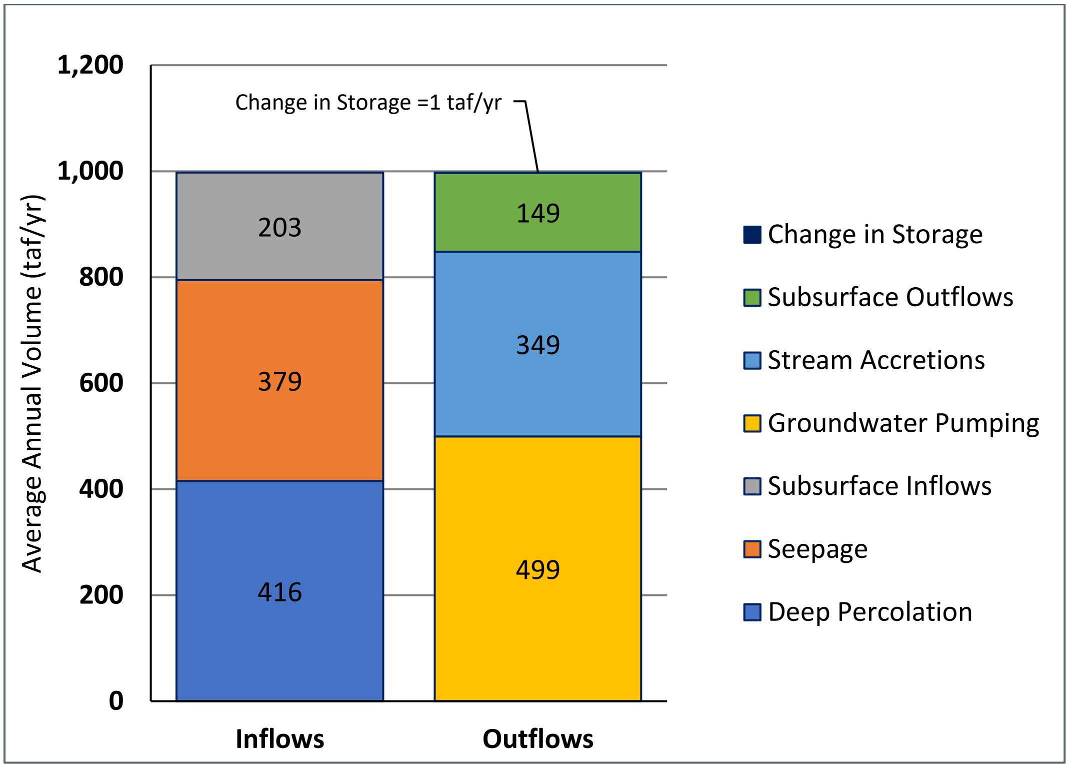


Figure 3-42. Average Annual Current Conditions Baseline Groundwater System Water Budget Summary (2016-2065, rounded to nearest taf/yr)

3.3.4.3 Future Conditions Scenarios

Three projected water budgets were developed for the subbasin to provide baseline scenarios representing potential future conditions considering planned development under the Colusa County 2030 General Plan and climate change centered around 2030 and 2070 based on central tendency climate change datasets provided by DWR. The projected water budget scenarios provide a foundation to understand the behavior of the subbasin considering potential future land use and urban demands over a broad range of hydrologic conditions, modified based on climate change projections. Use of a 50-year hydrologic period provides a basis for estimation of sustainable yield under potential future conditions.

3.3.4.3.1 Future Conditions, No Climate Change Baseline

Average annual inflows to and outflows from the subbasin for the future conditions without climate change projected land and surface water system baseline water budget were estimated to be 14,587 taf/yr. Average annual values were presented previously in Table 3-11 and are shown graphically in Figure 3-43.

Primary inflows to the land and surface water system include surface water inflows (12,556 taf/yr), precipitation (1,183 taf/yr), groundwater pumping (499 taf/yr), and stream gains from groundwater (349 taf/yr). Surface water inflows include the Sacramento River, other inflows from boundary streams including Stony Creek, as well as overland runoff of precipitation and applied water from upslope lands. Additionally, diversions from the Sacramento River and from Stony Creek are a primary source of surface water inflows. Surface water inflows include the Sacramento River, other inflows from boundary streams including Stony Creek, as well as overland runoff of precipitation and applied water from upslope lands. Additionally, diversions from the Sacramento River and from Stony Creek are a key source of surface water inflows.

Primary outflows from the land and surface water system include surface water outflows (12,003 taf/yr), evapotranspiration (1,790 taf/yr), deep percolation (415 taf/yr), and seepage (379 taf/yr). Surface water outflows include outflows through Sacramento River, Colusa Drain, Colusa Weir to Sutter Slough, and outflows to boundary streams including Stony Creek, as well as overland runoff of precipitation and applied water to downslope lands. Evapotranspiration is primarily from agricultural lands but also from managed wetlands, canal evaporation, native vegetation, and urban and industrial lands. Deep percolation is primarily from precipitation, but also from applied water. Seepage includes a combination of stream seepage and seepage from canals and drains.

The average annual change in storage in the land and surface water system (0.1 taf/yr) is negligible due to similar soil moisture content in the root zone, on average, across water years.

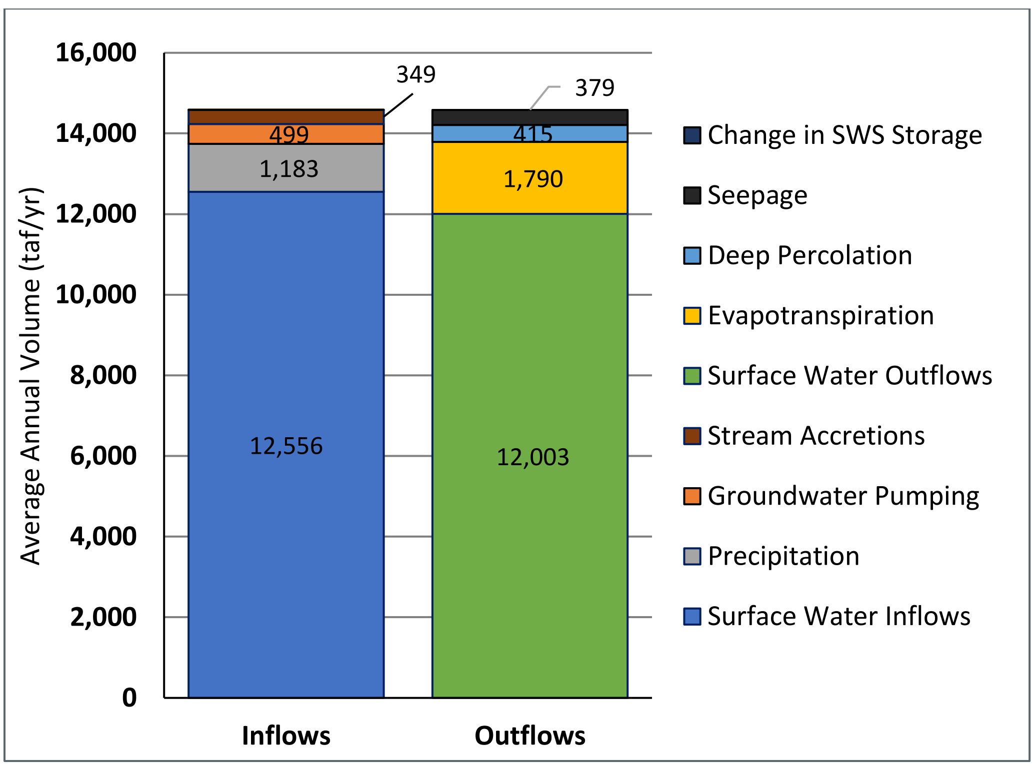


Figure 3-43. Average Annual Future Conditions, No Climate Change Baseline Land and Surface Water System Water Budget Summary (2016-2065, rounded to nearest taf/yr)

Average annual inflows to and outflows from the groundwater system were estimated to be 997 taf/yr for the future conditions without climate change simulation. Average annual values were presented previously in Table 3-12 are shown graphically in Figure 3-44**.**

Inflows to the groundwater system include deep percolation (415 taf/yr), seepage (379 taf/yr), and subsurface inflows from the Corning, Butte, Sutter, and Yolo Subbasins (203 taf/yr). Outflows from the groundwater system include groundwater pumping (499 taf/yr), stream gains from groundwater (349 taf/yr), and subsurface outflows to the Corning, Butte, Sutter, and Yolo Subbasins (149 taf/yr).

There is negligible change (+1 taf/yr) in groundwater storage under the future condition, no climate change baseline water budget.

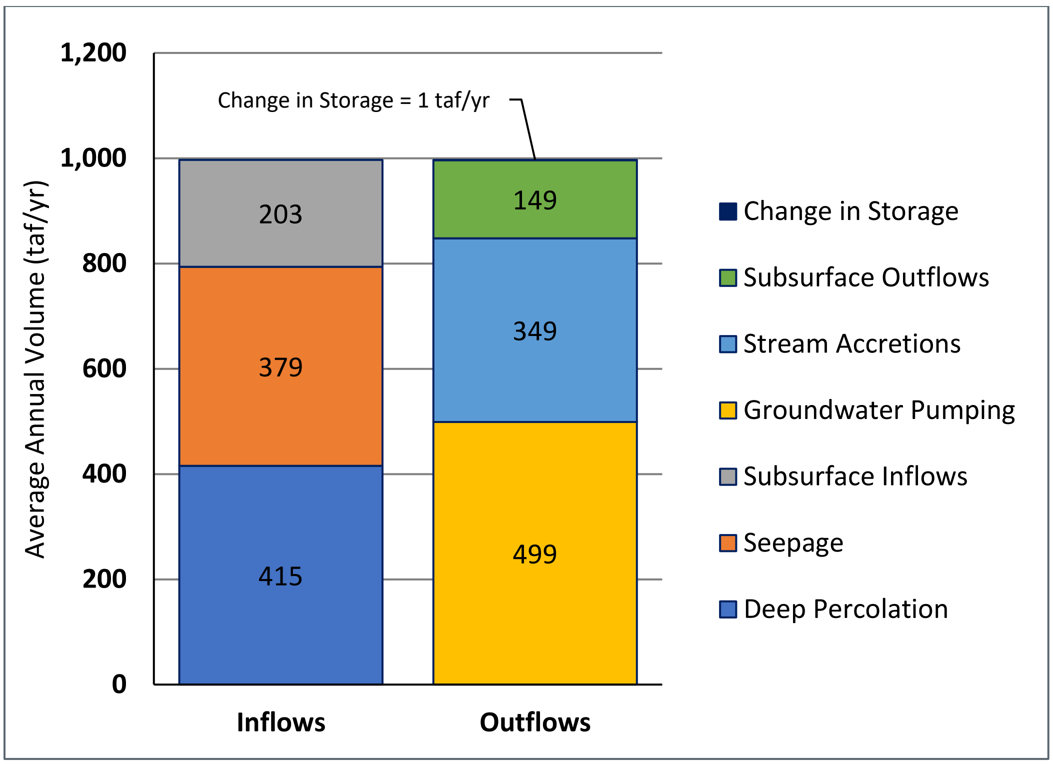


Figure 3-44. Average Annual Future Conditions, No Climate Change Baseline Groundwater System Water Budget Summary (2016-2065, rounded to nearest taf/yr)

3.3.4.3.2 Future Conditions, 2030 Climate Change Baseline

Average annual inflows to and outflows from the subbasin for the future conditions with 2030 climate change projected land and surface water system baseline water budget were estimated to be 14,657 taf/yr. Average annual values were presented previously in Table 3-11 and are shown graphically in Figure 3-45.

Primary inflows to the land and surface water system include surface water inflows (12,597 taf/yr), precipitation (1,198 taf/yr), groundwater pumping (525 taf/yr), and stream gains from groundwater (337 taf/yr). Surface water inflows include the Sacramento River, other inflows from boundary streams including Stony Creek, as well as overland runoff of precipitation and applied water from upslope lands.

Additionally, diversions from the Sacramento River and from Stony Creek are a key source of surface water inflows.

Primary outflows from the land and surface water system include surface water outflows (12,015 taf/yr), evapotranspiration (1,841 taf/yr), deep percolation (415 taf/yr), and seepage (387 taf/yr). Surface water outflows include outflows through Sacramento River, Colusa Drain, Colusa Weir to Sutter Slough, and outflows to boundary streams including Stony Creek, as well as overland runoff of precipitation and applied water to downslope lands. Evapotranspiration is primarily from agricultural lands but also from managed wetlands, canal evaporation, native vegetation, and urban and industrial lands. Deep percolation is primarily from precipitation, but also from applied water. Seepage includes a combination of stream seepage and seepage from canals and drains.

The average annual change in storage in the land and surface water system (0.1 taf/yr) is negligible due to similar soil moisture content in the root zone, on average, across water years.

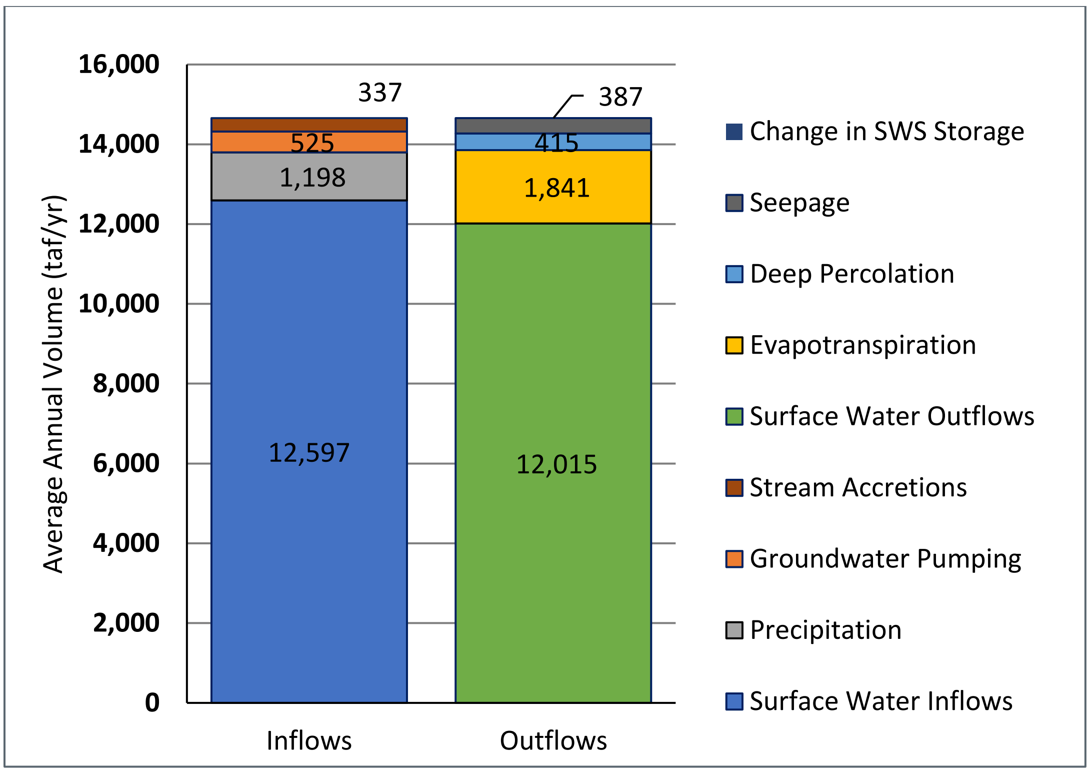


Figure 3-45.Average Annual Future Conditions, 2030 Climate Change Baseline Land and Surface Water System Water Budget Summary (2016-2065, rounded to nearest taf/yr)

Average annual future conditions 2030 climate change baseline groundwater system inflows and outflows were estimated to be 1,010 taf/yr during the 50-year simulation period. Average annual values were presented previously in Table 3-12 are shown graphically in Figure 3-46.

Inflows to the groundwater system include deep percolation (415 taf/yr), seepage (387 taf/yr), subsurface inflows from the Corning, Butte, Sutter, and Yolo Subbasins (205 taf/yr), and change in storage (3 taf/yr). Outflows from the groundwater system include groundwater pumping (525 taf/yr), stream gains from groundwater (337 taf/yr), and subsurface outflows to the Corning, Butte, Sutter, and Yolo Subbasins (148 taf/yr).

There is a very small (-3 taf/yr) change in groundwater storage under the Future Condition, 2030 Climate Change water budget.

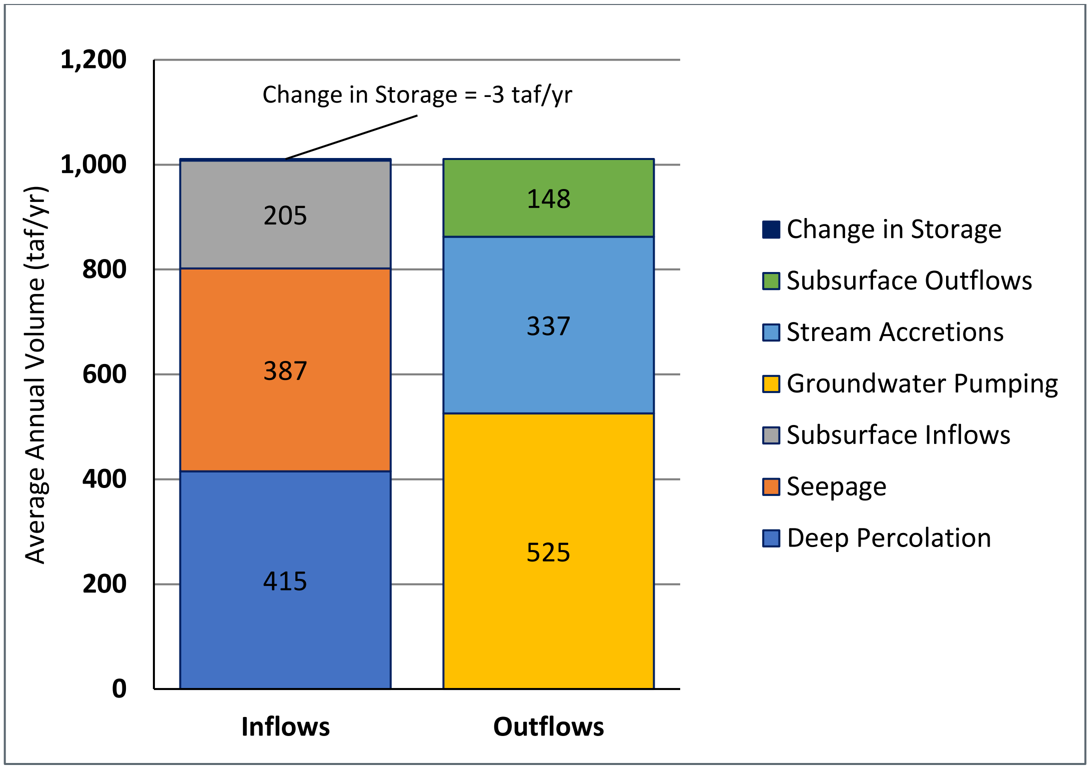


Figure 3-46. Average Annual Future Conditions, 2030 Climate Change Baseline Groundwater System Water Budget Summary (2016-2065, rounded to nearest taf/yr)

3.3.4.3.3 Future Conditions, 2070 Climate Change Baseline

Average annual inflows to and outflows from the Subbasin for the future conditions with 2070 climate change projected land and surface water system baseline water budget were estimated to be approximately 14,855 taf/yr. Average annual values were presented previously in Table 3-11 and are shown graphically in Figure 3-47.

Primary inflows to the land and surface water system include surface water inflows (12,715 taf/yr), precipitation (1,258 taf/yr), groundwater pumping (559 taf/yr), and stream gains from groundwater (323 taf/yr). Surface water inflows include the Sacramento River, other inflows from boundary streams including Stony Creek, as well as overland runoff of precipitation and applied water from upslope lands. Additionally, diversions from the Sacramento River and from Stony Creek are a key source of surface water inflows.

Primary outflows from the land and surface water system include surface water outflows (12,141 taf/yr), evapotranspiration (1,901 taf/yr), deep percolation (411 taf/yr), and seepage (401 taf/yr). Surface water outflows include outflows through Sacramento River, Colusa Drain, Colusa Weir to Sutter Slough, and outflows to boundary streams including Stony Creek, as well as overland runoff of precipitation and applied water to downslope lands. Evapotranspiration is primarily from agricultural lands but also from managed wetlands, canal evaporation, native vegetation, and urban and industrial lands. Deep percolation is primarily from precipitation, but also from applied water. Seepage includes a combination of stream seepage and seepage from canals and drains.

The average annual change in storage in the land and surface water system (0.1 taf/yr) is negligible due to similar soil moisture content in the root zone, on average, across water years.

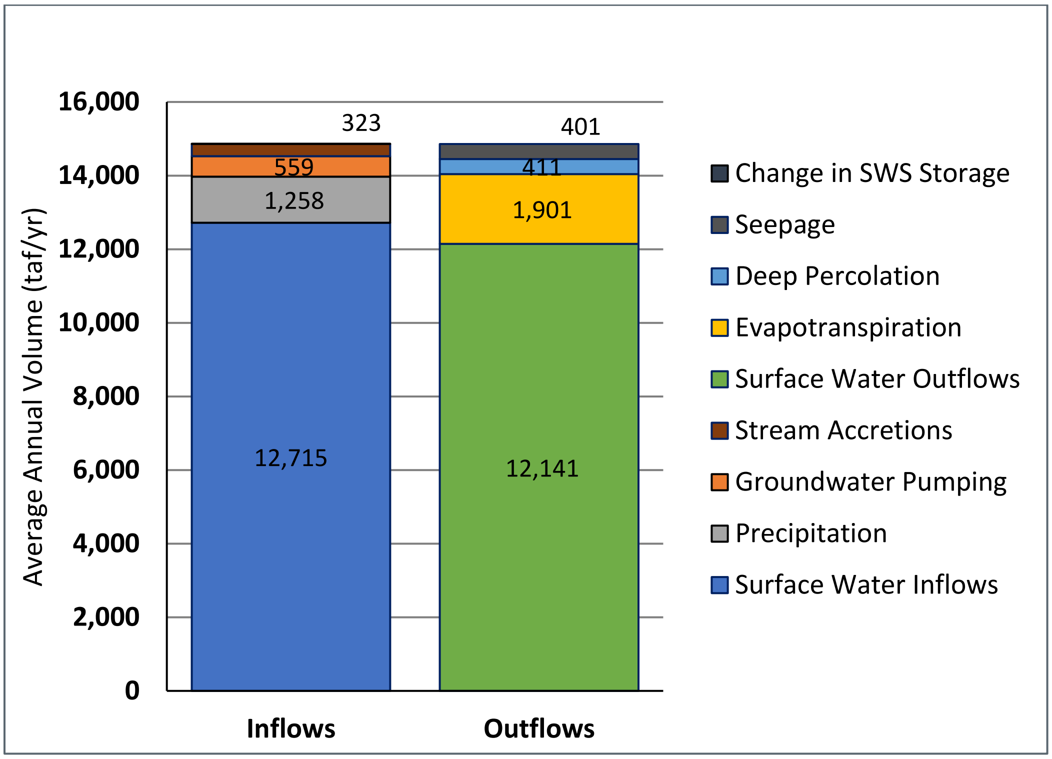


Figure 3-47. Average Annual Future Conditions, 2070 Climate Change Baseline Land and Surface Water System Water Budget Summary (2016-2065, rounded to nearest taf/yr)

Average annual inflows to and outflows from the groundwater system were estimated to be approximately 1,020 to 1,030 taf/yr during the 50-year simulation period. Average annual values were presented previously in Table 3-12 are shown graphically in Figure 3-48.

Inflows to the groundwater system include deep percolation (411 taf/yr), seepage (401 taf/yr), subsurface inflows from the Corning, Butte, Sutter, and Yolo Subbasins (209 taf/yr), and change in groundwater storage (-7 taf/yr). Outflows from the groundwater system include groundwater pumping (559 taf/yr), stream gains from groundwater (323 taf/yr), and subsurface outflows to the Corning, Butte, Sutter, and Yolo Subbasins (147 taf/yr).

There is a very small (-7 taf/yr) change in groundwater storage under the Future Condition, 2070 Climate Change water budget.

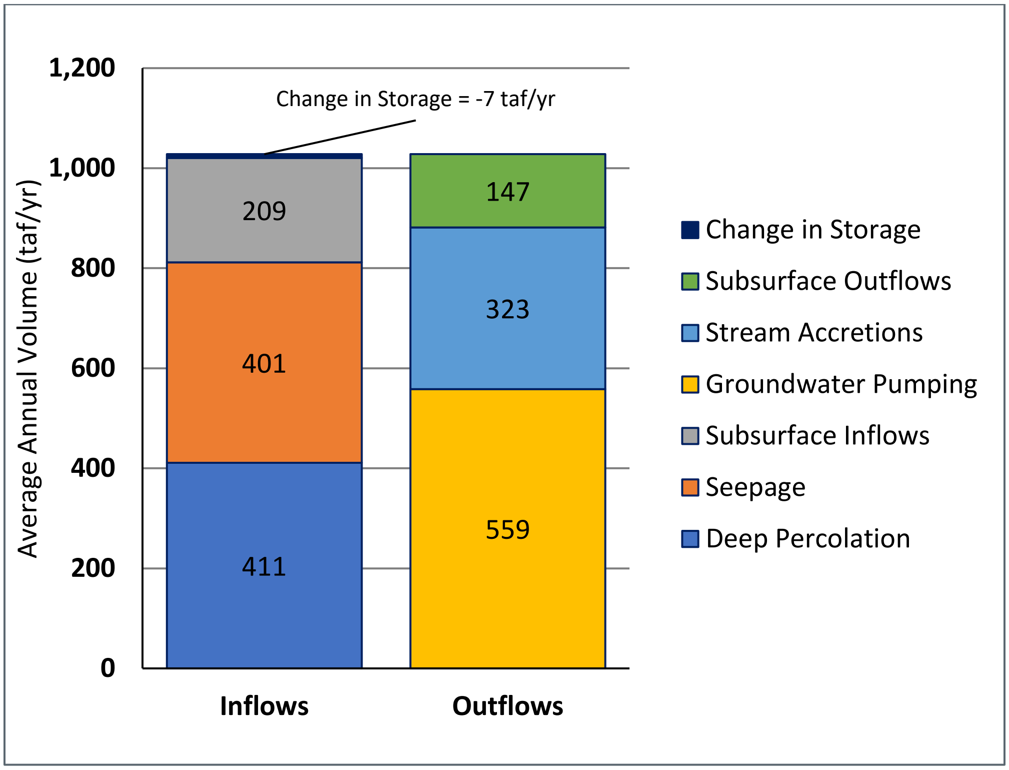


Figure 3-48. Average Annual Future Conditions, 2070 Climate Change Baseline Groundwater System Water Budget Summary (2016-2065, rounded to nearest taf/yr)

3.3.4.3.4 Comparison of Water Budget Scenarios

A figure depicting cumulative change in storage for the current conditions and three future conditions baseline scenarios is provided on the following page (Figure 3-49). In the figure, the cumulative change in groundwater storage is shown for the 50-year hydrologic period. The x-axis (horizontal axis) is labeled with the historical reference year along with the corresponding water year type based on the Sacramento Valley Water Year Index. Years are identified as wet (W), above normal (AN), below normal (BN), dry (D), or critical (C).

Estimated changes in storage are practically zero for the current conditions and future conditions without climate change scenarios. Current conditions and future conditions with no climate change are identical, except for minor urban growth represented in the future scenario without climate change. For the two future with climate change scenarios, there are small decreases in groundwater storage over the 50-year period, due primarily to increased groundwater pumping needed to meet increasing agricultural water demands resulting from climate change. For all scenarios, the changes in groundwater storage are substantial across wet and dry cycles, with the total range in storage change for all scenarios exceeding 800 taf over the 50-year period.

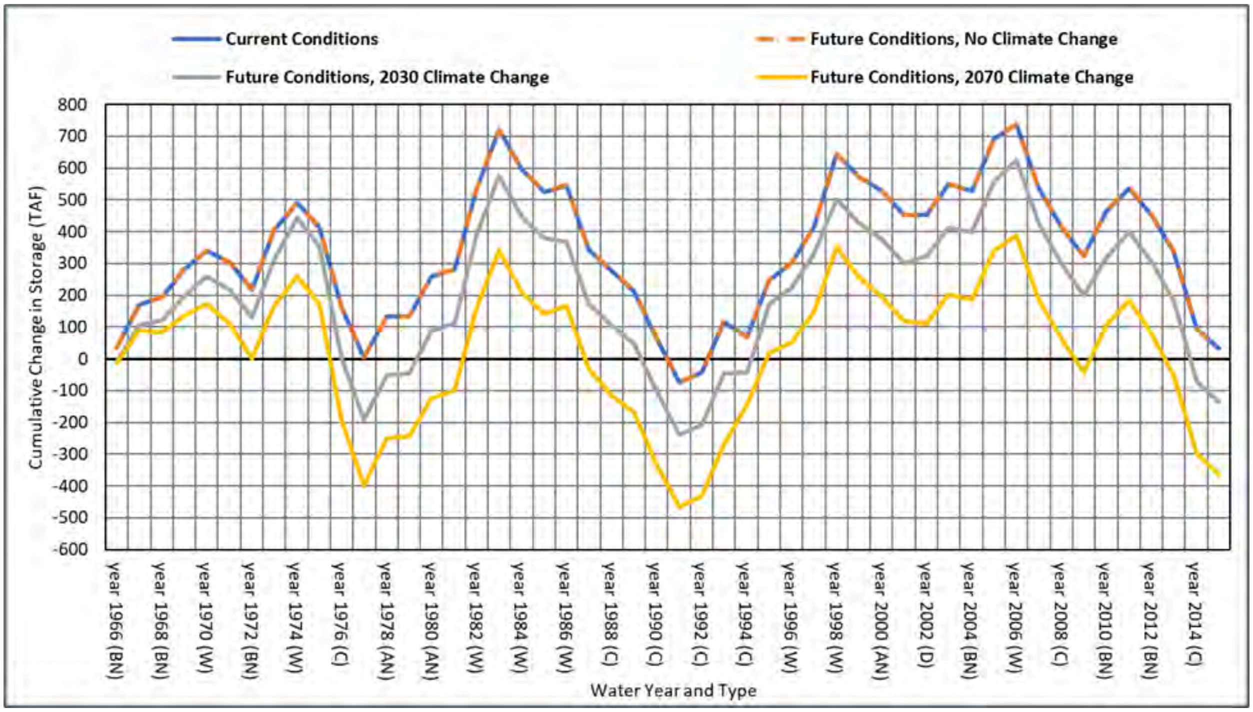


Figure 3-49. Cumulative Change in Groundwater Storage for Current and Future Conditions Baseline Scenarios

3.3.5 Water Budget Uncertainty

Water budget uncertainty refers to a lack of understanding of the subbasin setting that significantly affects an Agency's ability to develop sustainable management criteria and appropriate projects and management actions in a GSP, or to evaluate the efficacy of plan implementation, and therefore may limit the ability to assess whether a subbasin is being sustainably managed. Substantial uncertainty exists in all components of each water budget component. Substantial uncertainty also exits in the assumptions used to project potential future conditions related to planned development and associated urban demands, as well as projections of climate change. Consequently, the estimated negligible or very small changes in groundwater storage for current and future water budgets, calculated as total subbasin inflows minus outflows, are highly uncertain. It is anticipated that confidence in model results will be increased over time through additional monitoring and data collection, refinements to C2VSimFG-Colusa input, and coordination with neighboring subbasins.

However, the uncertainties that currently exist do not substantially limit the ability to develop and implement a GSP for the subbasin including the ability to develop sustainable management criteria and appropriate projects and management actions, including improved monitoring, nor the ability to assess whether the subbasin is being sustainably managed over time. GSPs are by nature iterative, and each opportunity will allow for improvements that will (1) lower uncertainty and (2) facilitate more refined analyses of sustainable management criteria and projects and management actions, and (3) refine the GSP implementation.

3.3.6 Overdraft Conditions

Overdraft refers to a negative average annual change in storage for the groundwater system over time. Based on the current conditions and future conditions with no climate change scenarios, which represent long-term average conditions in the subbasin, overdraft is expected to be negligible or very small in the Subbasin. An average annual change in storage of approximately 0.6 taf/yr is expected, as presented in Table 3-11 previously and Table 3-14 in the following section. However, based on the future condition scenarios with climate change, modest overdraft is expected to occur. Average annual overdraft is approximately 2.7 taf/yr in the 2030 scenario and 7.3 taf/yr in the 2070 scenario, corresponding to cumulative overdraft volumes of 135 taf and 365 taf, respectively, over the 50-year simulation of future conditions.

3.3.7 Sustainable Yield Estimate

As described previously, sustainable yield refers to the maximum quantity of water, calculated over a base period representative of long-term conditions in the subbasin, and including any temporary surplus that can be withdrawn annually from a groundwater supply without causing an undesirable result. Provisional estimates of sustainable yield have been calculated from water budget parameters for each scenario as the long-term annual average groundwater pumping, minus the average annual decrease in groundwater storage, as summarized in Table 3-14. Sustainable subbasin operation is expected to be achievable in current and future conditions scenarios, but modest overdraft is expected in future conditions with 2030 climate change and future conditions with 2070 climate change. Ultimately, it is anticipated that other factors will be considered in refining these sustainable yield estimates as part of development of sustainable management criteria for the subbasin, and as monitoring is improved and operational experience is gained during GSP implementation.

Table 3-14. Estimated Groundwater Pumping, Change in Groundwater Storage, and Sustainable Yield by Baseline Scenario, in taf/yr for the Water Budget Analysis Periods Listed in Table 3-9

Baseline Scenario	Groundwater Pumping	Change in Groundwater Storage	Sustainable Yield
Current	499	1	500
Future, No Climate Change	499	1	500
Future, 2030 Climate Change	525	-3	522
Future, 2070 Climate Change	559	-7	552
Future, 2070 Climate Change with Simulated Projects and Management Actions[a]	510	0	510

(a) Simulated projects and management actions are described in Appendix 6D.

3.4 MANAGEMENT AREAS

The GSP emergency regulations (at §354.20) provide that GSAs "may define one or more management areas with a basin if the Agency has determined that creation of management areas will facilitate implementation of the Plan". Both the CGA and the GGA boards considered defining management areas for purposes of developing and implementing the initial GSP. Both boards reached the conclusion that defining management areas is premature at this time because clear, compelling advantages could not be identified. However, both boards are receptive to the concept of management areas and will give them further consideration during GSP implementation.

CHAPTER 4
Monitoring Networks

Monitoring networks are required to better understand and evaluate changing conditions within the groundwater, surface water, and land surface systems. To optimize data collection and analysis, the network should be easily accessible, spatially and temporally relatable to other monitoring networks, sufficient for demonstrating spatial and temporal trends, and representative of actual conditions. The following sections discuss the Subbasin monitoring network objectives, requirements, monitoring protocols, network sites, data gaps, and proposed actions.

4.1 MONITORING NETWORK OBJECTIVES

Title 23 Section §354.34b of the California Code of Regulations (23 CCR §354.34(b)) states that the monitoring network objectives shall be implemented to:

> *(1) "Demonstrate progress toward achieving measurable objectives described in the [Groundwater Sustainability] Plan.*
>
> *(2) Monitor impacts to the beneficial uses or users of groundwater.*
>
> *(3) Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds.*
>
> *(4) Quantify annual changes in water budget components."*

Monitoring network objectives for the Subbasin were designed to address the requirements of five sustainability indicators (not including seawater intrusion, which is neither occurring nor anticipated to occur in the subbasin over the planning horizon) in support of the future measurable objectives and minimum thresholds. The overarching goals of the monitoring networks are to: (1) characterize current and historical conditions within the groundwater, surface water, and land surface systems, and (2) evaluate future conditions within the groundwater, surface water, and land surface systems due to water management practices, climatic influence, and GSP implementation within the Subbasin.

The monitoring network objectives are to characterize:

- Groundwater levels, availability, and flow characteristics, including impacts to groundwater storage;
- Surface water availability and interactions with groundwater, including impacts to native riparian land and groundwater dependent ecosystems (GDEs);
- Quality of groundwater; and,
- Extent and rate of land subsidence.

4.2 MONITORING NETWORKS

The following sections describe the monitoring sites included in the Subbasin groundwater level, groundwater quality, land subsidence, and surface water monitoring networks. Most of the networks consist of existing monitoring and reporting programs and are reliant on data collected and provided by other agencies. The Subbasin GSAs will continue to coordinate and collaborate with the other agencies regarding their monitoring programs, including changes to monitoring sites, monitoring protocols or frequencies, and management actions. Data acquisition is not anticipated to be an issue. If necessary, the

GSAs will consider implementing their own monitoring programs to address concerns over undesirable results, data gaps in the monitoring networks, or GSP project needs.

4.2.1 Groundwater Level Monitoring

Groundwater levels are and will continue to be monitored to evaluate groundwater elevations (GWE), reduction in groundwater storage, and stream-aquifer interactions throughout the subbasin. The GSP groundwater level monitoring network is based on the pre-existing groundwater monitoring networks of Colusa and Glenn Counties.

4.2.1.1 Requirements

The groundwater monitoring network should have sufficient density to represent spatial and temporal trends through the Subbasin:

- Spatial densities should sufficiently represent both lateral and vertical extents of the groundwater subbasin.
  - The quantity and density of groundwater monitoring wells should be sufficient to evaluate overall static groundwater conditions for each principal aquifer and sufficiently support evaluation of impacts from GSP implementation and water and land management practices.
  - The quantity and density of groundwater monitoring wells shall be sufficient to evaluate groundwater conditions for the subbasin (23 CCR §354.34(d)).
- Groundwater monitoring network shall be designed such that the sustainability indicators are adequately covered, not just over the entire groundwater basin, but also within any specific GSP-defined management areas (23 CCR §354.34(d)), of which there are none currently defined within the Subbasin. The sustainability indicators supported by the groundwater level monitoring network include:
  - **Chronic lowering of groundwater levels**
    - 23 CCR §354.34(c)(1) specifies that the groundwater monitoring network shall be sufficient to represent the seasonal occurrence, flow direction, and hydraulic gradients of groundwater within and between the principal aquifer and surface waters.
    - The representative groundwater level monitoring network is discussed in Section 4.2.5.1.
  - **Reduction in groundwater storage**
    - Data from the groundwater monitoring network shall be sufficient to enable calculations of annual changes in groundwater storage over time (Monitoring Network Best Management Practice [BMP], California Department of Water Resources [DWR], 2016b).
    - The representative groundwater quality monitoring network is discussed in Section 4.2.5.
  - **Depletion of interconnected surface water**
    - The groundwater monitoring network shall be sufficient to represent the seasonal occurrence, flow direction, and hydraulic gradients of groundwater between the principal aquifer and surface waters (23 CCR §354.34(c)(6)). Per the Monitoring Network BMP (DWR, 2016b), shallow groundwater monitoring wells should be appropriately located with respect to connected streams to enable characterization

of the groundwater levels adjacent to connected stream channels. The groundwater monitoring network should extend away from and along the stream course at appropriate intervals and be monitored on a frequency to capture seasonal pumping conditions (DWR, 2016b).

- The representative groundwater quality monitoring network is discussed in Section 4.2.5 and the surface water monitoring network is discussed in Section 4.2.4.

The Monitoring Network BMP states that the groundwater monitoring network should be able to provide data sufficient to:

- Represent the unconfined and confined parts of the principal aquifer.
- Support evaluation of groundwater level data to support evaluation of stream-aquifer interactions, impacts to GDEs, declining GWE, reduction in groundwater storage, and impacts to land subsidence.
- Support delineation of areas with declining GWE, recharge areas, and conditions at subbasin boundaries.
- Groundwater level monitoring frequencies shall be capable of representing:
  - Short-term, seasonal, and long-term trends (i.e., minimum of twice-annually to represent seasonal high and low groundwater conditions) per 23 CCR §354.34(c)(1)(b)).
  - Groundwater conditions, as necessary, to evaluate the progress of GSP implementation (23 CCR §354.34(a)).

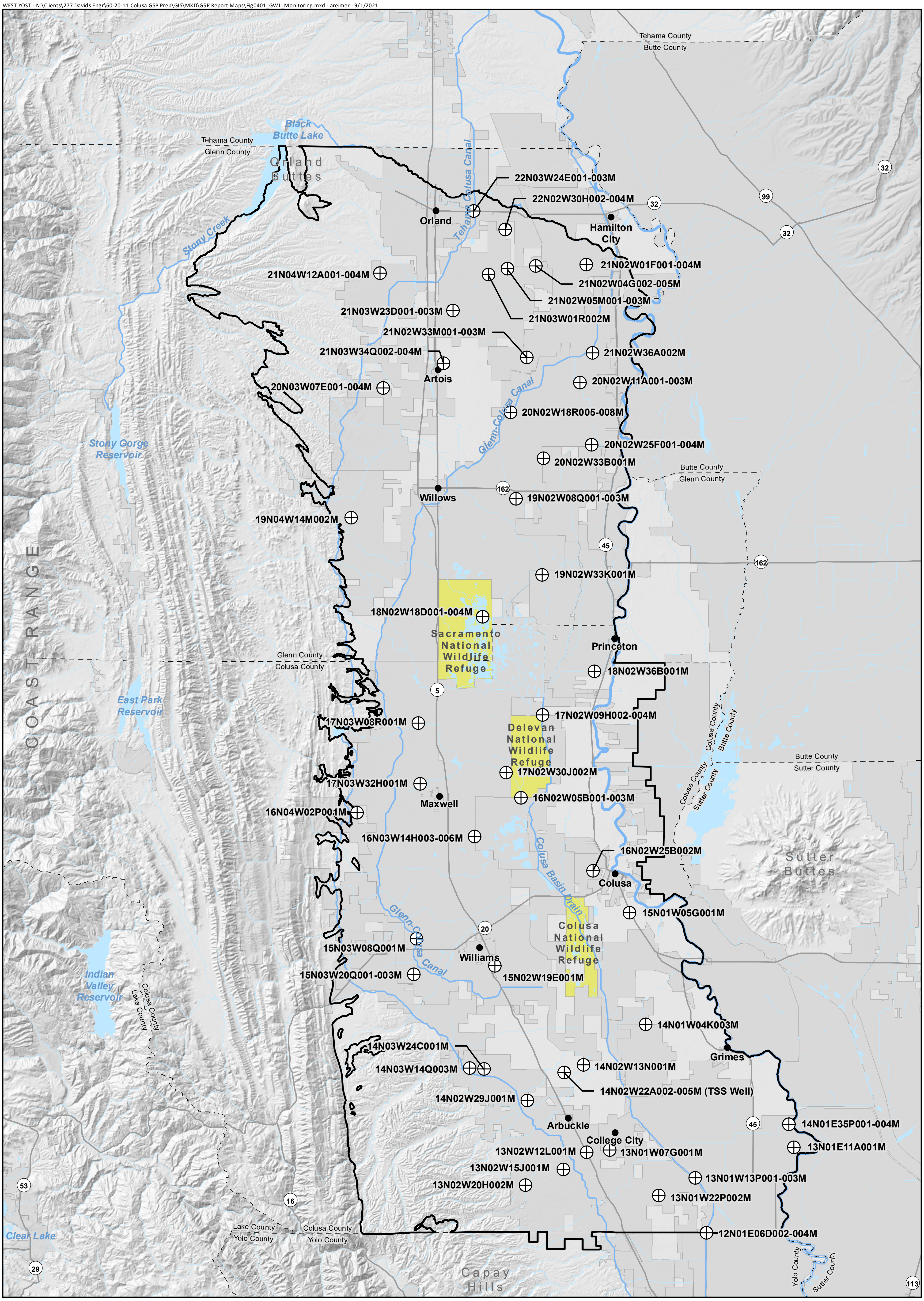
The Subbasin groundwater level monitoring network meets these requirements. Data gaps in the network are discussed in Section 4.2.1.4.

4.2.1.2 Groundwater Level Monitoring Network

The Subbasin groundwater monitoring network wells shown on Figure 4-1 are a combination of pre-SGMA Colusa County groundwater monitoring wells and pre-SGMA Glenn County dedicated groundwater monitoring wells (Glenn County wells that are dedicated observation wells and not used for supply). For the Glenn County wells, these exclude the Basin Management Objective (BMO) water supply wells and the wells included in the Glenn County annual water quality monitoring program discussed in Section 2.2. The Colusa County groundwater monitoring network includes active water supply wells as part of the County's groundwater level monitoring program.

All of the wells originally used for monitoring purposes by Colusa and Glenn Counties were assessed for their suitability as a groundwater monitoring network well. Table 4-1 lists the criteria used for evaluating the groundwater monitoring wells in the Subbasin groundwater monitoring network. These criteria were identified based on the groundwater monitoring network requirements discussed in the Monitoring Network BMP and 23 CCR §354.34.

There are 104 completions in 48 wells in the Subbasin groundwater level monitoring network. All of these wells are currently included in the California Statewide Groundwater Elevation Monitoring Program (CASGEM) database and monitored by DWR. Table 4-2 contains the entire current groundwater monitoring network with State Well Numbers (SWNs), CASGEM IDs, well completion report IDs, well status and use, location information, reference point information, construction, principal aquifer designations, and quality assessment categories. Well completion reports for the current Subbasin groundwater monitoring network wells, if available, are included in Appendix 4A.



⊕ Groundwater Monitoring Network Well

Colusa Subbasin

Water Agencies

U.S. Fish and Wildlife Refuge

Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

N

0 2.5 5

Scale in Miles

Figure 4-1

Groundwater Monitoring Network Wells

Colusa Groundwater Authority and Glenn Groundwater Authority

Colusa Subbasin

Groundwater Sustainability Plan

Table 4-1. Assessment Categories of the Groundwater Monitoring Network Wells

Characteristic	Importance
Known Construction Characteristics	Known well construction characteristics will enable evaluation of groundwater conditions at specific depths within the principal aquifer. Examples of construction characteristics include borehole depth, screened intervals, and the presence of seals within the annular fill.
Nested Multiple Completion Wells	Nested, multiple completion wells allow the measurement of water levels at discrete depths within the aquifer system. The degree of confinement of the aquifer increases with depth. Multiple completion wells can provide insight into how the aquifer system is connected and allow estimates of vertical gradients and vertical hydraulic conductivity to be made.
Non-Dedicated Monitoring Wells	Pumping causes cones of depression that impact the water levels at and near the pumping well. Pumping water levels are not indicative of the static condition of the aquifer system and can skew estimates of groundwater storage. Pumping wells included in the groundwater monitoring network should be verified as inactive when measurements are made.
Proximity to Streams and Interconnected Surface Waters	Wells, including multiple completion wells, near streams or interconnected surface waters are useful for evaluating interaction between the aquifer and interconnected streams and surface waters. Vertical hydraulic gradients measured in wells near stream gages can provide insight regarding the direction of flow into or away from the surface water feature.
Lateral and Vertical Density	To characterize groundwater levels throughout the Subbasin, accessible monitoring sites should be spatially distributed throughout the area of interest. Not only should the monitoring sites be distributed laterally, but their screened intervals should also be set at representative depths within the principal aquifer.
Accessibility and Usability	The monitoring sites need to be easily accessible by field staff. Additionally, well completions should be clear down-hole to allow access of water level measuring equipment.

Known Construction. Construction details are known for all but one of the groundwater monitoring wells (Table 4-2 and Figure 4-1). Colusa County monitoring well 13N02W12L001 is a U.S. Bureau of Reclamation (USBR) well without well construction information. This well is listed in Table 4-2 and shown on Figure 4-1 because there is historical groundwater level data available for the well.

Nested Multiple Completion Wells. Of the 48 groundwater monitoring sites (104 separate completions) shown on Figure 4-1 and listed in Table 4-2, over 20 are nested multiple completion wells. These nested wells are screened at discrete depths up to a maximum depth of 1,180 feet below ground surface. The nested wells enable measurement of vertical head gradients within the principal aquifer. Additionally, the nested wells support monitoring of the groundwater system and interconnected surface waters. The current groundwater monitoring network contains wells that provide a lateral and vertical density sufficient to enable characterization of groundwater within the principal aquifer.

Non-Dedicated Monitoring Wells. The majority of the active domestic, irrigation, and stock water wells included in the current groundwater monitoring network are located in Colusa County. The Monitoring Network BMP allows the temporary inclusion of water supply wells in the groundwater monitoring network if the wells are screened within a single water-bearing unit. Of these wells, three were identified to be perforated across broad depth intervals, potentially with different degrees of confinement, but all still zoned within the principal aquifer. These three wells are 18N02W36B001 (near Princeton), 15N03W08Q001 (west of Williams), and 14N02W13N001 (north of Arbuckle).

Proximity to Streams and Interconnected Surface Waters. The subbasin is bounded and traversed by irrigation canals and drains, as well as perennial, ephemeral, and intermittent streams. Many of the surface waters are near wells included in the current groundwater monitoring network, except for surface waters in the following areas:

- Within the Colusa National Wildlife Refuge, east of Williams (Figure 4-1). There are no network groundwater monitoring wells near the Colusa National Wildlife Refuge.
- North and northwest of Orland near Stony Creek.
- Northwest of Artois along the middle reaches of Walker Creek.
- Northwest of Willows along the middle reaches of Willow Creek.

Lateral and Vertical Density. The groundwater monitoring network has a lateral density of approximately 9.2 completions per 100 square miles and 4.2 well boreholes per 100 square miles in the principal aquifer, averaged over the entire subbasin. These well densities are sufficient to evaluate groundwater level trends throughout the subbasin, in accordance with the recommendations listed in the Monitoring Network BMP (DWR, 2016b). Additionally, there are sufficient depth-specific wells located throughout the subbasin to evaluate groundwater elevation trends, groundwater storage, surface water connectivity, and aquifer characteristics with depth.

Accessibility and Usability. Five completions within three wells included in the Glenn County or Colusa County monitoring networks were determined to be unusable due to damaged casings. These include 13N02W04G001, -003, -004, 16N03W35N002, and 22N03W28P002 (shown on Figure 4-2). These wells are not included in the Subbasin groundwater level monitoring network but are shown on Figure 4-2 along with one suggested replacement well. The suggested replacement well is an existing well with known construction. All of the Subbasin groundwater monitoring network wells listed in Table 4-2 are accessible for field investigations. However, the accessibility of these sites should be verified via site visits.

Table 4-2. Groundwater Monitoring Network Wells

No.	County	State Well Number	CASGEM[a] Station ID	Well Completion Report ID	Latitude, decimal degrees	Longitude, decimal degrees	Datum	Well Use	Well Status	Well Completion Type (single or nested)	Ground Surface Elevation, feet	Reference Point Elevation, feet	Reference Point Description	Borehole Depth, feet, bgs[b]	Completed Well Depth, feet, bgs	Screen Intervals, feet, bgs	Total Length of Screen, feet	Casing Diameter, inches	Representative GWL Site [c]	Representative ISW Site [d]	Primary Geologic Formation	Assessment Category: Existing Monitoring Network	Known Construction	Non-Pumping Well	Nested Well	Proximity to Surface Water[e]	Accessible and Usable	Notes
1	Colusa	12N01E06D002	16330	DWR, 2001[f]	38.92490	-121.91400	NAD 83[g]	Observation	active	nested	27.94	26.76	top of casing	1020	729	710-720	10	2			Tehama	x	x	x	x	x	x	Local Well LCB-4 Deep.
2	Colusa	12N01E06D003	33886	DWR, 2001	38.92490	-121.91400	NAD 83	Observation	active	nested	27.94	30.32	top of casing	1020	505	485-495	10	2			Tehama	x	x	x	x	x	x	Local Well LCB-4 Middle.
3	Colusa	12N01E06D004	16331	DWR, 2001	38.92490	-121.91400	NAD 83	Observation	active	nested	27.94	30.72	top of casing	1020	298	275-285	10	2	x		Tehama	x	x	x	x	x	x	Local Well LCB-4 Shallow.
4	Colusa	13N01E11A001	18534	2865	38.99371	-121.82401	NAD 83	Domestic	active	single	31.8	32.8	top of casing	158	145	136-158	22	8	x	x	Alluvium	x	x			x	x	Approximate screen or open hole 136-158 feet (Roy Hull, DWR, 2017)[h].
5	Colusa	13N01W07G001	36246	2868	38.99161	-122.01411	NAD 83	Irrigation	active	single	90.47	90.47	plug at top of casing, west side	180	180	108-180	72	12	x	x	Alluvium	x	x				x	
6	Colusa	13N01W13P001	18549	DWR, 2001	38.96935	-121.92587	NAD 83	Observation	active	nested	32.23	33.52	top of casing	1000	885	865-875	10	2			Tehama	x	x	x	x	x	x	Local Well LCB-1 Deep.
7	Colusa	13N01W13P002	25159	DWR, 2001	38.96935	-121.92587	NAD 83	Observation	active	nested	32.23	34.58	top of casing	1000	480	410-420 450-456	16	2			Tehama	x	x	x	x	x	x	Local Well LCB-1 Middle.
8	Colusa	13N01W13P003	36248	DWR, 2001	38.96935	-121.92587	NAD 83	Observation	active	nested	32.23	35.49	top of casing	1000	355	271-278	7	2	x		Tehama	x	x	x	x	x	x	Local Well LCB-1 Shallow.
9	Colusa	13N01W22P002	16357	40376	38.95531	-121.96311	NAD 83	Irrigation	active	single	60.46	61.16	not provided	236	236	196-236	40	12	x		Tehama	x	x				x	USBR[i] well.
10	Colusa	13N02W12L001	31899	115408	38.98981	-122.03751	NAD 83	Irrigation	active	single	135.49	135.99	not provided	778	NA[j]	NA	NA	NA	x		Tehama						x	USBR well.
11	Colusa	13N02W15J001	39884	77457	38.97631	-122.06161	NAD 83	Domestic	active	single	212.52	213.02	hole in plate	362	362	270-362	92	8	x		Tehama	x	x				x	
12	Colusa	13N02W20H002	25005	423344	38.96341	-122.10091	NAD 83	Domestic	active	single	342.58	343.58	not provided	320	320	200-260 300-320	80	5	x		Tehama	x	x				x	
13	Colusa	14N01E35P001	38718	E0109311A	39.01241	-121.82906	NAD 83	Observation	active	nested	46.88	48.74	not provided	1540	1039	985-995	10	2.5			Tehama	x	x	x	x	x	x	
14	Colusa	14N01E35P002	24655	E0109311B	39.01241	-121.82906	NAD 83	Observation	active	nested	46.88	48.36	not provided	1540	736	545-555 610-620 695-705	30	2.5			Tehama	x	x	x	x	x	x	
15	Colusa	14N01E35P003	24656	E0109311C	39.01241	-121.82906	NAD 83	Observation	active	nested	46.88	48	not provided	1540	275	135-145 215-225	20	2.5	x		Alluvium, Tehama	x	x	x	x	x	x	
16	Colusa	14N01E35P004	24657	E0109311D	39.01241	-121.82906	NAD 83	Observation	active	nested	46.88	47.62	not provided	1540	71	50-60	10	2.5			Alluvium	x	x	x	x	x	x	
17	Colusa	14N01W04K003	18554	USGS[k] Well Log	39.09301	-121.97671	NAD 83	Irrigation	inactive	single	37.43	37.43	top of casing, under pump base, northwest side	73	73	46-70	24	16	x	x	Alluvium	x	x				x	USBR well.
18	Colusa	14N02W13N001	18563	3027	39.06021	-122.04111	NAD 83	Irrigation	active	single	62.45	62.45	not provided	392	392	104-392	288	14	x		Alluvium, Tehama	x	x			x	x	USBR well.
19	Colusa	14N02W22A002	54756	WCR2020_ 003773	39.05398	-122.06067	NAD 83	Observation	active	nested	84	87.055	top of tallest casing	1200	1050	1020-1030	10	2	x		Tehama		x	x	x		x	
20	Colusa	14N02W22A003	54757	WCR2020_ 003773	39.05398	-122.06067	NAD 83	Observation	active	nested	84.38	86.9	top of 2nd tallest casing	1200	950	860-870 920-930	20	2			Tehama		x	x	x		x	
21	Colusa	14N02W22A004	54758	WCR2020_ 003773	39.05398	-122.06067	NAD 83	Observation	active	nested	84	86.825	top of 2nd shortest casing	1200	610	580-590	10	2			Tehama		x	x	x		x	
22	Colusa	14N02W22A005	54758	WCR2020_ 003773	39.05398	-122.06067	NAD 83	Observation	active	nested	84	86.69	top of shortest casing	1200	320	290-300	10	2			Alluvium, Tehama		x	x	x		x	
23	Colusa	14N02W29J001	18566	44455	39.03171	-122.09911	NAD 83	Irrigation	active	single	162.5	162.5	not provided	924	412	119-143 152-158 176-182 198-208 215-239 264-276 307.5-319.5 334.5-349.5	109	12	x		Tehama	x	x			x	x	
24	Colusa	14N03W14Q003	32324	20032	39.05761	-122.15861	NAD 83	Irrigation	active	single	172.52	172.52	open hole in pump base	704	685	390-480 500-590 614-685	251	16	x		Tehama	x	x			x	x	
25	Colusa	14N03W24C001	16691	72290	39.05691	-122.14351	NAD 83	Domestic	active	single	172.51	172.81	not provided	320	312	292-312	20	8	x		Tehama		x				x	USBR well. Records indicate the well is 160 feet deep (Roy Hull, DWR, 2017).
26	Colusa	15N01W05G001	14309	12982	39.18261	-121.99351	NAD 83	Domestic	active	single	47.42	48.82	not provided	140	140	75-140	65	8	x	x	Alluvium	x	x				x	Well is either screened or open hole after 75 feet.
27	Colusa	15N02W19E001	14319	71038	39.14011	-122.13251	NAD 83	Irrigation	inactive	single	87.46	88.11	top of casing	334	334	162-182 198-206 262-274 290-294 310-334	72	14	x		Alluvium, Tehama	x	x	x			x	Irrigation well with no pump installed.
28	Colusa	15N03W08Q001	NA	492125	39.16139	-122.21378	NAD 83	Irrigation	NA	single	NA	NA	NA	360	350	30-130 250-350	200	10.75 16	x		Alluvium, Tehama	x	x		x	x	x	
29	Colusa	15N03W20Q001	38293	802508C	39.13302	-122.21647	NAD 83	Observation	active	nested	128.56	130.32	top of short casing	620	424	370-410	40	2.5			Tehama	x	x	x	x	x	x	
30	Colusa	15N03W20Q002	24470	802508B	39.13302	-122.21647	NAD 83	Observation	active	nested	128.56	130.66	top of middle casing	620	170	130-160	30	2.5	x		Tehama	x	x	x	x	x	x	

Table 4-2. Groundwater Monitoring Network Wells

No.	County	State Well Number	CASGEM[a] Station ID	Well Completion Report ID	Latitude, decimal degrees	Longitude, decimal degrees	Datum	Well Use	Well Status	Well Completion Type (single or nested)	Ground Surface Elevation, feet	Reference Point Elevation, feet	Reference Point Description	Borehole Depth, feet, bgs[b]	Completed Well Depth, feet, bgs	Screen Intervals, feet, bgs	Total Length of Screen, feet	Casing Diameter, inches	Representative GWL Site [c]	Representative ISW Site [d]	Primary Geologic Formation	Assessment Category: Existing Monitoring Network	Known Construction	Non-Pumping Well	Nested Well	Proximity to Surface Water[e]	Accessible and Usable	Notes
31	Colusa	15N03W20Q003	38294	802508A	39.13302	-122.21647	NAD 83	Observation	active	nested	128.56	131	top of tall casing	620	82	30-80	50	2.5			Alluvium	x	x	x	x	x	x	
32	Colusa	16N02W05B001	25511	726832C	39.27527	-122.10568	NAD 83	Observation	active	nested	65	66.91	top of casing	986	797	730-750	20	4			Tehama	x	x	x	x	x	x	
33	Colusa	16N02W05B002	25512	726832B	39.27527	-122.10568	NAD 83	Observation	active	nested	65	65.55	not provided	986	535	462-472	10	2.5			Tehama	x	x	x	x	x	x	
34	Colusa	16N02W05B003	38669	726832A	39.27527	-122.10568	NAD 83	Observation	active	nested	65	66.34	not provided	986	301	174-184 246-256	20	2.5	x		Tehama	x	x	x	x	x	x	
35	Colusa	16N02W25B002	33868	Owner's Log	39.21651	-122.03121	NAD 83	Domestic	active	single	55.42	55.42	not provided	274	274	254-274	20	8	x		Tehama	x	x			x	x	Construction and lithology information provided by owner.
36	Colusa	16N03W14H003	24683	E0116237D	39.24391	-122.15401	NAD 83	Observation	active	nested	65.7	68.5	top of tallest	1500	1481	1370-1380 1410-1420	20	2.5			Tehama	x	x	x	x	x	x	Artesian flowing well.
37	Colusa	16N03W14H004	24684	E0116237C	39.24391	-122.15401	NAD 83	Observation	active	nested	65.7	68.21	top of second tallest	1500	1236	1140-1150 1170-1180	20	2.5			Tehama	x	x	x	x	x	x	
38	Colusa	16N03W14H005	37673	E0116237B	39.24391	-122.15401	NAD 83	Observation	active	nested	65.7	67.91	top of second shortest	1500	775	720-730	10	2.5			Tehama	x	x	x	x	x	x	
39	Colusa	16N03W14H006	24685	E0116237A	39.24391	-122.15401	NAD 83	Observation	active	nested	65.7	67.68	top of shortest	1500	378	295-305	10	2.5	x		Tehama	x	x	x	x	x	x	
40	Colusa	16N04W02P001	16308	77484	39.26291	-122.27541	NAD 83	Stock	active	single	162.53	163.03	not provided	203	203	112-203	91	8.625	x		Tehama	x	x			x	x	
41	Colusa	17N02W09H002	25514	726866A	39.34170	-122.08377	NAD 83	Observation	active	nested	67	69.36	top of casing	940	806	779-800	21	4			Tehama	x	x	x	x	x	x	
42	Colusa	17N02W09H003	25761	726866B	39.34170	-122.08377	NAD 83	Observation	active	nested	67	68.54	top of southernmost casing	940	578	460-470 510-520	20	2.5			Tehama	x	x	x	x	x	x	
43	Colusa	17N02W09H004	25515	726866C	39.34170	-122.08377	NAD 83	Observation	active	nested	67	68.78	top of northernmost casing	940	302	250-260	10	2.5	x		Tehama	x	x	x	x	x	x	
44	Colusa	17N02W30J002	16960	57983	39.29541	-122.12121	NAD 83	Domestic	active	single	63.43	63.43	not provided	182	159	157-159	2	6	x	x	Tehama	x	x				x	
45	Colusa	17N03W08R001	39127	49451	39.33521	-122.21241	NAD 83	Domestic	active	single	107.46	108.46	not provided	151	130	125-130	5	6	x		Alluvium	x	x			x	x	
46	Colusa	17N03W32H001	35475	93568	39.28610	-122.21046	NAD 83	Domestic	active	single	100.47	102.47	not provided	140	112	68-72 104-112	12	6.625	x		Alluvium	x	x				x	
47	Colusa	18N02W36B001	16914	177869	39.37721	-122.02981	NAD 83	Irrigation	unknown	single	75.4	76	square hole in disk blade atop well	455	410	88-128 195-225 240-340	170	18 18 16	x		Alluvium, Tehama	x	x			x	x	
48	Glenn	18N02W18D001	24953	E045412	39.42083	-122.14578	NAD 83	Observation	active	nested	82.43	83.03	top of shortest PVC	1200	1000	975-985	10	2.5			Tuscan A	x	x	x	x	x	x	
49	Glenn	18N02W18D002	38201	E045412	39.42083	-122.14578	NAD 83	Observation	active	nested	83.43	83.43	top of second shortest PVC	1200	700	620-630 670-680	20	2.5			Tuscan C		x	x	x	x	x	
50	Glenn	18N02W18D003	24992	E045412	39.42083	-122.14578	NAD 83	Observation	active	nested	84.43	84.03	top of second tallest PVC	1200	530	510-520	10	2.5			Tehama		x	x	x	x	x	
51	Glenn	18N02W18D004	38358	E045412	39.42083	-122.14578	NAD 83	Observation	active	nested	85.43	84.43	top of tallest PVC	1200	266	246-256	10	2.5	x		Tehama		x	x	x	x	x	
52	Glenn	19N02W08Q001	25762	726952	39.51596	-122.11143	NAD 83	Observation	active	nested	108.36	120	top of casing	1000	939.7	856.6-876.6	20	2.5			Tehama	x	x	x	x	x	x	
53	Glenn	19N02W08Q002	25763	726952	39.51595	-122.11143	NAD 83	Observation	active	nested	108.36	109.38	westernmost piezometer	1000	228	208-218	10	2.5	x		Tehama	x	x	x	x	x	x	
54	Glenn	19N02W08Q003	25764	726952	39.51596	-122.11143	NAD 83	Observation	active	nested	108.36	109.56	easternmost piezometer	1000	97	77-87	10	2.5			Tehama	x	x	x	x	x	x	
55	Glenn	19N02W33K001	19793	581475	39.45469	-122.08402	NAD 83	Irrigation	active	single	87.41	87.11	top of western sounding pipe	300	260	160-260	100	16	x		Tehama		x				x	
56	Glenn	19N04W14M002	25787	816220	39.50037	-122.28269	NAD 83	Observation	active	single	185.83	187.83	top of casing	366	65	45-55	10	2.5	x		Alluvium	x	x	x			x	Local Well GCAB303-1.
57	Glenn	20N02W11A001	17170	3669	39.60922	-122.04491	NAD 83	Observation	active	nested	125.40	125.90	top of board on northernmost piezometer	700	90	70-90	20	1.5	x	x	Modesto	x	x	x	x		x	
58	Glenn	20N02W11A002	17171	3669	39.60922	-122.04491	NAD 83	Observation	active	nested	125.40	125.90	top of board on southernmost piezometer	700	160	140-160	20	1.5			Tehama	x	x	x	x		x	
59	Glenn	20N02W11A003	35614	3669	39.60922	-122.04491	NAD 83	Observation	active	nested	125.40	125.90	top of board on middle piezometer	700	510	490-510	20	1.5			Tehama	x	x	x	x		x	
60	Glenn	20N02W18R005	23986	801448	39.58552	-122.11701	NAD 83	Observation	active	nested	131.38	132.45	top of lowest casing	1020	1000	920-930 970-980	20	2			Tuscan AB	x	x	x	x	x	x	
61	Glenn	20N02W18R006	23987	801448	39.58552	-122.11701	NAD 83	Observation	active	nested	131.38	132.98	top of second lowest casing	1020	675	635-655	20	2			Tehama	x	x	x	x	x	x	
62	Glenn	20N02W18R007	24259	801448	39.58552	-122.11701	NAD 83	Observation	active	nested	131.38	133.43	top of second highest casing	1020	545	450-460 515-526	20	2			Tehama	x	x	x	x	x	x	
63	Glenn	20N02W18R008	23988	801448	39.58552	-122.11701	NAD 83	Observation	active	nested	131.38	133.97	top of highest casing	1020	201	140-150 170-180	20	2	x		Modesto	x	x	x	x	x	x	
64	Glenn	20N02W25F001	23989	782025	39.55949	-122.03263	NAD 83	Observation	active	nested	102.20	105.56	top of lowest casing	1000	980	940-960	20	2			Tehama	x	x	x	x		x	Artesian flowing well; Data logger installed August 2016.

Table 4-2. Groundwater Monitoring Network Wells

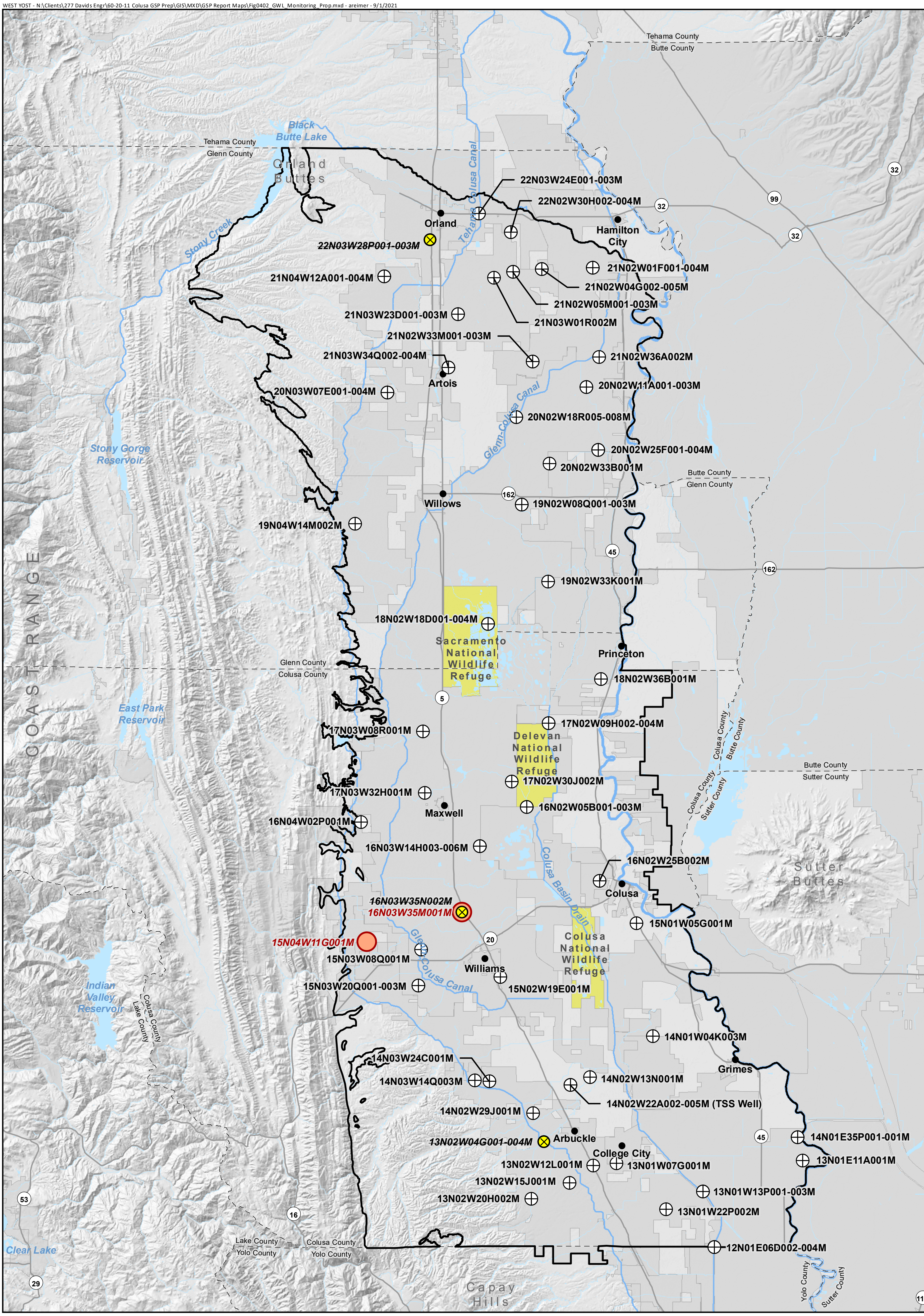
No.	County	State Well Number	CASGEM[a] Station ID	Well Completion Report ID	Latitude, decimal degrees	Longitude, decimal degrees	Datum	Well Use	Well Status	Well Completion Type (single or nested)	Ground Surface Elevation, feet	Reference Point Elevation, feet	Reference Point Description	Borehole Depth, feet, bgs[b]	Completed Well Depth, feet, bgs	Screen Intervals, feet, bgs	Total Length of Screen, feet	Casing Diameter, inches	Representative GWL Site[c]	Representative ISW Site[d]	Primary Geologic Formation	Assessment Category: Existing Monitoring Network	Known Construction	Non-Pumping Well	Nested Well	Proximity to Surface Water[e]	Accessible and Usable	Notes
65	Glenn	20N02W25F002	23990	782025	39.55949	-122.03263	NAD 83	Observation	active	nested	102.20	105.86	top of second lowest casing	1000	490	420-430 460-470	20	2			Tehama	x	x	x	x		x	Artesian flowing well.
66	Glenn	20N02W25F003	25519	782025	39.55950	-122.03263	NAD 83	Observation	active	nested	102.20	104.58	top of second highest casing	1000	280	190-200 250-260	20	2			Tehama	x	x	x	x		x	
67	Glenn	20N02W25F004	23991	782025	39.55949	-122.03263	NAD 83	Observation	active	nested	102.20	105.10	top of highest casing	1000	85	55-65	10	2	x	x	Tehama	x	x	x	x		x	
68	Glenn	20N02W33B001	17174	3686	39.54846	-122.08307	NAD 83	Observation	active	single	105.41	107.01	bottom of box	326	320	100-120 200-320	20 120	6	x		Tehama	x	x	x		x	x	
69	Glenn	20N03W07E001	37860	E057712D	39.60475	-122.24962	NAD 83	Observation	active	nested	179.17	180.83	top of lowest casing	1400	1030	984-1014	30	2			Tehama	x	x	x	x	x	x	
70	Glenn	20N03W07E002	24329	E057712C	39.60476	-122.24962	NAD 83	Observation	active	nested	179.17	181.06	top of second lowest casing	1400	656	616-636	20	2			Tehama	x	x	x	x	x	x	
71	Glenn	20N03W07E003	24330	E057712B	39.60475	-122.24962	NAD 83	Observation	active	nested	179.17	181.47	top of second highest casing	1400	505	380-410 465-485	50	2			Tehama	x	x	x	x	x	x	
72	Glenn	20N03W07E004	37861	E057712A	39.60475	-122.24962	NAD 83	Observation	active	nested	179.17	181.75	top of highest casing	1400	138	118-128	10	2	x		Tehama	x	x	x	x	x	x	
73	Glenn	21N02W01F001	38535	726740	39.70439	-122.03830	NAD 83	Observation	active	nested	160.88	162.13	top of lowest casing	600	578	547-557	10	2			Tuscan C	x	x	x	x		x	
74	Glenn	21N02W01F002	24205	726740A	39.70439	-122.03830	NAD 83	Observation	active	nested	160.83	162.28	top of highest casing	600	318	297-307	10	2			Tehama	x	x	x	x		x	
75	Glenn	21N02W01F003	39954	726741	39.70439	-122.03830	NAD 83	Observation	active	nested	161.84	162.84	top of lowest casing	125	124	109-119	10	2	x		Modesto	x	x	x	x		x	
76	Glenn	21N02W01F004	40029	726741	39.70439	-122.03830	NAD 83	Observation	active	nested	161.92	163.22	top of highest casing	125	75	55-65	10	2		x	Modesto	x	x	x	x		x	
77	Glenn	21N02W04G002	24993	E044112	39.70333	-122.09103	NAD 83	Observation	active	nested	178.41	180.21	top of shortest casing	1200	948	928-938	10	2			Tuscan B	x	x	x	x	x	x	
78	Glenn	21N02W04G003	24994	E044112	39.70333	-122.09103	NAD 83	Observation	active	nested	178.41	180.51	top of second shortest casing	1200	713	673.5-683.5 693.5-703.5	20	2			Tuscan C	x	x	x	x	x	x	
79	Glenn	21N02W04G004	38359	E044112	39.70333	-122.09102	NAD 83	Observation	active	nested	178.41	180.31	top of second tallest casing	1200	289	165-175 269-279	20	2	x		Tehama	x	x	x	x	x	x	
80	Glenn	21N02W04G005	24995	E044112	39.70333	-122.09102	NAD 83	Observation	active	nested	178.41	181.16	top of tallest casing	1200	77	57-67	10	2			Modesto	x	x	x	x	x	x	
81	Glenn	21N02W05M001	39676	801406	39.70082	-122.12076	NAD 83	Observation	active	nested	188.93	190.43	top of shortest casing	520	473	442-452	10	2			Tehama	x	x	x	x		x	
82	Glenn	21N02W05M002	36588	801406	39.70082	-122.12076	NAD 83	Observation	active	nested	188.93	190.91	top of middle casing	520	153	122-132	10	2	x		Tehama, Modesto	x	x	x	x		x	
83	Glenn	21N02W05M003	23996	801406	39.70082	-122.12076	NAD 83	Observation	active	nested	188.93	191.33	top of tallest casing	520	75	44-54	10	2		x	Modesto	x	x	x	x		x	
84	Glenn	21N02W33M001	38536	726724	39.62970	-122.10045	NAD 83	Observation	active	nested	149	151.60	top of 4" casing	1020	974.2	869-890	21	4			Tuscan AB	x	x	x	x		x	
85	Glenn	21N02W33M002	24206	726724	39.62970	-122.10045	NAD 83	Observation	active	nested	149	151.26	top of shortest 2" casing	1020	571.1	540-550	10	2			Tuscan C	x	x	x	x		x	
86	Glenn	21N02W33M003	24207	726724	39.62970	-122.10045	NAD 83	Observation	active	nested	149	151.49	top of tallest 2" casing	1020	171.1	140-150	10	2	x		Tehama	x	x	x	x		x	
87	Glenn	21N02W36A002	21239	315494	39.63341	-122.03194	NAD 83	Observation	active	single	135.39	136.29	top of chip board inside casing	155	145	120-140	20	6	x	x	Tehama	x	x	x			x	
88	Glenn	21N03W01R002	25232	726894	39.69624	-122.14048	NAD 83	Observation	active	single	203.32	206.77	bottom of hole cut in casing	1530	255	235-245	10	2	x		Tehama	x	x	x			x	Local Well OAWD-Mon Well.
89	Glenn	21N03W23D001	23992	801404	39.66720	-122.17735	NAD 83	Observation	active	nested	204.76	205.89	top of shortest casing	420	393.5	363-373	10	2			Tehama	x	x	x	x		x	
90	Glenn	21N03W23D002	25233	801404	39.66720	-122.17734	NAD 83	Observation	active	nested	204.76	206.43	top of middle casing	420	191.5	142-152 160-170	20	2	x		Modesto	x	x	x	x		x	
91	Glenn	21N03W23D003	23993	801404	39.66720	-122.17735	NAD 83	Observation	active	nested	204.76	206.93	top of tallest casing	420	93.5	42-72	30	2			Modesto	x	x	x	x		x	
92	Glenn	21N03W34Q002	25789	816224	39.62472	-122.18714	NAD 83	Observation	active	nested	166.65	167.07	top of shortest casing	1020	980	930-960	30	2			Tehama	x	x	x	x		x	
93	Glenn	21N03W34Q003	25234	816224	39.62472	-122.18714	NAD 83	Observation	active	nested	166.65	167.38	top of middle casing	1020	710	620-630 650-660 680-690	30	2			Tehama	x	x	x	x		x	
94	Glenn	21N03W34Q004	25790	816224	39.62472	-122.18714	NAD 83	Observation	active	nested	166.65	167.63	top of tallest casing	1020	80	60-70	10	2	x		Alluvium	x	x	x	x		x	
95	Glenn	21N04W12A003	38716	E0103388	39.69716	-122.25330	NAD 83	Observation	active	nested	247.50	250.12	top of tallest casing	1080	1070	955-975 1030-1050	40	2			Tehama	x	x	x	x	x	x	
96	Glenn	21N04W12A004	24650	E0103388	39.69717	-122.25330	NAD 83	Observation	active	nested	247.50	249.62	top of shortest casing	1080	660	520-530 590-600 630-640	30	2			Tehama	x	x	x	x	x	x	
97	Glenn	21N04W12A001	24000	726739	39.69717	-122.25330	NAD 83	Observation	unknown	nested	247.88	249.38	top of piezometer	640	629	598-608	10	2			Tehama	x	x	x	x	x	x	Local Well Big W-Deep.
98	Glenn	21N04W12A002	25725	726739	39.69716	-122.25330	NAD 83	Observation	active	nested	247.88	249.88	top of tallest casing	640	278	247-257	10	2	x		Tehama	x	x	x	x	x	x	
99	Glenn	22N02W30H002	25726	726922	39.73252	-122.12306	NAD 83	Observation	active	nested	204.43	205.22	top of shortest casing	920	900	850-880	30	2			Tuscan C	x	x	x	x	x	x	
100	Glenn	22N02W30H003	25727	726922	39.73252	-122.12304	NAD 83	Observation	active	nested	204.43	205.77	top of middle casing	920	275	130-140 150-160 250-260	30	2	x		Tehama, Modesto	x	x	x	x	x	x	

Table 4-2. Groundwater Monitoring Network Wells

No.	County	State Well Number	CASGEM[a] Station ID	Well Completion Report ID	Latitude, decimal degrees	Longitude, decimal degrees	Datum	Well Use	Well Status	Well Completion Type (single or nested)	Ground Surface Elevation, feet	Reference Point Elevation, feet	Reference Point Description	Borehole Depth, feet, bgs[b]	Completed Well Depth, feet, bgs	Screen Intervals, feet, bgs	Total Length of Screen, feet	Casing Diameter, inches	Representative GWL Site [c]	Representative ISW Site [d]	Primary Geologic Formation	Assessment Category: Existing Monitoring Network	Known Construction	Non-Pumping Well	Nested Well	Proximity to Surface Water[e]	Accessible and Usable	Notes
101	Glenn	22N02W30H004	38609	726922	39.73253	-122.12304	NAD 83	Observation	active	nested	204.43	206.43	top of tallest casing	920	80	45-55 60-70	20	2		x	Tehama, Modesto	x	x	x	x	x	x	
102	Glenn	22N03W24E001	25236	726923A	39.74717	-122.15597	NAD 83	Observation	active	nested	230.51	231.70	top of shortest casing	860	840	800-820	20	2			Tehama	x	x	x	x	x	x	
103	Glenn	22N03W24E002	38667	726923B	39.74717	-122.15597	NAD 83	Observation	active	nested	230.51	231.93	top of middle casing	860	195	130-150 170-180	30	2	x		Modesto	x	x	x	x	x	x	
104	Glenn	22N03W24E003	25758	726923C	39.74717	-122.15597	NAD 83	Observation	active	nested	230.51	232.41	top of tallest casing	860	70	50-60	10	2		x	Modesto	x	x	x	x	x	x	

(a) California's Statewide Groundwater Elevation Monitoring Program (CASGEM).
(b) Below ground surface (bgs).
(c) Representative Groundwater Level (GWL) Monitoring Network Site.
(d) Representative Interconnected Surface Water (ISW) Monitoring Site.
(e) Monitoring sites located within 200 feet of an existing water channel or water body.
(f) California Department of Water Resources (DWR), 2001, Lower Colusa Basin Conjunctive Use Investigation: Monitoring Network Completion Report, June 1999. (DWR, 2001)
(g) Latitude and longitude values are in North American Datum of 1983 (NAD 83), decimal degrees.
(h) Email correspondence from Roy Hull, DWR North Region Office, received November 16, 2017. (Roy Hull, DWR, 2017)
(i) U.S. Bureau of Reclamation (USBR).
(j) NA denotes field where data was not unknown or unavailable.
(k) U.S. Geological Survey (USGS).

WEST YOST - N:\Clients\277 Davids Engr\60-20-11 Colusa GSP Prep\GIS\MXD\GSP Report Maps\Fig0402_GWL_Monitoring_Prop.mxd - areimer - 9/1/2021



Groundwater Monitoring Network Well

Well Removed from Groundwater Monitoring Network due to Damage or Destruction

Existing Well to Potentially Add to the Groundwater Monitoring Network

Colusa Subbasin

Water Agencies

U.S. Fish and Wildlife Refuge

Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

N

0 2.5 5

Scale in Miles

Figure 4-2

Proposed Groundwater Monitoring Network Wells

Colusa Groundwater Authority and Glenn Groundwater Authority

Colusa Subbasin

Groundwater Sustainability Plan

4.2.1.3 Monitoring Protocols

Data will either be obtained from the agencies that are responsible for managing the monitoring sites within the groundwater quality monitoring network or downloaded from dataset host websites. The Subbasin GSAs will continue to coordinate and collaborate with other agencies regarding their monitoring programs and data acquisition. Issues with obtaining data is not anticipated to occur and the GSAs will consider implementing their own monitoring programs, if necessary. Water levels measured in the Subbasin groundwater monitoring network wells can be found in multiple online state websites including:

- CASGEM website: https://www.casgem.water.ca.gov
- DWR Water Data Library (WDL) website: https://wdlbeta.water.ca.gov/Map.aspx
- California Natural Resources Agency (CNRA) website: https://data.cnra.ca.gov/dataset/periodic-groundwater-level-measurements

Since all of the wells identified as part of the Subbasin groundwater monitoring network are included in existing DWR monitoring programs, water levels being collected comply with existing regulatory protocols. These protocols also comply with those required in the Monitoring Protocols BMP (DWR, 2016c), which are summarized below for both methodology and frequency.

4.2.1.3.1 Methodology

The Monitoring Protocols, Standards, and Sites Best Management Practices (Monitoring Protocols BMP, DWR, 2016c) recommends the following monitoring conditions:

- Groundwater levels should be measured from a pre-established and recorded reference point.
- Groundwater levels should be measured using approved measurement equipment. Equipment should be operated, calibrated, maintained in accordance with the manufacturer's instructions.
- When well caps are removed, signs of pressure release should be noted. If pressure release is noted, an appropriate time should be allowed for the water surface to equilibrate to aquifer conditions. Multiple measurements may be taken to assess whether equilibration has been reached.
- Questionable measurements should be appropriately noted at time of monitoring.
- All salient conditions should be recorded at time of monitoring.
- Water levels shall be measured to the nearest 0.1 foot, at a minimum (23 CCR §352.4(a)(3)).
- Water level equipment should be decontaminated after each use.
- Measurements should be collected from all monitoring sites within as short a time period as possible; in general, one to two weeks is acceptable. All data should be entered into the data management system as soon as possible.

In addition to manual measurements, pressure transducers connected to data loggers may be used to monitor groundwater levels (DWR, 2016). Pressure transducers should be installed in conjunction with manual depth to water measurements; it is recommended that GWE be calculated after data have been downloaded to prolong the battery life of the unit. The Monitoring Protocols BMP identifies the following requirements when using data loggers:

- All transducers should be installed, operated, and maintained in accordance with the manufacturer's specifications.
- Unvented pressure transducers should be corrected for barometric pressure with continuous data from a barometric transducer.
- Groundwater levels should be recorded to the nearest 0.1 foot, at a minimum.
- The pressure transducers should be assessed to determine if the unit is capable of recording data to an appropriate precision and accuracy. Instrument drift due to groundwater conditions, battery life, and storage capacity should be taken into consideration when GWE are being calculated.
- Manual groundwater levels should be measured to maintain data logger integrity.

4.2.1.3.2 Frequency

Manual water level measurements shall be collected twice annually, at a minimum, to ensure seasonal trends are well accounted for (23 CCR §354.34(c)(1)(B)). Manual measurements for all network wells should be collected in the spring and fall, at a minimum, unless more frequent measurements are required to characterize changes in groundwater levels.

4.2.1.4 Data Gaps in Groundwater Level Monitoring Network

23 CCR §354.38(b) defines data gaps as occurring where there is an insufficient number of monitoring sites, insufficient monitoring frequency, or unreliable monitoring sites. Data gaps can also occur when collected data are of insufficient quality or quantity to support evaluation of the sustainability indicators (Monitoring Network BMP, 2016b).

The groundwater monitoring network was assessed based on requirements listed in the Monitoring Network BMP and 23 CCR §354.34. Spatial or temporal density and quality of monitoring sites were then assessed to identify potential data gaps. Data gaps within the groundwater monitoring network were evaluated for all criteria and categorized as follows:

- Usability of the monitoring site due to:
  - Wells screened across multiple water-bearing units and principal aquifers
- Spatial distribution of monitoring sites with regard to:
  - Presence near a surface water body
  - Full lateral and vertical extent of coverage
  - Areas and depths with known groundwater level decline (e.g., near Orland where an increase of drying shallow domestic wells is currently occurring).

Many of the surface waters are near wells included in the current groundwater monitoring network, except for surface waters in the following areas:

- Within the Colusa National Wildlife Refuge, east of Williams (Figure 4-1). There are no network groundwater monitoring wells near the Colusa National Wildlife Refuge.
- North and northwest of Orland near Stony Creek.
- Northwest of Artois along the middle reaches of Walker Creek.
- Northwest of Willows along the middle reaches of Willow Creek.

4.2.1.5 Proposed Actions to Address Data Gaps

Figure 4-2 shows the Subbasin groundwater monitoring network and recommended revisions. The recommended revisions include:

- Potential "replacement" wells that would replace historical monitoring wells that have been removed from the groundwater monitoring network due to well destruction or damage. The "replacement" wells are existing wells that could be added to the Subbasin groundwater monitoring network.
- Potential existing wells to add to the Subbasin groundwater monitoring network to address data gaps in spatial coverage.

Existing wells proposed to be added to the groundwater monitoring network and the rationale for selection are listed in Table 4-3.

Table 4-3. Existing Wells Proposed to be Added to the Groundwater Monitoring Network

State Well Number	Location	Existing Groundwater Monitoring Network	Rationale for Selection
15N04W11G001	Colusa County	DWR CASGEM/WDL[a]	Expand lateral monitoring network coverage towards the subbasin's western margin.
16N03W35M001	Colusa County	DWR CASGEM/WDL	Replacement for 16N03W35N002M, an inaccessible caved-in well. Similar location and construction characteristics.

(a) California Department of Water Resources (DWR) California Statewide Groundwater Elevation Monitoring (CASGEM) and/or Water Data Library (WDL).

It is recommended that a field survey be conducted of all current groundwater monitoring network sites to verify latitude and longitude coordinates, well depths, ground surface elevations, reference point elevations, and descriptions in accordance with the requirements described in 23 CCR §352.4(a) through (c). Monitoring frequencies should also be verified for compliance with requirements set forth in 23 CCR §354.34(c)(1)(B).

Additional monitoring sites are recommended for urban areas, near surface waters, and within areas with reported occurrences of drying shallow domestic wells. New monitoring sites would require a well siting study or public survey, as well as continued coordination with local stakeholders and DWR, to determine existing wells to include as monitoring sites or determine land suitable for the construction of new monitoring wells. Evaluation of the shallow unconfined portion of the principal aquifer is ongoing by DWR and the Colusa Subbasin GSAs and will impact scope of work to address this data gap.

Annual reports and future revisions to the GSP will provide updates on actions taken to address data gaps over the reporting period.

4.2.2 Groundwater Quality Monitoring

The primary groundwater quality constituent of concern within the Subbasin is salinity, specifically the upwelling of brackish connate water into the principal aquifer. There are many existing programs that monitor for and manage salinity (e.g., total dissolved solids or electrical conductivity) in groundwater. In lieu of managing and monitoring a groundwater quality monitoring program of its own, the Colusa Subbasin GSAs will utilize data collected via existing groundwater quality monitoring programs. The GSAs will continue to coordinate and collaborate with other agencies regarding their monitoring programs, including changes to monitoring sites, monitoring protocols or frequencies, and management actions. Data acquisition is not anticipated to be an issue. If necessary, the GSAs will consider implementing their own monitoring programs to address concerns over undesirable results, data gaps in the monitoring networks, or GSP project needs. A discussion of recommendations to address any data gaps within the existing monitoring networks is provided in this section.

4.2.2.1 Requirements

In accordance with the Monitoring Network BMP (DWR, 2016b), the groundwater quality monitoring network shall be designed such that the sustainability indicators are adequately covered not just over the entire subbasin, but also within any specific GSP-defined Management Areas, of which there are none defined within the Subbasin. The groundwater quality monitoring network shall be designed to collect sufficient spatial and temporal data from the principal aquifer to enable determination of groundwater quality trends and to address known water quality issues (23 CCR §354.34(c)(4)).

Data collected from the groundwater quality monitoring network should be sufficient to:

- Enable definition of the three-dimensional extent of impacts;
- Enable mapping of transient water quality degradation;
- Facilitate assessment of groundwater quality impacts to beneficial uses and users;
- Enable evaluation of management practice impacts to groundwater quality degradation;
- Support evaluation of movement and concentration of brackish or saline waters.

The Subbasin groundwater quality monitoring network mostly meets these requirements. Data gaps within the groundwater quality monitoring network are mostly regarding mapping of three-dimensional impacts and migration of poor-quality waters. Data gaps in the network are discussed in Section 4.2.2.4.

4.2.2.2 Groundwater Quality Monitoring Network

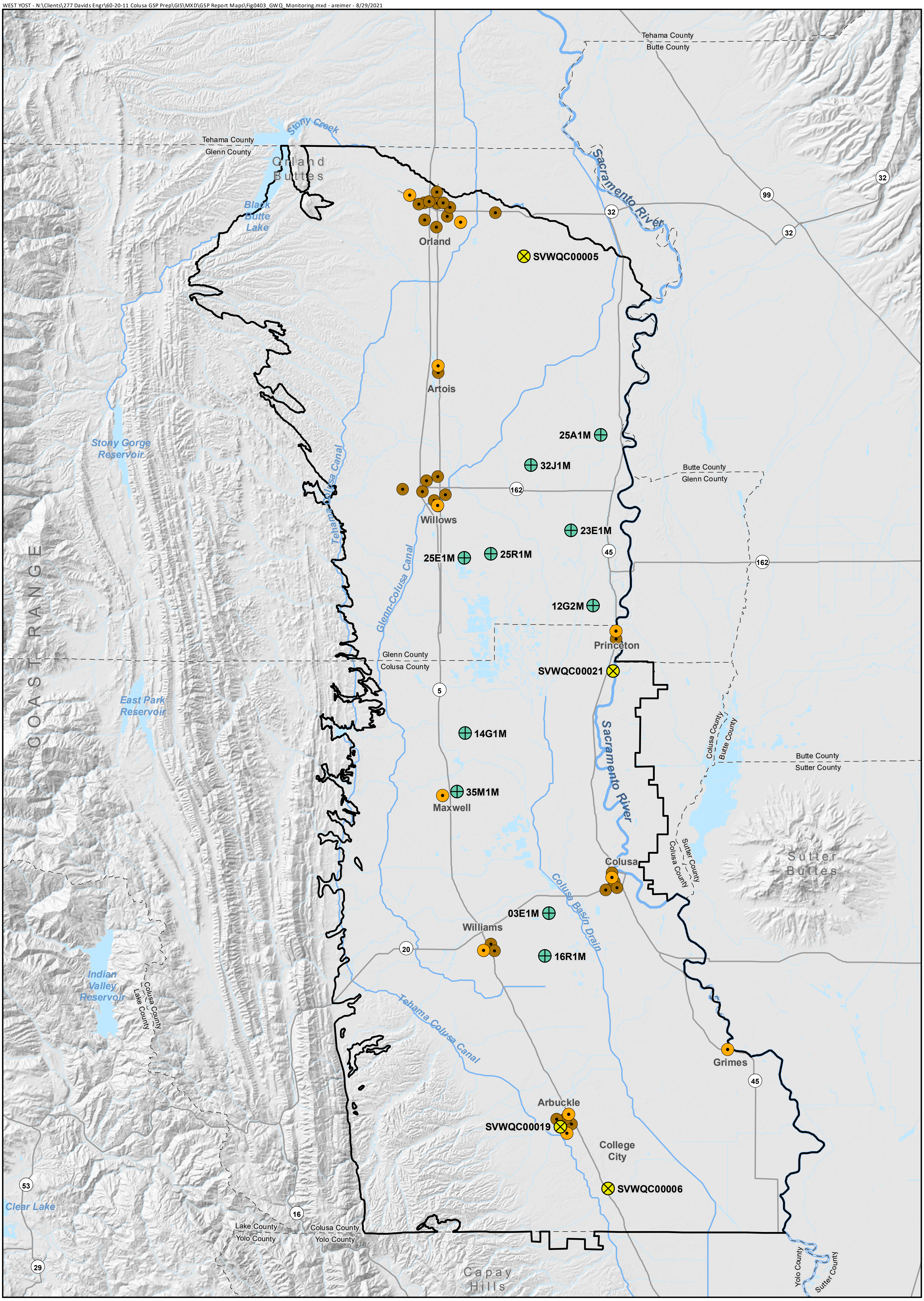
Groundwater quality monitoring network locations for the Subbasin include wells identified and currently being monitored for salinity under existing regulatory programs. These include groundwater monitoring conducted by coalitions formed under Irrigated Lands Regulatory Program (ILRP) and public drinking water supply communities regulated by the State Water Resources Control Board (SWRCB) Division of Drinking Water. The Subbasin representative groundwater quality monitoring network includes 54 monitoring sites. Table 4-4 includes the Subbasin groundwater quality monitoring network programs. The wells included in those programs as of 2020 are listed in Appendix 4B. Their locations are shown on Figure 4-3.

Table 4-4. Groundwater Quality Monitoring Network

Monitoring Program	Responsible Agency	Number of Wells in the Colusa Subbasin
SWRCB DDW[a,b]	Del Oro Water Company – Black Butte District	1
SWRCB DDW	Black Butte Mobile Home Park	1
SWRCB DDW	City of Orland	6
SWRCB DDW	Country Leisure Mobile Estates	1
SWRCB DDW	Orland Estates Mobile Home Park	2
SWRCB DDW	Orland Mobile Home Park	1
SWRCB DDW	Orland Oaks Mobile Home Park	1
SWRCB DDW	Shady Oaks Trailer Park	1
SWRCB DDW	Voyles Trailer Park	1
SWRCB DDW	Willows Mobile Home Community & RV Park	1
SWRCB DDW	Artois Community Service District	2
SWRCB DDW	Cal-Water Service Company - Willows	5
SWRCB DDW	Colusa County Water Works District #2 – Princeton	2
SWRCB DDW	Maxwell Public Utility District	1
SWRCB DDW	City of Colusa	5
SWRCB DDW	City of Williams	3
SWRCB DDW	Colusa County Water Works District #1 – Grimes	1
SWRCB DDW	Arbuckle Public Utility District	4
SWRCB DDW	Del Oro Water Company – Arbuckle District	1
ILRP[c]	California Rice Commission[d]	10
ILRP	Sacramento Valley Water Quality Coalition[e]	4

(a) SWRCB DDW = State Water Resources Control Board Division of Drinking Water.
(b) Representative groundwater quality monitoring wells were selected from the bolded agencies' monitoring well network.
(c) ILRP = Irrigated Lands Regulatory Program.
(d) Central Valley Regional Water Quality Control Board. 2016.
(e) Luhdorff and Scalmanini. 2019.

Active community water system wells regulated under SWRCB Division of Drinking Water from each municipal or community water system within the Subbasin were selected for the Subbasin groundwater quality monitoring network. Community water systems are defined as "public water systems that serve at least 15 service connections used by yearlong residents or regularly serves at least 25 yearlong residents of the area served by the system" and may include municipalities, community services districts, and mobile home and trailer parks. These public supply wells are constructed at varying depths throughout the subbasin and are sampled and monitored by their respective water supply agency. As of the issuance of this Colusa Subbasin GSP, there are 40 active wells being monitored by 19 public water supply agencies included in the SWRCB Division of Drinking Water.



Colusa Subbasin

Representative California Rice Commission Groundwater Monitoring Well

Representative Sacramento Valley Water Quality Coalition Groundwater Monitoring Well

Representative Public Water Supply Well

Other Active Public Water Supply Well

Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

N

0 2.5 5

Scale in Miles

Figure 4-3

Groundwater Quality Monitoring Network Wells

Colusa Groundwater Authority and Glenn Groundwater Authority

Colusa Subbasin

Groundwater Sustainability Plan

The California Rice Commission ILRP groundwater quality trend network includes USGS-managed wells within and surrounding the California Rice Commission management area (CH2MHILL, 2016a). Ten of these wells are within the Subbasin (CVRWQCB, 2016) and are included in the Subbasin groundwater quality monitoring network. All ten of the wells are relatively shallow (less than 40 feet deep) and located near rice ponds, irrigation canals, and other agricultural fields and infrastructure. Water chemistry within these wells will provide information regarding shallow instances of increased salinity within agricultural areas.

The Sacramento Valley Water Quality Coalition Groundwater Quality (SVWQC) Trend Monitoring Program, formed under ILRP, includes four wells within the Subbasin (Luhdorff and Scalmanini, 2019). One well is in Glenn County, just south of Stony Creek, one well is near the intersection of the Sacramento River and the Glenn-Colusa County boundary line, and the other two are near Arbuckle, Colusa County. The SVWQC wells are public or domestic water supply wells of moderate depths (100 to 300 feet deep). SVWQC's monitoring program started in 2020 and is relatively new. As such, there is not much information available for these wells as of the writing of this GSP.

The groundwater quality monitoring network will be re-evaluated and updated in annual reports and future revisions of the Subbasin, as necessary to address the needs and concerns of the GSAs and local stakeholders. The Colusa Subbasin GSAs will continue to coordinate with the existing monitoring agencies to account for any changes in well status or sampling frequencies. Additionally, water quality data from wells included in other groundwater quality monitoring programs discussed in Chapter 2, but not yet included in the Subbasin groundwater quality monitoring network, will be evaluated during future groundwater condition investigations for the Subbasin.

4.2.2.3 Monitoring Protocols

Data will either be obtained from the agencies that are responsible for managing the monitoring sites within the groundwater quality monitoring network or downloaded from dataset host websites. A listing of the websites is provided below:

- SWRCB Division of Drinking Water wells:
  - SWRCB Drinking Water Watch website: https://sdwis.waterboards.ca.gov/PDWW/
  - CNRA website: https://data.cnra.ca.gov/dataset/ground-water-water-quality-results
- California Rice Commission (CRC) wells:
  - California Rice Commission contact: https://calrice.org/
  - USGS National Water Information System (NWIS) website: https://waterdata.usgs.gov/nwis
  - GeoTracker Groundwater Ambient Monitoring & Assessment Program (GAMA) website: http://geotracker.waterboards.ca.gov/gama/
- Sacramento Valley Water Quality Coalition wells:
  - SVWQC contact: https://www.svwqc.org/
  - GeoTracker ESI website: https://geotracker.waterboards.ca.gov/

Most recent data will be more easily obtained directly from the responsible agency instead of via the alternate host websites. The GSAs will continue to coordinate and collaborate with other agencies regarding their monitoring programs, including changes to monitoring sites, monitoring protocols or frequencies, and management actions. Data acquisition is not anticipated to be an issue. If necessary, the GSAs will consider implementing their own monitoring programs to address concerns over undesirable results, data gaps in the monitoring networks, or GSP project needs. A discussion of recommendations to address any data gaps within the existing monitoring networks is provided later in this section.

Since all of the wells identified as part of the Subbasin groundwater quality monitoring network are included in existing monitoring programs, water quality samples being collected must comply with existing regulatory sampling and testing protocols. Water quality samples collected from public drinking water wells and reported to SWRCB comply with SWRCB sampling and testing protocols for drinking water. Water quality samples collected from the California Rice Commission and SVWQC wells comply with sampling and testing protocols required by the Regional Water Quality Board for compliance under ILRP and CV-SALTS. These protocols also comply with those required in the Monitoring Protocols BMP (DWR, 2016c), which are summarized below:

- All water quality analyses should be performed by a State Environmental Laboratory Accreditation Program certified laboratory.
- Groundwater quality sampling protocols should follow USGS National Field Manual for the Collection of Water Quality Data (Wilde, 2005 or more recent).
- Groundwater sampling protocols should ensure that salient data are recorded and all data are handled such that integrity is maintained.
- Samples from pumping wells should be collected near the wellhead.
- All sampling equipment and ports should be free of contaminants and decontaminated between sampling locations.
- Wells not equipped with low-flow sampling taps should be purged prior to sampling to ensure sampling is of ambient groundwater conditions and not borehole storage conditions. Typically, three casing volumes purged is adequate.
- If purging or pumping causes a well to be evacuated, allow 90 percent recovery prior to sampling.
- Samples should be collected under laminar flow conditions.
- Samples should be collected according to appropriate standards. The sample collection procedure should reflect the type of analysis being performed.
- Samples should be preserved at the time of sampling. Samples should be filtered, as appropriate.
- Samples should be chilled after collection to prevent degradation.
- Chain of custody forms should be used to track procession of the samples.
- Analytical laboratories should utilize reporting limits that are equal to or less than the regional water quality objectives and screening levels.

4.2.2.4 Data Gaps in Groundwater Quality Monitoring Network

Potential data gaps have been identified within the proposed groundwater quality monitoring network:

- The current California Rice Commission groundwater monitoring plan to collect groundwater quality samples every two years and the varying sampling frequency of public water supply wells may not be sufficient to satisfy the requirements set forth in the Monitoring Network BMP (DWR, 2016b) or to satisfy the Colusa Subbasin GSAs' goal of tracking salinity concentrations.

- The existing groundwater quality monitoring network does not provide full monitoring coverage in areas with salinity concerns. Specifically, sites may not be sufficient to monitor the movement of brackish or saline waters in the area west and south of the Sutter Buttes and near the City of Williams.
- It is possible that the existing groundwater quality monitoring networks may not be sufficient to adequately allow differentiation between upwelling or intrusion of deeper brackish/connate waters or percolation recharge of waters with elevated salinity into the freshwater aquifer system.
- Existing monitoring networks are managed by other agencies. Monitoring locations and frequencies are subject to change based on the needs of the existing monitoring programs.

4.2.2.5 Proposed Actions to Address Data Gaps

Groundwater quality data collected under existing regulatory programs may not be sufficient for SGMA compliance. The Colusa Subbasin GSAs will consider coordinating with the SVWQC, Northern California Water Association (NCWA), and the California Rice Commission in the establishment and ongoing evaluation of these groundwater quality monitoring network sites with the goal of using data collected under the ILRP for SGMA compliance.

The wells included in the groundwater level monitoring network (discussed in Section 4.2.1) provide ample spatial coverage throughout the Subbasin. These wells, shown on Figure 4-1, would be good potential sites to add to the groundwater quality monitoring network in areas with identified salinity and upwelling concerns. The wells could be sampled regularly, at varying frequencies, in accordance with the needs of the Colusa Subbasin GSAs and local stakeholders.

The SWRCB GeoTracker and GeoTracker GAMA databases include information from a variety of monitoring and public wells, including domestic and agricultural irrigation wells. The GeoTracker sites are continuously being updated with new data and should be evaluated for all future Subbasin water quality projects and studies.

Annual reports and future revisions to the GSP will provide updates on actions taken to address data gaps over the reporting period.

4.2.3 Land Subsidence Monitoring

Land subsidence has been measured within the Subbasin. There are several existing programs in place to monitor and measure ongoing land subsidence. Many of these existing programs are included in the Subbasin land subsidence monitoring network so that the GSAs and local stakeholders can best determine the rate and extent of subsidence within the subbasin boundaries.

4.2.3.1 Requirements

In accordance with the Monitoring Network BMP (DWR, 2016b), the land subsidence network shall be designed such that the sustainability indicators are adequately covered, not just over the entire subbasin, but also within any specific GSP-defined Management Areas, of which there are none defined within the Subbasin. The land subsidence monitoring network shall be designed to enable the characterization of the rate and extent of subsidence by providing consistent, accurate, and reproducible results (23 CCR §354.34(c)(5); DWR, 2016).

Monitoring sites shall be compliant with requirements listed in 23 CCR §352.4(a) through (b).

The Subbasin land subsidence monitoring network meets these requirements. Data gaps in the network are discussed in Section 4.2.3.4.

4.2.3.2 Land Subsidence Monitoring Network

The Subbasin land subsidence monitoring network is comprised of survey benchmarks, benchmarks, continuous GPS stations, extensometers, and remote sensing data. Table 4-5 lists the benchmarks, continuous GPS stations, and extensometers included in the land subsidence monitoring network. Figure 4-4 shows these locations relative to the subbasin. All of the land subsidence monitoring network sites and remote sensing programs are managed and monitored through the following agencies and programs.

California DWR Ground Surface Displacement - Land Subsidence Monitoring

Extensometers are land surface displacement sensors that are installed inside of groundwater monitoring wells. A cable or pipe attached to the bottom of the well is connected to a sensor at the top of the well. Subsidence or land displacement due to compaction of sediment between the bottom of the well and the top can be detected to the nearest 0.01 foot by installed extensometers.

DWR monitors eleven extensometers within the Sacramento Valley, four of which are installed in wells within the Subbasin. One extensometer is within the Glenn County portion of the Corning Subbasin, just north of Stony Creek. All five of the extensometers within Glenn and Colusa Counties are included in the Subbasin land subsidence monitoring network.

UNAVCO Plate Boundary Observatory GPS/GNSS Network

The University of California Agriculture and Natural Resources (UNAVCO) Plate Boundary Observatory (PBO) network of continuously operating global positioning system (CGPS) stations was developed for measuring vertical and horizontal deformation of the North American and Pacific tectonic plates in the western United States. The data collected with the CPGS stations, however, can be used for near-real-time measurements of land subsidence.

There are two CPGS stations within the Subbasin, both in Colusa County west of the Sutter Buttes. Two additional stations are located out of the Subbasin in the Coast Range foothills west of Willows and west of Arbuckle. One station is located in the Sutter Buttes. The stations are measured on 15-second intervals and data is evaluated to provide a daily displacement record.

Sacramento Valley Height Modernization Project

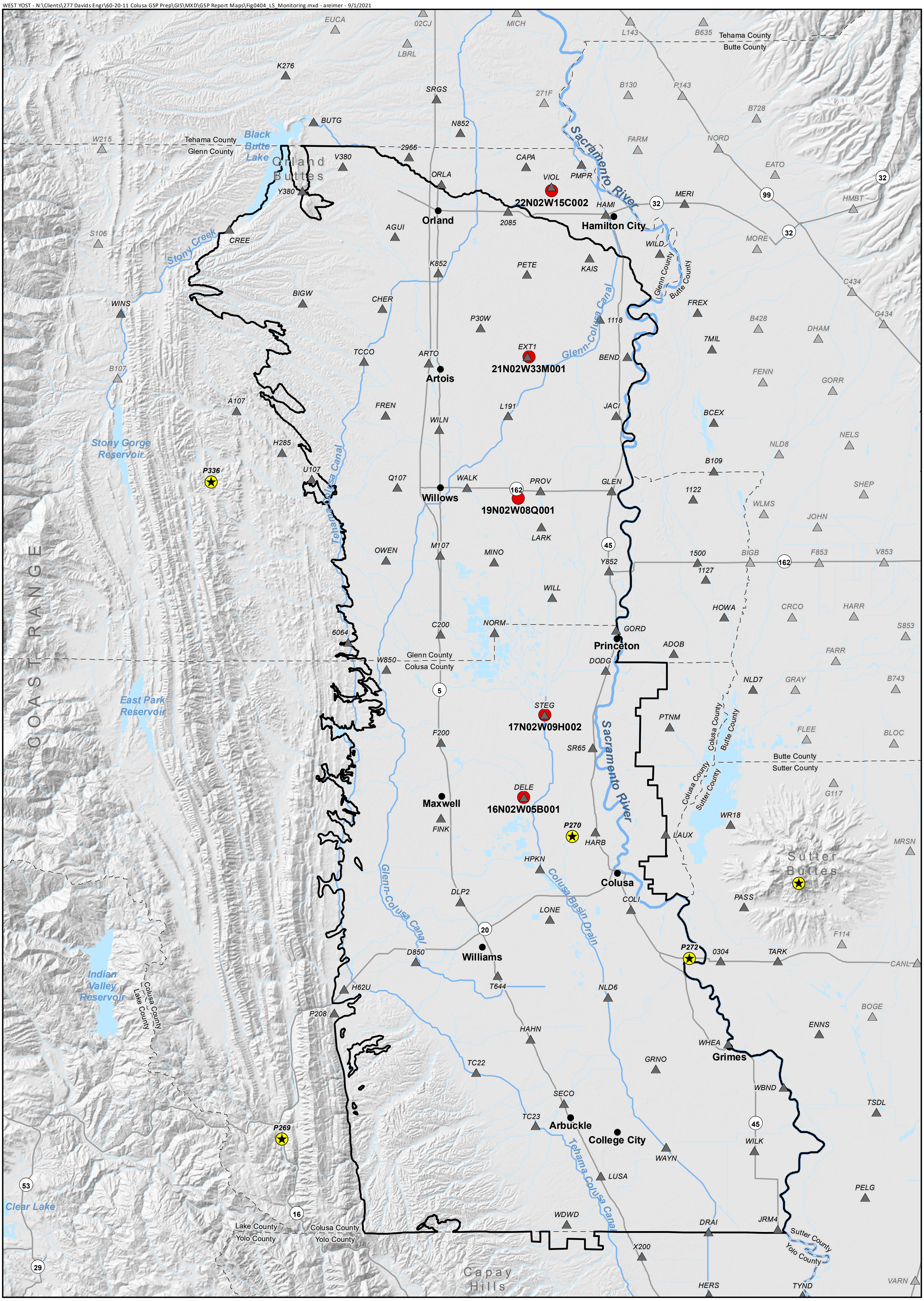
The Sacramento Valley benchmark network is managed by DWR in cooperation with USBR and local agencies to both monitor land subsidence and extend the high-accuracy geodetic control of USBR facilities. As of 2017, the network contained 305 benchmarks within the Sacramento Valley, of which 63 benchmarks are located within the Subbasin and 76 benchmarks are included in the Subbasin land subsidence monitoring network. The benchmarks are surveyed by field crews on an as-needed or as-requested basis.

Table 4-5. Land Subsidence Monitoring Network Extensometers and Benchmarks

Groundwater Subbasin	County	Station ID	Latitude[a]	Longitude	Frequency	Monitoring Agency	Site Type
Colusa	Colusa	16N02W05B001	39.27527	-122.10568	Daily	DWR[b]	Extensometer[c]
Colusa	Colusa	17N02W09H002	39.34170	-122.08377	Daily	DWR	Extensometer
Colusa	Glenn	19N02W08Q001	39.51596	-122.11143	Daily	DWR	Extensometer
Colusa	Glenn	21N02W33M001	39.62970	-122.10045	Daily	DWR	Extensometer
Colusa	Colusa	P270	39.24377	-122.05520	Daily	UNAVCO[d]	Continuous GPS Benchmark[e]
Colusa	Colusa	P272	39.14548	-121.93406	Daily	UNAVCO	Continuous GPS Benchmark
Colusa[f]	**Colusa**	**COLI**	**39.18514**	**-121.99461**	**TBD[g]**	**DWR**	**Benchmark[h]**
Colusa	**Colusa**	**D850**	**39.14268**	**-122.21725**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**DELE**	**39.27528**	**-122.10558**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**DLP2**	**39.19113**	**-122.17126**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**DODG**	**39.37739**	**-122.02070**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**DRAI**	**38.92529**	**-121.91457**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**F200**	**39.31920**	**-122.19154**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**FINK**	**39.25828**	**-122.19148**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**GORD**	**39.40956**	**-122.00997**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**GRNO**	**39.05664**	**-121.96914**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**H62U**	**39.12059**	**-122.29094**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**HAHN**	**39.08068**	**-122.09838**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**HARB**	**39.24734**	**-122.03128**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**HPKN**	**39.21772**	**-122.08883**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**JRM4**	**38.92774**	**-121.84330**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**LAUX**	**39.24547**	**-121.95867**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**LONE**	**39.17702**	**-122.07852**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**LUSA**	**38.97056**	**-122.02556**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**NLD6**	**39.11442**	**-122.01828**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**SECO**	**39.02883**	**-122.06393**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**SR65**	**39.31529**	**-122.03400**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**STEG**	**39.34150**	**-122.08425**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**T644**	**39.13183**	**-122.13209**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**TC22**	**39.05341**	**-122.15435**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**TC23**	**39.01061**	**-122.09302**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**W850**	**39.37778**	**-122.24806**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**WAYN**	**38.99358**	**-121.95819**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**WBND**	**39.04187**	**-121.83686**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**WDWD**	**38.93141**	**-122.06109**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**WHEA**	**39.07662**	**-121.89427**	**TBD**	**DWR**	**Benchmark**
Colusa	**Colusa**	**WILK**	**38.99058**	**-121.86709**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**1118**	**39.65967**	**-122.02694**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**2085**	**39.74664**	**-122.12269**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**6064**	**39.39964**	**-122.28803**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**AGUI**	**39.72608**	**-122.24058**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**ARTO**	**39.62432**	**-122.20473**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**BEND**	**39.62986**	**-121.99831**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**BIGW**	**39.67254**	**-122.33616**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**C200**	**39.40630**	**-122.19228**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**CHER**	**39.66815**	**-122.25317**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**CREE**	**39.73149**	**-122.41332**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**EXT1**	**39.62967**	**-122.10220**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**FREN**	**39.58243**	**-122.24968**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**GLEN**	**39.52165**	**-122.01480**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**JACI**	**39.58242**	**-122.01000**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**K852**	**39.69694**	**-122.19524**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**KAIS**	**39.70917**	**-122.03745**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**L191**	**39.58203**	**-122.12229**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**LARK**	**39.49276**	**-122.08760**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**M107**	**39.46981**	**-122.19286**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**MINO**	**39.46442**	**-122.13664**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**NORM**	**39.40751**	**-122.13629**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**OWEN**	**39.46565**	**-122.24895**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**P30W**	**39.65274**	**-122.15119**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**PETE**	**39.69582**	**-122.10299**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**PROV**	**39.52184**	**-122.08860**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**Q107**	**39.52422**	**-122.23729**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**TCCO**	**39.62555**	**-122.27261**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**V380**	**39.78232**	**-122.29498**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**WALK**	**39.52420**	**-122.16497**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**WILL**	**39.43593**	**-122.07612**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**WILN**	**39.57084**	**-122.19379**	**TBD**	**DWR**	**Benchmark**
Colusa	**Glenn**	**Y852**	**39.45718**	**-122.01761**	**TBD**	**DWR**	**Benchmark**
Butte	Butte	7MIL	39.63631	-121.90997	TBD	DWR	Benchmark
Butte	Butte	B109	39.53803	-121.90831	TBD	DWR	Benchmark
Butte	Butte	BCEX	39.57706	-121.90831	TBD	DWR	Benchmark
Butte	Butte	FREX	39.66553	-121.92506	TBD	DWR	Benchmark
Butte	Butte	NLD7	39.36214	-121.86808	TBD	DWR	Benchmark
Butte	Colusa	PTNM	39.33181	-121.95453	TBD	DWR	Benchmark
Butte	Glenn	1122	39.51501	-121.93004	TBD	DWR	Benchmark
Butte	Glenn	1127	39.45017	-121.91706	TBD	DWR	Benchmark
Butte	Glenn	1500	39.46406	-121.92539	TBD	DWR	Benchmark
Butte	Glenn	ADOB	39.39075	-121.95015	TBD	DWR	Benchmark
Butte	Glenn	HOWA	39.42011	-121.89788	TBD	DWR	Benchmark
Corning	Glenn	22N02W15C002	39.76352	-122.07727	Daily	DWR	Extensometer
Corning	Glenn	2966	39.79034	-122.22586	TBD	DWR	Benchmark
Corning	Glenn	CAPA	39.78244	-122.10402	TBD	DWR	Benchmark
Corning	Glenn	HAMI	39.74437	-122.02057	TBD	DWR	Benchmark
Corning	Glenn	ORLA	39.76848	-122.19233	TBD	DWR	Benchmark
Corning	Glenn	PMPR	39.78431	-122.04597	TBD	DWR	Benchmark
Corning	Glenn	VIOL	39.76637	-122.07760	TBD	DWR	Benchmark
Corning	Glenn	WILD	39.71269	-121.96469	TBD	DWR	Benchmark
Corning	Tehama	BUTG	39.81825	-122.32561	TBD	DWR	Benchmark
Corning	Tehama	K276	39.85558	-122.35492	TBD	DWR	Benchmark
Corning	Tehama	N852	39.80959	-122.17255	TBD	DWR	Benchmark
Corning	Tehama	SRGS	39.83700	-122.19756	TBD	DWR	Benchmark
Sutter	Sutter	0304	39.14328	-121.90174	TBD	DWR	Benchmark
Sutter	Sutter	ENNS	39.08444	-121.80039	TBD	DWR	Benchmark
Sutter	Sutter	PASS	39.18694	-121.87767	TBD	DWR	Benchmark
Sutter	Sutter	PELG	38.95292	-121.75322	TBD	DWR	Benchmark
Sutter	Sutter	TARK	39.14319	-121.84265	TBD	DWR	Benchmark
Sutter	Sutter	TSDL	39.02147	-121.74125	TBD	DWR	Benchmark
Sutter	Sutter	WR18	39.25300	-121.89167	TBD	DWR	Benchmark
Vina	Butte	MERI	39.75321	-121.93846	TBD	DWR	Benchmark
Yolo	Yolo	BIRD	38.84854	-122.04374	TBD	DWR	Benchmark
Yolo	Yolo	HERS	38.87468	-121.91444	TBD	DWR	Benchmark
Yolo	Yolo	TYND	38.87394	-121.81773	TBD	DWR	Benchmark
Yolo	Yolo	X200	38.90576	-121.98328	TBD	DWR	Benchmark
None	Colusa	P269	38.99953	-122.35455	Daily	UNAVCO	Continuous GPS Benchmark
None	Colusa	P208	39.10097	-122.30108	TBD	DWR	Benchmark
None	Glenn	P336	39.52808	-122.43047	Daily	UNAVCO	Continuous GPS Benchmark
None	Glenn	A107	39.58564	-122.40492	TBD	DWR	Benchmark
None	Glenn	H285	39.55203	-122.35723	TBD	DWR	Benchmark
None	Glenn	U107	39.53084	-122.32621	TBD	DWR	Benchmark
None	Glenn	WINS	39.66351	-122.52596	TBD	DWR	Benchmark
None	Glenn	Y380	39.76272	-122.33738	TBD	DWR	Benchmark
None	Sutter	SUTB	39.20583	-121.82058	Daily	UNAVCO	Continuous GPS Benchmark

(a) Latitude and longitude values are in North American Datum of 1983 (NAD 83), decimal degrees.
(b) Extensometers are maintained and managed by California DWR under their Ground Surface Displacement-Land Subsidence Monitoring program.
(c) Extensometers include those that are within or near the Colusa Subbasin. Extensometers are installed at depths of approximately 700-800 ft.
(d) Continuous global positioning system (GPS) benchmark data is received, cleaned, and managed by UNAVO's Geodetic Facility for the advancement of Geoscience (GAGE) Facility with support from the National Science Foundation and NASA.
(e) Continuous global positioning system (GPS) benchmark.
(f) Bolded benchmarks are included in the representative land subsidence monitoring network and were used to determine the sustainability thresholds discussed in Chapter 5.
(g) Frequency to be determined (TBD). Benchmarks have historically been re-surveyed irregularly, on an as-needed/as-requested basis, by DWR staff in coordination with local agencies.
(h) Benchmarks are those listed for the Sacramento Valley Height Modernization Project within 5 miles of the Colusa Subbasin.

WEST YOST - N:\Clients\277 Davids Engr\60-20-11 Colusa GSP Prep\GIS\MXD\GSP Report Maps\Fig0404_LS_Monitoring.mxd - areimer - 9/1/2021



- Extensometer
- Continuous GPS Station
- Sacramento Valley Benchmark Included in the Monitoring Network
- Sacramento Valley Benchmark Not Included in the Monitoring Network
- Colusa Subbasin

Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

N

0 2.5 5
Scale in Miles

Figure 4-4

Land Subsidence Monitoring Network

Colusa Groundwater Authority and Glenn Groundwater Authority
Colusa Subbasin
Groundwater Sustainability Plan

InSAR Remote Sensing

The land subsidence monitoring network is mostly comprised of discrete monitoring point locations. The exception to this are remote sensing datasets. Interferometric Synthetic Aperture Radar (InSAR) is a remote sensing technique that uses satellites to scan the earth's surface and measure displacement. The technology is used for studies regarding land subsidence, tectonic movement, earthquake and volcano activity, and public safety due to earth hazards.

As part of DWR's effort to provide relevant and up-to-date data to assist with SGMA-related projects and compliance, InSAR data was collected and analyzed for vertical land displacement across the State's groundwater basins (TRE ALTAMiRA, 2020). This data was used to assess existing land subsidence conditions within the Subbasin in Chapter 3. Future InSAR surveys and other remote sensing datasets contracted for local, state, or federal agency projects will be used to monitor land subsidence within the Subbasin as they become available, and so are included in the Subbasin land subsidence monitoring network.

4.2.3.3 Monitoring Protocols

Data will either be obtained from the agencies that are responsible for managing the monitoring sites within the land subsidence monitoring network or downloaded from dataset host websites. If necessary, the Colusa Subbasin GSAs will request resurvey of the Sacramento Valley benchmarks. The relevant websites are:

- California DWR Ground Surface Displacement – Land Subsidence Monitoring:
  - CNRA website: https://data.cnra.ca.gov/dataset/wdl-ground-surface-displacement
  - UNAVCO Plate Boundary Observatory GPS/GNSS Network:
  - UNAVCO website: https://www.unavco.org/data/data.html
- Sacramento Valley Height Modernization Project:
  - California DWR Northern Region Office: No website available
- InSAR remote sensing:
  - CNRA database: https://data.cnra.ca.gov/dataset/tre-altamira-insar-subsidence
  - UNAVCO website: https://www.unavco.org/data/data.html

Since all of the land subsidence monitoring locations identified as part of the Subbasin land subsidence monitoring network are included in existing state or federal monitoring programs, collection of displacement data complies with existing regulatory monitoring protocols.

The following land subsidence monitoring protocols have been established by DWR (DWR, 2016c):

- Levelling surveys should follow standards defined in the California Department of Transportation's (Caltrans) Surveys Manual (Caltrans, assorted dates).
- Continuous GPS surveys should follow standards defined in the Caltrans Surveys Manual.
- Extensometer instruments should be installed, calibrated, and maintained per the manufacturer's instructions.
- InSAR surveys should be obtained via interpretative reports for specific regions. Raw data files may be obtained and processed instead, if needed.

4.2.3.4 Data Gaps in Land Subsidence Monitoring Network

Land subsidence has been measured in the greater Arbuckle and southern Colusa County area (Section 3.2.6). The benchmarks must be manually surveyed in order to determine the magnitude of displacement. This is currently done on an irregular frequency and does not provide short-term insight regarding ongoing land subsidence. The installation of a CGPS station or extensometer would allow near real-time monitoring of subsidence in the Arbuckle area without relying on the irregular re-survey frequency of the Sacramento Valley benchmarks.

4.2.3.5 Proposed Actions to Address Data Gaps

No additional benchmarks are recommended at this time. However, a new CGPS station or extensometer near Arbuckle, where subsidence has been occurring, is recommended. A new near real-time monitoring site located in a location with known of subsidence would provide a better understanding of the rate and magnitude of subsidence.

Additionally, all future Sacramento Valley benchmark survey reports and results will be evaluated as they are made available. The Sacramento Valley benchmarks provide a good spatial distribution of vertical displacement measurements over time. Ongoing studies using InSAR data to determine vertical displacement should also be evaluated as they are published and data is made available.

Annual reports and future revisions to the GSP will provide updates on actions taken to address data gaps over the reporting period.

4.2.4 Surface Water Monitoring

Surface water monitoring is conducive for evaluating stream-aquifer relations. Comparing stream flows and stages with groundwater levels from specific monitoring wells can provide insight into how the surface waters are interconnected with the groundwater system. The surface water monitoring network includes stream gages placed on rivers, streams, and canals. All of the stream gages included in the surface water monitoring network are managed and monitored via existing federal and state programs. The representative surface water depletion monitoring network includes shallow groundwater level monitoring wells from which water levels will be used as a proxy for evaluating surface water depletions. The representative surface water depletion monitoring network is discussed in Section 4.2.5.3.

4.2.4.1 Requirements

In accordance with the Monitoring Network BMP (DWR, 2016b), the surface water monitoring network should be designed such that the sustainability indicators are adequately covered not just over the entire subbasin, but also within any specific GSP-defined Management Areas, of which there are none defined within the Subbasin. The surface water monitoring network shall be designed to characterize spatial and temporal changes between interconnected waters such that depletions from surface waters caused by groundwater extraction can be calculated (23 CCR §354.34(c)(6); DWR, 2016b).

Data collected from the surface water monitoring network shall be sufficient to:

- Characterize flow conditions including surface water discharge, stage, and baseflows.
- Identify locations and flow periods of ephemeral and intermittent stream channels, if any. The Monitoring Network BMPs state that monitoring of ephemeral or intermittent streams should be conducted annually or as appropriate to characterize flow changes (DWR, 2016b).
- Identify temporal trends due to localized, regional, and seasonal surface water discharge and groundwater extraction impacts.
- Identify and collect information necessary to evaluate adverse effects to the beneficial use of surface water.
- Support evaluation of stream-aquifer interactions, including impacts to surface water supplies due to changes in groundwater levels and impacts to native riparian land or GDEs.

Stream gages should be located along stream reaches with known groundwater connection, per the Monitoring Network BMP (DWR, 2016b). Locations should account for surface water diversions and return flows, if necessary. Per the Monitoring Network BMP (DWR, 2016b), surface water discharge monitoring should be accompanied by groundwater level monitoring within shallow wells.

The Subbasin surface water monitoring network has been established using the best available data and science to identify, assess, and select existing monitor wells and stream gages meeting these requirements. However, significant data gaps exist, which need to be addressed during implementation of this GSP. Data gaps in the network are discussed in Section 4.2.4.4.

4.2.4.2 Surface Water Monitoring Network

Table 4-6 lists the surface water monitoring network, their locations, and monitoring frequency. These station locations are shown on Figure 4-5 and include all of the active stream gages and monitoring sites managed state and federal agencies both within and upstream of the Subbasin. The surface water monitoring sites are managed and maintained by WDL, California Data Exchange Center (CDEC), and USGS NWIS.

There are 15 active stream gages within the Subbasin surface water monitoring network.

Table 4-6. Surface Water Monitoring Network Stream Gages

County	Station ID	Station Name	Latitude[a]	Longitude	Site Type	Frequency	Source
Colusa	BSO; A02967	Butte Slough at Outfall Gates near Colusa	39.195161	121.936567	Discharge [c]	Hourly	CDEC[b]; WDL[d]
Colusa	CDR; A02976	Colusa Drain at Highway 20	39.195512	122.060517	Discharge	Hourly	CDEC; WDL
Colusa	CLW; A02981	Sacramento River at Colusa Weir	39.23682	121.99476	Discharge	Hourly	CDEC; WDL
Colusa	A00647	Freshwater Creek at Leesville Road near Williams	39.129339	122.30993	Discharge	Daily	WDL
Sutter	MPS	Meridian Pumps	39.148	121.918	Discharge	Hourly	CDEC
Colusa	MLW; A02986	Sacramento River at Moulton Weir	39.33821	122.022627	Discharge	Hourly	CDEC; WDL
Glenn	BTC; A02500	Sacramento River at Butte City	39.45784	121.99416	Discharge	Hourly	CDEC; WDL
Colusa	11389500	Sacramento River at Colusa	39.214057	122.000251	Discharge	Daily	USGS
Glenn	HMC; A02630	Sacramento River at Hamilton City	39.750925	121.997877	Discharge	Hourly	CDEC; WDL
Glenn	ORD; A02570	Sacramento River at Ord Ferry	39.628132	121.993182	Discharge	Hourly	CDEC; WDL
Sutter	TIS	Sacramento River at Tisdale Weir	39.02644	121.822083	Discharge	Hourly	CDEC
Colusa	11390500	Sacramento River below Wilkins Slough near Grimes	39.009974	121.823398	Discharge	Daily	USGS
Glenn	WCF	South Fork Willow Creek near Fruto	39.541538	122.390045	Stage	Hourly	CDEC
Tehama	BBQ	Stony Creek below Black Butte Dam	39.8186	122.3239	Stage	Event	CDEC
Glenn	SCG	Stony Creek near Grizzly Flat (County Road 200A)	39.73181	122.413997	Discharge	Hourly	CDEC

(a) Latitude and longitude are reported in North American Datum of 1983 (NAD 83), decimal degrees.
(b) California Data Exchange Center (CDEC).
(c) The term “Discharge” means that stream flows are reported. If no flows are reported but stream stage is, then the term “Stage” is used.
(d) California Department of Water Resources (DWR) Water Data Library (WDL).

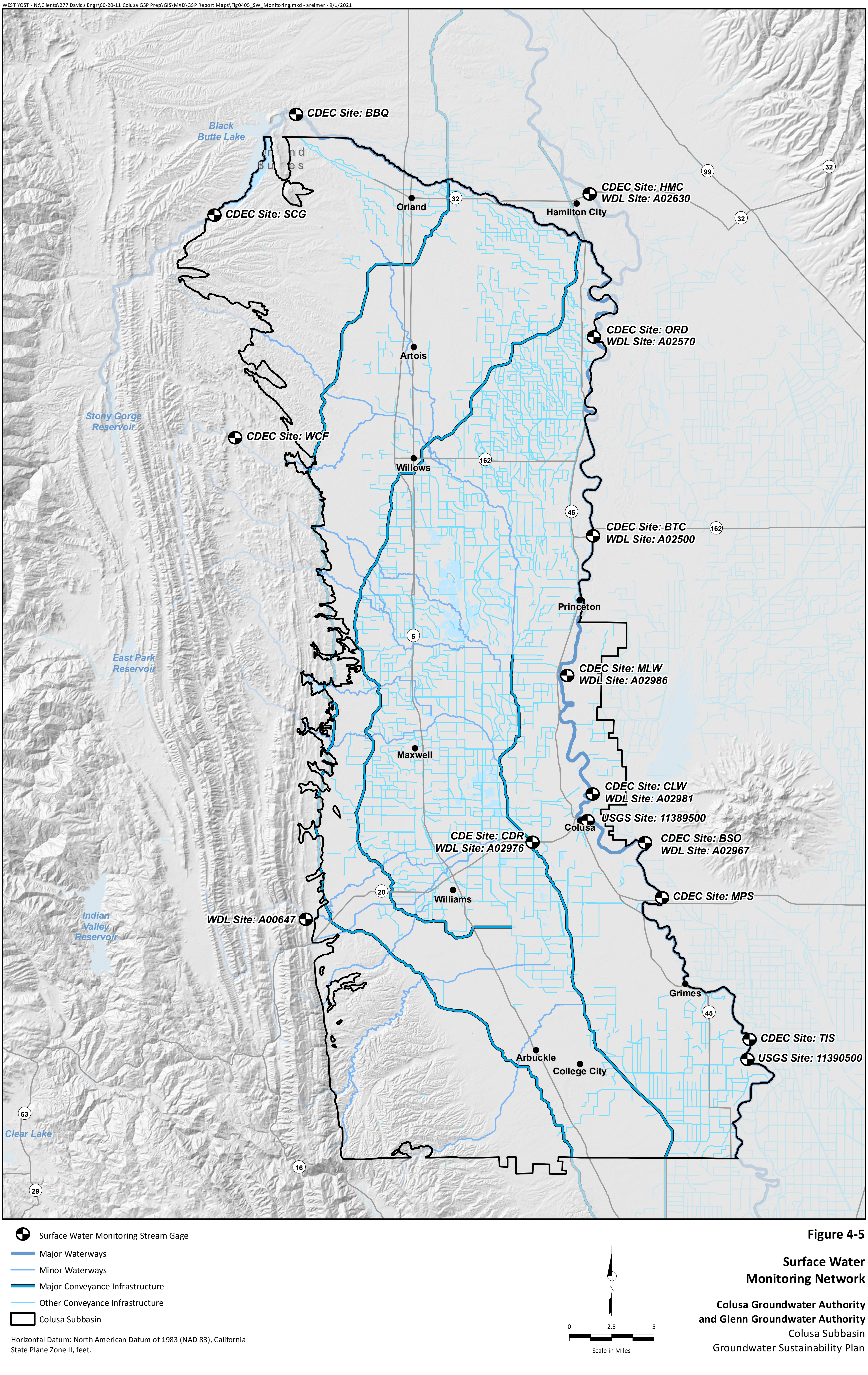


Figure 4-5

Surface Water Monitoring Network

Colusa Groundwater Authority and Glenn Groundwater Authority
Colusa Subbasin
Groundwater Sustainability Plan

4.2.4.3 Monitoring Protocols

Data will either be obtained from the agencies that are responsible for managing the monitoring stream gages within the surface water monitoring network or downloaded from dataset host websites.

- California DWR WDL: https://wdlbeta.water.ca.gov/Map.aspx
- CDEC: https://cdec.water.ca.gov/
- USGS NWIS: https://waterdata.usgs.gov/nwis

Since all of the stream gages identified as part of the Subbasin surface water monitoring network are included in existing state or federal monitoring programs, collection of discharge and river stage measurements comply with existing regulatory monitoring protocols.

Per the Monitoring Protocols BMP (DWR, 2016c), streamflow measurements should be collected, analyzed, and reported in accordance with procedures defined in the USGS Water Supply Paper 2175, volumes 1 and 2 (Rantz, 1982). This methodology is currently being used for both DWR and USGS surface water monitoring networks within the Subbasin.

4.2.4.4 Data Gaps in Surface Water Monitoring Network

Data gaps in the surface water monitoring network include the following:

- The temporal changes in ephemeral and intermittent stream stage and flow within the subbasin may not be sufficiently addressed by the existing surface water monitoring network to the extent required by 23 CCR §354.34(c).
- Colusa Basin Drainage Canal System (Colusa Drain) outflows from the Subbasin are not currently monitored, and historical monitoring records for Colusa Drain outflows from the Subbasin are not available within the CDEC, NWIS, and WDL databases.
- With the exception of the Black Butte Lake stream gages, there is currently no active stream gage on Stony Creek. A stream gage on Stony Creek that measured both discharge and river stage would benefit evaluating potential surface water depletions and help characterize the stream-aquifer relationship.

4.2.4.5 Proposed Actions to Address Data Gaps

The perennial streams (Stony Creek and the Sacramento River) that bound or intersect the Subbasin and adjacent subbasins are shown on Figure 4-4. Surface water monitoring, particularly as related to streamflow depletion, should be coordinated across subbasins. The Colusa Subbasin GSAs are participating in a surface water monitoring network data gap assessment and fulfillment in cooperation with neighboring GSAs.

Additionally, existing stream and drainage reports will be evaluated for additional information on the timing, stage, and magnitude of flows in ephemeral and intermittent streams in the subbasin, if necessary, to fill data gaps or support projects and management actions during GSP implementation. Willow or Walker Creek, two of the more prominent and long-ranging creeks in the Subbasin, could provide data representative of the subbasin's other ephemeral or intermittent creeks. If necessary, site-specific studies will be conducted to fill data gaps or address requirements for monitoring of ephemeral and intermittent streams, per 23 CCR §354.34(c)(6).

DWR is reportedly in the process of evaluating the adequacy of existing stream gages to support SGMA implementation. As a result of this effort, it is anticipated that DWR will identify data gaps and develop recommendations regarding the existing stream gage networks. There is one inactive USGS stream gage on Stony Creek (Station 11388500) near Hamilton City that may be identified as adequate to re-equip. Some of the ephemeral or intermittent streams within Subbasin have inactive stream gages that could also provide important information if re-equipped. Actions proposed by DWR, if any, will be taken into consideration by the Colusa Subbasin GSAs.

The need for additional monitoring wells to assist in the monitoring of stream-aquifer interactions will be assessed during implementation of this GSP. Evaluation of the new groundwater level data from the representative monitoring network described in the following section will be an important first step in determining the need for additional monitoring wells.

Annual reports and future revisions to the GSP will provide updates on actions taken to address data gaps over the reporting period.

4.2.5 Representative Monitoring Sites

Per 23 CCR §354.36, "*Each Agency may designate a subset of monitoring sites as representative of conditions in the basin or an area of the basin…*" to evaluate or monitor for sustainability indicators. Representative monitoring locations were designated to evaluate undesirable results due to lowering of groundwater levels, reduction of groundwater storage, groundwater quality degradation, inelastic land subsidence, and surface water depletions. The purpose and composition of the representative monitoring networks are discussed below. Undesirable results and sustainability thresholds determined by the representative monitoring networks are discussed in Chapter 5 (Sustainable Management Criteria).

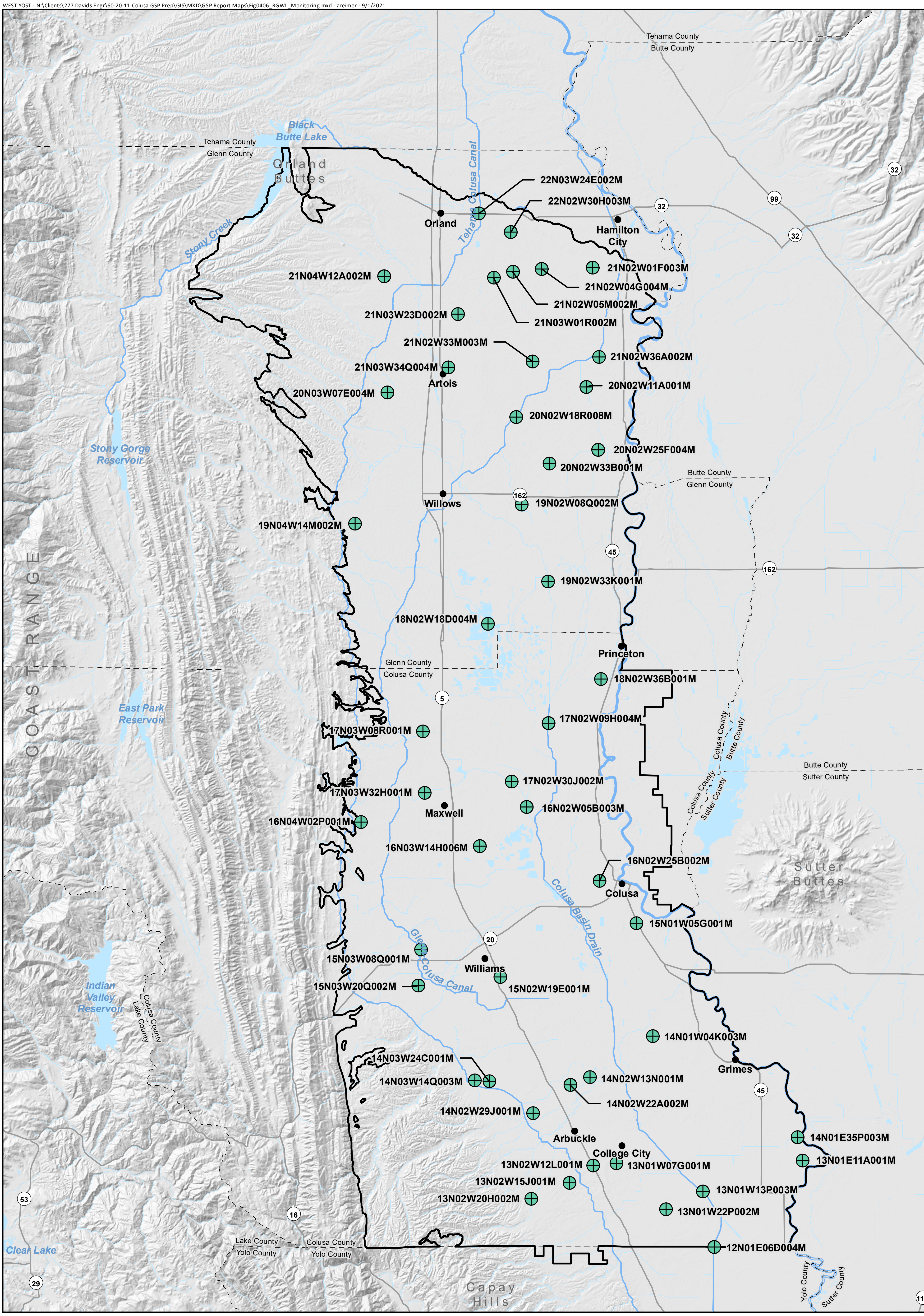
4.2.5.1 Representative Groundwater Level Monitoring Network

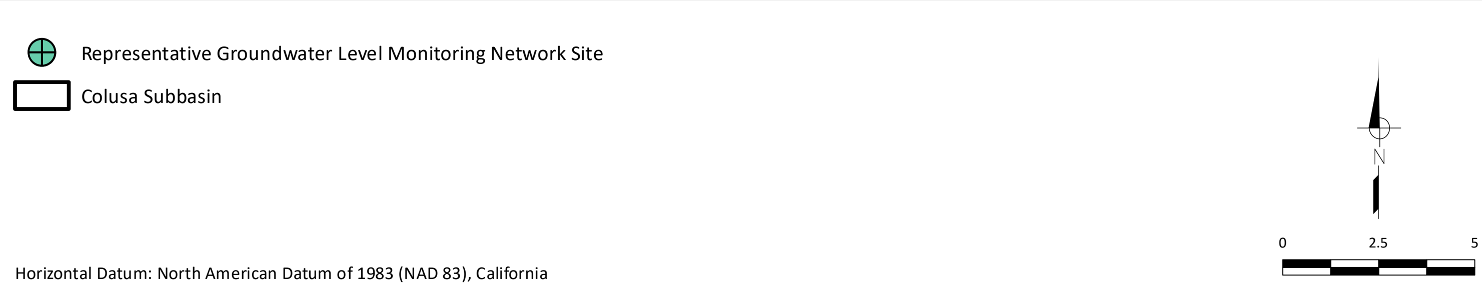
The representative groundwater level monitoring network includes one completion from each of the 48 wells in the groundwater monitoring network. The representative groundwater level monitoring sites are indicated in Table 4-2 and shown on Figure 4-6. Each single completion well is a representative groundwater level monitoring site. For multiple completion wells in the representative monitoring network, the completion depth was selected based on the median depth of domestic wells within the Thiessen polygon bounding each multiple completion monitoring well.

Additional information regarding the selection of these representative groundwater level monitoring sites and how they were used to determine sustainability thresholds can be found in Chapter 5 and Appendix 5B.

4.2.5.2 Representative Groundwater Quality Monitoring Network

The Subbasin representative groundwater quality monitoring network includes 25 monitoring sites to monitor for groundwater quality degradation due to increasing salinity concentrations, either via migration of deep brackish to saline waters into the freshwater aquifer system or recharge from agricultural runoff. The representative groundwater quality monitoring sites are indicated in Appendix 4B and shown on Figure 4-7.





Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

Figure 4-6

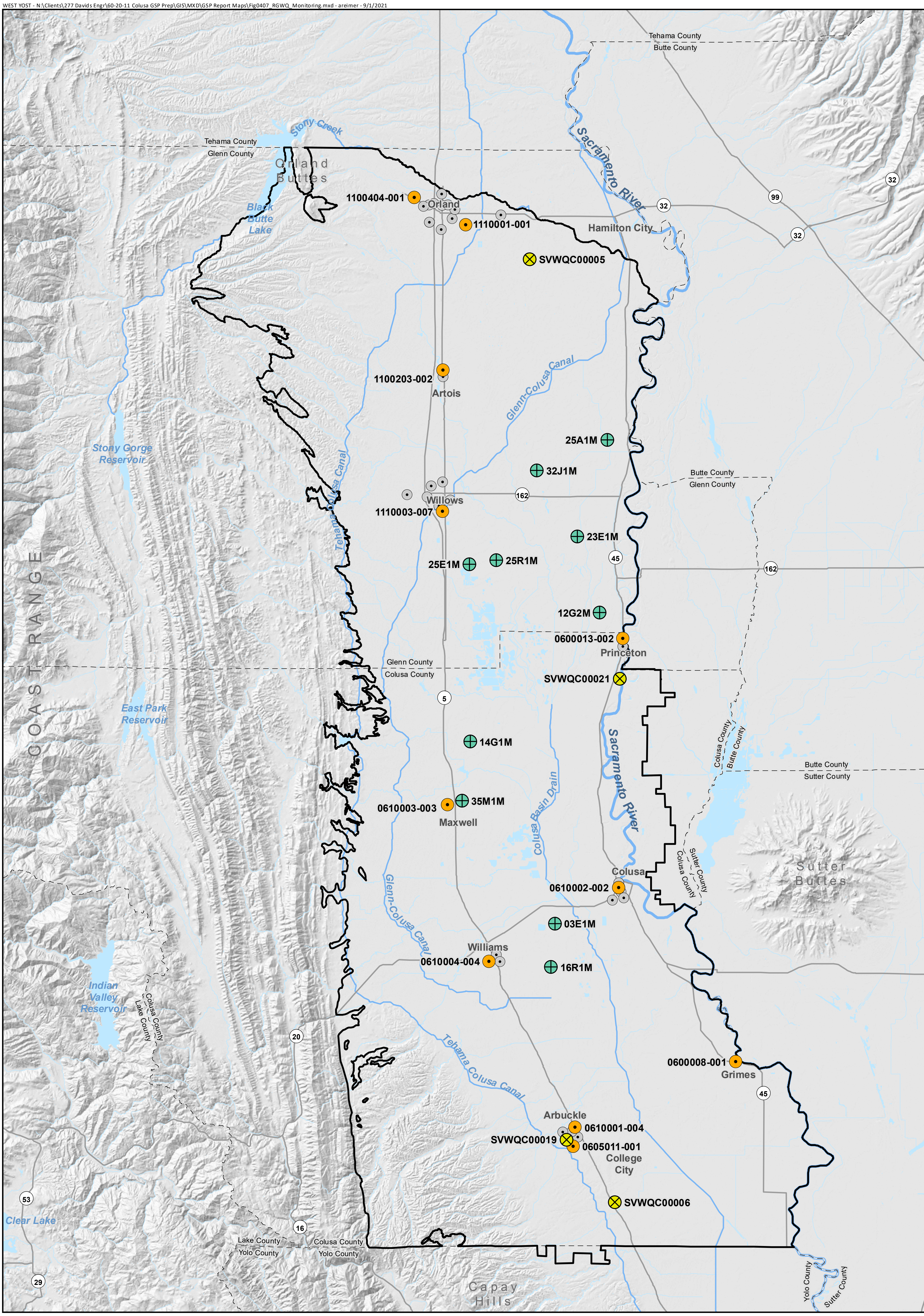
Representative Groundwater Level Monitoring Network

Colusa Groundwater Authority and Glenn Groundwater Authority

Colusa Subbasin

Groundwater Sustainability Plan

WEST YOST - N:\Clients\277 Davids Engr\60-20-11 Colusa GSP Prep\GIS\MXD\GSP Report Maps\Fig0407_RGWQ_Monitoring.mxd - areimer - 9/1/2021



Colusa Subbasin

Active Public Water Supply Well

Representative Groundwater Quality Monitoring Network Well

Representative Public Water Supply Well

Representative California Rice Commission Groundwater Monitoring Well

Representative Sacramento Valley Water Quality Coalition Groundwater Monitoring Well

Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

N

0 2.5 5

Scale in Miles

Figure 4-7

Representative Groundwater Quality Monitoring Network

Colusa Groundwater Authority and Glenn Groundwater Authority

Colusa Subbasin

Groundwater Sustainability Plan

Ten California Rice Commission wells were selected as representative monitoring sites due to their shallow construction (less than 30 feet deep) to monitor recharge waters, proximity to irrigated agricultural lands, proximity to areas with known salinity concerns, inclusion in an existing groundwater quality monitoring program with a focus on salinity, and dedicated observation well status. Four Sacramento Valley Water Quality Coalition wells were selected as representative groundwater quality monitoring sites due to their locations near irrigated agricultural lands and surface waters, proximity to areas with high domestic and agricultural wells, relatively deeper constructed depth than the California Rice Commission wells, and inclusion in an existing groundwater quality monitoring program with a focus on salinity. One well from each community-level public water system was selected as a representative groundwater quality monitoring site based on their proximity to urban areas, status, level of use, and conversations with water agency operational staff. The groundwater quality monitoring network includes 11 public drinking water wells.

Additional information regarding the selection of these representative groundwater quality monitoring sites and how they were used to determine sustainability thresholds can be found in Chapter 5.

4.2.5.3 Representative Land Subsidence Monitoring Network

Sixty-three (63) benchmarks within the Subbasin are included in the representative land subsidence monitoring network to determine sustainability thresholds and evaluate the occurrence of undesirable results. The benchmarks are shown on Figure 4-4 and bolded in Table 4-5. None of the CGPS stations, extensometers, or benchmarks outside of the Subbasin are included in the representative monitoring network. The benchmarks are evenly distributed throughout the Subbasin, including through the areas with current land subsidence occurrence, and are easily re-surveyed to measure for vertical displacement.

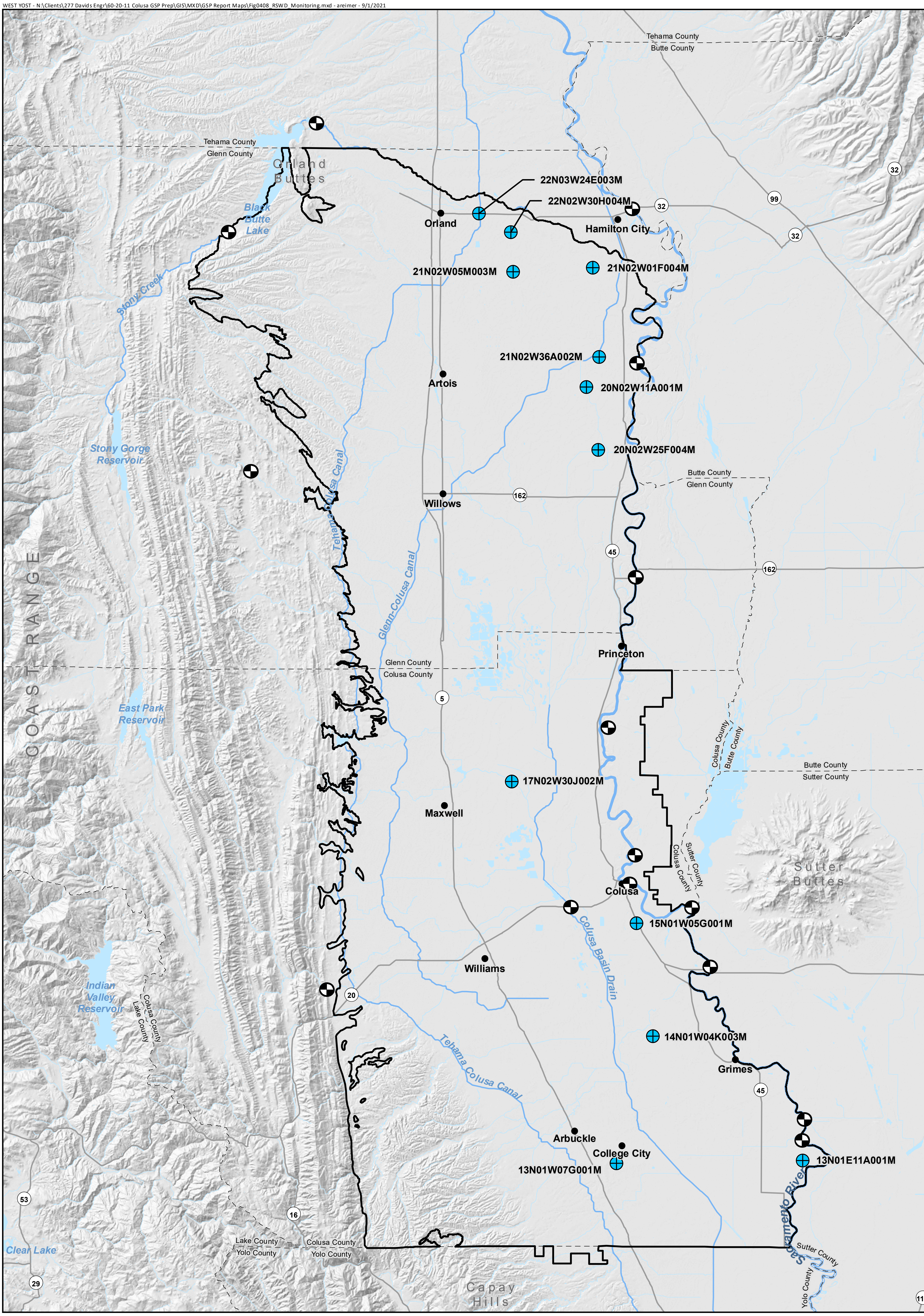
Additional information regarding the representative land subsidence monitoring sites and how they were used to determine sustainability thresholds can be found in Chapter 5.

4.2.5.4 Representative Surface Water Depletion Monitoring Network

Groundwater levels in shallow wells are being used as a proxy to monitor for surface water depletions and interconnected surface waters. The rationale and methodology for this is explained in Chapter 5 and Appendix 5B. The criteria for inclusion in the representative surface water depletion monitoring network was that the site must be:

- Less than 200 feet deep, and
- More than 2,000 feet and less than 5 miles from the surface water feature of concern.

Twelve (12) shallow wells from the groundwater level monitoring network qualified as representative monitoring sites. These wells may also be useful as monitoring sites for GDEs, although a dedicated network of shallow monitoring wells will be developed specifically for GDE monitoring during implementation of the GSP. The representative surface water depletion monitoring sites are indicated in Table 4-2 and shown on Figure 4-8. Additional information regarding the selection of these representative surface water depletion monitoring sites and how they were used to determine sustainability thresholds can be found in Chapter 5 and Appendix 5B.



Surface Water Monitoring Stream Gage

Representative Surface Water Depletion Monitoring Site

Colusa Subbasin

Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

0 2.5 5

Scale in Miles

Figure 4-8

Representative Surface Water Depletion Monitoring Network

Colusa Groundwater Authority and Glenn Groundwater Authority

Colusa Subbasin

Groundwater Sustainability Plan

CHAPTER 5
Sustainable Management Criteria

This chapter describes the sustainable management criteria (SMC) for each applicable sustainability indicator for the Subbasin (Subbasin). These sustainable management criteria are used by the CGA and GGA to gauge progress towards achieving the Sustainability Goal during GSP implementation. This chapter also describes undesirable results for each applicable sustainability indicator and how undesirable results are detected.

5.1 SUSTAINABILITY TERMINOLOGY

This section defines key terminology used is discussing groundwater sustainability in the Subbasin.

- **Sustainability goal**: The sustainability goal qualitatively describes the overall objectives of the GSP and desired conditions for the Subbasin.
- **Undesirable results**: Undesirable results statements describe the Subbasin conditions at which each applicable sustainability indicator would have significant and unreasonable effects on the beneficial uses and users of groundwater in the Subbasin.
- **Minimum thresholds**: Minimum thresholds are quantitative values established for each applicable sustainability indicator that, when exceeded, indicate that undesirable results could occur.
- **Measurable objectives**: Measurable objectives are quantitative goals for the maintenance or improvement of specified groundwater conditions, reflecting desired Subbasin conditions and providing a benchmark to achieve and maintain the Subbasin sustainability goal.
- **Interim milestones**: Interim milestones are target values representing measurable groundwater conditions, in increments of five years, set by the GSAs to provide a glidepath toward sustainability over the GSP implementation horizon, ultimately leading to the measurable objectives and achievement and maintenance of the Subbasin sustainability goal.
- **Sustainable management criteria**: Sustainable management criteria refer to the criteria by which the GSAs define conditions in the GSP that constitute sustainable groundwater management for the Subbasin. The sustainable management criteria include the processes by which undesirable results are characterized, and by which minimum thresholds and measurable objectives are established for each applicable sustainability indicator.

5.1.1 Sustainability Indicators

A sustainability indicator is defined in SGMA as one of six effects caused by groundwater conditions that, when significant and unreasonable, cause undesirable results. The six sustainability indicators are described by the DWR in the document *Sustainable Management Criteria, Best Management Practices for the Sustainable Management of Groundwater* (DWR, 2017) as follows:

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

SGMA allows several pathways to meet the distinct local needs of each subbasin, including:

- Development of sustainable management criteria for each sustainability indicator.
- Use of groundwater elevation as a proxy metric for other sustainability indicators
- Exclusion of specific indicators that are not applicable to the subbasin

Five sustainability indicators are applicable to the Subbasin:

- Chronic lowering of groundwater levels
- Reduction of groundwater storage
- Degraded water quality
- Inelastic land subsidence
- Depletions of interconnected surface water

Sustainable management criteria have been established herein for the chronic lowering of groundwater levels, degraded water quality, and inelastic land subsidence. For sustainability indicators that have a significant, demonstrated correlation to groundwater levels, the sustainable management criteria for groundwater levels may be used as a proxy metric. Both depletions of interconnected surface water and reduction of groundwater storage are significantly correlated to groundwater levels (as described below), and thus utilize groundwater levels as a proxy. Seawater intrusion is not applicable to the Subbasin due to the distances between the Subbasin and the Pacific Ocean, bays, deltas, or inlets ranging from about 30 to

60 miles. Because seawater intrusion is neither occurring nor anticipated to occur in the subbasin over the planning horizon, only the five applicable sustainability indicators are addressed hereinafter.

Continued data collection and an improved understanding of Subbasin conditions in the future may lead to changes in the sustainable management criteria discussed herein. Section 7.8 describes the 5-year GSP update process. Including an evaluation of the progress towards meeting interim goals and a reassessment of sustainable management criteria in light of new data.

5.2 SUSTAINABILITY GOAL

23 CCR §354.24 requires establishment of a sustainability goal for the subbasin that culminates in the absence of undesirable results by 2042. The sustainability goal provides a qualitative description of the Subbasin's objectives relative to sustainable management and desired groundwater conditions in the Subbasin. Information from Chapter 3, Basin Setting, including information on historical, current, and future water budgets, have informed understanding of the status of the Subbasin and, subsequently, development of the sustainability goal for the Subbasin. The sustainability goal is consistent with avoidance of locally-defined undesirable results and is supported by the quantitative minimum thresholds, measurable objectives, and interim milestones identified in this chapter. Demonstration of the absence of undesirable results supports a determination that a Subbasin is operating sustainably and thus the sustainability goal has been achieved.

The sustainability goal for the Subbasin is:

> *… to maintain, through a cooperative and partnered approach, locally managed sustainable groundwater resources to preserve and enhance the economic viability, social well-being and culture of all Beneficial Uses and Users, without experiencing undesirable results.*

5.2.1 Sustainable Operation of the Subbasin

Projects and management actions that the GSAs and other partners could implement to ensure that the Subbasin is operated sustainably (i.e., to avoid undesirable results) are described in Chapter 6. The Introduction to Chapter 6 describes an adaptive management approach for implementing projects and management actions that will be informed by monitoring of groundwater conditions and will lead to implementation of additional projects if Measurable Objectives (MOs) are not being maintained and Minimum Thresholds (MTs) are being approached.

An adaptive management approach recognizes that undesirable results do not currently exist in the Subbasin, and it is uncertain that undesirable results will develop in the future. The uncertainty is primarily related to the relatively small groundwater storage imbalances estimated to occur under future conditions (see Chapter 3, Section 3.3, Water Budget Information), the uncertainty associated with those estimates, and uncertainty associated with when and how potential future climate change actually affects the Subbasin. Monitoring of actual groundwater conditions over time will determine whether, when, and where implementation of projects and management actions may be needed to avoid undesirable results.

Despite the long-term adaptive implementation approach described above, certain Subbasin projects are currently moving toward implementation to address localized declining groundwater levels that are believed to be primarily drought-induced[2]. These planned projects are described in Chapter 6 and are regarded as projects that will contribute to long-term sustainable groundwater management in addition to alleviating temporary drought-induced effects in the near term.

5.2.2 Achieving Sustainability within 20 Years

As discussed above, the Subbasin does not currently have undesirable results, which shows that the Subbasin is being managed sustainably. Additionally, it is uncertain that undesirable results will occur in the future. If monitoring detects that Measurable Objectives are not being maintained and Minimum Thresholds are being approached, the GSAs and other project proponents are committed to implementing projects and management actions to avoid undesirable results, as described in Chapters 6 and 7.

5.3 UNDESIRABLE RESULTS

As described in 23 CCR §354.26, undesirable results occur when one or more significant and unreasonable effects are caused by groundwater conditions occuring throughout the Subbasin, as assessed using the five applicable sustainability indicators described earlier: chronic lowering of groundwater levels, reduction of groundwater storage, degraded water quality, inelastic land subsidence, and/or depletions of interconnected surface water. The DWR's *Sustainable Management Criteria Best Management Practices* was developed to help GSAs establish their sustainability criteria by first identifying the significant and unreasonable effects caused by groundwater conditions in the Subbasin that constitute undesirable results, and then identifying quantitative criteria to define when and where the effects of groundwater conditions cause undesirable results for each applicable sustainability indicator. These quantitative criteria define the number and location of monitoring points that may be below a specific minimum threshold prior to a GSA identifying conditions as an undesirable result. The *Sustainable Management Criteria* Best Management Practice (BMP) states that "undesirable results will be defined by minimum threshold exceedances" (DWR, 2017).

This section presents the undesirable results statements for the Subbasin, which were developed through a process that characterizes specific groundwater conditions that lead to undesirable results in the Subbasin and identifies minimum thresholds that, when exceeded, may indicate that undesirable results could occur. Input from Subbasin stakeholders, the public, and GSA members was used in conjunction with data collected and evaluated for preparation of the Plan Area and Groundwater Conditions chapters of this GSP (Chapter 2 and Chapter 3, respectively) to guide development of the undesirable results statements. These statements utilize quantitative thresholds (as described later in this section) to indicate where and when undesirable results might occur in the representative monitoring network, and therefore the Subbasin. Appendix 5A documents the decision-making process and adoption of the Subbasin sustainable management criteria by the CGA and GGA. The sustainable management criteria decision records identify these quantitative thresholds selected by the GSAs, and the process and considerations leading to these decisions.

Chapter 4 describes the Subbasin's monitoring networks and representative monitoring networks for each applicable sustainability indicator.

[2] A series of mostly dry years beginning in about 2007 has resulted in increased irrigation demands within the Subbasin and curtailments of Central Valley Project surface water supplies, and consequently increase in groundwater pumping. In some locations these effects of drought are compounded by expansion of irrigation lands served solely by groundwater.

The five applicable sustainability indicators are addressed to determine whether and when significant and unreasonable impacts are occurring on beneficial uses and/or users in the Subbasin. For each indicator, the potential for undesirable results is described. Causes of groundwater conditions leading to significant and unreasonable effects are identified, and undesirable results defined based on current Subbasin conditions, the California Water Code, SGMA regulations, BMPs, and stakeholder input. For each sustainability indicator, the following have been developed:

- Description of undesirable results – describes groundwater conditions causing the specific significant and unreasonable effects that constitute undesirable results.
- Identification of undesirable results – describes the criteria used to define when and where groundwater conditions cause undesirable results, defined and detected by minimum threshold exceedances.
- Potential causes of undesirable results – describes groundwater conditions that could lead to undesirable results.
- Potential effects of undesirable results – describes what could happen to beneficial uses and users of groundwater if undesirable results were to occur.
- Evaluation of the presence of undesirable results – describes whether undesirable conditions are present in the Subbasin and/or are detected through monitoring.

As previously noted, undesirable results related to seawater intrusion are neither occurring nor anticipated to occur in the subbasin over the planning horizon. Thus, criteria for undesirable results related to this sustainability indicator are not applicable to this GSP.

5.3.1 Chronic Lowering of Groundwater Levels

5.3.1.1 Description of Undesirable Results for Chronic Lowering of Groundwater Levels

The undesirable result for the chronic lowering of groundwater levels is a result that would cause significant and unreasonable reduction in the long-term viability of beneficial uses and users over the planning and implementation horizon of this GSP.

An undesirable result for chronic lowering of groundwater levels in the Subbasin is experienced if sustained groundwater levels are too low to reasonably satisfy beneficial uses and users within the Subbasin over the planning and implementation horizon of this GSP. Undesirable results for the chronic lowering of groundwater levels have not occurred historically and are not currently occurring. Per the projected water budget (Chapter 3), these effects are not likely to occur in the projected water budget analysis period (2016-2065).

Potential impacts of chronic lowering of groundwater levels and the extent to which they are considered significant and unreasonable were determined by the GSA members with input from local stakeholders and members of the public, as described in Chapter 2. During development of the GSP, potential undesirable results identified by stakeholders included:

- A significant and unreasonable number of wells going dry
- A significant and unreasonable reduction in the pumping capacity of existing wells
- A significant and unreasonable increase in the need for deeper wells or lower pump settings
- Adverse impacts to environmental uses and users, including reductions in the flows of interconnected surface waters and reductions in groundwater available to the root zones of groundwater-dependent ecosystems (GDEs)

As described in Chapter 2, most of the Subbasin is classified as an Economically Disadvantaged Area and has a high proportion of Disadvantaged Communities (DACs) and Severely Disadvantaged Communities (SDACs). These beneficial users, along with members of California Native American Tribes (Tribes), including the federally recognized Cachil Dehe Band of Wintun Indians and the Cortina Indian Rancheria of Wintun Indians of California, typically rely on groundwater to meet their drinking water needs. As expressed in California Water Code Section 106.3, "every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes." The human right to water extends to all Californians, including disadvantaged individuals and groups and communities in rural and urban areas (SWRCB, 2021). Undesirable results caused by chronic lowering of groundwater levels could affect the Human Right to Water by limiting the ability of drinking water beneficial users, including DACs, SDACs and Tribes, to access safe, clean, and affordable water for human consumption, cooking, and sanitary purposes. These drinking water beneficial users could experience cumulative effects of undesirable results caused by chronic lowering of groundwater levels and degraded water quality.

5.3.1.2 Identification of Undesirable Results

An undesirable result is considered to occur for the chronic lowering of groundwater levels during GSP implementation when 25 percent or more of the representative monitoring wells (i.e., 12 of 48 wells) in the Subbasin fall below their minimum groundwater elevation threshold levels for 24 consecutive months. The 12 wells must be the same subset of wells, not any combination of 12 wells. The subset of wells is not predetermined; rather, it is delineated only as wells collectively fall below their minimum threshold levels. Minimum threshold levels for each well were determined using the best available data by the process described in Section 5.4. Additional justification and information supporting the process and criteria used to define when and where the effects of the groundwater conditions may cause undesirable results are provided in Appendices 5B and 5C.

These criteria were determined based on an evaluation of the best available data pertaining to the Subbasin's specific conditions and characteristics, as described in the Plan Area and Basin Setting sections of this GSP (Chapter 2 and Chapter 3, respectively), in conjunction with input and feedback from the public, stakeholders, and GSA members. The GSAs determined these criteria based on the justification that minimum threshold exceedances of 25 percent or more of representative monitoring wells represent a "significant" impact, and that exceedance of these levels for 24 consecutive months or longer (e.g., no recovery of groundwater levels through two consecutive seasonal high periods) constitutes a chronic impact that would potentially harm the "long-term viability" of affected beneficial uses and users in the Subbasin. The criterion of 25 percent or more of the representative monitoring wells dropping below their minimum thresholds for 24 consecutive months was regarded as an indicator of a significant, widespread problem representing undesirable results.

5.3.1.3 Potential Causes of Undesirable Results

Potential causes of groundwater conditions that would lead to this undesirable result for the chronic lowering of groundwater levels are excessive groundwater pumping, reductions in recharge of precipitation and applied surface water, and other factors. Potential local impacts to groundwater levels could be caused by one or more of the following:

- Reduction in surface water supplies available to the Subbasin, particularly surface water diversions from the Sacramento River and Stony Creek
- Increases in groundwater pumping to meet increased crop consumptive use caused by climate change or shifts to higher water use crops

For example, if reductions in surface water supplies available under existing contracts are reduced due to changes in federal water allocation policy or other factors, such as State Board decisions or orders limiting diversions and transfers, then the Central Valley Project (CVP) Settlement Contractors and the contractors receiving water under Tehama Colusa Canal Authority contracts would have to increase groundwater pumping to meet any water supply shortages. If surface water supplies remained unchanged but crop consumptive use increased due to climate change, groundwater pumping would need to increase to meet higher irrigation requirements. Excessive groundwater pumping could cause lowering of groundwater levels leading to undesirable results.

5.3.1.4 Potential Effects of Undesirable Results

If groundwater levels were to reach levels indicating undesirable results have occurred, specific undesirable effects to beneficial uses and users of groundwater, land uses, property interests, and others could potentially include:

- De-watering of some existing groundwater production wells, starting with the shallowest wells (which are primarily domestic wells)
- Decreased access to safe, clean, and affordable drinking water
- Increased production well construction costs
- Increased groundwater pumping costs due to increased lifts
- Adverse effects on GDEs if the depth to groundwater falls below the root zones of GDEs
- Forced changes to lower water use, lower economic return crops, or to idling of agricultural lands
- Adverse effects on property values and the regional economy
- Permanent loss of crops due to lack of water
- Hauling of water to meet minimum household needs
- Stock water impacts (hauling water, selling livestock, etc.)

Implementation of the GSP is intended to avoid these effects by monitoring and implementing projects and management actions as needed to maintain groundwater levels above the minimum thresholds at representative monitoring network wells. An economic analysis of groundwater level minimum thresholds is included in Appendix 5C. Chapter 6 describes projects and management actions. Chapter 7 describes GSP implementation efforts directed towards maintaining groundwater levels and mitigating drought impacts to drinking water beneficial users.

5.3.1.5 Evaluation of the Presence of Undesirable Results

Section 5.4 discusses how minimum thresholds were selected. More information on how the thresholds were established is also included in Appendix 5B, along with hydrographs of groundwater levels for each monitoring site through 2020 and the established depth of the minimum threshold. Of the 48 monitoring wells, none were below the minimum threshold in the latest measurement in 2020, indicating that the Subbasin does not currently exceed the requirements for an undesirable result for the chronic lowering of groundwater levels. The GSAs will continue to monitor groundwater levels to identify potential undesirable results as part of GSP annual reports and five-year updates, and adapt GSP implementation, as needed, to avoid undesirable results.

5.3.2 Reduction of Groundwater Storage

5.3.2.1 Description of Undesirable Results for the Reduction of Groundwater Storage

The undesirable result for the reduction of groundwater in storage is a result that would cause significant and unreasonable reduction in the long-term viability of beneficial uses and users over the planning and implementation horizon of this GSP.

An undesirable result for the reduction of groundwater storage is experienced if storage volumes are insufficient to reasonably satisfy beneficial uses and users within the Subbasin over the planning and implementation horizon of this GSP. Undesirable results related to groundwater storage have not occurred historically and are not currently occurring. Per the projected water budget (Chapter 3), these effects are not likely to occur in the projected water budget analysis period (2016-2065).

5.3.2.2 Justification of Groundwater Levels as a Proxy

This GSP uses groundwater level minimum thresholds as a proxy for the reduction of groundwater storage sustainability indicator. GSP regulations allow GSAs to use groundwater level minimum thresholds as a proxy metric for any sustainability indicator provided the GSP demonstrates that there is a significant correlation between groundwater levels and the other metrics. In order to rely on groundwater levels as a proxy, one approach suggested by DWR is to:

> *Demonstrate that the minimum thresholds and measurable objectives for chronic declines of groundwater levels are sufficiently protective to ensure significant and unreasonable occurrences of other sustainability indicators will be prevented. In other words, demonstrate that setting a groundwater level minimum threshold satisfies the minimum threshold requirements for not only chronic lowering of groundwater levels but other sustainability indicators at a given site (DWR, 2017).*

Minimum thresholds for groundwater levels will effectively avoid undesirable results for reduction of groundwater storage if it is demonstrated that adequate storage remains in the Subbasin even if chronic lowering of groundwater levels occurs. Based on the estimated range of current storage volume in the Subbasin (Chapter 3) and the small percentage changes in storage estimated to occur over groundwater levels ranging from current levels to the groundwater levels minimum thresholds, it is anticipated that an undesirable result related to the chronic lowering of groundwater levels would occur before the Subbasin would experience significant and unreasonable effects related to reduction of groundwater storage. This is because the base of fresh groundwater is generally far below the groundwater level minimum thresholds that have been adopted, and large volumes of groundwater would remain in storage even if minimum thresholds were reached.

As discussed in Chapter 3, the current groundwater storage volume within the Subbasin, above the crystalline basement rocks and base of freshwater, is estimated to be between about 26 million acre-feet (maf) and 140 maf. The estimated reduction of groundwater storage over the Subbasin brought about by the average decline from the lowest historical groundwater levels measured at each of the 48 wells in the representative monitoring network prior to January 1, 2015 to the groundwater level minimum threshold for each of the 48 wells ranges from 1.4 to 7.7 maf, using the range of specific yield documented in Chapter 3. This represents a change of approximately five percent across the range of total estimated current groundwater storage volumes. This small percentage change is unlikely to trigger undesirable results based on storage impacts alone. Also, this range of estimated reduction in storage would not be likely to occur, because undesirable results would be triggered and addressed when groundwater levels in the first 12 of the 48 representative wells dropped to their minimum thresholds for 24 consecutive months.

Therefore, by setting minimum thresholds for groundwater levels as they have been, groundwater storage is effectively protected. The use of groundwater levels as a proxy metric for the groundwater storage sustainability indicator is effective and appropriate.

As discussed in Section 5.2.1, implementation of the GSP will be based on adaptive management, as required to adapt to changing climatic conditions. The SMCs for groundwater levels and storage will continue to be evaluated and updated as new information about groundwater conditions is acquired and data gaps are filled.

5.3.2.3 Identification of Undesirable Results

The undesirable result for the reduction of groundwater storage is monitored by proxy using groundwater levels and is considered to occur during GSP implementation when 25 percent or more of representative monitoring wells (i.e., 12 of 48 wells) fall below their minimum groundwater elevation thresholds for 24 consecutive months. The 12 wells must be the same subset of wells, not any combination of 12 wells. The subset of wells is not predetermined; rather, it is delineated only as wells collectively fall below their minimum threshold levels. Minimum threshold levels for each well were determined using best available data by the process described in Section 5.4. Additional justification and information supporting the criteria used to define when and where the effects of the groundwater conditions cause undesirable results is provided in Appendix 5B.

These criteria were determined based on the evaluation of best available data pertaining to the Subbasin's specific conditions and characteristics, as described in the Plan Area and Basin Setting sections of this GSP (Chapter 2 and Chapter 3, respectively), in conjunction with input and feedback from the public, local stakeholders, and GSA members. The GSAs selected these criteria based on the justification that minimum threshold exceedances of 25 percent or more of representative monitoring wells represent a "significant" impact, and that exceedance of these levels for 24 consecutive months or longer (indicating a significant lack of groundwater recharge through two consecutive periods of seasonal groundwater fluctuation) constitutes a chronic impact that would potentially harm the long-term viability of affected beneficial uses and users in the Subbasin. The criterion of 25 percent or more of the representative monitoring wells dropping below their minimum thresholds for 24 consecutive months was regarded as an indicator of a significant, widespread problem representing undesirable results.

5.3.2.4 Potential Causes of Undesirable Results

Potential causes of undesirable results for the reduction of groundwater storage are excessive groundwater pumping and decreases in recharge due to reductions in the availability of surface water or reductions in precipitation. Increases in groundwater pumping could be caused by increases in consumptive use of water due to increased agricultural productivity, and changes in land and water use. Increases in overall demand, especially for groundwater, and decreases in recharge of surface water and precipitation may cause groundwater conditions that lead to undesirable results if the reduction in groundwater storage is excessive (water budgets area described in Chapter 3).

Based on the estimated range of current storage volume in the Subbasin and the small percentage changes in storage estimated to occur over groundwater levels ranging from historical lows to the groundwater levels minimum thresholds, undesirable results due to decreases in groundwater levels would occur before undesirable results due to a significant reduction of groundwater storage. As such, the use of groundwater levels as a proxy for the establishment of thresholds for reductions in groundwater storage is protective of groundwater storage.

5.3.2.5 Potential Effects of Undesirable Results

Undesirable results for reductions in groundwater storage could potentially cause significant and unreasonable effects on beneficial uses and users of groundwater. These effects could be:

- De-watering of some existing groundwater production wells, starting with the shallowest wells (which are primarily domestic wells)
- Increased production well construction costs
- Increased groundwater pumping costs due to inreased lifts
- Adverse effects on GDEs if the depth to groundwater falls below the root zones of GDEs
- Forced changes to lower water use, lower economic return crops, or idling of agricultural lands
- Adverse effects on property values and the regional economy
- Stock water impacts (hauling water, selling livestock, etc.)

Implementation of the GSP is intended to avoid these effects by monitoring and implementing projects and management actions as needed to maintain groundwater levels above the minimum thresholds at representative monitoring wells.

5.3.2.6 Evaluation of the Presence of Undesirable Results

Section 5.4 discusses how minimum thresholds were selected; more information on the process used to establish minimum thresholds for groundwater levels (as a proxy for groundwater storage) is also included in Appendix 5B. Current groundwater level data show that none of the 48 monitored wells were below the minimum threshold in the latest measurement in 2020, indicating that the Subbasin does not currently exceed the requirements for an undesirable result for the reduction of groundwater storage. The GSAs will continue to monitor groundwater storage through groundwater levels to identify potential undesirable results as part of GSP annual reports and five-year updates, and adapt GSP implementation, as needed, to avoid these effects.

5.3.3 Seawater Intrusion

Seawater intrusion is not an applicable sustainability indicator because seawater intrusion is not present and is not likely to occur in the Subbasin due to the distances between the Subbasin and the Pacific Ocean, bays, deltas, or inlets ranging from about 30 to 60 miles.

5.3.4 Degraded Water Quality

5.3.4.1 Description of Undesirable Results for Degraded Water Quality

The undesirable result for degraded water quality is a result that would cause a significant and unreasonable reduction in the long-term viability of beneficial uses and users, including domestic, agricultural, municipal, environmental, or other beneficial uses and users over the planning and implementation horizon of this is GSP. An undesirable result for degraded water quality in the Subbasin is experienced if, as the result of projects and management actions implemented under the GSP or other groundwater development (such as groundwater extraction or groundwater recharge), groundwater quality for regulated constituents is degraded to levels exceeding historical levels existing prior to January 1, 2015, or applicable water quality objectives, including drinking water standards, whichever are greater over the planning and implementation horizon of this GSP.

Existing regulatory programs address most water quality concerns, and the CGA and GGA will coordinate with these programs, the lead regulatory agencies, and the regulated community within the Subbasin during implementation of this GSP, including during development and implementation of projects and management actions.

The State Water Resources Control Board (SWRCB) and the Central Valley Regional Water Quality Control Board (CVRWQCB) regulate point and nonpoint source discharges to land that have potential to impact groundwater quality under a range of policy and regulatory programs, including the Basin Plan Amendment for the Salt and Nitrate Control Program, and the Irrigated Lands Regulatory Program. The California Department of Toxic Substance Control regulates releases of toxic substances, including those that impact groundwater quality.

The California Safe Drinking Water Act addresses the regulation and control of public water systems in the State of California, including enforcing provisions of the federal Safe Drinking Water Act. The federal government first granted primary enforcement responsibility to the State in 1978. The SWRCB Division of Drinking Water is the agency responsible for enforcement in Colusa and Glenn Counties, including the entire Subbasin.

The CGA and GGA will rely on existing monitoring and reporting carried out by the regulated community within the Subbasin when and where possible to address water quality concerns. The CGA and GGA will conduct supplemental water quality monitoring using existing wells or new monitoring wells constructed for that purpose when and where necessary to fill data gaps and to develop and implement projects and management actions.

Groundwater quality in the Subbasin is generally good, with local exceedances of water quality objectives for some constituents. The sole groundwater quality concern not addressed by the existing groundwater quality regulatory programs is mobilization of saline water from deeper parts of the aquifer along faults, other geologic structures, or other naturally-occurring zones with high salinity as a result of GSP projects and management actions and other groundwater development. Sustainable management criteria for salinity have been established to supplement existing regulatory programs.

Potential impacts of degraded water quality caused by GSP projects and management actions and the extent to which they are considered significant and unreasonable were determined by the GSA members with input from local stakeholders and members of the public. During development of the GSP, potential undesirable results identified by stakeholders included:

- A significant and unreasonable number of additional public supply wells requiring treatment, blending, control or replacement to remain in service
- A significant and unreasonable reduction in pumping capacity in existing public supply due to water quality degradation
- A significant and unreasonable reduction in pumping capacity in existing irrigation or stock water supply wells due to water quality degradation
- A significant and unreasonable increase in the number of domestic supply wells exceeding water quality objectives
- Adverse impacts to environmental uses and users, including significant and unreasonable impairment to water quality of interconnected surface waters and groundwater available to the root zones of GDEs

Undesirable results caused by degraded water quality could affect the Human Right to Water by limiting the ability of drinking water beneficial users, including DACs, SDACs and Tribes, to access safe, clean, and affordable water for human consumption, cooking, and sanitary purposes. These drinking water beneficial users could experience cumulative effects of undesirable results caused by chronic lowering of groundwater levels and degraded water quality.

5.3.4.2 Identification of Undesirable Results

The undesirable result for degraded water quality is considered to occur during GSP implementation when 25 percent of representative monitoring sites (i.e., 6 of 25 wells) exceed their minimum thresholds for two consecutive years. The six sites must be the same subset of sites, not any combination of six sites. The subset of sites is not predetermined; rather, it is delineated only as sites collectively exceed their minimum threshold values. Minimum thresholds were selected for each site by the process described in Section 5.4.

These criteria were determined based on the evaluation of best available data pertaining to the Subbasin's specific conditions and characteristics, as described in the Plan Area and Basin Setting sections of this GSP (Chapter 2 and Chapter 3, respectively), in conjunction with input and feedback from the public, local stakeholders, and GSA members. The GSAs selected these criteria based on the justification that minimum threshold exceedances at 25 percent or more of representative monitoring sites represent a "significant" impact, and that exceedance of these levels for two years or longer (indicating a significant and prolonged degradation of groundwater quality through two consecutive periods of seasonal groundwater fluctuation) constitutes an impact that would potentially harm the long-term viability of affected beneficial uses and users. Exceedance of minimum thresholds for two consecutive years at twenty-five percent of the representative network wells was estimated to be an indicator of a significant, widespread problem indicating undesirable results.

5.3.4.3 Potential Causes of Undesirable Results

Potential causes of undesirable results for degraded water quality may be caused by:

- Mobilization of saline water from deeper parts of the aquifer along faults, other geologic structures, or other naturally-occurring zones with high salinity as a result of GSP projects and management actions and other groundwater development
- Mobilization of poor quality water, including contaminant plumes, monitored under existing regulatory programs as the result of GSP projects and management actions and other groundwater development
- Mobilization of naturally-occurring constituents in soils, the unsaturated zone, or the aquifer matrix as the results of projects involving direct groundwater recharge
- Direct groundwater recharge using water with constituent concentrations exceeding applicable water quality objectives or historical concentrations for the same constituents in groundwater

5.3.4.4 Potential Effects of Undesirable Results

If groundwater quality were degraded such that undesirable results occurred, the effects could potentially cause a shortage in supply to groundwater users without additional treatment, with domestic wells being most vulnerable as treatment costs or access to alternate supplies can be high for small users. This could limit access to safe, clean, and affordable drinking water for drinking water beneficial users, including DACs, SDACs and Tribes.

High salinity can impact both drinking water uses and agricultural uses, as there are maximum values associated with aesthetics (taste, color, and odor) for drinking water and crop health and yield for agriculture. Water quality degradation could potentially impact GDEs, surface water quality and the health of aquatic species, cause changes in crops grown and irrigation practices, and cause adverse effects to property values.

5.3.4.5 Evaluation of the Presence of Undesirable Results

Section 5.4 discusses how minimum thresholds were selected. Appendix 5D presents the historical salinity results expressed as electrical conductivity (EC) and the established minimum threshold for each representative monitoring site. Of the 25 monitoring sites, four wells exceeded their respective minimum thresholds in the most recent monitoring event after January 1, 2015. Although the Subbasin does not currently exceed the requirements for an undesirable result for degraded water quality, the CGA and GGA will coordinate with the entities responsible for monitoring, reporting, and compliance with applicable regulations to assess whether actions are required and being taken to achieve compliance for the wells.

The GSAs will continue to coordinate with the regulated community to identify potential undesirable results as part of GSP annual reports and five-year updates, and adapt GSP implementation, as needed, to avoid undesirable results. Chapter 7 describes GSP implementation efforts directed towards coordinating with drinking water providers and regulatory agencies to support drinking water beneficial uses and users.

5.3.5 Inelastic Land Subsidence

5.3.5.1 Description of Undesirable Results for Inelastic Land Subsidence

The undesirable result for inelastic land subsidence due to groundwater withdrawal is a result that would cause significant and unreasonable impacts to critical infrastructure over the planning and implementation horizon of this GSP.

An undesirable result is experienced if groundwater withdrawal causes inelastic land subsidence that substantially interferes with the condition or functionality of critical infrastructure within the Subbasin over the planning and implementation horizon of this GSP.

Potential impacts of inelastic land subsidence and the extent to which they are considered significant and unreasonable were determined by the GSA members with input from local stakeholders and members of the public. During development of the GSP, potential undesirable results identified by stakeholders included:

- Significant and unreasonable impacts to critical infrastructure in the Subbasin, including canals, pipelines, roadways, bridges, and groundwater wells.

5.3.5.2 Identification of Undesirable Results

Inelastic land subsidence within the Subbasin is monitored at 63 sites in DWR's Sacramento Valley Subsidence Monitoring Benchmark Network. An undesirable result is considered to occur during GSP implementation when 20 percent or more of representative monitoring locations (i.e., 13 of 63 locations) measure a subsidence rate greater than the specified minimum threshold of 0.5 feet per five years. The 13 locations must be the same subset of locations, not any combination of 13 locations. The subset of locations is not predetermined; rather, it is delineated only as sites collectively exceed their minimum threshold values. Minimum threshold levels were selected for each monitoring point by the process described in Section 5.4.

These criteria were determined based on the evaluation of best available data pertaining to the Subbasin's specific conditions and characteristics, as described in the Plan Area and Basin Setting sections of this GSP (Chapter 2 and Chapter 3, respectively), in conjunction with input and feedback from the public, local stakeholders, and GSA members. The GSAs selected these criteria based on the justification that minimum threshold exceedances at 20 percent or more of representative monitoring sites represent a significant impact, and that exceedance of these levels for 24 consecutive months or longer (indicating significant inelastic land subsidence through two consecutive periods of seasonal groundwater fluctuation) would substantially interfere with the condition or functionality of critical infrastructure within the Subbasin. Exceedance of the minimum thresholds for 24 consecutive months at 20 percent of monitoring sites was estimated to be an indicator of a significant, widespread problem indicating undesirable results.

5.3.5.3 Potential Causes of Undesirable Results

Inelastic land subsidence due to groundwater withdrawal is caused by a reduction in pore pressure brought about by pumping. The reduction in pore pressure increases the effective stress borne by the aquifer skeleton. The increase in the effective stress causes compaction of compressible clays.

The potential causes of undesirable results for inelastic land subsidence are:

- Increasing pumping or decreasing recharge in subsidence-prone areas
- Initiating pumping in areas or at depths with no or minimal historical groundwater pumping

5.3.5.4 Potential Effects of Undesirable Results

If inelastic land subsidence reaches levels indicating that undesirable results have occurred, the effects could potentially cause damage to local infrastructure such as canals, pipelines, roadways, bridges, and groundwater wells. Excessive subsidence may also lead to decreased groundwater storage and decreased hydraulic conductivity, with a resultant increase in well operations and maintenance costs.

5.3.5.5 Evaluation of the Presence of Undesirable Results

Section 5.4 discusses how the minimum thresholds were selected. Chapter 3 presents maps showing the extent and rate of historical subsidence. Of the 63 monitoring sites, none were below the minimum threshold in the latest measurement from 2017 indicating that the Subbasin does not currently exceed the requirements for an undesirable result for inelastic land subsidence. However, recognizing that there is uncertainty in Subbasin conditions and that data gaps exist, the GSAs will continue to monitor inelastic land subsidence to identify potential undesirable results as part of GSP annual reports and five-year updates, and adapt GSP implementation, as needed, to avoid undesirable results.

Ongoing monitoring of Subbasin conditions and data collection will inform potential updates to the SMC in the periodic updates. Chapter 7 documents plans to coordinate and fund additional surveys of the subsidence benchmarks.

5.3.6 Depletions of Interconnected Surface Water

5.3.6.1 Description of Undesirable Results for Depletions of Interconnected Surface Water

The undesirable result for depletions of interconnected surface water is a result that causes significant and unreasonable adverse effects on beneficial uses and users of interconnected surface waters within the Subbasin over the planning and implementation horizon of this GSP. During development of the GSP, potential undesirable results identified by stakeholders included:

- Significant and unreasonable impacts to stream flows
- Significant and unreasonable impact to riparian and riverine habitat
- Significant and unreasonable impacts to GDEs
- Significant and unreasonable impacts to springs

5.3.6.2 Justification of Groundwater Elevations as a Proxy

The use of groundwater elevation as a proxy metric for this sustainability indicator is necessary because the network of existing stream gages is not adequate to measure changes in stream accretions and depletions as related to the Subbasin. The network is inadequate because gages are not located such that changes in streamflow can be correlated directly and solely to Subbasin groundwater conditions. Additionally, it is unlikely that the relatively small, expected changes in streamflow associated with changes in groundwater conditions can be accurately quantified given the measurement error associated with the gages. In contrast, changes in streamflow volume and rates can be estimated by modeling of groundwater levels and stream stages together with characterization of soil and aquifer properties. However, the levels of uncertainty in the available Subbasin groundwater model are currently too great to allow sufficiently reliable quantification of the rates and volume of stream depletions during GSP implementation.

Depletions of interconnected surface water are driven by the gradient between water surface elevation in the surface water body and groundwater elevations in the connected, shallow groundwater system. By setting minimum thresholds in representative monitoring wells near interconnected surface water, the GGA and CGA can monitor and manage this gradient, and in turn, manage potential changes in depletions of interconnected surface water. Monitoring for impacts to interconnected surface waters will occur utilizing a subset of wells in the Subbasin's groundwater elevation monitoring network selected for this purpose (see Chapter 4).

5.3.6.3 Identification of Undesirable Results

The undesirable result for depletions of interconnected surface water is considered to occur during GSP implementation when 25 percent of representative monitoring wells (i.e., 3 of 12 wells) fall below their minimum groundwater elevation thresholds for 24 consecutive months. The three wells must be the same subset of wells, not any combination of three wells. The subset of wells is not predetermined; rather, it is delineated only as wells collectively fall below their minimum threshold levels. Minimum thresholds were selected for each site by the process described in Section 5.4. Additional justification and information supporting the criteria used to define when and where the effects of the groundwater conditions cause undesirable results is provided in Appendix 5B.

These criteria were determined based on the evaluation of best available data pertaining to the Subbasin's specific conditions and characteristics, as described in the Plan Area and Groundwater Conditions sections of this GSP (Chapter 2 and Chapter 3, respectively), in conjunction with input and feedback from the public, local stakeholders and GSA members. The representative monitoring network was selected based on identification of existing monitoring wells with locations and depths considered appropriate for monitoring groundwater with potential to influence interconnected streams in the Subbasin. These interconnected streams are the Sacramento River, the Colusa Drain and portions of Stony Creek below Black Butte Dam. Monitoring wells with screened intervals less than 200 feet deep located within 2,000 feet to five miles of the interconnected streams were selected.[4] These wells are expected to provide the best available monitoring of groundwater levels that have an influence on the volume and rates of stream depletion. Wells closer than 2,000 feet were excluded based on the assumption that wells in too close a proximity to an interconnected stream may be directly influenced by stream stage. Wells deeper than 200 feet and farther than five miles from interconnected streams were excluded because pumping at greater depths or distances was assumed to cause capture from multiple sources (e.g., recharge zones, springs, ponded water, and other wells), which cannot be resolved with existing data and models. The GSAs selected these criteria based on the justification that minimum threshold exceedances at 25 percent or more of representative monitoring sites represent a significant impact, and that exceedance of these levels for 24 consecutive months or longer (indicating significant depletions of interconnected surface water through two consecutive periods of seasonal groundwater fluctuation) constitutes an impact that would potentially harm the long-term viability of affected beneficial uses and users. The criterion of 25

[4] For wells within a few thousand feet of a waterway, groundwater levels are expected to be controlled by the elevation of the connected surface water. For wells in intermediate locations between waterways and groundwater pumping centers, declines in water levels could also indicate current and future streamflow depletion (EDF, 2018).

percent or more of the representative monitoring wells dropping below their minimum thresholds for 24 consecutive months was regarded as an indicator of a significant, widespread problem representing undesirable results.

5.3.6.4 Potential Causes of Undesirable Results

Potential causes of undesirable results for depletions of interconnected surface water are likely tied to groundwater production, which could result in lowering of groundwater elevations in shallow aquifers near the connected streams. Increased groundwater production near interconnected streams may cause groundwater conditions that lead to undesirable results if this production changes the hydraulic gradient between the stream stage and the groundwater level. For the connected streams, an increase in the hydraulic gradient between the shallow groundwater and the stream bed may result in increases in the rate and volume of stream depletions.

5.3.6.5 Potential Effects of Undesirable Results

If depletions of interconnected surface waters reach levels indicating that undesirable results have occurred, the effects could potentially reduce the availability or change the timing of streamflow available for beneficial uses and users of surface water. Additionally, reduced streamflow could potentially reduce the availability of water to GDEs and riparian habitats. In addition, reduced stream flows can lead to increased water temperatures which can also potentially negatively impact certain species.

5.3.6.6 Evaluation of the Presence of Undesirable Results

Section 5.4 discusses how minimum thresholds were selected; more information on how the thresholds were established is also included in Appendix 5B, along with hydrographs of groundwater levels through 2020 for the depletions of interconnected surface waters monitoring points and the established depth of the minimum threshold for each monitoring site. Of the 12 monitoring sites, none were below the minimum threshold in the latest measurement in 2020, indicating that the Subbasin does not currently exceed the requirements for an undesirable result for depletions of interconnected surface water.

5.4 SUSTAINABILITY THRESHOLDS

Sustainability thresholds include minimum thresholds, measurable objectives, and interim milestones. Sustainability thresholds are described below by sustainability indicator. No management areas are identified for the Subbasin (see Chapter 3), and the same methodology for establishing sustainability thresholds was applied subbasin-wide for each applicable sustainability indicator. Potential effects of the selected sustainability thresholds on other neighboring subbasins are summarized at the end of this section.

Table 5-1 summarizes the sustainability thresholds for all applicable sustainability indicators in the Subbasin. Additional information and considerations are provided in the sections that follow.

Table 5-1. Summary of Sustainability Thresholds for All Sustainability Indicators Applicable to the Subbasin

Sustainability Indicator	Monitoring Network	Undesirable Result	Minimum Threshold (MT)	Measurable Objective (MO)
Chronic Lowering of Groundwater Levels	48 Representative Monitoring Network (RMN) wells monitored at least 2 to 3 times annually by DWR	25% (12 of 48) RMN wells fall continuously below their MT for 24 consecutive months	The lower of 50% of measured historical groundwater elevation range below the historical measured low elevation and the elevation corresponding to the 20th percentile of domestic well depths in the RMN well's Thiessen polygon, subject to interbasin coordination and consistency to ensure operational compatibility	Mean of the most recent 5 years of available groundwater elevation measurements up to 2020 subject to interbasin coordination and consistency to ensure operational compatibility; A fixed value, not a rolling average
Reduction in Groundwater Storage	48 RMN wells monitored at least 2 to 3 times annually by DWR (same as Groundwater Level monitoring network)	Use groundwater levels as proxy	Use groundwater levels as proxy	Use groundwater levels as proxy
Seawater Intrusion	Not applicable	Not applicable	Not applicable	Not applicable
Degraded Groundwater Quality	25 RMN wells monitored by others at variable intervals under existing State of California regulatory programs	Electrical conductivity (EC) in 25% (6 of 23) of the RMN wells exceeds the MT for two (2) consecutive years	The higher of EC of 900 microSiemens per centimeter (µS/cm) (the recommended California Secondary Maximum Contaminant Level) OR the pre-2015 historical maximum measured EC	EC of 700 µS/cm (corresponding to an agricultural water quality objective providing for no yield reduction for crops commonly grown in the Subbasin)
Land Subsidence	Existing Sacramento Valley Height Modernization Project (SVHMP) benchmarks (63 sites)	20% or more (13 of 63) monitoring sites (benchmarks) experience subsidence rates above the MT	0.5 feet per five years	0.25 feet per five years
Depletions of Interconnected Surface Waters	12 RMN wells less than 200 feet deep and between 2,000 feet and five miles of interconnected stream (Sacramento River, Colusa Drain, Stony Creek)	25% (3 of 12) RMN wells fall below their MT for 24 consecutive months	Ten (10) feet below the observed fall 2015 groundwater level (Fall 2015 level is the measured elevation recorded on the date closest to Oct 15)	Mean of last 5 years available groundwater elevation measurements subject to interbasin coordination and consistency to ensure operational compatibility; A fixed value, not a rolling average

5.4.1 Chronic Lowering of Groundwater Levels

As described in Section 5.3.1, chronic lowering of groundwater levels is considered to be significant and unreasonable when:

> *… it causes a significant and unreasonable reduction in the long-term viability of beneficial uses and users over the planning and implementation horizon of this GSP.*

Chronic lowering of groundwater levels may cause undesirable results when 25 percent of monitoring wells fall below the minimum threshold for 24 consecutive months. The following subsections describe the sustainability thresholds used to monitor and track the chronic lowering of groundwater levels. Appendix 5B provides additional information describing how the minimum thresholds and measurable objectives were established. Appendix 5C documents an economic analysis of the groundwater level minimum thresholds. That analysis generally supports setting minimum thresholds at the specified levels.

As described in Chapter 3, Basin Setting, the Subbasin has one principal aquifer, and therefore one groundwater level monitoring network. Thresholds have been established for all 48 groundwater level representative monitoring wells, as presented in Chapter 4, Monitoring Networks.

5.4.1.1 Minimum Thresholds

Minimum thresholds for the chronic lowering of groundwater levels were developed primarily by considering historical and current groundwater conditions, with lesser emphasis on projected future groundwater conditions. In general, groundwater levels during the 26-year historical period from 1990 through 2015 were used as the primary reference. This period includes relatively wet and dry periods including the back-to-back critically dry years of 2014 and 2015. Evaluation of historical and projected groundwater use in the Subbasin is further discussed in the Plan Area and Basin Setting chapters of this GSP (Chapter 2 and Chapter 3, respectively). Minimum threshold values were defined for individual representative monitoring wells as the groundwater level below which conditions may lead to undesirable results for beneficial uses and users in the vicinity of each well. The minimum threshold for each groundwater level representative monitoring well was calculated by utilizing a simple stepwise function. The minimum threshold is calculated by finding the deeper value of:

1. **20th percentile of shallowest domestic well depths in the monitoring well's Thiessen polygon**: Based on stakeholder input, it was determined that dewatering of domestic wells may be a potential undesirable result that could potentially be used to confirm the adequacy of the minimum threshold methodology. Domestic wells are generally shallower than agricultural and municipal wells and thus more sensitive to undesirable effects from decreases in groundwater elevations, such as well stranding. Additionally, the loss of a domestic well usually results in a loss of water for consumption, cooking, and sanitation purposes, which can often have substantial impacts on the users of the water and can be financially difficult for the well owner to mitigate. These potential adverse effects are addressed in the State's commitment to the Human Right to Water as codified in California Water Code Section 106.3. To protect the beneficial uses and users of groundwater from domestic wells, including supporting the Human Right to Water, groundwater levels need to remain higher than the bottom depth of domestic wells. Analysis of the DWR Well Completion Report (WCR) Database by the GSAs suggests that not all wells provided in the database are still active. Some of the wells included in the database are old enough that the usable lifespan of the well has been exceeded, some wells may not be constructed to meet current health standards (e.g., sanitary seals or other aspects of the well construction or

condition may be deficient), and some well depths and screen intervals would suggest that some wells have been dewatered prior to the implementation of SGMA (i.e., prior to January 1, 2015). The GSAs therefore determined, based on the analysis and feedback from the public and stakeholders, that protection of 100 percent of domestic wells in the WCR database was not reasonable or warranted, and that protection of 80 percent of wells in the WCR database was reasonable and acceptable. Consequently, it was determined that minimum threshold exceedances at more than 20 percent of domestic wells in the current version of the WCR database may constitute an undesirable result. This results in a minimum threshold that would protect 80 percent of domestic wells contained in the current version of the WCR database.

2. **50 percent of range below the historical low groundwater elevation**: To protect the conjunctive use of groundwater for agricultural production, groundwater levels must be able to fluctuate, lowering during droughts when groundwater pumping increases to augment reduced surface water availability, and increasing during years when surface water is available for recharge. For agricultural conjunctive use, the effects of declining groundwater levels are expected to be significant and unreasonable when groundwater levels drop below the lowest historical groundwater elevation by more than 50 percent of the historical range. After an analysis of available historical data, and with considerations of groundwater conditions, the GSAs determined that 50 percent of the historical range below the historical low groundwater level provided adequate operational flexibility at each representative monitoring well site. Consequently, minimum threshold exceedances of this level may constitute an undesirable result.

Appendices 5B and 5C provide additional information on the setting and evaluation of the minimum thresholds. As documented in Appendices 5B and 5C, for the Subbasin as a whole, approximately 46 percent of the domestic wells in the WCR database are shallower than the pre-2015 historical groundwater levels as defined by the groundwater level representative monitoring network. Many of these shallow wells may no longer be used, or they may have been deepened because they would have otherwise been dry at times prior to 2015. Nevertheless, all wells in the WCR database were considered in the calculation of the groundwater level minimum thresholds. Including these shallow, potentially unused or deepened wells in the analysis of well completions depths resulted in groundwater level minimum thresholds that are shallower than they would have been if the wells had been excluded.

Setting minimum thresholds using this methodology is protective of beneficial users and uses of groundwater, including agricultural, municipal, environmental and domestic uses in the Subbasin. The minimum thresholds align with the State's Human Right to Water policy by supporting the ability of drinking water beneficial users, including DACs, SDACs and Tribes, to access safe, clean, and affordable water for human consumption, cooking, and sanitary purposes. The GSAs chose this methodology for calculating the minimum threshold to balance the needs of multiple beneficial uses and users of the groundwater by allowing for adequate flexibility to compensate for drought periods while potentially protecting approximately 80 percent of nearby domestic wells, therefore avoiding undesirable results. Additionally, anecdotal evidence provided by the GSA member stakeholders suggests that groundwater levels seen in recent drought periods did not result in significant and unreasonable Subbasin-wide impacts to beneficial uses and users. The GSAs therefore consider the 2015 historical low groundwater elevation to be protective of current and future beneficial uses and users. In addition, this methodology includes consideration of the spatial location of each monitoring site and variable conditions (such as hydrogeological conditions or nearby infrastructure) across the Subbasin.

Figure 5-1 is a sample hydrograph with the calculated thresholds plotted, including the minimum threshold, in relation to historical groundwater levels. Similar hydrographs for all wells in the representative monitoring networks are included in Appendix 5B.

Table 5-2 presents the minimum thresholds for representative monitoring wells in the chronic lowering of groundwater levels monitoring network in the Subbasin. Additional information on the calculation of minimum thresholds is provided in Appendix 5B.

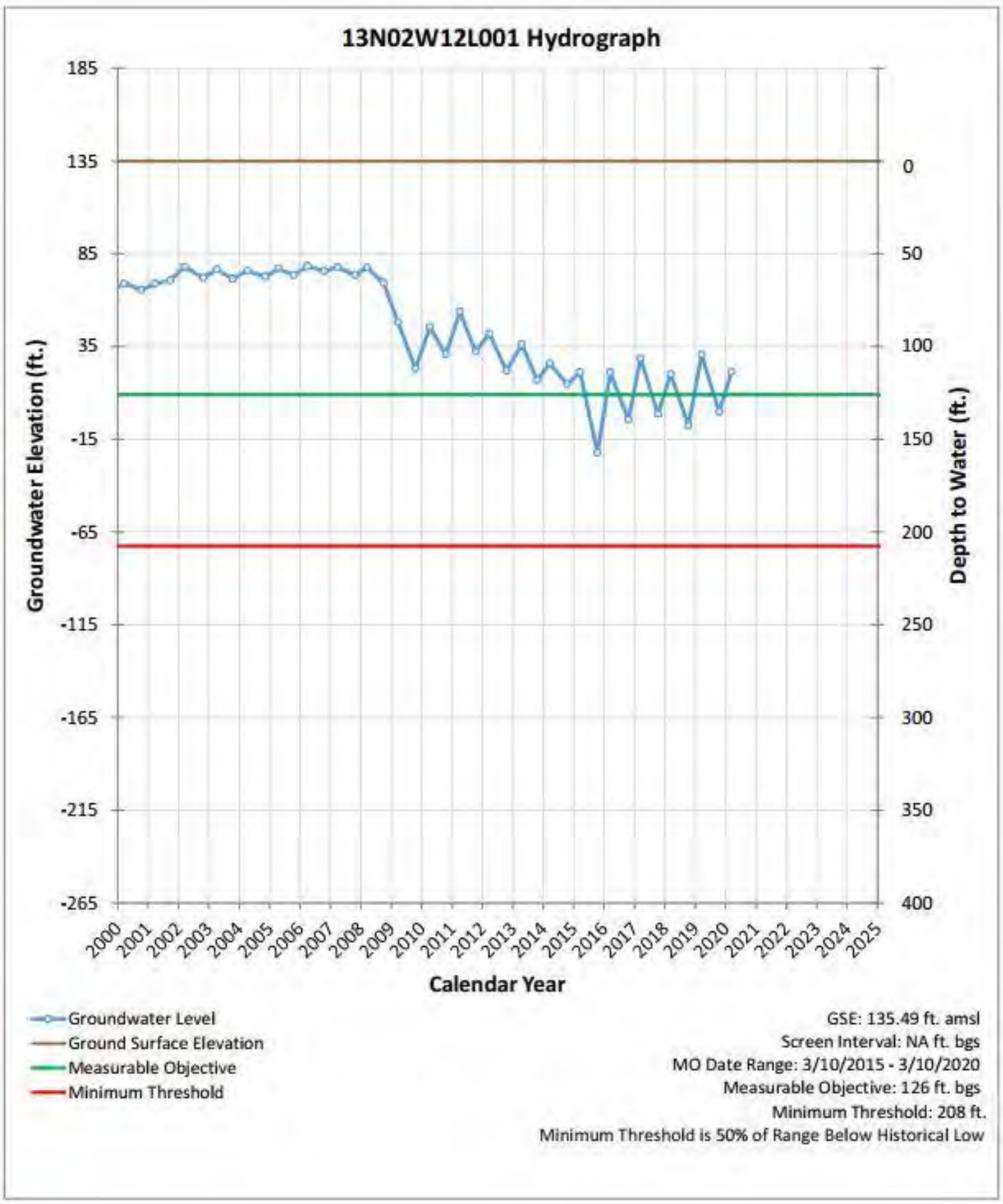


Figure 5-1. Hydrograph, Measurable Objective and Minimum Threshold for Groundwater Monitoring Well 13N02W12L001

5.4.1.1.1 Potential Effects on Other Sustainability Indicators

Groundwater levels have the potential to impact all other sustainability indicators applicable to the Subbasin. These potential effects are described below by sustainability indicator.

- **Reduction of Groundwater Storage:** Chronic lowering of groundwater levels is directly related to reduction of groundwater storage, as changes in groundwater levels are indicative of changes in groundwater storage in the Subbasin. As described in Section 5.4.2.1, the minimum thresholds for groundwater levels will effectively avoid undesirable results for reduction of groundwater storage since undesirable results related to chronic lowering of groundwater levels are expected to occur before the Subbasin would experience significant and unreasonable impacts related to groundwater storage, predominantly as a result of the large volume of groundwater in storage in the Subbasin.
- **Degraded Water Quality:** Chronic lowering of groundwater levels can impact groundwater quality by affecting the direction and rate of groundwater flows, potentially mobilizing saline water, and by affecting the location and characteristics of groundwater recharge or discharge, impacting the concentration of water quality parameters. The minimum thresholds determined for groundwater levels are not expected to contribute to undesirable results for degraded water quality, as they are protective of existing domestic well depths and historical groundwater elevations. Evaluation of 25 groundwater quality representative monitoring sites indicates that the Subbasins does not currently have undesirable results for degraded water quality. Implementation of the GSP is expected to maintain groundwater levels at the average of the last five years of measured groundwater level data (see Section 5.4.1.2). Given the similar trends in historical, current, and projected future groundwater levels, groundwater level sustainable management criteria are expected to support the maintenance of the generally good groundwater quality of the Subbasin.
- **Inelastic Land Subsidence:** Chronic lowering of groundwater levels can potentially cause inelastic land subsidence if it results in compaction of compressible clays in the subsurface. The minimum thresholds for groundwater levels are not expected to contribute to undesirable results for inelastic land subsidence, as they are protective of a range around historical groundwater elevations. Minimum thresholds for land subsidence have also been determined based on consideration of historical subsidence data between 2006-2017, providing flexibility around that range. Evaluation of 63 subsidence monitoring sites indicate that none were below the minimum threshold in the latest measurement from 2017, indicating that historical groundwater levels have not contributed to undesirable results for inelastic land subsidence.
- **Depletions of Interconnected Surface Water:** Reductions in groundwater levels can impact the rate and volume of stream depletions in interconnected streams and reduce the amount of groundwater available for GDEs. The representative groundwater level monitoring network used for monitoring the potential for depletions in interconnected streams is comprised of a selected, collocated subset of the representative monitoring network used for monitoring reductions in groundwater levels. For these selected wells, the interconnected stream depletions sustainable management criteria are more restrictive than the groundwater levels sustainable management criteria and take precedence over them. Therefore, coordinated implementation of the groundwater levels and the depletions of interconnected surface water sustainable management criteria are expected to be protective of interconnected surface waters and GDEs.

5.4.1.2 Measurable Objectives

Measurable objectives are quantitative goals that reflect desired Subbasin conditions and allow the Subbasin to achieve and maintain its sustainability goal. The measurable objectives for chronic lowering of groundwater levels in the Subbasin are shown in Table 5-2. The methodology for establishing these measurable objectives was determined by the Subbasin GSAs, including their respective Technical Advisory Committees, and bases the measurable objectives on the average of the last five years of measured groundwater level data. This method is generally representative of drought and recovery conditions within the Subbasin, as most wells utilize data collected between 2015 and 2020. These measurable objectives are expected to support achievement of the GSP sustainability goal and maintenance of groundwater sustainability over the planning and implementation horizon.

5.4.1.3 Margin of Operational Flexibility

The margin of operational flexibility is the difference between the measurable objective and the minimum threshold for each well. The margin of operational flexibility is intended to provide adequate flexibility to allow for increased groundwater production during drought years with recovery during normal or wet years, accounting for uncertainty in each. This ensures undesirable results are not triggered due to drought conditions that the GSAs cannot control, while allowing for adequate local recovery of groundwater levels after those drought periods, therefore maintaining sustainability in the long term. Because the measurable objective and minimum threshold at each well take into consideration the historical water budgets, seasonal and long-term trends, and periods of drought, the margin of operational flexibility also accounts for these factors.

The margins of operational flexibility for chronic lowering of groundwater levels are shown in Table 5-2.

5.4.1.4 Interim Milestones

Interim milestones are intended to provide a glidepath towards sustainability over the implementation horizon by providing progressive targets for groundwater levels every five years after GSP submittal. After sustainability is reached, interim milestones are not required and subbasins are managed according to the measurable objective (defined in the GSP Emergency Regulations as "…specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions…to achieve the sustainability goal for the basin"). For subbasins that are already sustainable (such as the Subbasin), interim milestones are intended to provide numerical metrics for GSAs to track progress toward meeting the subbasin's sustainability goal and ensuring that the subbasin remains sustainable. Because the minimum thresholds and measurable objectives for chronic lowering of groundwater levels were established to support Subbasin sustainability, the interim milestones were established to maintain water levels in the Subbasin's margin of operational flexibility as established by the minimum thresholds and measurable objectives. The interim milestones for chronic lowering of groundwater levels are consistent with the measurable objectives, as shown in Table 5-2.

Table 5-2. Groundwater Level Representative Monitoring Network and Sustainability Criteria

SWN	CASGEM ID	Ground Surface Elevation, ft	Minimum Threshold GWE, ft amsl	Minimum Threshold DTW, ft bgs	Minimum Threshold Method	Measurable Objective GWE, ft amsl	Measurable Objective DTW, ft bgs	Interim Milestone GWE, ft amsl	Interim Milestone DTW, ft bgs	Margin of Operational Flexibility, ft	20th Percentile Domestic Wells, ft bgs	50% of Range Below Historical Low, ft bgs
12N01E06D004	16331	28	-108	136	(a)	-1	29	-1	29	107	136	94
13N01E11A001	18534	32	-75	106	(a)	22	10	22	10	96	106	28
13N01W07G001	36246	90	-106	196	(b)	-9	99	-9	99	97	153	196
13N01W13P003	18549	32	-88	120	(a)	8	24	8	24	96	120	67
13N01W22P002	16357	60	-124	184	(a)	26	34	26	34	150	184	116
13N02W12L001	31899	135	-72	208	(b)	9	126	9	126	82	200	208
13N02W15J001	39884	213	-62	274	(b)	61	152	61	152	122	215	274
13N02W20H002	25005	343	95	248	(a)	174	169	174	169	79	248	201
14N01E35P003	38718	47	-118	165	(a)	28	19	28	19	146	165	32
14N01W04K003	18554	37	-86	124	(a)	12	25	12	25	99	124	44
14N02W13N001	18563	62	-80	142	(a)	24	38	24	38	104	142	78
14N02W22A002	54756	84	-126	210	(a)	84	0	84	0	210	210	0
14N02W29J001	18566	163	-86	248	(b)	22	141	22	141	107	216	248
14N03W14Q003	32324	173	-89	261	(b)	-13	186	-13	186	75	115	261
14N03W24C001	16691	173	-5	178	(b)	38	135	38	135	43	138	178
15N01W05G001	14309	47	-54	101	(a)	28	19	28	19	82	101	51
15N02W19E001	14319	87	-13	100	(a)	73	14	73	14	86	100	50
15N03W08Q001	N/A	113	43	70	(a)	107	6	107	6	64	70	10
15N03W20Q002	38293	129	60	69	(a)	113	16	113	16	53	69	28
16N02W05B003	25511	65	-71	136	(a)	47	18	47	18	118	136	48
16N02W25B002	33868	55	-25	80	(a)	30	25	30	25	55	80	54
16N03W14H006	24683	66	-94	160	(a)	51	15	51	15	145	160	40
16N04W02P001	16308	163	63	100	(a)	139	24	139	24	76	100	42
17N02W09H004	25514	67	-52	119	(a)	56	11	56	11	108	119	32
17N02W30J002	16960	63	-119	182	(a)	44	19	44	19	163	182	51
17N03W08R001	39127	107	-13	120	(a)	88	19	88	19	101	120	28
17N03W32H001	35475	100	-38	138	(a)	92	8	92	8	130	138	35
18N02W18D004	24953	85	-80	165	(a)	62	23	62	23	142	165	62

Table 5-2. Groundwater Level Representative Monitoring Network and Sustainability Criteria

SWN	CASGEM ID	Ground Surface Elevation, ft	Minimum Threshold GWE, ft amsl	Minimum Threshold DTW, ft bgs	Minimum Threshold Method	Measurable Objective GWE, ft amsl	Measurable Objective DTW, ft bgs	Interim Milestone GWE, ft amsl	Interim Milestone DTW, ft bgs	Margin of Operational Flexibility, ft	20th Percentile Domestic Wells, ft bgs	50% of Range Below Historical Low, ft bgs
18N02W36B001	16914	75	-3	78	(a)	53	22	53	22	56	78	59
19N02W08Q002	25762	108	12	96	(a)	98	10	98	10	86	96	40
19N02W33K001	19793	87	21	66	(a)	71	16	71	16	50	66	53
19N04W14M002	25787	186	46	140	(a)	151	35	151	35	105	140	50
20N02W11A001	17170	125	49	76	(a)	119	6	119	6	70	76	22
20N02W18R008	23986	131	47	84	(a)	120	11	120	11	73	84	18
20N02W25F004	23989	102	37	65	(a)	97	5	97	5	60	65	12
20N02W33B001	17174	105	31	74	(a)	100	5	100	5	69	74	17
20N03W07E004	37860	179	31	148	(a)	100	79	100	79	69	148	124
21N02W01F003	38535	161	71	90	(a)	124	37	124	37	53	90	67
21N02W04G004	24993	178	51	127	(b)	121	57	121	57	70	92	127
21N02W05M002	39676	189	55	134	(a)	140	49	140	49	85	134	112
21N02W33M003	38536	149	67	82	(a)	119	30	119	30	52	82	52
21N02W36A002	21239	135	24	112	(b)	91	44	91	44	68	81	112
21N03W01R002	25232	203	48	155	(b)	151	52	151	52	103	108	155
21N03W23D002	23992	205	84	121	(b)	140	65	140	65	56	89	121
21N03W34Q004	25789	167	42	125	(a)	112	55	112	55	70	125	89
21N04W12A002	24650	248	18	230	(b)	73	175	73	175	55	98	230
22N02W30H003	25726	204	82	122	(b)	150	54	150	54	68	76	122
22N03W24E002	25236	231	122	109	(b)	176	55	176	55	54	90	109

SWN = State Well Number
CASGEM ID = California Statewide Groundwater Elevation Monitoring Identification Code
GWE = groundwater elevation
DTW = depth to water
ft = feet
amsl = above mean sea level
bgs = below ground surface
Minimum Thresholds were calculated as either (a) the 20th percentile of domestic well depth near the monitoring well, or (b) 50 percent of the measured water level range below the historical low within the monitoring well.

5.4.2 Reduction of Groundwater Storage

The undesirable result for the reduction of groundwater storage is:

> *…a result that would cause significant and unreasonable reduction in the long-term viability of beneficial uses and users over the planning and implementation horizon of this GSP.*

The undesirable result for the reduction of groundwater storage is monitored by proxy using groundwater levels. The thresholds set for the reduction of groundwater storage have been established so that when 25 percent of monitoring wells fall below the minimum threshold for 24 consecutive months, an undesirable result is detected. The following subsections describe the sustainability thresholds used for the reduction of groundwater storage.

5.4.2.1 Proxy Monitoring

Monitoring for a reduction of groundwater storage in the Subbasin uses groundwater levels as a proxy for determining sustainability, as permitted by 23 CCR §354.28(d). As described above, any benefits to groundwater storage are expected to coincide with groundwater level management.

The limiting factor to storage use is existing well infrastructure (depth of wells) and near surface conditions, not the volume of groundwater in storage (see Section 5.3.2.2). Therefore, the established groundwater levels minimum thresholds are protective against significant and unreasonable changes in groundwater storage. Minimum thresholds for groundwater levels will effectively avoid undesirable results for reduction of groundwater storage since undesirable results related to chronic lowering of groundwater levels would occur before the Subbasin would experience significant and unreasonable impacts related to groundwater storage, predominantly as a result of the large volume of groundwater in storage in the Subbasin (see Section 5.3.2.2). Therefore, by setting minimum thresholds for groundwater levels, storage is also effectively managed and the use of groundwater levels as a proxy metric for the groundwater storage sustainability indicator is appropriate. Minimum thresholds for groundwater levels, and thus for groundwater storage, are calculated with consideration of historical trends, water year type, and historical and projected groundwater use within the Subbasin, and support sustainable operation, as described in Section 5.2.

5.4.3 Seawater Intrusion

Seawater intrusion is not an applicable sustainability indicator because seawater intrusion is not present and is not likely to occur in the Subbasin due to the distance between the Subbasin and the Pacific Ocean, bays, deltas, or inlets.

5.4.4 Degraded Water Quality

The undesirable result for degraded water quality is described as:

> *Significant and unreasonable degradation of water quality that occurs when GSP projects or management actions cause an increase in the concentration of applicable constituents of concern in groundwater supply wells that lead to adverse impacts on beneficial uses or users of groundwater.*

The thresholds set for degraded water quality have been established so that when 25 percent of representative monitoring sites exceed the minimum threshold for two consecutive years, an undesirable result is detected. The following subsections describe the sustainability thresholds used for degraded water quality. The foregoing sustainability thresholds were established with the GSAs' understanding that additional new or existing wells will need to be added to the monitoring network over time. Additionally, the GSAs acknowledge that the sustainability thresholds will need to be reviewed and evaluated, and potentially refined, as additional wells are added, and additional data is collected and analyzed.

Thresholds have been established for all 25 groundwater quality representative wells, as presented in Appendix 5D. Management areas were not used in the calculations of any thresholds.

5.4.4.1 Minimum Thresholds

The minimum threshold for degraded water quality has been established as the higher of either 900 microSiemens per centimeter (μS/cm) EC, which is consistent with the recommended California Secondary Maximum Contaminant Level (SMCL), or the pre-2015 historical maximum recorded EC value.[5] In developing the minimum thresholds for groundwater quality, beneficial uses of groundwater as a drinking water supply and as an agricultural supply were considered. The potential adverse effects to drinking water addressed in the State's commitment to Human Right to Water as codified in California Water Code Section 106.3 were considered. Setting minimum thresholds using this methodology is protective of beneficial uses and users of groundwater, including agricultural, municipal, and domestic uses in the Subbasin.

The minimum threshold for degraded water quality is calculated to be at an EC level that allows for adequate flexibility within the pre-2015 historical maximum EC level, to compensate for changing groundwater conditions during drought periods, while protecting SMCLs established for aesthetic reasons, such as taste, odor, and color. It is important to note that SMCLs are not based on public health concerns and established to address other non-health related concerns. Exceedance of these minimum threshold values may therefore cause undesirable results for domestic well users related to non-health related concerns at wells where the pre-2015 historical maximum EC level did not exceed the SMCL. At wells where the pre-2015 historical maximum EC level exceeded the recommended California SMCL, groundwater management through coordination with existing regulatory and monitoring programs with respect to this minimum threshold will ensure that degradation of groundwater quality does not exceed historical levels as a result of Subbasin groundwater management activities pursuant to the GSP.

5.4.4.2 Measurable Objectives

The measurable objective for degraded water quality is 700 μS/cm EC, which is consistent with the agricultural water quality objective providing for no yield reduction for crops commonly grown in the Subbasin. The measurable objective for degraded water quality therefore supports ongoing sustainability by protecting water quality within levels that are suitable for drinking water use and agricultural water use, among other beneficial uses. Measurable objectives have not been determined for other water quality constituents.

[5] Consistent with SGMA, the GSP "is not required to address undesirable results that occurred before, and have not been corrected by, January 1, 2015" (Water Code Section 10727.2 (b) (4)).

5.4.4.3 Margin of Operational Flexibility

The margin of operational flexibility for degraded water quality is 200 μS/cm EC (the difference between the measurable objective and minimum threshold). The margin of operational flexibility is intended to provide adequate flexibility to allow for changes in groundwater quality constituent concentrations during various subbasin conditions, such as drought years. This ensures undesirable results are not triggered due to temporary fluctuations in conditions that are anticipated to occur during the implementation horizon, accounting for uncertainty in future conditions. Because the measurable objective and minimum threshold at each site take into consideration historical water quality characteristics, the margin of operational flexibility also accounts for these factors.

5.4.4.4 Interim Milestones

Interim milestones are intended to provide a glidepath towards sustainability over the implementation horizon by providing progressive targets for groundwater quality every five years after GSP submittal. After sustainability is reached, interim milestones are not required and basins are managed according to the measurable objectives (defined in the GSP Emergency Regulations as "…specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions…to achieve the sustainability goal for the basin"). For basins that are already sustainable (such as the Subbasin), interim milestones are intended to provide numerical metrics for GSAs to track progress toward meeting the Subbasin's sustainability goal and ensuring that the Subbasin remains sustainable. Because the minimum thresholds and measurable objectives for degraded water quality were established to support Subbasin sustainability, the interim milestones were established to maintain water quality constituent levels in the Subbasin's margin of operational flexibility as established by the minimum thresholds and measurable objectives. The interim milestone for degraded water quality is consistent with the measurable objective, and is set at 700 μS/cm. This interim milestone is also consistent with the GSAs' role in working with the State of California to guarantee the Human Right to Water to the residents of the Subbasin. Additional discussion of the Human Right to Water and its relationship to the GSAs and the GSP is provided in Chapter 2.

5.4.5 Inelastic Land Subsidence

The undesirable result for inelastic land subsidence is:

> *…a result due to groundwater extraction that would cause significant and unreasonable impacts to critical infrastructure over the planning and implementation horizon of this GSP.*

The undesirable result for inelastic land subsidence is monitored by DWR extensometers, continuously operating global positioning system (CGPS) benchmarks, and traditional benchmarks. The thresholds set for inelastic land subsidence have been established so that when 20 percent of representative monitoring locations (i.e., 13 of 63 locations) exceed their minimum thresholds, an undesirable result is detected. The 13 locations must be the same subset of locations, not any combination of 13 locations. Management areas were not used in establishing or calculating thresholds.

5.4.5.1 Minimum Thresholds

Minimum thresholds for inelastic land subsidence were determined based on consideration of historical subsidence using data available from the Sacramento Valley Height Modernization Project. Minimum thresholds were calculated as the maximum rate of subsidence, described below, above which conditions could collectively generate undesirable results in the Subbasin. While the sensitivity of local infrastructure to land subsidence is not well understood at this time, the Subbasin has extensive networks of pipelines and open canals and drains owned by various surface water suppliers that are used to convey irrigation and drain water. These networks are likely the existing infrastructure most sensitive to land subsidence. A study is proposed in Chapter 7 that would evaluate the sensitivity of local infrastructure to potential subsidence in the Subbasin. Should additional information be developed on the vulnerability of this infrastructure to subsidence, these minimum thresholds may be refined. The GSAs will continue monitoring to continue to improve subbasin understanding during GSP implementation. Refinement of minimum thresholds and any improved understanding of subsidence in the subbasin will be reported in annual reports.

The minimum threshold for this sustainability indicator has been set at 0.5 feet per five years (6 inches).

The sustainable management criteria will be reviewed and adjusted to account for potential changes in subsidence rates brought about by implementation of projects and management actions and future groundwater resource development. The extent of subsidence-prone areas, which may be underlain by sediments that have greater susceptibility to subsidence due to groundwater withdrawal, will continue to be delineated as data gaps are filled through the ongoing subsidence monitoring programs (using data from benchmarks, extensometers and InSAR surveys) and subsidence-prone sediments are characterized during drilling for well construction, extensometer installation or other subsurface investigations needed for the development of specific projects and management actions.

Managing groundwater conditions in the Subbasin to avoid exceedance of the rate of inelastic subsidence established by the minimum threshold is considered unlikely to cause a significant and unreasonable reduction in the viability of the use of critical infrastructure over the planning and implementation horizon of this GSP.

5.4.5.2 Measurable Objectives

The measurable objective for inelastic land subsidence is set at 0.25 feet (3 inches) of subsidence per five years at each site. This rate, in conjunction with sustainable extractions of groundwater over the implementation horizon, is believed to provide enough operational flexibility during drought periods while protecting infrastructure and beneficial users and uses in the Subbasin.

The selected minimum threshold rate of 0.5 feet per five years allows for possible future acceleration of land subsidence. However, because the measurable objective is set at 0.25 feet per five years, projects and management actions will be implemented before the minimum threshold rates are reached.

DWR reports that the probable error in the subsidence values reported for the monitoring benchmarks is ±0.17 feet, meaning that for any reported value, the actual subsidence value is likely to fall in a range between plus or minus 0.17 feet of the reported value. The selected measurable objective subsidence rate of 0.25 feet per five years is deliberately greater than the reported probable error of ±0.17 feet as a means of avoiding false exceedance of the measurable objective.

5.4.5.3 Margin of Operational Flexibility

The land subsidence margin of operational flexibility is 0.25 feet per five years. This value is more than the potential error (±0.17 feet) in the benchmark measurements, allowing for a range of allowable subsidence between the minimum thresholds and a measurable objective that is set within the measurable range (outside the typical range of measurement error and uncertainty) to allow for management if the measurable objective were to be exceeded. Because the measurable objective and minimum threshold at each site take into consideration historical data from the Sacramento Valley Height Modernization Project, the margin of operational flexibility also accounts for these data.

5.4.5.4 Interim Milestones

Interim milestones are intended to provide a glidepath towards sustainability over the implementation horizon by providing progressive targets for subsidence rates every five years after GSP submittal. After sustainability is reached, interim milestones are not required and basins are managed according to the measurable objectives (defined in the GSP Emergency Regulations as "…specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions…to achieve the sustainability goal for the basin"). For subbasins that are already sustainable (such as the Subbasin), interim milestones are intended to provide numerical metrics for GSAs to track progress toward meeting the subbasin's sustainability goal and ensuring that the subbasin remains sustainable. Because the minimum thresholds and measurable objectives for inelastic land subsidence were established to support Subbasin sustainability, the interim milestones are to ensure subsidence rates remain in the Subbasin's margin of operational flexibility as established by the minimum thresholds and measurable objectives. The interim milestones for land subsidence are consistent with the measurable objectives and are set at 0.25 feet (3 inches) of subsidence per five years at each site.

5.4.6 Depletions of Interconnected Surface Water

The undesirable result for depletions of interconnected surface water is:

> *…a result that causes significant and unreasonable adverse effects on beneficial uses and users of interconnected surface water within the Subbasin over the planning and implementation horizon of this GSP.*

The undesirable result for depletions of interconnected surface water is monitored by proxy using groundwater levels. The thresholds set for depletions of interconnected surface water have been established so that when 25 percent of monitoring wells (i.e., 3 of 12 wells) fall below the minimum threshold for 24 consecutive months, an undesirable result is detected. The following subsections describe the sustainability thresholds used for depletions of interconnected surface water. Additional information describing how the minimum thresholds and measurable objectives were established is also included in Appendix 5B.

The foregoing sustainable management criteria were established with the GSAs' understanding that additional new or existing wells will need to be added to the monitoring network over time. Additionally, the GSAs acknowledge that the sustainability thresholds will need to be reviewed and evaluated, and potentially refined, as additional wells are added, and additional data is collected and analyzed.

5.4.6.1 Minimum Thresholds

Minimum thresholds for depletions of interconnected surface waters were determined based on evaluation of historical data from the monitoring network for interconnected surface water, which is composed of 12 shallow groundwater wells located proximate to interconnected streams in the Subbasin. The minimum thresholds set at these sites for assessing impacts to interconnected surface waters were calculated by finding the groundwater elevations in Fall of 2015 and adding 10 feet to that depth. Measurements selected for Fall 2015 were found by selecting measurements closest to October 15, 2015, considered to the be period of lowest groundwater elevations during the last drought based on review of historical groundwater levels and hydrologic data. All wells recorded measurements within three days of this date, providing a relative "snapshot" of groundwater conditions during this time. Management areas were not used in calculating the minimum threshold, or any other threshold for depletions of interconnected surface waters. Figure 5-2 provides an example hydrograph with all depletions of interconnected surface water thresholds plotted. Minimum thresholds for interconnected surface water are provided in Table 5-3. Additional information on the calculation of minimum thresholds is provided in Appendix 5B along with hydrographs for all representative monitoring wells in the interconnected surface water monitoring network showing the site-specific minimum thresholds. The minimum threshold was selected such that groundwater levels near interconnected surface water courses would be protective of the beneficial use and users of shallower groundwater near streams and rivers, including those of shallower domestic users and potential groundwater dependent ecosystems. Levels from Fall 2015 represent conditions during a drought period but are generally believed to have still protected beneficial users at that time and therefore avoid undesirable results. The addition of 10 feet to the Fall 2015 groundwater depth to water is intended to provide an appropriate margin of operational flexibility in the future during GSP implementation based on recommendations made through discussion with the GSAs and stakeholders.

Consideration for the location, quantity, and timing of depletions of interconnected surface water along the primary waterways in the Subbasin is described in Chapter 3 and Appendix 3D. Volumes of projected (future) streamflow depletion during the GSP implementation period and sustainability monitoring horizon were assessed using the C2VSimFG-Colusa model, the best available information to support quantification of streamflow depletion. Documentation of this model is provided in Appendix 3D. Results of these analyses indicate that streamflow gain and loss do not appear to be strongly affected by increases in groundwater pumping needed to satisfy increased irrigation requirements resulting from potential future climate change, or by recharge projects than could be implemented in the Subbasin. Therefore, it is concluded, on a provisional basis, that the effects of groundwater management in the Subbasin will not have significant and unreasonable effects on beneficial uses and users of surface water.

While information and understanding of interconnected surface waters is limited, groundwater levels that exceed the minimum threshold in the future for an extended period of time could impact the beneficial uses and users of shallow groundwater by dewatering domestic wells and limiting resources for groundwater dependent ecosystems. However, as additional data are collected during GSP implementation, the understanding of interconnected surface waters may change and the threshold calculations revised to reflect a better understanding of this complex interaction and the Subbasin's unique conditions.

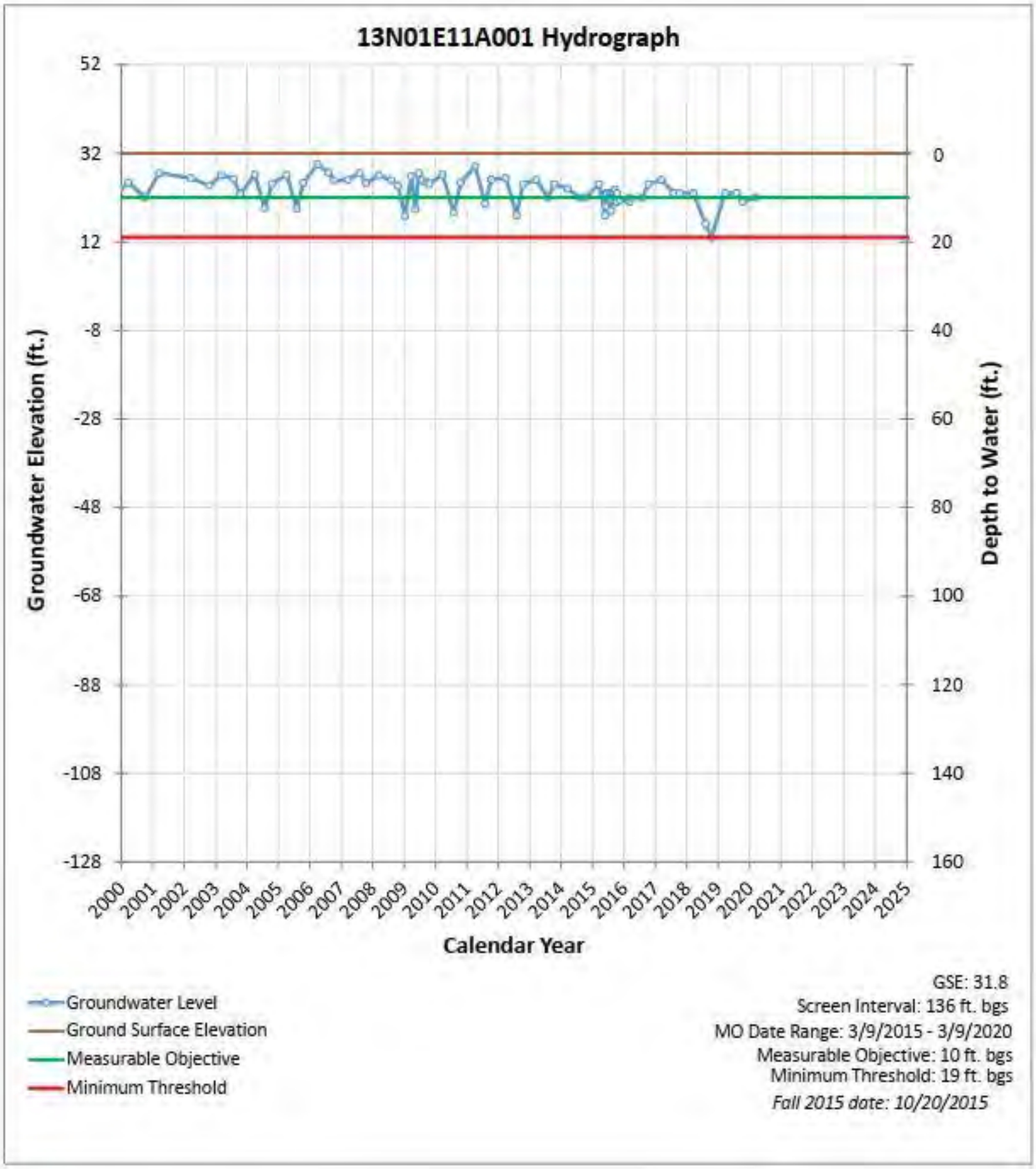


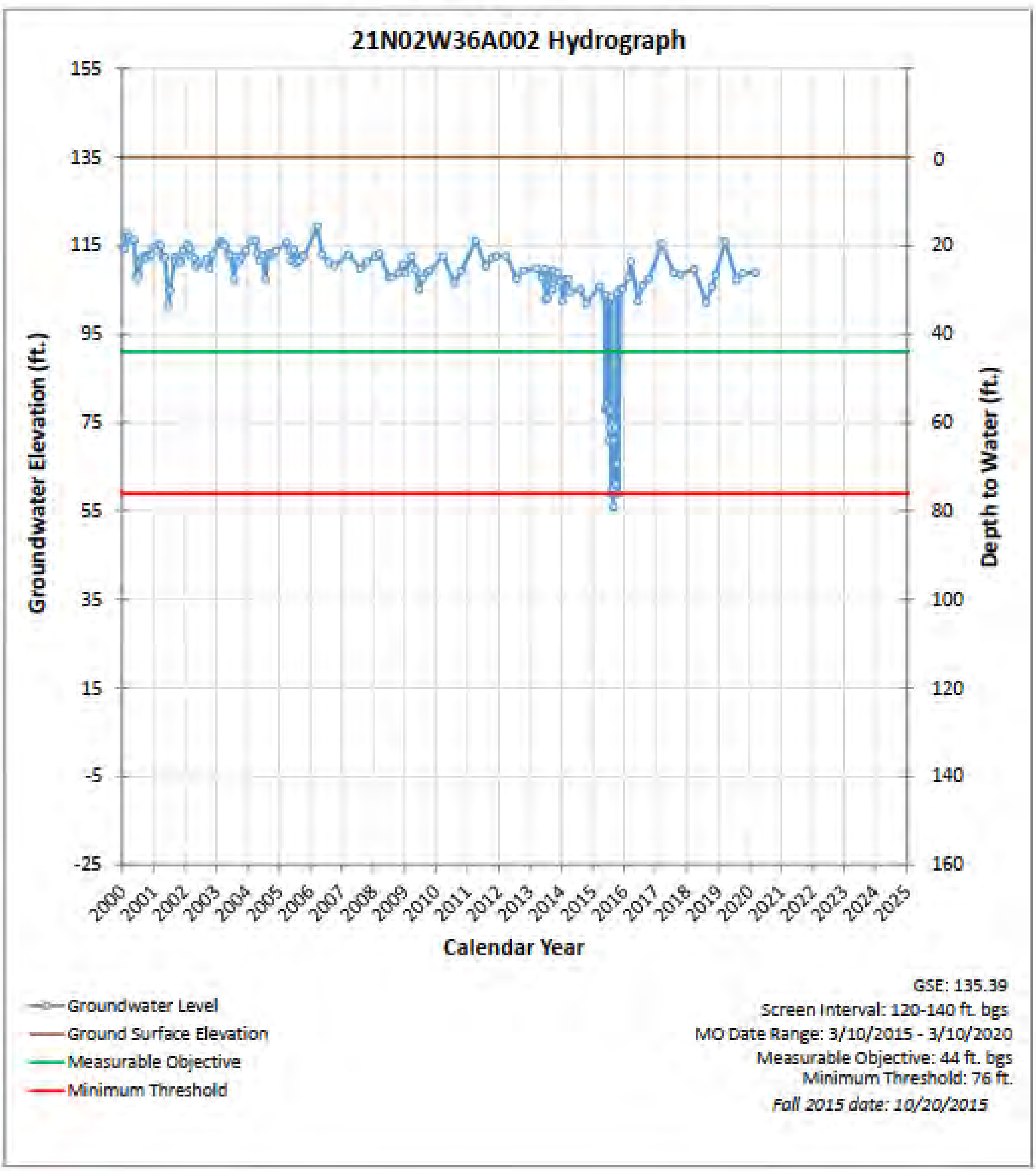
Figure 5-2. Hydrograph, Measurable Objective and Minimum Threshold for Interconnected Surface Water Monitoring Well 13N01E11A001

Table 5-3. Depletions of Interconnected Surface Water Representative Monitoring Network and Sustainability Criteria

SWN	CASGEM ID	Ground Surface Elevation, ft	Minimum Threshold GWE, ft amsl	Minimum Threshold DTW, ft bgs	Measurable Objective GWE, ft amsl	Measurable Objective DTW, ft bgs	Interim Milestone GWE, ft amsl	Interim Milestone DTW, ft bgs	Margin of Operational Flexibility, ft	Fall 2015 DTW, ft bgs
13N01E11A001	18534	32	13	19	22	10	22	10	9	9
13N01W07G001	36246	90	-19	110	-10	100	-10	100	10	100
14N01W04K003	18554	37	3	34	12	25	12	25	9	24
15N01W05G001	14309	47	19	29	27	20	27	20	9	19
17N02W30J002	16960	63	26	37	44	19	44	19	18	27
20N02W11A001	17170	125	106	20	119	6	119	6	14	10
20N02W25F004	23991	102	87	15	97	5	97	5	10	5
21N02W01F004	40029	162	105	57	126	36	126	36	21	47
21N02W05M003	23996	189	125	64	148	41	148	41	23	54
21N02W36A002	21239	135	59	76	91	44	91	44	32	76
22N02W30H004	38609	204	161	43	179	25	179	25	18	33
22N03W24E003	25758	231	194	36	208	23	208	23	13	26

CASGEM ID = California Statewide Groundwater Elevation Monitoring Identification Code
GWE = groundwater elevation
DTW = depth to water
ft = feet
amsl = above mean sea level
bgs = below ground surface

Special considerations were made in establishing the minimum threshold for monitoring well 21N02W36A002, which experienced drawdowns over an approximately eight-month period in 2015 and 2016. A deeper measurement recorded on October 20, 2015 was selected for the minimum threshold calculation for this well to better represent local conditions at that time, rather than adding an additional 10 feet (in order to be more protective). Figure 5-3 provides the depletions of interconnected surface water hydrograph with applicable thresholds plotted for well 21N02W36A002.



5

Figure 5-3. Hydrograph, Measurable Objective and Minimum Threshold for Interconnected Surface Water Monitoring Well 21N02W36A002

5.4.6.2 Measurable Objectives

Measurable objectives for depletions of interconnected surface water at representative monitoring locations are shown in Table 5-3. The measurable objective was calculated for each well using the average of the most recent five years of available groundwater level measurements. This methodology is consistent with that used in setting the measurable objectives for the chronic lowering of groundwater levels measurable objectives. This method is generally representative of drought and recovery conditions within the Subbasin as most wells utilize data recorded between 2015 and 2020. It is also consistent with the measurable objective calculation method for groundwater levels sustainability indicator.

5.4.6.3 Margin of Operational Flexibility

The margin of operational flexibility is the difference between the measurable objective and the minimum threshold for each well. The margin of operational flexibility is intended to provide adequate flexibility to allow for increased groundwater production during drought years with recovery during normal or wet years, accounting for uncertainty in each. This ensures undesirable results are not triggered due to drought conditions that the GSAs cannot control while allowing for adequate local recovery of groundwater levels after those drought periods, thereby maintaining sustainability in the long term. The margins of operational flexibility for depletions of interconnected surface water are shown in Table 5-3. The methodology used to set these margins of operational flexibility is consistent with that used for setting the margins of operational flexibility for the chronic lowering of groundwater levels. Because the measurable objective and minimum threshold at each well take into consideration the historical water budgets, seasonal and long-term trends, and periods of drought, the margin of operational flexibility also accounts for these factors.

5.4.6.4 Interim Milestones

Interim milestones are intended to provide a glidepath towards sustainability over the implementation horizon by providing progressive targets for groundwater levels every five years after GSP submittal. After sustainability is reached, interim milestones are not required and subbasins are managed according to the measurable objectives (defined in the GSP Emergency Regulations as "…specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions…to achieve the sustainability goal for the basin"). For subbasins that are already sustainable (such as the Subbasin), interim milestones are intended to provide numerical metrics for GSAs to track progress toward meeting the subbasin's sustainability goal and ensuring that the subbasin remains sustainable. Because the minimum thresholds and measurable objectives for the depletions of interconnected surface waters were developed to support Subbasin sustainability, the interim milestones were established to maintain water levels within the Subbasin's margin of operational flexibility as set by the minimum thresholds and measurable objectives. The interim milestones for depletions of interconnected surface water are shown in Table 5-3. The methodology used to set these interim milestones is consistent with that used for setting the interim milestones for the chronic lowering of groundwater levels.

5.4.7 Effects of Minimum Thresholds on Adjacent Subbasins

The minimum thresholds described in the preceding sections have been selected and evaluated to ascertain that they do not cause undesirable results in adjacent subbasins, and that they do not affect the ability of adjacent subbasins to achieve their groundwater sustainability goals.

Based on groundwater model results, sustainable management of the Subbasin under SGMA is not expected to significantly affect the net groundwater exchange with surrounding subbasins. Table 3-9 in Chapter 3, *Basin Setting*, summarizes the average annual groundwater system inflows and outflows over the historical, current, and projected (future) water budget periods. Over all scenarios, subsurface inflows and subsurface outflows to and from the Subbasin generally remain unchanged. Total subsurface inflows are approximately 200 to 209 thousand acre-feet per year (taf/yr), on average, while total subsurface outflows are approximately 146 to 149 taf/yr, on average. The variations between scenarios are considered to be within the uncertainty of the model, indicating no significant change in the net groundwater exchange with surrounding subbasins.

Likewise, groundwater model results do not suggest that sustainable management of the Subbasin will significantly affect the net depletions of interconnected surface water along waterways that flow through the Subbasin. As summarized in Appendix 3D, streamflow gain and loss along the Sacramento River, Stony Creek, and the Colusa Drain do not appear to be strongly affected by increases in groundwater pumping needed to satisfy increased irrigation requirements resulting from potential future climate change, or by recharge projects than could be implemented in the Subbasin. Therefore, it is concluded, on a provisional basis, that the effects of groundwater management in the Subbasin will not have significant and unreasonable effects on beneficial uses and users of interconnected surface water.

The Subbasin GSAs and the GSAs in the adjacent subbasins coordinated their approach to developing sustainable management criteria during development of their respective GSPs and will continue to coordinate their efforts during plan implementation. The Subbasin GSAs and the GSAs in the adjacent subbasins developed similar sustainable management criteria for degraded water quality and inelastic land subsidence. Because of the similarity in these sustainable management criteria across the subbasins, and the ongoing interbasin coordination efforts, it is anticipated that the minimum thresholds established in the Subbasin for degraded water quality and inelastic land subsidence will help avoid undesirable results for the Subbasin and the adjacent subbasins. Section 7.1.2 describes implementation activities focused on interbasin coordination for the degraded water quality, inelastic land subsidence, and other sustainability indicators.

The GSAs will continue to monitor the effects of groundwater management according to the sustainability thresholds described in this chapter throughout GSP implementation, including those effects on adjacent Subbasins. The CGA, GGA, and neighboring GSAs have coordinated throughout GSP development and will continue to coordinate and share technical data during GSP implementation. Ongoing and planned coordination activities are described further in Chapter 7 of the GSP.

CHAPTER 6
Projects and Management Actions

This chapter describes the projects and management actions (PMAs) that are ongoing or planned for implementation by agencies in the Subbasin, and potential PMAs in various stages of development. In accordance with 23 CCR §354.44, PMAs were developed to achieve the Subbasin sustainability goal by 2042 and avoid undesirable results over the GSP planning and implementation horizon. Projects generally refer to structural features whereas management actions are typically non-structural programs or policies designed to support sustainable groundwater management.

6.1 PROJECTS AND MANAGEMENT ACTIONS DEVELOPMENT APPROACH

6.1.1 Overview

PMAs developed for the Subbasin are described in this chapter in accordance with 23 CCR §354.44. PMAs were formulated primarily to address possible future changes in Subbasin conditions that could cause undesirable results over the long term, and in the near term, to address effects of recent historical (2014-2015) and current (2020-2021) drought conditions that pose challenges to groundwater management in the northwest and southwest portions of the Subbasin respectively.

PMA development and implementation in the Subbasin applies an adaptive management approach informed by continued monitoring of groundwater conditions using the monitoring network and methods described in Chapter 4. The adaptive management approach is consistent with SGMA (CWC §10728.2, §10733.8) and with DWR recommendations.

Recognizing the GSP data gaps and uncertainties in the basin setting (per 23 CCR §354.44(d)), and recognizing known areas with declining groundwater levels, the adaptive management approach in the Subbasin includes:

- Planned PMAs that are expected to be implemented primarily to address current, localized declining groundwater levels in the Orland and Arbuckle areas. This includes five groundwater recharge projects that are currently moving toward implementation, including three substantial in-lieu recharge projects, one multi-benefit managed aquifer recharge project, and another direct recharge pilot project. At full implementation, planned PMAs are expected to provide more than 80 thousand acre-feet per year (taf/yr) in combined gross average annual benefits that will offset groundwater pumping and support groundwater sustainability in the Subbasin.
- A portfolio of other ongoing and potential PMAs to achieve and maintain long-term sustainable groundwater management across the Subbasin. Potential PMAs will be further evaluated and implemented if established measurable objectives (MOs) cannot be maintained and minimum thresholds (MTs) are being approached.

In the adaptive management approach, GSAs will continue monitoring sustainability indicators throughout the GSP planning and implementation horizon and will address any challenges related to maintaining groundwater sustainability by scaling and implementing PMAs in a targeted and proportional manner in accordance with the needs of the Subbasin. Ongoing management of the Subbasin under this GSP is planned to achieve and maintain sustainability and respond to unforeseen future conditions that may impact sustainable operation of the Subbasin. If the planned and ongoing PMAs are insufficient to achieve and maintain sustainable groundwater conditions, additional PMAs will be considered and implemented. Any changes to the PMAs will be described in GSP annual reports and periodic evaluations.

Per 23 CCR § 354.44(b)(9), PMAs described in this GSP are expected to manage the balance of groundwater extractions and recharge to ensure that lowering of groundwater levels or depletion of supply during periods of drought is offset by increases in groundwater levels or storage in other years. In particular, PMAs that provide in-lieu and direct recharge benefits in the Arbuckle areas are planned to increase the use and recharge of available surface water supplies during wetter years, offsetting any potential increases in groundwater pumping during drought when curtailments of surface water supplies may occur. The expected recharge benefits of these PMAs are described in Section 6.3. The GSAs' extensive portfolio of additional PMAs will be informed by continued monitoring of groundwater conditions and implemented, as needed, to achieve and maintain long-term sustainable groundwater management.

6.1.2 Evaluation of Projected Future Conditions to Develop Projects and Management Actions

The possible future changes in Subbasin conditions without PMAs were assessed through comparison of the projected future water budget conditions without climate change and projected future water budget conditions adjusted by 2070 central tendency (CT) climate change factors (see Chapter 3 for additional water budget information).

Table 6-1 provides a comparison of key water budget parameters considered in formulation of PMAs. All water budget quantities are expressed in average annual volumes of taf/yr over the 50-year model simulation periods. An effect of climate change on Subbasin hydrology is a nearly 7 percent increase in agricultural evapotranspiration (ET), from 1,494 taf/yr to 1,596 taf/yr. A portion of this increased agricultural ET will be met by an approximate 6 percent increase in precipitation expected to result from 2070 CT climate change. The remaining increase in agricultural ET is expected to be met by increased groundwater pumping since projected future surface water diversions into the Subbasin from the Sacramento River and Stony Creek are not expected to be affected by climate change[1]. Pumping is projected to increase by 58 taf/yr, a nearly 13 percent increase from the projected future conditions without climate change.

Under projected future conditions without climate change, groundwater storage is forecast to increase modestly, at an average rate of 0.6 taf/yr. With 2070 CT climate change and the associated increase in groundwater pumping to meet increased irrigation demands, groundwater storage is projected to decrease at a rate of 7.3 taf/yr. This net change of -7.9 taf/yr is 0.8 percent of the approximately one million acre-feet (maf) that flow into and out of the Subbasin groundwater system annually.

[1] Average streamflow volumes in the Sacramento River and its tributaries are generally expected to increase slightly under 2070 Central Tendency climate change due to slightly increased precipitation. However, because Sacramento River and Stony Creek diversions are generally regulated in storage reservoirs, and because Central Valley Project water supplies from the Sacramento River are limited by contracts, it was assumed that future surface water supplies would be the same with and without climate change.

Table 6-1. Summary of Key Subbasin Water Budget Parameters Influencing Formulation of Projects and Management Actions (average annual volumes, taf/yr)

Water Budget Parameter[(a)]	Projected Future Conditions without Climate Change	Projected Future Conditions with 2070 Central Tendency Climate Change	Difference (Projected future with 2070 Central Tendency climate change minus without climate change)	Percent Difference[(b)]
Avg. Agricultural Evapotranspiration	1,494	1,596	102.0	6.8%
Precipitation	1,183	1,258	75.0	6.3%
Agricultural Pumping	458	516	58.0	12.7%
Avg. Rate of Change in Groundwater Storage, af/yr	0.6	-7.3	-7.9	-0.8%
Sacramento River and Stony Creek Diversions to Subbasin	1,287.0	1,287.0	0.0	0.0%
Net Steam Accretion	125	77	-48.0	-38.3%

(a) Water budget parameter values may differ from other summary tables due to rounding or slight changes in how parameters are aggregated from the C2VSimFG-Colusa model results.
(b) Calculated as the difference in the fourth column divided by the Projected Future Condition without Climate Change quantity in the second column, except for Avg. Rate of Change in Groundwater Storage, for which the percent difference is based on the approximately 1 million acre-feet that flow into and out of the Subbasin on an average annual basis. Water budget uncertainty is discussed in Chapter 3, Basin Setting, and model uncertainty is discussed in Appendix 3D. The average change in groundwater storage is considered to be within standard modeling error for this type of groundwater model analysis.

Under projected future conditions without climate change, net stream accretion (stream accretion minus stream depletion) is projected to be 125 taf/yr on average. This aggregate net stream accretion is for the Sacramento River, Stony Creek, and the Colusa Drain combined[2]. With 2070 CT climate change, net stream accretion is projected to remain positive but to decrease by about 48 taf/yr, or by 38 percent, with respect to the without climate change condition. Viewed in relation to the average Sacramento River flow above the Feather River confluence of approximately 11.7 million acre-feet per year (maf/yr) the projected change is roughly one half of one percent. The aggregate changes in groundwater storage, 0.8 percent, and net stream accretion, 0.5 percent of the average Sacramento River Flow, are considered to be within standard modeling error for this type of analysis.

Nevertheless, the GSAs have identified several planned PMAs (Section 6.3) that are expected to provide more than 80 taf/yr in combined gross average annual benefits that will offset groundwater pumping and support groundwater sustainability in the Subbasin. The GSAs will also continue to evaluate and review all Subbasin water budget parameters, including net stream accretion, as part of continued work to address data gaps and as part of ongoing monitoring to be reported in GSP annual reports. Chapter 4, Monitoring

[2] A more detailed assessment of projected streamflow accretion-depletion is presented in Appendix 3G. The analysis considers the Sacramento River, Stony Creek, and the Colusa Drain individually and collectively, and evaluates temporal accretion-depletion patterns over the 50-year simulation period.

Networks, and Chapter 3, Basin Setting, identify data gaps that will be addressed as part of GSP implementation (Chapter 7), which will improve the modeled outputs, water budget parameters, and understanding of the Subbasin groundwater conditions.

Despite these findings in the Subbasin boundary water budget, there are localized declining groundwater levels that have occurred over the past 15 to 20 years in the northwest and southwest portions of the Subbasin near the cities of Orland and Arbuckle, respectively (Figure 6-1). Water budget analyses suggest that groundwater level decline in these areas is due primarily to drought. A series of mostly dry years beginning in about 2007 has resulted in increased irrigation demands, curtailments of Central Valley Project surface water supplies, and consequent increases in groundwater pumping in these areas. Similar dynamics exist in the Orland area, compounded by recent expansion of irrigated agriculture into previously undeveloped lands that rely on groundwater supplies only. Localized declines in groundwater levels have also coincided with shifts in irrigation practices away from flood irrigation, which supplies substantial groundwater recharge, and toward pressurized drip and microirrigation methods. Localized effects of declining groundwater levels include stranding of shallow domestic and irrigation wells and increased rates of land subsidence, raising concerns both locally and more broadly within the Subbasin that mitigation actions should be taken as soon as possible. The planned PMAs are expected to address these localized declining groundwater levels in the Orland and Arbuckle areas by providing direct groundwater recharge or in lieu groundwater recharge in those areas of the Subbasin.

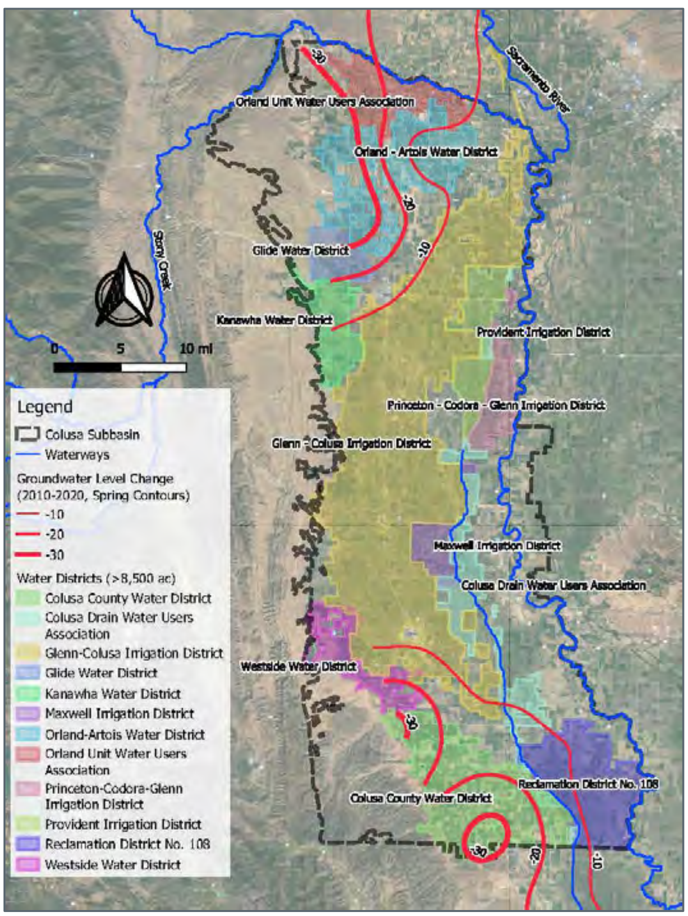


Figure 6-1. Localized Groundwater Level Declines in the Subbasin near Orland (Northwest) and near Williams and Arbuckle (Southwest)

6.1.3 Identification and Categorization of Projects and Management Actions

The PMAs included in this chapter have been planned or proposed by stakeholders, agencies, and interested parties in the Subbasin. During GSP development, the GSAs publicly requested that stakeholders and interested parties in the Subbasin submit plans and ideas for PMAs. The GSAs created a form to collect standard information about PMAs and hosted a webpage where PMA plans and ideas could be submitted by stakeholders and interested parties.[3] The GSAs and technical consultants reviewed the PMA plans and ideas, contacted project sponsors for clarifications and to gather additional PMA details, as needed, and proceeded through a screening process to categorize PMAs as "planned", "ongoing", or "potential." During GSP implementation, the GSAs plan to continue receiving PMA plans and ideas through this process, reviewing PMA submittals periodically and adding to the list of GSP PMAs if deemed appropriate.

PMAs are categorized and presented in this chapter according to the current status of implementation and development, as identified through the GSAs' screening process. However, the PMAs are not ranked. This categorization approach is consistent with the adaptive approach to PMA implementation and with development of PMAs based on the best available data and science (per 23 CCR §354.44(c)). This chapter also acknowledges ongoing investments made by agencies in the Subbasin (including prior to the passage of SGMA), such as projects that were identified and moved forward under regional water management planning efforts, including the Glenn and Colusa County Groundwater Management Plans and the Westside and Northern Sacramento Valley Integrated Regional Water Management Plans.

The PMA categories described in this chapter include:

- ***Planned*** **Projects and Management Actions** are PMAs that the GSA or other project proponents are working to implement that will support sustainable groundwater management in the Subbasin and mitigate historical and current drought effects. Detailed descriptions of these PMAs are presented in the GSP, reflecting available information including preliminary design and associated cost estimates. In accordance with 23 CCR §354.44(a) these are PMAs that would allow GSAs to achieve the sustainability goal for the Subbasin and avoid reaching the minimum thresholds defined in this GSP under future, changing conditions.
- ***Ongoing*** **Projects and Management Actions** are PMAs that are ongoing and will support sustainable groundwater management in the Subbasin. In accordance with 23 CCR §354.44(a) these are PMAs that would allow GSAs to achieve the sustainability goal for the Subbasin and avoid reaching the minimum thresholds defined in this GSP under future, changing conditions.
- ***Potential*** **Projects and Management Actions** are PMAs that may be implemented if necessitated by groundwater conditions in the Subbasin. These may have been studied by the project proponent, or in earlier regional water planning documents, but most project design, costs, and planning work has yet to be completed, and would only be initiated if the project is eventually triggered for implementation as a result of continued monitoring of groundwater conditions.

[3] https://colusagroundwater.org/projects-and-management-actions-submittals/

The rest of this chapter is structured as follows. Section 6.2 provides a summary of all (ongoing, planned, and potential) PMAs. The three subsequent sections – Sections 6.3 through 6.5 – describe the PMAs in each of the three categories. Within each category, PMAs are further classified by type (project or management action), which are described in corresponding subsections. Appendix 6A provides additional analysis of water available for recharge and other projects, as well as an assessment of incentives to encourage utilization of surface water supplies. Appendix 6B describes potential demand management action costs and Subbasin agricultural economic conditions. Appendix 6C provides a matrix summary of all planned, ongoing, and potential PMAs. Lastly, Appendix 6D describes modeling of selected PMAs to estimate the effects of those PMAs on groundwater conditions in the Subbasin.

6.2 PROJECT AND MANAGEMENT ACTIONS SUMMARY

6.2.1 Overview of All Proposed Projects and Management Actions

Table 6-2 summarizes all PMAs identified in the Subbasin. Summary information includes the PMA name, type, proponent, and a brief description. PMA types include:

- **Direct groundwater recharge:** PMAs that recharge groundwater using available surface water, flood water, stormflows, or other surface water supplies.
- **In-lieu groundwater recharge:** PMAs that offset groundwater pumping by supplying or otherwise incentivizing use of surface water or other surface water supplies “in lieu” of groundwater.
- **Management action:** Non-structural programs or policies designed to support sustainable groundwater management.
- **Reduce groundwater demand:** PMAs that reduce or remove sources of groundwater demand and extraction, such as invasive and non-native plant species along riparian corridors.

PMAs are grouped into subsections in the table according to their status (planned, ongoing, or potential). As described under Section 6.1 above, ongoing projects are currently being implemented in the Subbasin. Planned PMAs are currently being developed to achieve sustainable management conditions in the Subbasin. Potential PMAs will be implemented in the future, if or as required by changing conditions in the Subbasin.

All PMAs are described according to the requirements of 23 CCR §354.44(b). Planned projects are described in detail. Ongoing and potential PMAs are described concisely, reflecting the current operational status and “as-needed” basis of these projects. It is anticipated that additional information will be prepared in annual reports and five-year GSP updates, as needed.

Not all PMAs are the responsibility of the GSAs: some PMAs will be completed through a partnership with other agencies and proponents, while other PMAs will be completed by the agency or other proponents with support from the GSAs. The GSAs and/or other project proponents will notify the public and other agencies of the planned or ongoing implementation of PMAs through the communication channels identified in Sections 6.3 through 6.5 (23 CCR §354.44(b)(1)(B)). Noticing will occur as potential projects are being considered for implementation, and as ongoing and planned projects are implemented. Noticing will inform the public and other agencies that the GSA and/or other project proponents are considering or will be implementing the PMA, and will provide a description of the actions that will be taken.

The following subsections describe the planned, ongoing, and potential PMAs in accordance with the requirements of 23 CCR §354.44(b). The information presented in this chapter is based on the best available data and science. The estimated groundwater recharge benefit and capital, operating, and maintenance costs of developing and operating each project are shown. To the extent possible, project costs are adjusted and reported on a consistent basis. All costs are indexed using an appropriate index[4] and reported in current (2021) dollars. GSAs, districts, and other partners in the Subbasin will further develop projects during the GSP implementation period and refine estimated costs in GSP annual reports and five-year updates. Additional information about all PMAs is provided in a matrix format in Appendix 6C.

Table 6-2. Summary of All Projects and Management Actions

Project/ Management Action Name	Project/ Management Action Type	Proponent	Brief Description
Planned			
Projects			
Colusa County Water District (CCWD) In-Lieu Groundwater Recharge	In-lieu Groundwater Recharge	CCWD	CCWD will utilize 30 taf of additional surface water for irrigation in all years but Shasta Critical years for in-lieu recharge. The additional surface water will be made available through full use of the district's existing Central Valley Project (CVP) contract and annual and multi-year water purchase and transfer agreements. Additional surface water deliveries are estimated to be 27 taf/yr, enabling reduction of groundwater pumping by a like amount.
Colusa Drain MWC (CDMWC) In-Lieu Groundwater Recharge	In-lieu Groundwater Recharge	CDMWC	CDMWC diverters use both ground and surface water because Colusa Drain supplies are insufficient to satisfy all irrigation requirements. This project would provide additional surface supplies averaging approximately 28 taf/yr in the Drain allowing CDMWC diverters to increase their diversions of surface water to provide in-lieu groundwater recharge of a like amount.
Subbasin Multi-Benefit Groundwater Recharge	Direct Groundwater Recharge	CGA, GGA and TNC	The Nature Conservancy (TNC) is partnering with entities for an on-farm, multi-benefit groundwater recharge incentive program. The pilot program was initiated in Colusa County in 2018 and concluded in the spring of 2021, with plans to expand and continue into the future. DWR is a partner in the Subbasin Multi-Benefit Groundwater Recharge project as it moves into the expanded program.

[4] Either the Implicit Price Deflator or the Engineering News Report Construction Cost Index.

Table 6-2. Summary of All Projects and Management Actions			
Project/ Management Action Name	Project/ Management Action Type	Proponent	Brief Description
Orland-Artois Water District (OAWD) Land Annexation and Groundwater Recharge	Direct and In-lieu Groundwater Recharge	OAWD	OAWD is planning to annex approximately 12,000 acres of groundwater-dependent agricultural lands. Additional direct recharge may be considered on suitable annexed lands. The project is an area where groundwater levels have been in decline in recent years. It is estimated that a long-term average of approximately 23 taf/yr of surface water would be available, reducing groundwater pumping by approximately 23 taf/yr.
Sycamore Slough Groundwater Recharge Pilot Project	Direct Groundwater Recharge	Landowner	Proctor and Gamble (P&G) and Davis Ranches have entered into an agreement to implement a 10-year groundwater recharge pilot project. A 66-acre field on Davis Ranches will receive surface water for groundwater recharge and provide habitat for migrating shorebirds. Water would be diverted from the Sacramento River during fall/winter months using existing riparian rights or would be available from settlement contract supplies (should the project begin before November 1). An expansion of the project is planned for recharge and revegetation in the neighboring Sycamore and Dry Sloughs.
Ongoing			
Projects			
Reclamation District 108 (RD108) and Colusa County Water District (CCWD) Agreement for Five-Year In-Lieu Groundwater Recharge Project	In-lieu Groundwater Recharge	RD108 and CCWD	CCWD (and Dunnigan Water District [DWD]) purchases surface water from RD108 for distribution within its service area. The agreement expires in 2022. This project supplies additional surface water to CCWD (and DWD) that provides in-lieu recharge.
Glenn-Colusa Irrigation District (GCID) Strategic Winter Water Use for Groundwater Recharge and Multiple Benefits	Direct and In-lieu Groundwater Recharge	GCID	GCID holds a water right for winter water. This project will increase the groundwater recharge and habitat enhancement benefits of winter water use by increasing use for rice straw decomposition, irrigation, and frost control provided that certain constraints can be alleviated.
Sycamore Marsh Farm Direct Recharge Project	Direct Groundwater Recharge	Landowner	Sycamore Marsh Farm is developing a groundwater recharge plan to store groundwater. The plan provides for 205 acres of year-round recharge basins and 163 additional acres of winter recharge areas.

Table 6-2. Summary of All Projects and Management Actions			
Project/ Management Action Name	Project/ Management Action Type	Proponent	Brief Description
Glenn-Colusa Irrigation District Expansion of In-Basin Program for In-lieu Groundwater Recharge	In-lieu Groundwater Recharge	GCID	GCID has developed arrangements to supply district surface water to neighboring non-district agricultural lands that primarily use groundwater. These temporary arrangements expired in 2020. There is interest in continuing and expanding this in-basin surface water use for in-lieu groundwater recharge. Supplies would potentially be available only in Shasta Non-Critical years.
Orland Unit Water Users Association (OUWUA) Irrigation Modernization for Increased Surface Water Delivery and Reduced Groundwater Pumping	In-lieu Groundwater Recharge	OUWUA	Modernization of OUWUA southside system for more reliable and flexible farm deliveries that will provide incentive for growers to use more surface water and less groundwater.
Management Actions			
Urban Water Conservation in Willows	Management Action	California Water Service – Willows District	This project includes urban water conservation measures through water waste prevention ordinances, metering, conservation pricing, public education, and outreach programs to assess and manage distribution system real loss, water conservation program coordination and staffing support, and other demand management measures.
Potential			
Projects			
Glenn-Colusa Irrigation District In-lieu Groundwater Recharge	In-lieu Groundwater Recharge	GCID	GCID will investigate, develop, and implement measures to incentivize additional use of surface water supplied by GCID, which will provide in-lieu recharge through reduced groundwater pumping.
Westside Streams Diversion for Direct or In-lieu Groundwater Recharge	Direct and In-lieu Groundwater Recharge	CGA and GGA	A portion of western ephemeral stream flows could be diverted for in-lieu or direct groundwater recharge.
Sites Reservoir	Direct and In-lieu Groundwater Recharge	Sites Project Authority	The Sites Project is a new off-stream storage facility that is currently in development. Depending on project operation and yield, there is potential for groundwater benefits to accrue to the Subbasin from Sites Reservoir.

Table 6-2. Summary of All Projects and Management Actions

Project/ Management Action Name	Project/ Management Action Type	Proponent	Brief Description
Delevan Pipeline Colusa Basin Drainage Canal System (Colusa Drain) Intertie	Direct and In-lieu Groundwater Recharge	Interested Stakeholder	Intertie between proposed Delevan Pipeline component of the Sites Reservoir Project and the Colusa Drain, providing a connection to downstream water users, and providing protection for the ecosystems, and earthquake resilience.
Orland Unit Water Users Association (OUWUA) Flood Water Conveyance	Direct Groundwater Recharge	OUWUA	Divert Stony Creek water at OUWUA's south diversion and convey it to various locations for direct recharge within the OUWUA service area.
Orland-Artois Water District (OAWD) Direct Groundwater Recharge	Direct Groundwater Recharge	OAWD	OAWD would directly recharge groundwater. A pilot project was conducted in 2017.
Sycamore Slough Colusa Drain Multi-Benefit Recharge Project	Direct Groundwater Recharge	Landowner	Restoration of portions of Sycamore Slough would support diversion of winter flows from the Colusa Drain for recharge and restoration.
Tehama-Colusa Canal Trickle Flow to Ephemeral Streams	Direct Groundwater Recharge	RD108	Operate Tehama-Colusa Canal (TCC) existing gates for discharge into ephemeral streams at a rate where they do not flow out of the Subbasin but recharge the groundwater system.
Enhanced Infiltration of Precipitation on Agricultural Lands	Direct Groundwater Recharge	CGA and GGA	Develop and adoption of on-farm cultural practices to reduce precipitation runoff and increase infiltration, which would result in increased storage of precipitation in the crop root zone, thereby reducing irrigation water requirements and achieving some direct groundwater recharge.
Subbasin Flood-MAR	Direct Groundwater Recharge	CGA and GGA	The CGA and GGA would investigate, develop, and implement a program to divert flood waters within the Subbasin, when available, for spreading across agricultural lands for direct groundwater recharge.
Reclamation District 108 "Boards In" Program	Direct Groundwater Recharge	RD108	RD108 would institute a voluntary or financially incentivized program in which landowners leave spill boards in place during the winter to capture rainfall and hold it on the fields for recharge.
Colusa County Public Water System Water Treatment Plant	In-lieu Groundwater Recharge	Interested Stakeholder	Construct a water treatment plant on the Sacramento River between Colusa and Grimes to provide treated surface water to public water supply systems in Colusa and possibly Sutter and Yolo Counties.

Table 6-2. Summary of All Projects and Management Actions

Project/ Management Action Name	Project/ Management Action Type	Proponent	Brief Description
Glenn-Colusa Irrigation District Water Transfers to Tehama-Colusa Canal Authority (TCCA) CVP Contractors	In-lieu Groundwater Recharge	GCID	Evaluate potential for transferring water to CVP contractors served by the TCC for in-lieu groundwater recharge.
Subbasin In-lieu Recharge & Banking Program	In-lieu Groundwater Recharge	South Valley Water Resources Authority	Incentivize taking available contract surface water in-lieu of pumping groundwater, providing dedicated contribution to local groundwater sustainability, with a portion available to San Joaquin Valley partners.
Sycamore Marsh Farm In-lieu Recharge Project	In-lieu Groundwater Recharge	Landowner	Sycamore Marsh Farm is developing an in-lieu groundwater recharge plan, and could partner with additional lands in the CDMWC, allowing for diversion of surface water from CDMWC.
Westside Off-stream Reservoir and In-Lieu Groundwater Recharge	In-lieu Groundwater Recharge	TCCA Contractors	Construct off-stream surface reservoirs along the western edge of the Subbasin and up-slope from the TCC to divert surplus Sacramento River flows (e.g., Section 215 water) into these storage reservoirs. Release stored water on demand to serve lands otherwise served by groundwater.
Management Actions			
Domestic Well Mitigation Program	Management Action	CGA and GGA	To mitigate the effects of domestic well stranding due to groundwater level decline, the CGA and GGA will investigate implementing domestic well mitigation programs in their respective portions of the Subbasin.
Drought Contingency Planning for Urban Areas	Management Action	CGA, GGA, and cities (GSA member agencies)	The CGA and GGA will coordinate with M&I water suppliers dependent on groundwater to encourage drought planning consistent with the GSP.
Long-Term Demand Management Action	Management Action	CGA and GGA	Demand management broadly refers to any water management activity that reduces the consumptive use of irrigation water. A demand management action is one that incentivizes, enables, or possibly requires water users to reduce their consumptive use.
Strategic Short-Term Demand Management	Management Action	CGA and GGA	Develop a voluntary, flexible, short-run financial incentive program to alleviate impacts of drought in target areas through idling lands in drought-affected areas or in participating surface water-using portions of the Subbasin and conveying the saved surface water to the drought-affected areas.

Table 6-2. Summary of All Projects and Management Actions

Project/ Management Action Name	Project/ Management Action Type	Proponent	Brief Description
Well Abandonment Outreach and Funding Program	Management Action	CGA and GGA	Create a program providing outreach and education to landowners regarding the proper procedures for well decommissioning and abandonment, as well as funding sources. This effort would be accomplished by working with well permitting agencies.
Preservation of Lands Favorable for Recharge	Management Action	CGA and GGA	Working cooperatively with the counties, investigate, design, and implement a program providing incentives to landowners with lands favorable to groundwater recharge to preserve them as agricultural or undeveloped lands on which groundwater recharge.
Review of County Well Permitting Ordinances	Management Action	CGA and GGA	Review and revise the county well permitting processes in the Subbasin to ensure that future well permitting aligns with the Subbasin sustainability goal and that future changes to well permitting are reviewed by the GSAs. The GSAs would work with the counties to review and suggest revisions to ordinances (these are outside of the jurisdiction of the GSAs).
Reduce Non-beneficial Evapotranspiration/ Invasive Species Eradication	Reduce Groundwater Demand	CGA and GGA	Removal of invasive, non-native plant species from riparian corridors and other areas to reduce evapotranspiration from shallow groundwater and support native ecosystem restoration.
Development of a Dedicated Network of Shallow Monitoring Wells for GDE Monitoring	Management Action, Closing Data Gaps	CGA and GGA	Evaluate and develop a dedicated network of shallow monitoring wells specifically planned and sited for monitoring conditions in areas of the Subbasin where GDEs are most likely to be found. This action is also expected to incorporate biological monitoring to inform the location of new shallow monitoring wells and monitor whether GDEs are being impacted by changing groundwater conditions.

6.2.2 Benefits of Projects and Management Actions to Sustainability Indicators and Communities in the Subbasin

Volumetric benefits of all planned PMAs are identified in Table 6-2 and in Section 6.3. In total, the planned PMAs are expected to provide more than 80 taf/yr in gross average annual benefits at full implementation by offsetting groundwater pumping, providing direct recharge, and otherwise supporting groundwater sustainability. These benefits are expected to address potential sustainability concerns in the projected future conditions water budgets, even under the effects of 2070 CT climate change (Table 6-1). Planned PMAs are expected to help the GSAs achieve the sustainability goal for the Subbasin and avoid reaching the minimum thresholds defined in this GSP under future, changing conditions.

Table 6-3 summarizes how each type of PMA would benefit sustainability indicators in the Subbasin. All proposed PMAs are expected to benefit groundwater levels and groundwater storage, whether through direct or in-lieu groundwater recharge, management of water supplies, or demand reduction. Projects that incentivize additional use of available surface water in lieu of groundwater are also expected to reduce depletions of interconnected surface water. Planned PMAs will provide direct and in-lieu groundwater recharge benefits to the Subbasin, which the GSAs do not expect will significantly affect water quality conditions, including those experienced by domestic well users and DACs. However, the GSAs are planning to monitor groundwater quality during GSP implementation (Section 4.2.2), and will investigate additional PMAs and studies to improve water quality if they find that groundwater quality conditions are approaching MTs.

Many of the communities within the Subbasin are considered either a Disadvantaged Community (DAC) or a Severely Disadvantaged Community (SDAC)[5]. Additionally, nearly all of the Subbasin is considered an Economically Distressed Area (EDA).[6] The only area within the Subbasin that is not considered an EDA is the small portion of the Subbasin that exists within Yolo County (approximately 2.4 square miles, or 1,500 acres). Additional information about DACs, SDACs, and EDAs in the Subbasin is provided in Chapter 2, Plan Area. To the extent that PMAs are implemented directly in areas where these communities reside – the majority of areas across the Subbasin – and to the extent that PMAs benefit groundwater conditions throughout the Subbasin, PMAs are expected to benefit DACs, SDACs, and EDAs and prevent undesirable results for these communities. Ongoing outreach and implementation of the GSP and PMAs will directly benefit these communities and ensure that their concerns and feedback continue to be incorporated into PMA development and implementation.

Table 6-3. Sustainability Indicators Expected to Benefit from Projects and Management Action Types Proposed in the Subbasin

Project/ Management Action Type	Project/Management Action Names	Sustainability Indicators Expected to Directly Benefit				
		GW Levels	GW Storage	SW Depletion	Land Subsidence	Water Quality
Planned						
Direct Groundwater Recharge	Colusa Subbasin Multi-Benefit Groundwater Recharge; Sycamore Slough Groundwater Recharge Pilot Project	X	X	X	X	
In-lieu Groundwater Recharge	CCWD In-Lieu Groundwater Recharge; Colusa Drain MWC In-Lieu Groundwater Recharge	X	X	X	X	
Direct and In-lieu Groundwater Recharge	OAWD Land Annexation and Groundwater Recharge	X	X	X	X	
Ongoing						

[5] A DAC is identified as a community whose median household income is less than 80 percent of the statewide median household income (MHI), and an SDAC is identified as a community whose median household income (MHI) is less than 60 percent of the statewide MHI.

[6] Portions of the Subbasin that are identified as EDAs are areas of rural counties with a low population density and a median household income of less than 85 percent of the statewide MHI.

Table 6-3. Sustainability Indicators Expected to Benefit from Projects and Management Action Types Proposed in the Subbasin

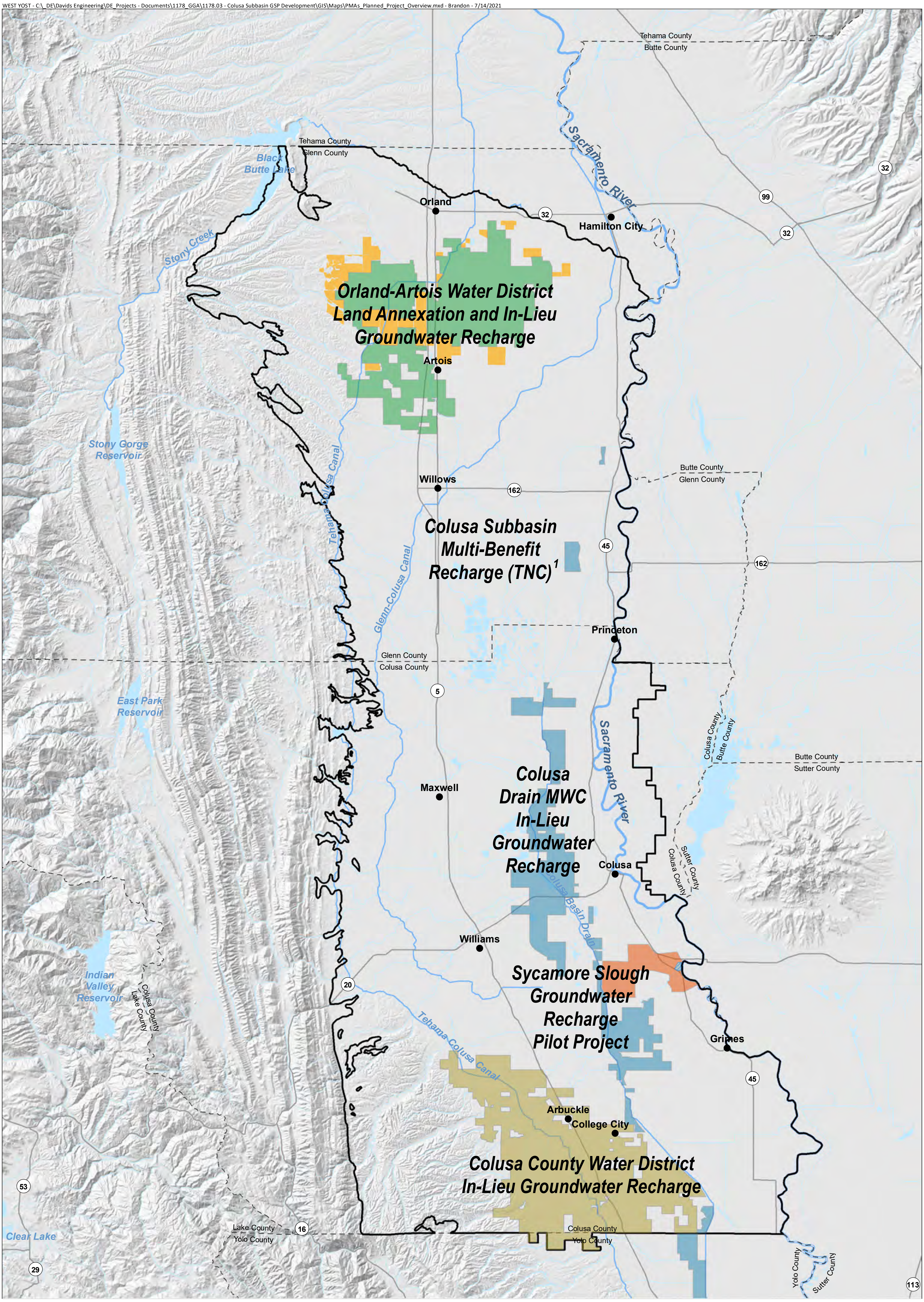
Project/ Management Action Type	Project/Management Action Names	Sustainability Indicators Expected to Directly Benefit				
		GW Levels	GW Storage	SW Depletion	Land Subsidence	Water Quality
Direct Groundwater Recharge	Sycamore Marsh Farm Direct Recharge Project	X	X	X	X	X
In-lieu Groundwater Recharge	RD 108 and CCWD Agreement for Five-Year In-Lieu Groundwater Recharge Project; GCID Expansion of In-Basin Program for In-lieu Groundwater Recharge; OUWUA Irrigation Modernization for Increased Surface Water Delivery and Reduced Groundwater Pumping	X	X	X	X	
Direct and In-lieu Groundwater Recharge	GCID Strategic Winter Water Use for Groundwater Recharge and Multiple Benefits	X	X	X		
Management Action	Urban Water Conservation in Willows	X	X	X		
Potential						
Direct Groundwater Recharge	OUWUA Flood Water Conveyance; OAWD Direct Groundwater Recharge; Sycamore Slough Colusa Basin Drain Multi-Benefit Recharge Project; TCC Trickle Flow to Ephemeral Streams; Enhanced Infiltration of Precipitation on Agricultural Lands; Colusa Subbasin Flood-MAR; Reclamation District 108 "Boards In" Program	X	X	X		
In-lieu Groundwater Recharge	Colusa Subbasin In-lieu Recharge & Banking Program; Sycamore Marsh Farm In-lieu Recharge Project; GCID In-lieu Groundwater Recharge	X	X	X	X	X
In-lieu Groundwater Recharge	Colusa County Public Water System Water Treatment Plant; Colusa Drain MWC In-Lieu Groundwater Recharge; GCID Water Transfers to TCCA CVP Contractors; Westside Off-stream Reservoir and In-Lieu Groundwater Recharge	X	X	X		
Direct and In-lieu Groundwater Recharge	Westside Streams Diversion for Direct or In-lieu Groundwater Recharge; Sites Reservoir; Delevan Pipeline Colusa Drain Intertie	X	X	X	X	
Management Action	Domestic Well Mitigation Program	X				

Table 6-3. Sustainability Indicators Expected to Benefit from Projects and Management Action Types Proposed in the Subbasin						
Project/ Management Action Type	Project/Management Action Names	Sustainability Indicators Expected to Directly Benefit				
		GW Levels	GW Storage	SW Depletion	Land Subsidence	Water Quality
Management Action	Drought Contingency Planning for Urban Areas; Strategic Short-Term Demand Management; Preservation of Lands Favorable for Recharge; Development of a Dedicated Network of Shallow Monitoring Wells for GDE Monitoring	X	X	X		
Management Action	Review of County Well Permitting Ordinances	X	X	X	X	X
Reduce Groundwater Demand	Reduce Non-beneficial Evapotranspiration/Invasive Species Eradication (Arundo, Eucalyptus, Tamarisk, etc.)	X	X	X		

6.3 PLANNED PROJECTS AND MANAGEMENT ACTIONS

The GGA and CGA have included five groundwater recharge projects that are planned for implementation. All five projects involve the use of surface water for direct or in-lieu recharge. Three of the five projects are substantial in-lieu recharge projects, meaning that they will require regulated surface water sources available on an irrigation demand schedule. These three projects are planning to acquire all or most of the required surface water through transfers of CVP water supplies that are available from other CVP water supply or Settlement Contractors.

Figure 6-2 illustrates the location and name of the five planned PMAs in the Subbasin. Planned projects are targeted to areas where groundwater levels have been declining in the Subbasin due primarily to historical and current drought conditions. In addition, recharge opportunities are targeted near the Sacramento River to provide multiple benefits including potential habitat and streamflow benefits.



Sycamore Slough Pilot Project Recharge Area
Davis Ranches Boundary
Colusa County WD Boundary
Colusa Drain MWC Boundary
Orland-Artois WD Boundary
Orland-Artois WD Planned Annexations
Colusa Subbasin Boundary

Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

Note:
1. Multi-benefit recharge locations will depend on grower enrollment and could be anywhere within the Colusa Subbasin where surface water supplies are available and recharge conditions are favorable.

0 2.5 5
Scale in Miles

Figure 6-2

Planned Projects Overview

Colusa Groundwater Authority and Glenn Groundwater Authority
Colusa Subbasin
Groundwater Sustainability Plan

Table 6-4 lists the planned PMAs, project type, proponent, expected first year of implementation, estimated capital cost, and estimated gross annual benefit (taf/yr).

Table 6-4. Summary of Planned Projects

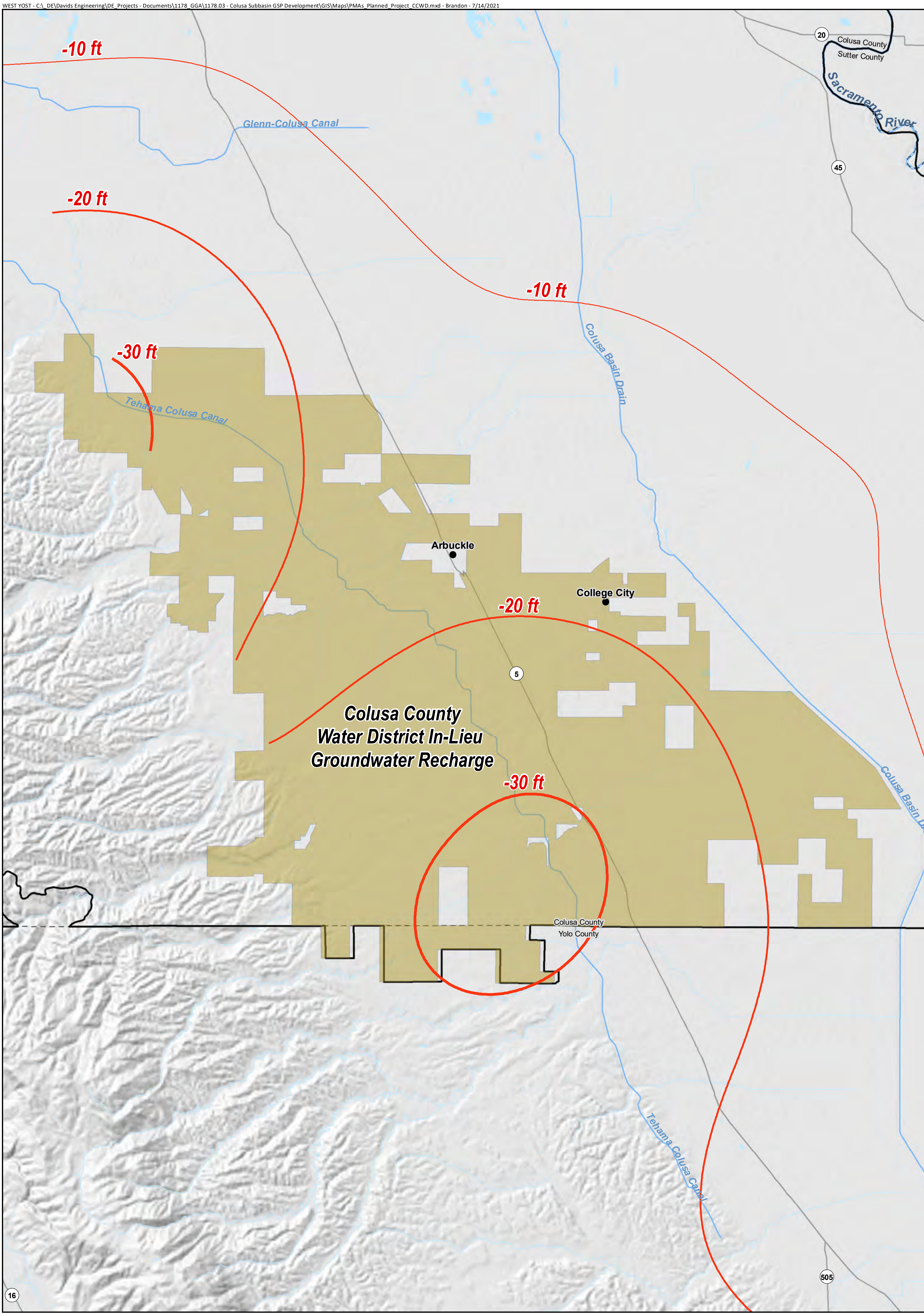
Project	Project Type	Proponent	Year Implemented	Estimated Capital / Establishment Cost, $ (thousands)[(a)]	Gross Average Annual Benefit, taf/yr
Colusa County Water District In-Lieu Groundwater Recharge	In-Lieu GW[(b)] Recharge	CCWD	2021	$100	27
Colusa Drain MWC In-Lieu Groundwater Recharge	In-Lieu GW Recharge	CDMWC	2021	$100	28
Colusa Subbasin Multi-Benefit Recharge	Direct GW Recharge	CGA, GGA, and TNC[(c)]	2021	$4 per site	5.2
Orland-Artois Water District Land Annexation and In-Lieu Groundwater Recharge	Direct and In-Lieu GW Recharge	OAWD	2020	$20,000	23
Sycamore Slough Groundwater Recharge Pilot Project	Direct GW Recharge	Landowner	2021	$28	0.5[(d)]

(a) Annual costs are summarized in the "Project Costs" sections of the project descriptions, below.
(b) GW = Groundwater
(c) TNC = The Nature Conservancy
(d) Project goal is to recharge 5 taf over 10 years.

6.3.1 Colusa County Water District In-Lieu Groundwater Recharge

6.3.1.1 Project Overview

Colusa County Water District (CCWD) includes over 45,000 acres within its service area, of which roughly 35,000 acres are irrigated. In this project, CCWD will utilize up to an additional 30 taf of surface water for irrigation in all years but Shasta Critical years, resulting in a long-term average annual additional surface water supply of 27 taf/yr. Shasta Critical conditions are declared when the forecast inflow to Lake Shasta for a particular water year is equal to or less than 3.2 maf. The additional surface water will be made available through full use of the district's existing CVP contract and annual and multi-year water purchase and transfer agreements. The additional water will be conveyed through the existing Tehama-Colusa Canal (TCC) and CCWD facilities and will be used primarily on existing district lands, resulting in in-lieu groundwater recharge through reduction of groundwater pumping. As an optional component of this project, CCWD is considering relatively small annexations of lands adjoining the district and supplying surface water to these lands in-lieu of groundwater pumping. If these annexations proceed, the additional water may also be used on the newly annexed lands that are currently dependent on groundwater and require construction of additional infrastructure for surface water delivery. Figure 6-3 illustrates the general location in CCWD where in-lieu recharge could occur, along with the groundwater elevation change between spring 2010 and spring 2020.



Spring 2010 to Spring 2020 Groundwater Elevation Change

-30 ft -20 ft -10 ft

Colusa County WD Boundary

Colusa Subbasin Boundary

Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

Notes:
1. Planning for this project is currently ongoing and map depictions are subject to change.
2. In-lieu recharge will occur within the Colusa County WD boundary.

N

0 1 2

Scale in Miles

Figure 6-3

Colusa County Water District In-Lieu Groundwater Recharge Overview

Colusa Groundwater Authority and Glenn Groundwater Authority

Colusa Subbasin

Groundwater Sustainability Plan

Use of additional surface water within CCWD will require a combination of incentivizing additional use of CCWD existing CVP supplies and transfer arrangements with other districts. Transfers already occur in many years and would continue to be negotiated between parties as part of GSP implementation. Incentivizing use of existing CVP supplies would require making the cost comparable to the cost of pumping groundwater. Historically, according to federal law under the CVP improvement Act of 1992, CVP irrigation water supply contracts required payments of tiered water rates for contractual water entitlements. The lowest, Tier 1, rate applied to 80 percent of the contractual water entitlement. The highest, Tier 3, rate reflected the full cost rate and applied to the last 10 percent of the contractual water entitlement. The Tier 2 rate, applied to the middle 10 percent, is an average of the Tier 1 and 3 rates.

Even when blended with Tier 1 water, using Tier 2 and Tier 3 water resulted in excessive water cost, and so some or all of the Tier 2 and Tier 3 water went unused. CCWD, along with other CVP contractors in the Subbasin, has recently converted its water service contract to a repayment contract, thus paying off and removing the capital component from CVP rates. However, repayment of CVP capital required borrowing money that the district will pay off over the next 15 years or more, which is reflected in water rates to growers.

Depending on the relative costs of district supply versus groundwater, under the repayment contracts, CCWD rates may be low enough already to encourage full use of CVP supply. However, if groundwater pumping remains a lower cost alternative to CVP water for some growers, incentivizing their use of CVP water in lieu of pumping would require an incentive that is at least equal to the difference between district surface supply and the variable cost of pumping groundwater.

Appendix 6A provides a summary of CVP rates, repayment contracts, and incentives to encourage additional use of district surface water supplies.

6.3.1.2 Implementation

Planning is currently underway for utilization of this additional surface water through CCWD's existing CVP contract and annual and multi-year water purchase and transfer agreements, as shown in Table 6-5 below. Utilization of additional surface water is anticipated to begin in 2022 (subject to the availability of water).

Table 6-5. CCWD In-Lieu Groundwater Recharge Implementation Timeline

Phase	Description	Start	End
Program Structure and Planning	Specify program goals, structure, and targets for implementation	2020	2022
Evaluate Incentives, Partners, and Develop Strategy	Evaluate grower incentives and on-farm costs for surface and groundwater irrigation, quantify willingness to pay for each system, and define program incentives. Work with partner districts to identify transfers	2020	2022
Initial/Pilot Program Implementation	Develop and implement a pilot program to evaluate participation, incentives, and assess landowner feedback	2022	2023

Table 6-5. CCWD In-Lieu Groundwater Recharge Implementation Timeline			
Phase	Description	Start	End
Program Implementation	Implement full program and scale up over time to achieve specified program goals for in-lieu recharge	2023	Ongoing
Monitoring	Monitor and report on the status of program development for GSP implementation (annual reports and five-year updates)	2021	Ongoing

6.3.1.3 Notice to Public and Other Agencies

Public noticing for this project will be done in accordance with noticing requirements in National Environmental Policy Act (NEPA) and CEQA (as needed), as well as noticing for public meetings held by the CGA, GGA, CCWD, Tehama-Colusa Canal Authority (TCCA), and Colusa Local Agency Formation Commission (LAFCO).

6.3.1.4 Construction Activities and Requirements

The project plans to utilize existing water conveyance facilities, including the TCC and the CCWD's piped distribution system. Under this project configuration, no additional construction activities would be required.

As an optional component of this project, CCWD is considering relatively small annexations of lands adjoining the district and supplying surface water to these lands in-lieu of groundwater pumping. However, the operation, benefits, and expected costs of the project does not depend on these annexations. Annexing lands would require construction of new water conveyance facilities for delivery and measurement of surface water to these newly annexed lands. These costs would be assessed as part of program development, if CCWD decides to annex lands.

6.3.1.5 Water Source

The surface water source for the project will come from CCWD's existing CVP contract and from multiple Sacramento Valley entities with existing surface water entitlements that are regularly available in below-normal to wet year types. These entities include CVP water supply and Settlement Contractors and, potentially, Sacramento River water rights holders.

The intent is to first utilize existing CCWD CVP supplies by making the cost of that supply comparable, or less, than the cost to pump groundwater. Additional water supply would be acquired through annual and multi-year, renewable water purchase or transfer agreements, building on similar existing agreements that CCWD has with certain Sacramento Valley entities. New surface supplies would be diverted from the Sacramento River at the Red Bluff Pumping Plant and Fish Screen facility and conveyed through the Tehama-Colusa Canal, which is operated and maintained by the Tehama-Colusa Canal Authority.

Appendix 6A summarizes an assessment of the volumes of water potentially available for in-lieu recharge. The CCWD project would acquire surface water primarily via water transfers from other entities with available CVP contract supplies and CVP Settlement Contract project water under the provisions of Central Valley Project Improvement Act (CVPIA) Section 3405(a). Transfer of project supplies under Settlement

Contracts alone would meet most of the needs of in-lieu recharge, with full use of existing contract supplies in CCWD and potential transfers of additional available CVP contract supplies adding to that amount.

6.3.1.6 Circumstances and Criteria for Implementation

This project is planned for immediate implementation. As described above, CCWD has already converted its water service contract to a repayment contract and is evaluating potential transfer opportunities with partner districts in the region. This process in 2021 was hampered by historically dry conditions across the state and the resulting lack of surface water. Beginning later in 2021, and into 2022 as water conditions hopefully improve, CCWD will begin evaluating incentives to encourage additional use of CVP supplies. It is anticipated that the utilization of additional surface water will begin in 2022.

Implementation of the in-lieu recharge program in CCWD does not depend on the implementation or performance of other PMAs or district activities. While operation of this project is not expected to terminate, any future changes will be made to align with CCWD goals and the overall Subbasin sustainability goal.

6.3.1.7 Legal Authority, Permitting Processes, and Regulatory Control

CCWD has the legal authority as a water district to provide for the acquisition and conveyance of supplemental surface water to its lands and pursue expansion of its service area. The planning and implementation of this project will be done in accordance with the required permitting processes and regulatory control. Required permitting and regulatory review is being initiated through consultation with applicable governing agencies.

Because the additional surface water supplies will be conveyed through the existing TCC and CCWD facilities and used primarily on existing district lands, there are no anticipated permitting requirements for this project. However, if additional land is annexed and new facilities are required to serve those lands, then permits will be required. In that case, governing agencies with which consultation may need to be initiated include, but are not limited to: DWR, the California State Water Resources Control Board (SWRCB), the California Department of Fish and Wildlife (CDFW), the Central Valley Flood Protection Board (Flood Board), Regional Water Boards, the United States Bureau of Reclamation (Reclamation or USBR), the United States Army Corps of Engineers (USACE), the United States Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), LAFCOs, the Counties of Colusa and/or Glenn, and the California Air Resources Board (CARB). Specific permitting and regulatory processes that may affect the construction of additional infrastructure include, but are not limited to:

- USACE Section 404 Permits (potential exemption under Section 404(f)(1)(C) of Clean Water Act)
- Regional Water Quality Control Board Section 401 Water Quality Certification (not required if exempt from USACE Section 404)
- SWRCB Construction General Permit and Storm Water Pollution Prevention Plan (SWPPP)
- State Historic Preservation Office (SHPO) and National Historic Preservation Act (NHPA) Section 106 Coordination
- California Endangered Species Act (CESA) Consultation
- Endangered Species Act (ESA) Compliance
- National Environmental Policy Act (NEPA) Compliance
- California Environmental Quality Act (CEQA) Compliance

6.3.1.8 Project Operations and Monitoring

CCWD will operate and maintain its existing district facilities and conduct project monitoring. If CCWD annexes additional lands into the district, the district would operate and maintain facilities developed for these lands, and conduct project monitoring.

Project monitoring will include a range of activities to evaluate the benefits described in the next section. This will include local monitoring to track the additional volumes of water made available through transfers and estimates of the reduction in pumping relative to pre-project baselines. Additionally, the district may monitor grower adoption through delivery records and periodic grower surveys during project design and implementation. Information gathered from these surveys would be used to refine the initial program design and encourage additional adoption.

The benefit of in-lieu recharge on sustainability indicators in the Subbasin (groundwater levels and groundwater storage) will be monitored using the monitoring network sites and monitoring practices described in the GSP (Chapter 4).

6.3.1.9 Project Benefits

The primary benefit of the project is reduction of groundwater pumping resulting from in-lieu groundwater recharge with benefits to the sustainability indicators previously shown in Table 6-3. It is estimated that approximately 30 taf of surface water would be delivered to annexed lands in all years but Shasta Critical years, resulting in an average annual reduction of groundwater pumping of approximately 27 taf/yr over the long term. Transfer volumes would vary in Shasta Non-Critical years based on the terms of the transfer agreements, and broader water market conditions, but the average annual quantity in all Shasta Non-Critical years is estimated to be 27 taf/yr. These benefits are expected to begin to be realized in 2022. Table 6-6 summarizes the expected annual volume. These project benefits have been assessed, and may continue to be assessed, using the C2VSimFG-Colusa model developed for GSP development by simulating groundwater conditions with and without the project. Additional information on the project modeling is described in Appendix 6D.

Table 6-6. CCWD In-Lieu Groundwater Recharge Estimated Average Recharge Volume by Year Type, in af/yr (2016-2065)

Year Type	Total Annual Volume	% of Years	Weighted Avg.
Shasta Non-Critical	Up to 30,000	90%	27,000
Shasta Critical	0	10%	0
Average Annual			**27,000**

6.3.1.10 Project Costs

Project costs include the cost of purchased water, applicable CVP costs associated with the use of the TCC, and CCWD operation and maintenance costs. If some additional lands are annexed into the district, costs will also include capital costs associated with construction of new facilities, but none are included in preliminary planning costs. Other fixed costs include $100,000 for CCWD effort to develop a preliminary project plan, and establish potential incentives based on an assessment of grower willingness to pay.

An initial estimate of $75 per af corresponding to estimated CCWD fully-loaded water rates (see Appendix 6A) is applied for the initial planning-level annual operating cost assessment. As described in Appendix 6A, this is CCWD staff's rough estimate of CCWD's 2021 water rate if it had received full CVP supply. It includes its repayment rate for CVP water, other CVP charges, Tehama-Colusa Canal Authority charges, and District charges. Using this rate, the total water supply cost would be approximately $2.0 million per year. Efforts are currently underway by CCWD to estimate and refine these project costs, and to identify funding sources and establish repayment terms. Table 6-7 summarizes project costs.

Table 6-7. CCWD In-Lieu Groundwater Recharge Estimated Project Costs

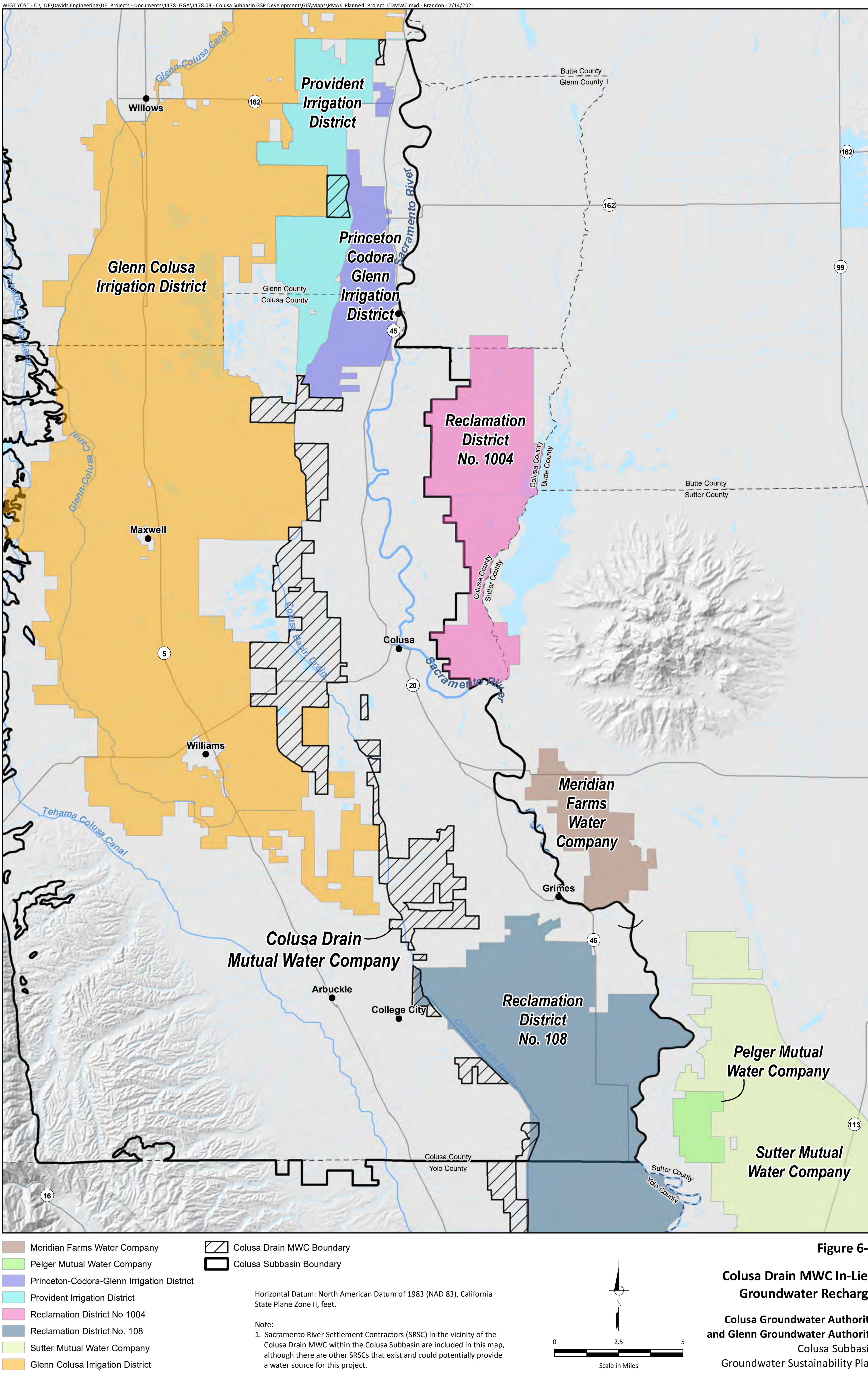
Item	Total Cost	Year Incurred	Notes
Capital Costs			
Project planning and development	$100,000	2021-2022	Project studies and planning; does not include any capital costs
O&M Costs			
Fully-loaded water supply cost	$2.0 million	All	Assumed water supply cost equal to CCWD fully-loaded rate in full water supply years

23 CCR §354.44(b)(8) requires a summary of how the district plans to pay these costs. It is anticipated that the cost of incentivizing additional use of CVP supplies, and transfer purchases would primarily be recovered through district assessments. This may include more land-based assessments to reduce the variable cost of water rates, thereby making district water comparatively less expensive than groundwater. Other potential funding sources include grants, loans, and bonds for capital financing, if new facilities are needed to serve any annexed lands. Debt service and operations would be funded through assessments and charges. Potentially, a type of cost-share program could be developed where other groundwater-dependent water users in the Subbasin share a portion of the costs since they will also realize regional benefits through this in-lieu recharge project. Appendix 7A in Chapter 7 describes different funding mechanisms, and the conceptual approach for allocating project costs across multiple potential project beneficiaries.

6.3.2 Colusa Drain Mutual Water Company (CDMWC) In-Lieu Groundwater Recharge

6.3.2.1 Project Overview

The CDMWC encompasses approximately 46,000 acres of agricultural land and environmental habitat adjacent to the Colusa Drain. Shareholders in CDMWC divert water for summer irrigation from the drain under a combination of appropriative water rights held individually by the shareholders, a long-term service supply agreement with the United States Bureau of Reclamation (Reclamation or USBR), and annual and multi-year transfer agreements with neighboring Settlement Contractors. Figure 6-4 illustrates the general locations of CDMWC, neighboring Settlement Contractors, and other entities in the surrounding area. Historically, many CDMWC diverters use both groundwater and surface water for summer irrigation because physical supplies of surface water in the Colusa Drain are often unreliable and insufficient to satisfy all irrigation requirements.



Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

Note:

1. Sacramento River Settlement Contractors (SRSC) in the vicinity of the Colusa Drain MWC within the Colusa Subbasin are included in this map, although there are other SRSCs that exist and could potentially provide a water source for this project.

Figure 6-4

Colusa Drain MWC In-Lieu Groundwater Recharge

Colusa Groundwater Authority and Glenn Groundwater Authority

Colusa Subbasin Groundwater Sustainability Plan

The purpose of this project is to provide a reliable and sufficient supply of surface water in the Drain allowing CDMWC diverters to increase their diversions of surface water and decrease groundwater pumping by an equal amount. It is estimated that an average annual yield of up to 28 taf of in-lieu groundwater recharge could be realized through this project.

6.3.2.2 Implementation

The project is currently being planned for implementation. The planned implementation timeline is shown in Table 6-8. CDMWC has existing transfer agreements with Settlement Contractors upon which the transfer terms under this project would be based. In addition, CDMWC has existing water rights, permitting, and infrastructure in place to operate the program. Initial program implementation will require a planning study of water transfer, prices, full-cost of transferred water delivered to CDMWC diverters, and a comparison to the cost to continue utilizing groundwater. This would establish program feasibility and potential program scale. Preliminary program design is already under way and will continue through 2022.

Benefits could begin to accrue as early as during the 2022 irrigation season, depending on availability of surface water via transfers. 2021 is a Shasta Critical year, with dry conditions across the state. Several criteria necessary for implementation are already in place:

- Most CDMWC shareholders have necessary infrastructure required to divert water from the drain and deliver it to their agricultural lands, and several Settlement Contractors have the infrastructure in place to introduce surface water supplies into the Colusa Drain for CDMWC diversion and use (pursuant to transfer agreements).
- CDMWC shareholders have the necessary licenses and permits in place with DWR and SWRCB to allow diversions from the drain.
- CDMWC has a long-term supply agreement with Reclamation to supply water into the Sacramento River to offset shareholders diversions from the drain that would otherwise infringe the rights of senior water right holders in the Sacramento River.
- CDMWC and Glenn-Colusa Irrigation District (GCID, a Settlement Contractor) currently have a transfer agreement in place that includes the necessary environmental permitting with Reclamation and DWR.

Following the model of the transfer agreement with GCID, CDMWC would establish transfer agreements with other Settlement Contractors or other entities to provide surface water to the Colusa Drain for CDMWC diversion and use.

These transfer agreements would need to be designed to provide settlement contractors with sufficient economic incentive to deliver water to the Colusa Drain and, at the same time, provide CDMWC diverters with a sufficient incentive to access and utilize this surface water supply in-lieu of using groundwater. Coordination and planning for these transfer agreements is currently underway.

Table 6-8. CDMWC In-Lieu Groundwater Recharge Implementation Timeline

Phase	Description	Start	End
Project Planning and Concept Development	Evaluate lands, existing infrastructure, permitting, and potential partners	2020	2021
Program Development and Incentives Analysis	Develop program costs and financial parameters; assess groundwater costs to CDMWC irrigators and willingness to accept payment for transfer from partners; establish program costs and structure	2021	2022
Transfer Agreements	Model and pursue transfer agreements based on the existing agreement with GCID	2019	Ongoing
Program Operation	Program implementation, monitoring, updates, and ongoing agreements	2022	Ongoing

6.3.2.3 Notice to Public and Other Agencies

Public noticing for this project will be done in accordance with noticing requirements and in public meetings held by CDMWC and others. This would include CGA public meetings.

6.3.2.4 Construction Activities and Requirements

There are no infrastructure construction activities and requirements, as the project will use existing infrastructure and facilities.

6.3.2.5 Water Source

The surface water source for the project will come from multiple Sacramento Valley entities with existing surface water entitlements that result in water available for transfer in some normal to wet year types. These entities include Settlement Contractors, Sacramento River water rights holders, and potentially others. The intent is to acquire the water through annual and multi-year, renewable water transfer agreements. A framework for this has already been established based on the existing agreement between CDMWC and GCID. New surface supplies would be provided to the Colusa Drain for diversion and use by CDMWC shareholders.

Appendix 6A summarizes an assessment of the volumes of water available for transfer in the Subbasin. The water availability assessment finds there is sufficient water available for transfer for the CDMWC project, in addition to the other four planned GSP recharge projects.

6.3.2.6 Circumstances and Criteria for Implementation

This project is planned for immediate implementation. Coordination and planning are currently underway, and depending on outcomes, implementation and project benefits could potentially begin in 2022.

Implementation of the CDMWC program does not depend on the implementation or performance of other PMAs or district activities. While operation of this project is not expected to terminate, any future changes will be made to align with CDMWC goals and the overall Subbasin sustainability goal.

6.3.2.7 Legal Authority, Permitting Processes, and Regulatory Control

As a mutual water company, CDMWC has the legal authority to plan for and pursue the acquisition and conveyance of supplemental surface water to its shareholders' lands. The planning and implementation of this project will be done in accordance with the required permitting processes and regulatory control. CDMWC already has water rights, permitting, and infrastructure in place to operate the program. CDMWC shareholders have the necessary licenses and permits in place with DWR and SWRCB to allow diversions from the drain, and CDMWC and GCID currently have a transfer agreement in place that includes the necessary environmental permitting with Reclamation and DWR. No additional permitting requirements are anticipated, though CDMWC will consult with governing agencies, as needed.

6.3.2.8 Project Operations and Monitoring

CDMWC will operate, maintain, and monitor its existing facilities that would be utilized for the project during implementation and operation. No new additional facilities are planned for development.

Ongoing project monitoring will include a range of activities to evaluate the benefits described in the next section. This will include local monitoring to track the use of additional volumes of surface water made available through the project and estimates of the reduction in groundwater use relative to pre-project baselines. Assessments of economic incentives will also be conducted to evaluate their utility in encouraging surface water usage. Monitoring may include additional outreach to shareholders, which would be used to refine the program design and encourage additional adoption. It is further anticipated that annual and multi-year transfer agreements would be continually reviewed, negotiated, and executed to ensure sufficient supplies to achieve the desired program scale.

The benefit of utilizing additional surface water for in-lieu recharge on sustainability indicators in the Subbasin (groundwater levels and groundwater storage) will be monitored using the monitoring network sites and monitoring practices described in the GSP (Chapter 4).

6.3.2.9 Project Benefits

CDMWC anticipates that the project would scale up over time, based on water transfer availability and the economics of utilizing those available supplies. A detailed assessment of project benefits will be completed during GSP implementation, as additional information is available from potential water transfer partners. A preliminary project benefits assessment was developed for the GSP.

The primary benefit of the project is reduction of groundwater pumping resulting from in-lieu groundwater recharge with benefits to the sustainability indicators previously shown in Table 6-3. A preliminary analysis estimates this project has the potential to provide 28 taf/yr of additional surface water for in-lieu recharge to CDMWC. The quantities transferred in each year would depend on water supply conditions in the Sacramento and San Joaquin Valleys. In Shasta Critical years, such as 2021, it is estimated that no water would be available for transfer for the project. Under recent historical conditions, this occurs approximately 1 in 10 years. In other, Shasta Non-Critical years it is estimated that an average of approximately 31 taf/yr would be transferred under agreements entered for this project.

Transfer volumes would vary in Shasta Non-Critical years based on the terms of the transfer agreements, and broader water market conditions. Prices for water transfers to the San Joaquin Valley have increased in recent years, affecting volumes available for transfer, particularly in drier years. Delta capacity constraints limit transfer potential south of the Delta in wet years. It is anticipated that CDMWC transfer volumes would vary with availability of CVP supplies in Shasta Non-Critical years. Table 6-9 summarizes the historical CVP final allocation for North of Delta agricultural water service contracts. Average CVP contract deliveries were 75 percent between 1990 and 2021, over the more recent 15 years, average deliveries were 67 percent of contracts.

Table 6-9. North of Delta CVP Water Service Contract Allocations Summary

CVP Water Service Contract Allocation (%)	Historical Period	
	1990 - 2021	2007 - 2021
>90%	63%	53%
50%-90%	13%	13%
25% - 50%	16%	13%
<25%	9%	20%
Average	**75%**	**67%**

Table 6-10 summarizes estimated project benefits. Project benefits would also be assessed using the C2VSimFG-Colusa model developed for GSP development by simulating groundwater conditions with and without the project. Benefits assume 31 taf/yr of transfers in Shasta Non-Critical years. As described above, the specific volume in each year type would be specified in transfer agreements. It is estimated that groundwater pumping within the CDMWC area is approximately 40 taf/yr. This project has the potential to provide an average of 28 taf/yr of additional surface water for in-lieu recharge. Therefore, assuming there is no development of groundwater on previously unirrigated lands, the project potential benefit would be 28 taf of in-lieu recharge, reducing the 40 taf annual pumping in CDMWC by 70 percent.

Table 6-10. CDMWC In-Lieu Groundwater Recharge Estimated Average Recharge Volume by Year Type, in af/yr (2016-2065)

Year Type	Total Annual Volume	% of Years	Weighted Avg.
Shasta Non-Critical	Up to 31,000	90%	28,000
Shasta Critical	0	10%	0
Average Annual			**28,000**

6.3.2.10 Project Costs

The primary project cost is the cost of purchased and transferred water. Water transfer prices will be defined in the water transfer agreements. A detailed assessment of the water transfer market in the Subbasin and greater Sacramento Valley is beyond the scope of this initial project investigation for the GSP. Water transfer prices have increased substantially over the last decade. This is due to a combination of more limited supply due to drought, GSP implementation in the San Joaquin Valley, and the biological opinion regarding operation of the CVP system, as well as demand driven by plantings of permanent crops and strong nut prices. Historical (1993 – 2020) data for water transfers (price and volume) for agricultural water within the Sacramento Valley were reviewed.

Table 6-11 summarizes that average and range of within-Sacramento Valley transfer prices. The range highlights the variability in observed prices. Water conditions are classified according to the Sacramento River Index (Sacramento 40-30-30 index), which is formally defined in the State Water Board's Decision 1641. Year types are classified as follows: Wet (Wet), Average (Above Normal, Below Normal, Dry), and Dry (Critical). Prices are typically lower in longer-term agreements, which would be included under this project. As such, the lower end of the range is applied for planning cost estimates in this GSP.

Table 6-11. North of Delta Water Transfer Price Summary

Sacramento Valley WY Index	Average, $/af	Range, $/af	
		Low	High
Wet	$140	$50	$225
Average	$210	$75	$415
Dry	$265	$95	$430
Weighted-Average	$192	$83	$347

Table 6-12 summarizes the estimated project costs. An initial estimate of the anticipated cost of the project is approximately $1.7 million per year. This assumes a water transfer cost of $62 per af for an average annual transfer volume of 28,000 af. This is within the range of prices observed in wetter conditions. It is anticipated that water transfer prices will depend on the length of the transfer, terms, and hydrologic conditions. The price of $62 per af is used for initial planning purposes and does not include any additional conveyance or delivery costs.

Table 6-12. CDMWC In-Lieu Groundwater Recharge Estimated Project Costs

Item	Total Cost	Year Incurred	Notes
Capital Costs			
Project planning and development	$100,000	Start of project	Initial project design, planning, and implementation
O&M Costs			
Water supply cost	$1.7 million	Annual average	Average annual water purchase cost that does not include any additional O&M or overhead costs.

23 CCR §354.44(b)(8) requires a summary of how CDMWC plans to pay the costs of the project. It is anticipated that the cost of transfer purchases would primarily be recovered through CDMWC assessments. Other potential funding sources include grants, loans, and potentially, a type of cost-share program where other groundwater-dependent water users in the Subbasin share a portion of the costs since they will also realize regional benefits through this project. Appendix 7A describes different funding mechanisms, and the conceptual approach for allocating project costs across multiple potential project beneficiaries.

6.3.3 Colusa Subbasin Multi-Benefit Groundwater Recharge

6.3.3.1 Project Overview

The Nature Conservancy (TNC) is partnering with private landowners and the Colusa and Glenn Groundwater Authorities for an on-farm, multi-benefit groundwater recharge incentive program. Program objectives are to benefit:

- Disadvantaged communities and other communities by replenishing critical domestic and agricultural water supplies,
- Private landowners economically through incentive payments,
- Migratory shorebirds through the creation of critical winter habitat on farms, and
- Groundwater conditions (via groundwater recharge).

Surface water from the Sacramento River, subject to availability, is conveyed and applied to participating fields using existing diversion, conveyance, and on-farm infrastructure, flooding and maintaining ponded conditions during the program's annual implementation period.

The pilot program was initiated on Davis Ranches in Colusa County and in other locations within the Subbasin in 2018 and concluded in the spring of 2021. The pilot program evaluated different durations and locations of flooding that would provide multiple benefits for migratory shorebird habitat and groundwater recharge. The habitat and recharge benefits are equal goals of the project.

The program is planned to expand into the future. DWR will be participating in the Multi-Benefit Groundwater Recharge Project as it is expanded into a larger program. Program expansion would include:

- Identifying willing landowner participants to participate in the program. Preliminary mapping based on migratory bird habitat and recharge suitability using the Soil Agricultural Groundwater Banking Index (SAGBI[7]) has been developed to identify potential areas of interest.
- Review and analyze pilot program data to quantify potential multi-benefits and evaluate economic incentives that would be required to support additional program enrollment.
- Evaluate options for funding sources to support program implementation. This may include State funding earmarked for the Department of Conversation to support multi-benefit agricultural land repurposing, or additional funding that may be allocated under potential bill AB-252 or similar initiatives.
- Develop program incentives and funding opportunities to encourage enrollment. Monitor and revise the program annually in response to landowner participant feedback and changing incentive conditions in the Subbasin (e.g., changes in the returns to farming that would affect willingness to accept payment to participate in the program). Continue to refine program to achieve desired multi-benefit outcomes.

[7] SAGBI is a suitability index indicating the potential for groundwater recharge on agricultural land, determined according to five main factors: deep percolation, root zone residence time, topography, chemical limitations, and soil surface condition. SAGBI ratings for lands in California are developed by the California Soil Resource Lab at University of California, Davis and University of California Agriculture and Natural Resources (UC-ANR) and are available online at: https://casoilresource.lawr.ucdavis.edu/sagbi/ .

With an incentive structure developed, the project would provide financial compensation for recharging groundwater through normal farming operations while also providing critical wetland habitat for shorebirds migrating along the Pacific Flyway, and potential ancillary benefits for water levels near disadvantaged communities or other communities in the Subbasin, depending on where the multi-benefit recharge projects are implemented.

Figure 6-5 below illustrates the location of lands that are potentially suitable for participation in the program near the Sacramento River, identified according to elements in the C2VSimFG-Colusa model domain. The areas indicated in Figure 6-5 were selected for modeling the potential project effects near the Sacramento River[8], though in general fields can be selected throughout the Subbasin by evaluating the SAGBI index to identify areas suitable for recharge and by evaluating land characteristics that benefit migratory shorebird habitat. In practice, the location and scale of the project will depend on the effectiveness of incentives to attract willing landowners, which might or might not be located near the river. Locations will depend on grower enrollment and could be anywhere within the Subbasin where surface water supplies are available and recharge conditions are favorable. Landowner participation would be voluntary, and subject to incentives that would be developed as part of ongoing program implementation.

6.3.3.2 Implementation

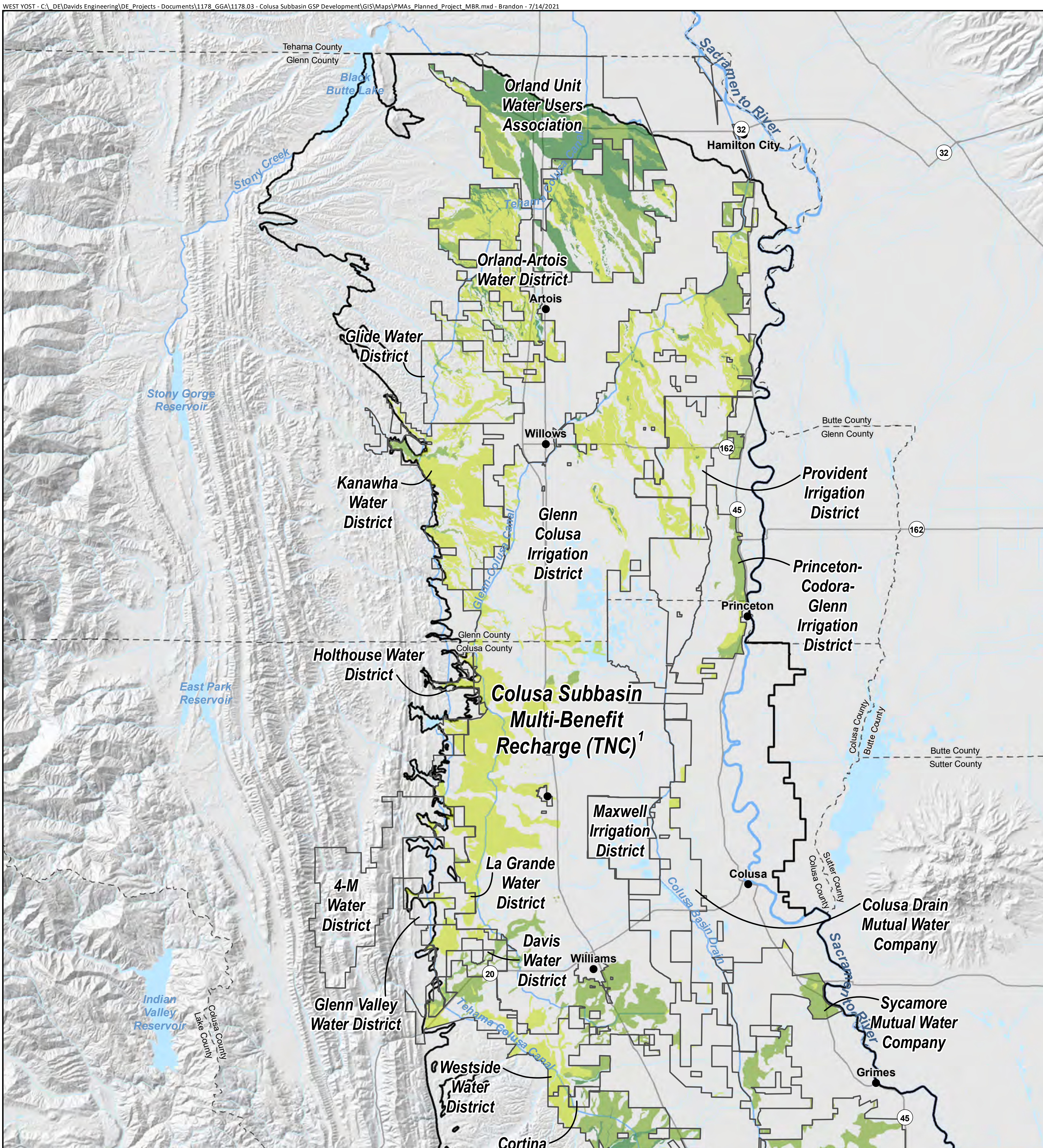
Following successful completion of a pilot program from 2018 to 2021, continuation and expansion of the project is currently being planned within the Subbasin. DWR will be participating in the Multi-Benefit Groundwater Recharge project as it is expanded into a larger program. Table 6-13 summarizes the expected implementation timeline for the expanded program.

Table 6-13. Colusa Subbasin Multi-Benefit Groundwater Recharge Implementation Timeline

Phase	Description	Start	End
Pilot Program	Completion of a pilot project for multi-benefit recharge on Davis Ranches	2018	2021
Planning for Expansion of Multi-Benefit Groundwater Recharge	Planning and coordination for expansion and continuation of multi-benefit recharge projects within the Subbasin	2018	2022
Implementation of Multi-Benefit Recharge	Implementation of multi-benefit recharge projects within the Subbasin	2022/2023	Ongoing, if deemed appropriate

[8] Project modeling is described in Appendix 6D. For modeling, proximity of lands to the Sacramento River was considered when selecting potential recharge areas because these lands are expected to have the greatest positive impact on streamflows.

WEST YOST - C:_DE\Davids Engineering\DE_Projects - Documents\1178_GGA\1178.03 - Colusa Subbasin GSP Development\GIS\Maps\PMAs_Planned_Project_MBR.mxd - Brandon - 7/14/2021



Water Purveyor	Total Acres by SAGBI Rating			
	Moderately Good	Good	Excellent	Total Moderately Good or Better
4-M Water District	586	58	0	644
Colusa County Water District	17,879	14,646	1,844	34,368
Colusa Drain Water Users Association	506	1,839	0	2,346
Cortina Water District	49	78	19	145
Davis Water District	243	638	0	881
Glenn Colusa Irrigation District	33,448	9,775	496	43,718
Glenn Valley Water District	263	0	0	263
Glide Water District	2,049	312	0	2,361
Holthouse Water District	1,113	0	0	1,113
Kanawha Water District	7,853	794	0	8,647
La Grande Water District	444	0	0	444
Maxwell Irrigation District	0	0	0	0
Myers-Marsh Mutual Water Company	9	109	0	118
Orland-Artois Water District	11,904	6,514	5,519	23,937
Orland Unit Water Users Association	1,309	4,298	9,177	14,783
Princeton-Codora-Glenn Irrigation District	891	2,150	0	3,041
Provident Irrigation District	2,692	153	20	2,866
Reclamation District No. 108	2,804	3,309	0	6,113
Sycamore Mutual Water Company	113	1,375	0	1,488
Westside Water District	4,074	2,091	111	6,275
Totals	**88,227**	**48,138**	**17,186**	**153,551**

SAGBI Rating Group

- Excellent
- Good
- Moderately Good

- Surface Water Purveyors
- Colusa Subbasin Boundary

Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

Notes:
1. SAGBI is an acronym for the Soil Agricultural Groundwater Banking Index, which is a standard suitability index for groundwater recharge on agricultural land.
2. SAGBI results are shown within the service area boundaries of surface water purveyors within the Colusa Subbasin; locations where water conveyance infrastructure already exists.
2. Multi-benefit recharge locations will depend on grower enrollment and could be anywhere within the Colusa Subbasin where surface water supplies are available and recharge conditions are favorable.

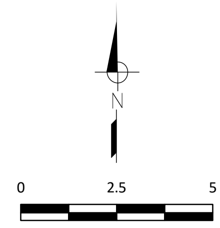


Figure 6-5

Multi-Benefit Recharge Project

Colusa Groundwater Authority and Glenn Groundwater Authority

Colusa Subbasin
Groundwater Sustainability Plan

6.3.3.3 Notice to Public and Other Agencies

Public noticing for this project will be done in accordance with noticing requirements in coordination with the CGA and GGA.

6.3.3.4 Construction Activities and Requirements

There are no infrastructure construction activities and requirements, as the project will use existing infrastructure and facilities.

This project may be configured and operated to utilize existing diversion and conveyance infrastructure and facilities. If existing infrastructure and facilities are available and used for this project, there would be no anticipated infrastructure construction activities and requirements upstream of participating fields.

The program would involve some on-farm activities for participating landowners to develop "pop up" recharge sites on existing fields. The program is designed to work within existing field infrastructure and irrigation systems. Any on-farm water management modifications are expected to be modest to increase standing water on fields in specific months to support both habitat and recharge.

Depending on the existing infrastructure available in participating fields, the project may also require some on-farm activities to support project monitoring. Required project monitoring equipment may include flow meters and groundwater level monitoring devices. Prior to field flooding, the project proponents could facilitate a survey of the fields and install pressure transducers and/or flow meters at inlets and outlets and in adjacent wells to facilitate measurement of applied water and changes in groundwater depth.

6.3.3.5 Water Source

The surface water source for the project will be Sacramento River water available under existing rights, subject to availability and agreements established between TNC, CGA, GGA, and private landowners that choose to participate in this voluntary program. The water supply would need to be available during prime flooding windows that support migratory bird habitat and recharge, which are generally in the late summer and early fall (July 15 through October 15) and/or spring (March 15 through April 15). It is anticipated that water will generally be available for this project in all years except Shasta Critical years.

6.3.3.6 Circumstances and Criteria for Implementation

This pilot program was completed in spring 2021. The expanded project is currently planned for implementation, and TNC is working with potential partners. However, due to dry conditions in 2021, the project implementation was delayed. Depending on the outcome of current implementation, and landowner interest, implementation and project benefits could potentially begin in 2022/2023.

Implementation will proceed in several phases. The first phase will be selection of sites suitable for multi-benefit recharge (see above). This would concurrently include initiation of any required environmental documentation. Site selection will be based on:

- Lands that would provide multiple benefits for bird habitat and local communities.
- Soil characteristics that are suitable for recharge, using the SAGBI index in addition to local data developed for the GSP or in coordination with landowner partners.

- Identification of crop types that are suitable for recharge and could accept flooding in late summer and early fall (July 15 through October 15) and/or spring (March 15 through April 15), with minimal impacts (costs) to crops and farming operations.
- Availability of surface water rights and infrastructure to support implementation of the program.
- Availability of existing measurement and monitoring infrastructure.

The second phase of implementation will include developing incentives to encourage landowner participation. This would concurrently include identification of potential funding sources to support the program. Incentives would consider:

- Landowner costs to participate in the program (e.g., on-farm costs, potential crop damage, other direct costs to implement recharge).
- Benefits that would accrue to the local region, the Subbasin, and general public from implementation of the program. These may include improved groundwater levels, other groundwater sustainability indicators, and regional benefits of improved habitat for migratory birds.
- Funding sources would be identified to develop financial incentives. In addition, some program costs could be covered with GGA and CGA participation, where costs would be allocated in proportion to benefits received.

The final phase of program implementation would include ongoing monitoring to measure groundwater (and habitat) benefits for the Subbasin. It is expected that this would result in adjustment to program parameters to support continued expansion and adoption of the program.

Implementation of the multi-benefit program does not depend on the implementation or performance of other PMAs or district activities. Operation of this pilot project could be continued if deemed appropriate. Any future changes will be made to align with landowner participant goals and the overall Subbasin sustainability goal.

6.3.3.7 Legal Authority, Permitting Processes, and Regulatory Control

The multi-benefit recharge project will be implemented as a collaborative effort between private landowners that have the legal authority to implement this project and facilitate multi-benefit recharge on their lands. Implementation will be done in accordance with the required permitting processes and regulatory control.

The following agencies have potential permitting roles for the multi-benefit groundwater recharge project: the Counties of Colusa and/or Glenn, the CGA and GGA, SWRCB, and Reclamation. The project may also require applications for permits required from the SWRCB for diversion of surface water to the extent that diversion is not already permitted under existing water rights and contracts. Recharge projects may also require an environmental 1199 process under CEQA. If required, this project would need either an Environmental Impact Report and Negative Declaration or Mitigated Negative Declaration.

6.3.3.8 Project Operations and Monitoring

Operations and monitoring will be completed by the various project proponents to evaluate the benefits described in the next section. It is anticipated that the total amount of surface water applied to the field will be measured, other flow paths will be measured or estimated, and the amount of recharge achieved will be determined using a mass balance approach. This is consistent with the approach used in the pilot program.

During the implementation period, participants will spread water on their fields and maintain a shallow depth (4 inches maximum) for four to six weeks. Landowner participants will record any changes in water flow in an irrigation log, or other field measurement as appropriate. TNC would coordinate monitoring of field depth, bird presence, water delivery, and changes in groundwater depth.

Project performance would be summarized as part of GSP annual reports and five-year updates.

6.3.3.9 Project Benefits

The primary benefits of the project are direct groundwater recharge and temporary habitat creation for migrating shorebirds, with benefits to the sustainability indicators previously shown in Table 6-3. The potential project groundwater recharge benefits were evaluated in the C2VSimFG-Colusa model, assuming that approximately 4,100 acres participate in the program each year that water is available (anticipated in all but Shasta Critical years). The model was used to simulate field flooding on participating land within the elements identified in Figure 6-5 during the annual project implementation period.[9] From this analysis, it is estimated that an average of 11.5 taf/yr of surface water could be delivered to those participating lands over all year types for multi-benefit recharge, or approximately 2.8 feet per acre of participating land. Over all years simulated, this results in an average annual net groundwater recharge benefit of approximately 5.2 taf/yr, or approximately 1.3 feet per acre of participating land. Additionally, environmental benefits will occur through habitat for migrating shorebirds. All benefits will ultimately depend on grower participation in the program, as it affects the scale of recharge areas and the location where recharge occurs.

During project implementation, actual benefits each year will be evaluated as described in Section 0. Potential project benefits have been assessed, and may continue to be assessed, using the C2VSimFG-Colusa model developed for GSP development by simulating groundwater conditions with and without the project. Additional information on the project modeling is described in Appendix 6D.

Program participation will vary from year to year, depending on landowner interest, financial incentives, water availability, changes in crop market conditions, and sustainability indicators. The program is anticipated to continue every year, providing both groundwater recharge and migratory bird habitat along the Pacific Flyway.

6.3.3.10 Project Costs

Project costs include costs of incentive payments to landowners, land preparation, water conveyance and application, and operations and monitoring.

---

[9] Multi-benefit recharge was modeled by applying water during a 30-day flooding window (September) to designated irrigated lands (approximately 4,100 acres total) within the selected model elements. Soil characteristics were set to simulate flooding by setting the target soil moisture equal the total porosity of the soil.

Table 6-14 summarizes typical program costs based on the results of the pilot project. Costs are greatest in the initial year of the program due to coordination and site preparation but would be expected to fall over time. Site-specific costs will vary based on field conditions and changes to the program over time. As such, the total costs of the program will vary over time, depending on the number of participating landowners.

Table 6-14. Colusa Subbasin Multi-Benefit Groundwater Recharge Estimated Project Costs

Item	Total Cost	Year Incurred	Notes
Capital Costs			
Site preparation	$4,000	First project year	Per site cost
O&M Costs			
Site management	$3,000	All years	Per site cost. Includes on-farm equipment, labor, and administration costs.
Other O&M cost	TBD	All years	Additional water costs, conveyance, and other site-specific costs would be assessed as part of entering into an agreement with willing landowners

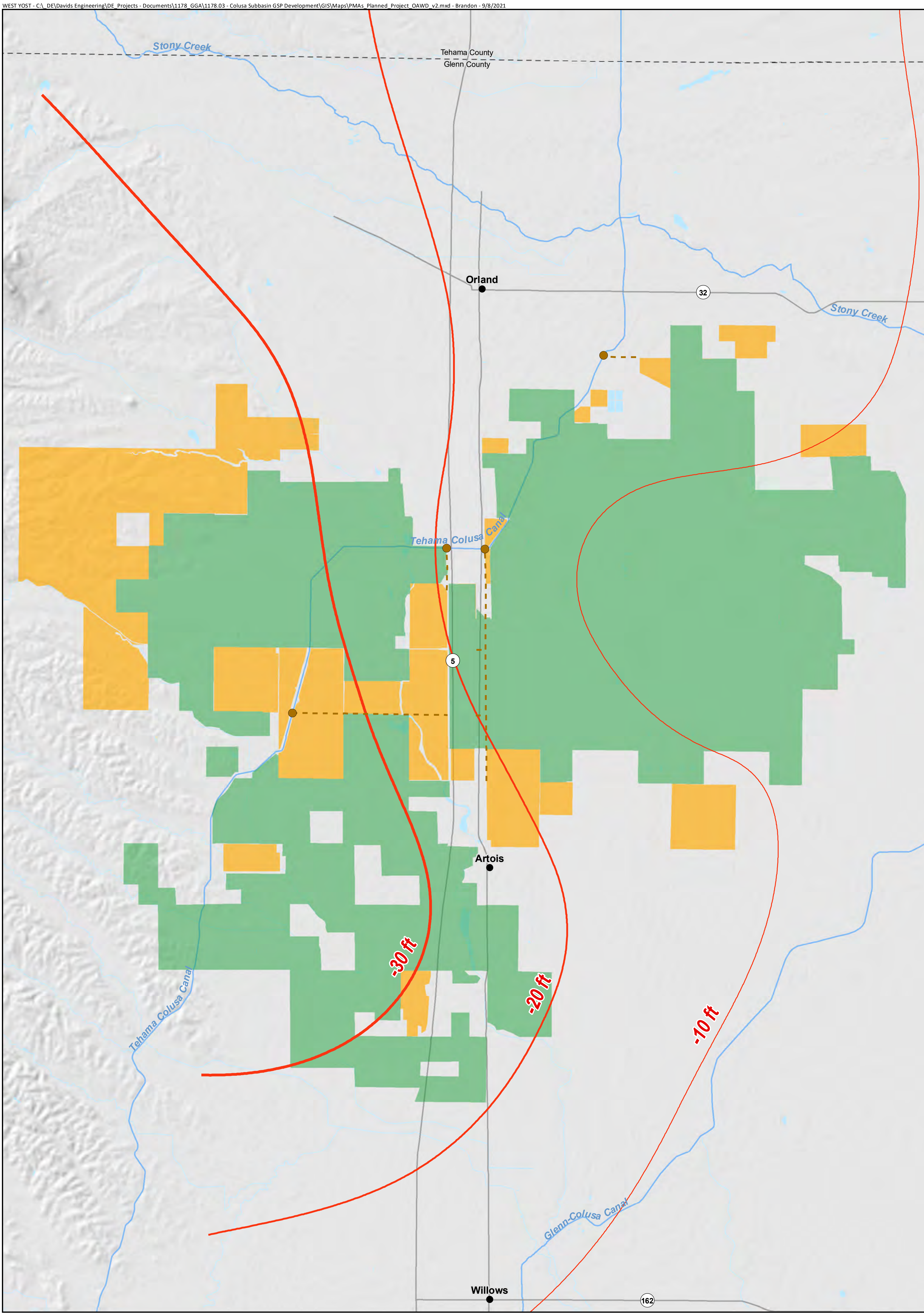
23 CCR §354.44(b)(8) requires a summary of how the project proponent plans to pay these costs. It is anticipated that the cost of incentivizing multi-benefit on-farm recharge would primarily be recovered through funding sources including grants, loans, and potentially, a type of cost-share program where other groundwater-dependent water users in the Subbasin share a portion of the costs since they will also realize regional benefits through this multi-benefit recharge project. Appendix 7A describes different funding mechanisms, and the conceptual approach for allocating project costs across multiple potential project beneficiaries.

6.3.4 Orland-Artois Water District Land Annexation and In-Lieu Groundwater Recharge

6.3.4.1 Project Overview

Orland-Artois WD (OAWD), a Central Valley Project (CVP) water contractor, is working with a group of neighboring non-district landowners to annex approximately 12,000 acres into the district. Figure 6-6 illustrates the location of lands that would be annexed into the district. These lands are already developed agricultural lands that currently rely solely on groundwater for irrigation water supplies. Supplemental surface water for the annexed lands would be secured through annual and multi-year purchase or transfer agreements with willing sellers, conveyed through the existing TCC, and distributed to the annexed lands through new distribution facilities. New facilities include turnouts off the TCC, pipelines, pumping plants, and metered farm deliveries.

It is estimated that approximately 25 taf of surface water would be delivered to annexed lands in all years but Shasta Critical years, resulting in a reduction of groundwater pumping of 23 taf/yr on average across all years. Additionally, certain annexed lands with high infiltration characteristics would be configured for direct recharge by surface spreading. Direct recharge would be done primarily with Section 215 water. Preliminary project design shows seven proposed recharge areas totaling 371 acres in the project. OAWD is evaluating recharge potential and will refine these estimates.



Spring 2010 to Spring 2020 Groundwater Elevation Change

-30 ft -20 ft -10 ft

- Proposed New TCC Turnout
- Proposed New Pipeline
- Orland-Artois WD Boundary
- Orland-Artois WD Planned Annexations

Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

Note:
1. Planning for this project is currently ongoing and map depictions are subject to change.

N

0 1 2
Scale in Miles

Figure 6-6

Orland-Artois WD Land Annexation and Groundwater Recharge Overview

Colusa Groundwater Authority and Glenn Groundwater Authority
Colusa Subbasin
Groundwater Sustainability Plan

This project would address an area within the Subbasin where groundwater levels have been in decline in recent years due to increasing irrigation demands being met through groundwater pumping, compounded in recent years by drought and related curtailments of surface water supplies to OAWD and other neighboring CVP contractors. The sustainability indicators expected to benefit from the project are groundwater levels, groundwater storage, and depletion of interconnected surface water.

6.3.4.2 Implementation

Planning is currently underway for annexation of these lands into OAWD and extension and expansion of the OAWD distribution system. Table 6-15 summarizes the current and planned implementation of the project. It is anticipated that annexed lands would receive surface water deliveries starting in 2025.

Table 6-15. OAWD Land Annexation and In-Lieu Groundwater Recharge Implementation Timeline

Phase	Description	Start	End
Annexation of Additional Lands	Determination of terms and conditions of annexation; development of agreements between OAWD and landowners; requires approval by OAWD, Reclamation, and Glenn LAFCO	2020	2022
Negotiation of Annual and Multi-year Water Purchase or Transfer Contracts	Including engineering and environmental review; requires approval by TCCA, Reclamation and OAWD	2021	2022
Design of New Facilities	Including engineering and environmental review; requires approval by TCCA, Reclamation, and OAWD	2021	2022
Construction of New Facilities	Construction of new turnouts off Tehama-Colusa Canal, pumping plants, pipelines, and metered farm deliveries	2023	2025
Delivery of Surface Water to Annexed Lands	Delivery of purchased or transferred surface water under multi-year agreements	2025	Annually, in perpetuity, except for Shasta-Critical years

6.3.4.3 Notice to Public and Other Agencies

Public noticing for this project will be done in accordance with noticing requirements in NEPA and CEQA, as well as noticing for public meetings held by OAWD, TCCA, and Glenn LAFCO.

6.3.4.4 Construction Activities and Requirements

Construction of new water conveyance facilities will be required for distribution of surface water from the existing TCC to the newly annexed lands. The new facilities include the following:

- Approximately four new turnouts on the TCC to regulate releases from the canal into newly constructed distribution facilities
- Pumping plants on the TCC to lift water to annexed lands that are up-gradient from the TCC

- Distribution pipelines ranging in size from approximately 12 to 36 inches in diameter
- Farm deliveries with instantaneous and totalizing flow measurement devices
- Recharge basins for surface spreading in certain locations with high infiltration rate (gravelly) soils

6.3.4.5 Water Source

The surface water source for the project will come from multiple Sacramento Valley entities with existing surface water entitlements that are willing to transfer water in normal to wet year types. These entities include CVP water supply and settlement contractors and, potentially, Sacramento River water rights holders. The intent is to acquire the water through annual and multi-year, renewable water purchase or transfer agreements, building on similar existing agreements that OAWD has with certain Sacramento Valley entities. Surface water supplies would be diverted from the Sacramento River at the Red Bluff Pumping Plant and Fish Screen facility and conveyed through the Tehama-Colusa Canal, which is operated and maintained by the Tehama-Colusa Canal Authority.

Appendix 6A summarizes an assessment of the volumes of water available for transfer in the Subbasin. The water availability assessment finds there is sufficient water available for transfer for the OAWD project, in addition to the other four planned GSP recharge projects.

6.3.4.6 Circumstances and Criteria for Implementation

This project is planned for implementation as soon as possible, with planning for annexation and new facilities design already underway. In the latter half of 2020 and in 2021, the planning effort has included multiple discussions with OAWD, TCCA and Glenn LAFCO. A formal letter has also been submitted by OAWD to the USBR notifying them of the proposed project. The initial feedback from all agencies has been positive to date.

6.3.4.7 Legal Authority, Permitting Processes, and Regulatory Control

As a Water District, OAWD has the legal authority to pursue expansion of their service area and provide for the acquisition and conveyance of supplemental surface water to these additional lands. The planning and implementation of this project will be done in accordance with the required permitting processes and regulatory control.

Governing agencies with which consultation may need to be initiated include, but are not limited to: DWR, SWRCB, CDFW, the Flood Board, Regional Water Boards, Reclamation, USACE, USFWS, NMFS, LAFCO, the County of Colusa and/or Glenn, and CARB.

Specific permitting and regulatory processes that may affect the construction of new infrastructure include, but are not limited to:

- USACE Section 404 Permits (potential exemption under Section 404(f)(1)(C) of Clean Water Act)
- Regional Water Quality Control Board Section 401 Water Quality Certification (not required if exempt from USACE Section 404)
- SWRCB Construction General Permit and SWPPP
- SHPO and NHPA Section 106 Coordination

- California Endangered Species Act (CESA) Consultation
- ESA Compliance
- NEPA Compliance
- CEQA Compliance

6.3.4.8 Project Operations and Monitoring

OAWD plans to operate and maintain its existing district facilities, new facilities for annexed lands, and conduct project monitoring.

Project monitoring will include a range of activities to evaluate the benefits described in the next section. This will include local monitoring to track the additional volumes of water made available through transfers and estimates of the reduction in pumping relative to pre-project baselines. The district plans to monitor deliveries of surface water to newly annexed lands in-lieu of groundwater pumping. The benefit of in-lieu recharge on sustainability indicators in the Subbasin (groundwater levels and groundwater storage) will be monitored using the monitoring network sites and monitoring practices described in the GSP (Chapter 4).

6.3.4.9 Project Benefits

The primary benefit of the project is reduction of groundwater pumping resulting from in-lieu groundwater recharge with benefits to the sustainability indicators previously shown in Table 6-3. It is estimated that approximately 25 taf of surface water would be delivered to annexed lands in all years but Shasta Critical years, resulting in an average reduction of groundwater pumping of 23 taf/yr across all years.

Certain annexed lands with high infiltration characteristics would be configured for direct recharge by surface spreading. Direct recharge would be done primarily with Section 215 water. The direct recharge capacity has not yet been estimated. These benefits would be realized after construction of the water delivery infrastructure is complete and delivery of surface water to these newly annexed lands begins.

Table 6-16 summarizes the expected annual volume of in-lieu recharge under the OAWD program. Project benefits have been assessed, and may continue to be assessed, using the C2VSimFG-Colusa model developed for GSP development by simulating groundwater conditions with and without the project. Additional information on the project modeling is described in Appendix 6D. Transfer volumes would vary in Shasta Non-Critical years based on the terms of the transfer agreements, and broader water market conditions. It is anticipated that OAWD transfer volumes would vary with availability of CVP supplies in Shasta Non-Critical years. Average CVP contract deliveries were 75 percent between 1990 and 2021, over the more recent 15 years, average deliveries were 67 percent of contracts. At full implementation (in 2025) the expected average annual volume equals 25 taf in Shasta Non-Critical years, with total average annual volume of 23 taf.

Table 6-16. OAWD Land Annexation and In-Lieu Groundwater Recharge Estimated Average Recharge Volume by Year Type, in af/yr (2016-2065)

Year Type	Total Annual Volume	% of Years	Weighted Avg.
Shasta Non-Critical	Up to 25,000	90%	22,500
Shasta Critical	0	10%	0
Average Annual	-	-	**22,500**

6.3.4.10 Project Costs

Project costs include the cost of purchased water, applicable costs associated with the use of the TCC, capital costs associated with construction of new facilities, and OAWD operation and maintenance costs for the facilities serving the annexed lands. Efforts are currently underway by OAWD and owners of proposed annexed lands to estimate these project costs, and to identify funding sources and establish repayment terms. Table 6-17 summarizes estimated project costs.

Table 6-17. OAWD Land Annexation and In-Lieu Groundwater Recharge Estimated Project Costs

Item	Total Cost	Year Incurred	Notes
Capital Costs			
Distribution system and LAFCO costs	$20 million	Start of project	Preliminary cost estimate; OAWD is currently refining the cost of expanding its distribution to serve the annexed lands. Annexed lands would be responsible for additional costs.
O&M Costs			
Water supply cost	$1.9 million	Annual average	Average annual water purchase cost to acquire water in W, AN, and BN years; costs are incurred in years when water is available.
Other O&M cost	$0.73 million	Annual average	Estimated O&M costs, not including volumetric charge.

The cost of purchased and transferred water will be defined in the water transfer agreements. A detailed assessment of the water transfer market in the Subbasin and greater Sacramento Valley is beyond the scope of this initial project investigation for the GSP. Water transfer prices have increased substantially over the last decade. This is due to a combination of more limited supply due to drought, GSP implementation in the San Joaquin Valley, and the biological opinion regarding operation of the CVP system, as well as demand driven by plantings of permanent crops and strong nut prices.

As shown in Table 6-11 in Section 6.3.2, the weighted-average cost for the lower range of within-Sacramento Valley transfer prices is $83 per af. With approximately 23 taf average annual supply, the expected annual water supply cost (excluding any additional O&M or overhead charges) is $1.9 million. Other operating and maintenance (O&M) costs for the annexed lands are estimated based on current OAWD charges, which include an operations charge of $38.11 per acre and CVP Construction charge of $23.00 per acre. This does not include any additional district O&M costs recovered through volumetric charges.

Potential funding sources include grants, loans, and potentially, a type of cost-share program where other groundwater-dependent water users in the Subbasin share a portion of the costs since they will also realize regional benefits through this in-lieu recharge project.

23 CCR §354.44(b)(8) requires a summary of how OAWD plans to cover the costs of the project. It is anticipated that the cost of transfer purchases would primarily be recovered through OAWD assessments. Landowners in annexed lands would pay for additional distribution system costs. Other potential funding sources include grants, loans, and potentially, a type of cost-share program where other groundwater-dependent water users in the Subbasin share a portion of the costs since they will

also realize regional benefits through this project. Appendix 7A describes different funding mechanisms, and the conceptual approach for allocating project costs across multiple potential project beneficiaries.

6.3.5 Sycamore Slough Groundwater Recharge Pilot Project

6.3.5.1 Project Overview

Proctor and Gamble (P&G) and Davis Ranches recently entered into a cooperative agreement to implement a 10-year groundwater recharge pilot project. The project will apply surface water diverted from the Sacramento River to a 66-acre field on Davis Ranches for groundwater recharge and to provide habitat for migrating waterfowl for 30 to 45 days during the fall or winter each year. The timing of the project may be targeted to provide fall and winter habitat for migratory shorebirds, in addition to groundwater recharge benefits. However, the precise timing of the project is flexible to accommodate changes in water availability and other factors between years.

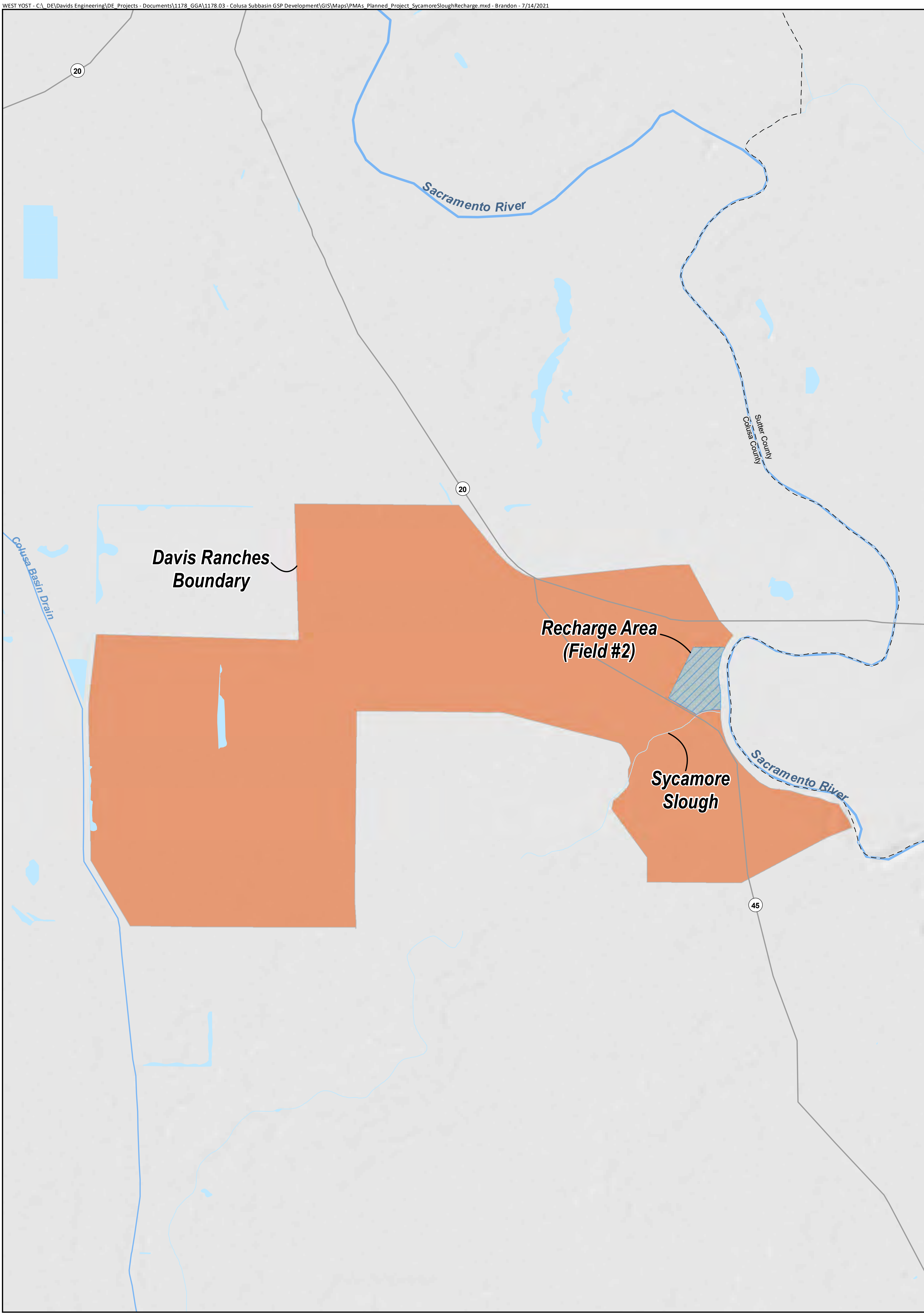
Sacramento River water is available to Davis Ranches under riparian rights and a Sacramento River settlement contract with Reclamation. If the project starts before November 1, settlement contract water would be used. Otherwise, riparian water rights would be exercised for beneficial use (habitat). The objective is to recharge 5,000 acre-feet over the 10-year study period and to revegetate a portion of Sycamore Slough. Monitoring of groundwater conditions will be done in eight existing groundwater wells, including dedicated monitoring wells and agricultural production wells. If the project is successful and cost effective it could be continued in perpetuity to sustain long-term groundwater recharge and environmental benefits. Subject to acquisition of funding, an expansion of the project is planned for recharge and revegetation in the neighboring Sycamore and Dry Sloughs. The general project location is shown in Figure 6-7.

6.3.5.2 Implementation

The project implementation timeline is shown in Table 6-18. The pilot project is scheduled to begin in the early fall of 2021 and will proceed for ten consecutive years. Subject to acquisition of funding, an expansion of the project is planned for neighboring Sycamore and Dry Sloughs in future years.

Table 6-18. Sycamore Slough Groundwater Recharge Pilot Project Implementation Timeline

Phase	Description	Start	End
Pilot Project	Develop and implement pilot project program	2021	2030
Evaluation and Project Updates	Perform periodic project assessments and update project accordingly	2021	2030
Project Expansion	Evaluate opportunities to expand the project to additional lands in Dry and Sycamore Sloughs	2025	2030
Full Program Implementation	Adjust program based on pilot project performance, and scale program based on interest and funding availability; implement full program	2031	Annually, in perpetuity



Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

Note:
1. Planning for this project is currently ongoing and map depictions are subject to change.

Figure 6-7

Sycamore Slough Groundwater Recharge Pilot Project Overview

Colusa Groundwater Authority and Glenn Groundwater Authority
Colusa Subbasin
Groundwater Sustainability Plan

6.3.5.3 Notice to Public and other Agencies

Public noticing for this project will be done in accordance with all legal noticing requirements. The project is funded through a private grant, and there is no requirement for public notice at initiation. However, the project proponents plan to host public outreach events and field days to communicate and illustrate project goals, challenges, and successes.

6.3.5.4 Construction Activities and Requirements

There are no infrastructure construction activities and requirements, as the project will use existing infrastructure and facilities. Minor earthwork would be required on the pilot project field to support increased recharge and bird habitat.

Future expansion of the program to other participating lands may require a similar level of earthwork to increase recharge and habitat benefits. No major construction activities are anticipated at this time.

6.3.5.5 Water Source

The surface water source for the project will be Sacramento River water available to Davis Ranches under existing riparian rights and an existing Sacramento River settlement contract with Reclamation (before November 1). The water would be diverted and conveyed through existing facilities.

6.3.5.6 Circumstances and Criteria For Implementation

The pilot project is scheduled to begin in the early fall of 2021 and will proceed for ten consecutive years through 2030.

Subject to acquisition of funding, an expansion of the project is planned for neighboring Sycamore and Dry Sloughs in future years. If the project is successful and cost effective it could be continued in perpetuity to sustain long-term groundwater recharge and environmental benefits.

6.3.5.7 Legal Authority, Permitting Processes, and Regulatory Control

As a private landowner, Davis Ranches has the legal authority to implement this project. Implementation will be done in accordance with the required permitting processes and regulatory control.

The following agencies have potential permitting roles for the Sycamore Slough groundwater recharge pilot project: the County of Colusa, SWRCB, and Bureau of Reclamation. Davis Ranches has access to water through existing riparian rights and a Sacramento River settlement contract with Reclamation.

Recharge projects may also require an environmental 1199 process under CEQA. If required, this project would need either an Environmental Impact Report and Negative Declaration or Mitigated Negative Declaration.

6.3.5.8 Project Operations and Monitoring

Davis Ranches will operate and maintain project facilities and monitoring equipment. Monitoring will be completed to evaluate the benefits described in the next section. The total amount of surface water applied to the field will be measured, other flow paths will be measured or estimated, and the amount of recharge achieved will be determined using a mass balance approach. Groundwater levels in eight groundwater wells in the project vicinity will be monitored and analyzed to determine the extent and magnitude of benefits to groundwater conditions.

6.3.5.9 Project Benefits

The primary benefits of the project are direct groundwater recharge and temporary bird habitat formation, with benefits to the sustainability indicators previously shown in Table 6-3. The objective of the pilot project is to recharge 5,000 acre-feet of water over ten years, with the potential to increase this volume if the project is expanded for neighboring Sycamore and Dry Sloughs in future years. Groundwater recharge benefits could also be assessed using the C2VSimFG-Colusa model developed for GSP development by simulating groundwater conditions with and without the project. Additionally, environmental benefits will occur through habitat for migrating waterfowl and revegetation of a portion of Sycamore Slough.

6.3.5.10 Project Costs

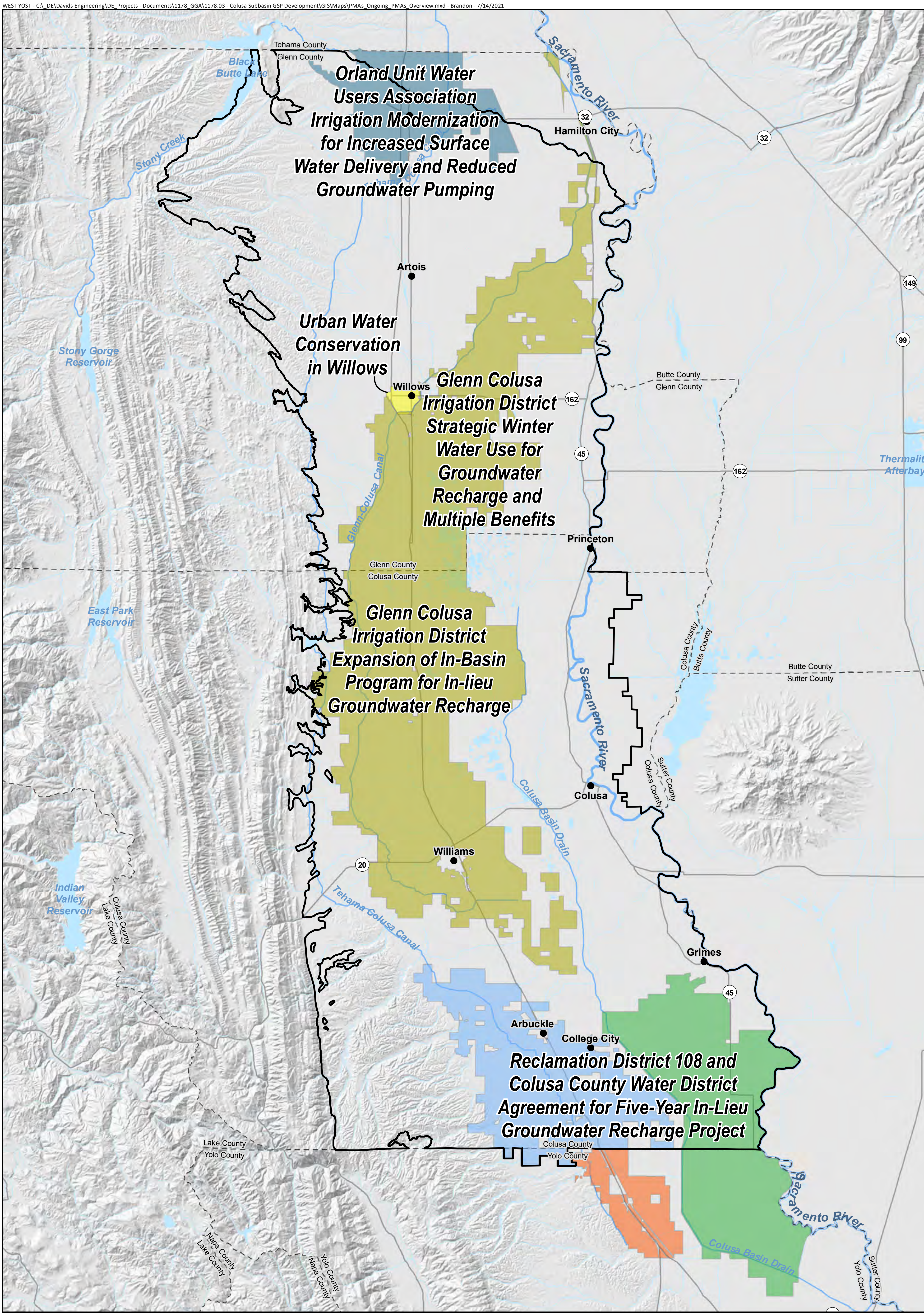
Project costs include costs of land preparation, water application, operations and monitoring, and revegetation costs. The estimated capital cost for monitoring equipment is approximately $28,000, and the estimated annual costs for project implementation total approximately $26,000 per year. The pilot project has secured funding through P&G for ten years, and Davis Ranches is currently working with the Freshwater Trust to identify other potential funders for expansion of the recharge program or longer-term funding beyond the 10-year pilot project.

23 CCR §354.44(b)(8) requires a summary of how P&G and Davis Ranches would cover the costs of the project. Initial program costs are covered under a grant. Potential future funding sources include grants, loans, and potentially, a type of cost-share program where other groundwater-dependent water users in the Subbasin share a portion of the costs since they will also realize regional benefits through this project. Appendix 7A describes different funding mechanisms, and the conceptual approach for allocating project costs across multiple potential project beneficiaries.

6.4 ONGOING PROJECTS AND MANAGEMENT ACTIONS

Several agencies and other proponents have ongoing projects and actions which could provide benefits with respect to one or more of the sustainability indicators. In accordance with 23 CCR §354.44(a) these are PMAs that would allow GSAs to achieve the sustainability goal for the Subbasin and avoid minimum thresholds defined in this GSP under future, changing conditions.

Data for these PMAs will be developed under future monitoring, and as the GSAs continue to identify and fill data gaps and reported in annual reports. Ongoing PMAs are classified by projects and management actions, which are described in the following subsections. Projects are generally structural activities that include direct recharge and in-lieu recharge. Management actions are activities to improve water management or reduce groundwater pumping. There is one ongoing management action, which is an urban water conservation project in the Willows area. Figure 6-8 illustrates the location of ongoing PMAs in the Subbasin.



Colusa Subbasin Boundary
Colusa County WD Boundary
Dunnigan WD Boundary
Orland Unit WUA Boundary
Reclamation District No. 108 Boundary
Glenn Colusa ID Boundary
City of Willows

Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

Notes:
1. Ongoing projects will take place within the service area boundaries of the project proponents.
2. The Sycamore Marsh Farm Direct Recharge Program is not depicted on the map.

N

0 2.5 5
Scale in Miles

Figure 6-8

Ongoing Projects and Management Actions Overview

Colusa Groundwater Authority and Glenn Groundwater Authority
Colusa Subbasin
Groundwater Sustainability Plan

Ongoing PMAs are described at a reconnaissance-level of detail relative to the planned projects described under Section 6.3, above. However, project information is still reported in accordance with 23 CCR §354.44(b). The required information is summarized in a table following the general description for each ongoing PMA. The information provided with each ongoing project table maps to the GSP regulation requirements as follows:

- Implementation (§354.44(b)(1)(A))
- Timeline (§354.44(b)(4))
- Notice to public and other agencies (§354.44(b)(1)(B))
- Water source and reliability (§354.44(b)(6))
- Legal authority, permitting processes, and regulatory control (§354.44(b)(3), (§354.44(b)(7))
- Benefits and benefit evaluation methodology (§354.44(b)(5), (§354.44(b)(9))
- Costs (§354.44(b)(8))

6.4.1 Ongoing Projects

This section describes ongoing projects. Ongoing projects include direct and in-lieu recharge opportunities being implemented across the Subbasin. Table 6-19 summarizes the ongoing projects included in the GSP. The following subsections provide project descriptions for each project.

Table 6-19. Summary of Ongoing Projects

Project	Project Type	Proponent	Year Implemented	Estimated Capital / Establishment Cost, $M	Gross Average Annual Benefit, af/yr
Reclamation District 108 and Colusa County Water District Agreement for Five Year In-Lieu Groundwater Recharge Project	In-lieu Groundwater Recharge	RD108 and CCWD	Pending Extension	Under Development	8,000
Glenn-Colusa Irrigation District Strategic Winter Water Use for Groundwater Recharge and Multiple Benefits	Direct and In-lieu Groundwater Recharge	GCID	2021	Under Development	TBD
Sycamore Marsh Farm Direct Recharge Project[(a)]	Direct Groundwater Recharge	Landowner	2020	Under Development	TBD
Glenn-Colusa Irrigation District Expansion of In-Basin Program for In-lieu Groundwater Recharge	In-lieu Groundwater Recharge	GCID	2021	Under Development	TBD
Orland Unit Water Users Association Irrigation Modernization for Increased Surface Water Delivery and Reduced Groundwater Pumping	In-lieu Groundwater Recharge	OUWUA	2021	Under Development	TBD

(a) Project is not depicted on the map in Figure 6-8.

6.4.1.1 Reclamation District 108 and Colusa County Water District Agreement for Five-Year In-Lieu Groundwater Recharge Project

RD108 and CCWD (and Dunnigan Water District [DWD] located in the neighboring Yolo Groundwater Subbasin) are entering the final year (2022) of a five-year agreement that provides for the purchase of water by CCWD (and DWD) from RD108. The purchased water is available to RD108 through contractual rights under Sacramento River Settlement Contract 14-06-200-876A between RD108 and the Bureau of Reclamation. Under the five-year agreement, 10,000 acre-feet is purchased by and transferred to CCWD and DWD, with 80 percent of the 10,000 acre-feet going to CCWD and 20 percent to DWD. Water purchased under the agreement is diverted at the Red Bluff Pumping Plant and Fish Screen facility and conveyed via the Tehama-Colusa Canal for distribution within CCWD and DWD. The price schedule for the water is tied to Reclamation's annual water rates with an additional charge per acre-foot that depends on CCWD's annual allocation under its CVP contract. The additional charge varies from $0 per acre-foot to $50 per acre-foot. However, in years when RD108's water supply under its settlement contract is cut by 75 percent, the price schedule does not govern and instead the price is $275 per acre-foot. It is expected that the five-year agreement will be extended with the price schedule potentially renegotiated.

This project supplies additional surface water to CCWD (and DWD) that provides in-lieu recharge to meet water demands that otherwise would be met through groundwater pumping.

A summary of the project is provided in Table 6-20.

Table 6-20. Reclamation District 108 and Colusa County Water District Agreement for Five-Year In-Lieu Groundwater Recharge Project Summary

Item	Description
Implementation	RD108 and CCWD proposed this project, if extended, for GSP implementation in the CCWD service area. The project provides in-lieu groundwater recharge through utilization of surface water supplies available to RD108. This is an ongoing project, which will be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	The current project is ending, and extension is still pending. Thus, the start and completion dates for this project have yet to be determined and will be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing is being facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The source is Sacramento River water available to RD108 through contractual rights under existing Sacramento River Settlement Contract 14-06-200-876A between RD108 and the Bureau of Reclamation.

Table 6-20. Reclamation District 108 and Colusa County Water District Agreement for Five-Year In-Lieu Groundwater Recharge Project Summary	
Item	Description
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review is project specific and being initiated through consultation with applicable governing agencies. Governing agencies for which consultation is being initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, land subsidence, and depletion of interconnected surface water. The expected yield of the project is 8,000 af/yr in Shasta Non-Critical years, and about 7,000 af/yr on average across all years. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and land subsidence. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	The current project is ending, and extension is still pending. Thus, the anticipated costs of this project have yet to be determined and will be reported in GSP annual reports and five-year updates when known. The project proponent is identifying funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.4.1.2 Glenn-Colusa Irrigation District Strategic Winter Water Use for Groundwater Recharge and Multiple Benefits

In addition to the water supply available to Glenn-Colusa Irrigation District under its settlement contract with the Bureau of Reclamation, GCID holds a 1999 water right permit[10] to divert Sacramento River water for irrigation and rice straw decomposition annually between November 1 and March 31. Water used under the permit is referred to as “winter water.” Use under the permit began in 2000 and on average between 2000 and 2019, about 43 percent of the district land planted to rice each year has used winter water. Additionally, use for winter irrigation of a variety of permanent and annual crops has gradually expanded, particularly to meet late fall irrigation demands of almonds. Finally, winter water is occasionally used for frost control purposes, particularly on almonds. Water applied for rice straw decomposition creates multiple benefits, including habitat enhancement for Pacific Flyway migrating waterfowl and groundwater recharge in the Subbasin. Water used for winter irrigation and frost control of non-rice crops contributes to in-lieu recharge to the extent that groundwater would have been used absent the availability of winter water.

The potential exists to increase the groundwater recharge and habitat enhancement benefits of winter water use by increasing winter use for rice straw decomposition, winter irrigation, and frost control provided that certain constraints can be alleviated. The main constraints include: the current cost of winter water; the labor cost and management effort involved with applying winter water; GCID’s inability to provide of winter water during its annual system construction and maintenance period traditionally

[10] GCID is currently preparing to petition the State Water Resources Control Board (SWRCB) to convert its winter water permit to a water right license.

from early January through late February each winter; and, water supply constraints posed by water right Term 91, which limits Sacramento River diversions during dry periods.

Under this project, working in collaboration with partners within the Subbasin and with environmental advocacy groups, GCID will investigate opportunities to increase winter water use by alleviating the constraints mentioned above. The objectives will be to incentivize growers to: 1) maximize winter water use on rice land including targeting rice lands with highest recharge potential, 2) expand use of winter water for irrigation and frost control where groundwater would otherwise be used, and 3) encourage temporary flooding of permanent and annual crop lands including targeting lands with the highest recharge potential. Critical elements of this investigation include demonstration on-farm economic and agronomic feasibility.

A summary of the project is provided in Table 6-21.

Table 6-21. Glenn-Colusa Irrigation District Strategic Winter Water Use for Groundwater Recharge and Multiple Benefits Summary

Item	Description
Implementation	GCID proposed this ongoing project for GSP implementation in the GCID service area. The project would provide direct and in-lieu groundwater recharge through increased winter water utilization. This is an ongoing project, which will be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is beginning in 2021 and will be ongoing.
Notice to public and other agencies	Public and/or Inter-Agency Noticing is being facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The source is an existing appropriative water right for diversion and use of "winter water" from November 1 through March 31 each year. Appropriative winter water supplies are subject to availability and curtailments according to water right Term 91.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review is being initiated through consultation with applicable governing agencies. Governing agencies for which consultation is being initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.

Table 6-21. Glenn-Colusa Irrigation District Strategic Winter Water Use for Groundwater Recharge and Multiple Benefits Summary	
Item	Description
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. Potential expansion of this project to increase recharge is currently in the early conceptual stage. Thus, the expected yield of this project has yet to be determined and will be reported in GSP annual reports and five-year updates when known. Other benefits are increased ponded habitat for migrating waterfowl and improved air quality through reduced rice straw burning. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	Project costs are primarily related to the cost of diverting and distributing winter water through the GCID canal network, with costs paid by participating growers. Current rates for winter water service vary between approximately $9 and $27 per acre depending on the level of service (duration of flooding), on top of a fixed assessment of about $42 per acre.

This project will be implemented by GCID working together with project collaborators by continuing use of winter water and investigating alternatives for alleviating constraints and developing incentives for expanding use of winter water. This will include the following actions, among others:

- Petitioning the SWRCB to license GCID's current water right permit, including investigation of provisions for relieving water supply limitations posed by Term 91.
- Characterizing baseline winter water use to better understand the destination of winter water to consumptive use, deep percolation (groundwater recharge), and surface return flows.
- Quantifying the groundwater recharge and habitat enhancement benefits derived from winter water use under baseline and potential future conditions with increased winter water use.
- Identifying beneficiaries of baseline and increased winter water use.
- Identifying and addressing data gaps associated characterizing winter water use and identifying beneficiaries.
- Exploring potential financial, operational, and other types of partnerships with beneficiaries and collaborators.
- Conducting temporary pilot programs to test operational and financial collaborations, potentially leading to implementation of permanent or long-term arrangements.
- Assessing environmental impacts and preparing environmental documents, as necessary.

Winter water would be diverted from the Sacramento River and delivered using GCID's existing distribution system, so no additional conveyance infrastructure is expected to be required. Minor facilities to connect the GCID system to lands currently served by groundwater only might be required.

6.4.1.3 Sycamore Marsh Farm Direct Recharge Project

Sycamore Marsh Farm has been in process of developing a groundwater recharge plan to store water in the aquifer by several different methods. The plan provides for 205 acres of year-round recharge basins and 163 additional acres of winter recharge areas. A summary of the project is provided in Table 6-22.

Table 6-22. Sycamore Marsh Farm Direct Recharge Project Summary

Item	Description
Implementation	The landowner proposed this ongoing project for GSP implementation which would be located on their property. The project provides direct groundwater recharge through several methods. This is an ongoing project, which will be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	The project began in 2020 and will be ongoing.
Notice to public and other agencies	Public and/or Inter-Agency Noticing is being facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The source for this project is the Colusa Drain. The reliability is to be determined. However, no new water rights are expected to be necessary.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review is being initiated through consultation with applicable governing agencies. Governing agencies for which consultation is being initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, depletion of interconnected surface water, land subsidence, and potentially groundwater quality. This project is still developing. Thus, the expected yield of this project has yet to be determined and will be reported in GSP annual reports and five-year updates when known. Other benefits include ponded habitat for migratory waterfowl. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This project is still developing. Thus, the anticipated costs of this project have yet to be determined and will be reported in GSP annual reports and five-year updates when known. The project proponent is identifying funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.4.1.4 Glenn-Colusa Irrigation District Expansion of In-Basin Program for In-lieu Groundwater Recharge

In cooperation with the Bureau of Reclamation (Reclamation), GCID has developed temporary arrangements to supply district surface water to neighboring non-district agricultural lands that primarily use groundwater. These temporary arrangements were implemented under agreements that recently expired in 2020. There is continued interest from participating landowners, and interest from landowners in additional closely neighboring areas, in continuing and expanding this in-basin surface water use. GCID is currently working in cooperation with Reclamation to renew these agreements and expand this program for the purpose of reducing groundwater pumping and increasing in-lieu groundwater recharge. Construction of new water delivery infrastructure may be required to deliver surface water to some neighboring lands. GCID is also evaluating the possibility of annexing some or all of these lands into its service area. Supplies would potentially be available for this project only in Shasta Non-Critical years. A summary of the project is provided in Table 6-23.

Table 6-23. Glenn-Colusa Irrigation District Expansion of In-Basin Program for In-lieu Groundwater Recharge Summary

Item	Description
Implementation	GCID proposed this recently expired project to become an ongoing project for GSP implementation in GCID and neighboring areas. The project would provide in-lieu groundwater recharge through increased surface water utilization. This is an ongoing project, which will be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project would resume in 2021 and be ongoing.
Notice to public and other agencies	Public and/or Inter-Agency Noticing is being facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The source is the Sacramento River under GCID's existing contractual and appropriative rights. Supplies would potentially be available in Shasta Non-Critical years. This is expected to be a reliable source during those years.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review is being initiated through consultation with applicable governing agencies. Governing agencies for which consultation is being initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.

Table 6-23. Glenn-Colusa Irrigation District Expansion of In-Basin Program for In-lieu Groundwater Recharge Summary	
Item	**Description**
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. Potential expansion of this project is currently in the early conceptual stage. Thus, the expected yield of this project has yet to be determined and will be reported in GSP annual reports and five-year updates when known. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	Potential expansion of this project is currently in the early conceptual stage. Thus, the anticipated costs of this project have yet to be determined and will be reported in GSP annual reports and five-year updates when known. The project proponent is identifying funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.4.1.5 Orland Unit Water Users Association Irrigation Modernization for Increased Surface Water Delivery and Reduced Groundwater Pumping

This project continues the modernization of the OUWUA's southside irrigation conveyance and distribution system involving the following features: regulating reservoirs, expanded and improved flow measurement and water level control, system interties, and expansion and upgrading of the existing supervisory control and data acquisition (SCADA) system. These improvements are expected to result in more reliable and flexible farm deliveries that will provide incentives for growers to use more surface water and pump less groundwater. In-lieu recharge is expected to increase groundwater levels within and neighboring the OUWUA service area. A summary of the project is provided in Table 6-24.

Table 6-24. Orland Unit Water Users Association Irrigation Modernization for Increased Surface Water Delivery and Reduced Groundwater Pumping Summary	
Item	**Description**
Implementation	OUWUA proposed this ongoing project for GSP implementation in the OUWUA service area and neighboring areas. The project provides in-lieu groundwater recharge through more efficient utilization of existing surface water. This is an ongoing project, which will be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is still developing. Thus, the start and completion dates for this project have yet to be determined and will be provided in GSP annual reports and five-year updates when known.

Table 6-24. Orland Unit Water Users Association Irrigation Modernization for Increased Surface Water Delivery and Reduced Groundwater Pumping Summary	
Item	Description
Notice to public and other agencies	Public and/or Inter-Agency Noticing is being facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The source is Stony Creek water available to the OUWUA under the Angle Decree. This is highly reliable with significant shortages historically occurring once every 10 to 20 years on average.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review is project specific and being initiated through consultation with applicable governing agencies. Governing agencies for which consultation is being initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. This project is still developing. Thus, the expected yield of this project has yet to be determined and will be reported in GSP annual reports and five-year updates when known. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This project is still developing. Thus, the anticipated costs of this project have yet to be determined and will be reported in GSP annual reports and 5-year updates when known. The project proponent is identifying funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.4.2 Ongoing Management Actions

This section described ongoing management actions. There is one ongoing management action, summarized in Table 6-25. It incentivizes urban water conservation in the Willows area, providing an important benefit in reducing groundwater pumping in the area.

Table 6-25. Summary of Ongoing Management Actions					
Management Action	Management Action Type	Proponent	Year Implemented	Estimated Capital Cost	Gross Average Annual Benefit, af/yr
Urban Water Conservation in Willows	Management Action	RD108 and CCWD	2016	TBD	2

6.4.2.1 Urban Water Conservation in Willows

The California Water Service - Willows District is implementing urban water conservation measures through water waste prevention ordinances, metering, conservation pricing, public education and outreach, programs to assess and manage distribution system real loss, water conservation program coordination and staffing support, and other demand management measures. These are described in greater detail in Chapter 9 of the 2020 Urban Water Management Plant (UWMP) for the California Water Service - Willows District. A summary of the management action is provided in Table 6-26.

Table 6-26. Urban Water Conservation in Willows Summary

Item	Description
Implementation	California Water Service - Willows District proposed this ongoing management action for GSP implementation which would occur in the City of Willows. The action would reduce demand for groundwater. This is an ongoing management action, which will be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This management action began in 2016 and is ongoing.
Notice to public and other agencies	Public and/or Inter-Agency Noticing is being facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	Not applicable for this demand management action.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual proponents have the authority to plan and implement management actions. Required permitting and regulatory review is being initiated through consultation with applicable governing agencies. Governing agencies for which consultation is being initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. The expected yield of this management action is 2 af/yr. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	The cost is being covered by rate structure of Cal Water - Willows Division.

6.5 POTENTIAL PROJECTS AND MANAGEMENT ACTIONS

In addition to the planned and ongoing projects and management actions identified above, the GSAs and other project proponents are considering a number of other potential PMAs that could provide benefits with respect to one or more of the sustainability indicators. These PMAs are still under development and require additional information that would be developed under future monitoring, and as the GSAs continue to identify and fill data gaps and reported in annual reports. This section provides descriptions for these identified potential PMAs.

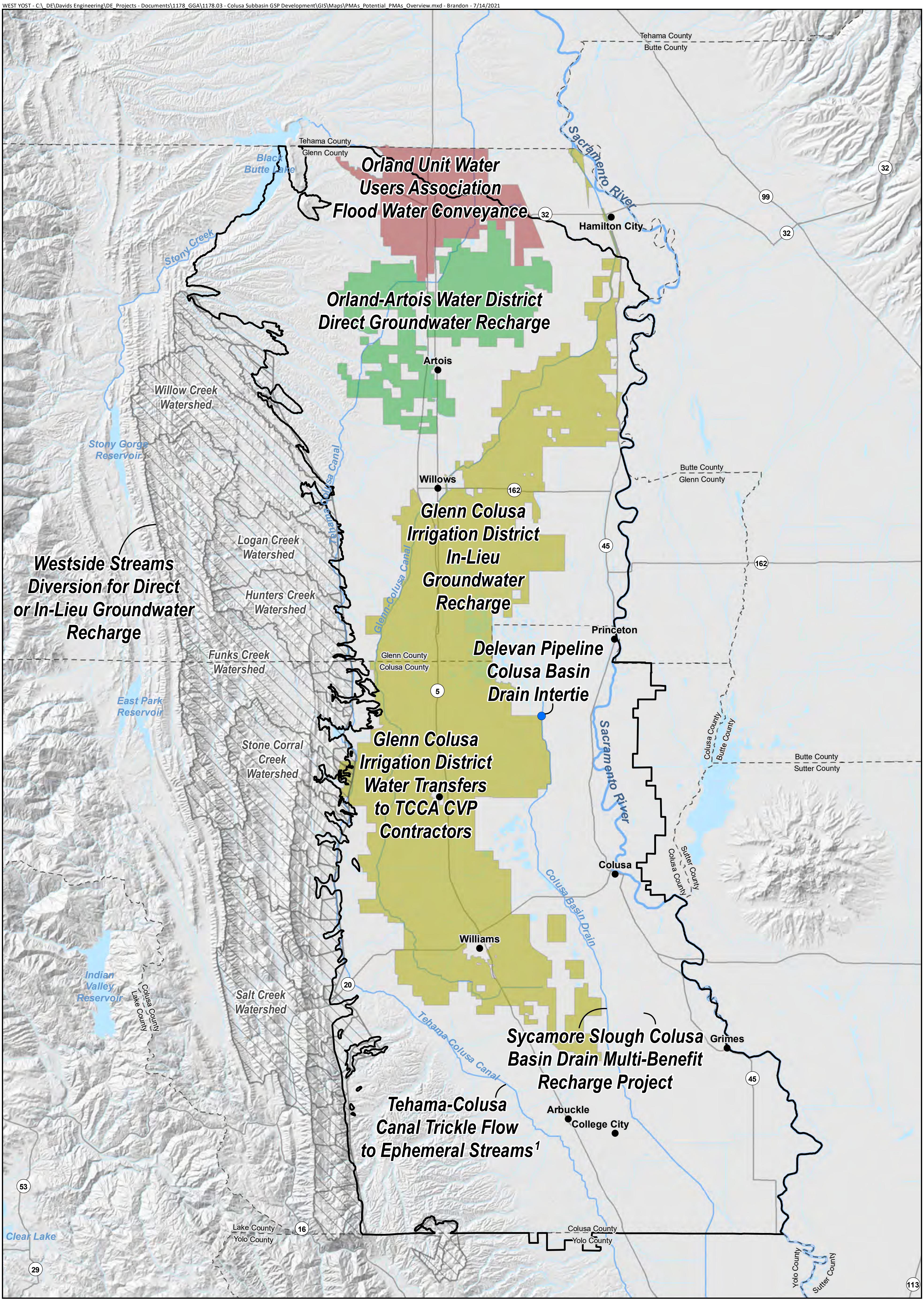
Figure 6-9 illustrates the location of potential PMAs in the Subbasin.

Potential PMAs are classified by projects and management actions, which are described in the following subsections. Projects are generally structural activities that include direct recharge, in-lieu recharge, and utilization of additional surface water supplies. Management actions are activities to improve water management or reduce groundwater pumping. Potential management actions include two demand management programs, which per 23 CCR §354.44(b)(2), could be rapidly implemented if the Subbasin is approaching minimum thresholds specified in the GSP.

Potential PMAs are described at a reconnaissance-level of detail relative to the planned projects described under Section 6.3, above. However, PMA information is still reported in accordance with 23 CCR §354.44(b). The required information is summarized in a table following the general description for each potential PMA. The information provided with each potential project table maps to the GSP regulation requirements as follows:

- Implementation (§354.44(b)(1)(A))
- Timeline (§354.44(b)(4))
- Notice to public and other agencies (§354.44(b)(1)(B))
- Water source and reliability (§354.44(b)(6))
- Legal authority, permitting processes, and regulatory control (§354.44(b)(3), (§354.44(b)(7))
- Benefits and benefit evaluation methodology (§354.44(b)(5), (§354.44(b)(9))
- Costs (§354.44(b)(8))

WEST YOST - C:_DE\Davids Engineering\DE_Projects - Documents\1178_GGA\1178.03 - Colusa Subbasin GSP Development\GIS\Maps\PMAs_Potential_PMAs_Overview.mxd - Brandon - 7/14/2021



- Potential Project Location
- Orland-Artois WD Boundary
- Orland Unit WUA Boundary
- Glenn Colusa ID Boundary
- Westside Stream Watersheds
- Colusa Subbasin Boundary

Horizontal Datum: North American Datum of 1983 (NAD 83), California State Plane Zone II, feet.

Note:
1. The Tehama-Colusa Canal (TCC) Trickle Flow to Ephemeral Streams project will occur at various points along the TCC where it intersects ephemeral streams, not in the location called out on the map.
2. There are an additional 14 potential projects and management actions that are not depicted on the map. This is due to either subbasin-wide implementation or the planning process not being far enough along to locate these projects at this time.

0 2.5 5
Scale in Miles

Figure 6-9

Selected Potential Projects and Management Actions Overview

Colusa Groundwater Authority and Glenn Groundwater Authority
Colusa Subbasin
Groundwater Sustainability Plan

6.5.1 Potential Projects

This section describes potential projects that would be implemented if determined to be necessary or desirable under future monitoring of the Subbasin. Potential projects include direct and in-lieu recharge opportunities that could be implemented across the Subbasin, as well as local and regional (e.g., Sites) storage projects. Table 6-27 summarizes the potential projects included in the GSP. The following subsections provide project descriptions for each project.

Table 6-27. Summary of Potential Projects

Project[(a)]	Project Type	Proponent
Glenn-Colusa Irrigation District In-lieu Groundwater Recharge	In-lieu Groundwater Recharge	GCID
Westside Streams Diversion for Direct or In-lieu Groundwater Recharge	Direct and In-lieu Groundwater Recharge	CGA and GGA
Sites Reservoir	Direct and In-lieu Groundwater Recharge	Sites Project Authority
Delevan Pipeline Colusa Drain Intertie	Direct and In-lieu Groundwater Recharge	Landowner
Orland Unit Water Users Association Flood Water Conveyance	Direct Groundwater Recharge	OUWUA
Orland-Artois Water District Direct Groundwater Recharge	Direct Groundwater Recharge	OAWD
Sycamore Slough Colusa Basin Drain Multi-Benefit Recharge Project	Direct Groundwater Recharge	Landowner
Tehama-Colusa Canal Trickle Flow to Ephemeral Streams	Direct Groundwater Recharge	RD108
Enhanced Infiltration of Precipitation on Agricultural Lands	Direct Groundwater Recharge	CGA and GGA
Colusa Subbasin Flood-MAR	Direct Groundwater Recharge	CGA and GGA
Reclamation District 108 "Boards In" Program	Direct Groundwater Recharge	RD108
Colusa County Public Water System Water Treatment Plant	In-lieu Groundwater Recharge	Landowner
Glenn-Colusa Irrigation District Water Transfers to TCCA CVP Contractors	In-lieu Groundwater Recharge	GCID
Colusa Subbasin In-lieu Recharge & Banking Program	In-lieu Groundwater Recharge	South Valley Water Resources Authority
Sycamore Marsh Farm In-lieu Recharge Project	In-lieu Groundwater Recharge	Landowner
Westside Off-stream Reservoir and In-Lieu Groundwater Recharge	In-lieu Groundwater Recharge	TCCA Contractors

(a) Fourteen projects and management actions are not depicted on the map in Figure 6-9. These projects and management actions are excluded either because they will be implemented subbasin-wide or because the planning process is not far enough along to locate these projects at this time.

6.5.1.1 Glenn-Colusa Irrigation District In-lieu Groundwater Recharge

Despite GCID having highly reliable surface water supplies, a small percentage of district lands rely primarily on groundwater for irrigation supply. GCID will investigate, develop, and implement measures to incentivize associated growers to utilize surface water supplied by GCID, which will provide in-lieu recharge through reduced groundwater pumping. A summary of the project is provided in Table 6-28.

Table 6-28. Glenn-Colusa Irrigation District In-lieu Groundwater Recharge Summary

Item	Description
Implementation	GCID proposed this planned project for GSP implementation in the GCID service area. The project will provide in-lieu groundwater recharge through increased surface water utilization. This project may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the early planning stage. Thus, the start and completion dates for this project have yet to be determined and will be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing will be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The source is the Sacramento River under GCID's contractual rights according to its Sacramento River Water Right Settlement contract and under an appropriative water right for diversion and use of "winter water" from November 1 through March 31 each year. Settlement contract water supplies are subject to 25% reductions in Shasta Critical years; appropriative winter water subject to availability and curtailments according to water right Term 91.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review will be project specific and initiated through consultation with applicable governing agencies. Governing agencies for which consultation will be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. This project is currently in the early planning stage. Thus, the expected yield of this project has yet to be determined and will be reported in GSP annual reports and five-year updates when known. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.

Table 6-28. Glenn-Colusa Irrigation District In-lieu Groundwater Recharge Summary

Item	Description
Costs	This project is currently in the early planning stage. Thus, the anticipated costs of this project have yet to be determined and will be reported in GSP annual reports and five-year updates when known. The project proponent would identify funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.5.1.2 Westside Streams Diversion for Direct or In-lieu Groundwater Recharge

There are numerous ephemeral streams that originate in the Coastal Range to the west of the Subbasin and flow eastward into the Subbasin. A portion of the winter and spring flows along these many streams could be diverted for a variety of in-lieu and direct groundwater recharge efforts in the Subbasin.

An analysis was completed to evaluate the potential recharge of diversions from the six largest streams along the western side of the Subbasin: Willow Creek, Logan Creek, Hunters Creek, Funks Creek, Stone Corral Creek, and Salt Creek[11]. A map of these watersheds and streams is shown on Figure 6-10. It is noted that other streams and creeks, such as Walker Creek and Hambright Creek, also provide significant recharge benefits and offer potential recharge opportunities. However, for the purposes of this preliminary analysis, only the six streams listed above were considered based on their size and available monthly flow estimates.

All of the westside streams considered in this preliminary analysis are tributary to the Colusa Drain, which flows southward out of the Subbasin at the Colusa-Yolo County boundary. The Colusa Drain is tributary to the Sacramento River near Knights Landing in Yolo County and has an average annual discharge of 358,000 acre-feet[12], including irrigation return flows as well as westside natural streamflow.

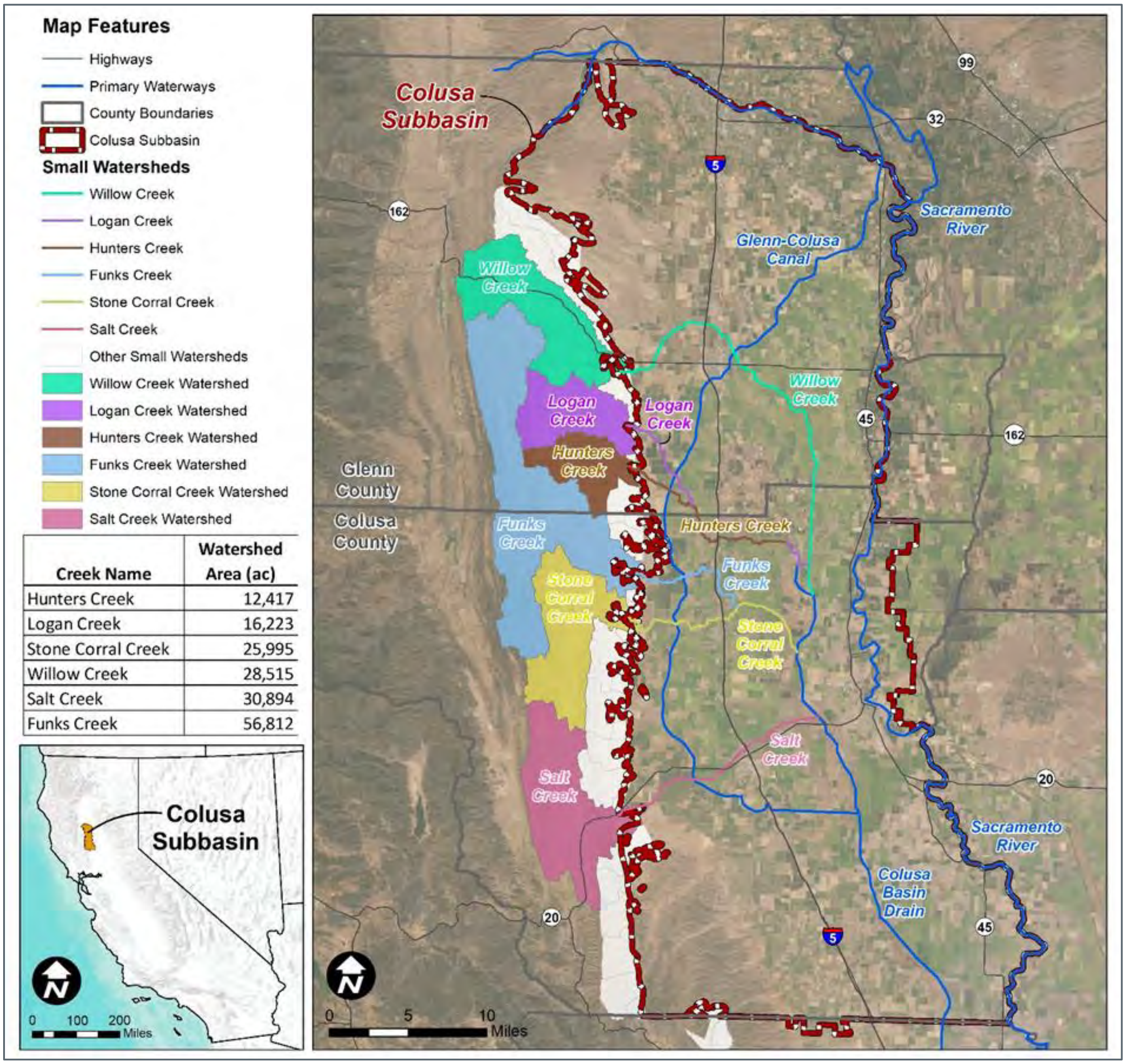
During periods of flow in the winter and spring, some portion of these flows could be diverted for either 1) off-stream storage and subsequent use for irrigation, or 2) direct groundwater recharge through Flood-MAR[13], dedicated recharge basins, or modified stream beds. A summary of the project is provided in Table 6-29.

---

[11] The location for Sites Reservoir is within the Funks and Stone Corral Creek watersheds. After construction of Sites Reservoir, flow through these creeks would primarily be inflow to Sites Reservoir and would no longer be available for downstream diversion and use within the Subbasin unless water were released into these creeks from Sites Reservoir in a pattern that matched historical flows.

[12] Average annual discharge of Colusa Drain at Knights Landing, 1986 through 2011.

[13] Flood-MAR stands for Flood-Managed Aquifer Recharge. It is a groundwater recharge strategy that takes advantage of periods of high flow to divert flood waters for aquifer recharge on agricultural lands or other working landscapes (i.e., wildlife refuges or flood bypasses).



Creek Name	Watershed Area (ac)
Hunters Creek	12,417
Logan Creek	16,223
Stone Corral Creek	25,995
Willow Creek	28,515
Salt Creek	30,894
Funks Creek	56,812

Figure 6-10. Watershed Area and Stream Path through Colusa Subbasin for the Six Largest Westside Streams

Table 6-29. Westside Streams Diversion for Direct or In-lieu Groundwater Recharge Summary

Item	Description
Implementation	This potential project is proposed by CGA and GGA and would be implemented in Colusa and Glenn Counties. The additional water diverted could be used as supplemental irrigation water to provide in-lieu recharge or be diverted to provide direct recharge through Flood-MAR, dedicated recharge basins, or modified stream beds. This project may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the early conceptual stage. Thus, the start and completion dates for this project have yet to be determined and will be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The water source would be the Westside Streams, which includes Willow Creek, Logan Creek, Hunters Creek, Funks Creek, Stone Corral Creek, Salt Creek, and potentially smaller streams. Water will only be available during periods of runoff occurring during heavy precipitation events or wet years.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review would be project specific and initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. This project is currently in the early conceptual stage. Thus, the expected yield of this project has yet to be determined and will be reported in GSP annual reports and five-year updates when known. Multi-benefits would include reduced flood impacts to the extent that diversions reduce the severity of downstream flooding. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This project is currently in the early conceptual stage. Thus, the anticipated costs of this project have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The project proponent would identify funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

A new water right (or rights) through the State Water Resources Control Board (SWRCB) would have to be obtained for this water use. While it is recognized that water rights permitting can take significant time to complete, this potential project is not intended to be implemented quickly. Thus, there is considered to be sufficient time to complete water rights permitting for this project.

New diversion, conveyance, and recharge infrastructure would also have to be constructed. This infrastructure would likely be located on private property through collaborative arrangements with landowners. Depending on the scale of implementation, this project would be expected to result in an average annual benefit ranging from roughly 1,000 af to 16,000 af for the Subbasin. The estimated costs of the project will vary depending on the scale of implementation.

This project concept has already been explored by two private landowners in the Subbasin and implemented on a small scale. One project captures storm water runoff on private lands for groundwater recharge through an underground recharge structure designed to mimic a residential septic leach field, and the other considers diversion of flood flows off of Sand Creek into an existing gravel pit (former excavation site) adjacent to the creek to facilitate direct groundwater recharge.

As described below, evaluation of this project by the CGA and/or the GGA and interested parties within the Subbasin will be done in conjunction with evaluation of the full suite of potential PMAs under consideration by the GSAs. A series of increasingly detailed studies, culminating in a feasibility study, would be required to evaluate project costs and benefits to determine whether or not to proceed with implementation. Because the outcomes of these studies are uncertain, the project implementation schedule cannot be determined at this time. Public noticing for this project as it progresses will be done in accordance with the general plan outlined in the Notice/Communication section of the GSP.

The water source would be natural flow from these six ephemeral streams (and potentially other, smaller westside streams) that flow into the Subbasin from the Coastal Range. To provide preliminary estimates, the timing and volume of these flows, expressed as an average monthly flow, were estimated using C2VSim model rainfall-runoff algorithms. The original C2VSim small watershed rootzone parameters were used in the analysis, and flows runoff from these small Coastal range watersheds into the Subbasin were extracted from the C2VSim small watershed output file. Substantial flow does not occur through these creeks in every year and depends on the seasonal timing and volume of precipitation. Based on simulated rainfall-runoff, this water source is highly variable from year to year, including years of essentially zero runoff, and from month to month within years. When flow does occur, it is typically between the months of December and June and largely occurs between January and April.

A pre-requisite for studying this project concept would be to install stream gages and conduct monitoring to gather multiple years of streamflow records, including stream discharge, water quality measurements, and sediment loads at different flows and for the rising and falling legs of runoff hydrographs. A design objective would be to divert low sediment load flows, probably on the falling leg of runoff events, to minimize the potential for clogging of recharge facilities. Water quality monitoring would also be required to evaluate flow through these streams and determine whether or not poor water quality exists and may impact beneficial uses provided through diversion for direct or in-lieu recharge.

This project would require the design and construction of new diversion and conveyance facilities, as well as either off-stream storage facilities or recharge facilities (i.e., spreading basins)[14]. Further study would

[14] In some cases, these facilities may already be in place and would only need to be repurposed to facilitate this new water use.

need to be conducted to identify estimated volumes of water available for diversion and suitable locations for diversion and recharge facilities; these analyses would result in more detailed information about size and capacity of required infrastructure improvements, construction requirements. and estimated costs.

Further investigation into this project will provide more detailed information of project costs and benefits, which, in comparison with the current and projected conditions of the Subbasin, will allow for determination of whether or not the project should be implemented, and at what scale, to contribute to sustainable operation of the Subbasin. The results of any further analysis will be reported in the annual reports. If implemented, monitoring and quantification of benefits would be accomplished by the GSAs in coordination with other stakeholders and partners.

The timing and volume of flows into the Subbasin through these six creeks have been modeled and evaluated to estimate preliminary potential project benefits. Assuming a range of maximum flow thresholds that can be diverted from each of the six streams when they are flowing, the volumes available for diversion can be calculated. These numbers are long-term annual averages; in some years, no water would be available, while in other years volumes greater than those seen in Table 6-30 would be available. These numbers only represent an initial estimate of potential project benefit volumes and require more in-depth evaluation to verify their accuracy. As shown, initial estimated volumes range from roughly 1,000 af to 16,000 af at different levels of implementation.

Table 6-30. Timing and Volume (af) of Flows into the Subbasin

Maximum Flow Threshold	Dec.	Jan.	Feb.	March	April	May	June	**Total**
Flow = 10 cfs	170	240	204	186	157	165	30	**1,153**
Flow = 20 cfs	286	589	386	523	459	324	68	**2,635**
Flow = 40 cfs	406	1,266	979	1,575	1,281	507	68	**6,082**
Flow = 60 cfs	406	1,817	1,590	2,770	1,854	628	181	**9,246**
Flow = 80 cfs	499	2,571	1,970	3,699	2,432	708	181	**12,061**
Flow = 100 cfs	615	3,462	2,467	5,252	2,961	927	181	**15,865**

Project costs will depend on the scale of implementation and other factors and will need to be estimated through further study, including an economic analysis and finance strategy designed to outline alternatives for meeting the costs for project implementation.

6.5.1.3 Sites Reservoir

The Sites Project would utilize existing infrastructure to divert unregulated and unappropriated flow from the Sacramento River at Red Bluff and Hamilton City and convey water to a new off stream reservoir west of the town of Maxwell. New and existing facilities would move water into and out of the reservoir, with ultimate release back to the Sacramento River system via existing canals and a new pipeline located near Dunnigan. The reservoir capacity would be between 1.3 maf and 1.5 maf depending on the project alternative selected. The reservoir would be operated in coordination with the State Water Project and Central Valley Project, yielding approximately 250,000 to 300,000 af in dry and critical years, and more in other year types. The managing agency is the Sites Project Authority. A summary of the project is provided in Table 6-31.

Table 6-31. Sites Reservoir Summary	
Item	Description
Implementation	The Sites Project Authority proposed this project concept which would be located in the Antelope Valley west of the Subbasin. The project may provide direct and in-lieu groundwater recharge through utilization of surface water from this project, as available. This project may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the early conceptual stage. Thus, the start and completion dates for this project have yet to be determined and would be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing will be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The source would be Sacramento River under new appropriative water rights. Settlement contract water supply is subject to 25% reductions in Shasta Critical years. New water rights would have junior priority and therefore would be subject to senior rights and water right Term 91
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review will be project specific and initiated through consultation with applicable governing agencies. Governing agencies for which consultation is being initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water (to the extent that project yield is dedicated to recharge projects). This project is currently in the early conceptual stage. Thus, the expected yield of this project for the Subbasin specifically has yet to be determined and will be reported in GSP annual reports and five-year updates when known. Evaluation of benefits is being quantified through post project monitoring. Additional benefits could include increased local, regional, and statewide water supply reliability, climate change resiliency, recreation, and increased cold water pool for endangered salmon. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	The full cost of the project is $5.2 billion. The portion of this which would be covered by Subbasin water users specifically is uncertain at this time.

6.5.1.4 Delevan Pipeline Colusa Drain Intertie

This project would construct an intertie between the proposed Delevan Pipeline component of the Sites Reservoir Project and the Colusa Drain. Currently, the only proposed intertie is the Dunnigan intertie. This intertie would provide a connection to downstream water users to utilize surface water storage from Sites

Reservoir, improve conjunctive use, and potentially decrease groundwater pumping. This intertie would also provide protection for the ecosystems upstream of the proposed Dunnigan intertie and redundancy in case the TCC becomes inoperable due to subsidence or earthquake damage. A summary of the project is provided in Table 6-32.

Table 6-32. Delevan Pipeline Colusa Drain Intertie Summary

Item	Description
Implementation	A landowner proposed this project concept, which would be located at the intersection of Colusa Drain and the proposed Delevan Pipeline. The project would provide direct and in-lieu groundwater recharge through utilization of surface water. This project may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the early conceptual stage. Thus, the start and completion dates for this project have yet to be determined and will be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The source would be Sacramento River under new appropriative water rights (conveyed to Sites Reservoir and through Delevan Pipeline). The reliability is uncertain at this time.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review would be project specific and initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. This project is currently in the early conceptual stage. Thus, the expected yield of this project has yet to be determined and will be reported in GSP annual reports and five-year updates when known. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This project is currently in the early conceptual stage. Thus, the anticipated costs of this project have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The project proponent would identify funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.5.1.5 Orland Unit Water Users Association Flood Water Conveyance

During periods of high flow and reservoir release on Stony Creek, water would be diverted at OUWUA's south diversion and conveyed to various locations for direct recharge within the OUWUA service area. Direct groundwater recharge could be conducted by OUWUA or by participating landowners and growers who have the ability to assist with groundwater recharge. Types of recharge facilities that may be used include creek beds, existing irrigation canals and laterals, agricultural fields, new, dedicated recharge basins, and, potentially, dry groundwater production wells. For example, flood water may be conveyed through existing facilities from the South Canal into the "Low Line Ditch" and Hambright Creek, or flood water may be strategically delivered to provide recharge in fields where groundwater levels have declined. Existing water rights may be used for this project, or a new water right (or rights) through the SWRCB may need to be obtained. While it is recognized that water rights permitting can take significant time to complete, this potential project is not intended to be implemented quickly. Thus, there is considered to be sufficient time to complete any necessary water rights permitting for this project. A summary of the project is provided in Table 6-33.

Table 6-33. Orland Unit Water Users Association Flood Water Conveyance Summary

Item	Description
Implementation	OUWUA proposed this potential project for GSP implementation in the OUWUA service area. The project would provide direct groundwater recharge through utilization of high flow and reservoir release on Stony Creek. This project may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the early conceptual stage. Thus, the start and completion dates for this project have yet to be determined and would be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The source would be Stony Creek flood releases that cannot be held in Stony Creek reservoirs. This would be highly variable year to year depending on hydrology.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review would be project specific and initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.

Table 6-33. Orland Unit Water Users Association Flood Water Conveyance Summary	
Item	Description
Benefits and benefit evaluation methodology	OUWUA would be responsible for operating and monitoring the project. This project is currently in the early conceptual stage. Thus, the expected yield of this project has yet to be determined and would be reported in GSP annual reports and five-year updates when known. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This project is currently in the early conceptual stage. Thus, the anticipated costs of this project have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The project proponent would identify funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.5.1.6 Orland-Artois Water District Direct Groundwater Recharge

OAWD is interested in recharging groundwater through Managed Aquifer Recharge (MAR) on agricultural land to improve aquifer conditions, especially in the groundwater cone of depression to the west of Artois. A pilot project for MAR was conducted in 2017 on the VanTol site using water from a Section 215 Temporary Water Contract from USBR. The 215 water is low-cost but is only available during high flow conditions in rivers and streams. A summary of the project is provided in Table 6-34.

Table 6-34. Orland-Artois Water District Direct Groundwater Recharge Summary	
Item	Description
Implementation	OAWD proposed this project concept for GSP implementation in the OAWD service area. The project would provide direct groundwater recharge through MAR. OAWD completed a pilot project for MAR in 2017. This project may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the early conceptual stage. Thus, the start and completion dates for this project have yet to be determined and would be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The source would be Sacramento River Section 215 water. This would be highly variable, and available only during periods of high flow in Sacramento River and tributaries.

Table 6-34. Orland-Artois Water District Direct Groundwater Recharge Summary	
Item	Description
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review would be initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. This project is currently in the early conceptual stage. Thus, the expected yield of this project has yet to be determined and would be reported in GSP annual reports and five-year updates when known. An additional benefit would be possible ponded habitat for migratory birds depending on timing of flooding. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This project is currently in the early conceptual stage. Thus, the anticipated costs of this project have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The project proponent would identify funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.5.1.7 Sycamore Slough Colusa Basin Drain Multi-Benefit Recharge Project

This project would restore portions of the Sycamore Slough through voluntary landowner participation in a multi-benefit recharge project. The recharge site will be hosted by Davis Ranches, a participating landowner within the Sycamore Mutual Water Company service. Water would be sourced from the Sacramento River during high flows in the system. The Sycamore Mutual Water Company is a Sacramento River Settlement Contractor, and could use a portion of its existing settlement contract water supplies for recharge if the project is initiated prior to November 1. If the project is initiated after November 1, water could be accessed using existing riparian water rights exercised for beneficial use (habitat). Field flooding would provide recharge, restoration, and multi-benefits such as winter floodplain habitat for migrating shorebirds/waterfowl as the field is pulse flooded, or habitat for monarch butterflies and other pollinator species. A summary of the project is provided in Table 6-35.

Table 6-35. Sycamore Slough Colusa Basin Drain Multi-Benefit Recharge Project Summary	
Item	**Description**
Implementation	This project would conduct multi-benefit groundwater recharge on fields within the Sycamore Mutual Water Company service area, restoring portions of the Sycamore Slough. This project may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the early conceptual stage. Thus, the start and completion dates for this project have yet to be determined and will be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The source would be the Sacramento River. Water could be accessed through existing riparian water rights or from existing settlement contract supplies (if the project is initiated before November 1). This source is expected to be reliable, but the precise volume of available water is unknown at this time.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review would be project specific and initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. This project is currently in the early conceptual stage. Thus, the expected yield of this project has yet to be determined and would be reported in GSP annual reports and five-year updates when known. Multi-benefits include ponded habitat for migratory birds, along with other environmental benefits. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This project is currently in the early conceptual stage. Thus, the anticipated costs of this project have yet to be determined and will be reported in GSP annual reports and five-year updates when known. The project proponent would identify funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.5.1.8 Tehama-Colusa Canal Trickle Flow to Ephemeral Streams

The TCC has existing gates that are used to dewater sections of the canal. The gates discharge into ephemeral streams that intersect the canal. Water could be discharged from the TCC into these streams at a rate where they do not flow out of the Subbasin but recharge the groundwater system. Flow measurement devices would need to be added to the gates. Surface water for recharge would be Sacramento River available water under existing Bureau of Reclamation water supply contracts held by Tehama-Colusa Canal contractors, existing water rights settlement contracts, and annual Section 215 contracts. A summary of the project is provided in Table 6-36.

Table 6-36. TCC Trickle Flow to Ephemeral Streams Summary

Implementation	RD108 proposed this project concept which would be located at TCC and ephemeral stream crossings. The project would provide direct groundwater recharge through utilization of surface water. While this project is proposed for areas along the TCC, this concept could be applied throughout the Subbasin. This project may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the early conceptual stage. Thus, the start and completion dates for this project have yet to be determined and would be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The source would be the Sacramento River (conveyed through TCC). Water could be supplied under existing Reclamation water supply contracts held by Tehama- Colusa Canal contractors, existing water rights settlement contracts, and annual Section 215 contracts. The reliability is uncertain at this time.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review would be project specific and initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. This project is currently in the early conceptual stage. Thus, the expected yield of this project has yet to be determined and would be reported in GSP annual reports and five-year updates when known. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.

Table 6-36. TCC Trickle Flow to Ephemeral Streams Summary

Item	Description
Costs	This project is currently in the early conceptual stage. Thus, the anticipated costs of this project have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The project proponent would identify funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.5.1.9 Enhanced Infiltration of Precipitation on Agricultural Lands

Current cultural practices, particularly in almond orchards, tend to reduce infiltration and increase runoff of precipitation. Development and adoption of on-farm cultural practices to reduce precipitation runoff and increase infiltration would result in increased storage of precipitation in the crop root zone, thereby reducing irrigation water requirements and groundwater pumping. Additionally, to the extent that infiltrated precipitation percolates through the root zone, this would result in increased direct groundwater recharge. The resulting in-lieu and direct recharge would benefit groundwater levels and reducing runoff could reduce soil erosion and provide water quality benefits. This project is proposed as a potential research management action; for example, a collaborative initiative between the GSAs and University of California Cooperative Extension, the Natural Resources Conservation Service, local resource conservation district, California State University Chico, or other interested organizations. A summary of the project is provided in Table 6-37.

Table 6-37. Enhanced Infiltration of Precipitation on Agricultural Lands Summary

Item	Description
Implementation	This potential project is proposed by CGA and GGA and would be implemented across the Subbasin through cooperating growers. The project would provide in-lieu groundwater recharge through storage of precipitation in the root zone, and direct groundwater recharge through increased percolation of precipitation. This project may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the early conceptual stage. Thus, the start and completion dates for this project have yet to be determined and would be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The main source of water providing additional recharge is precipitation. The reliability would be variable.

Table 6-37. Enhanced Infiltration of Precipitation on Agricultural Lands Summary	
Item	**Description**
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review would be project specific and initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. This project is currently in the early conceptual stage. Thus, the expected yield of this project has yet to be determined and would be reported in GSP annual reports and five-year updates when known. Other benefits would include reduction of soil erosion and water quality benefits.
Costs	This project is currently in the early conceptual stage. Thus, the anticipated costs of this project have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The project proponent would identify funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.5.1.10 Colusa Subbasin Flood-MAR

The CGA and GGA, in coordination with landowners and other agencies, would investigate, develop, and implement a program to divert flood waters within the Subbasin, when available, for spreading across agricultural lands or other working landscapes for direct groundwater recharge. A summary of the project is provided in Table 6-38.

Table 6-38. Colusa Subbasin Flood-MAR Summary	
Item	**Description**
Implementation	CGA and GGA proposed this project concept which would be implemented across the Subbasin with cooperating growers. The project would provide direct groundwater recharge through cooperating grower properties using flood waters when available. This project may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the early conceptual stage. Thus, the start and completion dates for this project have yet to be determined and would be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The source and reliability of flood water for recharge are to be determined.

Table 6-38. Colusa Subbasin Flood-MAR Summary	
Item	**Description**
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review would be project specific and initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. This project is currently in the early conceptual stage. Thus, the expected yield of this project has yet to be determined and would be reported in GSP annual reports and five-year updates when known. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This project is currently in the early conceptual stage. Thus, the anticipated costs of this project have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The project proponent would identify funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.5.1.11 Reclamation District 108 "Boards In" Program

RD108, in coordination with landowners, would institute a voluntary or financially incentivized program in which landowners leave their spill boards in place during the winter months to capture rainfall and hold it on their fields for recharge. The project would occur in any fields with spill boards throughout RD108, though the program concept could be expanded across the Subbasin. A summary of the project is provided in Table 6-39.

Table 6-39. Reclamation District 108 "Boards In" Program Summary	
Item	**Description**
Implementation	RD108 proposed this project, which would be implemented in coordination with landowners in fields with spill boards throughout RD108. The program concept could also be expanded Subbasin-wide. The project would institute a voluntary or financially incentivized program in which landowners leave their spill boards in place during the winter months to capture rainfall and hold it on their fields for recharge. This project is ready for implementation now, but may also be initiated, monitored, and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the conceptual stage, but could be implemented immediately. However, the precise start and completion dates for this project have yet to be determined and would be provided in GSP annual reports and five-year updates when known.

Table 6-39. Reclamation District 108 "Boards In" Program Summary

Item	Description
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings, and environmental/regulatory permitting notification.
Water source & reliability	This project relies on precipitation, not on water sources outside the Subbasin.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review would be project specific and initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. This project is currently in the conceptual stage. Assuming that approximately 20% of rice fields in RD108 participate each year, the estimated average annual recharge benefit of the project over the 2022 to 2065 period is approximately 1.8 taf/yr. The actual yield of this project would be reported in GSP annual reports and five-year updates when known. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This project is currently in the conceptual stage. Thus, the anticipated costs of this project, if any, have yet to be determined and would be reported in GSP annual reports and five-year updates when known. It is anticipated that the project will have no costs if implemented as a voluntary program. The project proponent would identify funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.5.1.12 Colusa County Public Water System Water Treatment Plant

This project would construct a water treatment plant on the Sacramento River between the Cities of Colusa and Grimes to provide treated surface water to public water supply systems in Colusa and possibly Sutter and Yolo Counties. A summary of the project is provided in Table 6-40.

Table 6-40. Colusa County Public Water System Water Treatment Plant Summary

Item	Description
Implementation	A landowner proposed this potential project which would be implemented in Colusa County. By increasing the surface water available for drinking water supply this project would provide in-lieu groundwater recharge. This project may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the early conceptual stage. Thus, the start and completion dates for this project have yet to be determined and will be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The water source would be the Sacramento River under new appropriative water rights. The reliability is uncertain at this time.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review would be project specific and initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. This project is currently in the early conceptual stage. Thus, the expected yield of this project has yet to be determined and would be reported in GSP annual reports and five-year updates when known. Other benefits would be improved drinking water quality, and less threat to 1) Arbuckle and Dunnigan facing loss of well supply, 2) Grimes and Princeton's drinking well arsenic contamination, and 3) Williams' elevated salinity (TDS) levels. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This project is currently in the early conceptual stage. Thus, the anticipated costs of this project have yet to be determined and will be reported in GSP annual reports and five-year updates when known. The project proponent would identify funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.5.1.13 Glenn-Colusa Irrigation District Water Transfers to TCCA CVP Contractors

GCID is exploring the possibility of transferring surface water to Central Valley Project (CVP) contractors served by the TCC to provide in-lieu groundwater recharge and reduce groundwater pumping. The water to be transferred would be Sacramento River water available to GCID under its water rights settlement contract that is temporarily surplus to GCID's needs under certain conditions. Transferred water would be diverted into the Tehama-Colusa Canal at the Red Bluff Pumping Plant and Fish Screen facility rather than at the GCID pumping plant and fish screen facility north of Hamilton City. Priority would be placed on transfers to CVP contractors in areas where groundwater levels have been declining over the past approximately 20 years, particularly in the areas around the cities of Orland and Arbuckle. A summary of the project is provided in Table 6-41.

Table 6-41. Glenn-Colusa Irrigation District Water Transfers to TCCA CVP Contractors Summary

Item	Description
Implementation	GCID proposed this potential project for GSP implementation with participating TCCA CVP contractors. The project would provide in-lieu groundwater recharge through increased CVP water utilization. This project may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the early conceptual stage. Thus, the start and completion dates for this project have yet to be determined and would be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The source would be the Sacramento River under GCID's existing contractual rights according to its Sacramento River Water Right Settlement contract. Settlement contract water supplies are subject to 25 percent reductions in Shasta Critical years.
Legal authority, permitting processes, and regulatory control	GSAs, Districts and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review would be project specific and initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. This project is currently in the early conceptual stage. Thus, the expected yield of this project has yet to be determined and would be reported in GSP annual reports and five-year updates when known. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. These analyses may include: flow measurement consistent with SBx7-7 (23 CCR §931-938), ET analysis, reductions in GW use, well monitoring, determination of infiltration rates, water balance analysis, as-built drawings and stream gaging. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.

Table 6-41. Glenn-Colusa Irrigation District Water Transfers to TCCA CVP Contractors Summary	
Item	**Description**
Costs	This project is currently in the early conceptual stage. Thus, the anticipated costs of this project have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The project proponent would identify funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.5.1.14 Colusa Subbasin In-Lieu Recharge & Banking Program

The project would incentivize landowners to take surplus contract surface water in-lieu of pumping groundwater by providing financial incentives (subsidizing surface water costs) to make surface water less expensive than groundwater. If needed, South Valley would subsidize the cost of new distribution systems to facilitate the delivery of additional surface water or provide funds to districts to implement other programs. The magnitude of such payments would depend on the size of the banking project but could exceed $100,000 per year per district. A predetermined portion of the additional water brought into the districts would be dedicated to contributing to local groundwater sustainability and some portion of the remaining quantities would be available for delivery, directly or by exchange, to South Valley members in the San Joaquin Valley. Additional groundwater production wells may need to be constructed to enable recovery of banked water. Such facilities would be paid for by South Valley but located and constructed in coordination with local districts. A summary of the project is provided in Table 6-42.

Table 6-42. Colusa Subbasin In-Lieu Recharge & Banking Program Summary	
Item	**Description**
Implementation	The South Valley Water Resources Authority proposed this project concept which would be located within the districts who participate. The project would provide direct and in-lieu groundwater recharge through utilization of surface water from this project, as available. This project may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the early conceptual stage. Thus, the start and completion dates for this project have yet to be determined and would be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	To be determined.

Table 6-42. Colusa Subbasin In-Lieu Recharge & Banking Program Summary	
Item	Description
Legal authority, permitting processes, and regulatory control	GSAs, Districts and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review would be project specific and initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, depletion of interconnected surface water, land subsidence, and potentially groundwater quality. This project is currently in the early conceptual stage. Thus, the expected yield of this project has yet to be determined and would be reported in GSP annual reports and five-year updates when known. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This project is currently in the early conceptual stage. Thus, the anticipated costs of this project have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The project proponent would identify funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.5.1.15 Sycamore Marsh Farm In-Lieu Recharge Project

Sycamore Marsh Farm is in the process of developing an in-lieu groundwater recharge plan. Sycamore Marsh Farm encompasses approximately 420 acres in the Colusa Drain Mutual Water Company (CDMWC) and has an additional 449 acres that could potentially be annexed into the CDMWC, allowing for diversion of surface water from CDMWC. A summary of the project is provided in Table 6-43.

Table 6-43. Sycamore Marsh Farm In-Lieu Recharge Project Summary	
Item	Description
Implementation	The landowner proposed this project concept for GSP implementation which would be located on their property. The project would provide in-lieu groundwater recharge through annexation into CDMWC. This project may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the early conceptual stage. Thus, the start and completion dates for this project have yet to be determined and would be provided in GSP annual reports and five-year updates when known.

Table 6-43. Sycamore Marsh Farm In-Lieu Recharge Project Summary

Item	Description
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The source for this project would be the Colusa Drain. The reliability is still to be determined.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review would be initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, depletion of interconnected surface water, land subsidence, and potentially groundwater quality. This project is currently in the early conceptual stage. Thus, the expected yield of this project has yet to be determined and would be reported in GSP annual reports and five-year updates when known. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This project is currently in the early conceptual stage. Thus, the anticipated costs of this project have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The project proponent would identify funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.5.1.16 Westside Off-stream Reservoir and In-Lieu Groundwater Recharge

TCCA Contractors would construct off-stream surface reservoirs along the western edge of the Subbasin and up-slope from the TCC. They would divert surplus Sacramento River flows (e.g., Section 215 water) at the Red Bluff Pumping Plant and Fish Screen, and convey water through the TCC and pump water up into storage reservoir(s). Stored water would be released into the TCC for irrigation supply to enable reduction of groundwater pumping (i.e., in-lieu groundwater recharge). New pumping plants on the TCC and new storage impoundments would need to be planned, designed, and constructed subject to a determination of economic and environmental feasibility. A summary of the project is provided in Table 6-44.

Table 6-44. Westside Off-stream Reservoir and In-Lieu Groundwater Recharge Summary

Item	Description
Implementation	TCCA Contractors proposed this project concept for GSP implementation which would be located on the western edge of the Subbasin. The project would provide in-lieu groundwater recharge through increased storage of surface water. This project may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the early conceptual stage. Thus, the start and completion dates for this project have yet to be determined and would be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	The source for this project would be Sacramento River Section 215 water. The reliability is highly variable; available only during periods of high flow in the Sacramento River and tributaries.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review would be initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. This project is currently in the early conceptual stage. Thus, the expected yield of this project has yet to be determined and would be reported in GSP annual reports and five-year updates when known. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This project is currently in the early conceptual stage. Thus, the anticipated costs of this project have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The project proponent would identify funding sources to cover project costs as part of project development. These may include grants, fees, loans, and other assessments.

6.5.2 Potential Management Actions

This section describes potential management actions that would be implemented if determined to be necessary under future monitoring of the Subbasin. Table 6-45 summarizes the potential management actions included in the GSP. The following subsections provide descriptions for each management action.

Table 6-45. Summary of Potential Management Actions

Management Action[a]	Management Action Type	Proponent
Domestic Well Mitigation Program	Management Action	CGA and GGA
Drought Contingency Planning for Urban Areas	Management Action	CGA, GGA, and cities (GSA member agencies)
Long-Term Demand Management Action	Management Action	CGA and GGA
Strategic Short-Term Demand Management	Management Action	CGA and GGA
Well Abandonment Outreach and Funding Program	Management Action	CGA and GGA
Preservation of Lands Favorable for Recharge	Management Action	CGA and GGA
Review of County Well Permitting Ordinances	Management Action	CGA and GGA
Reduce Non-beneficial Evapotranspiration/Invasive Species Eradication	Reduce Groundwater Demand	CGA and GGA
Development of a Dedicated Network of Shallow Monitoring Wells for GDE Monitoring	Management Action, Closing Data Gaps	CGA and GGA

(a) Fourteen projects and management actions are not depicted on the map in Figure 6-9. These projects and management actions are excluded either because they will be implemented subbasin-wide or because the planning process is not far enough along to locate these projects at this time.

6.5.2.1 Domestic Well Mitigation Program

Groundwater level measurable objectives (MOs) adopted for sustainable management of the Subbasin operation are based on the most recent five years of measured water levels in each representative monitoring well (generally 2015 through 2020 with some exceptions), and therefore should be highly protective of domestic water supply wells. However, it is possible that in certain portions of the Subbasin groundwater levels will fall below the adopted MOs and approach the adopted minimum thresholds (MTs) as projects and management actions are being implemented for recovery of groundwater levels. As a consequence, it is possible that that some domestic wells will go dry in the future.

To mitigate the effects of domestic well stranding due to groundwater level decline, the CGA and GGA will investigate implementing domestic well mitigation programs in their respective portions of the Subbasin. These programs may consider supporting consolidation of smaller public water systems and expansion of larger public water systems to cover domestic users that may see impacts to their existing wells. The exact details of the potential domestic well mitigation programs have yet to be determined, but will be reported in GSP annual reports and five-year updates when known. Outreach to domestic well users, including those in DACs, SDACs, and EDAs, will occur throughout program development and implementation using the communication pathways identified in Chapter 2 and in Table 6-46. Outreach will be conducted to ensure that the interests and feedback of domestic well users are known and considered throughout the development and implementation of these programs.

Program development would involve establishing a funding mechanism to accumulate mitigation funds, establishing a process and criteria for determining when dewatered wells are eligible for mitigation funding, and establishing criteria for scaling mitigation payments (for example, relatively new dewatered wells might qualify for more funding than old wells). Possible mechanisms that could be used to generate well mitigation funds include a groundwater extraction fee (which would require flow measurement at each well) and a per well assessment (which would not require measurement). A summary of the program is provided in Table 6-46.

Table 6-46. Domestic Well Mitigation Program Summary

Item	Description
Implementation	CGA and GGA proposed this potential management action for GSP implementation which would occur across the Subbasin. The action would respond to potentially changing conditions in the Subbasin and would be implemented as needed if groundwater levels fall. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This action is currently in the early conceptual stage. Thus, the start and completion dates have yet to be determined and would be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	Not applicable for this demand management action.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual proponents have the authority to plan and implement management actions. Required permitting and regulatory review would be initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit is groundwater levels, as this management action would alleviate problems associated with potential changes in conditions. The expected yield of this management action is not quantified as it is proposed for responding to changing conditions. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This management action is currently in the early conceptual stage. Thus, the anticipated costs have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The proponent would identify funding sources to cover costs as part of development of this management action. These may include grants, fees, loans, and other assessments.

6.5.2.2 Drought Contingency Planning for Urban Areas

The CGA and GGA will coordinate with cities, towns, and other municipal and industrial water suppliers, which are all fully dependent on groundwater in the Subbasin, to encourage drought contingency planning and drought preparedness in a manner consistent with sustainable groundwater management according the GSP. A summary of the management action is provided in Table 6-47.

Table 6-47. Drought Contingency Planning for Urban Areas Summary

Item	Description
Implementation	CGA, GGA, and cities (GSA member agencies) proposed this potential management action for GSP implementation which would occur across the Subbasin. The action would reduce the demand for groundwater pumping. This action may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This action is currently in the early conceptual stage. Thus, the start and completion dates have yet to be determined and will be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	Not applicable for this management action.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement management actions. Required permitting and regulatory review would be initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The sustainability indicators expected to benefit are groundwater levels, groundwater storage, and depletions of interconnected surface water. This management action is currently in the early conceptual stage. Thus, the expected yield has yet to be determined and would be reported in GSP annual reports and five-year updates when known. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This management action is currently in the early conceptual stage. Thus, the anticipated costs have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The proponent would identify funding sources to cover costs as part of development of this management action. These may include grants, fees, loans, and other assessments.

6.5.2.3 Long-Term Demand Management Action

The planned PMAs described in this chapter will be pursued by the Colusa Subbasin GSAs to achieve and maintain sustainable groundwater conditions. The GSAs have also included a potential demand management program as a "backstop" to other PMAs. Events that may trigger this management action include, but are not limited to: severe, prolonged drought conditions result in groundwater levels approaching MT in specific parts of the Subbasin; other PMAs are not achieving the expected level of benefits; or new information about projected future conditions show that sustainability objectives will not be met. This section describes the demand management action.

Demand management broadly refers to any water management activity that reduces the consumptive use of irrigation water. To be effective for purposes of sustainable groundwater management, demand management must result in a reduction in net groundwater pumping (pumping net of recharge). That is, it must reduce consumptive use or irrecoverable losses into a saline water body. Activities that, for example, reduce canal seepage or reduce deep percolation from irrigation will not be effective. They may decrease quantity of water diverted or applied but they also reduce recharge to usable groundwater, so do not improve the net pumping from the aquifer.

For purposes here, a demand management action is one that incentivizes, enables, or requires water users to reduce their consumptive use, but does not dictate exactly how users have to do it. Users can respond to demand management by changing to lower water-using crops, water-stressing crops (providing less water than the crop would normally consume for full yield), reducing evaporation losses, and reducing irrigated acreage.

The following types of demand management activities are included under this management action:

- **Allocation**. Under an allocation, the different sources of groundwater are quantified and allocated to individual parcels, wells, or entities (such as, for example, farming operations). Sources of groundwater that can be included in the allocation can include the sustainable yield, natural recharge, imported water recharge, new developed recharge sources, and, for a limited period of time, overdraft (sometimes called "transitional water"). By defining the quantities of groundwater available to individuals this can incentivize reductions in use and development of new recharge opportunities. Allocation design may include specific considerations for managed wetlands and other habitat uses of water.

  Implementing an allocation does not necessarily result in reducing groundwater use. For example, if the allocation is greater than historical use this would not be a constraint for groundwater users and would not result in less consumptive groundwater use. In the context of GSP implementation, the allocation is typically tied to the sustainable yield of the Subbasin. When the sustainable yield (including yield of other PMAs like recharge projects) is less than current pumping, the effect of an allocation is an overall reduction in net groundwater use.

  An allocation is a rigid method for implementing demand management. It effectively limits water use on a well, parcel, or operation basis. This could require idling land or switching crop on lands that have insufficient allocation to meet crop demand, which imposes costs on water users (e.g., growers). There are ways to increase the flexibility of allocations to reduce the costs of demand management. For example, the allocation could be defined as an average over a period of time rather than a fixed amount every year, or users could be allowed to carry over unused allocation into the next year.

- **Allocation + Water Market**. An allocation that is less than historical water use can be coupled with a water market. A groundwater market is another way to increase the flexibility of an allocation to reduce costs of demand management. A market is an institution that allows willing buyers and sellers to exchange groundwater allocation ("credits"). The market allows groundwater users to shift allocation to higher-valued uses. Defining an allocation across an entire farming operation establishes a kind of market in which the owner or manager moves water to produce the highest return (e.g., remove an older block of an orchard and use the allocation to meet crop demand on a more productive block). More broadly, a market allows a means to exchange allocation with another groundwater user, whether for a single season or using a multi-year trade. Willing sellers trade a part of their allocation to willing buyers in exchange for a payment that the seller expects will exceed the return he/she would have earned from using the water for irrigation. This additional flexibility reduces the cost to the GSA's users of achieving demand reduction under an allocation.

  Development of a water market institution is a complex process that encompasses more than defining the groundwater allocation. The water market requires an administrator (e.g., the GSA or a third party) and methods for monitoring, enforcement, and accounting of groundwater use. It also requires development of market rules that determine what sources of the allocation are tradeable, under what conditions, and over what periods of time. For example, market rules would consider, and possibly limit, the potential impacts of local concentrations of groundwater pumping if trades occur within specific areas. Other market rules might consider habitat and ecosystem service benefits. Finally, the water market requires a marketplace for buyers and sellers to post bids, review prices, and execute deals. The GSAs would consider these factors in the future if a groundwater market is considered.

- **Land Repurposing**. Land repurposing programs are more targeted than an allocation or market program but maintain flexibility for participants by its voluntary nature. Such a program would provide a financial incentive to willing participants for their currently irrigated lands to be repurposed into other, non-irrigated uses. Programs can focus on short-term drought conditions, or they can provide multi-year reductions in demand if that is needed under some conditions. For longer-term programs, lands can be repurposed to achieve other multi-benefit objectives - for example, to create habitat corridors or to support local endangered species[15].

  Land repurposing programs typically include incentives to stop irrigating. These incentives need, at minimum, to exceed the return to farming on a parcel. An additional incentive may be provided to convert land into an alternative use. For example, the United States Department of Food and Agriculture (USDA) Conservation Reserve Enhancement Program (CREP[16]) will pay lands to forgo irrigation and offer an additional per acre payment to convert lands into different types of habitats. Other land repurposing program considerations might consider strategic location of repurposed lands considering proximity to protected areas (e.g., National Wildlife Refuges).

[15] See, for example: Environmental Defense Fund, Strategic Land Repurposing. The Nature Conservancy, Rewilding Agricultural Lands.

[16] Note that CREP is state-specific and is not currently being implemented in California.

- **Other financial incentives**. Demand management can also be achieved through a range of other financial incentives. This could include positive financial incentives to reduce consumptive groundwater use. It could also include groundwater extraction fees that disincentivize groundwater use. Financial incentives could consider public benefits (e.g., habitat) separately from private benefits (e.g., irrigation) of water use.

  As described above, the demand management action could be triggered if required under future monitoring by the GSAs. The following principles would guide development of the demand management program; these are in no order of preference and the GSAs recognize that tradeoffs exist among these principles:

  — Minimize the economic impacts of any demand management

  — Maintain established water rights

  — Incentivize investment in water supply infrastructure

  — Incentivize economically efficient water use

  — Complement other PMAs such as direct and in-lieu recharge projects in aggregate, and in specific regions

  — Allow sufficient program flexibility for groundwater pumpers to adjust over time

  — Ensure access for domestic water users (de minimis domestic use as defined by SGMA is less than 2 af annually per user for domestic purposes only)

This potential management action will be evaluated further in GSP annual reports and five-year updates, as required by conditions in the Subbasin. Appendix 6B summarizes the economic value of irrigated agriculture to the Subbasin and quantifies the direct economic costs of demand management. Table 6-48 summarizes GSP regulation requirements and describes how the management action meets those requirements.

Table 6-48. Long-Term Demand Management Action Summary

Item	Description
Implementation	CGA and GGA proposed this management action for GSP implementation, but it would only be implemented if groundwater conditions in the Subbasin, or specific areas of the Subbasin, require it. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This action is currently in the early conceptual stage. Thus, the start and completion dates have yet to be determined and would be provided in GSP annual reports and five-year updates when known, and only if the management action is triggered for implementation.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	Not applicable for this demand management action.

Table 6-48. Long-Term Demand Management Action Summary	
Item	**Description**
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement management actions. Required permitting and regulatory review would be initiated through consultation with applicable governing agencies. This would likely include local county agencies, as appropriate.
Benefits and benefit evaluation methodology	The measurable objective expected to benefit is groundwater levels, as this management action would reduce net pumping to achieve sustainability conditions in specific areas. The expected yield of this management action is not quantified because: 1) it will only be triggered if necessary, and 2) the scale of the demand management program is flexible. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This management action is currently in the early conceptual stage. Thus, the anticipated costs have yet to be determined and would be reported in GSP annual reports and five-year updates when known, and only if the management action is triggered for implementation. The proponent would identify funding sources to cover costs as part of development of this management action. These may include grants, fees, loans, and other assessments.

6.5.2.4 Strategic Temporary Land Idling for Drought and Localized Short-Term Groundwater Management

The Colusa Subbasin GSP identified potential areas of concern in the Subbasin where groundwater levels have declined significantly over recent years due to disproportionate reliance on groundwater to meet crop irrigation demands. Planning and constructing projects (e.g., conveyance or recharge) to offset short-run impacts of drought and local groundwater level impacts would take time and require substantial capital costs. This program is a potential management action that would provide the GSAs with a voluntary, flexible, short-run response to alleviate impacts in local areas of concern.

The program would be focused on specific drought-affected areas with sustainability challenges. It would be voluntary and provide financial incentives (payments) to encourage participation. Payment terms and other conditions would be specified as part of program design. Two potential structures for the program are: 1) participating groundwater-using lands in drought-affected areas in the Subbasin would be idled and the quantified groundwater saved would be left in the ground to alleviate sustainability challenges, or 2) participating surface water-using lands anywhere in the Subbasin would be idled, and the saved surface water would be conveyed to replace groundwater pumping in other areas of the Subbasin with groundwater sustainability challenges.

Appendix 6B summarizes the economic value of irrigated agriculture to the Subbasin and quantifies the direct economic costs of demand management in the potential areas of concern. A summary of the management action is provided in Table 6-49.

Table 6-49. Strategic Temporary Land Idling for Drought and Localized Short-Term Groundwater Management Summary

Item	Description
Implementation	CGA and GGA proposed this management action concept for GSP implementation which would occur across the Subbasin. The action would reduce the demand for groundwater pumping. This action may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This action is currently in the early conceptual stage. Thus, the start and completion dates have yet to be determined and would be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	Not applicable for this demand management action.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual proponents have the authority to plan and implement management actions. Required permitting and regulatory review would be initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The measurable objectives expected to benefit are groundwater levels, groundwater storage, and depletions of interconnected surface water in areas with potential sustainability challenges. The expected yield of this management action will depend on the level of participation and water needs. There is also potential for multi-benefits on temporarily idled lands, depending on program design.
Costs	This management action is currently in the early conceptual stage. Thus, the anticipated costs have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The proponent would identify funding sources to cover costs as part of development of this management action. These may include grants, fees, loans, and other assessments.

6.5.2.5 Well Abandonment Outreach and Funding Program

The CGA and GGA will coordinate with Colusa and Glenn counties, respectively, to create a program providing outreach and education to landowners regarding the proper procedures for well decommissioning and abandonment, as well as a funding source to assist landowners with these procedures. This effort would be accomplished through coordination between the GSAs and well permitting agencies. This program is anticipated to improve the Subbasin well inventory and potentially have water quality benefits, as improperly abandoned wells are a potential point source for water quality contaminant transport from the ground surface to the underlying groundwater system. A summary of the management action is provided in Table 6-50.

Table 6-50. Well Abandonment Outreach and Funding Program Summary	
Item	**Description**
Implementation	CGA and GGA proposed this management action concept for GSP implementation which would occur across the Subbasin. The action would respond to potentially changing conditions in the Subbasin and would be implemented as needed based on the number of wells abandoned and water quality concerns. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This action is currently in the early conceptual stage. Thus, the start and completion dates have yet to be determined and would be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	Not applicable for this management action.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement management actions. Required permitting and regulatory review would be initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The measurable objective expected to benefit is water quality. The expected yield of this management action is not quantified as it is proposed for responding to changing conditions. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This management action is currently in the early conceptual stage. Thus, the anticipated costs have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The proponent would identify funding sources to cover costs as part of development of this management action. These may include grants, fees, loans, and other assessments.

6.5.2.6 Preservation of Lands Favorable for Recharge

The CGA and GGA will coordinate with those agencies having authority over land use planning in Colusa and Glenn counties, respectively, to investigate, design, and implement a program providing incentives to landowners with lands favorable to groundwater recharge to preserve them as agricultural or undeveloped lands on which groundwater recharge will be possible in perpetuity. An update of ongoing coordination will appear in annual reports. A summary of the management action is provided in Table 6-51.

Table 6-51. Preservation of Lands Favorable for Recharge Summary

Item	Description
Implementation	CGA and GGA proposed this management action concept for GSP implementation which would occur across the Subbasin. The action could help create additional direct groundwater recharge in the future. This action may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This action is currently in the early conceptual stage. Thus, the start and completion dates have yet to be determined and would be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	Not applicable for this management action.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement management actions. Required permitting and regulatory review would be initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The measurable objectives expected to benefit are groundwater levels, groundwater storage, and depletions of interconnected surface water. This management action is currently in the early conceptual stage. Thus, the expected yield has yet to be determined and would be reported in GSP annual reports and five-year updates when known. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This management action is currently in the early conceptual stage. Thus, the anticipated costs have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The proponent would identify funding sources to cover costs as part of development of this management action. These may include grants, fees, loans, and other assessments.

6.5.2.7 Review of County Well Permitting Ordinances

Modification to well regulations is one potential mechanism to ensure that groundwater sustainability is achieved and maintained in the Subbasin. Well permitting regulations can help avoid adverse impacts on groundwater beneficial users by reducing the potential for mutual well interference or streamflow depletion through limitations on well screen depths, well spacing, and/or setbacks.

This management action would review and suggest potential revisions to the county well permitting processes in the Subbasin to ensure that:

- Future well permitting aligns with the subbasin sustainability goal
- Future changes to well permitting are reviewed by the GSAs

Through this management action, the Counties and GSAs would coordinate to establish processes whereby the GSAs would review and agree upon future changes to well permitting requirements. This coordination could occur through the potential framework for coordination between the Counties and GSAs that is described in Chapter 7, Plan Implementation. The Counties would also review existing well permitting processes and assess whether additional well permitting requirements are warranted to maintain sustainable groundwater conditions in the Subbasin. Existing well regulations may be modified to help protect water quality, allow for appropriate screening, require depths be deeper than MTs, and avoid interference or impacts of pumping on neighboring wells. Efforts may also be designed to be protective of domestic wells.

A summary of the management action is provided in Table 6-52.

Table 6-52. Review of County Well Permitting Ordinances Summary

Item	Description
Implementation	This management action would review and suggest potential revisions to the county well permitting processes in the Subbasin to ensure that future well permitting aligns with the Subbasin sustainability goal and that future changes to well permitting are reviewed by the GSAs. This action may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This action is currently in the early conceptual stage. Thus, the start and completion dates have yet to be determined and would be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	Not applicable for this management action.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement management actions, and Counties have the authority to review and modify county well permitting ordinances. Required permitting and regulatory review would be initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.

Table 6-52. Review of County Well Permitting Ordinances Summary	
Item	**Description**
Benefits and benefit evaluation methodology	All sustainability indicators may benefit from changes in groundwater pumping that result from revisions to county well permitting ordinances. This management action is currently in the early conceptual stage. Thus, the expected yield has yet to be determined and would be reported in GSP annual reports and five-year updates when known. Evaluation of benefits will be based on analysis of pre- and post-project measurements supported by modeling. Measured parameters will include surface water deliveries, groundwater levels, and others to be determined. Modeling will be done with the C2VSimFG-Colusa model used for GSP development.
Costs	This management action is currently in the early conceptual stage. Thus, the anticipated costs have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The proponent would identify funding sources to cover costs as part of development of this management action. These may include grants, fees, loans, and other assessments.

6.5.2.8 Reduce Non-beneficial Evapotranspiration

This project would remove the invasive, non-native plant species (i.e., Arundo donax, eucalyptus, tamarisk, etc.) from riparian corridors and other areas they may be present. This would provide both a reduction in evapotranspiration from shallow groundwater and native ecosystem restoration. A summary of the management action is provided in Table 6-53.

Table 6-53. Reduce Non-beneficial Evapotranspiration Summary	
Item	**Description**
Implementation	This potential project is proposed by CGA and GGA and would be implemented across the Subbasin. This action could be done in coordination with neighboring GSAs, especially along Stony Creek. The project would reduce groundwater demand by reducing evapotranspiration. This action may be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, if sustainable levels are not reached following implementation of other projects and management actions. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This project is currently in the early conceptual stage. Thus, the start and completion dates for this project have yet to be determined and would be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	Not applicable.

Table 6-53. Reduce Non-beneficial Evapotranspiration Summary

Item	Description
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review would be project specific and initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The measurable objectives expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. This project is currently in the early conceptual stage. Thus, the expected yield of this project has yet to be determined and would be reported in GSP annual reports and five-year updates when known. Other benefits would include decreased ET, increased native vegetation and habitat, and decreased sediment trapping.
Costs	This project is currently in the early conceptual stage. Thus, the anticipated costs of this project have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The proponent would identify funding sources to cover costs as part of development of this management action. These may include grants, fees, loans, and other assessments.

6.5.2.9 Development of a Dedicated Network of Shallow Monitoring Wells for GDE Monitoring

This action would evaluate and develop a dedicated network of shallow monitoring wells specifically planned and sited for monitoring conditions in areas of the Subbasin where GDEs are most likely to be found. Although the GSAs used the best available scientific data and information to assess potential GDEs within the Subbasin during GSP development, significant data gaps exist in the understanding of GDEs and associated species in those GDEs. This action would be developed to close those data gaps, prioritizing installation of new monitoring sites in locations where the GSAs determine that GDEs are most likely to be found. It is expected that this action would also incorporate biological monitoring to collect biological data (e.g., biological surveys, remote sensing indexes, and/or assessment of vegetation rooting depth information). This data would be used to inform the location of new shallow monitoring wells and monitor whether GDEs are being impacted by changing groundwater conditions. A summary of the management action is provided in Table 6-54.

Table 6-54. Development of a Dedicated Network of Shallow Monitoring Wells for GDE Monitoring Summary

Item	Description
Implementation	This potential action is proposed by CGA and GGA and would be implemented across the Subbasin, focusing on areas determined during GSP development as most likely to be a GDE, and areas where GDE-related data gaps exist. This action could be done in coordination with neighboring GSAs and agencies, especially along Stony Creek and the Sacramento River. The action would evaluate and develop a dedicated network of shallow monitoring wells specifically planned and sited for monitoring conditions in areas of the Subbasin where GDEs are most likely to be found. This action is expected to be implemented and would be monitored and quantified with respect to groundwater conditions, as needed, during GSP implementation in order to close data gaps related to GDEs. This will be done in the context of Sustainable Management Criteria defined in Chapter 5 to ensure sustainable operation of the Subbasin.
Timeline	This action is currently in the early conceptual stage. Thus, the start and completion dates for this action have yet to be determined and would be provided in GSP annual reports and five-year updates when known.
Notice to public and other agencies	Public and/or Inter-Agency Noticing would be facilitated through GSA board meetings, GSA and/or cooperating agency website(s), GSA newsletter, member agency newsletter, inter-basin coordination meetings, member agency governing body public meetings, GSP annual report(s), public scoping meetings and environmental/regulatory permitting notification.
Water source & reliability	Not applicable.
Legal authority, permitting processes, and regulatory control	GSAs, Districts, and individual project proponents have the authority to plan and implement projects. Required permitting and regulatory review would be project specific and initiated through consultation with applicable governing agencies. Governing agencies for which consultation would be initiated may include, but is not limited to: DWR, SWRCB, CDFW, Flood Board, Regional Water Boards, USFWS, NMFS, LAFCO, County of Colusa and/or Glenn and CARB.
Benefits and benefit evaluation methodology	The measurable objectives expected to benefit are groundwater levels, groundwater storage, and depletion of interconnected surface water. This action is currently in the early conceptual stage. Thus, the expected yield of this action has yet to be determined and would be reported in GSP annual reports and five-year updates when known.
Costs	This action is currently in the early conceptual stage. Thus, the anticipated costs of this action have yet to be determined and would be reported in GSP annual reports and five-year updates when known. The proponent would identify funding sources to cover costs as part of development of this action. These may include grants, fees, loans, and other assessments.

CHAPTER 7
Plan Implementation

This chapter outlines the schedule and costs to implement the GSP over the first five years (through 2026) and describes implementation activities in accordance with §354.8(f)(3). Implementation of the GSP in the Subbasin will include GSA administrative requirements, periodic reporting required under 23 CCR §356.2 and §356.4, and studies to address data gaps and support implementation. In addition, to address possible future changes in the Subbasin conditions that could cause undesirable results over the long term, and in the near term, to address effects of recent historical (2014 to 2015) and current (2020 to 2021) drought conditions, a range of planned projects and management actions (planned PMAs) has been developed and will be implemented by the GSAs, as described in Chapter 6.

In accordance with 23 CCR §354.6(e), GSP implementation costs are estimated and described. Estimated costs are shown for the first five years of GSP implementation and any resulting changes from that set-forth herein will be reported in annual reports. Costs are split into the following two aggregate categories (which are further disaggregated in the subsequent subsections):

- **GSA Costs**. GSA costs are for activities related to GSP implementation that are (generally) not specific to a specific area or water district in the Subbasin. For example, this includes GSA administration costs for coordination, meetings, outreach, legal, and other general administrative requirements to support GSP implementation.
- **PMA Costs**. PMA costs are specific to PMAs that were described in Chapter 6 of this GSP. These costs may be covered by individual project proponents, the GSA more broadly, or be split between multiple entities. As such, they are reported separately from GSA costs.

The following GSP elements are described in this chapter:

- Costs for GSAs to administer GSP activities as required by 23 CCR §354.6(e)
- PMA-specific costs are summarized to illustrate the total cost of GSP implementation; however, PMAs are described in more detail (e.g., benefit, capital, and operating costs) in Chapter 6: Projects and Management Actions
- Financing approaches / funding mechanisms
- Timeline and roadmap for implementing all GSA projects and management actions between 2022 and 2042
- Implementation of additional actions to achieve Subbasin sustainability goals (Data Management System [DMS], monitoring wells, water model updates, etc.)
- Monitoring and reporting, including the contents of annual reports and five-year periodic evaluations that must be provided to the Department of Water Resources (DWR) (23 CCR §356.2 and §356.4)
- The Colusa Subbasin DMS

This chapter is structured as follows. The following section describes the different activities and costs that GSAs are estimated to incur for GSP implementation. This is followed by a summary of those costs and approximate breakdown by the two GSAs in the Subbasin. Section 7.3 summarizes costs for PMAs using the information presented in Chapter 6. Only planned PMAs are included in the GSP implementation cost estimates because these are the PMAs (in accordance with 23 CCR §354.44(a)) that would allow the GSAs to achieve the sustainability goal for the Subbasin and avoid reaching the minimum thresholds defined in this GSP under future, changing conditions. Section 7.4 summarizes all GSA and PMA costs, expressed on an annual basis, which represents the estimated total cost of GSP implementation. Section 7.5 describes the implementation schedule for GSP activities. Section 6 provides a concise overview of financing and funding mechanisms that provides the basis for how the GSAs plan to cover GSP implementation costs and Sections 7.7, 7.8, and 7.9 describe the required elements for the GSP annual reporting, periodic (five-year) evaluations, and features of the DMS.

7.1 GSA COSTS FOR GSP IMPLEMENTATION

Total GSP implementation costs include both PMA-specific costs and costs for the CGA and GGA to administer and support all other aspects of the GSP. GSP implementation costs will include costs for managing the GSP, planning and studies, monitoring, and providing general administration.

Estimated GSA costs for GSP implementation are split into the following four categories:

- **GSA Administration**. General costs for GSA operations including meetings, coordination, outreach, legal, accounting, and other services that are required to support GSP implementation and updates.
- **GSP Studies**. Technical evaluations that are required for GSP implementation. These include addressing data gaps, updating groundwater information to satisfy GSP Regulations, and studies that are required to evaluate and manage the Subbasin to achieve the sustainability goal.
- **GSP Updates**. GSP updates includes annual reports and five-year periodic evaluations. These are required under the GSP Regulations, as described in detail under Section 7.6 and 7.7.
- **GSA Contingency**. An additional contingency is included to cover unanticipated legal costs and other unanticipated cost associated with GSP implementation.

The following subsections describe the general types of required activities and costs for each of the GSA cost categories.

7.1.1 GSA Administration

Administrative costs generally include meetings, reporting, record keeping, bookkeeping, legal, continued outreach to stakeholders, and government relations. GSAs will also need to continue to monitor projects and management actions to assess their benefit, feasibility, and coordinate with stakeholders and water managers if modification of projects and management actions is necessary to ensure the Subbasin meets the sustainability objectives.

GSAs will implement programs to monitor groundwater, measure elevations, and track total water use to satisfy reporting requirements in the GSP Regulations. Monitoring activities may include data management, installing monitoring wells, maintaining existing wells, and initiating studies to support GSP implementation. Other activities may include data collection for both groundwater and water quality monitoring networks.

GSAs will oversee the groundwater monitoring programs outlined in Chapter 4. This will include tracking Subbasin conditions and sustainability indicators. Data from the monitoring programs will be routinely evaluated to ensure progress is being made toward sustainability or to identify whether undesirable results are occurring.

GGA and CGA administrative costs are based on the existing rate studies[1] adopted by each GSA in 2018 and a review of audited financial statements for fiscal year 2020 (year ended June 30, 2020). Audited financial statements for fiscal year 2021 are not currently available as of the publication date of this GSP (December 2021). The rate studies covered the five-year period spanning fiscal years 2019/20 through 2023/24 and were prepared as property-related fees for water service under Proposition 218. The estimated annual operations (administration) expenses are approximately $465,000 for the CGA and up to $550,000 in the GGA.

7.1.2 GSP Studies

During the GSP development process, various data gaps were identified, in addition to areas where additional studies will be needed to support refinements to the GSP. This includes planning and technical studies that will be required to meet the annual and five-year reporting requirements under 23 CCR §356.2 and §356.4. It is anticipated that many of the studies to support GSP implementation—particularly those that affect sustainable management criteria in future revisions to the GSP—would be conducted in the same public and transparent process with which the GSP was prepared. These studies are described below.

Table 7-1 summarizes the technical studies to support GSP implementation. A total of15 studies have been identified. Many of the studies listed focus on filling data gaps associated with monitoring networks. This includes developing a well inventory and registration program. The studies and estimated costs are described in detail in the following subsections.

Table 7-1. Summary of GSP Implementation Studies

Study	Description
Expand Shallow Groundwater Level Monitoring Network	To expand the shallow groundwater monitoring network, additional monitoring wells must be evaluated. This includes existing monitoring wells and suitable locations for the construction of new monitoring wells.
Expand Water Quality Monitoring Network	This study will evaluate and expand additional groundwater quality monitoring wells.
Colusa Subbasin Western Boundary Investigation	This study will evaluate data to better understand the physical characteristics and groundwater conditions of the principal aquifer along the western margin of the Subbasin.
Westside Streams Monitoring Program	Streams originating from the Coastal Range west of the Subbasin will be evaluated for potential recharge volumes, water quality, and the interconnectedness of the streams and the groundwater system within the Subbasin.
Groundwater Well Monitoring Program	This pilot program will evaluate the costs and benefits of continuous groundwater monitoring data collection via six irrigation production wells. Program expansion throughout the Subbasin will be considered based on the data utility and costs of the pilot program.
Groundwater Financial Incentives Investigation	This analysis will quantify the total costs of groundwater use and switching to surface water. The analysis will also identify grower financial incentives for in-lieu recharge and options for structuring those incentives.

[1] Fee Study for the Glenn Groundwater Authority, May 2019 and Fee Study for the Colusa Groundwater Authority, May 2019.

Table 7-1. Summary of GSP Implementation Studies

Study	Description
CV2SimFG-Colusa Model Updates and Enhancement	This program will implement the periodic model data updates necessary to adequately represent near-term and future conditions within the Subbasin, and to support annual and five-year periodic GSP reporting to the DWR.
Well Inventory Program	This program will inventory the estimated 20% of groundwater wells unaccounted for within the Subbasin, and would seek to identify wells that are no longer active.
Well Registration Program	This study will evaluate the potential of a program for landowners to inventory their well data. This will complement the well inventory program.
Increasing GSA Involvement in County Well Permitting and Land Use Planning	CGA and GGA will explore options for allowing GSA input to the counties' well permitting processes and land use planning. The objective of GSA input would be to ensure that wells are permitted and land uses are planned in a manner consistent with sustainable groundwater management according to the GSP.
GSA Coordination with Water Quality Coalitions and Regulatory Agencies	GSAs will coordinate with the various water quality coalitions, water stakeholders, and regulatory agencies regarding GSP and other regulatory program implementation. This will include helping to identify and address water quality problems across the Subbasin, including those affecting disadvantaged communities (DACs) and severely disadvantaged communities (SDACs), and consideration of opportunities to expand public water systems and consolidate small public systems to improve drinking water quality delivered to DACs and SDACs.
Sutter Buttes Rampart Water Quality Interbasin Working Group	The CGA, GGA and the GSAs in the Butte, Sutter, Yolo, North Yuba and South Yuba Subbasins should participate in an interbasin working group focused on collaborative discussions, consensus-building and planning to address groundwater quality matters associated with the unique geology of the Sutter Buttes area.
Participation in Interagency Drought Task Forces	The CGA and GGA should coordinate their responses to droughts with their respective county and state agency partners through existing Interagency Drought Task Forces established in each county by the Colusa and Glenn County Boards of Supervisors.
Sacramento Valley Subsidence Interbasin Working Group	The CGA and GGA should consider participating in a Sacramento Valley Subsidence Interbasin Working Group with DWR, the other GSAs in the Sacramento Valley and federal partners. The working group would provide a forum for collaborative discussions, consensus-building, and planning to address inelastic land subsidence in the Sacramento Valley.
Evaluate Infrastructure Sensitivity to Subsidence	This study will evaluate the sensitivity of infrastructure in the Subbasin to potential subsidence rates.

7.1.2.1 Expand Shallow Groundwater Level Monitoring Network

The shallow groundwater monitoring network will be used to monitor groundwater levels and groundwater quality of the unconfined portion of the principal aquifer. Additionally, groundwater levels in shallow groundwater monitoring wells within five miles of major surface water features will be used to monitor stream-aquifer interactions and groundwater dependent ecosystems (GDEs). Understanding the flow relationships between the shallow groundwater aquifer and surface waters can assist in evaluating any possible occurrences of surface water depletions or riparian habitat. Monitoring wells with multiple completions (i.e., boreholes with more than one well casing installed, each casing screened at different depth intervals, and sealed between screens) can be used to characterize aquifer properties such as vertical hydraulic conductivity and transmissivity. Better understanding the flow mechanics of the principal aquifer system improves the integrated hydrologic model, increases understanding of water flow relationships throughout the Subbasin, and can enable stakeholders to be more informed during their decision-making processes.

The current groundwater monitoring network contains 104 wells in 48 boreholes, of which 30 completions in 24 boreholes are screened at depths less than 200 feet and are considered to be in the shallow groundwater aquifer. The majority of these shallow wells are in the lowlands of the Subbasin. There are reports of domestic wells going dry in the western portion of the Subbasin, specifically near the uplands west of the City of Orland. Including additional shallow groundwater monitoring wells to the monitoring network in this area would be beneficial for monitoring and understanding the conditions of the shallow aquifer.

The representative surface water depletion monitoring network is comprised of a subset of the 30 shallow groundwater monitoring wells and includes 12 completions in 12 boreholes to monitor conditions within Stony Creek, the Sacramento River, and the Colusa Drain. Some of the wells are within range of more than one surface water feature, and will therefore be used to monitor conditions within multiple surface waters. Expanding the shallow groundwater monitoring network to include shallow wells closer to each specific surface water feature will provide better insight into how groundwater is influencing flows in their respective surface water feature.

This study proposes to evaluate additional existing wells to include in the shallow groundwater monitoring network and identify suitable locations for the construction of new monitoring wells. Evaluation of existing wells to add to the shallow groundwater monitoring network will cost approximately $50,000 and will include evaluation of existing wells and coordination. Newly constructed shallow wells will cost approximately $40,000 each and include planning through construction phases. It is anticipated that no more than ten new shallow wells will be considered.

7.1.2.2 Expand Water Quality Monitoring Network

The groundwater quality monitoring network is comprised of 25 wells, all of which are already being monitored for salinity under existing groundwater quality monitoring programs. Four wells are part of the Sacramento Valley Water Quality Coalition (SVWQC) monitoring network. Ten wells are part of the California Rice Commission (CRC) monitoring network. Eleven wells are municipal wells and are monitored under State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW) regulations. The SVWQC and CRC wells are regulated by the Regional Water Quality Control Board.

Data gaps in this monitoring network are described in Chapter 4 and include lack of deep aquifer monitoring for upwelling of brackish connate waters and low spatial density of monitoring locations. The CRC wells are all shallow and may represent conditions of percolating water from rice ponds instead of groundwater conditions. Additionally, since these wells are included in existing monitoring programs managed by other agencies, the GSAs currently have no say on the frequency or continuation of monitoring beyond what the existing monitoring entities have already planned.

This study proposes to evaluate including additional wells as groundwater quality monitoring wells. Existing wells in appropriate locations with appropriate construction in existing monitoring programs will be prioritized over drilling new wells. Wells that are in close proximity and/or are most representative of groundwater quality conditions experienced by DACs, domestic wells, tribes, and GDEs will also be prioritized. Existing wells in appropriate locations with appropriate construction will be considered to either be requested additions to existing monitoring programs managed by other entities or included in a new monitoring program managed directly by the GSAs.

Establishing a new monitoring program managed by GSA staff, and potentially in coordination with DWR, will cost approximately $50,000 for implementation and coordination and an additional approximate $50,000 annual fee (assuming quarterly sampling from 30 well completions). Adding existing wells to existing programs will be approximately $5,000 per well, annually, and includes evaluation of wells and monitoring coordination with GSA staff, property owner, and the monitoring agency. Drilling new multiple-completion monitoring wells, including planning through construction phases, will be approximately $120,000 per well. Sites for new wells would need to be evaluated for property access, proximity to areas of concern, and suitability. It is anticipated that no more than ten existing or new wells will be considered.

7.1.2.3 Colusa Subbasin Western Boundary Investigation

Geologic and groundwater condition data is sparse throughout the western margin of the Subbasin. This includes the uplands west of the City of Orland in the north, southward along the Coast Ranges, and into the extension of the Dunnigan Hills west of the Arbuckle area in the south. There are few wells drilled in these areas that can provide information regarding the subsurface lithologic or groundwater conditions. The wells that do exist are shallow domestic wells with little, if any, historical record.

DWR is conducting an airborne electromagnetic survey (AEM) that will provide subsurface information regarding lithologic interfaces and potentially water level and saline water interface depth information. The survey for the Subbasin is not yet scheduled but is expected to occur before 2023. The GSAs intend to coordinate with DWR in determining the AEM flight paths to ensure coverage of the western margin of the Subbasin.

This study will be an evaluation of future existing data to better understand the physical characteristics and groundwater conditions of the principal aquifer along the western margin of the Subbasin. Lithologic interfaces will be updated using geophysical data from oil and gas wells, potentially new exploratory boreholes in key areas of interest, AEM survey data, and new well logs available from DWR. Future revisions of the Colusa Subbasin GSP will be updated to reflect the new information. This study is estimated to cost $100,000. New boreholes will be addressed during the study and are not reflected in the above estimate.

7.1.2.4 Westside Streams Monitoring Program

The CGA and GGA, in coordination with landowners and other agencies, would design and implement a monitoring program to collect data on the westside streams that originate in the Coastal Range to the west of the Subbasin and flow eastward into the Subbasin. The monitoring program would include monitoring flow, water quality parameters, and sediment loads. The objectives of the program would be to evaluate potential recharge volumes and water quality and to evaluate the interconnectedness of these streams and the groundwater system within the Subbasin.

The total cost estimate for planning, installation, and first year of monitoring is estimated at $225,000. Annual monitoring is $105,000.

7.1.2.5 Groundwater Well Monitoring Program

The CGA and GGA are currently implementing a pilot program to collect continuous groundwater monitoring data (e.g., water levels, pumping volumes) at six selected irrigation production wells spread across the Subbasin (three each in Colusa and Glenn counties). The objective of the pilot program is to test the utility of these data, and to evaluate installation and maintenance costs in order to estimate the costs and benefits of expansion of the program throughout the Subbasin. Estimated costs are presented for continued operation and maintenance of the pilot program, as well as for expansion of the program with an estimated per well cost. Measurement of groundwater pumping by some means will be needed to support implementation of a groundwater extraction fee, if the GSAs decide to do so.

The total cost estimate for planning, installation, and first year of monitoring is estimated at $265,000. Annual monitoring is estimated at $130,000.

7.1.2.6 Groundwater Financial Incentives Investigation

Sixteen (16) planned, ongoing, or potential PMAs included in the Colusa Subbasin GSP would provide in-lieu recharge benefits in targeted areas of the Subbasin (see Chapter 6). Water sources for in-lieu recharge are expected to include a mix of water transfers and utilization of existing district contract supplies. Successful in-lieu recharge projects will require growers being willing to pay for surface water and forgo groundwater pumping. Some of the perceived advantages of using groundwater over delivered surface water include the growers' convenience of having a clean, reliable, on-demand supply from their groundwater wells. Therefore, the effective cost of surface water must be less than that of groundwater. This study will include two phases to: (i) establish crop production costs under groundwater and surface water systems and (ii) and develop potential grower incentives structures for in-lieu recharge in selected areas of the Subbasin.

The initial phase of the study will quantify the total cost of groundwater use and the cost to switch to surface water. Total costs will include all direct costs (e.g., energy, equipment, and labor) in addition to indirect costs associated with each system (e.g., convenience, irrigation scheduling, frost protection, other perceived benefits). It is anticipated that this would include interviews with growers, agricultural engineering assessment of on-farm costs, and establishment of baseline crop budgets for groundwater and surface water irrigation for selected areas and crops. The initial phase of the study would provide a full cost comparison of groundwater and surface water.

Incentivizing the use of district surface water in-lieu of pumping would require paying at least the difference between district surface supply and the variable cost of pumping groundwater. The results of the baseline cost assessment will be used to establish potential incentives needed to encourage growers to switch from groundwater to surface water. This will include establishing the growers' willingness to pay for groundwater relative to surface water deliveries and establishing potential financial incentive structures. Incentive structures will also consider existing district rate structures. As of 2021, many Central Valley Project (CVP) contractors in the Subbasin have converted their contracts to repayment contracts, thus paying off and removing the capital component from their CVP water rates. The new repayment rates are allocated to land assessments and volumetric charges, which vary by district. The financial incentive analysis will consider the ability to shift district rates between fixed and variable costs to reduce the effective cost of surface water relative to pumping groundwater. The output of this second phase of the analysis will be a summary of grower financial incentives for in-lieu recharge and options for structuring those incentives for different in-lieu recharge areas.

The estimated cost of the study and cost assumptions are:

- The incentives investigation would consider up to two specific crops based on the crop mix in the in-lieu recharge areas; a preliminary assessment suggests walnuts or almonds would be the primary candidate crops.
- Interviews would be limited, coordinated by the GSA, and targeted to the key crops in the study.
- The focus areas would target Planned PMA in-lieu recharge projects but could be scaled up (or down) to consider incentives for additional (or fewer) areas.
- The estimated cost of the study is $165,000.

7.1.2.7 CV2SimFG-Colusa Model Updates and Enhancement

The C2VSimFG-Colusa model is an integrated hydrologic flow model (IHM) based on DWR's Central Valley Groundwater-Surface Water Simulation Model – Fine Grid Beta2 (C2VsimFG) released in May 2019 with updates, enhancements, and calibrations made to better represent local conditions in the Subbasin. The model is being used to support development and implementation of the Colusa Subbasin GSP, including characterization of historical, current, and projected water budgets, and evaluation of potential projects and management actions. The model is currently calibrated for the period 1990 through 2015 and needs to be updated periodically to adequately represent near-term and future conditions in the Subbasin. Calibration challenges were encountered during model development, leading to identification of several additional, potential model refinements including: adjustment of model layering in the northwest and southwest portions of the model domain to better represent local geology, adjustments to the vertical distribution of groundwater pumping, improved representation of westside tributary streams, and evaluation of inter-basin groundwater flows in coordination with neighboring GSAs.

These refinements may include:

- **Extension of time series data past Water Year 2015**. With the calibrated model, extending time series data (e.g., precipitation, land use, stream inflows, evapotranspiration, surface water diversions, urban demand, groundwater pumping) allows for use of more recent data and improved accuracy of the model for predicting near-term and future conditions in the Subbasin.
- **Model layering**. Model layer thicknesses may be adjusted locally, primarily in the southwest and northwest areas of the model, to better represent local geologic conditions and potential faults in these areas.
- **Distribution of groundwater pumping between layers**. Model layer thicknesses may be refined such that distribution of groundwater pumping between model layers better matches groundwater extraction from different depth and layers of the aquifer.
- **Small watersheds**. The water coming from the foothills is simulated using small watersheds representing small streams and groundwater flowing into the western side of the Subbasin. Theseephemeral streams may need explicit representation and simulation in the model to better control recharge and flows from the foothills as some observed groundwater levels near the foothills show signs of recharge from nearby small streams.
- **Interbasin flows**. C2VSimFG-Colusa model is well calibrated along the eastern boundary of the Subbasin and the five-mile zone on the eastern side of this boundary. Quantification of Sacramento River recharge along the eastern boundary of the Subbasin and subsurface groundwater underflow across this boundary into and out of Colusa, Butte and Vina

Subbasins will be useful in building consensus for management of groundwater by these neighboring subbasins.

- **Model Grid Resolution**. The observed groundwater level data show high spatial gradients in the northwestern and southwestern areas of the model. The model grid may be refined in these areas to better simulate these local high groundwater gradients.

The estimated cost for the model updates and enhancements is $225,000.

7.1.2.8 Well Inventory Program

Both Glenn and Colusa Counties have existing initial inventories and geographic information system mapping (GIS) of many of the water supply wells in each respective county. The mapping and associated databases were developed to gain a better understanding of well development over time in each county and to provide data for earlier water management efforts and initial SGMA planning efforts. Both well databases are based on information from public sources, including primarily well completion reports available from the DWR and in Glenn County, records from the County Environmental Health Department were also utilized.

While these initial efforts were extremely valuable, there remain many data gaps that will be necessary to fill. It is estimated that only about 80 percent of existing wells have well logs on file with DWR, so approximately 20 percent of the wells in the Subbasin remain to be identified and inventoried. It is also unknown how many of the inventoried wells are no longer in operation. Additionally, for SGMA purposes, the two County maps will need to be merged and refined to fit within the Subbasin boundaries.

The proposed well inventory program would complete further analysis of well logs and county well permits, ground truth actual well locations, and identify wells that are no longer active to ensure a complete and accurate well inventory exists. Additional data from well completion reports could also be entered into the well database to improve the understanding of the hydrogeology of the Subbasin. This will require a great deal of time and effort, especially given the size of the Subbasin. It will also be necessary to set up protocols for keeping the inventory updated as new wells are installed and as wells are decommissioned. These activities could be complemented by a well registration program where landowners submit information about their wells through an online portal, if this is determined by the GSAs to be an effective, acceptable means of well data acquisition.

This program would improve the accuracy and reliability of this dataset through additional data collection and outreach to improve both the quantity and quality of data in the well inventory.

A comprehensive, reliable well inventory is a pre-requisite for implementation of the following activities:

- Gaining a complete picture of groundwater development in the Subbasin
- Potentially initiating a per-well fee and/or extraction fee to fund SGMA implementation and PMAs
- Identifying potential new monitoring sites to help fill data gaps
- Improving the understanding of the hydrogeology of the Subbasin by conducting hydrogeologic investigations (AEM and similar)

The estimated cost of the program and cost assumptions are:

- Program conducted by GSA staff members with outside, on-call technical support
- Five-year period to develop the complete well data base at an estimated cost of $100,000 for the first year and $50,000 per year for years 2-5, totaling $300,000
- Annual updates to add new wells and delete old wells at an estimated cost of $20,000 per year

7.1.2.9 Well Registration Program

A well registration program could be developed for landowners to enter well information via an online portal to improve the accuracy of the current well inventory, including well location, well construction details (if known), and well type/use. The amount of information collected could be scaled up or down depending on the needs of the Subbasin. The registration program has the ability to provide the necessary information to improve the well inventory database, improve the understanding of the Subbasin hydrogeology, provide information to support potential future fee structures, and provide information to support specific future projects. The well registration program could be implemented on an annual timescale or some other timescale that is determined appropriate.

Other pertinent data potentially reportable through the well registration program could include information subject to change from year to year, such as the acreage (or number of people or livestock) served by a well, the crops irrigated and irrigation systems used (if the well is operated for agricultural use), and the volume of water pumped. This information could potentially feed into design and implementation of projects and management actions.

The estimated cost of the program and cost assumptions are:

- Program conducted by GSA staff members with outside, on-call technical support
- Two-year period to design and implement the on-line registration system and conduct public outreach at an estimated cost of $90,000 per year
- Three-year period to maintain outreach, compile data, and merge data into the well inventory database at an estimated cost of $40,000 per year
- Ongoing program implementation and maintenance cost of $15,000 per year

7.1.2.10 Increasing GSA Involvement in County Well Permitting and Land Use Planning

For this study, the CGA and GGA will explore options for allowing input to the counties' well permitting and land use planning processes by the GSAs. The objective of GSA input would be to ensure that wells are permitted and land uses are planned in a manner consistent with sustainable groundwater management according to the GSP. This could include consideration of:

- Well spacing, well construction, or other appropriate measures needed for well permitting
- Potential impacts to existing wells, springs, GDEs, water quality and recharge areas due to proposed development projects and changes in land use designation and zoning

Additionally, the GSA could provide information to the prospective well owners regarding the GSP and potential projects and/or management actions that may require the owner to report specific information or management actions that affect the ability of the well to be used (i.e., pumping restrictions).

The estimated cost of the program and cost assumptions are:

- Program conducted by GSA staff members with on-call technical support and legal counsel
- Two-year period to investigate, publicly vet, establish, and implement coordination protocols and procedures at an estimated cost of $75,000 per year
- Ongoing program implementation and maintenance cost of $15,000 per year

7.1.2.11 GSA Coordination with Water Quality Coalitions and Regulatory Agencies

GSAs intend to coordinate with the various water quality coalitions, beneficial users, water stakeholders, and regulatory agencies. These would include CRC and SVWQC, the municipal and small public water systems, and domestic well owners and users within the Subbasin. Coordination would ensure consistency regarding monitoring locations, monitored chemical constituents, monitoring procedures and frequencies, management plans and actions for out-of-compliance constituents, and responsible agencies for each management action. GSAs may need to get involved with management actions depending on any occurrence of undesirable results or input from the different regulatory boards.

The CGA and GGA recognize that disadvantaged communities and small water systems are disproportionately affected by degraded groundwater quality. As documented in Chapter 2, many of the communities within the Subbasin are considered Disadvantaged or a Severely Disadvantaged Communities (DACs and SDACs). Nearly all of the Subbasin is considered an Economically Distressed Area (EDA) because it is rural, has a low population density and has a low median household income. The CGA and GGA will coordinate with the regulating agencies, regulated entities, municipalities, small public water systems, and residential well owners and users to help identify and address potential water quality problems across the Subbasin, including those affecting DACs and SDACs. This will include consideration of opportunities to expand public water systems and consolidate small public systems to improve drinking water quality delivered to DACs and SDACs. This study will be an ongoing process. Costs for staff time are estimated at $20,000 per a year.

7.1.2.12 Sutter Buttes Rampart Water Quality Interbasin Working Group

The CGA, GGA, and the GSAs in the Butte, Sutter, Yolo, North Yuba, and South Yuba Subbasins intend to participate in an interbasin working group focused on collaborative discussions, consensus-building, and planning to address groundwater quality matters associated with the unique geology of the Sutter Buttes area. The goals of the working group should be to:

- Identify and prioritize groundwater quality conditions
- Coordinate with local, state and federal agencies
- Develop data and information needs
- Conduct high-level planning for groundwater studies and projects to protect or improve groundwater quality as needed
- Identify and pursue grant funding opportunities for groundwater studies and projects
- Provide a forum supporting cooperation, collaboration, and information sharing during implementation of studies and projects

It is expected that groundwater studies identified by the interbasin working group would be grant funded and implemented by research entities, such as U.S. Geological Survey (USGS) or DWR. If projects are identified to protect or improve groundwater quality, they would be led and implemented by local entities such as the counties, agricultural water districts and agencies, municipalities, and other public water suppliers using a variety of funding sources, as described under Section 7.6.

Although the surface expression of the Sutter Buttes Rampart is limited to the Sutter Subbasin, the subsurface extent of volcanic deposits and associated geologic structures is greater and may influence groundwater quality in the adjacent Butte, Colusa, Yolo, North Yuba, and South Yuba Subbasins. Groundwater in the volcanic sediments of the Sutter Buttes Rampart has arsenic concentrations that frequently and significantly exceed the drinking water standard. The formation of the Sutter Buttes has resulted in the uplift of basement rocks, and corresponding reductions in the depth to the base of fresh groundwater. Faults may provide conduits or otherwise influence the movement of poor quality groundwater.

Objectives of the working group and the to-be-identified studies are to:

- Propose studies to:
  - Improve knowledge of the subsurface extent of the Sutter Buttes Rampart
  - Improve the understanding of local hydrogeology and faulting in the Sutter Buttes Rampart area
  - More fully characterize arsenic geochemistry within the subsurface extent of the Sutter Buttes Rampart
  - Improve knowledge of the depth to the base of freshwater and the structural features (folds and faults) that control the depth to the base of freshwater and groundwater movement in the area
  - Assess the risk of upwelling, or movement along faults, of saline or brackish connate groundwater
  - Assess the potential for mobilization of arsenic and/or connate waters beyond the subsurface extent of the Sutter Buttes Rampart
- Provide a forum for local entities to propose and develop projects to protect or improve groundwater quality

Participation in the working group will be an ongoing process. The estimated cost for GSA staff time is included in the GSAs' annual operating budget.

7.1.2.13 Participation in Interagency Drought Task Forces

The CGA and GGA intend to coordinate their responses to droughts with their respective county and state agency partners through existing Interagency Drought Task Forces established in each county by the Colusa and Glenn County Boards of Supervisors.

The Colusa County Interagency Drought Task Force consists of representation from the following entities:

- County Community Development Department
- County Water Resources Division
- County Office of Emergency Service (OES)/Sheriff's Office
- California OES
- DWR

- County Board of Supervisors
- County Administrative Officer
- Public Works Department
- Environmental Health Department
- City of Colusa
- City of Williams

The GGA participates in meetings of the Glenn County Drought Taskforce which are open to the public and consist of representation from a variety of entities, including:

- Planning and Community Development Services
- County OES/ Sheriff's Office
- California OES
- DWR
- County Board of Supervisors
- County Administrative Officer
- County Counsel
- Agricultural Commissioner
- Health and Human Services Agency
- UC Cooperative Extension
- Artois Community Services District
- City of Orland
- City of Willows
- California Water Service Company
- Water Agencies (Water Districts, Irrigation Districts, Reclamation Districts, Orland Unit Water Users Association, Stony Creek Water Master)
- Groundwater Sustainability Agency representatives
- California Legislator representatives
- Glenn County Farm Bureau
- Glenn County Resource Conservation District
- County Public works
- Fire Departments
- State Board Division of Drinking Water
- Members of the public

The drought task forces in both counties are ad hoc committees of the Board of Supervisors that meet in times of need such as the 2014 and 2021 drought emergencies. The primary purposes of the task forces are to:

- Coordinate the responses to drought at the local and state level
- Identify and track water supply instability, including dry wells and other drought-related issues
- Identify and make available resources that may be used to assist residents and businesses impacted by the drought
- Promote public awareness of the severity of the drought and the need for water conservation

The task forces implement the following coordinated functions at the county level:

- Education and outreach for drought preparedness
- Reporting and tracking of dry or impaired wells
- Identifying and applying for funding resources for programs to assist residents impacted by the drought
- Venue to share drought related experiences, challenges, and potential solutions

The task forces coordinate with the California Office of Emergency Services (OES), Department of Water Resources Northern Region Office, and the State Water Resources Control Board.

When households or small water systems in Colusa County experience a water shortage, they should fill out a “Well Outage Report” form and send that to the Colusa County Water Resources Division. The Water Resources Division verifies the information with the reporter and forwards the information to Colusa County OES.

When households or small water systems in Glenn County experience a water shortage, they should fill out a “Well Incident Report” form and send that to the Glenn County OES.

The respective County OES departments determines if assistance is available and coordinates with the California OES regional coordinators. The State (OES, DWR, SWRCB) provides funding for regional programs and short- and long-term solutions for water systems, and the drought task forces in each county work to procure funding for drought relief programs from these and other sources. Colusa and Glenn Counties are in Mutual Aid Region III of the Inland Administration Region of California OES.

Because the CGA and GGA will jointly implement the Colusa Subbasin GSP, their participation in the two drought task forces will help provide a coordinated response throughout the Subbasin and across the county line.

The CGA and GGA recognize that drought emergencies have a disproportionate effect on disadvantaged communities and small water systems. As documented in Chapter 2, many of the communities within the Subbasin are considered DACs or a SDACs. Nearly all of the Subbasin is considered an Economically Distressed Area because it is rural, has a low population density and has a low median household income. The CGA and GGA anticipate coordinating with the members of the Colusa and Glenn Interagency Drought Task Forces to address the effects of drought across the Subbasin and throughout these communities. The CGA and GGA also expect to coordinate with the members of the Colusa and Glenn Interagency Drought Task Forces to consider DWR’s recommendations for drought and water shortage contingency planning in Small Water Systems and Rural Communities Drought and Water Shortage Contingency Planning and Risk Assessment (DWR, 2021c).

Participation in the two drought task forces will be an ongoing process. The estimated cost for GSA staff time is included in the GSAs' annual operating budget.

7.1.2.14 Sacramento Valley Subsidence Interbasin Working Group

The CGA and GGA intend to participate in a Sacramento Valley Subsidence Interbasin Working Group with DWR, the other GSAs in the Sacramento Valley, and federal partners. The working group would provide a forum for collaborative discussions, consensus-building, planning and remedial actions where called for, to address inelastic land subsidence in the Sacramento Valley. The goals of the working group could include:

- Identify and prioritize areas of concern for inelastic land subsidence
- Identify and prioritize data collection efforts needed to fill data gaps
- Coordinate with local, state, and federal agencies
- Conduct high-level planning for data collection and implementation of projects to address or mitigate inelastic land subsidence
- Identify and pursue grant funding opportunities for data collection and project implementation
- Provide a forum supporting cooperation, collaboration, information sharing, and public outreach during implementation of data collection and projects

The Sacramento Valley Subsidence Network was last surveyed in 2017 and showed inelastic subsidence had occurred in the Sacramento Valley, including in the Subbasin, between 2008 and 2017. A key objective of the working group should be to confirm and reassess the locations and rates of historical subsidence identified based on the 2008 and 2017 surveys of the network. This new information about the locations and rates of inelastic subsidence would be used to reevaluate sustainable management criteria (SMCs) for inelastic land subsidence and help to guide the implementation of projects needed to address inelastic land subsidence.

It is expected that data collection needs identified by the interbasin working group would be grant-funded and implemented by state and federal agencies, such as DWR or USGS. If projects are identified to address or mitigate inelastic land subsidence, they would be led and implemented by local entities such as the counties, agricultural water districts and agencies, municipalities, and other public water suppliers using a variety of funding sources, as described under Section 7.6.

Participation in the working group will be an ongoing process. The estimated cost for GSA staff time is included in the GSAs' annual operating budgets and actions taken by the working group would be documented in subsequent annual reports.

7.1.2.15 Evaluate Infrastructure Sensitivity to Subsidence

The CGA and GGA have proposed a local assessment of infrastructure sensitivity to subsidence in the Subbasin. This study is proposed as one measure to close data gaps related to subsidence and its potential effects on beneficial uses and users in the Subbasin. The study would allow the GSAs to better characterize surface beneficial uses and users that may be susceptible to substantial interference as a result of subsidence, and plan for actions to expand monitoring and mitigation of potential subsidence. The study would provide the GSAs better understanding of the infrastructure that is most at risk of interference from potential subsidence, and the possible impacts of interference on social, economic, transportation, and other activities in the Subbasin. The study should evaluate infrastructure Subbasin-wide to provide a comprehensive understanding of sensitivity to subsidence, though the study could be phased or structured to initially focus on areas of the Subbasin where the potential risk of subsidence and severity of impacts could be the greatest. Outcomes of the study could include:

- Identification of infrastructure (e.g., canals, pipelines, roads) most at risk of interference (e.g., damage, diminished capacity, loss of use) from subsidence, prioritized by severity of potential interference and severity of potential consequences of that interference on activities in the Subbasin.
- Identification of potential impacts that may result from infrastructure damage or loss of use, especially social, economic, transportation, and sustainability-related impacts.
- A plan for expanding subsidence monitoring to examine changing land subsidence conditions that may lead to potential adverse effects on infrastructure in the Subbasin.
- A plan for actions to respond to changing land subsidence conditions to resolve or mitigate potential adverse effects on infrastructure in the Subbasin.

The study would be a cooperative effort with infrastructure owners and other stakeholders in the Subbasin. The GSAs could, but do not necessarily need to, lead the assessment. It is expected that data collection and analysis in this study would be grant-funded, though local funding sources could also be used. This study would likely be interconnected with work completed through the Sacramento Valley Subsidence Interbasin Working Group (Section 7.1.2.14) and ongoing work to install additional subsidence benchmarks and expand subsidence monitoring in the Subbasin.

7.1.3 GSP Annual Reports and Periodic Evaluations

The GSAs will manage annual reports and periodic (five-year) GSP evaluations. It is anticipated that the cost for annual reporting will be substantially lower than the cost of the five-year evaluations. However, the GSAs will engage in required monitoring and technical studies that are required for the five-year evaluations. For example, it is anticipated that the necessary updates to the Subbasin groundwater model would commence prior to applying the model for the five-year periodic evaluation.

Annual Reports. 23 CCR §356.2 requires GSAs to prepare and submit annual reports to DWR. GSAs will prepare required technical analysis, data, summary material, and provide a report on sustainable management objectives. GSAs expect that annual reports will also require inter- and intra-GSA coordination as well as stakeholder outreach. See Section 7.6 for a description of annual report elements. The estimated cost for annual reports is between $40,000 and $60,000 based on the cost of similar services for Critically Overdrafted subbasins. A conservative cost estimate of $46,000 per year is applied and split equally between the GSAs.

Periodic Evaluations. 23 CCR §356.4 requires GSAs to prepare and submit five-year evaluation reports. In contrast to the annual report, this report requires additional evaluation of sustainability conditions, objectives, monitoring, and documentation of new information that is available since the last update to the GSP. See Section 7.7 for a description of five-year update elements. The estimated cost for periodic evaluations is substantially greater than the annual reports because of the additional analysis and full updates to the GSP. The estimated cost is between $200,000 and $250,000. A conservative cost estimate of $226,000 per year is applied and split equally between the GSAs. This does not include the costs of GSP studies that are required for the five-year evaluations (e.g., updates/calibration to the groundwater model and groundwater monitoring). Those costs are reported separately (and described above) under GSP Studies.

7.1.4 Contingency

An additional contingency cost is included in estimated GSA budgets for planning purposes. Contingencies could include legal challenges or additional investigations required to support GSP implementation. A contingency cost of $50,000 per year for each GSA is added to the estimated costs.

7.2 GSA COSTS FOR GSP IMPLEMENTATION SUMMARY

The following subsections summarize estimated costs for each GSA to implement the GSP. Costs are presented for each of the four cost categories identified above. In practice, GSAs record expenses in different ways, and as such, may list different categories. Studies, annual reports, and five-year updates that apply to the entire Subbasin are split evenly between the CGA and GGA, though some details on the cost allocation between the GSAs remain to be finalized.

It is emphasized that costs are preliminary estimates based on the information available at the time of GSP development. As the GSP is implemented the GSAs will evaluate progress and adjust accordingly. It is anticipated that the GSP financing plan (see Section 7.4 for a summary of funding and financing approaches) would consider the cost-effectiveness of the GSP implementation plan, including planned PMAs and other GSA activities to support implementation. A cost-effective implementation plan would achieve GSP implementation benefits at the lowest feasible cost. Actual costs incurred will be made available in annual reports and yearly financial statements released by the GSAs.

7.2.1 Colusa Groundwater Authority GSA

Table 7-2 summarizes estimated CGA costs. The CGA estimated annual costs for GSP implementation averages approximately $780,000. This does not include PMA-specific costs (see Section 7.3). Several planned studies are assumed to begin in 2022. As such, estimated costs are greatest in 2023.

Table 7-2. Colusa Groundwater Authority GSA Estimated Implementation Costs

Cost Category	2022	2023	2024	2025	2026	2027+
GSA Administration	$322,000	$342,000	$322,000	$322,000	$322,000	$322,000
GSP Studies	$520,000	$560,000	$343,000	$230,000	$230,000	$315,000
GSP Updates	$23,000	$23,000	$23,000	$23,000	$23,000	$113,000
Contingency	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Total	**$915,000**	**$975,000**	**$738,000**	**$625,000**	**$625,000**	**$800,000**

7.2.2 Glenn Groundwater Authority GSA

Table 7-3 summarizes estimated GGA costs. The GGA estimated annual costs for GSP implementation averages approximately $945,000. GGA costs are slightly greater than CGA estimated costs based on the 2019 rate studies and actual expenditure summaries in the 2020 audited financial reports. This does not include PMA-specific costs (see Section 7.3). Several planned studies are assumed to begin in 2022. As such, estimated costs are greatest in 2023.

Table 7-3. Glenn Groundwater Authority GSA Estimated Implementation Costs

Cost Category	2022	2023	2024	2025	2026	2027+
GSA Administration	$445,000	$499,000	$499,000	$499,000	$499,000	$499,000
GSP Studies	$520,000	$560,000	$343,000	$230,000	$230,000	$315,000
GSP Updates	$23,000	$23,000	$23,000	$23,000	$23,000	$113,000
Contingency	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000
Total	**$1,038,000**	**$1,132,000**	**$915,000**	**$802,000**	**$802,000**	**$977,000**

7.3 PLANNED PMA IMPLEMENTATION COSTS

The costs for PMAs, described in Chapter 6, are reported separately from other GSP implementation costs. In addition, the costs of PMAs may be allocated to different entities or the Subbasin more broadly (see Section 7.5 and Appendix 7A).

There are currently five planned PMAs that the GSAs or other project proponents are working to implement (as described in GSP Section 6.3). Costs for ongoing and potential PMAs are not shown. This is because these projects are already underway (and therefore funded) or will not be implemented unless required by changing groundwater conditions in the Subbasin.

Table 7-4 summarizes planned PMA capital and initial study costs and ongoing operation and maintenance (O&M) costs. Capital and initial study costs are one-time expenses to build or design a project. For example, the Orland-Artois Water District (OAWD) land annexation project includes an initial capital cost for distribution system construction. OAWD is currently working to refine the estimated construction cost. Other PMAs include one-time expenses for studies to develop the project. O&M costs are annual costs after the project is implemented. The total estimated cost for capital and studies is approximately $20.6 million. Estimated annual O&M costs are approximately $6.7 million per year at full implementation of the planned PMAs.

Table 7-4. Planned Projects and Management Actions Estimated Implementation Cost Summary

Cost Category	2022	2023	2024	2025	2026	2027+
Colusa Subbasin Multi-Benefit Groundwater Recharge						
Capital/Studies	$328,000	-	-	-	-	-
O&M	-	$246,000	$246,000	$246,000	$246,000	$246,000
OAWD District Land Annexation and In-Lieu Groundwater Recharge						
Capital/Studies	-	$20,000,000	-	-	-	-
O&M	-	-	$2,642,000	$2,642,000	$2,642,000	$2,642,000
Sycamore Slough Groundwater Recharge Pilot Project						
Capital/Studies	$28,000	-	-	-	-	-
O&M	-	$26,000	$26,000	$26,000	$26,000	$26,000
Colusa County Water District (CCWD) In-Lieu Groundwater Recharge						
Capital/Studies	$100,000	-	-	-	-	-
O&M	-	$2,025,000	$2,025,000	$2,025,000	$2,025,000	$2,025,000
Colusa Drain Mutual Water Company (CDMWC) In-Lieu Groundwater Recharge						
Capital/Studies	$100,000	-	-	-	-	-
O&M	-	$1,736,000	$1,736,000	$1,736,000	$1,736,000	$1,736,000
Total (Planned PMAs)						
Capital/Studies	**$556,000**	**$20,000,000**	**-**	**-**	**-**	**-**
O&M	**-**	**$4,033,000**	**$6,675,000**	**$6,675,000**	**$6,675,000**	**$6,675,000**

7.3.1 Planned PMA Benefits

Figure 7-1 illustrates the expected gross average annual benefits of planned PMAs at full implementation. The gross average annual benefit to the Subbasin from planned PMAs is approximately 61,000 acre-feet in 2022 and will increase to 84,000 acre-feet by 2027 when planned PMAs are fully implemented.

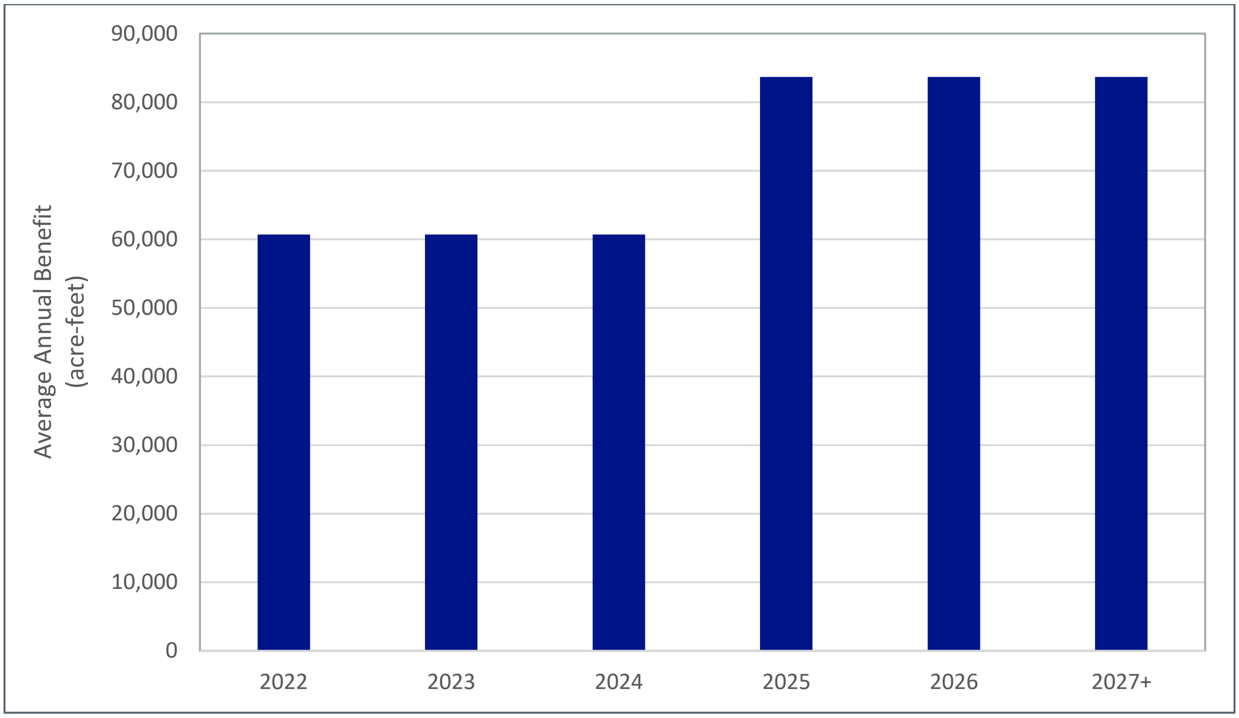


Figure 7-1. Colusa Subbasin Project Estimated Gross Benefit Timeline

7.4 GSP ANNUAL IMPLEMENTATION COST SUMMARY

The total GSP implementation costs include the sum of GSA costs (Section 7.2) and PMA costs (Section 7.3). These costs are expressed on an annual basis and summarized in Table 7-5. Estimated annual GSP implementation costs increase from approximately $1.5 million to around $9.5 million per year (including annualized capital costs). A substantial share of the total cost is attributable to surface water purchase costs for in-lieu recharge PMAs. Cost categories include:

- **Other Capital/Studies** includes one-time capital costs incurred from PMA implementation and GSP Study costs (See Section 7.1.2 and 7.3)
- **Debt-Financed PMA Capital Repayment** includes the estimated debt service for the OAWD District Land Annexation and In-Lieu Groundwater Recharge project capital costs (See Section 7.3). Capital costs for PMAs are annualized assuming repayment on a 30-year bond at 3 percent interest. All other costs are already annual expenses and reported as such
- **PMA O&M** costs are ongoing annual costs incurred after the first year of a PMA's implementation (See Section 7.3). These costs include annual surface water purchase costs. It is noted that this is the majority share of annual costs associated with each PMA
- **GSA Admin/Studies** costs are ongoing annual costs incurred by the GSAs that are not project specific (See Section 7.2)

Table 7-5. Total Estimated Cost Summary of GSP Implementation

Cost Category	2022	2023	2024	2025	2026	2027+
Other Capital/Studies	$556,000	$1,120,000	$685,000	$460,000	$460,000	$630,000
Debt-Financed PMA Capital Repayment	-	$1,020,000	$1,020,000	$1,020,000	$1,020,000	$1,020,000
PMA O&M	-	$4,033,000	$6,675,000	$6,675,000	$6,675,000	$6,675,000
GSA Admin/Studies	$914,700	$987,900	$968,200	$968,200	$968,200	$1,148,200
Total	**$1,470,700**	**$7,160,900**	**$9,348,200**	**$9,123,200**	**$9,123,200**	**$9,473,200**

7.5 IMPLEMENTATION SCHEDULE

Figure 7-2 illustrates the estimated implementation schedule for the GSP. The GSP implementation schedule allows time for GSAs to develop and implement projects and management actions to achieve the Subbasin sustainability goal. It is anticipated that Planned PMA implementation will commence in 2022, with initial project studies and project development. The GSP implementation schedule also shows mandatory reporting and updating for the GSP, including annual reports and five-year periodic evaluations prepared and submitted to DWR.

Task Name	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Plan Implementation																					
GSP Submittal to DWR	X																				
Memorandum of Understanding	X																				
Annual Reports	X	X	X	X	X		X	X	X	X		X	X	X	X		X	X	X	X	
Five-Year Periodic Evaluation						X					X					X					X
Outreach and Communication	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity
Monitoring and DMS	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity
GSP Studies	Planning and Development	Implementation	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity
Planned Projects and Management Actions																					
Colusa Subbasin Multi-Benefit Groundwater Recharge	Implementation	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity
OAWD District Land Annexation and In-Lieu Groundwater Recharge	Planning and Development	Implementation	Implementation	Implementation	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity
Sycamore Slough Groundwater Recharge Pilot Project	Implementation	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity
CCWD In-Lieu Groundwater Recharge	Implementation	Implementation	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity
Colusa Drain MWC In-Lieu Groundwater Recharge	Implementation	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity	Ongoing Activity

Legend
- Submittal: X
- Planning and Development
- Implementation
- Ongoing Activity

Figure 7-2. Colusa Subbasin Implementation Schedule

7.6 GSP FINANCING AND FUNDING MECHANISMS

Administering the GSP and monitoring and reporting progress is projected to cost approximately $9.5 million per year once all planned PMAs are implemented. Costs are expected to be higher during years in which a five-year periodic evaluation and report is prepared, and slightly lower during other years when an annual report is prepared. These include all costs required for implementation, including for example, PMAs implemented by individual water agencies. To fund GSA operations and GSP implementation, GSAs are developing a financing plan that will include one or more of the following financing approaches:

- **Grants and low-interest loans**: GSAs will continue to pursue grants and low interest loans to help fund planning studies and other GSA activities. However, grants and low-interest loans are not expected to cover most GSA operating costs for GSP implementation.
- **Groundwater extraction charge**: A charge per acre-foot pumped could be used to fund GSP implementation activities.
- **Other Fees and charges**: Other fees may include permitting fees for new wells or development, transaction fees associated with contemplated groundwater markets, or commodity-based fees, all directed at aiding with sustainability objectives. Depending on the justification and basis for a fee, it may be considered a property-related fee subject to voting requirements of Article XIII D of the California Constitution (passed by voters in 1996 as Proposition 218) or a regulatory fee exempt from such requirements.
- **Assessments:** Special benefit assessments under Proposition 218 could include a per-acre (or per-parcel) charge to cover GSA costs, or other fees under Proposition 26.
- **Taxes:** This could include general property related taxes that are not directly related to the benefits or costs of a service (ad valorem and parcel taxes), or special taxes imposed for specific purposes related to GSA activities.

The GSAs are considering a combined approach, targeting available grants and low interest loans, and considering a combination of fees, assessments, and charges to cover operating and program-specific costs. Costs borne by individual water agencies will be allocated and recovered within that agency based on its policy decisions and customer preferences. As required by statute and the Constitution, GSAs and agencies would complete an engineer's report, rate study, and other analyses to document and justify any rate, fee, or assessment. For example, both the CGA and GGA have prepared rate studies to fund near-term (fiscal years 2019/20 through 2023/24) administrative costs as property-related service charges under Proposition 218. Appendix 7A provides a summary and additional discussion of the funding and financing options available to GSAs and other local entities in the Subbasin.

Some cost recovery approaches can affect the cost of water for specific uses in the Subbasin. Agencies supplying surface water recognize that recovering GSP related costs as part of their surface water charge can be counter-productive by disincentivizing surface water use. All agencies are concerned that any fees, charges, or assessments will affect business (farm) income and, if large, may affect cropping decisions and farming practices in the Subbasin. Based on groundwater monitoring, land use changes, and other future conditions, the GSAs will reconsider or adjust fees/assessments as needed to complete required PMAs and activities that are required to achieve sustainability.

An important consideration for GSA financing plans is the allocation of different types of costs to entities or areas. Cost allocation is a multi-step process that determines how costs of GSP implementation components would be spread among and recovered from entities and areas covered by the GSP. For example, the implementation plan includes several categories of activities that must be paid for: administration, projects and management actions, monitoring, and studies. The categories may have their costs spread in different ways (among different entities and areas) depending on discussions and policy decisions. Considerations would include who is responsible for a cost, who benefits from an activity, what is fair, what is legally allowed or possible, what are the requirements for determining and justifying a cost allocation. Appendix 7A provides a summary overview of cost allocation concepts.

7.7 ANNUAL REPORTS

The GSP regulations require annual reports to be submitted to DWR by April 1 of each year following the adoption of the GSP (23 CCR §356.2). The GSAs will prepare and submit annual reports that comply with the requirements of §356.2. It is anticipated that the GSAs and their member agencies will need to develop independent analyses and data (e.g., quantifying surface water use within a particular GSA and/or member agency) as well as joint analyses (e.g., estimating the Subbasin-wide change in groundwater storage) in order to develop the required components of each annual report. The GSAs will work together to complete the annual reports.

Annual reports must provide general information about the Subbasin (23 CCR §356.2(a)) in addition to detailed, technical information that includes (23 CCR §356.2(b) and (c)):

- Groundwater elevation data from monitoring wells, analyzed and represented in:
  - Groundwater elevation contour maps
  - Groundwater elevation hydrographs
- Groundwater extractions in the preceding water year
- The surface water supply used or available for use in the preceding water year, including for groundwater recharge or other in-lieu uses
- Total water use in the preceding water year
- Change in groundwater storage, including maps and graphs
- A description of progress towards implementing the GSP, including achievement of interim milestones and implementation of PMAs

The following subsections provide a general outline of what information will be provided in each annual report. Each annual report submitted to DWR will fully comply with the requirements of §356.2.

7.7.1 General Information (§356.2(a))

General information provided in each annual report will include an executive summary that highlights the key content of the annual report. The executive summary will include:

- A description of the Subbasin sustainability goal
- A description of ongoing, newly implemented, and other planned GSP projects
- An updated implementation schedule
- A current map of the Subbasin

Any important changes or updates to the Subbasin, GSAs, or GSP implementation since the last annual report will be noted and described.

7.7.2 Subbasin Conditions (§356.2(b))

The Subbasin conditions section of each annual report will provide an update on groundwater conditions, surface water conditions, and water use in the Subbasin during the preceding water year.

Technical information will include a summary of current groundwater conditions in the Subbasin with respect to the Subbasin sustainability goal. The GSAs will summarize the groundwater monitoring network data and report the current groundwater elevation and change in groundwater elevation at monitoring sites. Data will be summarized in hydrographs and groundwater elevation contour maps for each aquifer in the Subbasin, tailored to specific hydrogeologic conditions across the region. This information will show seasonal high and low conditions within the current season and show historical data from at least January 1, 2015, to the current reporting year.

Groundwater extractions in the preceding water year will be summarized (in tabular and map form) by water use sector, and the method of measurement will be identified (e.g., metering, satellite analysis, crop-based evapotranspiration [ET] estimates, etc.). All data and methods used to characterize extractions and levels will follow best practices and be described in the annual report.

The surface water supply used or available for use in the Subbasin will be reported based on data that describes the total surface water diversions and total surface water inflows used or available for use in the Subbasin. The summaries will indicate whether the surface water supply was used or available for use for direct or in-lieu recharge, and will identify all data sources for each GSA.

Total water use from all sources will also be summarized by water use sector and water source type, with identification of the measurement method used to quantify all uses. Consumptive water use will also be summarized based on evapotranspiration of applied water (ET_{aw}) volumes, parsed into ET_{aw} of surface water and ET_{aw} of groundwater using the available information on applied surface water. All water use information will be collected using the best available measurement methods and data sources, which will be described in the annual report.

The Subbasin groundwater system water balance described in Chapter 3 will be used to estimate the change in groundwater storage each year. Change in storage will be summarized in tabular form and as a map for each principal aquifer in the Subbasin. A graph will show the water year type, groundwater use, annual change in storage, and cumulative change in storage for the Subbasin using historical data, including data from at least January 1, 2015, through the current reporting year.

7.7.3 Plan Implementation Progress (§356.2(c))

Each annual report will summarize the progress made over the past year in GSP implementation, including implementation of PMAs and other GSA-related activities. Each annual report will also describe progress toward established interim milestones and planned sustainability objectives. It will summarize sustainability conditions in the Subbasin.

7.8 PERIODIC EVALUATION (FIVE-YEAR UPDATES)

At least every five years, DWR will review the progress that GSAs have made toward meeting the GSP sustainability goals. Required components of the periodic evaluations are identified in 23 CCR §356.4. The GGA and CGA will prepare the periodic evaluation (or five-year update) at least every five years to summarize the status of GSP implementation, whether the GSP is meeting sustainability goals, and progress toward implementation of PMAs. An evaluation will also be made whenever the GSP is amended. Each periodic evaluation will fulfill all the requirements of 23 CCR §356.4. A summary of the general information that will be included in each periodic evaluation is provided in the following subsections.

7.8.1 Sustainability Evaluation (§356.4(a) - §356.4(d))

Each periodic evaluation will summarize current groundwater conditions for each applicable sustainability indicator and describe overall progress towards sustainability. Groundwater conditions will be evaluated and described in relation to interim milestones, measurable objectives, and minimum thresholds. If any minimum thresholds are found to be exceeded, the GSAs will investigate probable causes and implement actions to avoid undesirable results and correct groundwater conditions, as warranted.

Implementation of all PMAs will be documented and described in relation to the adaptive management strategy for the Subbasin. This description will include a summary of implementation timelines compared to the proposed timeline (Figure 7-1) and PMA implementation schedules described in Chapter 6. The description will also summarize the effect of the PMA on groundwater conditions in the Subbasin. If groundwater conditions are improving faster or slower than projected, the reason for the difference from the projection will be evaluated. If conditions are improving slower than projected because any PMAs are not being implemented according to the specified timeline, the deviation from the original plan will be documented and to the extent possible, corrective actions will be taken to speed implementation and/or implement other PMAs for adaptive management of the Subbasin.

The periodic evaluation will also analyze and describe the effects of PMAs on Subbasin sustainability indicators and compare those to the estimated gross benefits of the PMAs presented in Chapter 6. If differences are identified, those will be described in the periodic evaluation. If PMAs are not performing as expected, the periodic evaluation will describe steps the GSAs will take to implement additional PMAs or initiate demand management, if warranted. Those steps would include public outreach, notification, and other processes described in Chapter 6 for those PMAs. Any changes to the implementation schedule of PMAs will be described in the periodic evaluation.

As PMAs are implemented, monitoring data may indicate unanticipated effects. Also, land uses and economic conditions will change in ways that have not been anticipated or evaluated at this time. It may be necessary to revise the GSP to account for these changes. Elements of the GSP, including the basin setting, management areas, undesirable results, minimum thresholds, and measurable objectives will be reconsidered by the GSAs during the periodic evaluation. Any revisions will be proposed and documented in the evaluation.

7.8.2 Monitoring Network Description (§356.4(e))

Chapter 4 describes the planned monitoring network and protocols. The effectiveness of the monitoring network and overall GSP implementation depends on timely, accurate, and comprehensive data. The GSP includes Data Management System (DMS) protocols, as well as expanded monitoring wells and data collection. However, as described in Chapter 4, data gaps still exist in the Subbasin that will require expanding the monitoring network.

The periodic evaluation will include a description of the monitoring network within the Subbasin, will identify data gaps, and will identify any applicable areas within the Subbasin that are represented by data that does not satisfy the requirements established in the GSP regulations. A plan will be developed to improve the monitoring network, consistent with 23 CCR §354.38.

Additional data gaps may be identified in future GSP updates. The periodic evaluations of the GSP will assess changes to the monitoring program needed to acquire additional data sources, and how the new information will be used and incorporated into any future GSP updates. The installation of new data collection facilities and analysis of new data will be prioritized in the GSP.

7.8.3 New Information (§356.4(f))

The CGA and GGA will continue to monitor Subbasin conditions throughout GSP implementation. The DMS will allow GSAs to identify additional data gaps and implement procedures to secure additional data. Land use and economic incentives for farming and other water uses in the Subbasin will continue to change as the GSP is implemented. GSAs expect that new information about groundwater conditions, projects and management actions, and sustainability objectives will continue to be available. An adaptive management approach will be applied to identify, review, and incorporate all new information into the GSP.

Any significant new information available since GSP adoption, amendment, or the last periodic evaluation will be described. The evaluation will also clearly evaluate and indicate whether that new information warrants any changes to the GSP, including reassessment of the basin setting, measurable objectives, minimum thresholds, or the criteria that defines undesirable results.

7.8.4 GSA Actions ((§356.4(g) - §356.4(h))

The GGA and CCA will continue to monitor, manage, and collaborate to meet the sustainability goals specified in the GSP. Within their allowed authorities, if necessary, the GSAs will evaluate new regulations or ordinances that could be implemented to help achieve sustainability objectives. Any changes in regulations or ordinances will be summarized in the periodic evaluation.

The periodic evaluation will include a summary of state laws and regulations, or local ordinances related to the GSP that have been implemented since the previous periodic evaluation, and address how these may require updates to the GSP. Enforcement or legal actions taken by the GSAs in relation to the GSP will be summarized along with how such actions support sustainability in the Subbasin.

7.8.5 Plan Amendments, Coordination, and Other Information (§356.4(i) - §356.4(k))

Any proposed or completed amendments to the GSP will be described in the periodic evaluation. This will also include a summary of amendments that are being considered or developed at that time. Any changes to the basin setting, measurable objectives, minimum thresholds, or undesirable results will be described.

Any changes to applicable agreements will be documented and summarized in the periodic evaluation. GSAs will summarize any other information deemed appropriate to support the GSP and provide required information to DWR for review of an amended GSP.

7.9 DATA MANAGEMENT SYSTEM (§352.6)

The Subbasin DMS has been developed as an integrated network of digital file folders, databases and linked programs and tools. Each element is directly or indirectly linked the C2VSimFG-Colusa groundwater model and related water budget databases and tools that are used to calculate and summarize the Subbasin water budget (Figure 7-3). Inputs to the water budget are organized into inputs that are managed and implemented at the Subbasin-level and inputs that are managed at the GSA-level (or member agency-level). Subbasin-level inputs include:

- **Time series**: time series data managed in a database structure and used to quantify surface water inflows/outflows and groundwater levels
  - USGS station data
  - DWR-compiled data (Water Data Library [WDL] and California Data Exchange Center [CDEC])
- **Weather:** weather data managed in a database structure and used to quantify reference evapotranspiration and precipitation, and to support root zone water budget calculations (crop evapotranspiration, infiltration, runoff)
  - California Irrigation Management Information System (CIMIS) station data
  - National Oceanic and Atmospheric Administration's (NOAA's) National Centers for Environmental Information (NCEI) station data
  - PRISM Climate Group data
- **eWRIMS**: Electronic Water Rights Information Management System (eWRIMS) stores water rights diversion records managed publicly in a database structure and used to help quantify surface water supply utilized for irrigation
- **GIS:** spatially-defined geographic data managed in GIS and used to support land use analyses and spatial water use by sector
  - DWR spatial data (Subbasin boundaries, GSA boundaries, land use survey spatial coverages, Land IQ land cover classification and analysis)
  - DWR interpolation tool results (spatial and temporal interpolation of spatial coverages, using Ag Commission reports)
  - Local land use data comparison and validation

Inputs to the Subbasin water budget that are managed at the GSA or member-agency level include:

- **Time series:** time series data relating to GSA or member agency-specific inflows that are managed in a database structure and used to quantify surface water inflows/outflows
- **Local Data:** local data managed in spreadsheets and used to quantify GSA or member agency-specific inflows/outflows (diversions and deliveries not recorded in Subbasin-level data sources)
- **Deliveries**: Water district delivery data managed in a database structure and used to quantify surface water supply utilized for irrigation

The GSAs will manage data related to GSP project implementation within their boundaries. GSAs are continually working to refine data, identify data gaps, and incorporate additional information characterizing groundwater conditions in the Subbasin.

The GSAs are currently planning to review, update, and refine the current DMS to improve organization and more efficiently store, manage, and retrieve data. This will formalize the DMS, which will be developed to meet the requirements in the GSP Regulations, including 23 CCR §352.4, 23 CCR §352.6, and 23 CCR §354.4. The data will be managed so that appropriate tables, graphs, and maps supporting the GSP annual reports and periodic evaluations can be queried and provided to DWR.

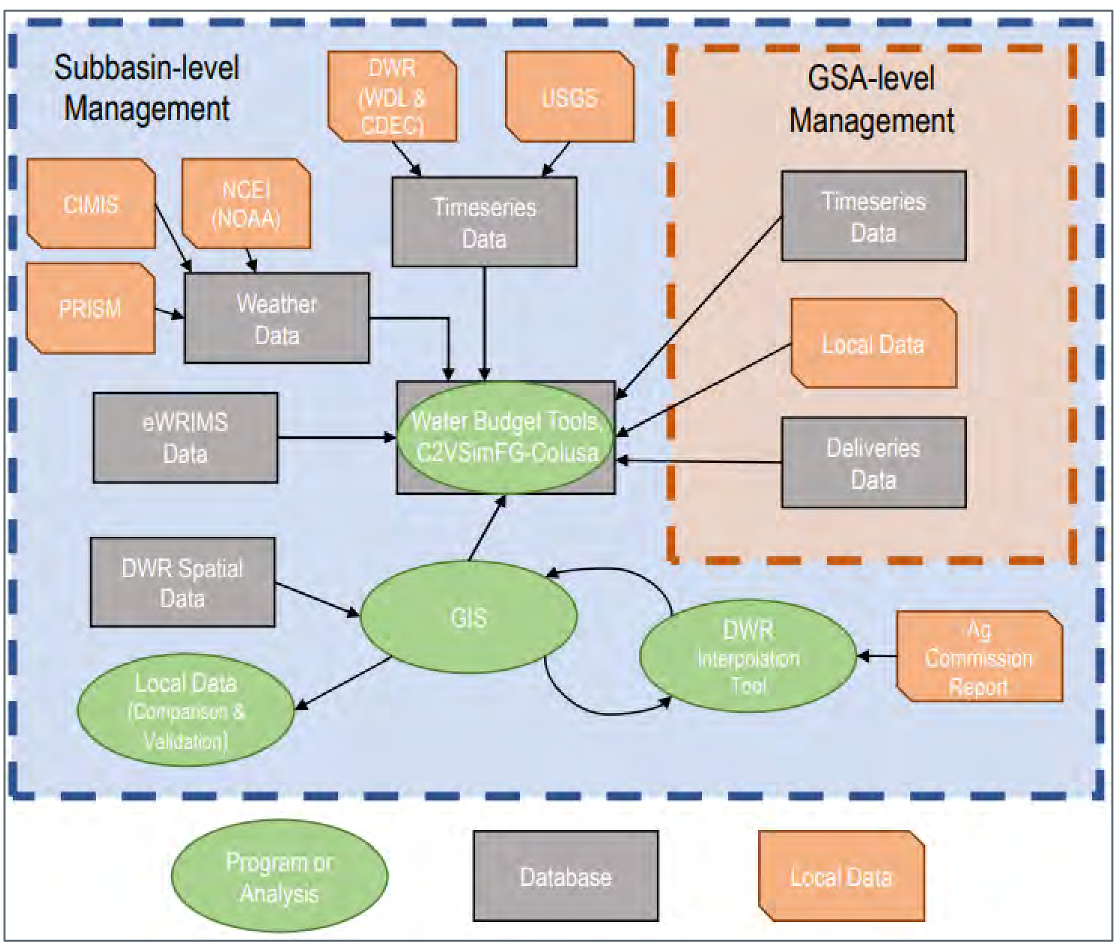


Figure 7-3. Data Management System Structure

(THIS PAGE LEFT BLANK INTENTIONALLY)

CHAPTER 8
References and Technical Studies

Bailey, E.H., Blake, M.C., and Jones, D.L. 1970. *On-land Mesozoic Oceanic Crust in California Coast Ranges.* U.S. Geological Survey Professional Paper 700-C:C70-C81.

Barlow, P.M., and Leake, S.A. 2012. *Streamflow depletion by wells—Understanding and managing the effects of groundwater pumping on streamflow.* U.S. Geological Survey Circular 1376, 84 p.

Bay Area Water Supply and Conservation Agency (BAWSCA). June 2020. *Regional Water Demand and Conservation Projections*.

Bertoldi, G.L. 1974. *Estimated Permeabilities for Soils in the Sacramento Valley, California*. U.S. Geological Survey Water-Resources Investigation 51-73, 17 p.

Bertoldi, G.L., R.H. Johnston, and K.D. Evenson. 1991. *Ground Water in the Central Valley, California – A Summary Report, Regional Aquifer System Analysis*. U.S. Geological Survey Professional Paper 1401-A.

Bertucci, P.F. 1983. *Petrology and provenance of the Stony Creek Formation, northwestern Sacramento Valley, California. Concord, CA.* Chevron U.S.A. Exploration Department.

Borchers, J.W. 1998. *Using Down-Well Television Surveys to Evaluate Land Subsidence Damage to Water Wells in the Sacramento Valley, in Land Subsidence*. Case Studies and Current Research, Proceedings of the Dr. Joseph F. Poland Symposium on Land Subsidence. J.W. Borchers, ed. Star Publishing Company, 576 p.

Brown and Caldwell. 2007. *Northern Sacramento Valley Sand Provenance Study Final Memorandum Report.* Prepared for the California Department of Water Resources, Northern District. October 2007.

Brown and Caldwell. 2013. *Tuscan Aquifer Investigation: Lower Tuscan Aquifer Monitoring, Recharge, and Data Management Project.* Prepared for Butte County Department of Water and Resource Conservation. May 2013.

Busacca, A.J., Singer, M.J., and Verosub, K.L. 1989. *Late Cenozoic Stratigraphy of the Feather and Yuba Rivers Area, California, with a Section on Soil Development in Mixed Alluvium Honcut Creek.* U.S. Geological Survey Bulleting 1590-G.

California Data Exchange Center. 2020. *Data Measurements from stations Black Butte Lake (BLB), Sacramento River at Ord Ferry-Main Channel (ORD), and Sacramento River below Wilkins Slough (WLK).* Accessed at http://cdec.water.ca.gov/.

California Geological Survey. 1981. *Geologic Map of the Sacramento Quadrangle.* Compiled by D.L. Wagner, C.W. Jennings, T.L. Bedrossian and E.J. Bortugno, 1:250,000, second printing. 1987.

California Geological Survey. 1982. *Geologic Map of the Santa Rosa Quadrangle.* Compiled by D.L. Wagner and E.J. Bortugno, 1:250,000, second printing. 1999.

California Water Service. 2016. *2015 Urban Water Management Plan – Willows District.* June 2016.

Caltrans. Assorted dates. *Caltrans Surveys Manual.* California Department of Transportation. Accessed at http://www.dot.ca.gov/landsurveys/surveys-manual.html

CDM. 2008. *Butte Basin Groundwater Model Update Phase II Report.* Prepared for Butte County Department of Water and Resource Conservation. March 2008.

Central Valley Regional Water Quality Control Board. 2016. *Review of the Groundwater Trend Monitoring Workplan and Data Gap Assessment Plan for the California Rice Commission.*

CH2MHILL & PlanTierra. 2013. *Rice-Specific Groundwater Assessment Report.* Prepared for Central Valley Regional Water Quality Control Board on behalf of California Rice Commission. July 2013.

CH2MHILL. 2016a. *Groundwater Quality Assessment Report.* Prepared for Central Valley Regional Water Quality Control Board on behalf of Northern California Water Association and Sacramento Valley Water Coalition. January 2016.

CH2MHILL. 2016b. *Groundwater Trend Monitoring Workplan and Data Gap Assessment Plan.* Prepared for Central Valley Regional Water Quality Control Board on behalf of California Rice Commission. March 2016.

Clemmens, A.J. and B.T. Wahlin. 2006. *Accuracy of Annual Volume from Current-Meter-Based Stage Discharges*. Journal of hydrologic engineering, 11(5), pp.489-501.

Colusa County. 2012. Comprehensive General Plan Update. July 2012.

Colusa, City of. 2007a. 2005-2025 General Plan Update October 2007.

Colusa, City of. 2007b. *Colusa General Plan Draft Master Environmental Impact Report.* Prepared by Pacific Municipal Consultants. July 2007. Accessed at Planning – City of Colusa

Davids Engineering, Inc. 2001. *Dunnigan Water District Groundwater Management Plan.* February 2001.

Davids Engineering, Inc. 2018. *Glenn County Preliminary Water Budget Development.* Prepared in cooperation with West Yost Associates for Glenn County. March 2018.

DeNovo Planning Group. 2012. *Colusa County General Plan*. Adopted July 31, 2012

Department of Public Health. 2020. *MCLs, DLRs, and PHGs for Regulated Drinking Water Contaminants: California Department of Public Health (DPH).* Revised August 2020.

Department of Toxic Substances Control (DTSC). 2020. *EnviroStor: California Department of Toxic Substances Control.* Website: http://www.envirostor.dtsc.ca.gov/public/

Department of Water Resources (DWR). 1978. *Evaluation of Groundwater Resources. Sacramento Valley, Bulletin 118-6.* Prepared in cooperation with the U.S. Geological Survey. August 1978.

Department of Water Resources. 2003. *Land Use Survey, Glenn and Colusa Counties.*

Department of Water Resources. 2004a. *California's Groundwater Bulletin 118: Sacramento Valley Groundwater Basin, West Butte Subbasin.* February 2004.

Department of Water Resources. 2004b. *Memorandum Report: Dunnigan Aquifer Study.* Dunnigan Water District, Dunnigan California. April 2004.

Department of Water Resources. 2006a. *California's Groundwater Bulletin 118: Sacramento Valley Groundwater Basin, Colusa Subbasin.* January 2006.

Department of Water Resources. 2006b. *California's Groundwater Bulletin 118: Sacramento Valley Groundwater Basin, Corning Subbasin.* January 2006.

Department of Water Resources. 2009a. *California Water Plan Update 2009 Sacramento River Integrated Water Management.* Bulletin 160-09, Volume 3.

Department of Water Resources. 2009b. *Glenn-Colusa Irrigation District Test-Production Well Installation and Aquifer Testing*. Prepared by the California Department of Water Resources Northern District Groundwater Section in cooperation with Glenn-Colusa Irrigation District. March 2009. GIS shapefiles provided by DWR 2008.

Department of Water Resources. 2014a. *Geology of the Northern Sacramento Valley.* Prepared by the California Department of Water Resources Northern Region Office, Groundwater and Geologic Investigations. Updated September 2014.

Department of Water Resources. 2014b. Land and Water Use Survey for 2003 and 2014. California Department of Water Resources.

Department of Water Resources. 2014c. *Summary of Recent, Historical, and Estimated Potential for Future Land Subsidence in California*. California Department of Water Resources.

Department of Water Resources. 2016a. *Best Management Practices for the Sustainability Management of Groundwater: Hydrogeologic Conceptual Model.* December 2016.

Department of Water Resources. 2016b. *Best Management Practices for the Sustainability Management of Groundwater. Monitoring Networks and Identification of Data Gaps*. December 2016.

Department of Water Resources. 2016c. *Best Management Practices for the Sustainability Management of Groundwater: Monitoring Protocols, Standards, and Sites.* December 2016.

Department of Water Resources. 2016d. *California's Groundwater Bulletin 118 Interim Update 2016.* December 2016.

Department of Water Resources. 2017. *Draft Sustainable Management Criteria Best Management* Practices. Accessed on September 10, 2020. Available online at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-6-Sustainable-Management-Criteria-DRAFT_ay_19.pdf

Department of Water Resources. 2018a. *2017 GPS Survey of the Sacramento Valley Subsidence Network.* California Department of Water Resources, Division of Integrated Regional Water Management, Northern Office. December 2018.

Department of Water Resources. 2018b. *Summary of the "Natural Communities Commonly Associated with Groundwater" Dataset and Online Web Viewer.* California Department of Water Resources and The Nature Conservancy. Website: https://gis.water.ca.gov/app/NCDatasetViewer/

Department of Water Resources. 2019. *Bulletin 118 Basin Boundary GIS Data, v.6.1.* Accessed at https://water.ca.gov/Programs/Groundwater-Management/Bulletin-118

Department of Water Resources. 2020a. *California Central Valley Groundwater-Surface Water Simulation model – Fine Grid (C2VSimFG) Development and Calibration, Version 1.0.* California Department of Water Resources, Sustainable Groundwater Management Office. December 2020.

Department of Water Resources. 2020b. *Sustainable Groundwater Management Act 2019 Basin Prioritization, Process and Results.* California Department of Water Resources. May 2020.

Department of Water Resources. 2020c. *Water Data Library.* California Department of Water Resources. Accessed at http://wdl.water.ca.gov/waterdatalibrary/index.cfm

Department of Water Resources. 2021a. *Online System for Well Completion Reports (OSWCR) Map Application.* California Department of Water Resources and California Open Data Portal. Accessed at https://dwr.maps.arcgis.com/apps/webappviewer and https://data.ca.gov/dataset/well-completion-reports

Department of Water Resources. 2021b. *SGMA Data Viewer*. Accessed at https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#currentconditions

Department of Water Resources, 2021c, Small Water Systems and Rural Communities Drought and Water Shortage Contingency Planning and Risk Assessment, Report Pursuant to Section 10609.42 of the California Water Code, Part I: Part 1 – Recommendations for Drought and Water Shortage Contingency Plans, and Part 2 – Drought and Water Shortage Vulnerability Assessment and Risk Scoring, Water Use Efficiency Branch, March.

Dupuy, D.I., Nguyen, D.H., and Jurgens, B.C. 2019. *California GAMA Priority Basin Project: Trends in water-quality for inorganic constituents in California public-supply wells (1st ed.).* U.S. Geological Survey. Accessed at https://ca.water.usgs.gov/projects/gama/public-well-water-quality-trends/https://doi.org/10.5066/P9AD3Q76

Ehorn, W. 2016. Letter from William Ehorn, North Region Office, California Department of Water Resources to Colusa County Board of Supervisors and Colusa County Water Commission, dated September 2016.

Environmental Defense Fund (EDF). 2018. Addressing Regional Surface Water Depletions in California: A Proposed Approach for Compliance with the Sustainable Groundwater Management Act. Accessed June 30, 2021. Available online at: https://www.edf.org/sites/default/files/documents/edf_california_sgma_surface_water.pdf

Evenson. 1985. *Chemical Quality of Ground Water in Yolo and Solano Counties, California.* U. S. Geological Survey Water-Resources Investigation Report 84-2444.

Evernden, J.F., D.E. Savage, G.H. Curtis, G.T. James. 1964. *Potassium-argon Ages and the Cenozoic Mammalian Chronology of North America.* American Journal of Science, V. 262, pp.145-198.

Farr, T.G., Jones, C., and Liu, Z. 2015. *Progress Report: Subsidence in the Central Valley, California.* California Department of Water Resources and California Institute of Technology under contract with NASA.

Frame, J.F. and D'Onofrio, D. 2008. *DWR/USBR Sacramento Valley Subsidence Project, Project Report.* California Department of Water Resources and U.S. Bureau of Reclamation. September 2008.

Garrison, N.J. 2004. *Geology, Geochronology and Geochemistry of the Mid-Miocene Lovejoy Flood Basalt, Northern California.* Master of Science Thesis, University of California, Santa Barbara. 2004.

Glenn County. 2005. *Northern Sacramento Valley (Four County) Drinking Water Quality Strategy Document.* Glenn County Department of Agriculture. June 2005.

Glenn County. 2012. *Groundwater Coordinated Resource Management Plan.* County Code Directory, Title 20, Chapter 30, 20.030.

Glenn-Colusa Irrigation District (GCID). 1995. *Groundwater Management Plan AB3030.* Glenn-Colusa Irrigation District.

Glenn-Colusa Irrigation District. 2017. Accessed at https://www.gcid.net/.

Guy, D.J. 2016. *Groundwater Quality Assessment Report Revision.* Letter to Central Valley Regional Water Quality Control Board. January 2016.

Harwood, D.S., and E.J. Helley. 1987. *Late Cenozoic Tectonism of the Sacramento Valley, California.* U.S. Geological Survey Professional Paper 1359.

Harwood, D.S., E.J. Helley and M.P. Doukas. 1981. *Geologic Map of the Chico Monocline and Northeastern Part of the Sacramento Valley, California.* U. S. Geological Survey Miscellaneous Investigations Map I-1238, scale 1:62,500.

Hausback, B.P. and Nilsen, T.H. 1999. *"Sutter Buttes," in DL Wagner and SA Graham, Geologic Field Trips in Northern California.* Centennial Meeting of the Cordilleran Section of the Geological Society of America, Special Publication 119. California Division of Mines and Geology, pp. 246-254.

Helley, E.J. and Harwood, D.S. 1985. *Geologic Map of the Late Cenozoic Deposits of the Sacramento Valley and Northern Sierran Foothills, California.* U.S. Geological Survey Field Studies Map MF-1790, scale 1:62,500, GIS geodatabase.

Hull, L.C. 1984. *Geochemistry of the Ground Water in the Sacramento Valley, California*. U.S. Geological Survey Professional Paper 1401-B. Regional Aquifer System Analysis.

Ikehara, M.E. 1994. G*lobal Positioning System Surveying to Monitor Land Subsidence in Sacramento Valley, California, USA.* Hydrological Sciences Journal, V. 39, No. 5, pp. 417-429.

Jennings, C.W. and Strand, R.G. 1960. Geologic Map of California, Olaf P. Jenkins edition, Ukiah Sheet. Department of Natural Resources Division of Mines and Geology (CDMG) Geologic Atlas Map GAM-24, third printing 1992, scale 1:250,000.

Jones, D.L., Bailey, E.H., and Imlay, R.W. 1969. *Structural and Stratigraphic Significant of the Buchia Zones in the Colyear Springs-Paskenta Area, California.* U.S. Geological Survey Professional Paper 647-A.

Jurgens, B.C., Fram, M.S., Rutledge, J., Bennett V., G.L. 2020. *Identifying Areas of Degrading and Improving Groundwater-Quality Conditions in the State of California.* USA, 1974–2014. Environ Monit Assess 192, 250. Accessed at https://doi.org/10.1007/s10661-020-8180-y

Klausmeyer K., J. Howard, T. Keeler-Wolf, K. Davis-Fadtke, R. Hull, A. Lyons. 2018. *Mapping Indicators of Groundwater Dependent Ecosystems in California: Methods Report*.

Koenig, J.B. 1963. Geologic Map of California, Olaf P. Jenkins edition, Santa Rosa Sheet. California Department of Natural Resources Division of Mines and Geology Geologic Atlas Map GAM-22, scale 1:250,000.

Lettis, W.R. 1988. Quaternary Geology of the Northern San Joaquin Valley, in Graham, S.A., ed. Studies of the San Joaquin Basin: SEPM, Pacific Section, V. 60, pp. 333-351.

Luhdorff and Scalmanini, Consulting Engineers. 2019. *2018 Annual Groundwater Monitoring Results, Sacramento Valley Water Quality Coalition*. May 1, 2019.

Lydon, P.A. 1968. *Geology and Lahars of the Tuscan Formation, Northern California.* Geological Society of America Memoir 116, pp. 441-475.

Maloney, D.F. 2017. *The Tehama Formation at Black Butte Lake with a Review of the Geology of the Orland Buttes.* California State University, Chico Masters of Science Thesis. Summer 2017.

McPherson, BJOL and Garven, G. 1999. *Hydrodynamics and Overpressure Mechanisms in the Sacramento Basin, California.* American Journal of Science 299, pp. 429-466.

Moxon, I.W. 1990. *Stratigraphy and Structure of Upper Jurassic-Lower Cretaceous Strata, Sacramento Valley.* Sacramento Valley Symposium and Guidebook, Stanford University, pp. 5-29.

National Resources Conservation Service. 1986. *Urban Hydrology for Small Watersheds.* Conservation Engineering Division, Natural Resources Conservation Service. U.S. Department of Agriculture Technical Report 55. June 1986.

National Resources Conservation Service (NRCS). 2017. *Soil Survey Geographic Database (SSURGO).* National Resources Conservation Service, Colusa and Glenn Counties.

National Water Quality Monitoring Council. 2020. *National Water Quality Monitoring Council Water Quality Portal.* Accessed at https://www.waterqualitydata.us/portal/, in 2020.

O'Geen, A.T. et. al. 2015. *Soil Suitability Index Identifies Potential Areas for Groundwater Banking on Agricultural Lands.* California Agriculture, volume 69, number 2, pp 75-84. GIS files obtained November 2017.

Ojakangas, RW. 1968. *Cretaceous sedimentation, Sacramento Valley, California.* Geological Society of America Bulletin 79(8):973-1008.

Olmsted, F.H. and Davis, G.H. 1961. *Geologic Features and Ground-Water Storage Capacity of the Sacramento Valley, California.* U.S. Geological Survey Water-Supply Paper 1497.

Orland Municipal Services. 2014. *Orland Municipal Services Review.* Adopted April 14, 2014, Glenn LAFCO Resolution 2014-03.

Orland, City of. 2014. *Water System Capacity Study.* Prepared by Rolls Anderson & Rolls. July 1, 2014.

Pacific Municipal Consultants and North Fork Associates. 2007. *City of Colusa General Plan Update 2005-2025*. Adopted October 30, 2007. Adopted by Resolution No. 07-30

Pacific Municipal Consultants. 2008. *City of Orland, Draft General Plan 2008-2028*. July 2008.

Page, R.W. 1986. *Geology of the Fresh Ground-Water Basin of the Central Valley, California with Texture Maps and Sections, Regional Aquifer System Analysis*. U.S. Geological Survey Professional Paper 1401-C.

Page, R.W. 1998. *A Compressible Diatomaceous Clay, Sacramento Valley, California, in Land Subsidence.* Case Studies and Current Research. Proceedings of the Dr. Joseph F. Poland Symposium on Land Subsidence. J.W. Borchers, ed., Star Publishing Company, 576 p.

Page, R.W. and Bertoldi, G.L. 1983. *A Pleistocene diatomaceous clay and a pumiceous ash*. California Geology, v. 36, p. 14-20.

Page. 1995. From Springhorn dissertation, reference for Lovejoy Basalt.

QUAD Consultants. 1993. *Glenn County General Plan Volume 1.* June 15, 1993. Adopted by Resolution No. 93-61

Rantz, S.E. and others. 1982. *Measurement and Computation of Streamflow.* U.S. Geological Survey Water Supply Paper 2175. Accessed at https://pubs.usgs.gov/wsp/wsp2175/

Reclamation District 108. 2008. *Groundwater Management Plan.* Reclamation District No. 108. November 2008.

Redwine, L.E. 1984. *The Tertiary Princeton Submarine Valley System Beneath the Sacramento Valley, California.* American Association of Petroleum Geologists. Publication Paleogene Submarine Canyons of the Sacramento Valley, California, pp. 53-80.

Rohde, M. M., S. Matsumoto, J. Howard, S. Liu, L. Riege, and E. J. Remson. 2018. *Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans*. The Nature Conservancy.

Russell, R.D. 1931. *The Tehama Formation of Northern California.* University of California Ph.D. Thesis, 142 p.

Saucedo, G.J. and Wagner, D.L. 1992. *Geologic Map of the Chico Quadrangle.* Department of Conservation Division of Mines and Geology (CDMG). Regional Geologic Map Series Map No. 7A, scale 1:250,000.

Springhorn, S.T. 2008. *Stratigraphic Analysis and Hydrogeologic Characterization of Cenozoic Strata in the Sacramento Valley near the Sutter Buttes.* Master of Science Dissertation, California State University, Chico.

State Water Resources Control Board (SWRCB). 2017. *Groundwater Information Sheets, Assorted Chemicals.* California State Water Resources Control Board, Division of Water Quality, GAMA Program. Revised November 2017.

State Water Resources Control Board. 2018a. *Maximum Contaminant Levels and Regulatory Dates for Drinking Water, U.S. EPA versus California.* California State Water Resources Control Board. Revised October 2018.

State Water Resources Control Board. 2018b. *California Code of Regulation Title 22. Division 4. Chapter 15. Article 16. Secondary Water Standards.* California State Water Resources Control Board. Revised October 2018.

State Water Resources Control Board. 2020a. *GeoTracker Groundwater Ambient Monitoring and Assessment (GAMA)*: California State Water Resources Control Board. Accessed at http://geotracker.waterboards.ca.gov/gama

State Water Resources Control Board. 2020b. *GeoTracker Map.* California State Water Resources Control Board. Accessed at http://geotracker.waterboards.ca.gov/map

State Water Resources Control Board. 2020c. *Drinking Water Notification Levels and Response Levels: An Overview.* California State Water Resources Control Board Division of Drinking Water. Revised February 2020.

State Water Resources Control Board. 2021. *Human Right to Water Portal.* Accessed at https://www.waterboards.ca.gov/water_issues/programs/hr2w/ , November 18, 2021.

Tehama-Colusa Canal Authority. 2009. Accessed at http://www.tccanal.com/about.php, in 2020.

Theis, C.V. 1935. *The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well using Ground-water Storage.* Transactions of the American Geophysical Union, V. 16, pp. 519-524.

TRE ALTAMiRA. 2020. *InSAR Land Surveying and Mapping Services in Support of the DWR SGMA Program Technical Report*. March 2020.

U. S. Bureau of Reclamation (USBR) and Colusa Basin Drainage District. 2000. *Integrated Resources Management Program for Flood Control in the Colusa Basin.* Draft Programmatic EIS/EIR. May 2000.

U.S. Department of the Interior. 2014. *Classification of Wetlands and Deepwater Habitats of the United States.* U.S. Department of the Interior (USDI) Fish and Wildlife Service (FWS), Washington D.C., FWS/OBS-79-31.

U.S. Environmental Protection Agency (USEPA). 1986. *Quality Criteria for Water [The Gold Book].* U.S. Environmental Protection Agency. May 1986.

U.S. Environmental Protection Agency. 2020. *Safe Drinking Water Information System (SDWIS) Federal Reporting Services, Drinking Water Branch, Drinking Water Watch, California Public Water Supply Systems.* U.S. Environmental Protection Agency. Accessed at https://sdwis.waterboards.ca.gov/PDWW/index.jsp

U.S. Fish and Wildlife Services (USFWS), Sacramento, Delevan, Colusa, and Sutter National Wildlife Refuges. 2009. *Final Comprehensive Conservation Plan, and Environmental Assessment, Volume 1.* March 2009.

U. S. Geological Survey (USGS). 2018. *The National Map.* U.S. Geological Survey. Accessed at http://viewer.nationalmap.gov/.

U.S. Geological Survey. 2020. *National Water Information System.* U.S. Geological Survey. Accessed at https://waterdata.usgs.gov/nwis/qw

U. S. Geological Survey. 2021. *Sustainable Groundwater: Interconnected Surface-Water Depletion.* U.S. Geological Survey. Website: https://ca.water.usgs.gov/sustainable-groundwater-management/interconnected-surface-water-depletion.html

University of Texas, Austin. 2017. *Gravity Recovery and Climate Experiment.* University of Texas, Austin jointly implanted by NASA and DLR under the NASA Earth System Science Pathfinder Program. Accessed at http://www2.csr.utexas.edu/grace/

Unruh, J.R. 1990. *Stratigraphy and Lake Cenozoic Deformation in the Oroville Area, East-Central Sacramento Valley, California*. Ph.D. Dissertation, University of California, Davis.

URS Corporation Americas. 2020. *Contract No. 10-T1126 Groundwater Monitoring Report, October 2019, Orland Dry Cleaners Site, Orland, California.* Prepared by URS Corporation Americas for California Department of Toxic Substances Control, Region 1. May 2020.

Van Den Berge, J.C. 1968. *The Paleogeomorphological Features of the Lovejoy Formation in the Sacramento Valley, California.* Master of Science Thesis, University of California, Davis.

Water Resources Association of Yolo County. 2004. *Draft Volume 1 of the Yolo County Integrated Regional Water Management Plan.* Prepared in cooperation with the California Department of Water Resources. August 2004.

Weissmann, G.S., J.F. Mount, and G.E. Fogg. 2002. *Glacially Driven Cycles in Accumulation Space and Sequence Stratigraphy of a Stream Dominated Alluvial Fan, San Joaquin Valley California.* USA, Journal of Sedimentary Research, V. 72, No. 2, pp. 240-251. March 2002.

Welch, A.H., Lico, M.S., and Hughes, J.L. 1988. *Arsenic in Ground Water of the Western United States: Groundwater.* Vol. 26, No. 3, May-June, pp. 333-347.

West Yost & Associates (WYA). 2004. *Draft Technical Memorandum: Results of Deep Aquifer Pumping Test, Phase I Southern Yolo County Deep Aquifer Study.* July 2004.

West Yost & Associates. 2012. *Aquifer Performance Testing Report: prepared for Stony Creek Fan Partners.* December 2012.

West Yost & Associates. 2014. *Northern Sacramento Valley Integrated Regional Water Management Plan.* Prepared by the Counties of Butte, Colusa, Glenn, Shasta, Sutter, and Tehama with assistance from West Yost Associates. Adopted March 2014.

West Yost & Associates. 2018. *Monitoring Network Assessment Report*. Prepared in cooperation with Davids Engineering for the Counties of Colusa and Glenn. March 2018.

Western Regional Climate Center (WRCC). 2020. *Historical Western U.S. Climate Summaries – NOAA COOP Stations.* Accessed 2020: https://wrcc.dri.edu/ in 2020.

William Lettis and Associates. 2002. *Phase II fault and seismic hazards investigations: North of Delta offstream storage DWR — Integrated Storage Investigations.* William Lettis and Associates, Walnut Creek, California.

Williams, City of. 2010. 2010 General Plan Update. May 2012.

Williams, City of. 2012. *City of Williams General Plan Update Background Analysis.* May 2012.

Williams, H. and Curtis, G.H. 1977. *The Sutter Buttes of California: A Study of Plio-Pleistocene Volcanism.* University of California Publications, Bulletin of the Department of Geological Sciences, v. 18 p. 103-220.

Williamson, A.K., D.E. Prudic and L.A. Swain. 1989. *Ground-Water Flow in the Central Valley, California, Regional Aquifer System Analysis*. U.S. Geological Survey Professional Paper 1401-C.

Winter, T.C., Harvey, J.W., Franke, O.L., and Alley, W.M. 1998. *Ground water and surface water—A single resource*. U.S. Geological Survey Circular 1139, 79 p.

Wood Rodgers. 2008. *Colusa County Groundwater Management Plan.* September 2008.

Woodard and Curran and Davids Engineering, Inc. 2020. *Draft C2VSimFG-Colusa Model Development and Calibration Technical Memorandum*: prepared as part of the Groundwater Sustainability Plan for the Colusa Subbasin.

WRIME. 2003a. *Stony Creek Fan IGSM Model Development Calibration and Analysis.* Prepared for Orland-Artois Water District Orland Unit Water Users' Association, and Glenn-Colusa Irrigation District in coordination with California Department of Water Resources. May 2003.

WRIME. 2003b. *Stony Creek Fan Integrated Groundwater and Surface Water Model (SCFIGSM) Hydrogeology and Conceptual Model*. Prepared for Orland-Artois Water District Orland Unit Water Users' Association, and Glenn-Colusa Irrigation District in coordination with California Department of Water Resources. May 2003.

COLUSA SUBBASIN