Appendix 6D

Development of Modeling Parameters for Simulating Projects and Management Actions in the Colusa Subbasin

Technical Memorandum

To: Colusa Groundwater Authority and Glenn Groundwater Authority

From: Davids Engineering

Date: July 14, 2021

Subject: **Development of Modeling Parameters for Simulating Projects and Management Actions in the Colusa Subbasin**

Introduction

The Groundwater Sustainability Plan (GSP) emergency regulations, described in 23 CCR §354.44[1], require Groundwater Sustainability Agencies (GSAs) to describe projects and management actions (PMAs) that will achieve the sustainability goal for the basin and respond to changing conditions in the basin. Among other required information, GSAs must describe the benefits that are expected to be realized from the PMAs and how those benefits will be evaluated (23 CCR §354.44(b)(5)). The development and description of PMAs must be supported by the best available information and best available science (23 CCR §354.44(c)).

This technical memorandum (TM) describes the modeling approach and model inputs that were used to simulate the expected benefits of planned PMAs in the Colusa Subbasin (or Subbasin) using the C2VSimFG-Colusa model (model). The model inputs reflect the anticipated volume and timing of surface water supply available through specific PMAs for direct and in-lieu groundwater recharge. The model inputs also characterize where that water would be beneficially used within the Subbasin.

In addition to the model inputs, this memorandum summarizes model results from the PMA simulations that represent the quantitative benefits of these PMAs on projected future groundwater conditions in the Colusa Subbasin. At the time of GSP development the model is considered to provide the best available information on groundwater conditions in the Subbasin, and the accuracy of this information is generally sufficient to support GSP preparation, including description of PMA benefits.

Overview of Modeled PMAs

There are five planned projects described in the Colusa Subbasin GSP that are on track for implementation. Three of those projects were selected for simulation in the model in order to gain initial insights into the magnitude of impacts from these projects. These three projects are substantial recharge projects that could have large effects on groundwater conditions relative to other PMAs. Model inputs and model

[1] California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2 Groundwater Sustainability Plans, Article 5, Section 354.28 Minimum Thresholds.

results for the three modeled projects are the focus of this TM. However, the modeling approach and inputs described for these projects can be adapted to simulate other similar projects.

General background on the three modeled projects is provided below. Additional information about these PMAs and others is included in Chapter 6 of the Colusa Subbasin GSP, Projects and Management Actions.

Colusa County Water District In-Lieu Groundwater Recharge

Colusa County Water District (CCWD) has a total service area of approximately 46,000 acres, of which 39,875 acres are currently irrigable with existing District infrastructure. The majority of irrigated land is used to cultivate permanent crops. CCWD delivers surface water to approximately 35,000 acres, with the remaining acres being idle or irrigated with privately pumped groundwater. Currently, CCWD has access to Central Valley Project (CVP) water supplies through its own contracts and through transfers primarily from Westside Water District and, more recently, from Reclamation District 108 (RD108). Despite the availability of district surface water, some CCWD growers choose to pump groundwater because it is less expensive than surface water and because groundwater requires less screening and filtering compared to district surface water.

Under the CCWD In-Lieu Groundwater Recharge project, CCWD will acquire additional surface water and will establish incentives to make the cost of surface water the same or less than the cost of pumping groundwater, thereby incentivizing growers who would otherwise use groundwater to use surface water. The additional surface water is expected to be acquired under long-term water transfer agreements with other CVP contractors, including Sacramento River Settlement Contractors (settlement contractors), and potentially other sources. The plan is to acquire and deliver 30,000 acre-feet per year (AF/yr) except in Shasta Critical years (approximately one in 10 years[2]) when groundwater stored through in-lieu recharge in prior years would be used.

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

Orland-Artois Water District (OAWD) has an existing service area of about 29,000 acres and delivers water to district landowners through 110 miles of pipelines and 300 metered delivery points. Surface water delivered by OAWD is available under a CVP water supply contract with the United States Bureau of Reclamation (Reclamation) and through short- and long-term transfer agreements with other CVP water contractors and settlement contractors. Historically, water transfers have been from Maxwell Irrigation District, Princeton-Codora-Glenn Irrigation District, and others.

As part of the OAWD Land Annexation and In-Lieu Groundwater Recharge project, OAWD is working with a group of neighboring non-district landowners to annex approximately 12,000 acres of groundwater-dependent agricultural land into the district. Additional surface water for the annexed lands would be secured through multi-year purchase or transfer agreements with willing sellers, conveyed through the existing Tehama-Colusa (TC) Canal, and distributed to the annexed lands through new distribution facilities. Potential transferors include CVP water supply contractors and settlement contractors. The plan is to acquire and deliver 25,000 AF/yr of surface water to the annexed lands except in Shasta Critical years (approximately one in 10 years) when groundwater banked through in-lieu recharge in prior years would be used.

[2] Over the 50-year period from 1966-2015, five years were declared “Shasta Critical.”

Colusa Subbasin Multi-Benefit Groundwater Recharge

The Colusa Groundwater Authority (CGA) and The Nature Conservancy (TNC) collaborated in a multi-benefit pilot project from 2018 through 2020 to demonstrate the project benefits to direct groundwater recharge and creation of habitat for migrating shorebirds. In the pilot project, multi-benefit recharge was conducted by recharging groundwater through normal farming operations at strategic times of year in order to also provide critical wetland habitat for shorebirds migrating along the Pacific Flyway, and potential ancillary benefits for water levels near disadvantaged communities in the subbasin. The pilot project concluded that multi-benefit recharge is feasible and does generate the intended recharge and habitat benefits, serving as an example of how a Colusa Subbasin-wide program could work.

The planned Colusa Subbasin Multi-Benefit Groundwater Recharge project would expand on the pilot project to identify and contract with willing landowners who will participate in the program, and to develop program incentives and funding opportunities that will encourage enrollment, especially in areas that are most suitable for multi-benefit recharge. Each year, multi-benefit recharge would be implemented by applying surface water to participating fields and maintaining a shallow depth (4 inches maximum) for typically four to six weeks between late summer and early fall, when migratory bird habitat is needed.

While the actual location and scale of the project will depend on voluntary landowner participation, areas in the Colusa Subbasin that are potentially favorable for multi-benefit recharge have already been identified through preliminary mapping based on:

- Land use and crop characteristics that are suitable for recharge and could accept flooding in late summer and early fall, with minimal impacts to crops and farming operations
- Soil characteristics that are suitable for recharge, using the Soil Agricultural Groundwater Banking Index (SAGBI[3]) rating
- Availability of surface water supplies for field-flooding during prime periods when migratory bird habitat is needed
- Proximity to the Sacramento River, as those lands are expected to have the greatest positive impact on streamflows

Analytic Approach

Modeling Approach

The quantitative benefits of the three modeled projects to groundwater conditions in the Colusa Subbasin were evaluated using the C2VSimFG-Colusa model (model), an integrated hydrologic flow model for the Colusa Subbasin. Development and refinement of this model to support GSP development is described in Appendix 3D. The C2VSimFG-Colusa model was adapted from the Fine Grid California Central Valley Groundwater-Surface Water Simulation Model (C2VSimFG).

The model simulates inflows and outflows between the Subbasin surface water system and groundwater system in a grid of land elements, stream nodes, and groundwater nodes that span and

[3] 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 UC Davis and UC-ANR, and are available online at: https://casoilresource.lawr.ucdavis.edu/sagbi/.

surround the Colusa Subbasin. The model calculates a water budget for each element and node on a monthly timestep for different historical, current, and projected (future) scenarios described in the GSP. Results of these element and node-level water budgets are aggregated to quantify the historical, current, and projected water budgets for the entire Colusa Subbasin, as required in the GSP regulations.

Among their many functions, user-defined model inputs are used to determine when, where, and how much water is applied to lands and ultimately recharges the groundwater system. Key water budget parameters that were evaluated to quantify the groundwater recharge benefits of the three modeled projects include:

- Surface Water Diversions: Surface water diverted from a stream node and delivered to elements. Surface water diversions are a user-defined model input, and are summarized to describe the average annual surface water volume diverted for the PMA.
- Groundwater Pumping: Groundwater pumped to meet water demand in elements. For these projects, groundwater pumping is calculated by the model to meet the remaining irrigation demand after surface water is applied.
- Seepage: For these projects, seepage represents water that is lost from streams, canals, or conveyance systems, flowing through the soil and to the groundwater system. Seepage is a component of groundwater recharge, and is calculated by the model.
- Deep Percolation: For these projects, deep percolation represents the fraction of water applied to fields that flows through the soil and to the groundwater system. Deep percolation is a component of groundwater recharge, and is calculated by the model.

Additional information about how the model operates, its inputs, and assumptions are provided in the model documentation and Appendix 3D.

Modeled Project Areas

Three project areas were explicitly defined in the C2VSimFG-Colusa model to quantify the effects and benefits of PMAs on the Colusa Subbasin water budget, specifically those related to groundwater conditions. These project areas, shown in Figure 1, include:

1) **Planned CCWD Project Area**: a group of elements that approximately represents the CCWD service area
2) **Planned OAWD Project Area**: a group of elements that approximately represents the existing OAWD service area and the 12,000 acres that OAWD plans to annex
3) **Multi-Benefit Recharge Project Area:** a group of elements that represents a hypothetical selection of potential recharge areas, containing fields identified through the process described in Section 0 of this TM

Each project area is represented by a group of elements that approximately represents the areas in which specific projects are expected to occur. Model inputs developed for the three modeled PMAs were applied and simulated in the elements represented in each project area.

The C2VSimFG-Colusa model calculates the water budget for each model element for each monthly timestep, including the elements in each project area. For all elements in each project area, the element-level water budget results were summed to aggregate project area water budget results.

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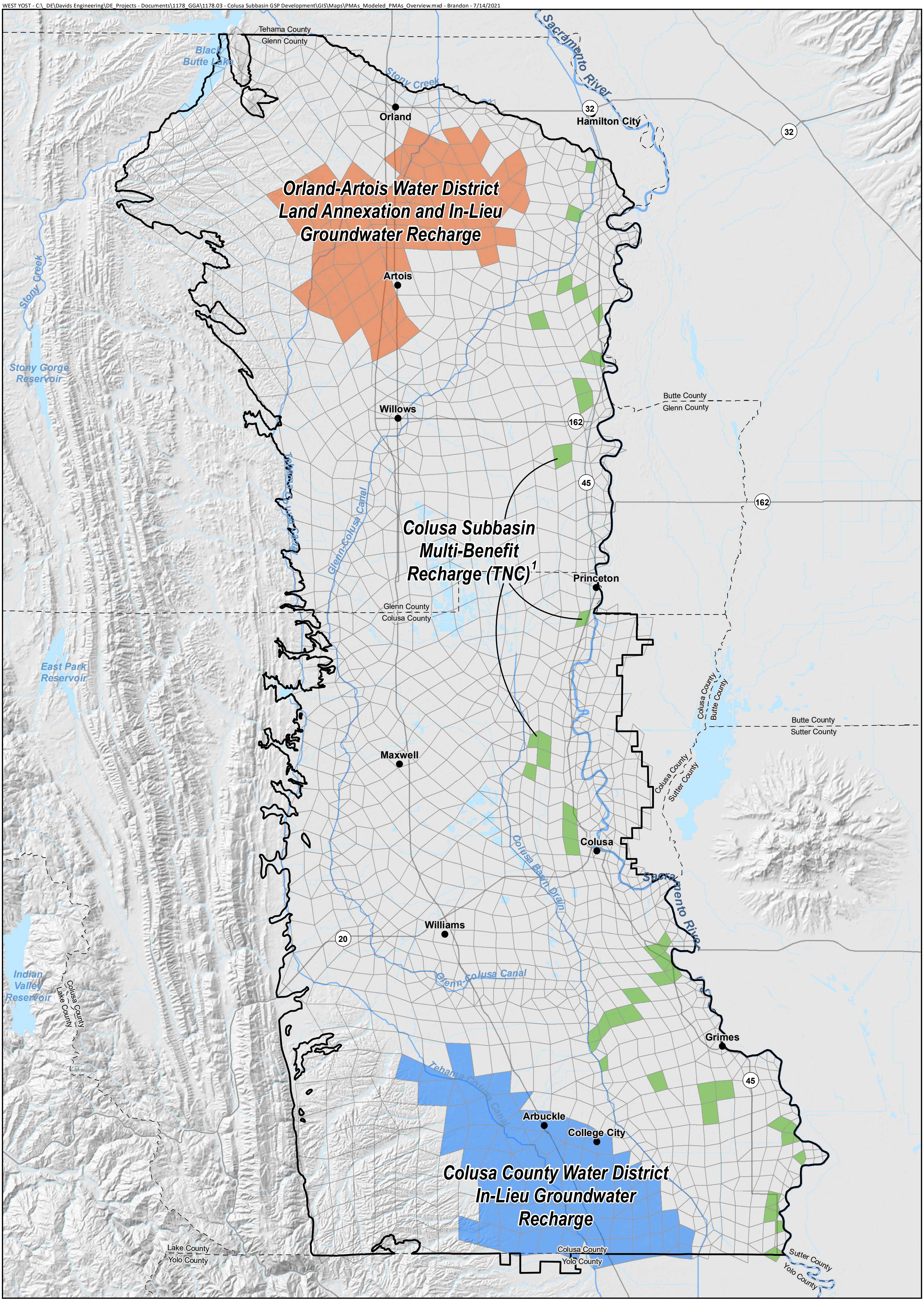

Planned CCWD PMA Project Area
Multi-Benefit Recharge PMA Project Area
Planned OAWD PMA Project Area
Model Elements Without Modeled PMAs
Colusa Subbasin Boundary

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. For purposes of modeling project impacts, elements were selected based on lands with cropping schedules that allow for flooding during bird migration periods and total roughly 4,000 acres.

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0 2.5 5
Scale in Miles

Modeling Projects and Management Actions

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

Model Scenarios

Two model scenarios were considered for quantifying the effects and benefits of PMAs on the Colusa Subbasin:

- **Without-Projects Scenario**—Projected Future Conditions with 2070 Climate Change and without Projects. This is the projection of future conditions over the 50-year period from 2016 through 2065, assuming climate change effects are occurring but that no groundwater recharge or other types of projects are implemented. Climate change adjustments were made to the precipitation, evapotranspiration, and surface water supply model inputs to reflect the estimated effects of climate change based on the 2070 Central Tendency climate change datasets provided by DWR to support GSP development.[4] The main effect of these adjustments is an estimated increase in future crop water requirements, which result in the need for increased groundwater pumping.
- **With-Projects Scenario**—Projected Future Conditions with 2070 Climate Change and with Projects. This is the same as the "without-projects" scenario, except that it is assumed that the three modeled projects are in operation during the full duration of the 50-year simulation.

Hereinafter, for convenience, these model scenarios are referred to as the "without-project" and "with-project" scenarios, respectively. The model inputs differ only due to projects; thus, differences in model results between these scenarios are due entirely to the effects of the projects.

The analysis period and assumptions about hydrology, land use, and water supplies associated with each model scenario are summarized in **Table *1***. Projected future water supplies and land use are expected to vary depending on Shasta watershed hydrologic conditions and related CVP operations plans prepared by Reclamation. Water supplies and flows through the Colusa Subbasin may be reduced in hydrologic years designated by Reclamation as "Shasta Critical"[5], such as 2015, resulting in reduced cropped acreage in those years. In "Shasta Non-Critical" years, water supplies and land use are expected to be similar to current conditions in recent non-drought years, such as 2013. In the future analysis period (2016-2065), future years are mapped to a series of historical years that were selected to represent historical hydrology as the baseline for estimating future hydrology (23 CCR §354.18(c)(3)). The Shasta Critical or Non-Critical designation of those historical years was also mapped to the corresponding future years.

Additional information on these scenarios is provided in Chapter 3, Section 3.3, of the Colusa Subbasin GSP.

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[4] Climatological, hydrological, and water operations datasets, change factors, and the DWR Climate Change Resource Guide are available at: https://data.cnra.ca.gov/dataset/sgma-climate-change-resources.

[5] In general, "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 million acre-feet. Conversely, Shasta Non-Critical conditions are declared when the forecast inflow to Lake Shasta for a particular water year exceeds 3.2 million acre-feet. Between 1966-2015, five years were "Shasta Critical," or approximately 1 in 10 years.

Table 1. Summary of Water Budget Assumptions Used for the Without-Projects Scenario and With-Projects Scenario

Model Scenario	Analysis Period[1]	Hydrology	Land Use	Water Supplies
Without-Projects Scenario: Projected Future Conditions with 2070 Climate Change and without Projects	2016-2065	Historical (1966-2015), adjusted based on 2070 Central Tendency climate change datasets	Current (2013 and 2015) used for Shasta Non-Critical and Shasta Critical, respectively	Same as Current (see above), adjusted for 2070 Central Tendency climate change
With-Projects Scenario—Projected Future Conditions with 2070 Climate Change and with Projects.	2016-2065	Historical (1966-2015), adjusted based on 2070 Central Tendency climate change datasets	Current (2013 and 2015) used for Shasta Non-Critical and Shasta Critical, respectively	Same as Current (see above), adjusted for 2070 Central Tendency climate change

1 Results over the analysis period are summarized by water year (October 1 through September 30)

Model Inputs for PMAs

As described above, model inputs for the three modeled PMAs reflect the anticipated volume and timing of surface water supply available through the PMAs for direct and in-lieu groundwater recharge. The model inputs also characterize where that water is beneficially used within the Subbasin. Model inputs developed for each of the three modeled PMAs are described below.

Colusa County Water District In-Lieu Groundwater Recharge

Under the CCWD In-Lieu Groundwater recharge project, CCWD plans to acquire and deliver 30,000 acre-feet per year (AF/yr) of additional surface water except in Shasta Critical years (approximately one in 10 years[6]).

For modeling, it was assumed in the with-project scenario that an additional 30,000 AF/yr will be delivered to all irrigated agricultural land in model elements that approximately represent the CCWD service area (Figure 1) during Shasta Non-Critical years in the 2016-2065 analysis period. The 30,000 AF is in addition to surface water supplies delivered in the without-project scenario. In Shasta Critical years, no additional surface water is delivered to those elements.

Orland-Artois Water District Land Annexation and Groundwater Recharge

As part of the OAWD Land Annexation and In-Lieu Groundwater Recharge project, OAWD plans to annex approximately 12,000 acres of groundwater-dependent agricultural land into the district. OAWD also plans to acquire and deliver 25,000 AF/yr of surface water to the annexed lands except in Shasta Critical years (approximately one in 10 years).

For modeling, it was assumed in the with-project scenario that an additional 25,000 AF/yr will be delivered to all irrigated agricultural land in the OAWD project area (Figure 1) during Shasta Non-Critical years in the 2016-2065 analysis period. The OAWD project area contains model elements that

[6] Over the 50-year period from 1966-2015, five years were declared "Shasta Critical."

approximately represent the OAWD service area as well as the 12,000 acres that OAWD plans to annex. The 25,000 AF/yr is in addition to surface water supplies delivered in the without-project scenario. In Shasta Critical years, no additional surface water is delivered to the OAWD service area and groundwater is the sole irrigation supply source for the annexed area.

Colusa Subbasin Multi-Benefit Groundwater Recharge

In the Colusa Subbasin Multi-Benefit Recharge project, voluntarily participating growers will apply surface water to fields and maintain a shallow depth (4 inches maximum) for typically four to six weeks between late summer and early fall, when migratory shorebird habitat is needed.

For modeling the multi-benefit groundwater recharge project, key assumptions and analyses were developed to identify one hypothetical project configuration as a "bookend" scenario, in which maximal grower participation occurs in areas with the greatest multi-benefit groundwater recharge potential. In practice, the actual location and scale of the project will depend on voluntary landowner participation from year to year. The assumptions and analyses underpinning the with-project scenario model inputs were formulated to estimate:

- Where the greatest potential combination of multi-benefits could occur (considering groundwater recharge potential, habitat creation suitability, and other factors of interest),
- When the project would be implemented (on a monthly and annual basis), and
- How much voluntary participation could occur (assuming, at a maximum, that all lands with the greatest potential combination of multi-benefits will participate each year water is available)

The specific approach and assumptions are as follows:

- A geospatial analysis was completed to identify all "potential recharge areas" in the Colusa Subbasin. All lands with the following characteristics were identified as potentially suitable for multi-benefit groundwater recharge, and were assumed to enroll in the program in the with-project scenario:
    - Location:
        - Within the service area of a surface water supplier (Lands were assumed to have access to surface water supplies)
        - Within 6 miles of the Sacramento River (Lands were considered to allow maximum mitigating effects on streamflow depletion, a factor of interest to modeling; this may not necessarily be a factor in actual program implementation)
    - Soil characteristics: Soils that are suitable for groundwater recharge (indicated by a SAGBI rating of "moderately good," "good," or "excellent")
    - Land use: Crops that are suitable for recharge and could accept flooding in late summer and early fall, with minimal impacts to crops and farming operations (excluded lands include: non-agricultural land uses (urban, native vegetation, riparian), permanent crops, ponded crops, and other crops with growing seasons incompatible with flooding between August-October)

    - Minimum size of 25 acres

      A total of 4,122 acres were found to satisfy these criteria, and are located within the model elements identified in Figure 1. These “potential recharge areas” were assumed to all participate in multi-benefit groundwater recharge.

- For all potential recharge areas, it was assumed that:
    - Shasta Non-Critical years: Multi-benefit groundwater recharge would occur and lands would be flooded with surface water for 30 days (during the month of September)
    - Shasta Critical years: Normal farming and irrigation practices would continue, without multi-benefit groundwater recharge due to likely surface water shortages in those years.
- For all potential recharge areas, model inputs for the with-project scenario were changed from the without-project scenario as follows:
    - Crop assignment: In Shasta Non-Critical years, lands were classified as non-ponded crops planted in March or April and harvested by August. In Shasta Critical years, lands remained in their original crop assignment.
    - Soil characteristics: In September, target soil moisture (TSM) was set equal to the total porosity of the soil to simulate ponding. In other months, TSM was estimated as the weighted average TSM of all lands identified from the geospatial analysis.
    - Irrigation period: Set to March or April through September in all years.
    - Crop evapotranspiration: In Shasta Non-Critical years, crop evapotranspiration was estimated as the weighted average evapotranspiration of all lands identified from the geospatial analysis, with adjustment for idle lands that are typically unirrigated. In Shasta Critical years, crop evapotranspiration returned to the original crop assignment.
    - Diversions:
        - In Shasta Non-Critical years: Additional diversions to potential recharge areas were estimated based on a simulation of average additional water demand in project area elements in September of Shasta Non-Critical years. The additional diversions were then specified as new supply from the Sacramento River, and applied to project area elements.
        - In Shasta Critical years: No additional diversions were specified.

Model Results for PMAs

This section compares the model results in the with-projects and without-projects scenarios. The difference between the without-project and with-project model results represents the net effect of the project on those water budget parameters.

Results for Each Modeled Project Area

The tables below summarize key results of the without-project and with-project model scenarios for each of the three modeled PMAs. Results are averaged over the entire 2016-2065 projected future period, including Shasta Critical years (approximately 10 percent of all years) when it is expected that additional surface water supplies will be unavailable for projects. The results are aggregated from the water budgets of elements in the project areas identified in Figure 1.

The average net benefit to the groundwater system of each modeled project is reported as "net recharge from the surface water system," calculated as the sum of all groundwater recharge (seepage and deep percolation) minus the sum of all groundwater extraction (groundwater pumping) in the project area and model scenario. Positive values indicate that more recharge is occurring, on average, while negative values indicate that more extraction is occurring.

On average across all years, the CCWD In-Lieu Groundwater Recharge project is expected to provide approximately 27,000 AF/yr of additional surface water to the CCWD project area, offsetting a similar volume of groundwater pumping (**Table *2***). The average net benefit to the groundwater system of the CCWD project is estimated to be approximately 27,000 AF/yr.

The OAWD Land Annexation and In-Lieu Groundwater Recharge project is expected to provide approximately 22,500 AF/yr of additional surface water to the OAWD project area, offsetting a similar volume of groundwater pumping on average across all years (**Table *3***). The average net benefit to the groundwater system of the OAWD project is estimated to be approximately 22,500 AF/yr.

The Colusa Subbasin Multi-Benefit Groundwater Recharge project is expected to provide approximately 11,500 AF/yr (2.8 AF per acre (AF/ac)) of surface water to potential recharge areas for field flooding (**Table *4***). A portion of this water results in deep percolation (approximately 4,000 AF/yr, or 1.0 AF/ac) or additional seepage (approximately 900 AF/yr, or 0.2 AF/ac). The average net benefit to the groundwater system of the OAWD project is estimated to be approximately 5,200 AF/yr (1.25 AF/ac).

Table 2. Key Model Results from the Colusa County Water District In-Lieu Groundwater Recharge Project (Average AF/yr, 2016-2065)

Scenario	Surface Water Diversions	Groundwater Pumping	Seepage	Deep Percolation	Net Recharge from the Surface Water System[1]
Without-Project	65,859	63,314	0	48,460	-14,854
With-Project	92,901	36,140	0	48,403	12,263
Difference (With-Project – Without-Project)	27,042	-27,174	0	-57	27,117

[1] Net Recharge from the Surface Water System = Seepage + Deep Percolation – Groundwater Pumping

Table 3. Key Model Results from the Orland-Artois Water District Land Annexation and In-Lieu Groundwater Recharge Project (Average AF/yr, 2016-2065)

Scenario	Surface Water Diversions	Groundwater Pumping	Seepage	Deep Percolation	Net Recharge from the Surface Water System[1]
Without-Project	48,026	62,067	0	45,324	-16,742
With-Project	70,534	39,520	0	45,307	5,788
Difference (With-Project – Without-Project)	22,509	-22,547	0	-17	22,530

[1] Net Recharge from the Surface Water System = Seepage + Deep Percolation – Groundwater Pumping

Table 4. Key Model Results from the Colusa Subbasin Multi-Benefit Groundwater Recharge Project (Average AF/yr, 2016-2065)

Scenario	Surface Water Diversions	Groundwater Pumping	Seepage	Deep Percolation	Net Recharge from the Surface Water System[1]
Without-Project	34,151	7,521	5,037	7,565	5,081
With-Project	45,683	7,212	5,924	11,540	10,252
Difference (With-Project – Without-Project) (AF/yr)	11,533	-308	886	3,976	5,171
Difference (With-Project – Without-Project) (AF/ac[2])	2.8	-0.1	0.2	1.0	1.25

[1] Net Recharge from the Surface Water System = Seepage + Deep Percolation – Groundwater Pumping

[2] Calculated assuming 4,122 acres of "potential recharge area" will participate in multi-benefit groundwater recharge.

Results for the Colusa Subbasin

The tables below summarize key results of the without-projects and with-projects model scenarios for the entire Colusa Subbasin. Results are averaged over the entire 2016-2065 projected future period, including Shasta Critical years (approximately 10 percent of all years) when it is expected that additional surface water supplies will be unavailable for projects. The results are aggregated across all model elements in the Colusa Subbasin.

Table *5* summarizes the water budget results for the Colusa Subbasin surface water system. On average across all years, all three modeled projects are expected to reduce groundwater pumping by approximately 49,000 AF/yr on average across all years and increase the total surface water inflows to the Subbasin by approximately 27,000 AF/yr. Stream gains from groundwater are also expected to increase by nearly 15,000 AF/yr compared to the without-projects scenario.[7] Deep percolation in the with-projects scenario is expected to slightly increase (approximately 4,000 AF/yr), while seepage is expected to slightly decrease (approximately 10,000 AF/yr) compared to the without-projects scenario.

Table *6* summarizes the water budget results for the Colusa Subbasin groundwater system. In the without-projects scenario, the average annual change in groundwater storage across all years is expected to be approximately -7,000 AF/yr, indicating an average net decline in groundwater storage. When all three modeled projects are in effect, the average annual change in groundwater storage across all years is expected to be approximately 0 AF/yr, indicating no net decrease in groundwater storage.

These model results suggest that planned projects in the Colusa Subbasin are sufficient to support sustainable management of groundwater extractions and recharge to ensure that chronic lowering of groundwater levels or depletion of supply during periods of drought is offset by increases in groundwater storage during other periods (23 CCR §354.44(b)(9)).

[7] A more detailed assessment of projected streamflow accretion-depletion is presented in Appendix 3-?. 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. Note to reviewer: Appendix 3-? was prepared following public review of Chapters 1-4 and will be released with the complete draft Groundwater Sustainability Plan scheduled for August 31, 2021.

Table 5. Without-Projects and With-Projects Surface Water System Water Budget Results for the Entire Colusa Subbasin (Average AF/yr, 2016-2065)

Component	Without-Projects	With-Projects	Difference (With-Projects – Without-Projects)
Inflows			
Surface Water Inflows	12,714,561	12,741,210	26,649
Sacramento River Diversions	1,195,939	1,255,291	59,352
Stony Creek Diversions	90,707	90,707	0
Sacramento River Inflows	11,335,460	11,302,757	-32,703
Other Inflows from Boundary Streams	92,455	92,455	0
Precipitation	1,257,503	1,257,503	0
Groundwater Pumping	558,561	509,702	-48,859
Agricultural	515,996	466,936	-49,059
Urban and Industrial	10,098	10,098	0
Managed Wetlands	32,467	32,668	201
Stream Gains from Groundwater	322,713	337,389	14,676
Total Inflow	**14,853,338**	**14,845,804**	**-7,534**
Outflows			
Evapotranspiration	1,900,935	1,902,885	1,949
Agricultural	1,596,222	1,597,393	1,171
Urban and Industrial	28,407	28,410	3
Managed Wetlands	73,292	73,292	0
Native Vegetation	167,144	167,146	2
Canal Evaporation	35,869	36,643	774
Deep Percolation	411,004	415,312	4,308
Precipitation	156,055	157,003	947
Applied Surface Water	158,089	170,370	12,281
Applied Groundwater	96,859	87,940	-8,919
Seepage	400,727	391,052	-9,675
Streams	252,897	242,325	-10,572
Canals and Drains	147,829	148,727	898
Surface Water Outflows	12,140,789	12,136,608	-4,180
Precipitation Runoff	59,795	60,180	384
Applied Surface Water Return Flows	90,012	91,563	1,551
Applied Groundwater Return Flows	20,352	20,096	-256
Sacramento River	11,186,667	11,156,439	-30,227
Colusa Basin Drain	773,816	786,947	13,130
Colusa Weir to Sutter Bypass	0	0	0
Other Outflows to Boundary Streams[1]	10,146	21,384	11,238
Total Outflow	**14,853,455**	**14,845,858**	**-7,597**
Change in Storage (Inflow - Outflow)	**-117**	**-53**	**63**
Stream gains minus seepage	-78,014	-53,663	24,351

Table 6. Without-Projects and With-Projects Groundwater System Water Budget Results for the Entire Colusa Subbasin (Average AF/yr, 2016-2065)

Component	Without-Projects	With-Projects	Difference (With-Projects – Without-Projects)
Inflows			
Subsurface Water Inflows	208,855	196,891	-11,964
Deep Percolation	411,004	415,312	4,308
Precipitation	*156,055*	*157,003*	947
Applied Surface Water	*158,089*	*170,370*	12,281
Applied Groundwater	*96,859*	*87,940*	-8,919
Seepage	400,727	391,052	-9,675
Streams	*252,897*	*242,325*	-10,572
Canals and Drains	147,829	148,727	898
Total Inflow	**1,020,586**	**1,003,255**	**-17,330**
Outflows			
Subsurface Water Outflows	146,626	156,416	9,790
Groundwater Pumping	558,561	509,702	-48,859
Agricultural	547,769	498,906	-48,862
Urban and Industrial	10,098	10,098	0
Managed Wetlands	34,672	34,870	198
Stream Gains from Groundwater	322,713	337,389	14,676
Total Outflow	**1,027,899**	**1,003,507**	**-24,392**
Change in Storage (Inflow - Outflow)	**-7,314**	**-252**	**7,062**