The Freshwater Trust®

South Sacramento County Agriculture and Habitat Lands Recycled Water, Groundwater Storage, and Conjunctive Use Program

Conceptual Ecological Plan & Ecosystem Benefits

Introduction

South Sacramento County Agriculture and Habitat Lands Recycled Water, Groundwater Storage, and Conjunctive Use Program (South County Ag Program or program) is a groundwater storage project that is designed to balance water resources sustainability, with ecosystem enhancement and agricultural sustainability in the Sacramento Region. The program will integrate water management in the southern Sacramento region by combining in-lieu recharge of recycled water with conjunctive use, using groundwater storage and banking to promote water urban-agricultural cooperation, improve agricultural land viability, enhance water quality and ecosystem health, and support statewide water systems in proximity to the Delta. The benefits of the program are extensive and include: recharging the groundwater basin (through in-lieu use) to help restore groundwater levels; providing a sustainable, drought-proof water supply to agriculture and habitat lands; and helping to restore riparian forests, emergent wetlands, and natural stream flows in the lower Cosumnes River. The program will stabilize and improve the local groundwater conditions by increasing groundwater levels, ultimately reversing the groundwater flow direction back to the Cosumnes River, Snodgrass Slough, and Stone Lakes National Wildlife Refuge.

Through these actions, significant ecological values in the program area will be maintained, enhanced, or created; what we call “environmental uplift”. Benefits to “listed” or otherwise at-risk species and habitat will result from reversing the groundwater declines and through supporting targeted conservation actions such as ecological easements and weed management, to maintain resilience in the face of climate change. Environmental enhancement is provided through improving existing conditions that may be of marginal or low value without management. Habitat creation will occur by reclaiming or providing new habitat functional values to enhance survival for native species and their habitat.

The goal of this report, authored by The Freshwater Trust (TFT), is to document the magnitude of the anticipated ecosystem benefits associated with the program, as well as the implementation plan necessary to achieve these benefits. The content will serve as the foundational document on the ecosystem benefit quantification needed to support the Water Storage Investment Program (WSIP) grant application.

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1. ECOLOGICAL PLAN SUMMARY

1.1. Purpose of the Plan

This ecological plan is initially intended as a supporting document to assist Regional San to refine the programmatic elements of the South Sacramento County Agriculture & Habitat Lands Recycled Water Program (South County Ag Program or program). In addition to supporting the California Environmental Quality Act (CEQA) analysis, the plan is intended to provide the framework for identifying and maximizing the ecological benefits from the in lieu and wintertime recharge elements of the program. These benefits are articulated in the form of Ecosystem Priorities and their associated Physical Benefits identified in the Water Storage Investment Program (WSIP) application. The ecological plan is intended to inform and support the program operations plan by laying the foundation for the ecological benefits that the groundwater operations plan creates.

In order to optimize the benefits of this groundwater improvement, the plan guides strategic selection of locations that could be targeted for these actions, and identifies the appropriate timing of these actions to have the greatest benefits. The plan also puts into effect the monitoring program required under the WSIP and other grants, to ensure that the benefits are accruing as expected, and to direct adaptive management actions as the science evolves and to adjust for potential climatic variation.

1.2. Plan Approach and Goals

The plan's approach in its most simple form is the improvement of the water table such that the gradient flows back to the streams, instead of away from them as currently happens due to significant groundwater overdraft. The increased stream flow improves migrating (anadromous) fish passage days in the Cosumnes River, improves year-round native (resident) fish habitat conditions through cool groundwater flows toward the river (upwelling), improves riparian vegetation regeneration due to the raising of the water table (reduced rates and reversal of hydrograph decline), supports much larger areas of riparian vegetation with near-surface water tables, and provides drought persistence for mature riparian vegetation with shallow groundwater maintenance.

The program location is identified in Figure 1, which shows the relative footprint of the groundwater replacement element, and the adjacent geography, including the major towns, freeways and water bodies. In order to orient the program area, Figure 2 identifies the relationship of the various major land ownership patterns or existing land management plans. The improved groundwater conditions alone would be of significant benefit to the local region. For example, Figure 3 identifies the California Natural Diversity Database observations, highlighting the distribution of and context for species' use of the area. Figure 4 shows current groundwater elevations relative to the surface under baseline conditions, while Figure 5 illustrates the new groundwater elevation with the proposed program in place under the California Department of Water Resources' (DWR) provided 2030 climate change scenario.

These groundwater improvements have significant ecological effects through the reversal of the cone of depression in the northern part of the program area depicted in the Appendix. The existing and future groundwater elevations (without the project) form a cone of depression that reverses the natural gradient to the Cosumnes River and Snodgrass Slough complex such that those water bodies lose water to the gradient and act as "losing streams" for most water years under baseline conditions. The program results in a reversal of that cone of depression and rapidly equilibrates the groundwater system such that these rivers become "gaining" reaches in approximately ten years.

It is critical to note two key results of these analyses. The first is that the mapping provided in these figures assumes that the in-lieu and winter recharge happens evenly across the program area. This is a conservative approximation so that reviewers can see the project benefits that would accrue under a likely program execution scenario. However, the purpose of this plan is also to identify the strategic implications of the water recharge in targeted areas for ecological benefits. Recharging preferentially to the east and south, closer to the Cosumnes River, can significantly improve the habitat connectivity and recharge flow benefits. A more southeastern delivery approach would also maximize the area of the River that has benefits in both climate change scenarios, in effect reversing the modeled impacts of climate change entirely for this area.

The second result is that, without this project, the Stone Lake National Wildlife Refuge, the complex of private conservation lands, and the Cosumnes Preserve, all would be disconnected from the water table under all water year classes by 2070. Resulting in significant losses of habitat function in those areas that cannot supplement with surface water.

These projected groundwater benefits can be enhanced by changes in land management practices that improve habitat. By implementing a strategic groundwater supplementation program through winter recharge, terrestrial and wetland species that are seasonally present in the agricultural areas will have substantially more habitat available during the critical overwintering period, and local benefits to stream recharge through the groundwater are directed to where they are needed the most.

The hydrogeographic benefits of the program will by themselves create the conditions that support native riparian vegetation. However, supporting acres of habitat and linear feet of riparian habitat, as critical as it is, can be *significantly enhanced* through invasive weed management, widening the riparian corridor belt width, and reconnecting areas that have been modified to create a longitudinal connection along the corridor. The strategic acquisition of contracts and easements, both long- and short-term, allow for wildlife-friendly crops and cropping practices, riparian and wetland management areas, access for weed management, and flexibility to adapt management practices that address climate change. These goals can be supported by adaptive management of the water application that would allow for spreading of the winter water potentially beyond the currently delineated delivery area to maximize benefits (described further in the next section).

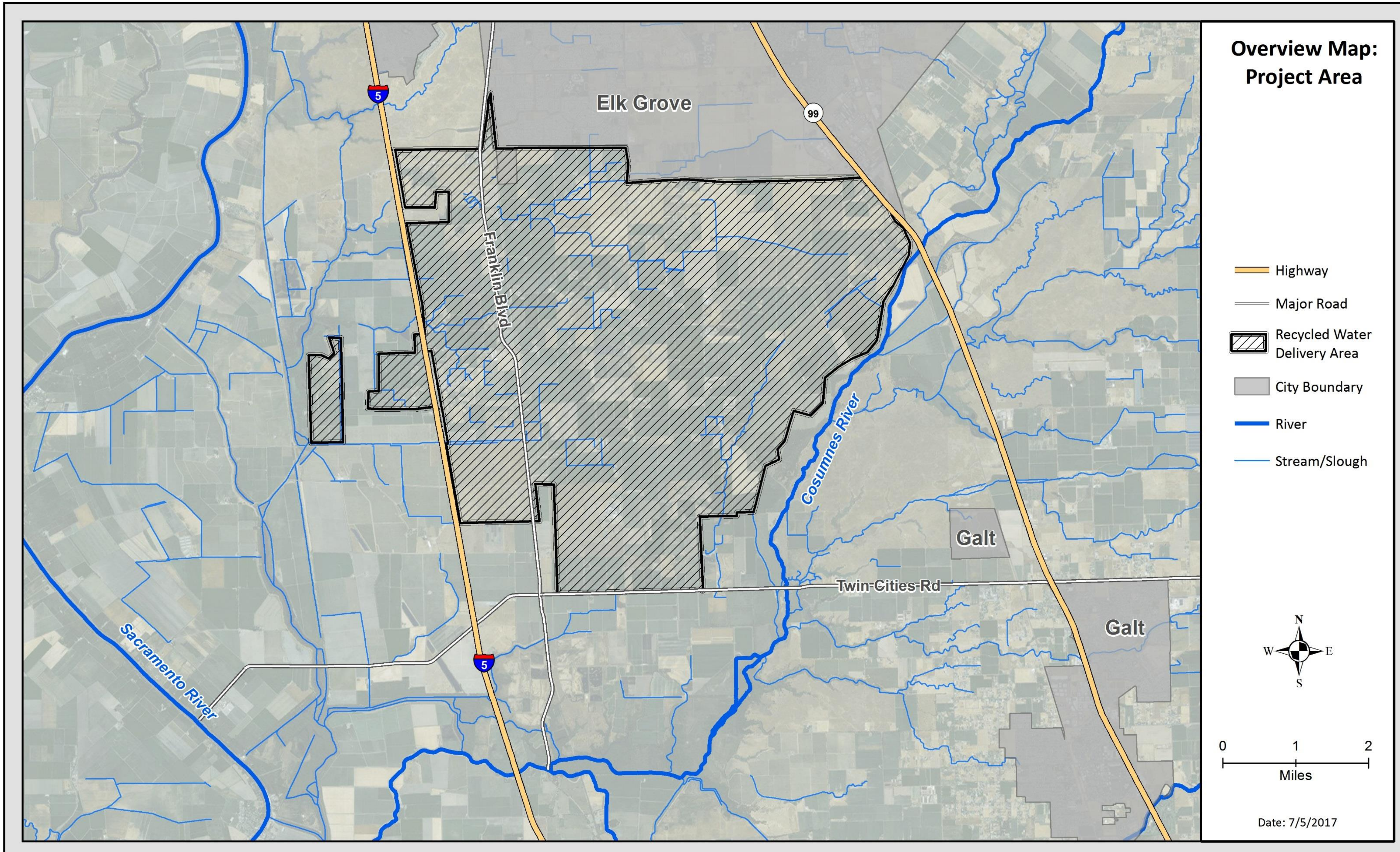

Figure 1. Overall South Sacramento County Agriculture & Habitat Lands Recycled Water Program area, including the recycled water delivery area and the surrounding waterbodies.

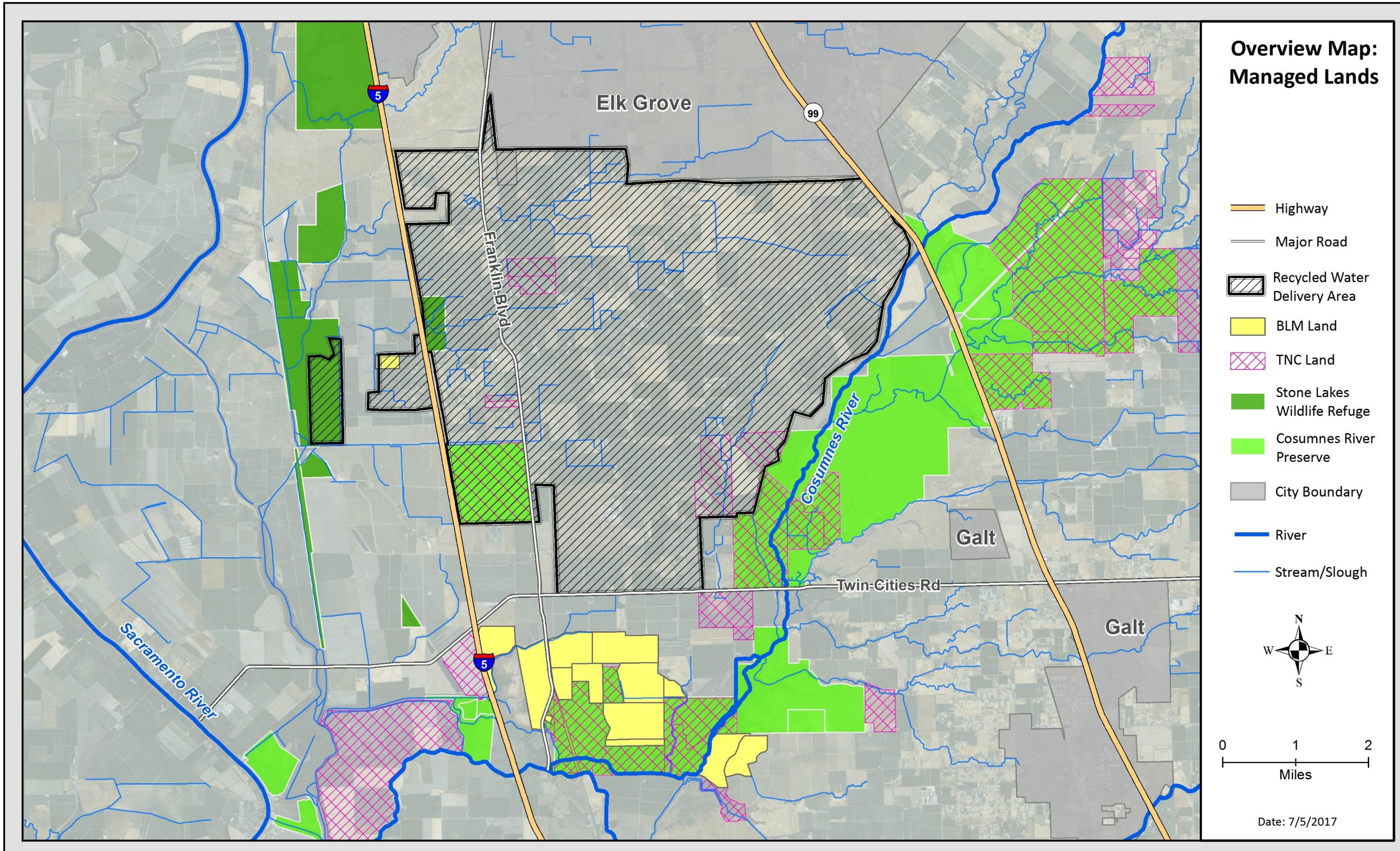

Figure 2. Lands in the South Sacramento County Agriculture & Habitat Lands Recycled Water Program area that are currently managed for conservation and habitat.

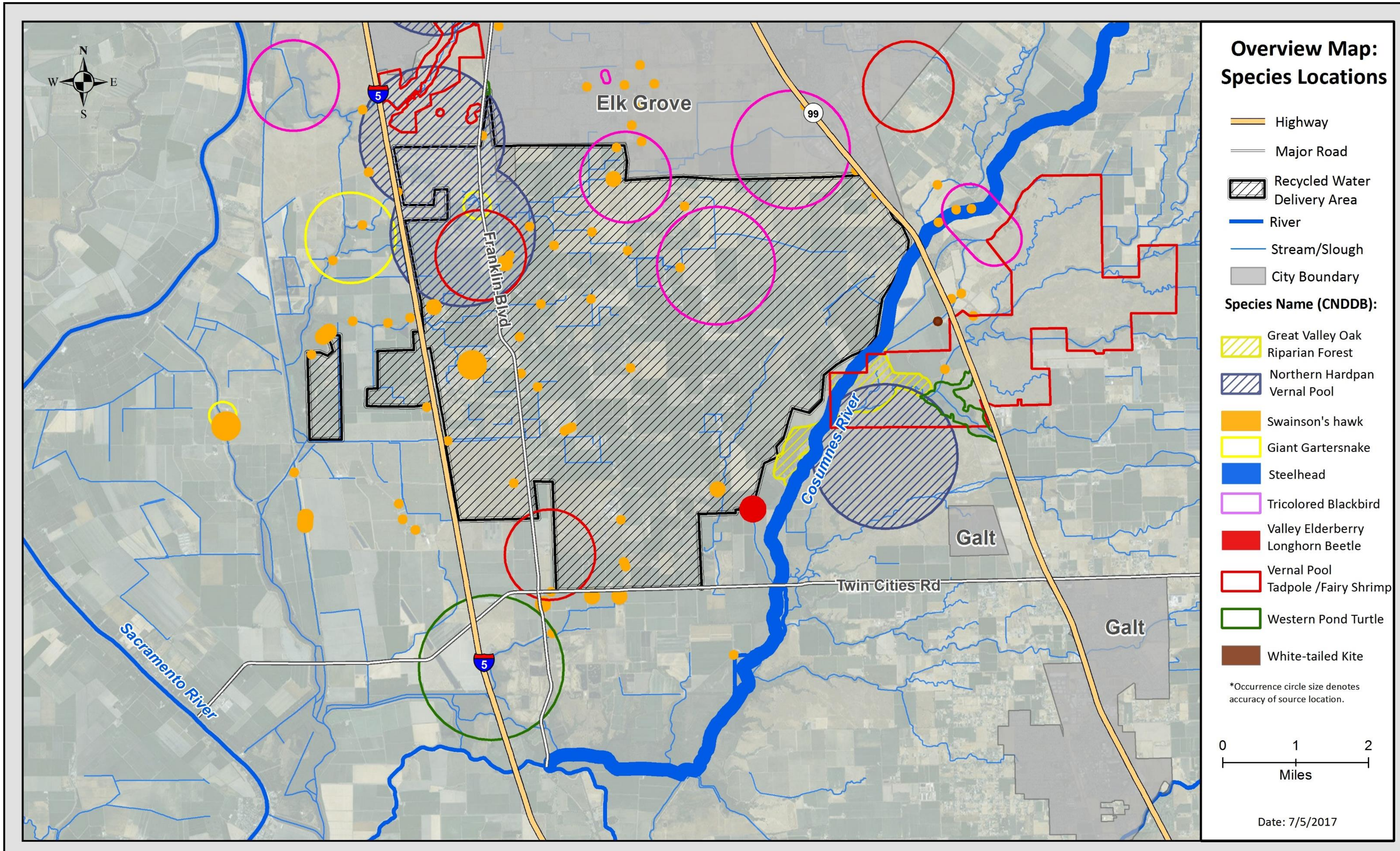

Figure 3. Species observations in the South Sacramento County Agriculture & Habitat Lands Recycled Water Program area. Species observations from the California Natural Diversity Database (CNDDB).

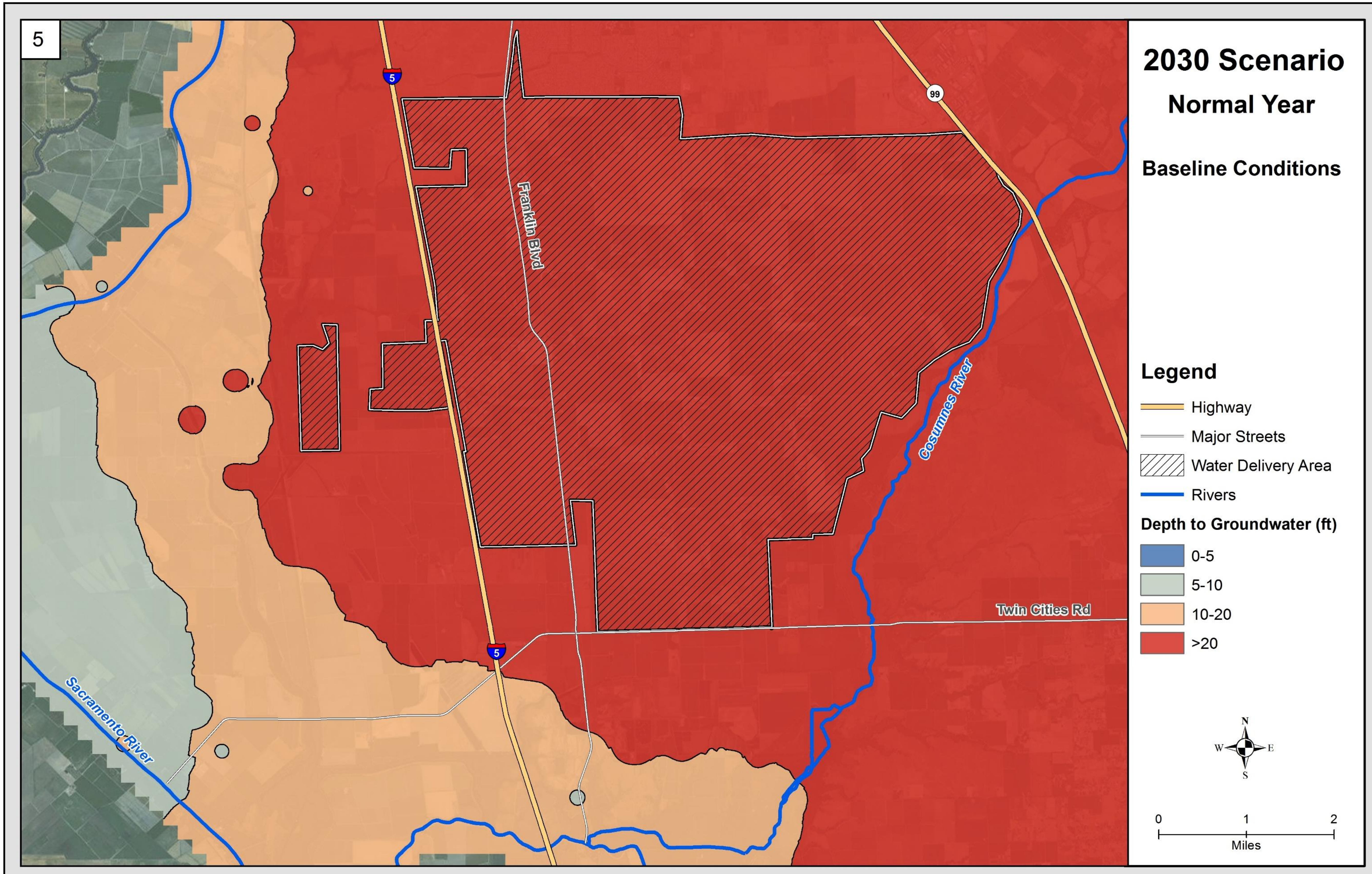

Figure 4. Depth to groundwater under baseline conditions for a normal water year under the 2030 climate change scenario. Additional scenario maps are included in the Appendix.

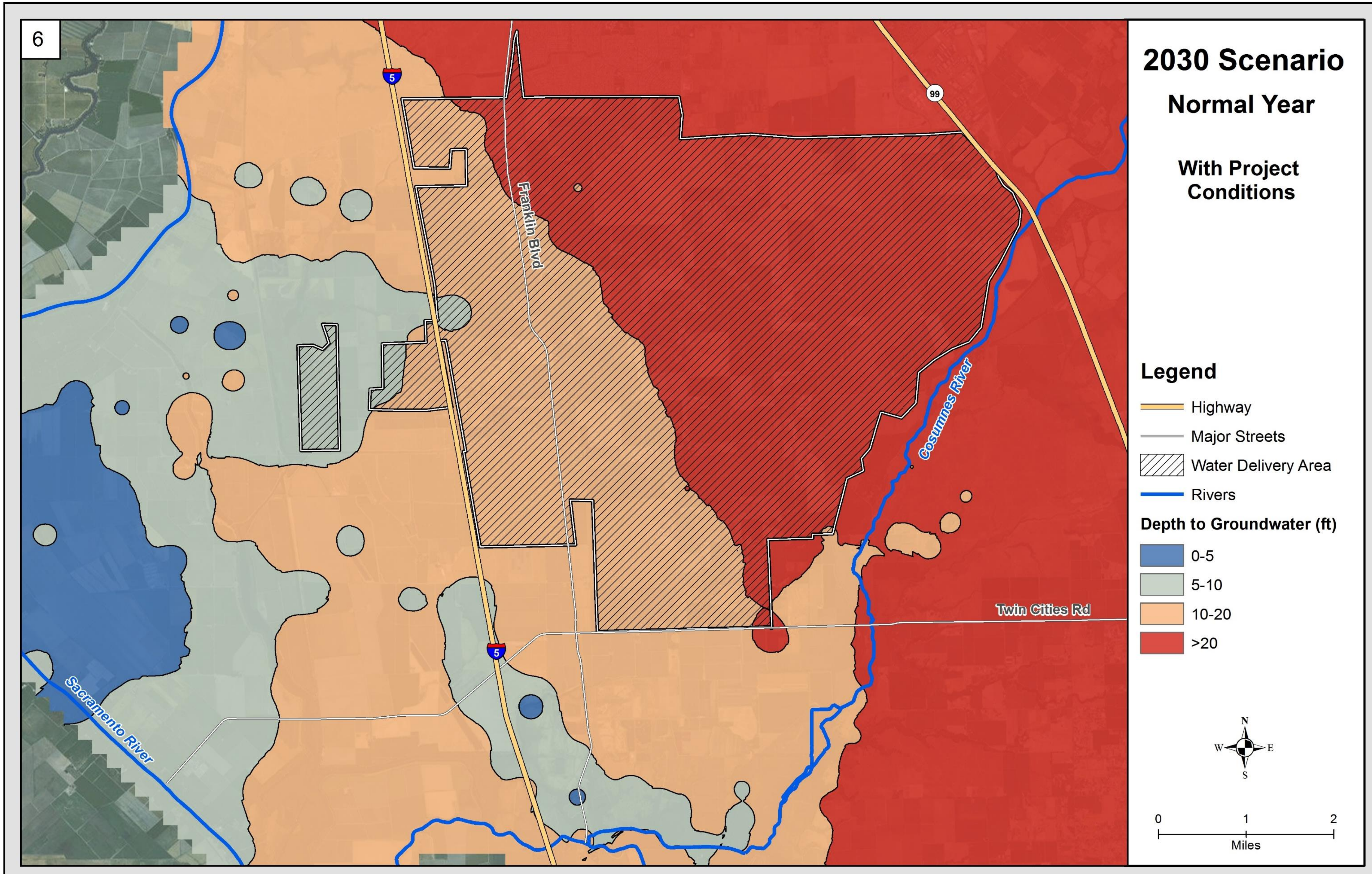

Figure 5. Depth to groundwater with the South County Ag Program in place for a normal water year under the 2030 climate change scenario. Additional scenario maps are included in the Appendix.

1.3. Project and Benefit Location

The 'project' or program delivery area is almost entirely outside of the legal Sacramento-San Joaquin Delta, as defined in Water Code section 12220. However, the program provides habitat improvements and direct and indirect wildlife benefits inside of the legal Delta from the recharge of groundwater immediately adjacent to the legal Delta. In order to most accurately identify and quantify those benefits, a combination of modeling approaches were used. The methodological approach to model the project benefits is identified in the groundwater model analysis developed by RMC.

The assessment for wetland, riparian, and riverine benefits is based on the preliminary engineering analyses and program modeling. This baseline approach assumes robust landowner willingness and homogeneous distribution of water over the program area; however, this Ecological Plan provides for a more granular approach that allows for provision of that water in the same general location within the larger program footprint. Ecological benefits would accrue in the program footprint and to the south and east of the program area, as well as targeted winter recharge to the eastern corner of the program area along the length of the Cosumnes River. That targeted winter recharge could also include selective in lieu recharge, water use efficiency, and other best management practices (BMPs). This more refined approach to recharge would make available an additional area for agriculturally compatible ecological improvements, including restoration.

As the specific impacts of climate change can vary widely and are expected to result in more severe weather events, a flexible management plan that allows for targeting of the benefits and tracking of those benefits will be critical. Adaptive management in this context requires the ability to optimize the project benefits in a complex area with multiple land management agencies, crop patterns, and shifting water demands. This analysis focused on the provision of a base level of ecological benefits that seem readily achievable given the recharge water and wide potential area for application. However, by optimizing the recharge and adding BMPs, we can greatly expand the area of benefit and moreover target the benefits to the entire length of the Cosumnes supported by the program recharge, where there are willing landowners.

1.4. Relationship to Delta Planning Activities

As one of the most critical and unique ecosystems in California, the Sacramento-San Joaquin River Delta and the surrounding watersheds are subject to a number of environmental planning and management activities. The South County Ag Program not only advances those plans and activities and provides the resilience that those activities need to flourish into a climate change-driven future. The program is intended to support those plans and activities will be coordinated where appropriate, but will not be dependent on those planning efforts.

Several planning and management efforts related to water quality are ongoing. The State Water Resources Control Board has established a Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. This Water Quality Control Plan includes the portion of the Sacramento River outside of the program area, but within the secondary program benefit area. Thus, this section of the Sacramento River will beneficially affected from the program, though this stretch of river lies outside of the strict boundaries of the program. The existing beneficial uses for the Delta include: municipal and domestic supply, industrial service and process supply, agricultural supply, groundwater recharge, navigation, contact and noncontact recreation, shellfish harvesting, commercial and sport fishing, warm and cold freshwater habitat, migration, spawning, estuarine habitat, wildlife habitat, and rare, threatened, and endangered species habitat.

The Central Valley Regional Water Quality Control Board has also adopted a Basin Plan. The Water Quality Control Plan for the Sacramento and San Joaquin River Basins identifies the existing and potential beneficial uses of surface waters. The area covered by this plan includes the Cosumnes River, which is adjacent to and beneficially affected by the program. The most recent iteration of this Basin Plan identifies the Cosumnes River as having the following existing beneficial uses: municipal and domestic water supply, agricultural irrigation and stock watering, contact recreation, canoeing and rafting, noncontact recreation, warm and cold freshwater habitat, wildlife habitat, and warm and cold water migration and spawning habitat.

Taken together, these two water quality control plans detail the water quality goals for the two main waterbodies beneficially affected by the program. The two plans identify the Sacramento River and the Cosumnes River as having existing beneficial uses for a vast majority of the potential beneficial use designations. The program will positively support a majority of these existing beneficial uses, improving the condition of the watersheds.

Furthermore, the Sustainable Groundwater Management Act requires local agencies or counties to take responsibility for achieving groundwater sustainability. The responsible agencies have 20 years to develop and implement groundwater sustainability plans to accomplish that goal. The South County Ag Program will assist in the attainment of this goal by addressing the groundwater overdraft in the program area. The addition of surface water that percolates to the groundwater table both augments the groundwater supply and lessens the demand for groundwater. Therefore, the program will constitute an important factor in the ongoing groundwater planning efforts and management activities.

The water quality and sustainability planning efforts aside, the program will provide significant benefits to the overall watershed in ways that will advance a several ongoing planning efforts in the region. A number of planning activities related to the public lands, conserved lands, and threatened species habitat exist in and around the program area, such as Stone Lakes National Wildlife Refuge, the Cosumnes Preserve, and the South Sacramento Habitat Conservation Plan. The South County Ag Program will generate benefits for those lands in the form of additional habitat connectivity, expansion of habitat complexity, augmented surface water flows, and decreased water demand. As such, the program administrators will represent a valuable partner in the ongoing planning activities, both directly and indirectly. In many instances, the program will not wholly attain the goals and objectives of those plans, as the goals and objectives require environmental improvements on a scale not contemplated by the program. However, many of the discrete actions will be realized by the program, making progress toward the overarching goals and objectives.

For instance, the program will assist in the realization of the goals and objectives identified in NOAA Fisheries' Recovery Plan for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead. This Recovery Plan has two main objectives: secure existing populations by addressing the stressors, and reintroduce populations into historically populated areas. The South County Ag Program will not reintroduce species, though it will help to advance the recovery actions, such as the conservation of water and the promotion of water transactions that benefit species and water supply reliability.

The South County Ag Program will also advance the three main goals of the State Wildlife Action Plan. Those goals are (1) maintain and increase ecosystem and native species abundance and richness, (2) maintain and improve ecosystem conditions, and (3) enhance ecosystem functions and processes. The program will directly advance all three of these goals through the in lieu recharge and habitat improvement activities, with those benefits increasing as climate change accelerates. Similarly, the program will advance the California Water Action Plan goals of reliability, restoration, and resilience. The increase in water supply reliability, water recycling, direct ecosystem improvements, fish and wildlife benefits, are all actions considered by the Plan to further the underlying goals.

The Central Valley Joint Venture Implementation Plan likewise finds support from the South County Ag Program in a variety of ways. This Plan fosters partnership between a number of entities in order to identify and prioritize habitat needs for various bird groups. One of the issues identified by that Plan is the loss of irrigated agriculture to urban development. The program will curb the expansion of Elk Grove and Galt in the project area by executing into conservation easements to preserve the agricultural lands, one of the actions the Joint Venture Plan recommends. Further, the program will create additional Sandhill Crane habitat in the Cosumnes River area, one of the specific points of emphasis in the Plan. Hence, the South County Ag Program will markedly improve the environmental goals and specific actions contemplated by the Joint Venture Implementation Plan.

Beyond benefiting water quality, aquatic species, avian species, and habitat generally, the program will further the goals of the Recovery Plan for the Giant Garter Snake. The recovery plan lays out three objectives to advance the goal of recovering the species: (1) establish and protect self-sustaining populations, (2) restore and conserve healthy Central Valley wetland ecosystems, and (3) ameliorate or eliminate threats to the species. The Plan further lays out ten actions to help achieve these objectives. The South County Ag Program will not completely restore the giant garter snake. It will, however, restore and conserve healthy ecosystems in the Central Valley by undertaking a number of the ten actions the recovery plan identifies.

The various management plans in the region entail quite lofty goals and objectives. The South County Ag Program will not be able to singlehandedly achieve these aims. Yet, the program will make meaningful progress toward a multitude of these desired regional outcomes, improving the environment in the program area and measurable gains to the surrounding landscape. These benefits will constitute important components of the environmental health of the region broadly.

1.5. Plan Implementation

This conceptual framework is intended to provide a common platform for understanding the technical foundation, ecological benefits, and possible partnership opportunities. The plan's implementation schedule is determined by the available funding, developing partnerships, and a future revision that provides project-level specificity.

The plan's implementation is guided by specific ecological metrics that establish both the baseline values and the specific milestones. The tools available for the implementation are wide ranging, including supporting and expanding existing land management activities, funding actions through annual or multi-year contractual relationships, securing easements to be held and managed by third parties (land trusts, state agencies, federal agencies, or some combination thereof), and land purchase and title transfer to land management agencies or organizations.

For example, weed management assists the long-term habitat quality of an area that has been enhanced by the program. In order to ensure that the weed management is cost-effective and has the desired ecological benefits, a weed management plan is developed as a component of the larger ecological plan and is tracked by the plan's monitoring element. Restoration weed management is often completed by the California Conservation Corps, and monitoring is typically subcontracted to experts. For both easements and land acquisition and transfer, the transactions are contracted to experts in both the legal and land trust specialty, and the agency can choose to hold title or transfer title depending on their desired future involvement.

Land management can take many forms in this mixed rural-rural residential-protected land region, and many forms of agricultural management and associated activities are compatible with wildlife habitat. That compatibility, however, requires a management plan to make available the structures and functions to the species at the right time in their life history. This plan is intended not to fully define each element of a complete ecological plan for this region, but instead to provide a consistent framework for understanding how to retain program compatibility with existing agricultural uses, how to target and implement habitat enhancement, restoration and creation, and how to measure and monitor those outcomes.

1.6. Ecological Enhancement

Ecological enhancement includes improvements on existing wetlands and channel margins, such as weed management, that improve existing habitat and raise its functional value(s). In particular, land application of water can achieve exceptional waterfowl habitat with minimal impact to existing agriculture uses, provided the application timing is planned carefully. Further, raising groundwater levels support terrestrial ecosystems and generates benefits to surface water that improve riparian and aquatic ecological conditions.

1.7. Habitat Restoration

Habitat restoration includes the improvement of historically valuable habitat to high levels of function, with design focus on self-sustainability of processes. The goal is to reclaim habitat that has detrimental modifications that impair the habitat's ability to maintain its own structures and functions through natural processes. Restoration would be considered strategically to improve structure and function in an existing riparian corridor. The goal of restoration would be to expand the vegetated buffer width where feasible, and prioritize riparian connectivity. Even small positive changes in riparian connectivity and patch size can dramatically improve habitat function and support sensitive species.

1.8. Habitat Creation

In unusual circumstances, creating new habitat can connect large habitat patches or secure rare habitats within a matrix of other habitats. This approach is the most expensive, so it would be only applied strategically to optimize the other forms of selected species support and habitat improvements.

1.9. Plan Development

The plan would use spatial analysis tools to classify the program area by land use, proximity to water features, slope and soil type, then apply the relative use by species of interest (acres in current use vs. potential acres). The net number of potential acres in each ecological class would be identified in a table, and the plan would identify how to maximize their values in a mix of land ownerships. The plan would then provide the narrative in support of the application. However, the plan would not include a visualization of prioritized areas given the sensitivity of conceptual estimates on private and public lands.

One land management approach involves dividing the sub-watershed into relatively homogeneous management units of similar soil types (based on infiltration capacity) that would allow the program to contract on an annual or multi-year basis for acreage of winter-flooded agricultural land with targeted crop residues. This would allow agricultural producers to opt-in and opt-out as needed, while still maintaining a pool of candidate private agricultural acreage with the most suitable soil types. As the producers would be aware of the annual habitat acreage targets, it would allow them to plan field-level cropping patterns in advance to generate the most economic benefit and reduce the cost of participation.

1.10. Plan Tools

The approach to integrated habitat management in mixed-ownership lands requires the use of the complete toolset of visualization, prioritization, analysis and synthesis, informed by the scientific, legal, and administrative approaches that TFT has applied in similar situations elsewhere. As described earlier, the plan's approach is to identify the most ecologically important parcels for maximizing the ecological benefits, securing property interests to protect those values, and then tracking to ensure that those values are maintained. See Section 6 for additional information on specific basin assessment methods.

Acquiring the property interests necessary to protect the ecological benefits can be achieved through the use of conservation easements or long-term leases. Easements provide permanent protection, though often are more difficult and expensive to acquire. Leases, on the other hand, are for a set time period (usually years or decades) and allow greater flexibility to fit the needs of the parties. With either mechanism, the parties negotiate the specific terms such as duration, liability, cost, etc. and formally record the binding agreement to ensure that it remains applicable to any future property owners. While the longest-term legal structures to maintain those values are always preferred, there are locations that have exceptional value that can be brought into a program on a shorter-term basis.

Moreover, shorter-term agreements foster a collaborative learning and trust-building process by which producers can see how the approach does not impair their agricultural productivity and that these values can actually support each other. TFT's experiences in similar programs demonstrate that initial successful collaboration and program implementation builds a rapport with local landowners. This improves landowners' trust in the program, increasing interest in participation and enabling more permanent agreements.

1.11. Program Area

As part of the program, the application of recycled water on agricultural lands is expected within or adjacent to the currently delineated delivery area (Figure 1); however, the program benefits expand far beyond the delivery area (Figure 6). The reduction in groundwater pumping and the improved recharge in the delivery area are expected to increase the groundwater elevations by 20 to 30 feet. The benefits of these improved groundwater elevations expand far outside of the delivery area. For the purpose of evaluating the ecosystem benefits associated with the South County Ag Program, the expanded program area illustrated in Figure 6 was assessed. In the following sections, the described ecosystem benefits are from the benefits that occur within the delivery area, but also in the expanded program benefit area. More detailed documentation of the groundwater benefit maps can be found in the Appendix.

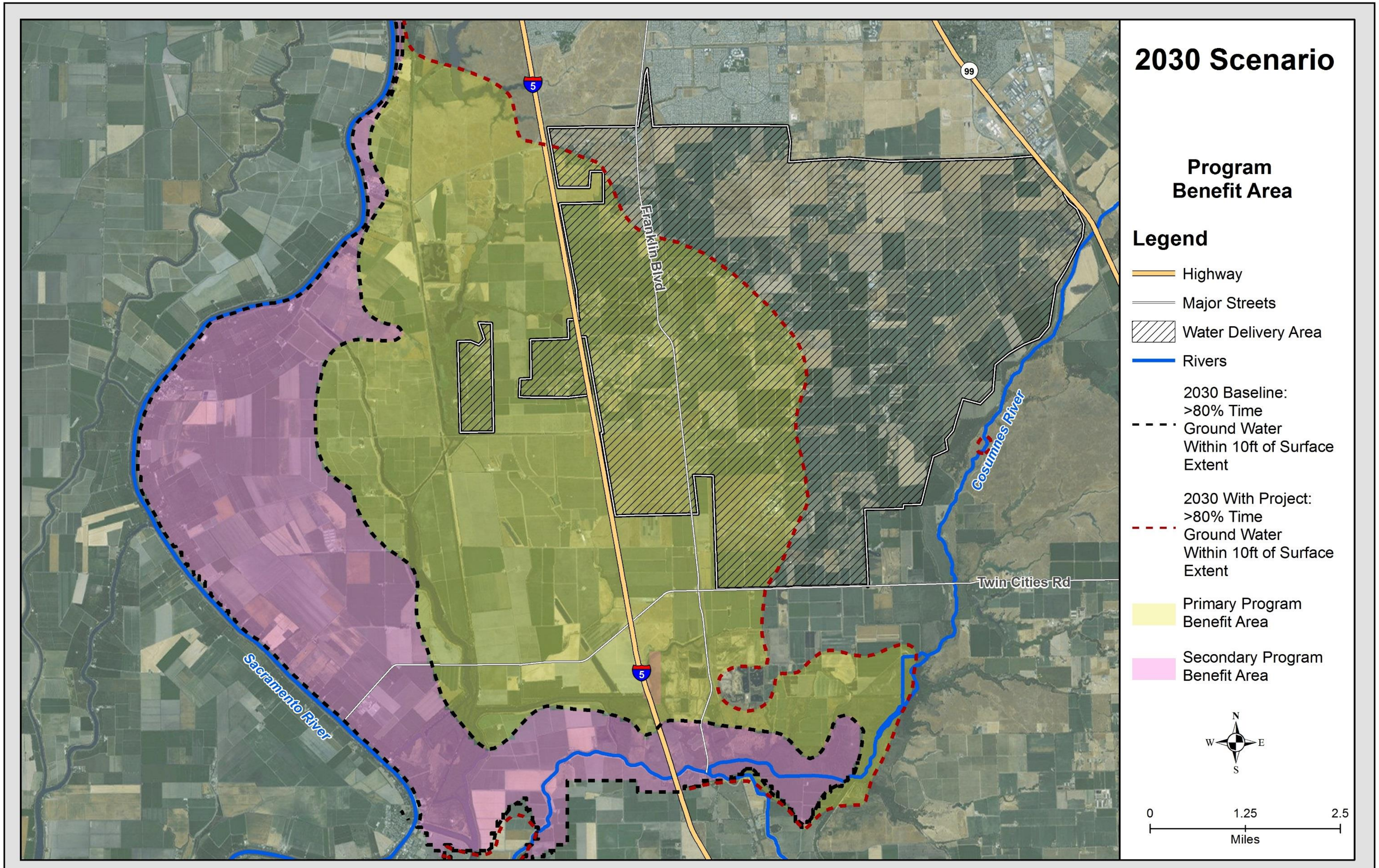

Figure 6. Overall ecosystem benefit area of the South County Ag Program from improved groundwater levels. The Primary Program Benefit Area (yellow) represents the area with the greatest projected ecological change as a result of the program. The Secondary Program Benefit Area (pink) represents the area where some benefit from the improved groundwater elevations is expected, but the magnitude of the benefit is smaller.

2. ECOSYSTEM BENEFITS

There are four primary ecosystem benefits expected from the program: (1) direct improvement as a result of the water application and delivery, (2) direct improvements that require active management to achieve the ecosystem benefit (e.g. weed treatment), (3) habitat restoration that requires active management or implementation, and (4) complimentary changes in land management to support wildlife. The following sections describe the ecosystem benefits that are expected as a result of the program. The expected benefits have been quantified using the groundwater modeling results (Onsoy & Blanke, 2017), as well as the available literature and spatial data. Any assumptions or data sources used to complete the ecosystem quantification are included in the description. Additionally, any anticipated time-lag associated with the program benefits are documented and quantified.

The focus of the ecosystem benefit assessment has been on identifying the change in physical conditions from the program that will support native species. As noted in Figure 3, there are many endangered, sensitive, and threatened species in the program area. The ecosystem benefits of the program will directly improve habitat for many of these species, including:

- California tiger salamander, *Ambystoma californiense*
- Chinook salmon, *Oncorhynchus tschawytscha*
- Giant garter snake, *Thamnophis gigas*
- Greater sandhill crane, *Grus canadenis tabida*
- Riparian brush rabbit, *Sylvilagus bachmani riparius*
- Sacramento splittail, *Pogonichthys macrolepidotus*
- Swainson's hawk, *Buteo swainsoni*
- Tricolored blackbird, *Agelaius tricolor*
- Valley elderberry longhorn beetle, *Desmocerus californicus dimorphus*
- Vernal pool fairy shrimp, *Branchinecta lynchi*
- Vernal pool tadpole shrimp, *Lepidurus packardi*
- Western pond turtle, *Clemmys marmorata*
- White-tailed kite, *Elanus leucurus*
- Willow flycatcher, *Empidonax traillii*
- Yellow warbler, *Setophaga petechia*

More detailed species information, including habitat and lifecycle needs in the program area are presented in the Appendix.

The physical benefits presented in the following sections have been quantified using the groundwater modeling results of the program under two climate change scenarios: 2030 and 2070. The benefits that are presented have been aggregated for the entire modeling period and are expressed as means, medians, or totals as appropriate. Aggregating the physical benefits incorporates the year-to-year variability that occurs as a result of different climate conditions (e.g., wet versus dry year conditions) into the total benefit value. As such, these total values also take into consideration the future drought conditions, as well as the need for periodic groundwater extraction during dry periods to meet agricultural needs. In addition, the aggregate benefits also incorporate the time-lag that occurs at early in the program while the aquifer is recharging and the groundwater improvements have yet to accrue.

By expressing the ecosystem benefits in aggregate, the annual variability is included in the total value and provides a more conservative estimate of the program's benefits. Furthermore, for the purposes of completing the valuation for the WSIP application, additional time-delay factors have been incorporated to address the delay in benefit accrual and program implementation. More detailed information can be found in the annual benefit attachment (South County Ag Program Monetized Benefits).

2.1. Habitat Benefits from Improved Shallow Groundwater Conditions

Numerous studies of the program area have documented the potential ecosystem benefits associated with a reduction in groundwater extraction (Eisenstein & Mozingo, 2013; Fleckenstein et al., 2004, 2001; Kleinschmidt Associates, 2008). As a result of the program, groundwater extraction in the delivery area will be substantially reduced, resulting in improved groundwater conditions. These improved conditions will result in groundwater elevations that are substantially closer to the ground surface under all hydrologic conditions. These changes in groundwater will result in improved conditions for groundwater dependent ecosystems, including riparian areas and wetlands.

One of the important changes includes the increase in the shallow groundwater level and frequency that the shallow groundwater is close to the ground surface. Riparian and wetland vegetation is dependent on shallow groundwater to both support mature vegetation and for seedling establishment (Rood, Braatne, et al., 2003). When shallow groundwater levels decline, it can result in reduced plant growth and in more severe cases plant mortality (Shafroth et al., 2000). Land management activities, including groundwater extraction, can affect the shallow groundwater levels that support hydrophilic vegetation (Rood, Gourley, et al., 2003).

Woody riparian vegetation is dependent on the presence of shallow groundwater close to the ground surface (Scott et al., 1999; Shafroth et al., 2000). Stromberg and colleagues (1996) found that mature cottonwood and willow trees required mean depths to groundwater of 4.9 ft ± 3.6 (1.5 m ± 1.1) and 4.6 ft ± 2.0 (1.4 m ± 0.9) respectively (Table 1). The range of supporting groundwater depths extended to over 16 feet below the ground surface for mature cottonwood and over 10 feet for mature willows (Table 1).

Table 1. Mean depth to groundwater, standard deviation, minimum and maximum depth for two mature woody riparian species. Data from Stromberg et al. (1996).

	Depth to Groundwater (feet)		
Mature Species	**Mean ± 1 SD**	**Minimum**	**Maximum**
Fremont's cottonwood (*Populus fremontii*)	4.9 ± 3.6	0.3	16.7
Gooding's willow (*Salix gooddingii*)	4.6 ± 2.0	0.3	10.5

The shallow groundwater depths necessary to support seedling establishment is closer to the ground surface than for mature vegetation (Mahoney & Rood, 1998). For cottonwood seedlings Mahoney and Rood (1998) found that successful recruitment occurred when the shallow groundwater table was within 2 to 6.6 feet (0.6-2 m) due to the combined effects of capillary fringe zone and initial root growth.

Stromberg and others (1996) found that juvenile cottonwood and willow species required mean depths to groundwater of 3 ft ± 1.6 (0.9 m ± 0.5) and 2 ft ± 2.0 (0.6 m ± 0.6) respectively (Table 2).

Table 2. Mean depth to groundwater, standard deviation, minimum and maximum depth for two juvenile woody riparian species. Data from Stromberg et al. (1996).

	Depth to Groundwater (feet)		
Juvenile Species	**Mean ± 1 SD**	**Minimum**	**Maximum**
Fremont's cottonwood (*Populus fremontii*)	3.0 ± 1.6	0.7	6.6
Gooding's willow (*Salix gooddingii*)	2.0 ± 2.0	0.3	6.6

Stromberg et al. (1996) found that like woody species, herbaceous wetland species are also dependent on shallow groundwater levels close to the ground surface. The mean depth to groundwater ranged from 0.3 to 9.8 feet (0.1 to 3.0 m) for facultative and facultative wetland species (Stromberg et al., 1996).

For the purpose of assessing the potential for the program to support riparian and wetland plant communities, two shallow groundwater depths were selected: (1) 5 feet below the ground surface, and (2) 10 feet below the ground surface. These two depths were selected to represent the range of supporting conditions for mature species, as well as seedling establishment. The accuracy of the groundwater modeling was also taken into consideration when selecting these two depths. As such, these five-foot increments were selected to reflect the physical conditions necessary to support hydrophilic vegetation, while also remaining within the bounds of the predictive capacity of the groundwater model. Additionally, for the purposes of assessing the potential benefits to groundwater dependent ecosystems, TFT used the groundwater modeling results for layer 1, which corresponds to the depth of the shallow groundwater table.[1]

[1] The SacIWRM model aquifer layers are delineated into three aquifer layers. The top two aquifer layers, Upper Aquifer (Model Layer 1) and Lower Aquifer (Model Layer 2), are freshwater bearing aquifers. The third aquifer layer (a non-freshwater bearing aquifer) starts from the bottom of the fresh groundwater, which is defined as having a concentration of total dissolved solids less than 2,000 mg/L, to the bottom of the continental deposits. The percentage of time within a certain distance to the ground surface are presented using results from Model Layer 1, as these values are more appropriate for evaluating shallower conditions related to riparian forest health maintenance and stream-aquifer interaction.

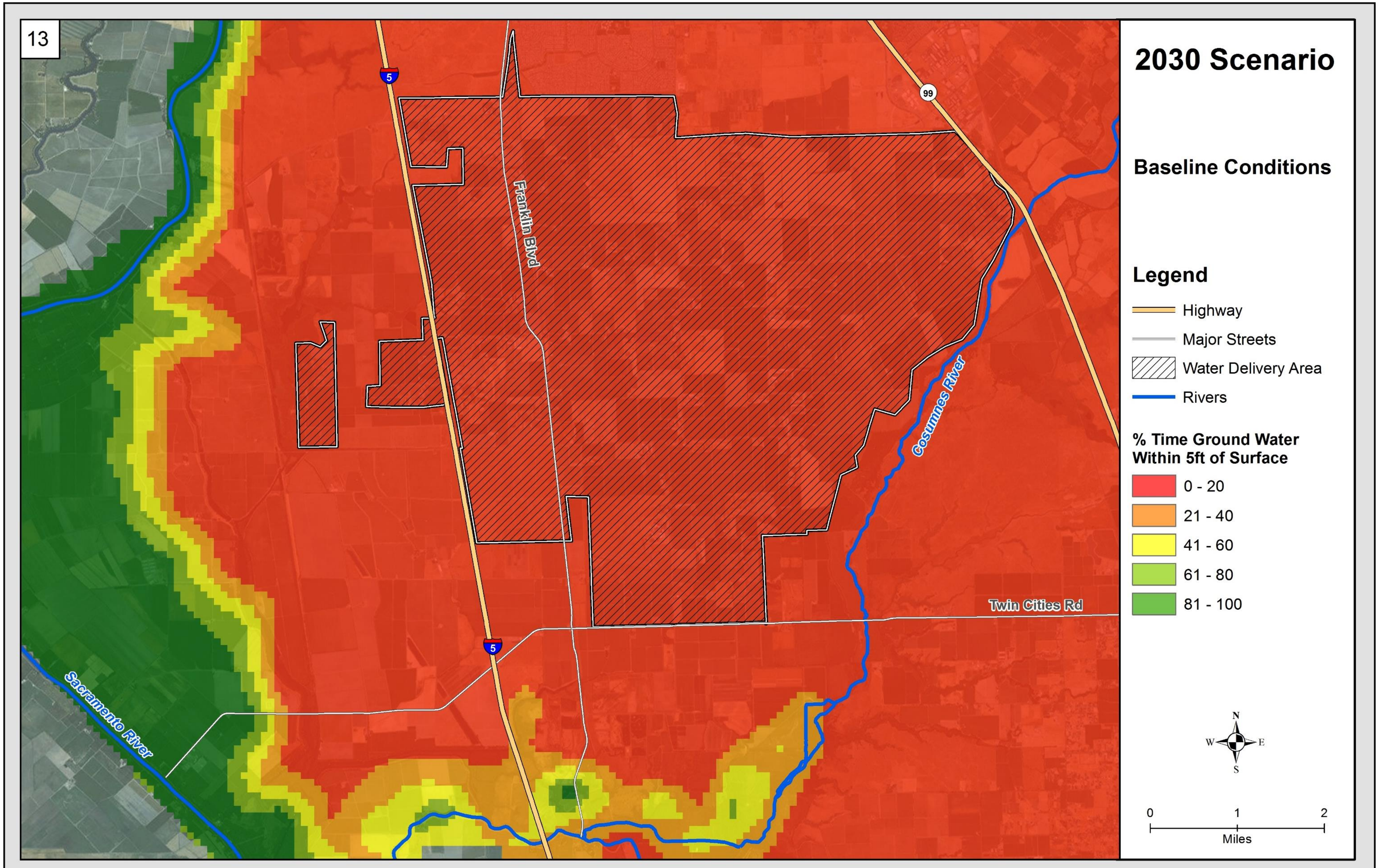

Figure 7. Percent of time that the shallow groundwater is within 5 feet of the ground surface given baseline conditions under the 2030 climate change scenario. Please see the Appendix for additional map results.

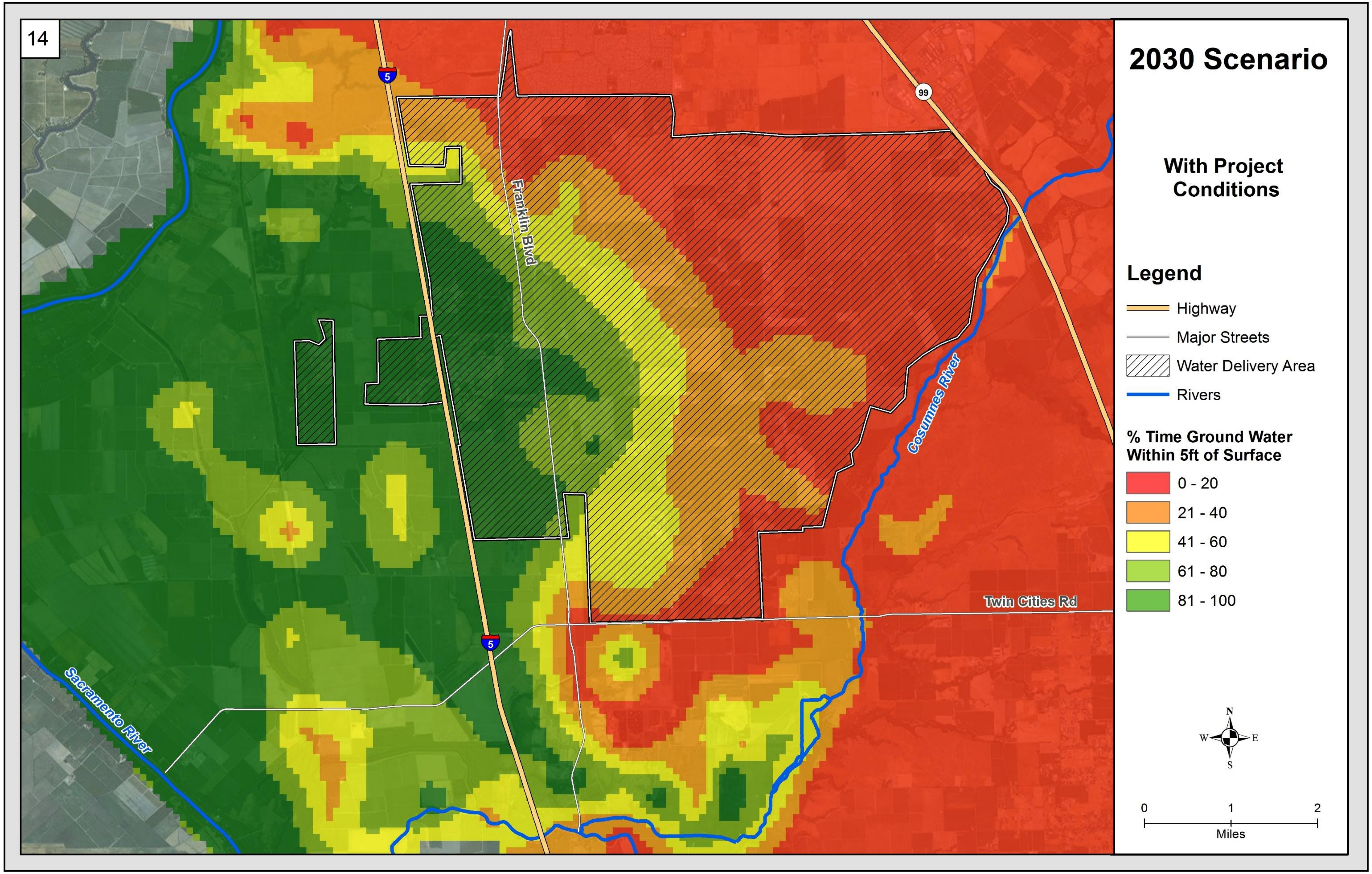

Figure 8. Percent of time that the shallow groundwater is within 5 feet of the ground surface with the South County Ag program in place under the 2030 climate change scenario. Please see the Appendix for additional map results.

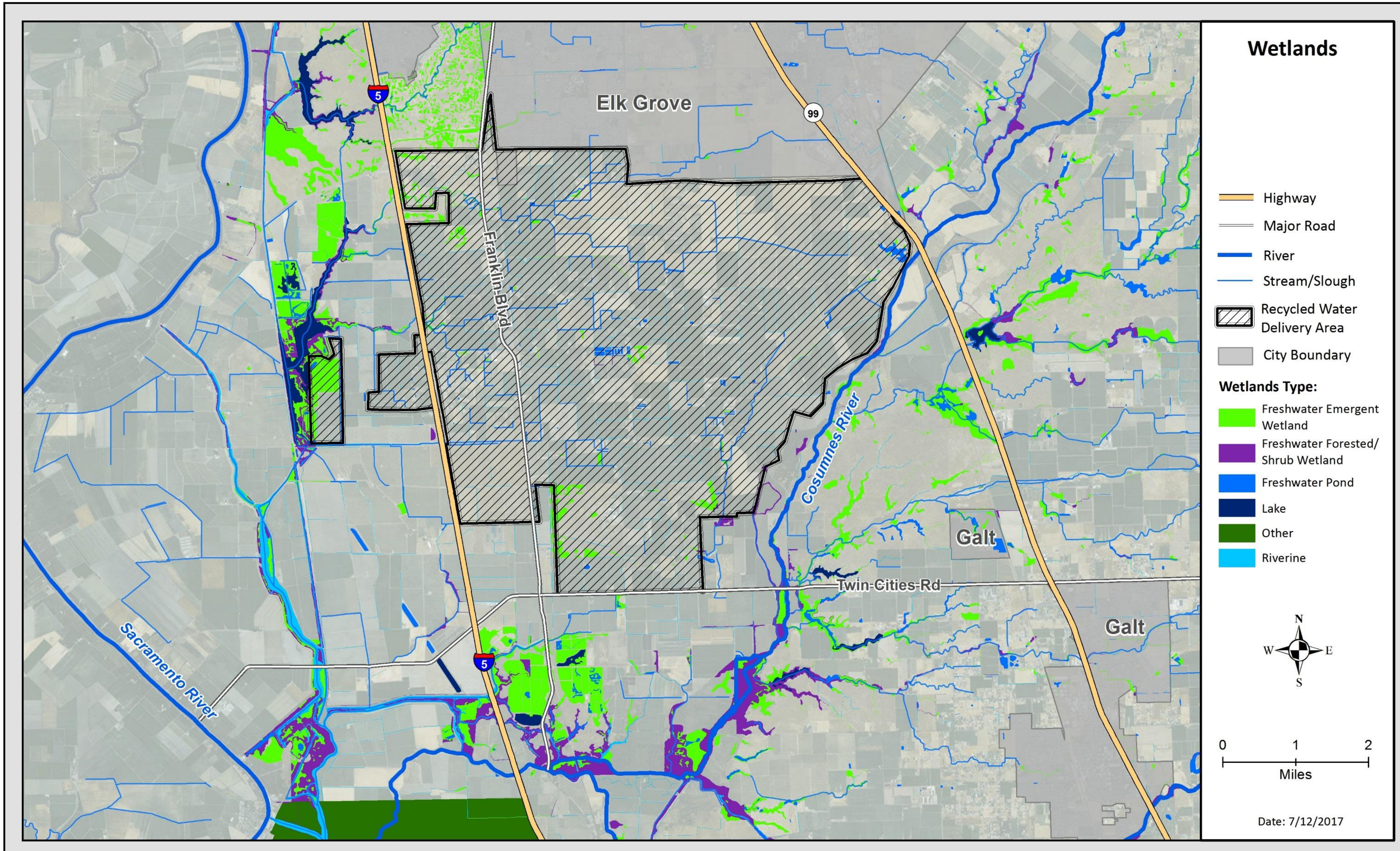

Figure 9. Distribution of riparian and wetland areas in the overall program area. Spatial data are from the National Wetland Inventory (NWI; U.S. Fish and Wildlife Service, 2016)

The timing of the groundwater benefit is an additional consideration when quantifying the ecosystem benefits of the program. Seasonal fluctuations in groundwater levels is normal and once established, riparian species are able to survive periodic declines (Stromberg & Patten, 1992). For the purposes of quantifying the riparian and wetland benefit of the program, only areas where the shallow groundwater levels were within 5 feet of the ground surface for more than 80% of the modeled months were considered suitable for recruiting riparian and wetland vegetation (Figure 7 and Figure 8). The same requirement was used to categorize the areas suitable for supporting riparian and wetland vegetation: shallow groundwater levels within 10 feet of the ground surface for more than 80% of the modeled months (see Appendix). The benefits discussed in this section are not the direct result of water application to the areas specified (flooding), but are instead the product of the resulting improvements in groundwater conditions.

Given the depths to groundwater necessary to support the establishment of woody species (Table 2), the number of riparian and wetland acres with shallow groundwater levels within 5 feet will increase from 146 to 1,627 acres under the 2030 climate change scenario (Table 3). This represents an additional 1,481 acres of habitat that can support the establishment of woody species. Approximately 55% of these acres are actively managed for conservation purposes.

Table 3. Number of wetland acres where the shallow groundwater is within 5 feet of the ground surface more than 80% of the time. Wetland acreages are presented for baseline and with program conditions for both climate change scenarios.

Wetland Acres with Shallow Groundwater within 5 feet >80% of the Time				
	2030 Climate Change Scenario		**2070 Climate Change Scenario**	
	Baseline	**With Program**	**Baseline**	**With Program**
Managed Wetlands				
Emergent	40	566	27	57
Forested/Shrub	11	228	6	28
Riverine	18	86	17	19
Managed Subtotal	***69***	***880***	***50***	***104***
Unmanaged Wetlands				
Emergent	17	250	1	47
Forested/Shrub	44	237	3	63
Riverine	16	260	1	39
Unmanaged Subtotal	***77***	***747***	***5***	***149***
Total	**146**	**1,627**	**55**	**253**

Managed wetlands represent areas that are currently managed for conservation purposes. These areas include the Cosumnes River Preserve, land managed by The Nature Conservancy or other agencies, and the Stone Lakes National Wildlife Refuge.

Given the depths to groundwater necessary to support mature woody species (Table 1) and herbaceous wetland vegetation, the number of riparian and wetland acres with shallow groundwater levels within 10 feet of the ground surface will increase from 1,095 to 4,228 acres under the 2030 climate change scenario (Table 4). This represents an additional 3,133 acres of habitat that can support herbaceous and mature woody species. Approximately 37% of these acres are actively managed for conservation purposes.

Table 4. Number of wetland acres where the shallow groundwater is within 10 feet of the ground surface more than 80% of the time. Wetland acreages are presented for baseline and with program conditions for both climate change scenarios.

Wetland Acres with Shallow Groundwater within 10 feet >80% of the Time				
	2030 Climate Change Scenario		2070 Climate Change Scenario	
	Baseline	With Program	Baseline	With Program
Managed Wetlands				
Emergent	162	850	65	739
Forested/Shrub	232	549	69	461
Riverine	115	282	59	245
Managed Subtotal	***509***	***1,681***	***193***	***1,445***
Unmanaged Wetlands				
Emergent	96	1,177	45	535
Forested/Shrub	284	574	173	492
Riverine	206	796	144	588
Unmanaged Subtotal	***586***	***2,547***	***362***	***1,615***
Total	**1,095**	**4,228**	**555**	**3,060**

Managed wetlands represent areas that are currently managed for conservation purposes. These areas include the Cosumnes River Preserve, land managed by The Nature Conservancy or other agencies, and the Stone Lakes National Wildlife Refuge.

The riparian and wetland acreages presented in Table 3 and Table 4 represent the total area that are estimated to benefit from the implementation of the program. The groundwater improvements will support these ecosystems by providing the necessary conditions to recruit and sustain hydrophilic vegetation. When quantifying the magnitude of these benefits, it is important to consider how the ecosystem conditions will change. As included in Section 404 of the Clean Water Act, ecosystem condition refers to: “the relative ability of an aquatic resource to support and maintain a community of organisms having a species composition, diversity, and functional organization comparable to reference aquatic resources in the region.” (33 CFR 332.2; 40 CFR 230.92)

Multiple methods exists to evaluate the condition and function of riparian and wetland areas (Brinson, 1993; Somerville, 2010). Typically, these functional assessments are used to assess the potential loss of function as a result of development or other impacts, and include a field survey to classify the on-the-ground conditions. The output of the functional assessment often includes a score that categorizes the level of ecosystem function relative to reference conditions (Czarnomski & Skidmore, 2013; NRCS, 2009).

Within the managed areas that will benefit from the program, four wetland condition surveys using California's Rapid Assessment Method (CRAM; California Wetlands Monitoring Workgroup, 2013) were available. The index scores for these four sites range from 65 to 91 (maximum potential score of 100; Table 5), suggesting that the current overall conditions in these managed areas is currently relatively high. As such, the potential improvement in conditions of these habitats is relatively low. On average, the maximum potential increase in condition is 17 points.

Table 5. California's Rapid Assessment Method (CRAM) results for four survey sites within the program benefit area. CRAM scores reflects wetland condition and stressors affecting the wetland function. Data from EcoAtlas (CWMW, 2017).

Survey Sites	Survey Year	Index Score (Maximum Score: 100)
Cosumnes Pond 11	2014	65
Cosumnes River Preserve depression	2012	87
Tall Forest	2005	91
Wendell's Levee	2005	89

No quantitative habitat quality data were available for riparian or wetland areas on lands not actively managed for conservation purposes. It is likely, however, that these areas experience additional stressors and do not exhibit the same level of function as the managed lands. As such, there likely exists a greater potential for improvement on the unmanaged habitats. This potential for improvement would be reflected in lower CRAM scores. Pre- and post-project CRAM assessments will be completed, and these and other quantitative monitoring approaches will be used to track the success of the project and adapt the management as needed.

While the improvements in groundwater as a result of this project will be critical to support increased functions on the managed lands, it is unlikely that they will be able to restore all areas to full function (i.e., a maximum index score of 100). For the purposes of this assessment, TFT has assumed the functional improvement is limited to 10% for all managed riparian and wetland acres with plant establishment benefits from the program (acres with shallow groundwater within 5 feet of the ground surface; Table 3). For the managed acres where the program benefit is limited to increases in shallow groundwater that can support mature woody and herbaceous vegetation but not establishment, TFT has assumed a 5% functional improvement in conditions (acres with shallow groundwater within 10 feet of the ground surface; Table 4).

Under the 2030 climate change scenario, approximately 800 acres of managed riparian and wetland habitat will benefit from improved shallow groundwater levels that support the establishment of hydrophilic vegetation (Table 6). An additional 361 managed acres will benefit from groundwater improvements that support mature vegetation (Table 6).

Table 6. Number of actively managed riparian and wetland acres that will experience improvements in conditions that facilitate plant establishment and support mature vegetation. Benefited acres are presented for the two climate change scenarios. Acres presented in the Support columns do not include acres where there is overlap with Establishment acres.

	2030 Climate Change Scenario		2070 Climate Change Scenario	
Managed Wetlands	**Establishment** 10% functional improvement (Acres)	**Support** 5% functional improvement (Acres)	**Establishment** 10% functional improvement (Acres)	**Support** 5% functional improvement (Acres)
Emergent	526	162	30	644
Forested/Shrub	217	100	22	370
Riverine	68	99	2	184
Total	**811**	**361**	**54**	**1,198**

Given that the existing conditions of the unmanaged riparian and wetland areas are expected to be lower than the managed lands, the changes in shallow groundwater will likely result in greater functional improvements. As with the managed lands, it is unlikely that the groundwater changes will be able to restore all areas to full function (i.e., a maximum index score of 100). For the purposes of this assessment, the functional improvement on unmanaged riparian and wetland acres is assumed to be a result of improvements to both hydrology and vegetation conditions. For unmanaged acres with plant establishment benefits from the program (acres with shallow groundwater within 5 feet of the ground surface; Table 3), the assumed functional improvement is 50%. For the acres where the program benefit is limited to increases in shallow groundwater that can support mature woody and herbaceous vegetation but not establishment, TFT has assumed a 25% functional improvement in conditions (acres with shallow groundwater within 10 feet of the ground surface; Table 4).

Under the 2030 climate change scenario, 670 acres of unmanaged riparian and wetland habitat will benefit from improved shallow groundwater levels that support the establishment of hydrophilic vegetation (Table 7). An additional 1,291 acres will benefit from groundwater improvements that support mature vegetation (Table 7).

Table 7. Number of unmanaged riparian and wetland acres that will experience improvements in conditions that facilitate plant establishment and support mature vegetation. Benefited acres are presented for the two climate change scenarios. Acres presented in the Support columns do not include acres where there is overlap with Establishment acres to avoid double counting.

	2030 Climate Change Scenario		2070 Climate Change Scenario	
Unmanaged Wetlands	**Establishment** 50% functional improvement (Acres)	**Support** 25% functional improvement (Acres)	**Establishment** 50% functional improvement (Acres)	**Support** 25% functional improvement (Acres)
Emergent	233	848	46	444
Forested/Shrub	193	97	60	259
Riverine	244	346	38	406
Total	**670**	**1,291**	**144**	**1,109**

2.2. Instream Flow Benefits

An additional benefit of the increased groundwater levels is increased flows in the Cosumnes River. The Cosumnes River experiences reduced instream flows during the fall, limiting the migration of fall-run Chinook salmon (Fleckenstein et al., 2001). In past years, instream flows during the migration period (October to December) have been so low that reaches of the lower Cosumnes River have been dry for much of the migration window (Fleckenstein et al., 2004). These conditions have limited fish passage and impacted fall-run Chinook.

As mentioned above, one of the direct benefits of the program will be the improved instream flows in the Cosumnes River. In particular, the expected instream improvements will be greatest under low-flow conditions (Figure 10 and Figure 11). For example, under the 2030 climate change scenario, Cosumnes River flows near Twin Cities Road are predicted to exceed 1 cfs 85% of the time under baseline conditions, and 97% of the time with the program in place (Figure 10).

The magnitude of the instream improvement as a result of the program is evident at higher base flow. Under the 2030 conditions, Cosumnes River flows are expected to exceed 10 cfs 64% under baseline conditions, and 80% of the time with the program in place (Figure 10). These improved base flows will not only benefit the returning Chinook salmon, but will also provide habitat for the native resident fish and aquatic organisms in the Cosumnes River, including Pacific lamprey (*Lampetra tridentata*), Prickly sculpin (*Cottus asper*), and riffle sculpin (*Cottus gulosus*). Without the program in place, the instream conditions within the Cosumnes River will continue to degrade under both climate change scenarios, effectively eliminating the flow and habitat necessary to support these resident fish. Benefits for these resident fish are also expected under the 2070 climate change scenario. Under the 2070 scenario, baseline flows would exceed 10 cfs 56% of the time, but with the program in place, flows would exceed 10 cfs 64% of the time (Figure 11).

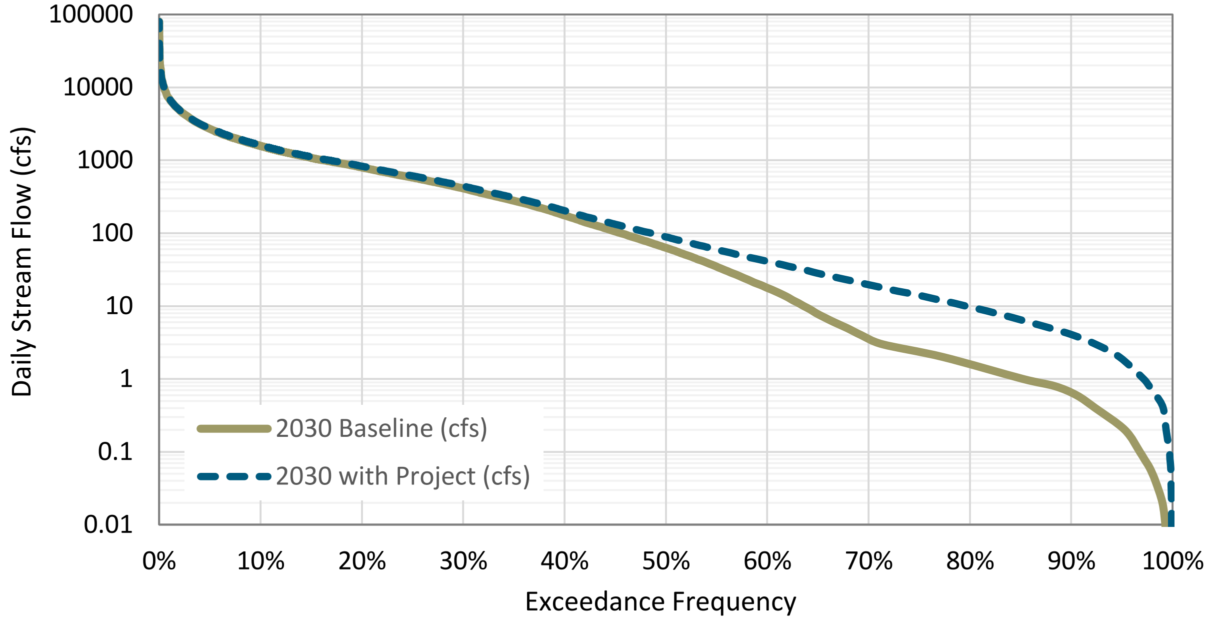

Figure 10. Cosumnes River stream flow exceedance frequency for both the baseline conditions and the with program conditions for the 2030 climate change scenario at Twin Cities Road.

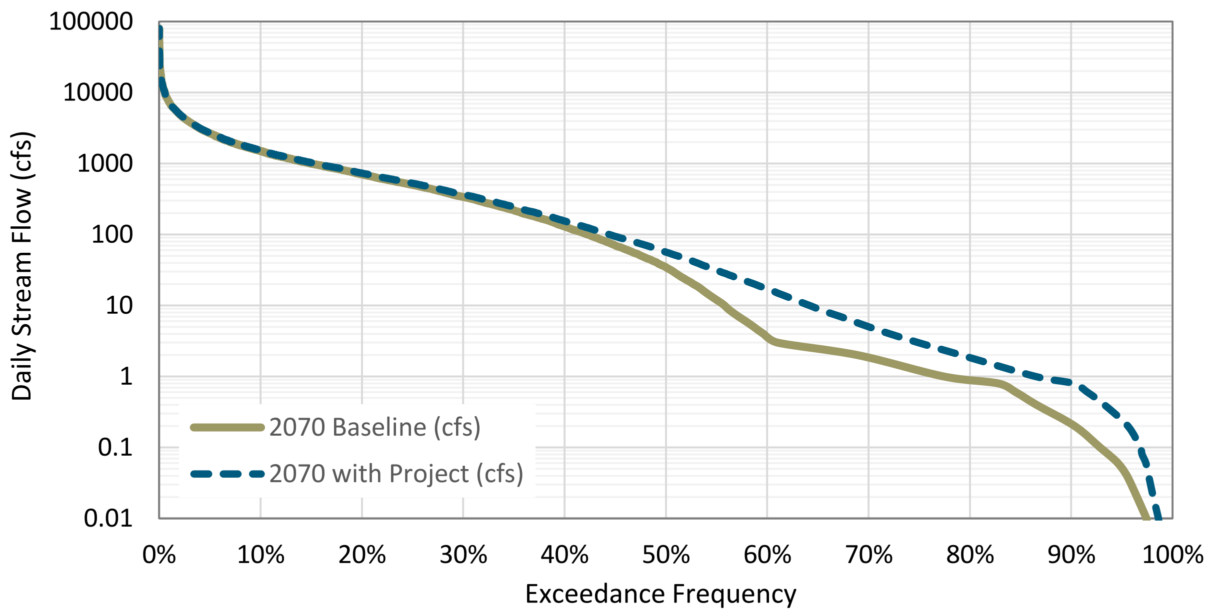

Figure 11. Cosumnes River stream flow exceedance frequency for both the baseline conditions and the with program conditions for the 2070 climate change scenario at Twin Cities Road.

The improved flow illustrated in Figure 10 and Figure 11 highlight the instream benefits from the program to the Cosumnes River. These benefits can also be articulated as a total flow volume improvement to the river (acre-feet/year). Across all 84 modeling years, the improve flows in the Cosumnes River can be converted into a mean total water volume increase of approximately 15,500 acre-feet/year under the 2030 climate change scenario (Table 8; Figure 12). This represents a water volume improvement in the Cosumnes River as a result of the South County Ag Program that could not be achieved through other means. The expected improvement under the 2070 climate change scenario is approximately 12,000 acre-feet/year throughout the life of the program (Table 8; Figure 12).

Table 8. Total water volume due to an increase in flow in the Cosumnes River with the South County Ag Program in place under the 2030 and 2070 climate change scenarios. The increase represents the difference from the baseline conditions.

Scenario	Mean Annual Volume Increase (Acre-Feet/Year)	Median Annual Volume Increase (Acre-Feet/Year)
2030	15,511	16,039
2070	11,987	12,208

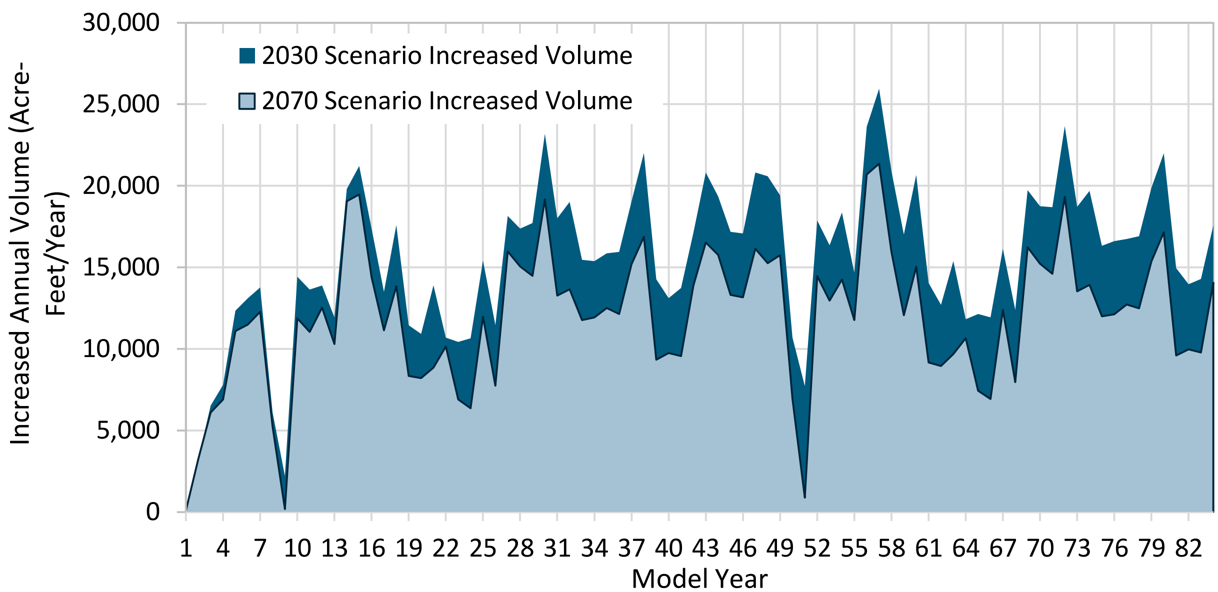

Figure 12. Total annual increase in water volume (in acre-feet per year) in the Cosumnes River with the program in place under the 2030 and 2070 climate change scenarios for each modeling year. The annual volume increase is calculated based on the change in instream flow presented in Figure 10 and Figure 11 and the increase represents the difference from baseline conditions.

In addition to the magnitude of the improved instream flow conditions, the timing of those improvements are relevant to supporting fall-run Chinook in the Cosumnes River. During the migration period (October to December), fish passage through the lower Cosumnes River is limited by the reduced instream flows. To support passage through the system, Fleckenstein et al. (2004) identified a minimum discharge of 20 cfs (0.57 m^3/s) during the migration window for the Cosumnes River.

The base flow improvements of the program will also benefit fall-run Chinook in the Cosumnes River by supporting a longer time period during the migration window where flow exceeds the minimum flow needed for passage. Under the baseline conditions, only 38.4 days meet or exceed the minimum flow for the 2030 climate change scenario (Table 9). This corresponds to 42% of the migration window. With the program, the number of days that meet or exceed a flow target of 20 cfs is 51.5, or 56% of the migration window for the 2030 climate change scenario (Table 9). Under the 2030 climate change scenario, the program is expected to increase the number of days that support fall-run Chinook passage by 34%.

Table 9. Mean number of days where Cosumnes River flows are greater than 20 cfs for the baseline and with program conditions under the 2030 climate change scenario.

2030 Climate Change Scenario Mean Number of Days with Instream Flow >20 cfs				
Scenario	**October**	**November**	**December**	**Total**
Baseline	4.5	12.3	21.6	38.4
With Program	8.0	17.0	26.5	51.5
Increase	***3.5***	***4.7***	***4.9***	***13.1***

Similar base flow improvements are expected under the 2070 climate change scenario. Under the baseline conditions, only 26.5 days meet or exceed the minimum flow for the 2070 climate change scenario (Table 10). This corresponds to 29% of the migration window. With the program, the number of days that meet or exceed a flow of 20 cfs is 32.5, or 35% of the migration window for the 2070 climate change scenario (Table 10Table 9). Under the 2070 climate change scenario, the program is expected to increase the number of days that support fall-run Chinook passage by 23%.

Table 10. Mean number of days where Cosumnes River flows are greater than 20 cfs for the baseline and with program conditions under the 2070 climate change scenario.

2070 Climate Change Scenario Mean Number of Days with Instream Flow >20 cfs				
Scenario	**October**	**November**	**December**	**Total**
Baseline	2.0	7.6	16.9	26.5
With Program	3.0	9.2	20.3	32.5
Increase	***1.0***	***1.6***	***3.4***	***6.0***

Historically, the Cosumnes River has supported a larger population of fall-run Chinook salmon than what is observed today. Restoration goals for fall-run Chinook in the Cosumnes River include a mean annual spawning run population of 2,000 adults, with a 10-year mean ranging from 1,000 to 5,000 adults (Kleinschmidt Associates, 2008). Past observations of returning fall-run Chinook range from 0 to 1,350 adults, with a mean of 418 (California Department of Fish and Wildlife, 2017; Figure 13).

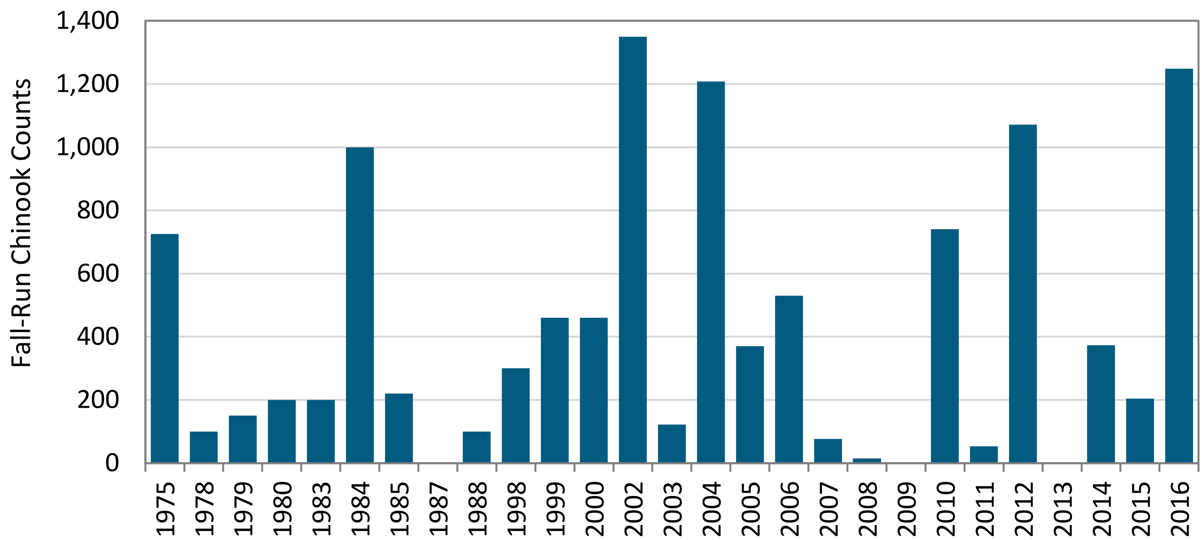

Figure 13. Cosumnes River fall-run Chinook population estimates. No population data were available for years that are not included on the graph (1976, 1977, 1981, 1982, 1986, 1989-1997, and 2001). Population data is from the California Department of Fish and Wildlife (2017).

While the exact benefit of the improved Cosumnes River flows to fall-run Chinook populations is not known, the expected population improvements can be estimated based on the larger migration window. As mentioned above, the mean length of the migration window will increase by 13.1 days with the program in place under the 2030 climate change scenario.[2] This corresponds to a 34% increase in the length of the migration window. Assuming that the increase in the length of the migration window will support a proportionally larger population of fall-run Chinook, this 34% increase was applied to the mean fish population of 418 to estimate the expected increase (Table 11). The same assumption was applied to the increased migration window under the 2070 climate change scenario (Table 11).

Table 11. Estimated increase in adult fall-run Chinook populations as a result of the improved base flows from the program during the migration window (October to December). Increases in populations are based on the percent increase in the length of the migration window and the observed annual mean population of 418 adults (Figure 13).

Scenario	Increase in Migration Window (Days, % Increase)	Estimated Increased fall-run Chinook Population (Number of Adults)
2030 Climate Change	13.1 (34%)	143
2070 Climate Change	6.0 (23%)	95

[2] The mean values presented in Table 1 are based on the results from the full set of simulations, including the initial ramp-up period at the beginning of the project. As such, the mean values reflect both the expected annual variation in flow as a result of the cycle of hydrologic years, but also reflects the fact that the full instream flow benefits of the project will not be immediately realized.

2.3. Groundwater-supported Wetland & Riparian Forest Restoration

The shallow groundwater benefits described in Section 2.1 highlight the broad-scale ecosystem improvements associated with the program. While the increase in shallow groundwater levels alone will help to support riparian and wetland habitats, some of the unmanaged areas are severely degraded. As such, it is unlikely that the shallow groundwater improvements will be sufficient to improve conditions on the unmanaged acres. In these areas, the abundance of invasive weeds, such as perennial pepperweed (*Lepidium latifolium*), has resulted in large monocultures that exclude native species (Andrew & Ustin, 2006). To maximize the ecosystem improvement, weed treatment and active restoration is needed on these unmanaged acres.

Riparian forests and forested wetlands provide habitat for many different species in Central Valley (Golet et al., 2008). Much of the historic riparian forests of the Central Valley have been lost as a result of human settlement (Hunter et al., 1999). While many of these impacts continue today, restoration efforts throughout the region have documented the potential for improved canopy conditions to support an increase in species diversity, as well as an increase in populations (Gardali et al., 2006; Golet et al., 2008). Many of these studies have identified the importance of elongating riparian forests to increase available habitat (Gardali & Holmes, 2011).

Active revegetation efforts can include noxious weed treatment followed by the planting of trees and shrubs. While typically effective, active planting can be costly and recent restoration efforts in the area have documented the effectiveness of passive restoration techniques (Robertson-Bryan, 2006). These recent efforts have documented the successful natural recruitment of woody riparian vegetation by restoring hydrologic connectivity to floodplain areas (Robertson-Bryan, 2006; Swenson et al., 2003). Restoring floodplain connectivity facilitates the natural colonization of riparian areas, reducing the cost of restoration.

The existing canopy conditions indicate that very few riparian and wetland areas support a forest canopy.[3] For example, with the program in place, only 17 of the 237 acres of unmanaged forested wetlands have a canopy with trees 25 feet or taller (Table 12). That is, with the program in place under the 2030 climate change scenario, only 7% of the 237 acres that are capable of supporting the establishment[4] of woody vegetation currently have a forest canopy. Substantial restoration potential exists on these acres.

[3] Canopy conditions were characterized from the available 2013 Light Detection and Ranging (LiDAR) data for the program area. The canopy model was developed by calculating the difference between the first-return heights and the bare earth elevations.

[4] Where shallow groundwater levels are within 5 feet of the ground surface more than 80% of the time.

Table 12. Number of acres designated as forested wetlands in the National Wetland Inventory where the shallow groundwater is within 5 feet of the ground surface more than 80% of the time. Acreages are divided into two categories based on LiDAR canopy height. Results are presented for the two climate change scenarios.

Forested Wetland Acres with Shallow Groundwater within 5 feet >80% of the Time				
	2030 Climate Change Scenario		**2070 Climate Change Scenario**	
	Baseline	**With Program**	**Baseline**	**With Program**
Managed Forested Wetlands				
Canopy < 25 feet	10	188	5	25
Canopy ≥ 25 feet	1	41	1	2
Managed Subtotal	***11***	***228***	***6***	***28***
Unmanaged Forested Wetlands				
Canopy < 25 feet	39	221	3	56
Canopy ≥ 25 feet	6	17	0	7
Unmanaged Subtotal	***44***	***237***	***3***	***63***
Total	**55**	**466**	**9**	**91**

The 2070 climate change scenario results highlight that even with the program in place, the number of riparian and wetland areas with groundwater conditions capable of supporting the establishment of woody vegetation is substantially smaller (Table 12). The conditions necessary to support mature[5] hydrophilic vegetation, however, are present under the 2070 climate change scenario with the program in place (Table 13). As such, the 2070 climate change conditions do not preclude the reforestation of riparian and wetland areas. Rather, the results underscore the benefit of implementing restoration work earlier in the program so that plants can become established when conditions are more favorable. Once established, vegetation is better able to tolerate the lower groundwater levels, thus substantially increasing the resiliency of the ecosystem.

Additionally, the 2070 shallow groundwater conditions do not prevent the success of revegetation efforts. Rather, under these conditions practitioners would need to utilize different implementation approaches, such as the usage of irrigation, to support initial plant establishment. With the program in place, any established vegetation will have the shallow groundwater conditions necessary to support a mature forest under both climate change scenarios.

[5] Where shallow groundwater levels are within 10 feet of the ground surface more than 80% of the time.

Table 13. Number of acres designated as forested wetlands in the National Wetland Inventory where the shallow groundwater is within 10 feet of the ground surface more than 80% of the time. Acreages are divided into two categories based on LiDAR canopy height. Results are presented for the two climate change scenarios.

Forested Wetland Acres with Shallow Groundwater within 10 feet >80% of the Time				
	2030 Climate Change Scenario		**2070 Climate Change Scenario**	
	Baseline	**With Program**	**Baseline**	**With Program**
Managed Forested Wetlands				
Canopy < 25 feet	172	459	59	384
Canopy ≥ 25 feet	60	90	9	77
Managed Subtotal	***232***	***549***	***69***	***461***
Unmanaged Forested Wetlands				
Canopy < 25 feet	256	527	153	451
Canopy ≥ 25 feet	29	47	20	42
Unmanaged Subtotal	***284***	***574***	***173***	***492***
Total	**517**	**1,123**	**242**	**953**

While implementing active restoration or weed treatment on all of these unmanaged acres is beyond the scope of this program, targeted projects and treatment on a subset of acres is a part of the program proposal. As part of the South County Ag Program, 500 acres of riparian and wetlands habitat will be targeted for restoration to improve canopy conditions.

Detailed restoration and management plans require site-specific information. These site-specific restoration and stewardship plans will be developed as sites are identified throughout the implementation of the program. These plans will include long-term stewardship objectives and monitoring to ensure that the future ecological conditions and functions are achieved at each individual project. Given the high level of observed ecological function at many of the actively managed sites in the area (Table 5), TFT expects that the restoration and stewardship of the targeted 500 acres will also result in high levels of function. Additionally, these area will also have the supportive shallow groundwater conditions necessary for mature woody vegetation. For the purposes of quantifying the expected improvement in ecological function, TFT is assuming that these restored acres will achieve a level of function equivalent to a CRAM score of 95.

2.4. Changes in Land Management to Support Wildlife

The presence of agriculture in the program area does not preclude the potential to support wildlife. An important aspect of the program will be the collaboration with agricultural producers to receive recycled wastewater for irrigation. Working directly with producers will allow for a unique opportunity to engage producers in changes in land management to support wildlife. This complementary aspect of the program will include a combination of targeted applications of water during the winter to flood agricultural fields with changes in residue management. Combined these actions will increase the acreage of available habitat for greater sandhill cranes (*Grus canadenis tabida*) within the delivery area.

The Sacramento-San Joaquin River Delta region (Delta) provides essential winter habitat for the California Central Valley greater sandhill crane population (Ivey et al., 2014). Approximately half of all sandhill cranes counted as part of a recent Pacific Flyway survey were observed in the Delta, highlighting its importance as an area for conservation to support the recovery of California sandhill cranes (Ivey et al., 2014).

During the winter, greater sandhill cranes will migrate and over-winter in agricultural regions that are dominated by cereal and grain crops, including the Delta (Littlefield & Ivey, 2000). Combined with nearby wetlands for roosting and loafing, the landscape in and around the delivery area is well suited to support greater sandhill cranes (Kleinschmidt Associates, 2008). Additionally, wintering habitat represents an important aspect of the annual life history of greater sandhill cranes as the migrating population is present within the program area from September through March (Littlefield & Ivey, 2000).

Essential aspects of greater sandhill crane habitat includes grain crops as a source of carbohydrates, and grasslands, pastures, or alfalfa fields for obtaining protein and other nutrients (Golet, 2011). Greater sandhill cranes utilize these habitats for foraging and nearby flooded agricultural fields and wetlands for roosting (Littlefield & Ivey, 2000).

Given their lifecycle and habitat needs, the greater sandhill cranes can benefit substantially from changes in land management on agricultural lands. Such changes include reduced disking or plowing of harvested cropland to minimize the amount of waste grain that is buried as a result of tillage practices, targeted field flooding to create suitable roost sites, and increasing the rate of seeding to compensate for the loss due to foraging (Golet, 2011). Increasing the amount of wintering habitat will help to support the greater sandhill crane population.

In order to estimate the potential acreage of available habitat suitable for greater sandhill cranes, TFT evaluated the past five years (2012-2016) of agricultural practices on fields within the delivery area (USDA, 2016). To do so, the boundary of each agricultural field was delineated using recent orthoimagery (NAIP; USDA Farm Service Agency, 2016). The majority crop type within the field boundary was identified by applying the ArcGIS *Zonal Statistics* tool to each CropScape raster dataset to determine the most abundant crop on each field. The purpose of this assessment was to reduce the potential noise present in the crop dataset.

Between 2012 and 2016, approximately 100 agricultural fields within the delivery area have been under corn or wheat production. This corresponds to a total of approximately 5,000 acres of actively farmed land that may be suitable for foraging and roosting habitat. Outside of the recycled water delivery area, an additional 5,500 acres of agricultural land have the similar characteristics.

While approximately 10,500 acres of cropland in the program area may be well-suited to land management changes to support greater sandhill cranes, it is unlikely that improved management practices can be implemented on all fields. For example, some agricultural fields may not have soils appropriate for flooding, or a producer’s practices may not be compatible with the wildlife objectives. Additionally, changes in cropping patterns may also limit the availability of potential habitat. In order to ensure a conservative estimate of the program’s wildlife benefit, only a portion of the available acreage is being targeted. While all efforts will be taken to maximize the acreage of wintertime habitat for greater sandhill cranes, the program will target one-third of the available acreage within the program area, which corresponds to approximately 3,000 acres. Using a tracking and transaction program (as described in Section 6.1), landowners with suitable acreage that can be reliably maintained in suitable condition, would be targeted for long-term agreements, and adjacent properties with similar values would be secured using shorter-term agreements so that in any one year, the program would have no less than 2,500 acres dedicated to cranes and an annual average of 3,500 acres would be implemented.

At the time of this report, no studies were available that documented the habitat abundance necessary to support greater sandhill crane populations. To estimate the magnitude of the expected benefit to the greater sandhill crane population in the program area, it was necessary to rely on observations and characteristics from the surrounding area. Littlefield and Ivey (2000) estimated the size of the Central Valley greater sandhill crane population to be approximately 6,000 adults. A substantial portion of this population is located near the program area. The Staten Island Ranch (located in the Central Sacramento-San Joaquin River Delta) is an agricultural property managed by The Nature Conservancy to support wildlife. Recent assessments of the greater sandhill crane population on the Island estimate a current population of approximately 1,500 individuals (Golet, 2011). Approximately 8,400 acres of the Island are suitable for farming, of which approximately 90% are planted in corn or winter wheat (Golet, 2011). Assuming an even distribution of individuals, the 1,500 population is supported by approximately 7,500 acres of suitable cropland, which corresponds to approximately 5 acres of habitat per individual.

Using the density calculated above (5 acres per individual) and the habitat target for the program (3,500), it is possible estimate the greater sandhill crane population benefit. With the 3,500 acre target in place, the program has the potential to support an additional 700 individuals (Table 14). Site specific results are not presented due to the sensitive nature of restoration and conversation on private lands.

Table 14. Potential acreage of wintertime habitat for greater sandhill cranes within the recycled water delivery area and the targeted benefit of the program.

Total Potential Acreage of Crane Habitat	Proposed Acreage of Habitat Managed for Cranes	Estimated Increase in Greater Sandhill Crane Population
10,500 acres	3,500 acres	700 individuals

2.5. Conservation and Restoration of Vernal Pools

Vernal pools are shallow, depressional wetlands fed by precipitation in the winter and spring (Smith & Verrill, 1998). These seasonal wetlands begin filling with water during the winter, but become dry during the summer. Given the ephemeral nature and wide-ranging conditions, these wetlands create a unique ecosystem that provides habitat for a large number of species, many of which are endemic (Marty, 2005). Vernal pools provide habitat for many different sensitive species, including California tiger salamanders (*Ambystoma californiense*), vernal pool tadpole shrimp (*Lepidurus packardi*) and vernal pool fairy shrimp (*Branchinecta lynchi*).

The project has the unique ability to tie in wide expanses of summer raptor foraging habitat, winter crane habitat, and vernal complexes in a single large, connected region. By integrating vernal pools and channels and their associated upland contributing watershed into the program, the ecological values are maximized and overall management requirements are simplified as the land is managed for these values as a region, instead of small parcels.

Vernal pool habitat loss in the Central Valley has been substantial: approximately 50-85% of the pre-settlement acres have been lost (King, 1998). Importantly, the impacts to vernal pool habitats have continued in recent years. An estimated one third of the remaining vernal pool habitat in Sacramento County has been converted as a result of recent development (Marty, 2005). As such, conservation and restoration of these unique habitats is a priority in the region (Kleinschmidt Associates, 2008).

The land use within the program area is dominated by agriculture, however, these agricultural land management practices do not preclude the potential for vernal pool conservation of restoration. In fact, recent research has documented that habitat function and species diversity in vernal pools are enhanced by livestock grazing (Marty, 2005). The South County Ag Program provides a unique opportunity to expand the initial work with producers to include vernal pool conservation and restoration. Vernal pool conservation would require collaborating with producers to develop a comprehensive, site-specific management plan to address the limiting factors at the site. Large areas with appropriate topography (depressional areas) and soils (poorly drained) will be targeted as part of the program.

TFT completed a spatial analysis to evaluate the potential for vernal pool conservation and restoration in the delivery area. The spatial analysis incorporated multiple landscape characteristics to estimate potential site suitability. The assessment focused on agricultural fields that are currently identified as under production for grasses, hay, idle pasture, or pasture (USDA, 2016). Within the larger program benefit area (Figure 6), approximately 9,100 acres on 240 fields meet this criteria. Using remote sensing data, TFT evaluated these areas to determine whether they have the necessary micro-topography to support vernal pools. Depressional areas were identified using a combination of LiDAR, Normalized Difference Vegetation Index (NDVI), and Normalized Difference Water Index (NDWI).[6] The available LiDAR data was used to identify whether shallow depressions were present on a field. In addition to the depressions identified using LiDAR, agricultural fields that included high variation in photosynthetic activity (large NDVI range) as well as NDWI values indicative of more moisture were classified as potentially suitable for vernal pool habitat.

The results of the spatial analysis indicate that approximately 100 agricultural fields within the delivery area are likely well-suited for vernal pool restoration (Table 15). All areas are 5 acres or larger, with a mean field size of approximately 50 acres. This corresponds to a total of approximately 4,600 acres within the delivery area. Site specific results are not presented due to the sensitive nature of restoration and conversation on private lands.

Table 15. Potential for vernal pool habitat restoration in the delivery area.

Number of Fields	Total Area (acres)	Mean Field Size (acres)	Conservation Target (acres)
98	4,615	47	500

[6] The Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) were calculating the available NAIP orthoimagery from 2016.

While implementing active restoration or conservation on all of these potential acres is beyond the scope of this program, targeted projects on a subset of the vernal pool acres is a part of the program proposal. As part of the South County Ag Program, 500 acres of vernal pool habitat will be targeted for restoration and conservation to improve habitat conditions. In addition to improved vernal pool habitats, securing strategic conservation easements in the program area will help protect these valuable habitats from future conversion to crops within minimal habitat value, such as grapes.

2.6. Water Delivery-supported Wetland Restoration

The final ecosystem benefit of the project discussed involves a combination of the management tools described above: targeted, site-specific winter water application and invasive weed management. Managed and unmanaged wetland areas exist within and surrounding the currently delineated water delivery area for which for the modeled groundwater benefits are minimal; therefore, these wetland areas are not included in the benefits described in Sections 2.1 and 2.3 above. However, delivery of water to these existing wetlands can mitigate the risk of reduced function resulting from disconnection of wetland plants and soils from the groundwater table. Winter flooding, as discussed in Section 2.4 for the support of sandhill crane habitat, can maintain shallow groundwater conditions to support wetland soils and vegetation, allowing for the continued provisioning of important ecosystem services by these wetland areas (e.g., listed species habitat and nutrient cycling). Additionally, controlling the presence and spread of invasive species within wetlands receiving water from the project will further increase wetland health and resulting function. This type of wetland conservation and restoration would require collaborating with landowners to develop a comprehensive, site-specific management plan to address the limiting factors at the site. Large areas with appropriate topography (depressional areas) and soils (poorly drained) will be targeted as part of the program.

Through the National Wetlands Inventory database (U.S. Fish and Wildlife Service, 2016) and the National Land Cover Database (U.S. Geologic Survey, 2011), TFT identified approximately 1,500 acres and 1,000 acres of potential wetlands appropriate for water delivery on managed and unmanaged lands, respectively. Wetlands currently managed by The Nature Conservancy or other agencies, including those within the Cosumnes River Preserve and the Stone Lakes National Wildlife Refuge, can likely be improved through water delivery and weed management to a lesser extent than the those on unmanaged lands because of existing management practices. It is expected that unmanaged areas experience additional stressors and do not exhibit the same current level of function as the managed lands. As such, there likely exists a greater potential for improvement on the unmanaged habitats.

For the purposes of this assessment, TFT has assumed the functional improvement through water delivery and weed management is limited to 10% for all managed wetland acres and 50% for all unmanaged acres. This is consistent with TFT's assumptions of functional increases for wetlands resulting from improved groundwater levels that reach 5 feet of the surface 80% of the months as a result of the project (see Section 2.1 for calculations of these estimated improvements).

Using a tracking and transaction program (as described in Section 6.1), landowners with suitable acreage that can be reliably maintained in suitable condition, would be targeted for long-term agreements, and adjacent properties with similar values would be secured using shorter-term agreements. The willingness of landowners to participate, as well as the existence of appropriate conditions of this type of management, is expected to differ between managed and unmanaged lands, with more willingness and feasibility anticipated on currently managed wetlands. Therefore, TFT has set project targets for participation at 1,000 acres of the 1,500 managed wetland acres (approximately two-thirds) and 300 of the 1,000 unmanaged wetland acres (approximately one-third).

2.7. Summary of Ecosystem Benefits

As mentioned above, there are four primary ecosystem benefits expected from the program: (1) direct improvement as a result of the water application and delivery, (2) direct improvements that require active management to achieve the ecosystem benefit (e.g. weed treatment), (3) habitat restoration that requires active management or implementation, and (4) complimentary changes in land management to support wildlife. These benefits will accrue at different rates depending on the timeline of groundwater improvements or anticipated management action implementation. Table 16 (which spans two pages) summarizes the benefits discussed above and the corresponding units of uplift used for monetization.

Additional detailed groundwater modeling during the project planning phase will allow the type of strategic application of water to improve flows in the Cosumnes River (Section 2.2), improve wetlands both by increasing groundwater levels (as described in Sections 2.1 and 2.3) and by applying water to areas that will not experience groundwater levels high enough to be supportive (Section 2.6), and provide increased sandhill crane (Section 2.4) and vernal pool (Section 2.5) habitat. This Ecological Plan describes a combination of land acquisition, management, and delivery strategies that result in a matrix of habitat types, including both on working agricultural lands and preservation areas, to support a variety of wildlife species and ensure continued ecosystem services provisioning in this region. The ecological improvement resulting from the project are distributed across the landscape, increasing habitat connectivity longitudinally along the Cosumnes River, as well as between the Cosumnes River and Snodgrass Slough. When benefits depend on land acquisition and management, TFT has conservatively estimated the ability to acquire or lease the available lands needed.

Table 16. Summary of the ecosystem benefits from the South County Ag Program under the 2030 and 2070 climate change scenarios (continued on following page).

Ecosystem Benefit	Current Land Use	2030 Climate Change Scenario	2070 Climate Change Scenario	Site-specific Water Application	Weed Management	Unit for Monetization
Direct Program Benefits from Groundwater Improvements						
Increased migration window in Cosumnes River for fall-run Chinook	N/A (instream benefit)	143 adults	95 adults			Additional adult salmon supported
Increased flow volume in the Cosumnes River (acre-feet/year)		15,511 AFY (annual mean)	11,987 AFY (annual mean)			Increased flow volume
Improved groundwater conditions to support existing wetland vegetation (10ft of surface 80% of time; acres)	Managed wetlands	361 ac	1,198 ac			Acres with 5% functional improvement
Improved groundwater conditions to support establishment of wetland vegetation (5ft of surface 80% of time; acres)		811 ac	54 ac			Acres with 10% functional improvement
Improved groundwater conditions to support existing wetland vegetation (10ft of surface 80% of time; acres)	Unmanaged wetlands	1,291 ac	1,109 ac			Acres with 25% functional improvement
Improved groundwater conditions to support the establishment of wetland vegetation (5ft of surface 80% of time; acres)		670 ac	144 ac			Acres with 50% functional improvement

Table 17 (continued). Summary of the ecosystem benefits from the South County Ag Program under the 2030 and 2070 climate change scenarios.

Ecosystem Benefit	Current Land Use	2030 Climate Change Scenario	2070 Climate Change Scenario	Site-specific Water Application	Weed Management	Unit for Monetization
Program Benefits from Management & Restoration						
Habitat management for wildlife (Greater sandhill cranes; acres)	Agricultural fields (row crops)	3,500 ac (project target)	3,500 ac (project target)	X		Increase acres of habitat or # cranes supported
Vernal pool restoration/ re-establishment (acres)	Agricultural fields (with potential for vernal pools)	500 ac (project target)	500 ac (project target)	X	X	Increased acres of habitat
Groundwater-supported wetland & riparian forest restoration (acres)	Wetland forests	500 acres (10 miles) (project target)	500 acres (10 miles) (project target)		X	Acres with 95% function
Water delivery-supported wetland restoration (acres)	Managed wetlands	1,000 ac (project target)	1,000 ac (project target)	X	X	Acres with 10% functional improvement
	Unmanaged wetlands	300 ac (project target)	300 ac (project target)	X	X	Acres with 50% functional improvement

3. RECREATION

Included in the traditional ecological benefits associated with the preservation and enhancement and restoration activities associated with this program are the associated recreational benefits. As a part of the direct physical benefits, is the increased number of visitors to the Cosumnes River as a result of increased flow from the program. Loomis and Creel (1992) related increased flow in rivers to increased visitor frequency to river recreational areas, such as the Cosumnes River Preserve.

4. ECOSYSTEM RESILIENCY

The recharge program is unique in that it has essentially constant water available since the tertiary treated water is being produced every day, each year. That continuous supply creates resiliency because it does not require costly transfers or complex predictions of precipitation patterns and flood control requirements, nor is it subject to competing environmental demands.

That recharge water is unlikely to decrease since the region's population is stable, and there is significant land area available for additional growth. Because of effective conjunctive use management and the Sustainable Groundwater Management Act planning, as well as evolving agricultural water use efficiency, there is likely to be more water available for recharge and less demand in the recharge area than the estimations made for this program.

Operational Drought Resiliency

The only periods that recharge water is not being provided are under limited scenarios with multi-year droughts. The modeled program benefits under a conservative approach, even with 3 out of 10 years of limited or no recharge, demonstrated that the project groundwater benefits would continue. The provided analysis and figures from the modeling already include that drought resiliency scenario to ensure that the project benefits would continue to accrue. This operational flexibility means that a variety of groundwater management programs could function even under sustained droughts to still achieve the project benefits.

However, the modeled scenarios do not reflect operational flexibility that can be gained at the local scale. The program has the ability to strategically provide water at specific locations throughout the delivery area to ensure that the benefits will be provided at the correct locations to optimize the ecological benefits regardless of local variations in groundwater hydrology and drought conditions.

Ecological Resiliency

The program provides considerable resiliency benefits today and in the future in two primary ways:

1. Reversing the groundwater-stream gradient from losing to gaining, stabilizing and improving the ecological resilience under today's climate.
2. Most starkly, absent the program, baseline conditions in 2030 and 2070 show that the groundwater conditions would not support any of the existing public conservation lands in the area.

Stated another way, the groundwater improvements and surface water benefits from this project provide the resiliency from modeled climate change impacts to support and protect the existing private and public investments which have been focused in the watershed. This in addition to the proposed project benefits.

The benefits of the South County Ag Program will extend far beyond the values calculated in Section 2. The program combines improved water management with changes in land management for wildlife and habitat restoration, creating a holistic program that address a multitude of limiting factors. Combined, these benefits will not only enhance conditions within the region, but will improve the region's resiliency to the impacts of climate change. Enhancing ecosystem resiliency will allow these systems to withstand increased disturbances before changing state, as well as improving their ability to recover from natural disturbances.

One important aspect of the modeling effort is the inclusion of not only the anticipated changes in climate, but also the anticipated periodic drought cycle for the region. Some groundwater extraction is anticipated under these drought conditions and are included in the groundwater modeling. Incorporating these varying conditions into the modeling provides an opportunity to evaluate the potential ecosystem impacts from these dynamic conditions. The modeling results demonstrate not only the persistence of the ecosystem benefits generated by the program, but also the magnitude of the ecosystem improvements. That is, even with variable hydrologic conditions and the anticipated impacts of climate change, the program will have substantial, and persistent, ecosystem benefits to the program area.

As the modeling results demonstrate, projects like the South County Ag Program are more important than ever to buffer against, or even reverse, the negative effects of climate change. Without the program in place, instream flows in the Cosumnes River will continue to decline, leaving the river with effectively no flow (less than 1 cfs, Figure 11) for 25% of the year. The groundwater declines that are anticipated under the climate change scenarios will continue to degrade riparian and wetland ecosystems without the program in place; not only harming the existing high-quality habitat, but limiting the potential for restoration opportunities as it will become increasingly difficult to establish and sustain these ecosystems.

One of the important benefits of the South County Ag Program will be the improved ecosystem resiliency for the entire area, including the area currently managed for conservation. The results of the climate change modeling highlight the extensive negative impact that these changes will have on the currently high-quality ecosystem communities in the program area. Over the past few decades, many millions of both public and private dollars have been invested in the region to improve ecological conditions. This work has resulted in significant ecosystem improvements that are at risk of degrading, or being lost altogether, in the face of climate change. Under the baseline conditions, the continued decline in groundwater levels will occur under both climate change scenarios, resulting in fewer acres capable of sustaining riparian or wetland vegetation. Without the program in place, the declining groundwater elevations will severely impact the ecological function of these conserved and restored habitats. As such, an additional benefit of the program will be the continued support of these managed ecosystems, protecting the extensive resources that have been invested in the region against the impacts of climate change.

5. PROGRAM MONITORING

It is essential to monitor the progress of the program towards achieving the desired future ecological conditions. To confirm that the program remains on a trajectory toward success, monitoring can follow a three-tiered approach, including: (1) rapid qualitative monitoring at individual sites, (2) remote effectiveness monitoring of the program area, and (3) quantitative confidence monitoring on a sample of sites. These complementary approaches can be used to meet different monitoring objectives, and when combined will provide the necessary assurances that the anticipated ecological benefits are on track to be produced and adaptively managed throughout the life of the program.

Program monitoring will include three main components: (1) an assessment of the land management practices (wintertime field flooding, crop residue management, etc.) that are in place to create habitat and support wildlife, (2) riparian and wetland vegetation surveys to evaluate site conditions and function, and (3) monitoring to assess biological response.

In the case of the first component, annual monitoring of land management practices will ensure that the appropriate practices are being implemented. Information about practices can be gained from surveys of agricultural fields. The specific metrics included in each survey will be dependent on the land management practices that is being monitored, however, such surveys are largely qualitative. The results of the field surveys can inform future actions, as well as provide information to inform the adaptive management of the program. Additionally, the field surveys can be used to determine whether site-level corrective actions are necessary to achieve the desired habitat goals.

Vegetation monitoring is an essential component of the long-term program monitoring. Riparian and wetland areas are naturally dynamic ecosystems, as such, it is important to monitor conditions over time to ensure that the ecological functions continue to be supported. A key component of ecological function is driven by vegetation conditions. For example, the proliferation of noxious weeds can severely impact the function at a site. Vegetation monitoring should include all three of the monitoring tiers (quantitative, qualitative, and remote methods) to characterize site conditions and change over time. The frequency of monitoring will be driven by the successional stage of the site and the expected level of variability in site conditions.

One of the primary objectives of the ecological enhancement, restoration, and creation is to improve conditions for aquatic and terrestrial species. Assessing the functions, as described previously, provides insight into the aspects of the program that are known to impact these species, but they do not document changes in the abundance and distribution of these organisms. To ensure that the program is supporting these species as intended, the third monitoring component includes surveys to assess biological response. Qualitative surveys can be conducted more frequently to determine the presence or absence of certain species, as well as their distribution. Quantitative monitoring is necessary to determine abundance and migration patterns.

5.1. Qualitative Monitoring

The goal of rapid qualitative monitoring is to quickly ensure that all sites remain in place and are continuing to demonstrate progress toward achieving the expected ecological benefits. Qualitative monitoring can be conducted annually on every site from project implementation through "establishment." Once sites are established, qualitative monitoring can be used to confirm project trajectory and function over the life of the project, but the frequency of qualitative monitoring at a project site would decrease after establishment. In the case of areas that include a change in annual land management (such as changes in agricultural practices during the critical overwintering period for wildlife), no establishment is expected. Rather, program monitoring would include annual qualitative monitoring of the changes in land management practices for the life of the program.

Qualitative monitoring can be completed by project managers, maintenance crews, or field technicians who have been trained to collect basic monitoring data using standardized protocols. This data collection could include repeat annual photo point monitoring at sites and a rapid, standardized project site assessment "checklist" that is meant to both determine that the site's performance and to identify maintenance concerns that need to be addressed at individual sites. The narrative and visually-based questions on the checklist address the same ecological performance objectives assessed in quantitative monitoring.

5.2. Remote Effectiveness Monitoring

All implemented project sites can also be monitored periodically via remote sensing (i.e., LiDAR, satellite imagery, etc.). This method of monitoring allows for efficient tracking of sites spread over a broad geographic area and provides a set of digitized images that allows for effective comparison of site conditions from year to year. As on-the-ground qualitative monitoring decreases in frequency after establishment, remote sensing can help confirm that sites continue to endure and progress. As remote monitoring technology becomes more accurate, efficient, and affordable, methodologies can be adapted to support continued improvements in remote monitoring over the life of the project.

5.3. Quantitative Monitoring

In addition to qualitative monitoring and remote sensing, quantitative monitoring should occur on the ground at a geographically relevant sample of project sites. Quantitative confidence monitoring can be used to meet three goals: 1) generate empirical data about how project sites are progressing toward performance objectives known to represent ecological function (e.g., percent canopy cover, invasive weed cover, percent native woody understory cover for riparian sites); 2) serve as an internal quality control check by connecting empirical trends with qualitative monitoring tool questions and options; and 3) improve effectiveness of implementation and maintenance over time based on the empirical evidence analyzed from these project sites.

6. ECOLOGICAL PLAN IMPLEMENTATION

The following are the site-specific goals and objectives of the plan.

6.1. Basin Approach for Strategic Implementation

TFT's approach to developing and implementing the system for groundwater supply management relies on these methods:

6.1.1. Basin-Scale Opportunity Assessment and Prioritization

This method uses GIS to extract and organize data to identify sites within a basin where restoration or conservation actions would provide ecological benefit. Through the use of existing, publicly available data and models, the first step is to assess current groundwater usage and basin characteristics. Next, the potential benefit possible at each site will be estimated, making it possible to select the sites that would generate the greatest ecological uplift. TFT has used this assessment methodology to identify and quantify opportunities to reduce solar load, nitrogen, phosphorus and sediment impacts, and augment groundwater and surface water quantity within a basin.

For the purposes of evaluating the feasibility of implementation given the total supply of prioritized benefits identified, it is important to consider the proportion of each action that could likely be recruited over the course of the program. In order to estimate likely recruitment success rates, TFT has surveyed other restoration professionals (e.g. local NRCS, watershed councils, and land trusts) and reviews its own programs. This can also yield important information about lessons learned in contracting with landowners for riparian revegetation project sites, instream habitat project sites, and for leasing instream flows. There are a number of important variables involved in landowner recruitment including incentive structure for participation, contractual framework, contract duration, outreach approach and timing, outreach resources, momentum, and perception of the program from potential landowner participants. In addition, because every potential project site is not always paired with a willing landowner, successful programmatic recruitment depends on having more than enough potential properties with sufficient project sites and enough time to engage landowners. Many landowners may be reluctant to participate in a restoration program at first, but become more amenable through further conversation and with access to additional information.

Annual recruitment conversion rates (the annual recruitment required for enrollment in a program compared to overall benefit need; lower conversion rate means fewer landowners must participate in order to achieve program goals) can be lower when significant implementation time is available. There is more opportunity to build relationships in the community and establish rapport with individual landowners. Participation levels in the program and the experience of early participants will impact opinions throughout a community. The dynamic landscape of land ownership is also an important factor (typically between 1–2% of properties change ownership each year). The response from a single outreach effort, such as in-person individual home visits or phone calls, only provides a snapshot of overall landowner interest and is not the basis for predicting the overall recruitment success of a program.

6.1.2. Collect and Synthesize Data

Data needed to support the plan's goals include factors from the Soil Agricultural Groundwater Banking Index (SAGBI), a suitability index for groundwater recharge on agricultural land: ability of soil to percolate water, the residence time of water in the root zone, any chemical limitations in the soil, any topographic limitations, and surface limitations (whether the soil can withstand the flooding without being altered). Other data includes land use, crop type, proximity to water features, slope and soil type, and use by species of interest. Data would be synthesized to determine infiltration rates and soil health metrics and link those to the most suitable fields for over-winter flooding. The costs and potential benefits of implementing over-winter flooding would be informed by these data as well.

6.1.3. Scenario Planning and Optimization

In order to maximize the ecological outcomes from restoration actions, all potential project sites should be prioritized according to a set of defined and transparent criteria. This can be completed using an Excel-based Solver tool where a programmatic target is set and the optimum sites to meet that target are identified. All potential sites can also be ranked across multiple, user-defined variables (e.g. water quantity effects, agricultural goals, habitat or species benefit, project cost constraints and landowner recruitment feasibility), or through the development of an algorithm to aggregate Through a prioritization process like this, it is possible to assess the impacts of one type of conservation action across multiple fields, helping to target landowner outreach to the highest priority projects.

When designing its own conservation programs, TFT typically considers several recruitment “arcs” scenarios as part of implementation. In developing recruitment arc scenarios, annual conversion rates for both landowners and environmental benefits (such as habitat acres) are considered. When a program is first introduced, conversion rates are lower. In these formative years, recruiters spend most of their time establishing an accurate understanding of the program within the landowner community and seeking out early adopters. For example, TFT’s 30-plus acre, 600 million kilocalorie Medford water quality trading program recruitment efforts relied on focus groups with local conservation organizations and some of their partner landowners. In this program, the first contract signed was a landowner invited to a focus group by the local Council of Governments. The second phase of outreach involves building on the success of early adopters to recruit as many priority landowner properties as possible. Landowner-to-landowner recruitment will help accelerate recruitment during this period. For example, in the Medford program, three properties with priority project sites were recruited simultaneously as a result of successfully engaging one neighbor. The third phase of recruitment is a combination of completing the obligation with lower priority properties and contracting with landowners of priority properties who may have been slow to commit or had a favorable change of ownership. TFT’s recruitment efforts for the Medford program are currently transitioning from the second to third phase. Approximately two-thirds of the program obligations have been delivered and most priority properties with willing landowners have been signed within the first five years.

6.1.4. Basin-Scale Tracking and Reporting

As the plan is implemented, plan administrators should plan for streamlined and integrated reporting processes. A basin-scale performance tracking system that can be used to compile the required field level information, contextualize the impact of field level improvements within the entire basin and easily report on aggregated data to meet multiple compliance requirements is recommended in order to assess progress toward ecological objectives. Streamlined collection of the appropriate data will ensure consistent improvements are happening in the right places. The tracking and reporting systems should clearly visualize the plan’s objectives and planned targeted conservation actions, and track progress over time – linking overall plan progress to individual site monitoring data and information.

In addition to tracking monitoring data, performance confirmations will document project site-success over time. Through clear documentation and verification systems, the South County Ag Program will be able to demonstrate program progress over time. Additionally, if regulatory compliance or water banking is of interest in the future, the level of rigor described here and in Section 5 for monitoring is typically required (for example, mitigation programs and carbon markets rely on program verification, tracking, and reporting). There are multiple systems that can be used to track program progress. Markit Environmental Registry is a web-based platform that includes the following features: 1) individual projects benefits and transactions are accounted for and can be tracked over time, 2) publicly available information for project design documents and monitoring reports are stored and available and 3) program standards are clearly defined and linked.

6.2. Adaptive Management

Long-term maintenance and monitoring of the components of the South Count Ag Program are essential the program's success and the attainment of the ecosystem improvements. The three-tiered monitoring approach described in Section 5 will allow for programmatic tracking and evaluation of progress toward the achieving the ecosystem benefit and programmatic goals. The multi-decadal timeframe of the program necessitates the ability to adapt implementation, maintenance, monitoring, and performance tracking practices to reflect new knowledge and information as it emerges. As technologies, land management, production, and monitoring practices evolve, it is expected that more efficient approaches or better knowledge about sources and methods to achieve program goals will also develop.

Adaptive management of the South County Ag Program will be implemented on a five-year cycle. A five-year review cycle provides a regular opportunity to review available data from the previous years of implementation, maintenance, and monitoring, and to incorporate new technologies and lessons learned through previous implementation and management cycles into the upcoming implementation, as well as monitoring, maintenance, and performance tracking (Figure 14). Periodic review also affords transparency and quality control. A review period of five years is recommended to allow enough time to properly evaluate: 1) progress toward overall programmatic goals, as well as 2) the effectiveness of maintenance approaches and monitoring protocols. Additionally, the five-year cycle aligns with the anticipated time periods for ecosystem benefit accrual, particularly at the beginning of the program. As such, a five-year window provides enough flexibility to appropriately collect and analyze these data, but also ensures that if management changes are necessary, they can be implemented in a timely manner. Periodic review of implementation and performance progress will also allow for course correction with respect to the ongoing implementation milestones and obligations, should any be needed.

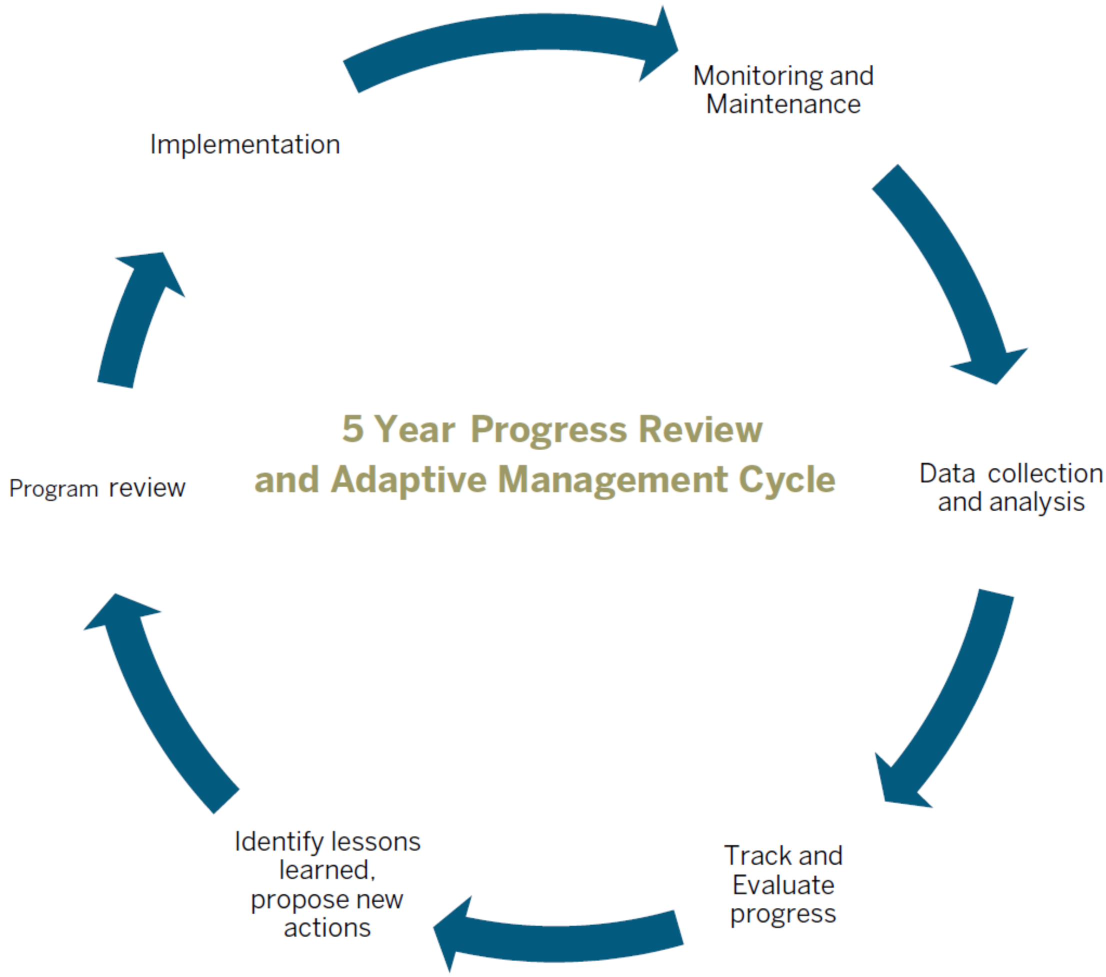

Figure 14. Adaptive management cycle for the South Count Ag Program. For each adaptive management cycle the adaptive management approach should include: 1) pre-implementation data collection, which is essential to gauge the impacts of program implementation; and 2) monitoring and maintenance data. Monitoring data will be used to confirm the program benefits and maintenance data will be used to determine what sort of issues are being encountered. Every five years, program implementation, maintenance, and monitoring data should be evaluated and summarized in aggregate. At this time, new restoration actions, recommended changes to implementation or land management approaches, monitoring, and maintenance protocols, etc. may be considered and discussed. The adaptive management cycle should repeat for the next five years of the South County Ag Program.

7. SUMMARY

The South County Ag Program will balance water resources sustainability, with ecosystem enhancement and agricultural sustainability in the Sacramento Region. As analyses above demonstrate, the ecosystem improvements as a result of the program will be extensive. The direct benefits of the program will improve groundwater elevations in the region, reversing the impacts from past groundwater extraction. These improvements will bring the shallow groundwater closer to the ground surface, creating the conditions necessary to not only support woody riparian and wetland vegetation, but the conditions necessary for the establishment of new vegetation communities. Additionally, these improved groundwater conditions will have a direct benefit on flows in the Cosumnes River. Without the program, these reaches of the river are frequently dry during the fall Chinook migration window, which not only hinders the returning salmon, but also severely impacts the resident fish population.

In addition to the direct benefits from the improved groundwater conditions, the program includes an extensive restoration and land management component. These aspects of the program include riparian revegetation, vernal pool restoration, and changes in land management to support wildlife. These actions will complimentary benefits to the region. Combined, these benefits will not only enhance conditions within the region, but will improve the region's resiliency to the impacts of climate change. Enhancing ecosystem resiliency will allow these systems to withstand increased disturbances before changing state, as well as improving their ability to recover from natural disturbances.

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APPENDICES

Appendix A: Listed Wildlife Species and Habitat Needs within the Project Area

		Listing Status		Habitats				Agricultural Land Uses				Notes
Species	**Season**	**CA**	**Federal**	**Riparian Forest**	**River Instream**	**Grassland -Vernal Pool Complex**	**Freshwater Wetlands/ Marsh/ Ponds**	**Cereal grains (Corn, wheat)**	**Hay Crops (Alfalfa)**	**Rangeland /Pasture**	**Ditches /Stock Ponds**	
California tiger salamander (*Ambystoma californiense*)		T	T			X	X					
Giant garter snake (*Thamnophis gigas*)		T	T				X				X	
Western pond turtle (*Clemmys marmorata*)		SSC	SC		X		X				X	
Riparian brush rabbit (*Sylvilagus bachmani riparius*)		E	E	X								
Swainson's hawk (*Buteo swainsoni*)	Summer (breeding)	T	--	X[N]		X[F]			X[F]	X[F]		Unsuitable foraging habitat: vineyards, orchards, certain row crops, rice, corn and cotton.
Yellow warbler (*Setophaga petechia*)	Summer (breeding)	SSC	--									
White-tailed kite (*Elanus leucurus*)	Year round	--	--	X[N]		X	X			X		
Willow flycatcher (*Empidonax traillii*)	Summer (breeding)	E	--	X			X					
Tricolored blackbird (*Agelaius tricolor*)	Year round	--[1]	--	X[N]		X	X	X	X	X		

		Listing Status		Habitats				Agricultural Land Uses				Notes
Species	**Season**	**CA**	**Federal**	**Riparian Forest**	**River Instream**	**Grassland -Vernal Pool Complex**	**Freshwater Wetlands/ Marsh/ Ponds**	**Cereal grains (Corn, wheat)**	**Hay Crops (Alfalfa)**	**Rangeland /Pasture**	**Ditches /Stock Ponds**	
Greater sandhill crane (*Grus canadenis tabida*)	Late August to Mid-March (non-breeding)	T	--			X	X	X		X		
Sacramento splittail (*Pogonichthys macrolepidotus*)		SSC	SC		X		X[S,R]					Current use of channel and floodplain habitats
Chinook salmon (*Oncorhynchus tschawytscha*)	Fall/late fall run	SSC	SC	X[R]	X		X[R]					Current use of channel, riffles, and floodplain habitats; Central Valley ESU.
Vernal pool fairy shrimp (*Branchinecta lynchi*)		--	T			X						
Vernal pool tadpole shrimp (*Lepidurus packardi*)		--	E			X						
Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*)		--	T	X								Suitable habitat is provided in shrubs with stems that are 1in or more in diameter at ground level.

Appendix B: Complete Groundwater Modeling Results Showing 2030 and 2070 Climate Change Scenarios Under Baseline and With-Project Conditions