Leveraging Water Markets to Secure Water for Nature and Agriculture

Final Report

The Nature Conservancy of California
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Summary

This report provides a final progress update on the Conservation Innovation Grant (CIG), Leveraging Water Markets to Secure Water for Nature and Agriculture [Award #69-3A75-17-289]. This CIG catalyzed over $3.5M for conservation projects, in direct and matching funds, over nearly four years (August 2017-July 2021). This CIG award funded four distinct projects: (i) Fox Canyon Groundwater Market (ii) Water Sharing Investment Partnership (renamed Water Trust) (iii) Data Analytics for Shorebirds and (iv) Pasture Deficit Irrigation that collectively touched down across three separate geographies in California: Ventura County, the Sacramento Valley and the Shasta Valley. Given the discrete nature of each of these projects, this report first provides a high-level summary of the impacts of each project, followed by separate sections for each of the four projects that provide more detail on background, methods, results, challenges, outputs and impact and next steps.

Impacts

The main impacts associated with the four projects that were part of the Water Markets CIG are as follows:

- Launched the first, and still only, active groundwater market under California's Sustainable Groundwater Management Act of 2014. The Fox Canyon groundwater market provides farmers with the flexibility to adapt to steep groundwater cuts—over 40 percent basinwide by 2040—by buying and selling groundwater, which increases the opportunities for agriculture to stay in production and serve as an important conservation buffer to the Los Angeles metropolitan area. Fox Canyon is a model for other well-designed groundwater markets, which are increasingly forming under SGMA.
- Piloted a Water Trust in the Sacramento Valley using a private loan to acquire a ranch with a senior water right on Mill Creek, a major salmon-supporting tributary to the Sacramento River. Subsequent transfers of this newly acquired water right, combined with existing TNC water rights on Mill Creek, to the Glenn-Colusa Irrigation District and Woodland-Davis Clean Water Agency generated instream flows for salmon, wetland habitat for migratory birds and revenue to repay nearly half of the private loan, demonstrating the ability to secure and deploy impact capital towards ecological objectives.
- Conducted four separate research projects that used data analytics to better understand habitat needs for shorebirds that use private rice fields in the Sacramento Valley. The analyses allowed TNC to better target when, where and how much to flood rice fields to provide shorebird habitat through our BirdReturns program, which provides incentive payments to rice farmers.
- Conducted a study, led by the University of California Cooperative Extension, on the impacts of deficit irrigation on pasture in the Shasta Valley. The study found that ceasing irrigation in mid-September does not likely have a big impact on grass yield and production. This finding will allow us to improve our Shasta Fall Flow program, which leases water from irrigators and leaves the water instream for migrating Fall Chinook salmon, to benefit both agriculture and nature.

Fox Canyon Groundwater Market

Background / Rationale

Ventura County is one of the nation's most productive agricultural counties, with $2 billion in agricultural revenue in 2019 the majority of which is generated in Fox Canyon. Water users there are

largely groundwater-dependent, and decades of overpumping landed two of the region's basins—the Oxnard and Pleasant Valley basins—on the list of 21 SGMA-designated "critically overdrafted basins." Cuts of up 40 percent or more in groundwater use are expected for the Oxnard and Pleasant Valley basins to achieve their respective sustainable yields, which is the Sustainable Groundwater Management Act's (SGMA's) requirement for a locally-determined cap on total water use that balances the needs of communities, agriculture and nature. The magnitude of this reduction motivated growers in the Oxnard basin to call for a groundwater market as a tool to provide flexibility, allowing those with unused water allocations to sell to those with unmet demand. Since 2016, the Fox Canyon Groundwater Management Agency (FCGMA), the designated Groundwater Sustainability Agency (GSA) for implementing SGMA in the Oxnard and Pleasant Valley basins, has worked with California Lutheran University (CLU), The Nature Conservancy (TNC), growers and other stakeholders to design and test a groundwater market in the Oxnard basin.

TNC has had a presence in Ventura County for 20 years. We own multiple properties, many of them agricultural, with the dual objectives of avoiding their conversion to development and restoring natural floodplains along the Santa Clara River, Southern California's last free-flowing river. As an agricultural landowner, and a consumptive water user, TNC has been formally involved in the process of creating the Oxnard and Pleasant Valley Groundwater Sustainability Plan (GSP). TNC desires that all GSPs address groundwater dependent ecosystems (GDEs), as required by SGMA, and that the plans employ robust methods to accomplish that goal and others. GSAs may consider groundwater markets as one such method. Through our work on the Fox Canyon groundwater market, we have attempted to create a market structure that supports implementation of the GSP, including protection of GDEs.

Methods

Before launching the full-scale market, FCGMA opted to run two pilot phases in a portion of the Oxnard basin. The Phase I Pilot was limited to a portion of the Oxnard Basin and tested the basic functions of the water market, such as enrolling participants, verifying well ownership, checking for unresolved violations, ensuring up-to-date meter calibration and installing automated metering infrastructure (AMI), telemetric metering hardware. Phase I also served as an AMI demonstration project, testing the capabilities of AMI hardware and identifying and troubleshooting site-specific installation challenges. The Phase I Pilot ran from April through July 2017. The goal of the Phase II Pilot was to enroll a larger number of growers and test trading over a longer time frame and in a larger geography. FCGMA opted for a third party to administer the market, and the Phase II pilot sought to allow for a robust test of the exchange administrator's system prior to opening the market to all pumpers in the Oxnard and Pleasant Valley basins. Phase II ran from March through August 2020, and then again from June through September 2021 (see *Challenges* for a discussion of delays and timing associated with the pilots).

Results

The Fox Canyon groundwater market saw a number of notable milestones, including:

- Creation of the first market under SGMA to actively trade groundwater.
- Installation of AMI on 457 active agricultural wells (98.5 percent compliance), with the CIG funding installation on 306 wells.
- Enrollment of 78 wells (83 percent of eligible wells) in the Phase II Pilot, with 47 percent of participants submitting bids or offers to transfer allocation.
- Transfer of 341 AF in the Phase II Pilot, at an average price of $287 per acre-foot (AF). This included the transfer of 198 AF out of two Special Management Areas, designated to reduce and if possible, reverse the impacts of seawater intrusion and a cone of depression.

- Purchase of groundwater by one grower during the Phase II Pilot that avoided $345,000 in pumping surcharges.
- Purchase by TNC of 146 AF, effectively retiring a portion of pumping to benefit nature.
- Creation of a framework for well-designed groundwater markets that can be replicated by other GSAs (see *Outputs*).

Challenges

The creation of a water market is a considerable undertaking that requires significant, dedicated capacity from GSA staff, partners and participants. As a GSA for critically overdrafted basins, FCGMA was required to submit its GSPs in January 2020. This meant that agency staff were working on the groundwater market and GSPs in tandem, and their capacity was quite limited. In addition, to comply with SGMA, FCGMA chose to move its growers to fixed groundwater allocations, a necessary element of cap-and-trade style markets, but also an extremely controversial exercise, as farmers were beginning to feel the reductions set into motion by SGMA. The result was a series of delays around launching the pilot phases, as FCGMA staff were focused on the allocations debate.

The Phase II Pilot was originally scheduled to run for the 2018 water year (October through September) but experienced significant delays in selecting and contracting with the AMI vendor and passing the necessary ordinances, especially the establishment of pumping allocations under SGMA (beyond just the market), which were highly controversial. Because neither pilot phase ran for an entire year, Phase II was extended, with the goal of running October 2020 through September 2021. Further delays associated with allocations, specifically FCGMA's decision to implement a "surcharge waiver" that allowed farmers to pump beyond their first-year allocations under SGMA led to further delays, and the extended Phase II pilot did not begin until June 2021. The surcharge waiver dampened market activity, as it created an artificial abundance of water by allowing many growers to pump more than in prior years, so there was limited demand for additional water.

A final challenge that has arisen throughout the creation and implementation of the Fox Canyon groundwater involves market power. During the Phase I Pilot, a packer/shipper sought to learn the identities of all growers in the market in order to restrict their participation by threatening not to enter into contracts within them in the future. Fox Canyon growers chose an anonymized market with blind, algorithmic matching to guard against the abuse of market power by larger growers and packer/shippers. During the extended Phase II Pilot, market power emerged through the aggregation of wells under larger growers who are also packers/shippers. FCGMA has long allowed farmers to aggregate multiple wells under a single "combcode" in an attempt to simplify the accounting of groundwater use. In the first year of SGMA compliance, packer/shippers who own one or two wells aggregated many wells, owned by other, smaller growers, under a single combcode, essentially creating informal markets where pumping could be transferred among many wells. The exertion of market power reflected earlier iterations, where packers/shippers threatened not to buy from small farmers if they did not join the single combcode and agree to make their water available to others in need, particularly when a crop needed to be finished. These informal markets served as competition with the formal Fox Canyon groundwater market, which saw lower participation and trading in the latest pilot phase.

Outputs

In addition to launching the first active groundwater market under SGMA, we produced two publications on the Fox Canyon groundwater market that outline a framework for well-designed water markets, intended to guide efforts by other GSAs:

1. An article in *California Agriculture,* the University of California's primary agriculture and natural resources journal, entitled, "The first SGMA groundwater market is trading: The importance of good design and the risks of getting it wrong": https://calag.ucanr.edu/archive/?type=pdf&article=ca.2021a0010
2. A whitepaper, both full report and summary brief, detailing the development of the Fox Canyon groundwater market: https://groundwaterresourcehub.org/public/uploads/pdfs/TNC_FoxCanyon_Market_SummaryBrief.pdf https://groundwaterresourcehub.org/public/uploads/pdfs/TNC_FoxCanyon_GroundwaterMarketCaseStudy.pdf

Environmental Market Specialists, Inc. has built out the trading platform for the Fox Canyon groundwater market, both desktop and mobile versions. They are currently beta-testing a software product that may also be scaled beyond Fox Canyon, with the potential for adoption by other GSAs considering groundwater markets as a tool to adapt to SGMA.

FCGMA retained Farallon Geographics to review their current database for tracking groundwater pumping and issue recommendations on improvements to comply with SGMA, including the Fox Canyon groundwater market. See Attachments for a detailed report on the review of current business operations and draft recommendations on improvements.

Impact & Next Steps

The creation of a water market is a considerable undertaking that requires significant, dedicated capacity from GSA staff, partners and participants. The Water Markets CIG is directly responsible for the development of the first, and still only, actively trading groundwater market under SGMA. The installation of AMI on all active agricultural wells effectively moved growers from a flawed system of semi-annual self-reporting to highly accurate telemetric data collection, which will enable FCGMA to better track pumping over time and comply with overall basin sustainability goals, including the operation of a sound market. In the short-term, the Fox Canyon groundwater market allowed participating farmers to experience greater flexibility than a pure command-and-control approach, by either selling surplus water and generating additional revenue or buying needed water and avoiding steep surcharges (in the first iteration of the Phase II Pilot). In the long-term, the hope is for the Fox Canyon groundwater market to provide sufficient flexibility to farmers so as to minimize the conversion of agricultural land to urban or other development. As the first, and still only, active market under SGMA, it was essential that Fox Canyon model good design, and it is already being pointed to as the "Cadillac" of groundwater markets that other GSAs would be lucky to emulate.

Going forward, TNC will continue to work with FCGMA, CLU and others to ensure that the Fox Canyon groundwater market is durable over time. In addition, we are currently evaluating the opportunities for cities in Ventura County, who were involved in the early stages of design, to join the market, as both potential buyers and sellers of groundwater. Matthew Fienup, Fox Canyon's market administrator from

CLU, is engaged in the design of a groundwater market for the Mid-Kaweah GSA in the San Joaquin Valley, representing an opportunity to replicate our approach to ensuring that groundwater markets are well-designed. The San Joaquin Valley has significant challenges with respect to GDEs and access to drinking water by vulnerable communities, two issues that were not present in Fox Canyon, but which our approach to market design is well-suited to address. The California Water Commission has recently been charged with issuing recommendations (in March 2022) on how to ensure groundwater markets under SGMA are well-designed to the California Department of Water Resources, the State Water Resources Control Board, and the California Department of Fish and Wildlife. Sarah Heard from TNC is serving on the Commission's Stakeholder Advisory Group, where she brings the on-the-ground experience of developing Fox Canyon, still the only actively trading market under SGMA to inform the development of new state policy.

Water Sharing Investment Partnership

Background / Rationale

California's Central Valley water supplies are intensively managed to serve millions of acres of farmland and millions of people and must also support the needs of wildlife. These competing demands mean that wildlife's needs often go unmet. The Central Valley is a critical stopover for migratory birds of the Pacific Flyway, and over 95 percent of historical wetlands have been lost to conversion to agriculture and other uses. Fortunately, the birds have become well-adapted to the agricultural landscape, and private landowners and producers are instrumental in providing bird-friendly farmland. The NRCS WHEP has included hundreds of participating landowners and tens of thousands of acres since 2012. In the majority of recent years, however, limited water availability has prevented the creation of habitat at the places and times necessary to support bird migration. In 2014, a critically dry year, many WHEP producers were simply unable to provide habitat, preventing the participating producers from fulfilling their three-year contracts. In an era of increasing water scarcity, we must update our approach by using data analytics to identify the best opportunities to create additional habitat, and by ensuring adequate water supplies are available for wetland creation projects.

Our hypothesis was that impact investing could play a pivotal role in attracting the capital necessary to replicate and scale the outcomes generated by WHEP and similar programs. Impact investors are increasingly hungry for projects that benefit nature and also generate a financial return, and water markets, which provide users the flexibility to monetize their water holdings and/or donate them to environmental and social needs, are particularly compelling to those investors. We believed that a program that generated returns for investors through (i) the sale/leasing of water to other stakeholders and (ii) the longer-term capital appreciation of the underlying water assets, could be coupled with providing water supplies to meet targeted environmental and social objectives. We set out to pilot a such a program – a Water Sharing Investment Partnership (WSIP), which we later transitioned to calling our California Water Trust strategy (Water Trust) – to explore and pilot this idea in the Central Valley, where conditions are ripe to develop innovative solutions to address the pressures of drought, climate change, and the growing demands on our water resources within an active water market. We also aimed to identify and overcome the barriers that entities would encounter in performing the roles of a water trust. The roles of a water trust include amassing a portfolio of water assets of sufficient size to make a significant positive difference for nature and deploying those assets to have significant benefits

for nature in a way that is sustainable over the long-term. Part of sustainability means that given philanthropic and public funds will always be limited, we need to develop approaches to serving as "nature's water broker" that are financially sustainable, such as by leasing or selling some water rights at times when it would not have significant impacts to our ability meet nature's needs, which could help defray the costs of managing the overall portfolio.

Methods

Our preliminary Water Trust operating strategy was to deploy TNC's water rights to provide benefits to nature (e.g. migratory birds and fish in the Sacramento and San Joaquin Valleys) at critical times of year. When feasible and practical, these deployments to nature would also coincide with a water lease to a downstream user to secure incidental revenue that defray costs, and also potentially to pay back loans originally used to purchase the water.

Our work proceeded in phases, focused on developing a viable WSIP (Water Trust) model in California and conceptual operating plan, working with a water broker and consultants to develop a pipeline of water rights available to acquire to seed a water portfolio, acquiring a small portfolio using private investment and testing agreement structures and deployments of those water rights guided by data analytics.

Results

The WSIP saw the following milestones during the term of the Water Markets CIG:

- In winter 2020, TNC acquired the 465-acre Nobmann Ranch with its senior water right on Mill Creek, a major salmon-supporting tributary to the Sacramento River, seeding a pilot Water Trust in the Sacramento Valley. To acquire the $2.5M property and water right, we engaged a new funder and private individual who provided a $1.2M, low-interest impact loan, the first test of this kind of financing for the Water Trust. The balance of the funding was philanthropic from individuals.
- In fall 2020, TNC jointly executed a short-term water transfer agreement of the Nobmann water right and two other TNC-owned Mill Creek water rights to the Glenn-Colusa Irrigation District (GCID). In the course of the transfer, our water rights would be left instream in Mill Creek, increasing dry season flows for salmon until diverted downstream by GCID past the Mill Creek-Sacramento River confluence. Then, once diverted, GCID agreed to flood private post-harvest rice fields to create 1,000 acres of shorebird habitat. Additionally, GCID agreed to pay TNC a small per-acre-foot charge for the water to offset our transaction costs and to assist us with paying back the low-interest loan to acquire the right. Unfortunately, political constraints and legal ambiguities involving the Bureau of Reclamation prevented the transfer from moving forward at the eleventh hour.
- In summer 2021, TNC executed and completed a multi-benefit water transaction with the Woodland-Davis Clean Water Agency (WDCWA), which provides water to the people of Woodland, Davis and the University of California at Davis. Under this agreement, WDCWA is diverting total of up to 3,000 AF of our water rights out of the Sacramento River downstream of the Mill Creek confluence to backfill critically-dry-year water shortages within the WDCWA service area. En route to the agency, the water from our rights is secured in Mill Creek, improving habitat conditions for migrating salmon in a year when Mill Creek will see otherwise very low flows or even dry conditions. This multi benefit project provided $183,000 back to TNC to pay back the principal on the private loan secured to acquire the water. We are currently in negotiations with WDCWA to continue the transaction into the winter months, which will transfer an estimated 4,000 AF (depending on flow

available in Mill Creek). The combination of the two agreements will result in paying off nearly 50% of the loan principal within 18 months of receiving it, demonstrating the ability to secure and deploy private investor capital toward ecological objectives.

Challenges

In the early stages of the WSIP work, TNC completed a feasibility assessment and financial model that led us to conclude that a pilot-scale water fund focused on achieving conservation outcomes would not guarantee enough of a return-on-investment to secure impact investor commitment and therefore, need philanthropic support. This is due to widely variable hydrology influencing the cost and availability of water on an annual basis and the uncertainties inherent in California's water market. If successful at the pilot scale, a larger-scale fund that blends philanthropic and impact capital could be explored.

Ultimately, TNC experienced political, institutional and legal challenges in acquiring and deploying water in the Sacramento Valley. Negotiations for water rights purchases on the Sacramento River and Battle Creek, a tributary to the Sacramento River, slowed or stalled due to unstandardized water rights valuations and sellers who are unfamiliar or uncomfortable with the significant due diligence required to verify the water right is not "paper" (or essentially forfeited) water. We also learned through our pilot transactions that even when we own a water right, there are significant political and social barriers to dynamically deploying that water, even when doing so would more efficiently achieve multiple conservation and human uses with the same water supply. This is especially true in adjudicated systems like those in the Lassen Foothill tributaries to the Sacramento River, where we see the greatest potential to make a difference instream and deliver downstream benefits to people and nature in the Sacramento Valley, but where legal challenges and lack of precedent slow innovation and progress.

We are using our experience to inform our policy reform and agency education strategies to overcome many of these barriers. We are now also pursuing new strategies that still involve acquiring and delivering water for people and nature but will use more established methods, including harnessing short-term transfers of water from idled rice fields, which could deliver conservation benefits and urban drought water supplies if managed strategically.

Outputs

The WSIP produced the following outputs during the term of the Water Markets CIG:

- Completed Feasibility Assessment (see Attachments) of a conceptual WSIP / Sacramento Valley Water Trust, evaluating how strategically redeploying water supplies acquired with investor capital could meet key ecological needs for migratory birds and other species in California's Central Valley, while also generating a financial return to investors and sufficient revenues to cover implementation costs.
- Completed financial model, documented in the Feasibility Assessment, that tests the viability of using investor capital to create a financially sustainable, and scalable funding model for securing a portfolio of water rights for nature. The model simulates the performance of a portfolio of water assets deployed in a strategic way over a 10-year period, managing the water each year by either leasing it to agricultural water users, or sending the water to nature to create habitat. The model is useful to understand the trade-offs between generating revenue and achieving conservation outcomes.

- Completed scientific analyses, including bioenergetics, to precisely identify when and where migratory bird habitat extent is inadequate to support the migratory bird populations at their current and future targeted levels. Paired analyses with satellite-based imagery to develop a model that indicates in near real-time where wetland habitat is most needed for migratory birds (see more detail in the *Data Analytics for Shorebirds* section below) .
- Developed new and advanced analytics tools and methods to prioritize habitat investments on and water deployments to private lands. Successfully implemented a BirdReturns habitat auction using this model and continue to use it to help guide subsequent auctions and optimize water deployments for nature on post-harvest and idled agricultural land (see more detail in the *Data Analytics for Shorebirds* section below).
- Applied a Structured Decision-Making (SDM) approach to set ecologically meaningful habitat objectives and evaluate the potential for compounding instream flow benefits with wetlands benefits through strategic water acquisitions and deployments. The results of this effort provided criteria for selecting water rights to pursue for acquisition as part of a pilot Water Trust in the Sacramento Valley.

Impact & Next Steps

One of the strategies that emerged from our WSIP work builds on transfers that are already happening routinely in the Sacramento Valley from rice idling. Transfers of water away from rice are common, especially in dry years when large volumes of water are sold to high-value crops, like orchards in the San Joaquin Valley or to urban water utilities along the coasts, instead of irrigating conservation-compatible crops like rice in the Sacramento Valley. To minimize the environmental impact of these transfers while still supporting the viability of agriculture and drought resilience for people, we are exploring the potential for an Urban-Riceland Habitat and Water Exchange partnership between Sacramento Valley rice water districts, Bay Area urban water suppliers and TNC. The Urban-Riceland Water Exchange Program would provide an “on call” drought water supply to urban water districts in exchange for a constant revenue stream, consistent range of flooded habitat delivered on idled riceland in every year and use of the water for conservation needs in wetter years when the urban water district declines the water supply. Our priority in this partnership would be to lock habitat provisioning into the structure of water transfer agreements, to minimize the impacts on birds due to drought year water transfers.

We plan to conduct a small pilot next summer to deliver habitat on idled rice fields by purchasing or working with project partners to purchase a “leave behind” volume of water from a water transfer to flood the field and create habitat conditions while monitoring the consumptive use of water of that practice to facilitate agency acceptance. We will also continue to test and explore the scalability and financial sustainability of a longer-term agreement.

Integrating habitat creation within the terms of a voluntary water transfer would be a win for both people and nature. Such an arrangement could lead to more stability and resilience for farmers, cities and migratory birds in the midst of increasingly frequent droughts and declining ecological conditions. Applied at scale, this is one water management approach that could maintain sustainable agricultural production (in this case, rice) while minimizing impacts to habitat and water quality.

Data Analytics for Shorebirds

Our data analytics work focused on improving habitat for shorebirds in the Sacramento Valley. There were four main components to this work: (i) analytics for auctions (ii) factors influencing use of flooded fields (iii) habitat shortfalls relative to precipitation and (iv) flooding effects on shorebird and salmon food production.

Analytics for Auctions

An updated approach to modelling shorebird response to habitat projects was developed to inform implementation of our BirdReturns program. BirdReturns uses a reverse auction[1] to source rice farmers interested in receiving incentive payments for flooding their fields to provide shorebird habitat. This updated modeling approach was used to guide the selection of bids, and hence field enrollments, in a series of landowner incentive habitat projects. Applied at the early implementation stage of projects, this method has helped increase TNC's return on investment. A significant advancement in the current model is its ability to "impose flooding" on individual parcels to predict bird response when particular fields are selected for enrollment.

Factors Influencing Use of Flooded Fields

With Point Blue Conservation Science (Point Blue), we conducted a study to identify local and landscape factors that influencing shorebird use of dynamic conservation agricultural wetlands. This study, which involved analysis of our BirdReturns data collected from 2014-2019, furthered an understanding of how to best locate habitat projects as well as how to manage field conditions. This has directly led to increased return on investment in our habitat incentive programs with private landowners

Habitat Shortfalls Relative to Precipitation

A separate component of our work with Point Blue under this grant agreement focused on defining when there are habitat shortfalls for migratory shorebirds in the Central Valley, and how this differs as a function of annual rainfall patterns. This information is critical for guiding the implementation of seasonal habitat programs on private farmlands and was used to modify the program design of BirdReturns. Adjustments made included the timing of enrollments, and the relative allocation of investment between fall and spring habitat.

Flooding Effects on Shorebird and Salmon Food Production

A final study that this grant contributed funding towards investigated how water management in flooded fields influences the production of food for fish and shorebirds. The study showed that increased residence time of floodwaters on fields leads to greater food production for both species groups. The main impact of this work has been to better establish the potential complementarity of these management practices for birds and fish, thereby advancing a powerful multi-benefit restoration strategy.

Background / Rationale

[1] An auction where the traditional buyer and seller roles are reversed so that one buyer sources bids from multiple sellers.

Analytics for Auctions

This project was done to help identify which bids should be selected in the reverse habitat auctions. In these auctions the growers submit bids for how much they wish to be paid to flood their fields. TNC's implementing team then needs to select which bids are likely to provide the greatest return on investment in terms of supporting the greatest number of waterbirds.

Factors Influencing Use of Flooded Fields

This study was conducted to provide management guidance for dynamic conservation programs targeting shorebirds in agricultural landscapes. It was an effort to better understand what the most important variables were for influencing shorebird use of the habitat that was created. This information is valuable in guiding the implementation of future programs.

Habitat Shortfalls Relative to Precipitation

This project was focused on identifying how the magnitude of habitat shortfalls varied seasonally for shorebirds in the Central Valley during the nonbreeding season, and how these patterns differed in wet and dry years. This is critical information for prioritizing when to create habitat, and how to balance effort between wet and dry years.

Flooding effects on shorebird and salmon food production

This ongoing study, which is being conducted in conjunction with USGS's Western Ecological Research Center, is focused on quantifying the availability and types of benthic invertebrate prey (shorebird food) present in harvested Sacramento Valley rice fields. It and is being done in collaboration with CalTrout who are studying aquatic invertebrates (salmon food) in these same fields. Collectively the project team is seeking to determine how water management, and specifically flooding and drawdown cycles, on post-harvest agricultural fields can be optimized to maximize prey resources for both waterbirds and salmon.

Methods

Analytics for Auctions

This modelling work applied spatial data for planning and decision-making to the habitat auctions. It did so by developing habitat suitability scores for shorebirds in different locations and during different time periods based on previously collected data from structured surveys and filtered eBird records. The study leveraged cloud-based systems to store all data, and programming code, and generated optimization outputs using lpsolve packages in program R.

Factors Influencing Use of Flooded Fields

In this study we analyzed data on shorebird use of fields previously enrolled in the BirdReturns program to provide management guidance for dynamic conservation programs targeting shorebirds in agricultural landscapes. It was a deep dive into the more than 17,000 survey records that were collected over 5 years of implementing the BirdReturns habitat program. Models for the spring and fall enrollments were developed separately (in program R).

Habitat Shortfalls Relative to Precipitation

The study applied an existing bioenergetics model (Dybala et al. 2017) to data collected over 4 successive years (2014-2017) that included both record-setting droughts and floods. The model

compares the daily energy needs of the shorebird community against the daily energy supply available from suitable foraging habitat. Similar bioenergetic approaches have been used to assess food resources for overwintering and migrating waterfowl. Habitat availability varies throughout the non-breeding season with variation in the timing, extent, and depth of open water in managed wetlands and croplands and this study examined this temporal variation across years.

Flooding effects on shorebird and salmon food production

In this manipulative field experiment, two rounds of invertebrate sampling were done over a six-month time frame in two successive years. To assess shorebird food availability, benthic invertebrates were sampled with a 10 cm coring device in randomly selected locations across three sets of fields. These were divided equally between ones in which water was managed for long, medium and short residence times. Simultaneously collaborators at CalTrout sampled the water column for aquatic invertebrates (fish food).

Results

Analytics for Auctions

The main result of this study was to establish a mechanism for incorporating consideration of the set of factors (e.g., timing of habitat, duration of flooding, acres of wetlands nearby) that have been shown to be most important in affecting shorebird response in flooded fields into the bid selection process in the habitat auctions.

Factors Influencing Use of Flooded Fields

This study confirmed the importance of certain factors in influencing shorebird response in flooded fields and identified some new ones. For example, the timing of flooding, size of the field, and proximity to other flooded habitats were all confirmed as being important, but so too was the duration of flooding and the water source used to flood the fields.

Habitat Shortfalls Relative to Precipitation

This study identified late fall and early summer as the most consistent times of food energy shortfall for shorebirds in the Central Valley. It also suggested that spring, and particularly April can be a time when there is insufficient flooded habitat on the landscape. Moreover, this work demonstrated that even in years when there is abnormally high rainfall, there are still times of persistent shortall. This is a result of how highly managed surface waters are in the Central Valley.

Flooding Effects on Shorebird and Salmon Food Production

This study demonstrated that production of both shorebirds and fish food is maximized with longer residence times of water on floodplain fields. This has implications for water management, particularly in bypasses, which are already recognized as important foraging areas for waterbirds and rearing habitat for salmon and other fishes.

Challenges

Analytics for Auctions

As our understanding of what influences shorebird response in flooded fields has increased, so too has our ability to model expected performance of enrolled fields. Even so, significant challenges remain in

identifying which bids will yield the greatest habitat benefits. In part, this is because bid selection takes place well before the enrollment periods begin, and it is very difficult to predict what the habitat conditions will be in the valley in advance. Rainfall, in particular, can have a significant influence on when and how much additional habitat is needed in the springtime period, and long-range rainfall forecasting has a high degree of uncertainty associated with it.

Factors Influencing Use of Flooded Fields

Although this study was very informative in identifying what factors most influence shorebird use of flooded fields, knowing this does not necessarily translate into creating the ideal habitat conditions on the ground. This is because most fields are privately owned and in agriculture and thus, have constraints that prevent certain shorebird management actions from being taken. Even so, the knowledge gained here is very important and helps define a best-case scenario of habitat creation.

Habitat Shortfalls Relative to Precipitation

The main challenge that this study highlights, from a management standpoint, is the difficulty in providing sufficient additional habitat during the identified periods of shortfall, particularly in late summer/early fall. Another challenge is the difficulty in anticipating how much rain will fall in springtime so that additional habitat can be provided or not as conditions dictate.

Flooding Effects on Shorebird and Salmon Food Production

In terms of maximizing prey production, one significant challenge is the capability of managing the flow of water through the bypasses and other water management structures to maximize food production while simultaneously meeting other water management needs, such as flood production.

Outputs

Analytics for Auctions

A PowerPoint presentation was produced to communicate the how bid selection is being done and how this process evolved over time (see Attachments).

Factors Influencing Use of Flooded Fields

A draft manuscript based on this analysis has been completed and is included below. Following revisions, this will be submitted for publication consideration to a peer-reviewed journal.

Local and landscape factors drive shorebird use of flooded rice land in California's Central Valley

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Abstract. Because of the importance of the Central Valley of California to shorebirds along the Pacific Flyway, a dynamic habitat incentive program was created to pay farmers to put temporary habitat on privately owned agricultural lands. These activities target seasons (early fall and late spring) when flooded shorebird habitat is relatively sparse. We collected and analyzed data on shorebird use of fields enrolled in the program to provide management guidance for dynamic conservation programs targeting shorebirds in agricultural landscapes. As expected, we found higher shorebird abundance during early fall and late spring. In the fall, earlier flooding was significantly correlated with higher shorebird abundance. Fields managed to be

approximately 50% flooded, 5 or 10 cm deep (in spring and fall, respectively), and have straw incorporated into the soil (not laying on the surface) are had significantly higher shorebirds. Fewer shorebirds were observed in survey areas embedded within landscapes with ample flooded rice habitat, potentially because shorebirds spread across the landscape. Flooding consistency – either at a site that is continually flooded over many months or a site that has been flooded in previous years – led to more shorebirds. Finally, soil clay and water source affected shorebird abundance, potentially through their influence on invertebrate communities.

Habitat Shortfalls Relative to Precipitation

A manuscript on this study was written by the project team and submitted to *Ecological Monographs* for publication consideration and is included below. We are currently awaiting a decision from the journal.

Shorebird food energy shortfalls and the effectiveness of habitat incentive programs in record wet, dry and warm years

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Abstract. In response to wetland habitat loss in the Central Valley of California, and the need to compensate for recent drought conditions, several shorebird habitat incentive programs have been established to pay private landowners to flood their fields and create additional habitat during the non-breeding season. However, it remains unclear how successful these programs have been in supporting baseline shorebird population needs or meeting established population goals, particularly in the face of changing environmental conditions. To address these questions, we used bioenergetics modeling to estimate shorebird food energy needs over four consecutive years that had the highest annual mean air temperatures ever recorded in California, and included years of extreme drought, as well as the second wettest winter on record. Our objectives were to: (1) characterize annual variability in the timing and magnitude of shorebird food energy shortfalls, (2) estimate the contributions that incentive programs made to meeting these needs, and (3) develop recommendations for implementation of future habitat programs to advance shorebird conservation in the region.

Overall, we found a high level of consistency in the timing and magnitude of habitat shortfalls over the four years, especially in fall, despite large differences in annual rainfall—a result that was unexpected, but that emphasizes how highly managed the hydrological system is in the Central Valley. We also found that the magnitude of both fall and spring energy shortfalls increased, relative to recent (2007-2014) previous estimates, perhaps due to excessively warm conditions.

Incentive programs implemented to provide supplemental habitat were somewhat effective in reducing shortfalls for the assumed baseline population, but there were consistent unmet habitat needs when there were not enough shallow open water foraging areas available. Strategies to offset these remaining food energy deficits include scaling up habitat investments, adjusting the timing of habitat programs to better match the migration patterns of the birds, and adapting programs to new geographies. To the extent that there is variability in annual habitat need we recommend implementing a dynamic conservation approach. This involves scaling the amount of additional habitat created to match the shifting needs of the birds to maximize return on investment.

Flooding Effects on Shorebird and Salmon Food Production

A preliminary data report was produced based on analysis of the first year's experiment entitled, "Evaluating the effects of post-harvest rice field water residence time on benthic invertebrate prey resources: an experimental approach" (see Attachments). In addition, a poster presentation was prepared and presented at the annual Bay-Delta Science Conference (see Attachments).

Impact & Next Steps

Analytics for Auctions

The overall impact of this work is an increase in TNC's return on investment in its BirdReturns program and the shorebird habitat it creates. With more refined modelling the project team is better able to identify and select the bids that have the greatest likelihood of yielding high shorebird response. An important next step will be to evaluate how the outputs of this modelling change when additional shorebird focal species are considered.

Factors Influencing Use of Flooded Fields

By increasing our understanding of the specific factors that affect shorebird response, this study has led to changes in the design and implementation of TNC's projects that create shorebird habitat, including BirdReturns. In addition, it has contributed to an advancement in the auction analytics. A next step is to gather some additional data from farmers about their management practices during the enrollment period.

Habitat Shortfalls Relative to Precipitation

The main impact of this study has been an advancement in understanding of how habitat shortfalls for migrating and overwintering shorebirds are influenced by annual precipitation. Most significantly it showed that habitat shortfalls always occur in the late summer and early fall, even following very wet years. A critical next step is to find a way to scale the habitat programs to overcome these shortfalls, particularly in fall.

Flooding Effects on Shorebird and Salmon Food Production

This study has led to an increased awareness of the potential value of appropriately managed floodplain habitat for both birds and fish and has demonstrated that there are opportunities to deliberately manage resources for multiple benefits. Moreover, this study demonstrates that the same projects can benefit both species groups, and that resources dedicated to one group need not be at the expense of the other. Through support from another grant, data from the second year are being analyzed and a final report/draft manuscript is being written by the project team. An important next step in this project is to provide better spatial definition of exactly where these fish food production fields can be located, so that the potential scaling of this restoration strategy can be assessed.

Pasture Deficit Irrigation

Background / Rationale

Irrigated pasture makes up a large proportion of the irrigated acreage in the Shasta Valley, located in the Klamath River Basin of northern California. Pastures are primarily utilized for cattle, but some are harvested for hay production. As California continues to experience a drying climate,

there is a growing interest in identifying and implementing water conservation methods as a mechanism to providing water supply reliability for people as well as the watershed's aquatic resources. Since 2009, TNC's water transaction program (Fall Flow Program) has been leasing water from Shasta Valley irrigators during September to increase stream flows for adult migrating Fall Chinook salmon. These short-term water leases last anywhere from 14 to 30 days and involve working with water rights holders to cease their diversions during this time, allowing this water to stay instream. In some cases, water rights holders are compensated for the water they do not divert during this time period. This program has provided reliable streamflow for adult Chinook salmon for 12 years, but there is limited information available to assess how this partial season fallowing of fields impacted grass production. The objective of this study was to quantify how early season irrigation water cutoffs impacted forage production and yield while also assessing impacts on stand persistence the following spring. Assessing impacts to pasture production would further inform the Fall Flow Program and other water conservation efforts in the basin.

Methods

This study was conducted on privately owned flood irrigated pastures in the Shasta Valley. Seven pastures were evaluated in 2013-2014, six pastures in 2017-2018 and eight pastures in 2018-2019. The University of California's Cooperative Extension (UCCE) Office in Yreka conducted the study and worked closely with landowners to coordinate the timing of irrigation applications. Each pasture was divided into three treatment areas that corresponded with three irrigation cut-off periods: mid-August, early September and late September. Pasture forage biomass and forage quality was collected along with soil moisture levels, and forage composition.

Results

As predicted, results from this study showed that ceasing irrigation of grass/hay fields during August resulted in the largest impacts to forage production and yield, while ceasing irrigation in mid-September yielded less of an impact. The level of impacts to yield and production varied, however, depending on the study site. Carryover impacts of the study treatments were not statistically significant, so we are not sure how these treatment types impacted production and yield the following spring. Based on these findings, we have greater confidence that asking irrigators to cease irrigating their fields in mid-September, to leave water instream, does not likely have a big impact on grass yield and production. This information will be useful to the Shasta River's Fall Flow Program in landowner outreach and in evaluating what may be an appropriate price to pay irrigators for the water not diverted during this time period.

Challenges

Two similar studies had previously been conducted on drought-related management solutions locally. The first study occurred in the adjacent Scott Valley and looked at how deficit irrigation impacted alfalfa production. The second study occurred in the Tule Lake Basin and looked at how different pasture grasses faired under deficit irrigation conditions. The Tule Lake study was conducted at a UCCE research station in Tule Lake under a very controlled environment. While both studies have informed some of the water management approaches in the region, the impacts of deficit irrigation on cool season grasses and pasture production hadn't been done in situ. Given this study was intentionally done on real-world pastures under flood irrigation, there were inherent challenges in the natural variability between the

study plots. Plots were distributed across the valley, wherever we could get willing landowners to participate, and as a result they varied by soil type, slope, aspect, timing of irrigation water application, nutrient content, etc. The variability across study plots created different results. A second challenge included the drought that impacted California during the second year of the study during 2017-2018. The drought resulted in some of the study sites not receiving any irrigation water due to water shortages.

Outputs

Researchers from UCCE's Yreka and Tule Lake offices produced a report that provides more detail on the rationale, methods and results of this study (see Attachments).

Impact & Next Steps

The results of this study will be used to inform ongoing and future efforts to balance the water needs of fish in the Shasta River while working with local landowners to keep their businesses and livelihoods economical. As stated above, the Shasta Fall Flow Program is in its 12th year of operation, and we continue to be grateful to those diverters in the agricultural community who contribute flows to the system during this critical time of year. This study will be used to re-evaluate the price for the leases that the program pays and can be used to inform future efforts to create a resilient system for both people and nature.

Attachments

Fox Canyon Groundwater Management Agency
Review of Business Operations
June 28, 2021
Final

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Table of Contents

Section 1: Introduction

Fox Canyon Groundwater Management Agency (FCGMA or Agency) has recognized that its current data management system is ill-equipped to support the significant new basin management opportunities and responsibilities facing the agency.

New and advanced groundwater metering technologies, the emergence of a groundwater market within the managed basin, and the need for innovative management practices to ensure long term sustainability of the basin are all driving the need for the deployment of a next generation data management system.

However, identifying an appropriate data management system capable of properly tracking FCGMA's complex well inventory, meter calibration, groundwater extraction/storage activities, and billing/payment communication management isn't straight forward. Selecting the optimum application (or suite of applications) will require a well-documented understanding of FCGMA's current and future basin management procedures and practices.

This document summarizes the current and anticipated future business procedures, information flows, and technologies FCGMA will require to manage the basin in a sustainable manner.

1.1 Agency Background

The FCGMA was created in 1982 by the California State Legislature to manage and administer groundwater resources in southern Ventura County. As a special district, the agency operates independently from County and local city governments. In 2015, the Agency expanded its authorities under the Sustainable Groundwater Management Act becoming the Groundwater Sustainability Agency for the groundwater basins within its jurisdiction.

FCGMA's primary purpose is to preserve and manage groundwater resources within the area of the Fox Canyon aquifer and its related basins for the common benefit of the public, as well as agricultural, domestic, and municipal and industrial users.

FCGMA's groundwater basins cover approximately 183 square miles, and encompass several basins, sub-basins and groundwater management areas. The basins include several primary aquifers and surface water resources. Historically, groundwater extraction within the basin has exceeded its sustainable yield. Consequently, a primary goal of the agency is to work with stakeholders to meet long-term sustainable management practices for the basin.

1.2 Key Partners and Stakeholders

As a special district, the agency operates independently from County and local city governments. Since its formation, FCGMA has contracted with the County of Ventura to staff and administer the Agency. Additionally, FCGMA works effectively with selected departments within the County of Ventura government to oversee the permitting of groundwater extraction wells and ensure that groundwater extraction fees owed by well owners are processed and paid. United Water Conservation District is a key partner in management of some of the basins.

The agency's key stakeholders include:

- Extraction well owners and operators (primarily agricultural and municipal/industrial entities)
- Vendors supporting groundwater producers such as flowmeter installation and calibration companies
- Vendors supporting groundwater extraction metering. Examples include companies that provide telemetered groundwater extraction information.
- Water importers. These are entities that purchase water outside the basin and import it with the intent of storing the water within selected aquifers within the basin.

- Water market participants. A nascent water market exists within the basin, allowing certain water producers to buy and sell groundwater allocations. Accurate and timely data on extractions and compliance status are needed to support the water market.
- The public. As a public agency overseeing a key resource, FCGMA has a responsibility to operate and communicate openly with the public.
- Cities, water districts, and companies that construct and operate water supply projects.
- County of Ventura GIS division, Public Works Agency IT division and Groundwater division

Section 2: Objectives and Approach

This review of business operations at FCGMA aims to identify and summarize the current procedures and processes in use by agency staff to meet its mission of achieving the sustainable management of the groundwater basins in its jurisdiction.

After identifying FCGMA's key business operations for managing its groundwater basins, this study identified the primary flow of information between the agency and its stakeholders, as well as important data flows within the organization.

The overall objective of this effort is to document the current business operations employed by FCGMA to document the volume of groundwater extracted from its basins, the extraction fee invoicing process, and the procedures used to determine future groundwater extractions. This information will be used by the agency to define the requirements, features, and capabilities of a data management system that will replace its current aging groundwater data management application.

2.1 Study Approach

FCGMA's objective is to replace its aging groundwater data management system with an application or suite of applications that can better support its key business processes. To ensure that the agency can make an optimum decision on the replacement applications, FCGMA has identified the following steps in the decision-making process:

Step 1: Review Business Operations (this report). This step includes a review of current business operations at the agency with a focus on groundwater data management, extraction fee statement creation, and well allocation determination.

Step 2: Data Management System Requirements Document. This step will use the results from Step 1 to identify the capabilities and functional requirements for an application (or applications) may improve the agency's current processes and replace its existing data management technology. The Data Management System Requirements document will help inform a future Request for Proposal document.

Step 3: Recommendations for a Data Management System. This step will include identifying and reviewing potential technologies and software applications that can meet the agency's system requirements, as identified in Step 2.

Step 4: Data Management System Request for Proposal (RFP). This step includes developing a RPF document that the agency can distribute to qualified vendors for acquiring a data management system.

2.2 Methodology

To complete Step 1 of the technology definition process, our project team met via web meetings to discuss the agency's history, business processes, information flows, current technologies.

Listing of meetings (date, subject, attendees)

Meeting 1
Date: March 3
Subject: Agency Goals, Background, and System Stakeholders
Attendees: Kim Loeb, Kathleen Riedel, Kathy Jones

Meeting 2
Date: March 4
Subject: Business Process

Attendees: Kim Loeb, Kathleen Riedel, Kathy Jones

Meeting 3
Date: March 9
Subject: Business Process and legacy system
Attendees: Kim Loeb, Kathleen Riedel, Kathy Jones

Meeting 4
Date: March 11
Subject: Legacy System Architecture and Technology
Attendees: Kim Loeb, Kathy Jones, Tony Sheppard, Matt Bencomo

Meeting 5
Date: March 18
Subject: Extraction Reporting and Billing
Attendees: Kim Loeb, Kathleen Riedel, Kathy Jones

Meeting 6:
Date: April 1
Subject: Well Permitting and Registration
Attendees: Kim Loeb, Kathleen Riedel, Kathy Jones, Keely Royas

Meeting 7
Date: April 5
Subject: Allocations
Attendees: Kim Loeb, Kathleen Riedel

As part of these interviews, Farallon observed the agency's current data management system and reviewed the key data entry screens needed to complete essential tasks such as tracking well information, flowmeter calibration data, groundwater extraction information for a well, and extraction fee statements.

Our meetings included extensive discussion of the data flows, both external and internal to FCGMA, used to support business operations at the agency.

Section 3: Summary of Current Business Processes

To manage the four groundwater basins in its jurisdiction, FCGMA relies on a series of key business processes to ensure that:

- Extraction wells are permitted,
- Groundwater extraction is accurately measured and reported,
- Required equipment is in compliance,
- FGCMA business systems group well information by well owner and operator to ensure accurate billing and future allocations,
- Groundwater extraction fees are accurately assessed and is payment verified,
- Groundwater extraction allocations are determined for wells or well groups according to established business rules.
- Groundwater extractions can be tracked by the Water Market Administrator to ensure there is water available for trade as bids and offers are matched.

The following sections summarize FCGMA's major business processes.

3.1: Well Permitting Process

Managing groundwater extraction well permitting is an important FCGMA business process. Prior to issuance of a County well permit, applicants must obtain a permit from FCGMA for extraction wells in the basins within FCGMA's jurisdiction.

3.1.1 Well Permit Initiation and Review

Applicants must obtain a permit from FCGMA for domestic, agricultural, and municipal and industrial (M&I) groundwater production wells within the Agency's basins.

All pumping wells within the Agency must be registered with FCGMA. An applicant for a new pumping well must first apply for two permits before it may be constructed:

- A FCGMA Water Well Permit
- A Ventura County Well Permit

The FCGMA Water Well Permit requires applicants to provide well ownership, location, location of current and proposed groundwater use, proposed crop types or M&I or domestic use(s), type of irrigation distribution system, estimated average annual quantity of water use, identification of source of allocation, analysis of potential impacts.

After reviewing a water well permit application, FCGMA issues a disposition on the application:

- Approve the application and provide a permit. The applicant is still required to obtain a permit from Ventura County for well construction activities.
- Approve the application with conditions and provide a permit: The application is still required to obtain a permit from Ventura County but must comply with FCGMA's conditions for construction and operation of the well. An example of permit conditions includes extraction limits.
- Deny the application: The applicant may not construct the well.

An approved FCGMA Water Well Permit is required before an applicant may apply for a Ventura County well construction permit.

3.1.2 Manage Approved Permit Conditions and Well Construction Information

Well permits approved by both FCGMA and Ventura County allow for the drilling and construction of water wells.

If constructed, FCGMA obtains well completion information from Ventura County and incorporates selected well information into its data management system. At FCGMA's request, notifications of well completions from the County have recently been formalized by a policy aimed at improving the timeliness of communication between the two organizations. To support the ability to confirm that water well owners comply with all the conditions set in the water well permit application, FCGMA may need to refer to the permit long after (potentially years) the permit has been granted.

3.2: Well Registration, Authorization

Although it is Ventura County that issues a permit to construct a well, groundwater extraction wells may not be operated without being registered with FCGMA. By statue, all groundwater extraction wells must be registered with FCGMA within 30 days of well completion.

Registering new extraction wells requires the well owner to provide contact information, contact information for the well operator (if different from the owner), and well information including:

- FCGMA Permit Number
- Ventura County Permit Number
- Well construction information (depth, casing diameter, perforated intervals)
- Water flowmeter information for each meter associated with a well (Manufacturer, serial number, size, meter units and multiplier, pump motor, inlet and outlet pipe diameters)
- AMI (Advanced Metering Infrastructure)
- Location (assessor parcel number (APN), groundwater basin, address, State Well Number (SWN))
- Use type (Agricultural, Domestic, Municipal/Industrial, Other)
- Preferred well grouping

In addition, FCGMA authorizes operation of the well so long as the well owner acknowledges their responsibility for reporting extractions and fees associated with well operation.

3.2.1 Owner Well Documentation

To manage the well registration process, FCGMA conducts outreach to well owners. Communications with well owners included a new well registration package that requires a response within 30 days.

3.2.2 Well Registration Validation

Once the Groundwater Extraction Facility Registration Form is returned by the owner, FCGMA validates the information for final incorporation into the system for ongoing monitoring and billing. This validation includes:

- Verifying information reported by owner from the package (Legal owner, Location, Designated Operator)
- Correlation with well permitting information
- Assigning CombCode
- Verify extractions did not occur prior to registration

3.2.3 Updating Existing Well Registration

Well registration can be conceptualized as a one-time event. However, registration details will likely need to be updated over time. Examples of details that must be kept up to date, with

historical information maintained, include legal owner, the address for the legal owner, the corporate officer representing the legal owner, operators, and CombCodes.

3.3: Well Grouping

Agriculture and M&I groundwater users often own multiple groundwater extraction facilities/wells. To ease billing, allocation management, and communications with groundwater pumpers, FCGMA must manage groups of extraction wells.

3.3.1 Identifying Well Groups

Because agriculture and M&I groundwater users often own and operate many extraction wells, FCGMA may decide to define an allocation to a well, group of extraction wells, or parcel. This process has several benefits:

- Allocating a groundwater extraction volume to a group of wells provides well owners or operators a greater degree of flexibility in choosing which wells to pump.
- Well groups simplify FCGMA's ability to bill well owners for their groundwater extraction
- Well groups simplify communication between FCGMA and well owners and operators
- Well groups provide a means of managing future allocations to multiple wells

3.3.2 Manage Well Groups

Well Groups are managed in the legacy system using CombCodes (owner or operator designated combination of wells on an account). CombCodes are accounts in which one or many wells may be assigned. If there is more than one well on a given CombCode, the well group can share extraction allocation budgets.

Ideally, wells associated to a single CombCode should meet business rules such as:

- Same allocation system
- Draw groundwater from the same basin and management area
- All wells must have the same operator

As extraction wells are destroyed, become inactive, or new wells are permitted and constructed, FCGMA must update the appropriate well group (e.g.: CombCode) to reflect the set of wells participating in the group.

Although CombCodes are a useful means for allocating pumping to well operators, CombCodes have some limitations:

- Wells in a well group are not required by current database to be in the same basin as required by the Agency Ordinance Code, nor are they required to be located in the same basin management area. This complicates the overall basin management practice and the water allocation process for FCGMA.
- CombCodes will likely complicate the transition of allocating groundwater pumping to a parcel-based model.

3.4: Flowmeter Equipment Management

FCGMA relies on flowmeters installed at each extraction well to document the actual volume of groundwater pumped within a basin, sub-basin and management area. Well owners/operators self-report extractions semiannually. Ensuring that flowmeters are used properly and accurately measure flow volumes is essential for FCGMA to properly bill groundwater pumpers, monitor whether groundwater allocations have been met or exceeded for a well or well group, and manage the basins.

3.4.1 Flowmeter Registration and Status

FCGMA requires flowmeter installation on active wells for recording and documenting the volume of water pumped from a well. Flowmeters associated with a well can change over time,

additionally, flowmeters can be moved and associated with different wells. The status of each flowmeter is tracked.

In some cases, multiple operators pump from a single extraction well. Wells used by multiple operators require a separate flowmeter for each operator so that FCGMA may properly track water production from a well and calculate the appropriate pumping fee for each operator.

Because flowmeters are a primary tool for documenting the actual volume of groundwater pumped from a well, FCGMA requires Operators to report on the status of flowmeter equipment using a variety of forms. Activities requiring documentation include installations, replacements, repairs, totalizer resets, calibrations, new well owner/operator, upgrade to equipment, changes in utilization (such as possible exemption), or changes in classification of well.

Certain wells, such as inactive wells or single-family domestic wells, do not require a flowmeter.

3.4.2 Advanced Metering Infrastructure (AMI)

In February 2018 FCGMA required that all flowmeters be fitted with Advanced Metering Infrastructure (AMI), a means of automatically transmitting groundwater pumping data to an approved AMI vendor.

Well operators may select from a list of AMI vendors to install, test, and calibrate the equipment.

FCGMA currently uses the AMI telemetry data as a secondary means of documenting water production from each well. However, it is the long-term vision that FCGMA will use AMI as the primary means in the future as the technology improves and operators become accustomed to working with them. AMI is vital to the water market as up-to-date extraction information is needed to ensure the availability of pumping allocation offered on the market. While not tracked by the Agency the water market Exchange Administrator needs to be able to view these data weekly.

3.4.4 Flowmeter Calibration

FCGMA requires well operators to provide proof of flowmeter accuracy for each active well. Flowmeter accuracy is to be tested at least once every three years. Failure to meet the calibration deadline may result in FCGMA fining the offending operator. Operators may select an approved flowmeter calibration contractor from an approved list. The contractor is then responsible for conducting the calibration test and providing the results to the well operator to send to FCGMA. Flowmeters are considered accurate if they measure the volume of water pumped within an error tolerance of +/- 5 percent. Both passing and failing tests are to be provided to the Agency.

Owners or operators of small wells (e.g.: those using pump motors less than 10 horsepower and extracting less than 10 ac-ft of water over a 5-year period) may apply for a flowmeter waiver or calibration extension.

3.5: Flowmeter Data: Monitoring and Reporting

FCGMA relies on flowmeter data to determine the overall groundwater withdrawal from the basin, subbasin and management area each reporting period. In addition, flowmeter data are used to determine the pumping fees for wells or well groups, whether operators have exceeded their allocation, or if an operator has pumped less than the water allocated to them.

3.5.1 Operator Meter Reporting Requirements

FCGMA requires that well operators provide well pumping information for each 6-month reporting period so that the agency can calculate the groundwater extraction fee for the well.

Operators are required to provide a picture of the well's flowmeter each reporting period, showing the total volume pumped from the well. In addition, operators report the flowmeter totalizer reading on a semi-annual extraction statement.

3.5.2 AMI Vendor Meter Reporting Requirements

AMI vendors are required to provide FCGMA with a monthly summary of groundwater extraction from each well.

AMI vendors were directed to provide extraction data in a particular format to be transmitted to a CSV receiving file. Presently, there is not a CSV receiving file and there are a variety of formats received. That data is transferred by FCGMA staff to an excel spreadsheet to support basin wide groundwater production estimates. These data will be used to improve the groundwater models that are designed to use monthly extraction data to reflect seasonal variations.

The water market Exchange Administrator has access to the AMI data through a data portal for water market participants. This information is not shared with the Agency and is not tracked in a database.

3.6: Statement (Invoice) Management

Billing well owners or operators for the groundwater that they pump provides FCGMA with the revenue stream to fund Agency administration. In addition, the groundwater production data allows the agency to compare actual extractions to the sustainable yield for each basin, helping to inform water allocations for the subsequent water year.

Penalties and surcharges that are imposed by FCGMA when well owners or operators exceed their allocations. Credits for future allocations for municipalities and water districts that store water represent some of the ways that the agency may influence water producers to adopt more sustainable practices in the future.

3.6.1 FCGMA Semi-Annual Extraction Statement Review Process

FCGMA verifies calculation of fees reported on semi-annual extraction statements provided by the Agency (e.g.: invoices for well owners or operators) based on water pumping data provided by the well owners or operators.

Well owners or operators are required to send FCGMA meter readings and calculation of the volume of water pumped from each of their wells during a reporting period, along with a picture of each well flowmeter showing the cumulative flowmeter reading.

Determining the total volume of water pumped from a well may require several calculations, including unit conversions; a process in which a well owner or operator might inadvertently introduce a mathematical error. Consequently, FCGMA staff review each flowmeter calculation to confirm that the reported groundwater extractions are correct.

If necessary, FCGMA staff may review flowmeter information, such as make/serial number and calibration data, multiplier and divisor unit to confirm that the owner/operator reported pumping volumes are reasonable.

If an owner or operator provides incomplete data, FCGMA must follow up with operator for complete information. Staff may validate extraction data from the well's AMI device to estimate the volume of groundwater produced by a well

An operator may change the flow meter on a well during the reporting period. This results in a significant and labor-intensive effort on the part of FCGMA to confirm extraction volumes from multiple flowmeters to determine the total amount of groundwater produced at a well.

Changing flow meters during a reporting period also requires FCGMA to confirm that damaged or retired meter is not used by the operator for the next statement period and removed from the statement.

3.6.2 Operator Communications

As with any agency required to generate and manage invoices to its customers, FCGMA engages in direct communications with well operators and owners to ensure:

- Owners and operators provide the required well flowmeter information on a timely basis
- Discrepancies with reported well flowmeter readings are resolved
- Questions from well owners regarding a reporting period statement are resolved
- Payment is received in full

3.6.3 Extraction Fee Calculation, Semi-Annual Extraction Statement (SAES) Creation

Every six months FCGMA issues a statement or invoice summarizing all wells assigned to CombCode. Although well owners provide meter readings from the last day of the reporting period to calculate AF extraction for a given period of their water production, FCGMA calculates the water produced by each well using flowmeter data provided by well owners or operators.

The SAES calculation effort can be complicated by missing, incomplete, or inaccurate flowmeter data, often resulting in revised or retroactive adjustments to a fee statement. In addition, flowmeter units may vary from well to well, so a specific flowmeter reading may require differing calculations to convert flowmeter data to the groundwater volume units used to calculate extraction fees.

Creating SAESs is further complicated if a well owner or operator's pumping data is late. Changes in extraction rate fees, allocation adjustments, and differing flowmeter equipment may all complicate the creation of an accurate statement.

FCGMA's use of CombCodes to group wells and ownership information may also add complexity to the extraction fee statement creation effort. Wells that are re-assigned to a different CombCode during a billing statement may require significant additional effort to generate a statement.

3.6.4 Penalties

As part of the SAES creation process, FCGMA reviews production data for each well or well group to determine whether any penalties should be assessed for the billing period.

Penalties may be accrued for late reporting of pumping data or late payment of fees owed. Owners may request a review of assessed penalties, requiring further management of an extraction fee statement.

3.6.5 Surcharges

Surcharges are assessed when a well owner/operator extracts more than the allocated amount for the well or well group (CombCode) after adjustments are made for allocation bought or sold on the water market

3.6.6 Payment Processing and Invoice Reconciliation

Processing the payment of extraction fees is also a complex process. Although FCGMA issues SAESs, the County of Ventura Public Works Fiscal Department (Fiscal) receives payment, provides evidence of payment to FCGMA, then processes actual payment once FCGMA identifies how to apportion to various accounts by producing a receipt and submitting to Fiscal. Consequently, FCGMA posts payments received by Fiscal to the current database.

Because FCGMA issues statements, it must also generate receipts documenting payment apportionment, calculate refunds or fee adjustments for individual statements (requiring additional coordination with the County Finance Department), and determine whether penalties for late, incomplete, or non-payment are due.

3.7: Groundwater Extraction Allocation Process

FCGMA engages in a suite of business practices to define overall water allocations for its various basins, as well as for specific well owners. Once allocations have been defined for a given year, FCGMA review and manage requests for variances, storage credits, and transfer (may be directly between owners via a Water Market)

3.7.1 Basin-wide and Well Type Allocations

A key business goal for FCGMA includes managing the total volume of groundwater extracted from its various basins. Allocations not only must be set by basin and sub-basin, but ultimately by management areas within a basin. At present, annual allocations allow for over-drafted pumping of the basin and will require that FCGMA manage future allocations in a sustainable manner.

Historically, FCGMA managed allocations in all its basins together and relied on historical baseline pumping data for wells. As of October 2020, the Agency has begun transitioning to allocations for individual basins. In the future allocations may be determined for sub-basins and management areas, and potentially for aquifer zones within sub-basins.

In addition to basin-wide allocations, FCGMA also determines allocations for some wells based on well type. Allocations for agricultural wells (or groups of wells) have been based on irrigation efficiency rather than historical pumping since 2014; the Agency is transitioning from this to fixed allocations. De minimis Domestic wells have specific minimum allocations.

Pumping allocations may be managed as “pools” that define the available groundwater extraction volumes by basin management areas and by usage type in one or more basins.

Specific annual allocations may also be influenced by litigation, basin model forecasts, and new water-supply and infrastructure projects. Ultimately, the annual pumping allocation determines the “size of the pie” for basin-wide extraction of groundwater by all stakeholders to achieve sustainable management of the basins.

3.7.2 Allocation Determination for Well Owners

In addition to determining the overall groundwater pumping allocation for the entire basin, FCGMA also defines the allocated pumping for individual wells or well groups. Ensuring that the actual volume of groundwater pumped from a well or well group is the responsibility of the well owner.

Typically, well allocations are set for a year. However, it is possible for FCGMA to update the allocation for a particular well or well group within a semi-annual statement (e.g.: billing) period. Allocations for a well group can change during the reporting period though the buying and selling allocation on the water market.

Well-based allocations have been generally determined by historic use; in the future well extractions may be based on a percentage of the overall basin or management area allocation to help attain sustainable pumping rates.

For new wells (without historic pumping data), allocations may be related to the total pumping volume of a well group. For example, adding a new well to a well group simply shifts the proportion of groundwater extracted by each well in the group without changing the overall allocation of the well group. For cases where a new well is constructed to replace a decommissioned well, the new well may inherit the previous well's allocation.

For domestic wells, groundwater pumping volumes are typically very small, and any allocation limits for these wells are handled as variances (see 3.7.x).
New domestic well: see variances

If basin-wide allocations define the "size of the available groundwater pie", well allocations define the "size of the slice" for a specific well or group of wells.

3.7.3 Irrigated Acreage Reporting

Historically, agricultural operators chose to have allocations be based on the type and acreage of irrigated crops, as well as the evapotranspiration zone of the crop. This was required for all agricultural operators in 2014. These allocations are meant to reflect efficiencies in water use and are referred to as Efficiency Allocations or IAI (e.g.: Irrigation Allowance Index) allocations.

FCGMA provides a web-based tool to aid well owners in calculating irrigated acreage and other information required for an IAI allocation. Despite the web tool, managing IAI allocations is complex as it requires the well owner to provide a description of the geospatial and temporal extents of crops.

Once a well owner submits the required information, FCGMA staff must complete a cumbersome and time-consuming review of IAI submittals to ensure that owners aren't seeking an undue advantage in their IAI request.

Because allocation based on irrigation efficiency is variable and not fixed, FCGMA is transitioning away from it to fixed allocations for all wells. Currently, water market participants are not allowed Efficiency Allocations and must operate with a fixed allocation.

3.7.4 Variances

Once FCGMA determines the groundwater pumping allocation assigned to a well or well group, a well owner may request a variance on the allocated allowance based on specific criteria. FCGMA must review variance requests and may decide to increase the pumping allocation.

If approved, variances may be valid for a limited time or may be granted in perpetuity. Variances may be awarded with conditions and can be revoked if the well owner or operator does not satisfy the conditions set.

In all cases, variances are not transferable (e.g.: they can't be transferred to a new owner, nor to another well owner), nor can the allocations associated with them be sold in the basin's Water Market.

3.7.5 Carry-Over, Storage Credits

FCGMA tracks information on allocation usage by well or well group. When a well operator pumps less than their annual allocation, the unused portion of their allocation may be carried over into the next water year.

An example calculation of carry-over allocations is as follows:

Well allocation: 100 ac-ft
Actual volume of groundwater pumped: 80 ac-ft
Carry-over: 20 ac-ft
Next water year allocation: 120 ac-ft

Operators can only carry over up to 50% of their year's allocation into the next water year and carry-overs may only accrue up to a total of 100% of a well's allocation. During well operation, the carry-over volume is deemed to be the "first water" pumped from a well.

Carry-overs may also be used to offset surcharges in future water years. For example:

Well allocation for a water year: 100 ac-ft
Carry-over from previous year: 20 ac-ft
Total pumping for the year: 130 ac-ft
Surcharge: 10 ac-ft (e.g.: not 30 ac-ft)

Carry-overs are meant to support flexible pumping by allowing operators to bank water from wet years for use in dry years. It should be noted that the Agency Board may institute future changes to carry-over.

Storage Credits:
Well owners who contribute water to the basin, via groundwater injection or other foreign water imports, may earn groundwater extraction storage credits. These activities are seen as a well owner banking water for future use.

Storage credits are assigned to a well owner and are not usually transferrable (although possible with Board approval). The credits may have associated expiration dates.

Well owners who wish to accrue storage credits must notify FCGMA and obtain approval before storing water in the basin. Note that permitting and overall regulation of injected water is overseen by State agencies and not FCGMA.

3.7.6 Parcel vs. Well based Allocation

FCGMA intends to move to a parcel-based (as opposed to the current well-based) allocation model for agricultural wells in at least some of its basins.

This business decision would allow operators to divide the allocation for a parcel among one or more extraction wells. Of course, parcel-based allocations would then need to be updated upon sale or sub-division of a parcel. Moreover, parcels and wells might then be required to fall within the same billing (e.g.: "CombCode") account, which is not a current requirement.

3.7.7 Allocation Transfers

FCGMA's water allocation business process includes tracking the transfer of allocations outside of the water market.

Individual well owners may transfer allocations between one another on either a temporary or permanent basis. Allocation transfers are often initiated when an owner decommissions or

destroys a well and wishes to apply the old well's allocation to a new well. Alternatively, an owner may wish to transfer a well allocation when sub-dividing a parcel to the new landowner, or an offsite well under different ownership provided water to a parcel in the past. This is distinct from the water market as those trades are anonymous and are limited to the year the trade is made.

At present, FCGMA limits allocation transfers to wells within the same basin. In the future, allocation transfers may be limited to wells within the same sub-basin, basin management area, aquifer system or aquifer .

3.7.8 Allocation Modelling for Future Extractions

Groundwater extraction within FCGMA's jurisdiction currently exceeds the basin's sustainable yield. As part of its mandate, FCGMA is developing allocation models and policies so that future allocations are consistent with long-term sustainable groundwater basin management practices.

3.7.9 Basin Water Market

A nascent water market exists for certain basins and groundwater user types. Trading consists of sales of and purchases of annual groundwater extraction allocation each water year in units of acre-feet. The water market is administered by a third party, the Exchange Administrator. The Exchange Administrator has access to the water market data portal showing all participants pumping year-to-data reported through AMI. This ensures a seller has the allocation available to sell when an offer is made.

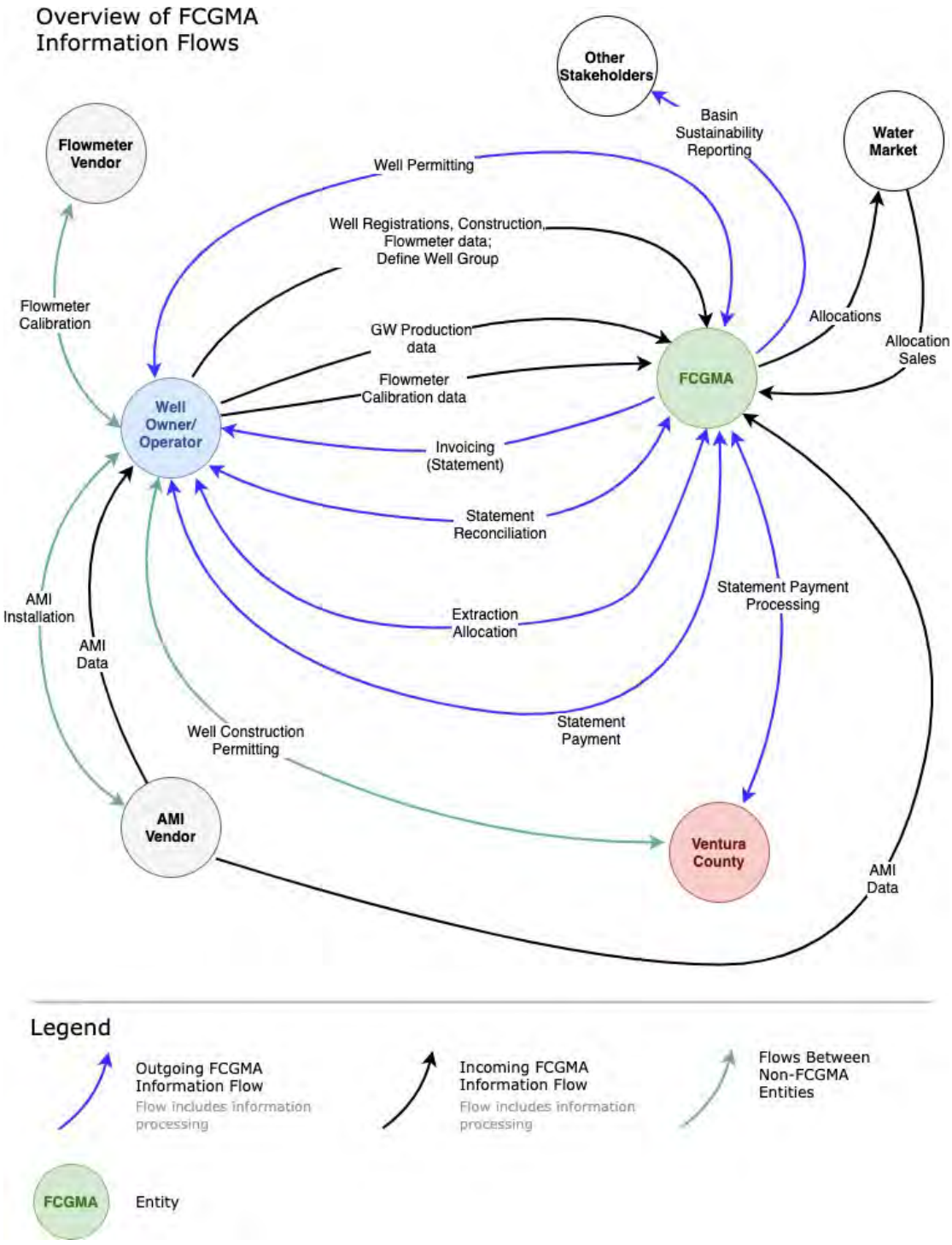
Agricultural well owners/operators may buy or sell allocations in the market via a blind bidding model. This means that buyers and sellers are unaware of the entities involved in the transaction. Only a Participant or Participant's Authorized Representative may submit to the Exchange Administrator bids to buy and offers to sell electronically through the water market trading portal. A bid or offer be may amended or withdrawn at any time before it is matched, and the Exchange Administrator may cancel a bid or offer at any time before it is matched if it does not comply with the rules or to otherwise ensure a fair, orderly and transparent market.

Bids and offers are matched through a blind algorithm by taking the highest bid with the lowest offer and matching them in the middle. To be protective of the basin no transfer shall be approved that results in a net increase in total market allocation for extraction facilities located in an area designated by the Agency as subject to seawater intrusion or in a pumping trough area.

Water Market transactions require that FCGMA reflect market trades of allocations for specific wells or well groups in the extraction fee statement. Compliance with all Agency rules and regulations including all fees and penalties are paid is required for eligibility in the water market.

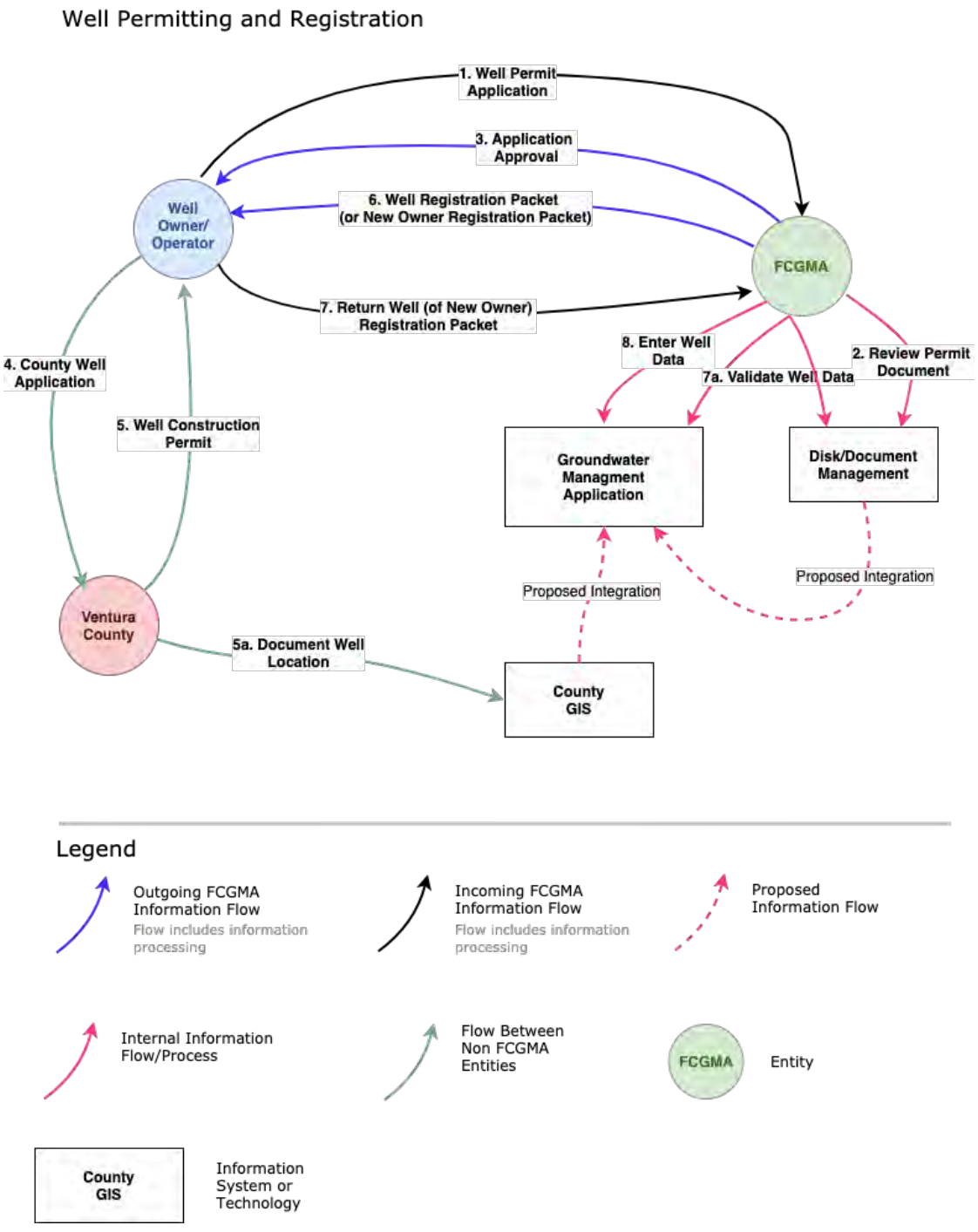
Section 4: Information Flows and Current Technologies

To manage the basin and ensure that groundwater extraction fees are calculated accurately, FCGMA relies on a flow of information between key entities including well owners/operators, flowmeter vendors, AMI vendors, and the County of Ventura. The following diagram shows key information flowing between basin entities.



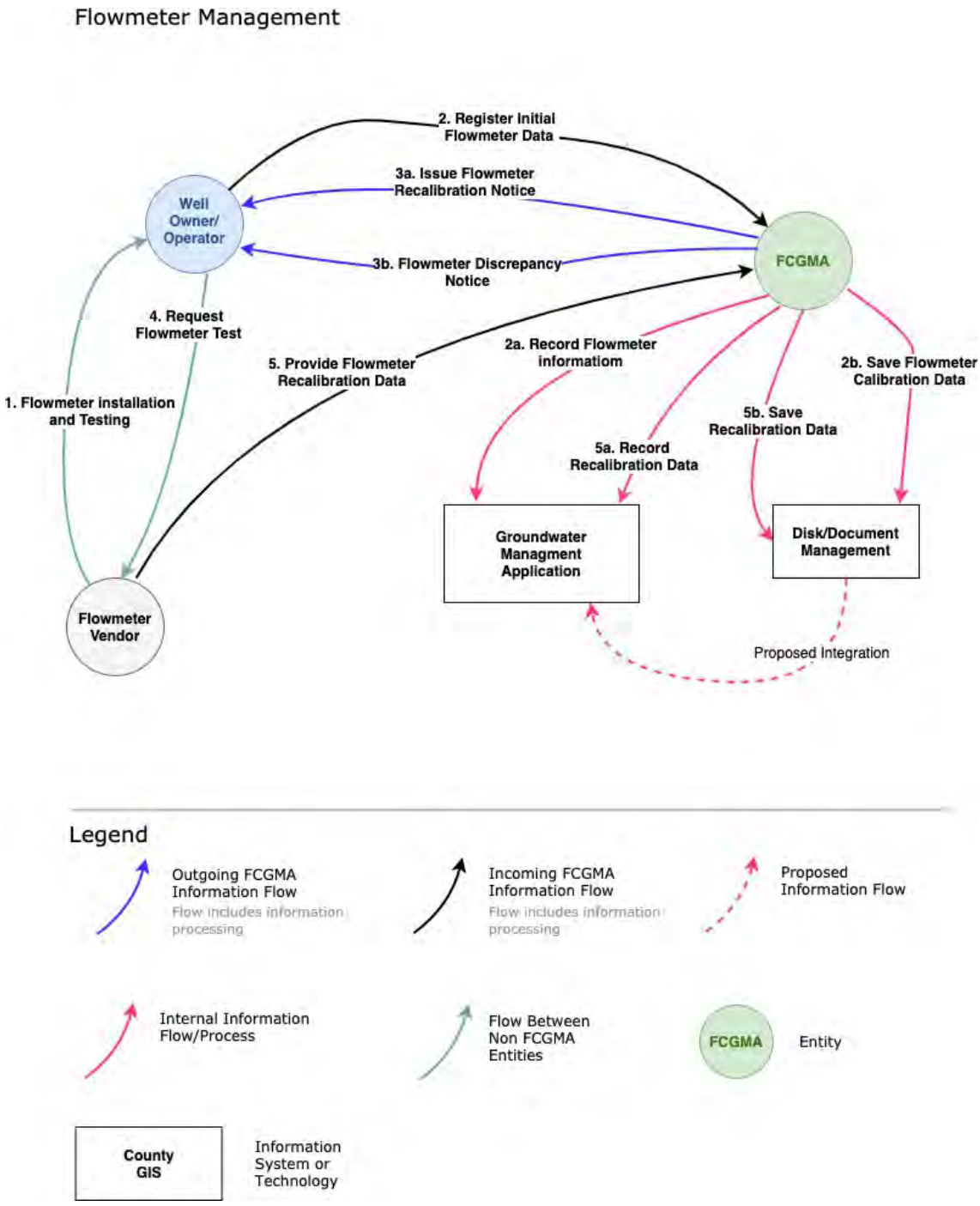
4.1: Well Permitting and Registration

FCGMA processes information from well owners, and indirectly from the County of Ventura, to track extraction wells in the basin and ensure that they are grouped by owner to allow for accurately calculating extraction fees. The primary information flows are:



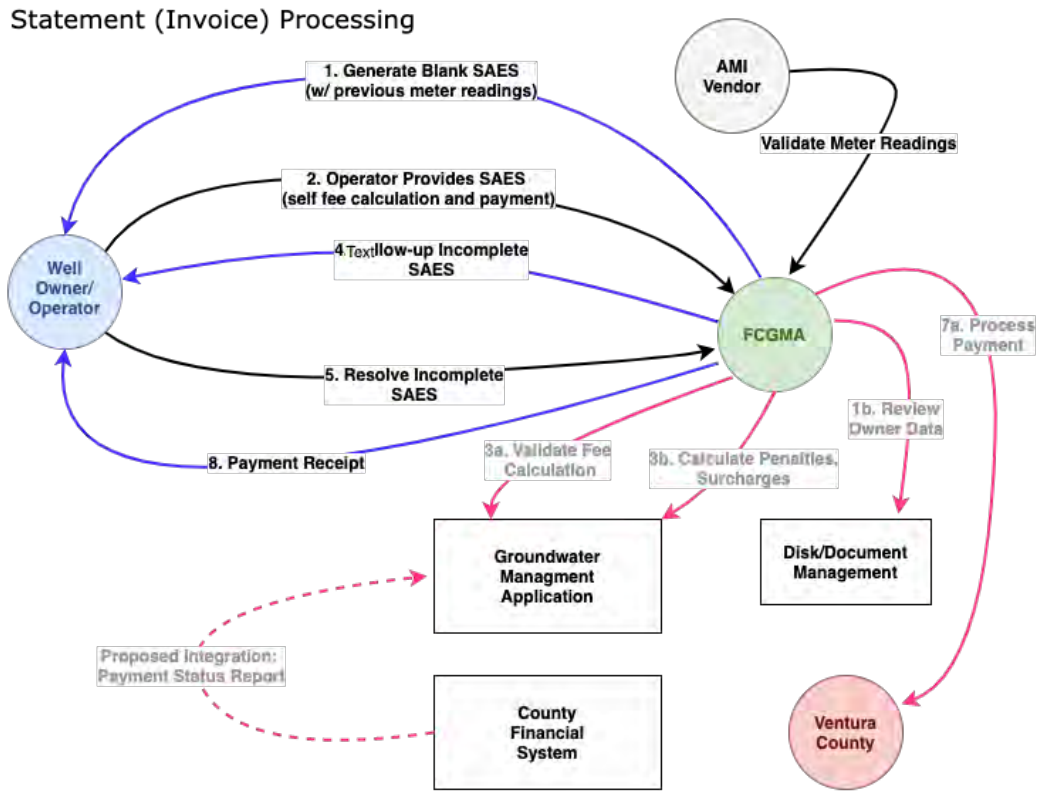
4.2: Flowmeter Management

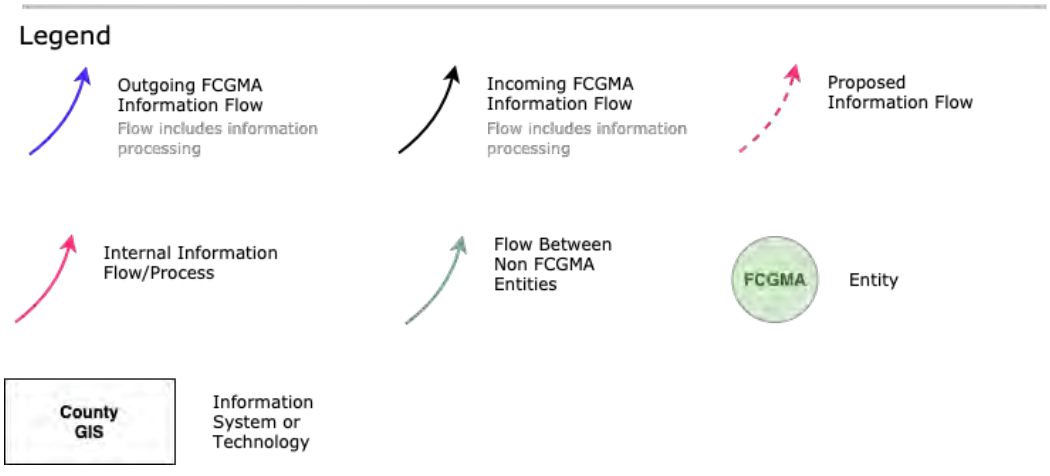
FCGMA processes information from well owners/operators and flowmeter vendor to ensure that groundwater extraction is measured accurately. The primary information flows are:



4.3: Statement Processing

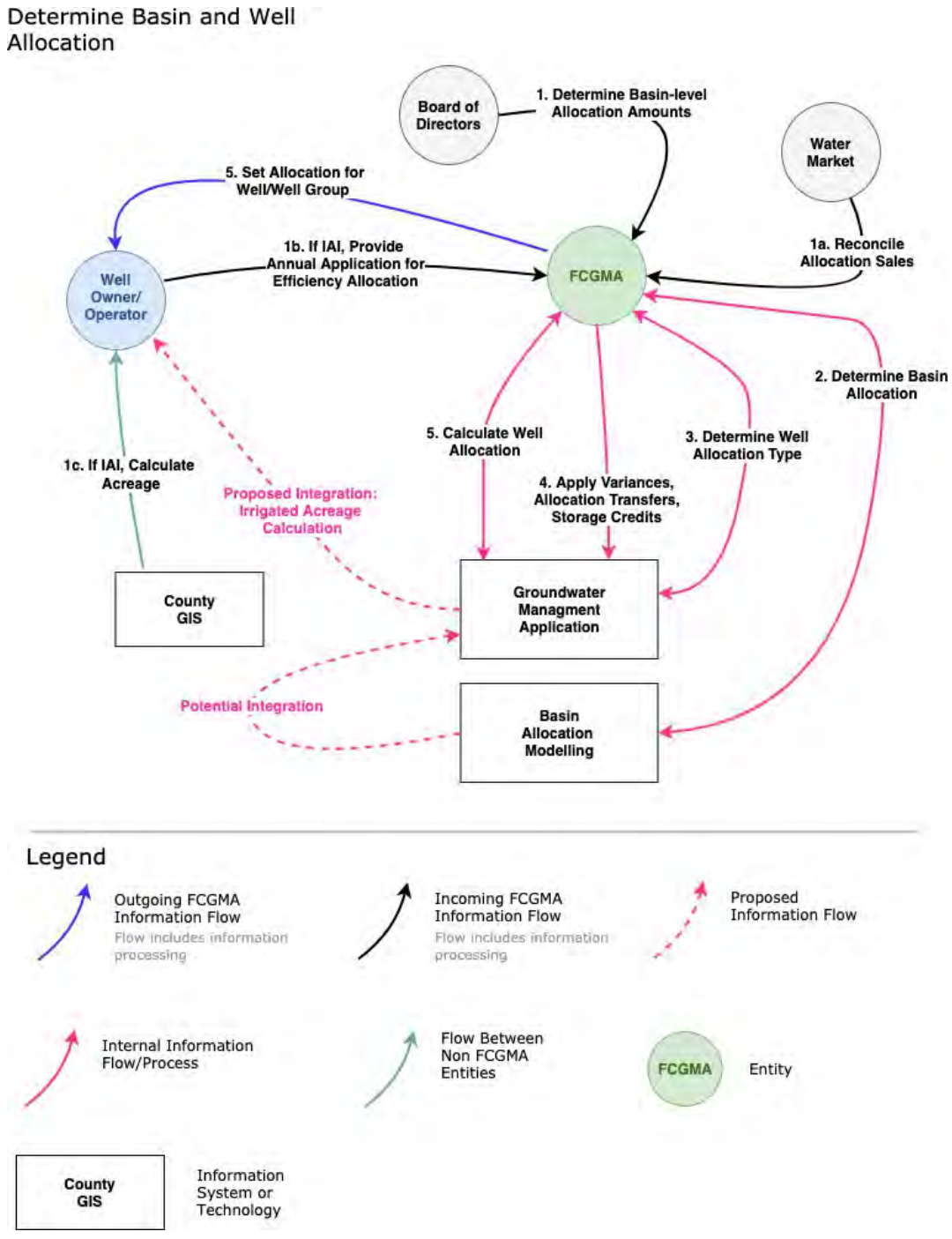
FCGMA processes information from well owners/operators, AMI vendors, and Ventura County to complete its groundwater extraction fee process. The primary information flows are:





4.4: Allocations Determination

Each year, FCGMA determines the total allowable groundwater extraction from its basins and allocates a portion of the total to each well/well group. The primary information flows required to support this business process include:



Section 5: Summary

This document summarizes the key business processes and information flows supporting FCGMA's groundwater resources management efforts. FCGMA recognizes this work as a necessary first step in defining the capabilities and data management requirements for a technology or suite of applications capable of replacing the agency's aging information management system.

To meet its mandate, FCGMA must complete five fundamental tasks:

- Accurately tracking groundwater extraction from wells/well groups within the basin
- Generating groundwater extraction fee statements and managing the fee collections process
- Defining groundwater extraction allocations for well owners/operators for the upcoming water year
- Accurately provide data reports and summaries for basin management and enforcement
- Communication / notification management for compliance and enforcement

FCGMA relies on a number of data flows to complete these key business tasks in an effective manner. Given the complexity of these core processes, a next generation data management solution will likely be required that supports improved integration with key systems such as GIS, finance, document management, and basin yield models.

FARALLON GEOGRAPHICS INC.

DRAFT (20210907)

Data Management System
Use Cases and Requirements Document

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A. BACKGROUND AND PURPOSE

Fox Canyon Groundwater Management Agency (FCGMA) has recognized that its legacy data management system is ill-equipped to support the significant new basin management opportunities and responsibilities facing the Agency.

New and advanced groundwater metering technologies, the emergence of a groundwater market within the managed basins, and the need for innovative management practices to ensure long- term sustainability of the basin are all driving the need for the deployment of a next generation data management system.

FCGMA is taking a methodical approach to planning and implementing a new system. This document is preceded by a review of existing that must be supported by the new system (see Fox Canyon Groundwater Management Agency Business Operations Review, dated June 28, 2021). In the business operations review document, we summarize how wells are registered and permitted, flowmeters are tracked and managed, and extraction data are collected.

The purpose of this document is to define the requirements and capabilities of an information management system that supports the business objectives of the Agency. As a future step, the capabilities defined in this document will become part of a software procurement RFP so that qualified bidders may propose a solution that meets FCGMA's requirements.

B. SOFTWARE CAPABILITIES DEFINITION METHODOLOGY

Defining the software capabilities for an application as ambitious as the Fox Canyon's Data Management begins by understanding the activities and goals of the application's stakeholders: Fox Canyon Staff, owners and operators of wells, Ventura County, and others.

This document summarizes stakeholders' requirements for the Groundwater Management System by writing User Stories. User Stories describe real-world expectations of an application from the perspective of a person who wishes to use the software to achieve an outcome.

B.1 APPLICATION THEMES AND USER STORIES

Our stakeholder interviews provided us with a set of business processes common throughout the system's targeted user community. We have organized these business processes into a set of **Application Themes** that describe the core capabilities required of the new system.

Each Application Theme consists of a number of specific tasks or objectives that a stakeholder commonly wishes to complete. We have documented each of these tasks as a **User Story**.

Application Themes

Application themes provide a framework for describing the functionality of a software system. Because themes are meant to summarize actual business processes, they can help developers, project managers, end users, and executive staff (who will fund the application development) better understand the scope and expected capabilities of the software system.

Just as real-world business processes are broken into smaller steps or tasks, Application Themes consist of tasks called User Stories. You may find it helpful to think of Application Themes as high-level summaries of software functionality, with each user story providing a description of a single task in the workflow.

User Stories

A user story is a short description that summarizes what a person does or needs to do as part of their job function. User stories are written without jargon or overly technical language so that all members of the application development team can readily understand the goals of a business task.

Each user story is intended to describe a single task so that a software developer can quickly understand the objective of a user and design the code needed to support the task.

A good user story captures what a user does or needs to do as part of his or her job function in one or two sentences. Often, user stories follow a template such as:

"As a <*role*>, I want to <*goal/desire*> so that <*benefit*>"

For example, a user story might be:

> *"As a Data Manager, I want to calculate allocation per Well Group so that I can apply surcharges appropriately each statement period."*

It's possible that a single user story may require the development of several software components. In the example above, a software developer would need to create:

- A method for determining allocation for all wells in a Well Group
- A way to compare the allocation against metered usage
- A method to calculate the surcharge based on the difference between usage and allocation

User stories capture the 'who', 'what' and 'why' of a requirement in a simple, concise way understandable to both the domain experts who will be working with the finished product and the application developers tasked with building the software.

C. GROUNDWATER MANAGEMENT SYSTEM PRODUCT DEFINITION

The Groundwater Management System's core purpose is to collect groundwater extraction data and use it in a manner that supports sustainable groundwater management within the basins managed by the Agency.

To meet this goal, the system must track extraction wells within the basins, collect extraction readings from associated flow meters every reporting period, track water extraction and allocation , and support collection of revenues based on extractions to support Agency operations.

Further, the data collected and managed in the system must be available for analysis (both within the system and outside of it) to support improvements in understanding the Basin's sustainable groundwater yield, how and where Operators are extracting groundwater, and Agency policy and business practices.

C.1 TERMINOLOGY

This document uses the following terms:

Well Group: A group of wells and flow meters. Well groups represent the set of wells and flow meters operated in a geographical area and are used to produce one extraction statement for each reporting period. Well groups allow an Operator to manage the wells used to extract their allocated water volume in a water year. FCGMA's current data management system refers to well groups as "CombCodes".

Well Allocation: Allocation is the volume of water that may be extracted by an Operator at a given well without incurring a surcharge.

Surcharge: When groundwater extraction volume exceeds allocation, the cost per unit of water increases based on a Board-approved additional charge called a surcharge. The surcharge is intended to dis-incentivize groundwater pumping beyond non-sustainable thresholds. Surcharge funds are principally used for purchase of supplemental water and to increase the sustainable yield of the basins.

Statement: Operators are required to provide information stating the volume of water extracted from a well during a reporting period. This information comes to the Agency in the form of a formal "Statement" provided by the well Operator.

Variance: The Agency can modify allowable well allocation for certain circumstances.

Water Market: A managed market in which Operators of wells can buy or sell extraction allocation in a given water year.

Carryover: In some cases, the groundwater extraction allocation for a well can be reserved for usage in a future water year. This increases the allocation for that well in the future water year.

Storage Credit: Water that is contributed back into the groundwater basin, typically via injection or percolation, or in-lieu water delivery. Operators can receive credit to their well allocation based on the volume of water contributed.

Automated Metering Infrastructure (AMI): The system of hardware, software, and networking infrastructure that allows flowmeter readings to be electronically communicated on a recurring and automated basis.

Provisional Data: Data that has been entered by an untrusted user and that therefore requires review and validation by a trusted user for promotion as "authoritative data". An example might be extractions totals entered by an Operator that still requires review by appropriate Fox Canyon staff.

Authoritative Data: Data that has been entered by a trusted user or has been reviewed by a trusted user and promoted to "authoritative" status.

C.2 DATA MANAGEMENT SYSTEM ROLES

Application roles are the distinct user types that will be interacting with the Data Management System.

System Administrator:
Configures the application, creates users, and supports the system through administrative user interfaces and command line interfaces.

Data Manager (Business Process Coordinator):
Responsible for ensuring accurate tabulation of groundwater extraction statements and bills.

Groundwater Analyst (Groundwater Specialist):
Subject Matter Expert (SME) in the capacity of the basins to support sustainable groundwater extraction. Provides science-based input and data analysis to support sustainable groundwater usage proactive. Reviews well permit applications and prepares well permits for issuance.

Compliance Specialist:
Responsible for ensuring compliance of well Operators with permit conditions and Agency rules and regulations.

Well Permit Applicant:
A landowner who is applying for a permit to drill a new well.

Well Owner:
The owner of a given well. Generally, the owner of a well is also the landowner of the parcel that the well is on.

Well Operator:
Operators are granted the ability to pump water from a well by the well owner. Sometimes the Operator also happens to be the well owner.

County Public Works Agency:
The Agency that it responsible for issuing permits for drilling and constructing wells.

Payment Processor:
This is the user that receives and deposits payments, and forwards relevant payment information to FCGMA staff for inclusion in the system. Currently, this role is filled by the County.

Water Market Administrator:
Manages the process of buying and selling extraction allocation credits on the water market. Outside user of the system for increased independence.

AMI Vendor:
A vendor who sells and services Automatic Metering Instrumentation. This is equipment capable of automatically collecting and reporting water extraction information as recorded by a flowmeter on a well.

Flowmeter Vendor:

A pre-vetted vendor who services flowmeters. Flowmeter vendors also calibrate flowmeters or repair them when they are not operating correctly.

Calibration Contractor:
A flowmeter vendor or an independent contractor who certifies that flowmeters meet Agency calibration requirements.

Other Stakeholders:
All other parties with interests in the basin that are not well owners or operators. Certain information needs to be provided to Other Stakeholders on the public side of the website application without the need to log in.

D. FOX CANYON DATA MANAGEMENT SYSTEM USER STORIES

User stories typically describe a variety of goals and requirements for a software application. Often, user stories are related, making it advantageous to organize them thematically. Application themes provide a way to group related user stories, making it easier to understand how multiple stories describe key application capabilities.

The Application Themes for the Fox Canyon Data Management System includes:

- System Administration
- Well Permitting and Registration
- Flowmeter Equipment Management
- Allocations
- Extractions Monitoring and Reporting
- Payment Processing
- Export and Reporting

D.1 SYSTEM ADMINISTRATION THEME

The System Administration Theme includes user stories that describe how users want to control access to data and configure the system on a year-to-year basis to support changing conditions such as statement generation and allocation formulas.

Use Case ID	Use Case Title
SA-001	Create accounts for system users
SA-002	Authenticate Users Accessing the System
SA-003	Apply user security group roles
SA-004	Enable users to recover credentials
SA-005	Define and apply user roles
SA-006	Track and review edits to data in the system

Create Accounts For System Users

ID: SA-001 Priority: High

Theme: System Administration

User Story:

As a System Administrator
I want to Create accounts for system users
So that Individual end users access the system with their own distinct credentials

Story Details:

- A new user should be able to create their own account, but the administrator must assign privileges beyond those granted to an anonymous user

Authenticate Users Accessing The System

ID: SA-002 Priority: High

Theme: System Administration

User Story:

As a System Administrator
I want to Be sure that the system authenticates users when they log in to the application
So that I can determine what privileges to grant the user

Story Details:

- Different roles should have differing privileges to access various data and functionalities within the system. Generally, roles (as defined in this document) will be associated with a user group and individual users will be associated with one or more user groups.
- Individual users should be associated to user role(s) with predefined system privileges
- Note that some users may have CREATE, UPDATE, or DELETE privileges to specific aspects of the system.

Apply User Security Roles

ID: SA-003 Priority: Medium

Theme: System Administration

User Story:

As a	System Administrator
I want to	Apply user security roles to users
So that	I can take advantage of role-based security to streamline the application of security privileges among users

Story Details:

[None]

Enable Users To Recover Credentials

ID: SA-004 Priority: Low

Theme: System Administration

User Story:

As a	System Administrator
I want to	Enable users to recover their account credentials when
So that	Lost usernames and/or passwords do not require staff time to recover

Story Details:

[None]

Define And Apply User Group Security (Roles)

ID: SA-005 Priority: Medium

Theme: System Administration

User Story:

As a	System Administrator
I want to	Define and apply user group security (roles)
So that	Applying security settings to individual users is streamlined

Story Details:

- Most users will be external Operators and/or Owners. They can have their roles automatically assigned when they sign up.
- Remaining users will be internal FCGMA staff. Their user privileges will likely be managed by the administrator with the help of pre-defined roles.

Track And Review Edits To Data In The System

ID: SA-006 Priority: High

Theme: System Administration

User Story:

As a	System Administrator
I want to	Track and review edits to data in the system
So that	I can review data entered into the system to identify the source of invalid or inaccurate data

Story Details:

- Edits should be tracked along with the user who committed the edit

D.2 WELL PERMITTING AND REGISTRATION THEME

The Well Permitting and Registration Theme includes user stories that describe how users want to initiate new wells within the Fox Canyon jurisdiction.

Use Case ID	Use Case Title
WPR-001	Create an Account
WPR-002	Initiate a well permit application
WPR-003	Track permit application status
WPR-004	Document communications with permit applicant
WPR-005	Define permit conditions
WPR-006	Track well application status
WPR-007	Assign one or more flowmeters to an extraction well
WPR-008	Assign each flowmeter to an Operator
WPR-009	Create or assign well group identifiers
WPR-010	Create or assign unique well identifier to each flowmeter
WPR-011	Reassign well to a new owner
WPR-012	Distinguish owners and operators on every well and flowmeter
WPR-013	Verify ownership of wells
WPR-014	Allow parcel-based groundwater usage registration

Create An Account

ID: WPR-001 Priority: High
Theme: Well Permitting and Registration

User Story:

As a Well Permit Applicant
I want to Set up a system account
So that I can securely access the system and manage my well application and registration

Story Details:

- By registering as a non-anonymous user, the permit applicant can then fill out a permit application directly in the system in a manner that only the applicant and FCGMA staff can see the information.
- This registration also serves as the basis for downstream workflows like managing correspondence during the permitting process and entering extraction data directly into the system.

Initiate A Well Permit Application

ID: WPR-002 Priority: High
Theme: Well Permitting and Registration

User Story:

As a	Well Permit Applicant
I want to	Begin entering the required information for a well permit
So that	I can initiate the process of obtaining permit to drill a new well

Story Details:

- Currently this is submitted as a paper application based on FCGMA's well application form.
- System should allow applicant to enter the information required for a well application over several editing sessions, if necessary
- System should require and capture geospatial location of the proposed well and other geospatial information required in the form: "dimensions of area(s) to be irrigated. Indicate crop type for each area. For M & I or other uses, show location of water distribution system, type of water use and location of structures to be served"
- Should allow upload of a number of supporting documents.

Track Permit Application Status

ID: WPR-003 Priority: High
Theme: Well Permitting and Registration

User Story:

As a	Groundwater Analyst
I want to	Track the status of permit applications
So that	I know whether the evaluation of a permit is resolved or requires further action

Story Details:

- The actual determination of whether a permit will be granted is largely handled outside of the system

Document Communications With Well Applicant

ID: WPR-004 Priority: Medium
Theme: Well Permitting and Registration

User Story:

As a	Groundwater Analyst
I want to	Document communications with the well applicant
So that	I can inform the applicant of missing information and communicate permitting conditions and status of their application.

Story Details:
[None]

Define Permit Conditions

ID: WPR-005 Priority: High
Theme: Well Permitting and Registration

User Story:

As a	Groundwater Analyst
I want to	Define the well permit conditions for approval of a well permit
So that	The agency can enforce permit conditions when extraction actually occurs.

Story Details:

- Conditions for permit approval can vary significantly between wells. Consequently, the system should record the conditions that were placed on approval of the well application so those conditions can be enforced in the future.
- In the legacy system permit approval conditions are isolated from actual extraction data. This makes identifying cases where well usage violates conditions difficult because it requires a person to remember the conditions on a specific well and then notice that the conditions are being violated in extraction data.
- Over time permit conditions may expire or change (generally associated with changes to Ordinance Code).

Well Registration

Track Well Application Status

ID: WPR-006 Priority: High
Theme: Well Permitting and Registration

User Story:

As a	Data Manager
I want to	Track the status of a well application
So that	I can take appropriate steps to finalize a well registration process

Story Details:

- Well registration is a complicated, multi-step process involving communications with the well owner.

Assign One Or More Flowmeters To An Extraction Well

ID: WPR-007 Priority: High
Theme: Well Permitting and Registration

User Story:

As a	Operator, Data Manager

I want to	Assign one (or more) flowmeters to an extraction well
So that	The Agency will know which meters are measuring extraction from a well and the base reading for each flowmeter

Story Details:

- This story also supports knowing when the flowmeter(s) need to be recalibrated.
- Flowmeter associated with well may change over time.
- Well flowmeter history is to be maintained.
- There may be more than one flowmeter associated with a well during a single reporting period.
- Flowmeter data/details may need to be updated or revised after initial input.

Assign Each Flowmeter To An Operator

ID: WPR-008 Priority: High
Theme: Well Permitting and Registration

User Story:

As a	Operator, Data Manager
I want to	Assign each flowmeter to an operator
So that	I know how much water is being extracted be each Operator on a given well

Story Details:

- Generally, one Operator extracts water from a well at any given time. However, there are many cases where there are multiple Operators drawing water on a single well. In order to measure the amount of water extracted by an Operator, each Operator must have their own flowmeter even when drawing from a shared well.

Create Or Assign Well Group Identifiers

ID: WPR-009 Priority: High
Theme: Well Permitting and Registration

User Story:

As a	Data Manager
I want to	Create or assign an identifier for flowmeters that are related to an owner or operator
So that	I can aggregate the extraction and billing information for multiple flowmeters by well operator

Story Details:

- Operator should be able to suggest a new group, but not create one
- Anything an Operator does must require review by a Data Manager to make authoritative

Create Or Assign Unique Well Identifier To Flowmeter

ID: WPR-010 Priority: High
Theme: Well Permitting and Registration

User Story:

As a	Operator, Data Manager
I want to	Create or assign an account for each flowmeter on each well
So that	I can aggregate extraction totals and compose bi-yearly statements by account in a manner consistent with Agency policy

Story Details:

- Well identifiers should also be associated with Well Group identifiers so that FCGMA can identify the set of wells that are related to an owner and operator
- Important to track the timeframe on which a flowmeter is associated to a well because flowmeters can move between wells.

Reassign Well To A New Owner and/or Operator

ID: WPR-011 Priority: High
Theme: Well Permitting and Registration

User Story:

As a	Operator, Data Manager
I want to	Reassign an existing well to a new owner
So that	The Agency always knows who the latest owner is for billing and compliance purposes without losing the ownership history of a well

Story Details:

- FCGMA wants to retain the full owner history for a well
- The legacy system supports this by forcing a new registration to occur. FCGMA staff may think of this as a registration process.
- Re-assigning a well implies updating flowmeter information and updating the Well Group identifier for the well

Distinguish Owners And Operators On Every Flowmeter

ID: WPR-012 Priority: High
Theme: Well Permitting and Registration

User Story:

As a	Data Manager
I want to	Distinguish the Owner and Operator(s) of a given well independently of each other

So that	Owner-operated wells can be transferred to a different Operator if the owner so chooses.

Story Details:

- Wells have owners. Flowmeters have Operators. In some cases, the Owner happens to be the Operator of the flowmeter(s) on the well. However, an Owner has the option to give over Operatorship to a tenant Operator. The system should allow this.

Verify Ownership of Wells

ID: WPR-013 Priority: High
Theme: Well Permitting and Registration

User Story:

As a	Data Manager
I want to	Verify ownership of wells
So that	I am confident that well ownership is consistent with land parcel ownership.

Story Details:

- Access to GIS parcel data could play a role in supporting this functionality. This could just be a matter of having both the well and parcel layer on a map and allowing access to parcel owner info on the parcel.
- The well owner isn't necessarily the landowner (trusts, llc's, easements). System should allow this.
- Some wells may not be associated with a parcel (e.g.: wells located in a public right-of-way)
- The Assessor's roll may not always be current enough to establish land ownership

D.3 FLOWMETER MANAGEMENT

FCGMA must verify that flowmeters capturing extraction data are in excellent working order and are truly associated to the well against which extraction data is being reported. This is critical to ensuring that the Agency is collection accurate groundwater extraction volume data. These user stories describe what is necessary to support the flowmeter tracking effort. Also calibration.

Flowmeter Management User Stories

Use Case ID	Use Case Title
FMM-001	Register new or replaced flowmeters
FMM-002	Notify Operators when flowmeter calibration is due
FMM-003	Enter Flowmeter Calibration Data
FMM-004	Record when a flowmeter is moved to a different well
FMM-005	Exempt certain flowmeters from calibration requirements
FMM-006	Flag flowmeters that are past due for calibration
FMM-007	Associate Advanced Metering Infrastructure (AMI) to a flowmeter
FMM-008	Associate flowmeter(s) to wells over time range
FMM-009	Track repairs to flowmeters
FMM-010	Capture estimated extraction when flowmeter was broken
FMM-010	Register Flowmeter Calibration Contractor

Register New Or Replaced Flowmeters

ID: FMM-001 Priority: High
Theme: Track Flowmeter Status

User Story:

As a Compliance Specialist
I want to Register new or replaced flowmeters
So that I can know baseline extraction readings and calibration status of in-use flowmeters

Story Details:

- Most flowmeters must be recalibrated by an approved flowmeter calibration contractor every three years for the meter to be in compliance
- Part of flowmeter registration is uploading a photo of the flowmeter face, serial number, and installation from a distance, as well as documentation regarding calibration and when flowmeter installed [work order or receipt]

Notify Operators When Flowmeter Calibration Is Due

ID: FMM-002 Priority: High
Theme: Track Flowmeter Status

User Story:

As a	Compliance Specialist
I want to	Notify Operators when flowmeter calibration is due
So that	Operators are reminded to stay in compliance with flowmeter maintenance requirements and avoid penalties, and so we can ensure the flowmeters take accurate extraction readings

Story Details:

- Most flowmeters must be recalibrated by a qualified vendor every three years. System should track each flowmeter (even if it gets used at multiple wells over time) and notify the Operator whenever recalibration is coming due.
- Would be ideal if the system managed this automatically by date-stamping whenever a flowmeter is recalibrated and auto-generating the notification three years later.
- Some flowmeters have a 5-year calibration period, not 3. Some flowmeters are exempted from calibration requirements while well is inactive but must be calibrated when well becomes active if last calibration is more than 3 or 5 years.
- Some flowmeters have calibration data submitted more frequently than once every three years.

Enter Flowmeter Calibration Data

ID: FMM-003 Priority: High
Theme: Track Flowmeter Status

User Story:

As a	Calibration Contractor
I want to	Enter flowmeter calibration data directly in the system
So that	The agency knows that operators are in compliance with calibration requirements

Story Details:

- This work is currently accomplished on paper using this form. FCGMA wish to migrate to an e-system that alleviates need for staff to hand enter the calibration data.
- Regular flowmeter calibration is needed to ensure that FCGMA can accurately calculate the water extracted from the well that the flowmeter is associated with

Record When A Flowmeter Is Moved To A Different Well

ID: FMM-004 Priority: High

Theme: Track Flowmeter Status

User Story:

As a	Data Manager
I want to	Associate flowmeters to wells over a time range
So that	Flowmeters can be used at one well during one timespan and then re-used at another well during another timespan.

Story Details:

- Information related to moving a flowmeter to a different well are captured on the Flowmeter Update Form
- Requires close monitoring of dates and readings when the flowmeter is moved so that its clear how to determine the volume of water extracted from each well.

Exempt Certain Flowmeters From Calibration Requirements

ID: FMM-005 Priority: High
Theme: Track Flowmeter Status

User Story:

As a	Data Manager, Compliance Specialist
I want to	Exempt certain flowmeters from calibration requirements
So that	Calibration notices are not created for inactive and destroyed wells. Some wells have longer periods between submittal of proof of flowmeter accuracy.

Story Details:

- Inactive wells are exempt from the flowmeter requirement.
- Flowmeter calibration is to be current when extractions occur / well returns to active status and used for groundwater extractions.
- Some domestic wells can be granted extensions to the 3-year requirement for submittal of proof of flowmeter accuracy.

Flag Flowmeters That Are Past Due For Calibration

ID: FMM-006 Priority: High
Theme: Track Flowmeter Status

User Story:

As a	Data Manager
I want to	Flag flowmeters that are past due for calibration
So that	I can alert the appropriate operator and (potentially) levy a penalty if the Operator does not provide calibration data

Story Details:

[None]

Associate Advanced Metering Infrastructure (AMI) To Flowmeters

ID: FMM-007 Priority: High
Theme: Track Flowmeter Status

User Story:

As a	Data Manager, Operator, AMI Vendor
I want to	Associate AMI to flowmeters
So that	I can collect extraction data using AMI technology

Story Details:

- An AMI device is usually separate from the flowmeter itself and can be moved between flowmeters. The system needs to track which flowmeter has which AMI through any given timeframe. Some flowmeters have integrated AMI.
- AMI attributes are summarized here.

Track Repairs On Flowmeters

ID: FMM-009 Priority: High
Theme: Track Flowmeter Status

User Story:

As a	Data Manager
I want to	Track repairs on flowmeters
So that	I am informed about the state of repair for flowmeters capturing extractions data

Story Details:

- Need ability to upload documents

Capture Estimated Extraction When Flowmeter Was Broken

ID: FMM-010 Priority: High
Theme: Track Flowmeter Status

User Story:

As a	Operator, Data Manager
I want to	Capture estimated extraction when flowmeter was broken
So that	The best possible extraction data is captured in the system for the timeframe when the meter was not operating correctly.

Story Details:

- It should be clear that extraction data is estimated, not recorded
- Estimate should be justified by historical usage, and other documentation
- Documentation upload would be useful for justifying extraction estimates

Register Flowmeter Calibration Contractors

ID: FMM-011 Priority: High
Theme: Track Flowmeter Status

User Story:

As a	Compliance Specialist
I want to	Register flowmeter calibration contractors
So that	Operators can know who the qualified contractors are for calibrating flowmeters and reporting the results back to the Agency

Story Details:

- Contractors should be trained in the most efficient way to report results to the Agency
- Operators should have easy access to an updated list of registered contractors
- There is an aspect of relationship management with these contractors

D.4 ALLOCATIONS

The Determining Allocations Theme includes user stories that describe how users determine the type and amount of allocation granted to a given well or well group.

Allocations User Stories

Use Case ID	Use Case Title
AL-001	Determine well allocation type
AL-002	Add, retire, or modify allocation types
AL-003	Calculate allocation
AL-004	Transfer of allocation
AL-005	Support parcel-based allocations
AL-006	Track approved variances
AL-007	Track water market trades
AL-008	Track carry-overs
AL-009	Track storage credits

Determine Well Allocation Type

ID: AL-001 Priority: High
Theme: Determining Allocation

User Story:

As a	Data Manager
I want to	Determine each flowmeter's allocation type for a given period
So that	I can apply the appropriate formula for determining a well group's allocation budget

Story Details:

- Each allocation type has its own formula for determining allocation amount. The system should support allocation types that are defined by a matrix of use type (agricultural, manufacturing/industrial, and domestic) and groundwater basin.
- Potential allocation types are: Historical Allocation, Baseline Allocation, Efficiency Allocation, Temporary Extraction Allocation, IAI Allocation, Fixed Allocation, OPV Allocation, LPVB Allocation Pool 1, LPVB Allocation Pool 2. Most of these are legacy systems that do not need to be supported by the new system. The resulting allocation calculations need to be imported.
- Allocation should be tracked at the flowmeter level because different Operators drawing from the same well will have different allocations.
- Allocation is aggregated to the well group level for the purpose of producing statements
- On a given statement, Operators calculate their own allocation and extraction totals and send payment based on that calculation. Much of the work of staff is checking, validating, and revising these calculations.
- In the future, allocation may be assigned at the parcel/APN level

Add, Retire, Or Modify Allocation Types

ID: AL-002 Priority: High
Theme: Determining Allocation

User Story:

As a	Administrator
I want to	Add, retire, or modify allocation types
So that	Other staff (like the Data Manager) enter the appropriate data to arrive at consistent, reproducible results for my allocation.

Story Details:

- Allocation is determined based on formulas decided upon by the FCGMA Board. These formulas are reflections of policy which may shift as the goals of the Board change over time. As such, it is important that there is a clear pathway to revising the allocation formulas within the system. It is fine if this is a backend administrative (or even programmer) activity, but the allocation formulas should not be hard coded into the system without regard for the need to add new ones, retire old ones, or modify existing ones.

Calculate Allocation

ID: AL-003 Priority: High
Theme: Determining Allocation

User Story:

As a	Owner
I want to	Assign allocation for my well(s) in a step-by-step workflow
So that	I can validly enter the appropriate data to arrive at consistent, reproducible, and accurate results for my allocation

Story Details:

- Data elements needed to track well allocations include variances, transfers, water-market trades, carry-overs, and storage credits, and calculation of the final allocation. It will also be necessary to track the timeframe (e.g.: water year) and conditions related to a well allocation.
- Save a static report (as a pdf) summarizing the calculation for the allocation value for a well. Note that the well allocation for a water year may be associated with a semi-annual statement.
- Calculating allocation may be a time intensive process that takes more than one session to complete. The workflow should have the option to save the progress in an unfinished state and return later to complete.
- In the case of IAI-based allocation, the system should provide a map-based interface to allow the Operator to draw crop coverage areas and push the acreage of that area into the

allocation calculation engine. This would ostensibly be a context-sensitive step in the workflow defined in the Calculate Allocation Workflow.

-

Transfer of Allocation

ID: AL-004 Priority: High
Theme: Determining Allocation

User Story:

As a	Owner
I want to	Transfer the allocation from one well to a replacement well or split among multiple wells
So that	New wells or other wells can inherit allocation

Story Details:

- Retire allocation can occur as well
- Allocation can be transferred on a permanent basis or on a time-constrained basis. System should track timeframe associated to a given allocation.

Support Parcel-Based Allocations

ID: AL-005 Priority: High
Theme: Determining Allocation

User Story:

As a	Data Manager
I want to	Support Parcel-based allocations
So that	I can produce semi-annual statements and invoices at the parcel level

Story Details:

- FCGMA envisions parcel-based allocations as a likely future requirement based on a potential change in Agency policy. The goal will be to charge parcel owners based on groundwater usage rather than well/flowmeter operators based on extraction. The challenge will be in managing legacy data that did not adhere to this business rule within the new system.
- Only certain agricultural and domestic usage will likely receive allocations by parcel (not M&I). Therefore, the system will need to indefinitely support both well-based allocation and parcel-based allocation.

- Supporting this in the short-term is not a critical requirement, however, understanding the need and outlining a clear pathway to supporting this requirement in the future is critical.

Track Approved Variances

ID: AL-006 Priority: High
Theme: Determining Allocation

User Story:

As a	Data Manager
I want to	Track approved allocation variances
So that	Variances are properly accounted for in calculation of allocation and bi-yearly invoice

Story Details:

[None]

Track Water Market Trades

ID: AL-007 Priority: High
Theme: Determining Allocation

User Story:

As a	Data Manager
I want to	Track water market trades that may alter a well allocation
So that	I can modify allocation appropriately based on those trades

Story Details:

- Consider that some trades will span multiple water years and therefore multiple statements.

Track Carryover Allocation

ID: AL-008 Priority: High
Theme: Determining Allocation

User Story:

As a	Data Manager
I want to	Track allocation carryover
So that	Surcharges are applied properly when a carryover applies

Story Details:

- Extractions below an allocation can carry over the to the next water year with certain restrictions and conditions.

Track Storage Credits

ID: AL-009 Priority: High
Theme: Determining Allocation

User Story:

As a	Data Manager
I want to	Track storage credits
So that	Storage credits are applied properly and accrued

Story Details:

- Injecting water into the basin can result in a storage credit which increases the allocation in a given water year or multiple years.
- Providing "foreign water" in place of groundwater extractions in a basin can result in a storage credit which increases the allocation in a given water year or multiple years.
- Credits may be used, expire, or roll over

D.5 EXTRACTION MONITORING AND RECORDING

Extraction totals are collected by the Agency using self-reported statements provided by the Operators. The process requires sending partially populated statements to Operators every reporting period so that the Operators can fill in the new extraction totals and send the forms back to the Agency for entry into the system.

In the future, it is planned that this approach will be retired in favor of using AMI to automatically report extractions data into the system.

Use Case ID	Use Case Title
EMR-001	Issue a statement to Operators on semi-annual basis
EMR-002	Modify aspects of the bi-annual statement template
EMR-003	Issue multiple statements on a well's flowmeter
EMR-004	Submit fully populated extraction statements with payment
EMR-005	Automatically import AMI well extraction data
EMR-006	Validate submitted extractions statements
EMR-007	Track communications with operators when there are reporting discrepancies
EMR-008	Correct previously resolved statements from the past

Issue A Statement To Operators On A Semi-Annual Basis

ID: EMR-001 Priority: High
Theme: Statement Generation

User Story:

As a	Data Manager
I want to	Issue statements to Operators on a semi-annual basis
So that	Operators can capture final extraction readings and then calculate fees and pay the preliminary semi-annual extraction fee and other fees, interest, penalty, surcharge, or portions thereof (installment payments)

Story Details:

- This is a legacy process that the system must support for as long as self-reporting of extractions is a technical necessity. When/if automated extraction reporting becomes possible in all cases (ostensibly via AMI), this will no longer be necessary, and the Agency will just calculate the fees based on extraction and issue invoices.
- Statements are currently mailed to Operators, and the system should support that, but it should also consider supporting notification of a statement to an operator via electronic means.
- Operator calculates their total groundwater extraction volume, the related fee, and sends a check for the correct amount to FCGMA. FCGMA staff check and validate the Operator's volume and fee calculations to confirm that no errors were made.
- FCGMA's current system issues statements that have all information necessary to calculate the groundwater extraction fee once an Operator determines the groundwater volume extracted from a well. If paper forms are submitted, the Operator is responsible for calculating both the extraction volume for the pay period and the corresponding fee. The current system will calculate monies due if extraction volume is entered online.

Modify Aspects Of The Bi-Annual Statement Template

ID: EMR-002 Priority: High

Theme: Statement Generation

User Story:

As a	Data Manager
I want to	Modify aspects of the content and design of bi-annual statement template
So that	Bi-annual statements appropriately reflect the content required per latest Agency Board requests and requirements in online and print versions.

Story Details:

- The method for calculating an extraction fee may vary from one semi-annual statement to another (e.g.: to include a new fee or a revised fee schedule). Consequently, FCGMA staff may need to modify the statement sent to operators for a semi-annual reporting period. To the extent reasonable, FCGMA staff should be able to make changes to the templates used to create statements.
- The software should clearly designate which classes of changes can be implemented by Data Manager, a System Administrator, and those that require custom coding.

Issue Multiple Statements On Single Well's Flowmeter

ID: EMR-003 Priority: High

Theme: Statement Generation

User Story:

As a	Data Manager
I want to	Issue multiple statements on a single well's flowmeter
So that	If an Operator changes the flowmeter to another well during the course of a statement cycle, the proper extraction volume from each well can be summarized on multiple statements

Story Details:

[None]

Submit Fully Populated Extraction Statements With Payment

ID: EMR-004 Priority: High

Theme: Statement Generation

User Story:

As a	Operator
I want to	Submit fully populated extraction statements with payment
So that	I am in compliance with Agency regulations

Story Details:

There are several methods used to determine how extraction statements may be submitted and paid by the Operator. They include:

- Via Automated Metering Infrastructure (AMI)
- Via mobile online submittal
- Via PC-based online submittal
- By email or snail mail (by populating a semi-annual extraction statement on paper and then staff hand-entering data)

While the system must support all of these methods in the short term, these are arranged in order of preference for the long term. The new system should allow all Operators to submit via online if desired and import AMI data if available.

FCGMA wishes to incorporate AMI data for all flowmeters. Therefore, the new system needs a pathway for integrating AMI data when it's ready to be integrated. In the meantime, it must be capable of taking submitted readings using legacy self-submittal process.

The flowmeter extraction reading must be accompanied by a picture of the reading. The system should support loading this image and saving it with the extraction information.

Automatically Import AMI Well Extraction Data

ID: EMR-005 Priority: High

Theme: Statement Generation

User Story:

As a	Data Manager
I want to	Automatically import AMI extractions data
So that	The system captures reliable extraction data for use in groundwater management and invoicing without requiring manual data entry.

Story Details:

- FCGMA's vision for the future is that AMI data will be the default method through which flowmeter readings are delivered to the system and that extraction statements will only exist to verify/validate the information being fed to the system via AMI.
- This implies that need to automate the import of AMI data for each well from an AMI vendor.
- FCGMA's goal is to more fully automate the calculation of groundwater extracted from each well
- System should support automatic import of data from AMI vendors and validation of imported data.

Validate Submitted Extraction Statements

ID: EMR-006 Priority: High

Theme: Statement Generation

User Story:

As a	Data Manager
I want to	Validate extraction statements submitted by Operators
So that	Extraction information is properly recorded, and appropriate payment is received

Story Details:

- Verify that the flowmeter documentation provided by an Operator (typically a picture of the device) is the same as the flowmeter on record for the well in the system.
- Check that meter readings submitted by Operator are consistent with the meter reading on the image
- Check the fee calculations submitted by the Operator
- Verify that surcharges and penalties are properly accounted for
- Verify that transfers, variances, and storage credits are properly accounted for

- Submitted statements with issues must be flagged for follow up with the Operator

Track Communications With Operators When There Are Reporting Discrepancies

ID: EMR-007 Priority: High

Theme: Statement Generation

User Story:

As a	Data Manager
I want to	Track communications with Operators when there are reporting discrepancies
So that	Staff can know what has and has not been communicated to the Operator when resolving reporting and payment issues.

Story Details:

- Examples of discrepancies can include:
  - Payment calculation
  - Surcharges and penalties incorrectly applied
  - Incomplete statement information, such as missing flowmeter image or flowmeter reading

Correct Previously Resolved Statements From The Past

ID: EMR-008 Priority: High

Theme: Statement Generation

User Story:

As a	Data Manager
I want to	Correct previously resolved statements from the past
So that	When new information becomes available, extractions data can be made more accurate and payments can be appropriately debited or credited

Story Details:

[None]

D.6 PAYMENT PROCESSING

The Payment Processing Theme includes stories that describe how users process payments and reconcile those payments with previously delivered statements.

Payment Processing User Stories

Use Case ID	Use Case Title
PP-001	Enter received payments
PP-002	Provide statement documentation and payments online
PP-003	Validate Operator-provided statement documentation and payment
PP-004	Track which portion of a payment goes to what account
PP-005	Calculate surcharges
PP-006	Calculate penalties
PP-007	Reconcile Payments with Statements
PP-008	Generate special invoices

Enter Payment Information

ID: PP-001 Priority: High
Theme: Payment Processing

User Story:

As a Data Manager
I want to Enter received payments
So that So that I can know which statements have been reconciled with an appropriate payment amount

Story Details:

- Payments are received and processed by Ventura County Financial staff. The County emails an image of a check and other payment details to FCGMA staff
- The process should not be dependent on County Financial to handle the checks. Hence, developing a dependency or integration with a County system is not desirable.
- Attributes should include an image of the check
- Acceptable solutions might include a method to allow e-payment of statements
- The system will need to support payment of an invoice from multiple bank accounts
- A payment (such as single check) may apply to multiple accounts

Submit Statement Documentation And Payments Online

ID: PP-002 Priority: High
Theme: Payment Processing

User Story:

As a	Operator
I want to	Submit statement documentation and payment online
So that	My payment calculations pass automated validation and reduce time required to pay my groundwater bill

Story Details:

- A wizard for providing statement documentation (like a meter read image) would ensure that all required data is added and meets a cursory level of validity.

Validate Operator-Provided Extraction Documentation And Payment

ID: PP-003 Priority: High
Theme: Payment Processing

User Story:

As a	Data Manager
I want to	Validate Operator-provided statement documentation and payments
So that	I can verify that the Agency has received the correct payment for the Operator's extractions

Story Details:

- System should flag Operator-entered data as "provisional" until appropriate Fox Canyon staff have reviewed the data, made changes if required, and flagged it as "authoritative".

Track Which Portion Of A Payment Goes To Which Account

ID: PP-004 Priority: High
Theme: Payment Processing

User Story:

As a	Data Manager, County Financial
I want to	Track which portion of a payment goes to which account
So that	Revenue gets deposited into the proper account

Story Details:

- Different accounts receive money based on factors such as aquifer pumped and whether an allocation is a surcharge or baseline charge. Given this, the system should support how much of a given payment gets parsed among the various deposit accounts.
- County Financial informs the Data Manager that a payment was received and in what amount but does not deposit the check until after the Data Manager informs them of what account(s) should receive what amount(s) from the check.

Calculate Surcharges

ID: PP-005 Priority: High

Theme: Statement Generation

User Story:

As a	Data Manager
I want to	Calculate surcharges
So that	I can appropriately bill operators if they extract more than the allocated amount from a well

Story Details:

- Surcharges are charged only when an Operator extracts above its allotment, once carry-overs and other credits have been applied.

Calculate Penalties

ID: PP-006 Priority: High

Theme: Statement Generation

User Story:

As a	Data Manager
I want to	Calculate penalties
So that	I can appropriately bill Operators if their activities warrant a penalty

Story Details:

- Penalties result from things like delinquent payment, mis-reporting extractions
- Penalty waivers or reductions may be issued by the Board or the Executive Officer. The system should be capable of taking these into consideration in applying a penalty.

Reconcile Payments With Statements

ID: PP-007 Priority: High

Theme: Payment Processing

User Story:

As a	Data Manager
I want to	Reconcile payments with statements

So that	I know which statements have been settled by the Operators

Story Details:

- Unsettled statements require follow up.
- Statements with payments based on inaccurately calculated fees, surcharges, and/or penalties require follow up.
- Accurately calculated payments can be flagged as resolved.
- Once a flowmeter reading is known, the software should calculate correct payment and flag if there is a discrepancy
- Capturing the postmarked and received date as separate pieces of data associated to a payment is useful to prevent invalid penalties from being levied.

Generate Invoices Unrelated To Extraction Statements

ID: PP-008 Priority: High
Theme: Payment Processing

User Story:

As a	Data Manager
I want to	Generate special invoices
So that	So that I can collect revenues due from issues unrelated to extractions such as past-due penalties, variance application fees

Story Details:

[None]

D.7 EXPORT AND REPORTING

The purpose of Groundwater data management system is not only to manage data, but also to export it for use in other contexts, and to provide user-friendly reports and visualizations that communicate important information to stakeholders. These user stories outline the export and reporting capabilities that are desirable in the system.

Surcharges and Penalties User Stories

Use Case ID	Use Case Title
ER-001	Export key datasets
ER-002	Aggregate and report on key datasets
ER-003	Create hydrographs for wells, aquifers, basins, and management areas
ER-004	View maps visualizing magnitude of extraction by sector
ER-005	See up-to-date monitoring of extractions vs allocation

Export Key Datasets

ID: ER-001 Priority: High
Theme: Export and Reporting

User Story:

As a Groundwater Analyst
I want to Export key datasets from the groundwater management system
So that I can use software external to the system to conduct analyses not supported directly in the Groundwater Management System

Story Details:

- Key datasets include:
  - Well data (location, extractions, water level measurements, owner, operator, well group)
  - Billing data (charges, violations, notifications)
  - Flowmeter status data (installation, calibration reports, repairs, wells associated with, period of use)
- Ability to choose/configure which columns will be included in the export
- External software to interact with the data might include hydrologic modeling software, GIS (including water level contour maps), financial analysis, Excel
- Support ability to filter exported data by calendar year, water year, basin, and management area
- Exported data will support allocation modeling (at both basin/management area and well levels) for future water years

Aggregate And Report On Key Datasets

ID: ER-002 Priority: High
Theme: Export and Reporting

User Story:

As a	Groundwater Analyst
I want to	Aggregate and report on key datasets
So that	I can see a wholistic view of how water and financial resources are being allocated

Story Details:

- Key datasets include Wells, Well groups, Allocations, Extractions, Credits, Operators, Owners, parcels, and flowmeters
- Aggregation facets include reporting periods, aquifer, basin, management areas, use type, reporters/non reporters
- Financial resources references billings per aggregation facet

View Maps Visualizing Magnitude Of Extraction

ID: ER-004 Priority: High
Theme: Export and Reporting

User Story:

As a	Groundwater Analyst
I want to	View maps showing magnitude of extraction (by well and well group)
So that	I can identify which wells and Operators require increased attention on their impact to the basin

Story Details:

- These maps are useful for developing reports to external State agencies.

See Up-To-Date Monitoring Of Allocation Vs Extractions

ID: ER-005 Priority: High
Theme: Determining Allocation

User Story:

As a	Water Market Manager, Groundwater Analyst, Data Manager
I want to	See Up-To-Date Information on Extractions and Allocation
So that	I can determine whether an Operator has access to the extraction allocation that they wish to trade on the Water Market.

Story Details:

- This will be more relevant when the system ingests extractions data via AMI on a more regular basis

Enforcement/Compliance

- Non reporters (1st, 2nd, 3rd notices)

- Meters in use – well status – calibration status – compliance status (1st, 2nd, 3rd notices)

Review and Approval Process

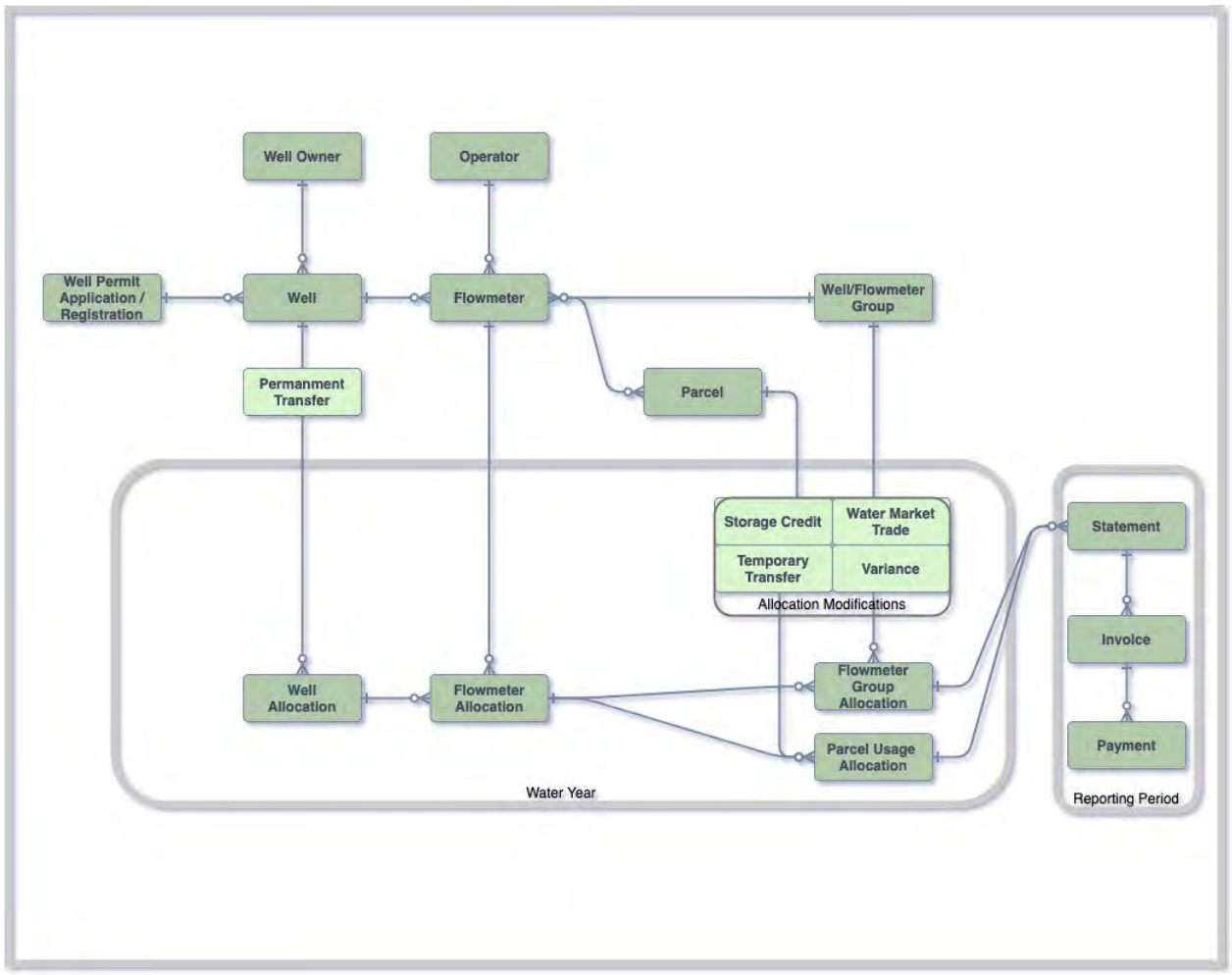
E. GROUNDWATER MANAGEMENT SYSTEM DESIGN

Following modern software development standards, the Groundwater Management System is expected to be web-based to allow access by both internal Fox Canyon staff and stakeholders outside of the Fox Canyon domain such as well operators.

E.1 CONCEPTUAL DATA MODEL

A conceptual data model is a high-level description of informational needs underlying the design of a database. It typically includes only the system's main data entities and the relationships among them. A conceptual model aims to identify the primary business information needed to support the requirements and capabilities of the data management system.

The diagram below is a conceptual model for the Groundwater Management System.



Well Permit Application/Registration: This represents the well permit application data as it exists before approval or rejection. This entity will likely have a status and be related to communications with the applicant.

Well: Represents the inventory of existing and previously-existing wells within the Agency's jurisdiction. A well may be active, inactive, or destroyed.

Well Owner: The owner of a well. One owner can own many wells. One well can have only one owner at any point in time. However, wells can have many owners over different timespans as wells can be bought and sold.

Flowmeter: At a given point in time, one well can have one or more flowmeters – each of which is reported upon by a separate Operator. A flowmeter can be associated with more than one well over time.

Well/Flowmeter Group: Each flowmeter is part of one and only one flowmeter group at a given point in time. The flowmeters' extraction totals are summed by flowmeter group every reporting period to produce a statement.

Parcel: To support future reporting by parcel, the system must be able to sum flowmeter readings by usage of the extraction volume on each parcel. The idea here is to simultaneously support parcel-based reporting and well-based reporting during an indefinite transitionary period.

E.2 SYSTEM INTEGRATIONS

FCGMA's business processes for managing well ownership, the determination of groundwater extraction, annual water allocations, and extraction fee collection are quite complex. This is one reason FCGMA's current data management software is a custom application.

Given the complexity of FCGMA's business processes, the replacement system may require a modular design that includes:

- A core data management application for wells, owners/operators, flowmeter data, and well allocations
- An invoice management application to support semi-annual statements generation and fee payment
- A geospatial system (or module of the core data management application) to manage well location, basin extents, parcels, and hydrogeologic data
- A module for determining allocations (or integration with an external application used to determine well allocations)
- A simple module for managing customer relationships (or integration with a simple Customer Relationship Management system) for the purpose of tracking communications with Operators and Owners.
- Ability to integrate with key systems or data providers such as AMI vendors

The Nature Conservancy in California

Sacramento Valley Water Trust Feasibility Assessment

This assessment was completed for exploratory purposes.
The information provided in this report does not indicate
Any commitment by The Nature Conservancy or its
affiliates to execute the recommendations herein.

Sacramento Valley Water Trust Focus Group:
J. Brantigan, J. Wellwood, S. King, S. Heard, J. Gearen, C. Burns, P. Spraycar, J. Barfield, A. Bergonia, M. Reynolds

7-23-2018

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Acronyms

BOT	Board of Trustees
CFR	Corporate and Foundation Relations
CLC	California Leadership Council
CVP	Central Valley Project
CWC	California Water Code
DWR	California Department of Water Resources
IRR	Internal Rate of Return
MET	Metropolitan Water District of Southern California
NWR	National Wildlife Refuge
PRI	Program-Related Investments
ROI	Return on Investment
RWSP	Refuge Water Supply Program
SB	Senate Bill
SGMA	Sustainable Groundwater Management Act
SOP	Standard Operating Procedure
SVWT	Sacramento Valley Water Trust
SWC	State Water Contractor
SWP	State Water Project
SWRCB	State Water Resources Control Board
TNC	The Nature Conservancy
WSIP	Water Sharing Investment Partnership

Executive Summary

Freshwater dependent ecosystems in California have been severely impaired by human development that has fundamentally altered the landscape as well as the movement of water throughout the state. We see this problem in sharp relief in the Central Valley, where large, regulated surface water systems now control the flow of water to cities and farms, as well as the water needed to support instream flows and wetland ecosystems.

Despite the efforts of multiple state and federal agencies to manage this water for multiple needs, we find that existing policies, regulations, and public funding fall short of providing sufficient water for freshwater species and ecosystems. Ninety-five percent of our state's historical wetlands – critical stopovers for migrating birds – have been lost, corresponding with steep shorebird population declines. Endemic fish species populations also continue to decline to critical levels.

In recent years, The Nature Conservancy (TNC) has been working to develop and demonstrate an innovative concept that leverages water markets and private and/or public capital to provide critically needed water for nature while also generating revenue, creating a new way to sustainably fund our conservation work. TNC has pioneered this approach in Australia, Texas and Washington, deploying a variety of forms of capital (such as impact capital, program-related investment [PRI] loans, and 0% loans from major donors) to acquire and allocate water for nature while generating revenue sufficient to cover programmatic costs and fulfill any financial obligations to funders. In this model (Figure 1), a portfolio of water assets is acquired and managed entirely for nature's benefit in some years, while a portion of the portfolio is leased to other water users to generate revenue in other years.

Over the past two years, the California Chapter has been evaluating the feasibility of using this type of approach in the Sacramento Valley to acquire and manage water to secure wetland habitat for migratory birds, through the formation of a Sacramento Valley Water Trust (SVWT). In summary we found that:

1. A SVWT appears to be a feasible, financially sustainable approach to providing significant quantities of water for wetlands in the Sacramento Valley and beyond. TNC has a unique role to play as one of only a few organizations in the world that could successfully fundraise and implement such a complex model.
2. We estimate that a $25M fund could meet up to 15% of the water needs of Central Valley migratory birds outside the refuge system, or 10% of the unmet needs of south-of-Delta wildlife refuges (Figure 2). A $100M fund could meet up to 60% of wetland habitat needs outside the refuge system, or 40% of the unmet south-of-Delta refuge needs. This would constitute a ground-breaking advance in migratory bird conservation in California and would be financially self-sustaining over a period of 10 years.
3. Developing a SVWT is timely, due to the promising water investment opportunities emerging with new groundwater legislation (i.e. the Sustainable Groundwater Management Act) and increasing demands on our water supply that will put even more pressure on California's freshwater biodiversity in the next decade.

4. If SVWT assets were operated to maximize nature benefits (i.e. by providing all water assets to nature throughout the life of the fund and not leasing any water to other consumptive water users), we estimate that we could generate returns (IRR) of 5-11%. Leasing a portion of the portfolio to agricultural or municipal water users in a subset of years would allow us to dedicate all SVWT water to nature in most years, while also generating revenue to cover programmatic costs and meet funder obligations, and/or to enable long-term retention of the water assets to benefit nature in perpetuity. In no single year would we need to lease all SVWT water to be financially solvent.
5. Financial viability of a SVWT relies on leasing water from north-of-Delta (Sacramento Valley) sources to south-of-Delta (San Joaquin Valley and southern coastal) buyers in some years, which inherently raises reputational considerations for TNC. These will need to be carefully evaluated prior to launch, and the fund operated to minimize these risks. By participating in the Central Valley's water market and designing transfers with the environment at the forefront, and by making well-informed trade-off decisions based on ecological needs, we believe we have an opportunity to bring about changes in the current water market that benefit conservation with far less opposition than through regulation.

We recommend the California Chapter pursue the following phased approach to launching a SVWT:

Design Phase

Time Frame: 6-12 months

To validate key assumptions and hypotheses before making significant financial commitments, conduct final scientific, financial, reputational, operational and legal due diligence; finalize ecological, financial, and other objectives and criteria; complete a thorough risk assessment and mitigation plan; develop an initial operating plan; and develop a preliminary portfolio by identifying, evaluating, and testing available assets.

Implementation Phase 1

Time Frame: 10 years, following completion of Design Phase and TNC approval

Establish an initial $25 million fund comprised primarily of philanthropic grants (with the potential for including PRI loans from foundations and zero-interest loans from Board of Trustees and California Leadership Council members), designed to evaluate whether ecological objectives can be met, test key assumptions and mechanisms, and confirm that risks can be adequately managed. The portfolio of assets acquired with these funds would include a diversity of appropriative water rights and federal or state water project contracts.

Once an initial portfolio of assets is acquired, TNC would implement the operating plan developed during the Design Phase. Based on this plan and informed by the latest data on ecological needs and water supply conditions, TNC would decide annually how much water to make available for conservation purposes and how much, if any, to use for short-term leases to water buyers. The timing and frequency of exercising a short-term lease would depend on the individual water asset and buyer demand in each circumstance, and would be selected strategically to maximize opportunities to achieve environmental benefits while covering programmatic costs and any external funder obligations.

Implementation Phase 2 (Optional)

Time Frame: 10 years, commencing approximately 3 years after establishment of Phase 1 fund

If the initial $25 million fund is successful (meets the preliminary Phase 1 objectives provided in Section 8, *Implementation phases and early work* of this Feasibility Assessment) and market research indicates there is sufficient funder interest, TNC could choose to establish a second, larger fund after approximately three years, allowing us to dramatically increase our ecological impact. A substantially larger fund, such as one with a target of $100 million—the size we estimate would meet about one-quarter of all currently unmet migratory bird habitat needs throughout the entire Central Valley, within and beyond the refuge system—would likely require a shift from a philanthropic funding model to one that relies largely on impact capital. An operating plan similar to that used for the $25 million fund would be developed and refined for Phase 2, and the $100 million fund would be operated accordingly with a similar annual decision-making approach.

Close-out(s)

Time Frame: At the end of the 10-year horizon of each fund

At the conclusion of each fund's time horizon (10 years), we would determine whether to sell or retain the water assets. Permanent sale of the assets would provide TNC with the returns necessary to meet any outstanding internal costs or external funder obligations that were not already achieved through any short-term water leasing activities during the life of the fund. Alternatively, if during the life of the fund we have secured enough revenue from short-term water leasing, or have raised sufficient funds in other ways, we could retain some or all of the water assets for nature's benefit in perpetuity.

We have made substantial progress in evaluating the feasibility of a SVWT, but there are still many questions to answer. Recommended next steps for the coming 12-18 months include completing the Design Phase, including remaining scientific, financial, operational, reputational and legal due diligence. Pending completion of this phase and all necessary internal TNC approvals, we would then launch Implementation Phase 1 of the SVWT by entering into 4 to 5 option agreements to purchase water using philanthropic funds (including grants, zero-interest loans and/or PRI loans) and potentially public funds ($20-$25 million in total). Once option agreements were executed, we would complete initial water transactions for nature and/or revenue generation with these assets.

1. Introduction

Freshwater dependent ecosystems in California have been severely impaired by human development that has fundamentally altered the landscape as well as the movement of water throughout the State. We see this problem in sharp relief in the Central Valley, where large, regulated surface water systems now control the flow of water to cities and farms, as well as the water needed to support instream and wetland ecosystems. Despite the efforts of multiple state and federal agencies to manage this water for multiple needs, we find that existing policies, regulations, and public funding fall short of providing sufficient water for freshwater species and ecosystems. Ninety-five percent of our state's historical wetlands—critical stopovers for migrating birds—have been lost, corresponding with steep shorebird population declines. Endemic fish species populations also continue to decline to critical levels.

The Nature Conservancy (TNC) is working to address this problem on multiple fronts. One way is by improving the flexibility and cost-effectiveness of conservation strategies to better meet the dynamic wetland water needs of migratory shorebirds**;** essentially, by allowing water-based conservation on private land to be done more efficiently. In 2014, TNC launched BirdReturns, which integrates big data analytics, a reverse auction and robust field monitoring to drive down the cost of wetland conservation while delivering targeted, temporary habitat for migratory birds at precise times of year. Using peer-reviewed as well as citizen science to provide habitat precisely when and where birds need it, we have shown that compared to the traditional conservation approach of buying and restoring land, conservation resources—including water and funding—can be more efficiently deployed using a dynamic approach. A reverse auction format works to drive down the cost of providing habitat, and engages private landowners in the conservation process. Now, we're evaluating ways to achieve financially sustainable programs designed to provide water for nature dynamically, so that we can execute these projects over a longer time-frame, and scale our approach across and beyond the Central Valley.

Another strategy that TNC has proposed to address the problem of insufficient water and funding for conservation is through proliferation of voluntary environmental water transactions by local water trust entities. We believe this can substantially benefit the environment if we can successfully demonstrate and hone transactional tools, enhance enabling conditions for water transactions, and develop sustainable financing solutions. For this strategy, water is directly acquired through a variety of funding mechanisms and provided for conservation through environmental water transactions. TNC has developed an innovative concept that combines water transactions and impact investing to acquire and allocate water for nature while generating a return on investment. In this model (Figure 1), a portfolio of water assets is acquired by a water trust entity with public and/or private capital[1] and held for a set period of time before selling the assets to fulfill any financial obligations to funders. While the assets are held, they are managed entirely for nature's benefit in some years, while a portion of the portfolio is leased to other water users to generate return on investment in other years. This approach has the potential to create a financially sustainable fund that provides water for nature. TNC has played a

[1] Water trust entities may elect to launch a pilot fund with philanthropic and/or public dollars prior to seeking to raise and deploy impact capital, to manage risk and build a track record of successfully transacting in the market.

leadership role in creating such a fund in Australia's Murray-Darling Basin, and is exploring the concept in Texas and Washington.

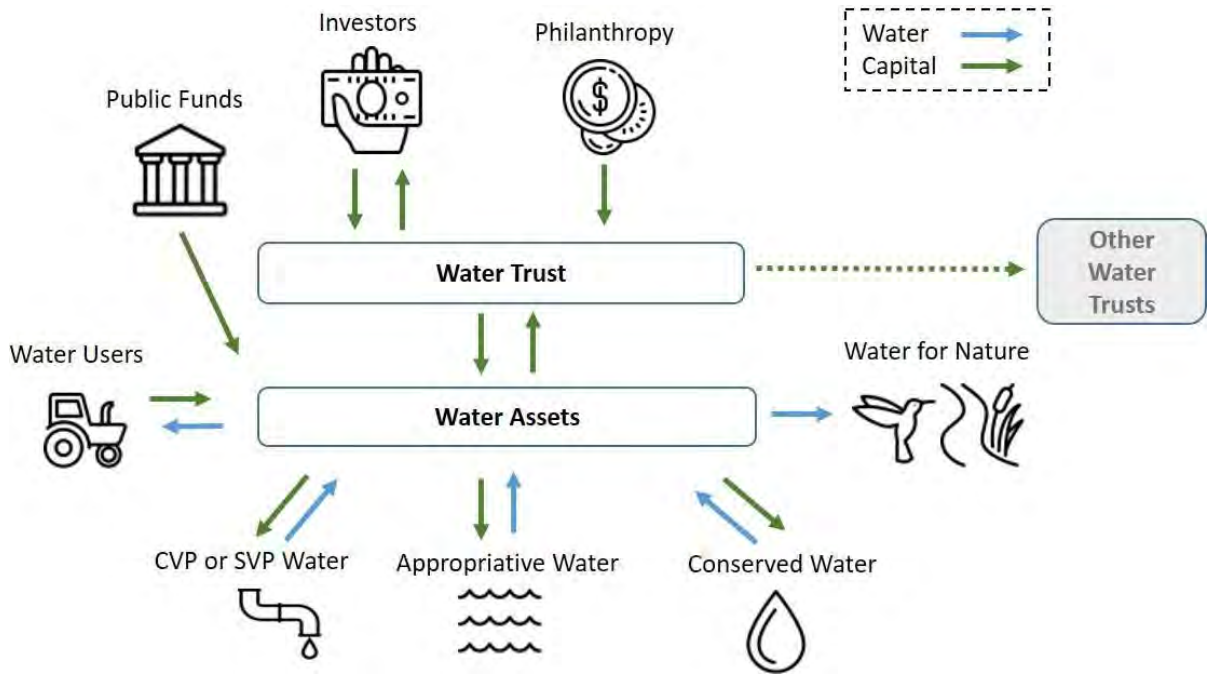


Figure 1. Schematic diagram for the Sacramento Valley Water Trust

Source: Adapted from the UCSB Bren School of the Environment Group Project in collaboration with TNC, "Sacramento Valley Water-Sharing Investment Partnership: A Comprehensive Feasibility Assessment," 2017

Over the past two years, the California Chapter has been evaluating the feasibility of establishing this new water trust concept in the Sacramento Valley, to provide water for wetland habitat for birds and provide sustainable funding for that water. First, members of the California Chapter's Water Program and Investments Department held a workshop in Spring 2017, along with Chapter Science, NatureVest, and Global Water staff, to discuss how this approach could be developed in California. Workshop participants concluded unanimously that California, home to the western United States' largest water market, offers an excellent opportunity to test a similar model and that TNC should move quickly to further evaluate feasibility so as not to miss the opportunity to participate in California's increasingly competitive water market.

Since that workshop, a subset of Water Program and Investments team members have examined the viability of creating a Sacramento Valley Water Trust (SVWT) that would provide water to create wetlands for migratory birds. The SVWT Focus Group (Focus Group) evaluated the financial, legal, and logistical feasibility of acquiring water, and investigated how water could be managed and reallocated to provide water for nature while generating financial returns.

The Focus Group explored a model whereby TNC would acquire assets (water rights and/or land with water rights) in the Sacramento Valley and deploy water either for nature (by transferring water to wildlife refuges or by delivering water to private agricultural fields for wetland habitat creation using a mechanism similar to our approach with BirdReturns) or revenue primarily in the San Joaquin Valley (by leasing to agricultural or urban users). Since the primary objective of the SVWT is to provide water for nature, our analysis focused foremost on a concept in which we would deploy most of the portfolio in the majority of years for nature. To cover TNC's programmatic costs of operating the fund, and to meet any financial obligations to funders, a portion of the water portfolio would be leased in some years. The Focus Group established a 10-year horizon over which to hold the water assets (and deploy them for nature or revenue) before determining whether to sell off or retain the assets.

Figure 2 shows the location of potential water sources, conservation targets, buyers, and major conveyances that we will refer to throughout this Feasibility Assessment.

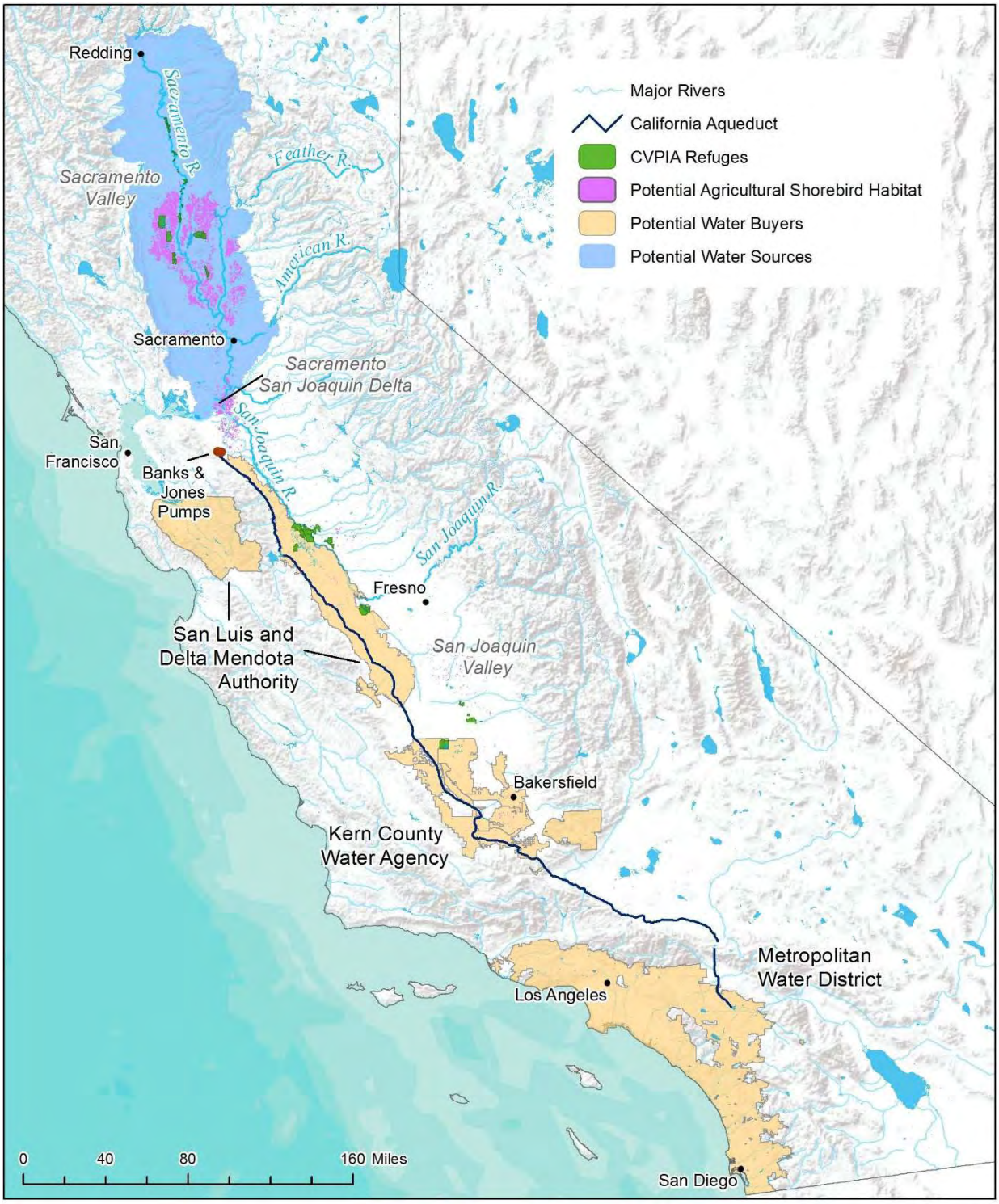


Figure 2. Locations of SVWT conservation targets, potential water sources and buyers, and major conveyances

Source: TNC Internal

Purpose and intended audience

This Feasibility Assessment describes our evaluation of the feasibility of implementing a SVWT, discusses our findings, and outlines a phased implementation approach. Recommended next steps include commencing a Design Phase, in which we will refine objectives and criteria, assess risks, and evaluate internal and external roles moving forward, with the goal of launching a pilot fund and, potentially, a subsequent larger fund.

This report is intended for internal audiences (within TNC), specifically for those in involved in developing the SVWT concept and those moving forward the California Chapter's strategies focused on water trust proliferation, dynamic management, and market- and investment-based conservation solutions. This is also intended to update and inform TNC leadership. A streamlined version of this Feasibility Assessment will be created for the Natural Resource Conservation Service as a deliverable for a Conservation Innovation Grant that has, in part, funded contributing analyses. An external-facing version may also be created for use with potential donors and/or investors.

Importantly, this Feasibility Assessment contains proprietary and confidential information on developing TNC strategies and water market metrics made available to us under a nondisclosure agreement. No part of this Feasibility Assessment should be shared outside TNC without written permission from the authors.

Study elements

The SVWT Feasibility Assessment consists of the following study elements:

A. **Ecological focus and habitat water needs:** Using the latest science, we identified focal species and the ecological water needs of these species that would benefit measurably from the secure and adaptive water supply provided by a SVWT.
B. **Central Valley water market:** With expert help, we developed an understanding of the Central Valley water market, including current activity and drivers, **suitable water buyers** according to their demand and willingness to pay, and **available water assets** to acquire, either immediately or in the near future. We also developed proactive approaches for identifying SVWT portfolio assets best suited to meeting our objectives and selecting buyers that may be able to provide additional conservation benefits through water conservation efforts.
C. **Water Trust operations:** We developed an understanding of the mechanisms necessary to make a water asset available for transfer to either conservation or to market during the life of the fund and assessed the feasibility of conveying water through the Sacramento-San Joaquin Delta. We identified further analyses that would help to inform trade-off decisions when designing a SVWT operating plan.
D. **Financial viability:** We developed a financial model to evaluate potential returns to investors and to conservation over a 10-year time horizon, informed by water market assumptions based on expert consultants. We also explored a variety of funding sources that could be used for the SVWT, including philanthropic, public, and investment capital.

E. **Pilot water transactions for nature:** Using water rights we currently own or control and by leasing water from other entities, we are currently completing several short-term pilot water transfers to nature, through which we are gaining a valuable, practical understanding of the complexities of deploying water in California. This water is expected to be delivered by Fall 2018.
F. **Legal and institutional considerations and risks:** At a cursory level, we identified legal constraints to TNC buying and selling water, compatibility with TNC Standard Operating Procedures, TNC capacity and skill-set needs, and risks that require further investigation or mitigation.
G. **Implementation phases and next steps:** We describe a phased approach to further test, design, and implement a SVWT, and additional next steps.

Information sources

For water market information, strategy development, and water transactional support, the Focus Group consulted with three primary water consultants and brokers active in the Western United States: Sierra Water Development, Inc.; Tully & Young, Inc.; and WestWater Research. The Focus Group also gleaned lessons from analogous TNC efforts in Australia, Washington, Texas, and Chile, as well as from an external, successful water fund in Southern California. Additionally, students from the University of California, Santa Barbara (UCSB) Bren School of the Environment contributed an initial feasibility study on water markets in the Sacramento Valley, and TNC Summer Associate, Carlos Juri, helped analyze relative deal complexity by creating an Excel-based, decision-tree tool.

2. Ecological focus and habitat water needs

Water from a SVWT could contribute to improving instream flows for fish or to terrestrial habitat water needs such as wetlands for migratory birds, as well as be a source to recharge groundwater to protect groundwater dependent ecosystems. For several reasons, we focused this SVWT feasibility analysis on the potential to meet the dynamic needs of Pacific Flyway migratory birds. In California's Central Valley, the regulatory and political climate surrounding instream flows for fish is a challenging space, and at a pilot scale it would be difficult for a SVWT to create a measurable ecological outcome for fish. In contrast, wetland habitat that supports migratory birds, particularly shorebirds, in the Central Valley is critically limited, and relatively small quantities of water could make a significant and measurable ecological difference. Regulatory attempts to meet the needs of migratory birds have largely fallen short to this point, and a new market-based approach such as that proposed with the SVWT is a promising alternative.

Through what's become known as the "Bird-Fish Collaboration", a small group of NGOs including TNC recently worked together to estimate how much water Central Valley birds and fish need from the Sacramento River watershed, accounting for where and when those needs occur throughout the year. A manuscript on this work is forthcoming by Fall 2018. Among the findings of this effort is that, despite rhetoric that pits water diverted for migratory bird habitat against instream flows for fish, there is little

temporal conflict for water between water for wetlands and instream flow needs. However, we are cognizant that, with limited water supplies, trade-offs between ecological needs could exist, and we recommend a science-based process be developed to evaluate these trade-offs prior to implementing the SVWT.

Water needs for Central Valley migratory bird habitat

Arguably the most unmet or inconsistently met migratory bird habitat needs in the Central Valley are shorebird habitat[2] on agricultural land and refuge (specifically managed wetland) habitat in the San Joaquin Valley south-of-Delta. Water is clearly limiting for San Joaquin Valley wildlife refuges.[3] A map of these targets is provided in Figure 2. Both water availability and cultural practices may be limiting for Central Valley shorebird habitat, but for the purposes of this study, we assume that water is the only limiting factor, and focus our efforts in the Sacramento Valley where we have established habitat provisioning programs and relationships with landowners through BirdReturns and other efforts. Figure 3 shows the estimated volume of water needed to meet existing shortfalls of shorebird habitat on Central Valley agricultural land and at San Joaquin Valley refuges. Across an entire year, the water needed to create agricultural shorebird habitat in the Central Valley amounts to approximately 85,000 acre-feet per year[4], and San Joaquin Valley refuges need approximately 123,000 acre-feet per year.

If a SVWT portfolio was managed solely for conservation benefits, it could make a modest difference, especially at scale. For example:

- A portfolio size of 12,500 acre-feet could provide up to 15% of the unmet needs of Central Valley shorebirds outside the refuge system, or up to 10% of the unmet (or unreliably met) needs of south-of-Delta refuges.

[2] The Central Valley Joint Venture (CVJV), a regional partnership of organizations and agencies focused on the conservation of bird habitat and wetlands under the North American Waterfowl Management Plan and the North American Bird Conservation Initiative, has set basin-specific targets for Central Valley shorebird habitat necessary to meet population objectives. These targets are not adequately met in most years. Recent work to update those objectives has provided short-term (10-year) habitat objectives and existing shortfalls on a Central Valley-wide scale, on which we base current shorebird habitat needs (Dybala et. al. "A Bioenergetics Approach to Setting Conservation Objectives for Non-Breeding Shorebirds in California's Central Valley." San Francisco Estuary & Watershed Science. 15(1). 2017)

[3] The Central Valley Project Improvement Act of 1992 requires Reclamation to acquire water from willing sellers and deliver that water to Central Valley wildlife refuges every year. This volume of water that must be acquired and delivered to refuges is known as Incremental Level 4 water, totaling 186,271 acre-feet throughout the Central Valley, with 122,665 acre-feet at San Joaquin Valley refuges. On average, only about half of this water is provided to San Joaquin Valley refuges—far less in dry years—and the water that is provided is not secure. Currently, water supplies are adequate to meet needs at Sacramento Valley refuges in most years, but SVWT water could be provided to these refuges in the future if the situation changes.

[4] Estimated water needed to create shorebird habitat on compatible agricultural land is unpublished and preliminary. Estimate is based on the water needed to create and maintain mudflat conditions at 4-inch depth over the extent of acres and months of the year needed to achieve habitat objectives. Does not include the water needed to grow the compatible crop such as rice.

- A portfolio size of 50,000 acre-feet could provide up to about 60% of the unmet needs of Central Valley shorebirds outside the refuge system, or up to 40% of the unmet (or unreliably met) needs of south-of-Delta refuges.

This would be a significant contribution in a landscape where every acre of additional wetlands lessens the bottleneck and allows birds the opportunity to stop and rest and feed along their migration. Moreover, this approach could secure a more reliable water supply specifically for these important conservation targets, rather than relying on the whims and changing priorities of other water use sectors to provide water for nature and allow habitat managers some flexibility and efficiency in meeting needs when and where the habitat is most needed.

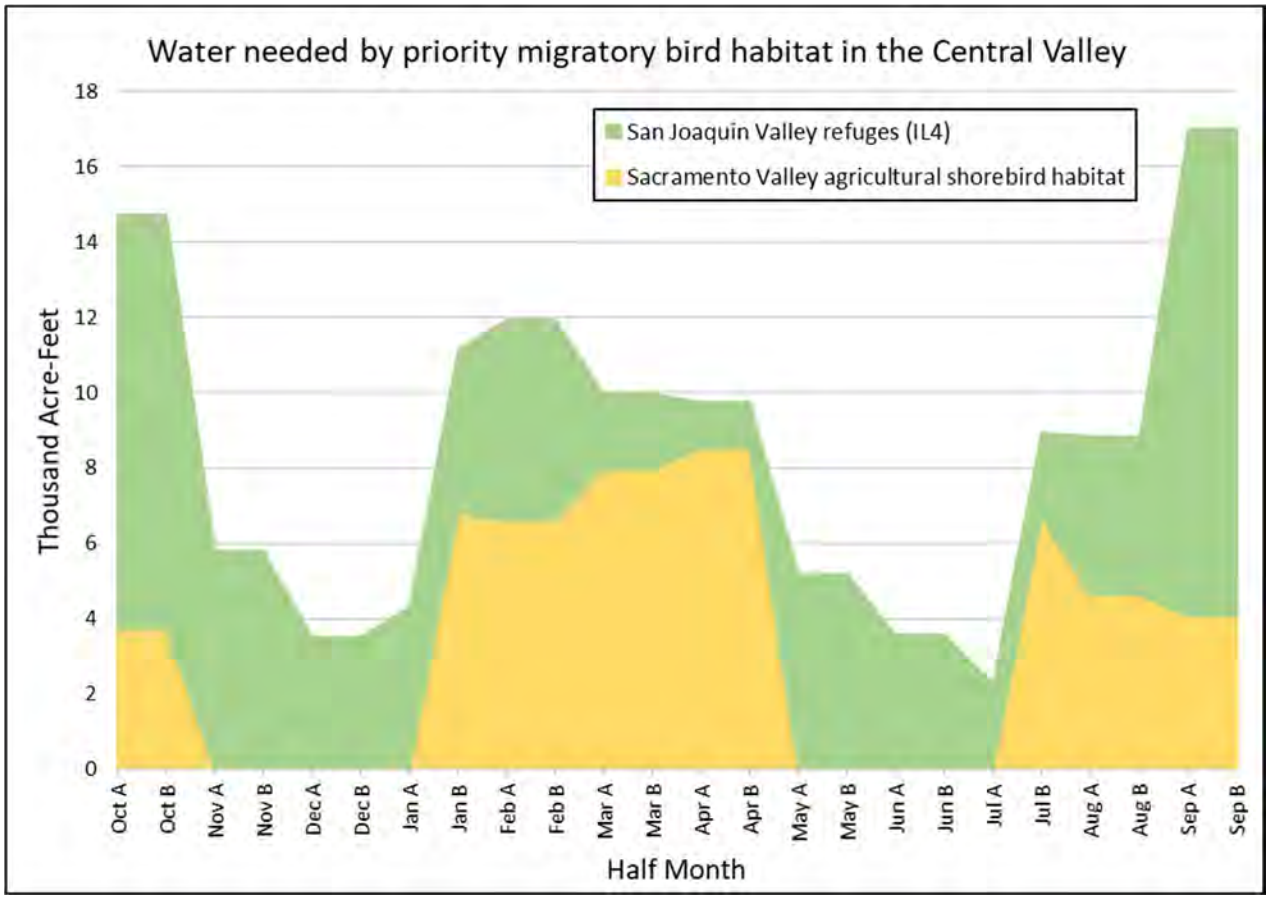


Figure 3. Water needed by high priority migratory bird habitat in the Central Valley

Note: Chart is "stacked" to show total water requirements of both ecological needs

Preliminary data derived from these sources: Bureau of Reclamation, Report on Refuge Water Supply Investigations, Central Valley Hydrologic Basin, California, March 1989; Dybala et. al. A Bioenergetics Approach to Setting Conservation Objectives for Non-Breeding Shorebirds in California's Central Valley. San Francisco Estuary & Watershed Science. 15(1). 2017.

In addition to water supply reliability in general, two particular challenges face habitat managers. Consideration should be given to the types of water assets acquired for the SVWT portfolio so that the timing and priority of available water is able to address these challenges as much as possible:

1. **Meeting both refuge and shorebird habitat needs in dry years:** To a large degree, refuge water managers currently rely on water acquired annually from willing sellers on the spot market. Water is significantly more expensive in dry years when acquired in this manner, if it is available at all, and federal programs responsible for acquiring the water are typically not able to afford it for a variety of reasons. With respect to shorebird habitat, as water supplies are curtailed during dry years, less water is provided to agriculture, and what supplies are available are prioritized for growing crops rather than for creating habitat through incentive programs or rice decomposition. Crop idling could also occur, resulting in less habitat on these compatible agricultural lands.

2. **Meeting shorebird needs in late February through April and from August through early October:** Studies have shown that there is less standing water available on the agricultural landscape to supply shorebird habitat during these critical migration periods, when rice fields are typically drained and dried to prepare for planting or harvest, compared to earlier in the winter and later in the fall when water is more commonly applied to aid in straw decomposition. Incentive programs can help provide temporary habitat, but additional shallow-flooded wetlands are needed at these times and water availability could be a limiting factor.

3. Central Valley water market

A SVWT would acquire water assets that may include water rights and land with water, through typical market-based approaches. Although meeting ecological needs will be the primary focus of the SVWT, the financial viability of the SVWT concept also depends on leasing some portfolio assets on a short-term basis to agricultural and municipal water users to generate revenue. This section provides a brief background on the Central Valley water market that enables these transactions to occur, then describes the recommended target buyer pool for short-term leases of SVWT water, where these buyers are, and what is driving their behavior. Finally, we recommend water assets to consider sourcing for a SVWT portfolio, and an approach to acquiring them.

Water market fundamentals and drivers

A successful SVWT would take advantage of an active, though opaque, water market in the Central Valley. The Public Policy Institute of California has estimated the annual volume of water trades, illustrated in Figure 4 (PPIC 2016).[5] Over the last 20 years, between 1.0 and 1.5 million acre-feet of water has been traded annually through a mix of short-term and long-term leases and permanent sales. Primarily, cities and farms acquire water through the market, and some water is acquired for the environment (such as for wildlife refuges, through Reclamation's RWSP).

[5] The Public Policy Institute of California's Water Policy Center has compiled information on water transfers in several reports, including "California's Water Market" (July 2016), "California's Water Market, By the Numbers, Update 2012" (November 2012), "Who Should be Allowed to Sell Water in California?" (July 2003), and "California's Water Market, By the Numbers" (October 2002).

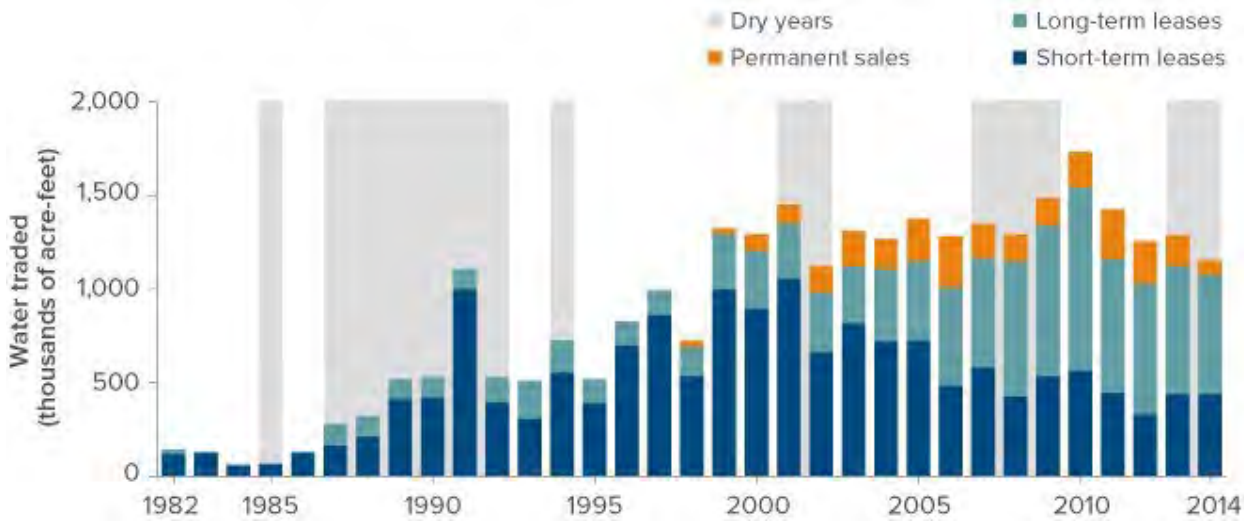


Figure 4. California's historic water market activity

Note: The figure shows water traded between entities that are not members of the same water district or wholesale agency. It excludes volumes committed under long-term lease and permanent-sale contracts that were not physically transferred because of hydrologic conditions or other factors (in 2014, roughly 800,000 acre-feet). Dry years are those classified as critical or dry for the Sacramento Valley.

Source: Updated in 2016 from E. Hanak and E. Stryjewski. Public Policy Institute of California. "California's Water Market, By the Numbers: Update 2012"

Most of California's precipitation falls in the winter in the northern, mountainous part of the state, but most of California's population and farmland is in the south and along the coasts, where water is used primarily in the spring, summer, and fall. Massive state and federal storage and conveyance systems, the Central Valley Project (CVP) and the State Water Project (SWP), routinely move water from north to south. On average, about 8% of the water used across the state is conveyed annually by these projects through the Sacramento-San Joaquin Delta via large pumping facilities and conveyance systems to the San Joaquin Valley and coastal areas. In many years, particularly years with below normal precipitation, additional water is also transferred on a temporary basis from Sacramento Valley water rights holders to agricultural and urban water users south-of-Delta. This market is well developed. In the first half of 2018, approximately 335,000 acre-feet of short-term through-Delta water transfers have been approved. Using typical water costs in 2018, the total market for these transfers is likely over $100 million. It is likely that the majority of the 2018 transfer market is made up of post-1914 appropriative water rights, but state and federal contract supplies and pre-1914 water rights are also transferred.

Since 2009, Biological Opinions (BiOps) for CVP and SWP operations issued by the state and federal fish and wildlife agencies[6] have limited the total volume of water that can be pumped south and have restricted transfer activity through the pumps to only July, August, and September each year. These opinions have resulted in less project water being made available to SWP and CVP contractors south-of-

[6] USFWS (U.S. Fish and Wildlife Service). 2008. Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and the State Water Project (SWP). Available: https://www.fws.gov/sfbaydelta/Documents/SWP-CVP_OPs_BO_12-15_final_OCR.pdf

Delta on an annual basis compared to pre-BiOp conditions and consolidated the volume of transfer activity to a shorter window every year. Transfer activity has also been restricted in some years when SWP and SWP contract supplies, that have top priority at the state and federal pumping facilities, are occupying all available pumping capacity. Challenges to these opinions over the years, as well as new opinions that may be developed as the CVP and SWP develop new long-term operations plans, have created an atmosphere of uncertainty and risk associated with moving water through the Delta. Despite this, the south-of-Delta demand for water from the north continues to grow.

Importantly, there have been few permanent sales of water rights from the Sacramento Valley to south-of-Delta water users.[7] Despite the routine practice of moving water from north to south, most water users south-of-Delta have relied on only short-term water purchases or groundwater pumping to cope with dry year situations. The risks associated with reliably conveying water through the Delta, discussed above, have suppressed the demand for permanent through-Delta transfers. Simply, local water supplies have been enough in most years to outweigh the alternative of taking on the risks associated with purchasing and moving water from north to south every year.[8] The Sacramento-San Joaquin Delta remains a critical limiting factor due in part to constraints placed on pumping to protect water quality and critical and endangered species in the Delta.[9]

The situation is changing. South-of-Delta water supplies are becoming scarcer across all year types. The recent drought in California decreased the overall volume of water available throughout the state and served as a wake-up call for those who've come to rely on wetter-year water supplies, especially those who have implemented permanent crops like orchards that need water consistently every year. Compounding this, the Sustainable Groundwater Management Act of 2014 (SGMA)[10], when implemented starting in 2020, will restrict where and how much groundwater can be pumped across the Central Valley, particularly in critical basins in the San Joaquin Valley that have relied significantly on this source of supply, either as a regular or dry year supply. SGMA will also drive the market to acquire surface water supplies to flood recharge basins and fill groundwater banks. At first, this drive will be to acquire locally-available water supplies, but as these drivers restrict the water supplies available to south-of-Delta users, they will be forced to look north for more permanent sources for surface water. In short, these trends point to a greater demand for less-available water south-of-Delta, which could influence south-of-Delta water users to take on more through-Delta conveyance risk, driving up the market for north-of-Delta supplies.

[7] WestWater Research 2017 and Sierra Water Development 2018

[8] Sierra Water Development 2018

[9] Public Policy Institute of California 2011. Managing California's Water: From Conflict to Reconciliation. http://www.ppic.org/content/pubs/report/R_211EHR.pdf

[10] SGMA requires governments and water agencies of high and medium priority basins in California to halt overdraft and bring groundwater basins into balanced levels of pumping and recharge. Local agencies are forming Groundwater Sustainability Agencies (GSAs) to manage basins and requires those GSAs to adopt Groundwater Sustainability Plans (GSPs) for crucial groundwater basins. Under SGMA, these basins should reach sustainability within 20 years of implementing their sustainability plans. (DWR 2018)

These factors present an investment opportunity for a SVWT. Although at the moment there is little competition among south-of-Delta buyers for long-term water supplies from the north, our work with consultants and water brokers suggests there will soon be more. As discussed in more detail below in Water sources for a SVWT portfolio), by entering the market now, we can secure a block of north-of-Delta water at prices that are likely to rise in the future and lease a portion of those water assets at what already is a high price south-of-Delta. We also see an investment opportunity for nature, as demands for water and pressure on ecosystems increase, to secure long-term water supplies for the future with conservation as the top priority.

Short-term buyers of SVWT portfolio water

With consultant support, the Focus Group evaluated the buyer market for short-term water leases, comparing demand and willingness to pay across sectors in the Sacramento and San Joaquin Valleys to identify the most suitable buyers for SVWT water and to confirm assumptions used in the financial model. We've determined that the most suitable buyers for water made available through a short-term lease of SVWT water are located in agricultural and urban areas in the San Joaquin Valley and along the central and southern coastlines. In short, water buyers south-of-Delta are able to pay a higher price and purchase water more frequently than water buyers north-of-Delta. Selling to south-of-Delta buyers would ultimately result in greater financial returns over time than selling to north-of-Delta buyers.

The Central Valley water market is, in part, driven by a disparity between water availability in the north and water demands in the south. Although the demand for water across all of California is greater in dry years than in wet years, most Sacramento Valley water users generally do not need to purchase water in most years because they have adequate water supplies to meet their needs. Some short-term buyers in the Sacramento Valley do exist in drier years, although likely in fewer than 3-out-of-10 years on average. By some estimates, 30% (by volume) of all short-term leases in the Central Valley as a whole are within the Sacramento Valley,[11] and the demand for that water exists only in drier years. Furthermore, the prices for leased water within the Sacramento Valley are lower than for water leased to San Joaquin Valley users due to a smaller disparity between supplies and demands, coupled with a lower willingness to pay due to the predomination of lower-value crops like rice. Rice and other annual crops grown in the Sacramento Valley also allow for idling if critically dry conditions exist, which shrinks demand (and also price) in drier years. This is in sharp contrast to the San Joaquin Valley, where high-value permanent crops with hardened water demand prevail, and where urban areas along the southern coasts require relatively consistent supplies on an annual basis, making for consistently high demand and willingness to pay for water.

Sales to south-of-Delta buyers would be possible (demand exists) in 9 out of 10 years on average if water supplies and conveyance were available. Water could also be sold at a much higher price to these southern buyers than to those in the north. Conveyance constraints under current regulatory conditions discussed previously indicate that water conveyance is only possible through SWP facilities at a frequency of about 3 out of 10 years; however, modeling has demonstrated that even if water were only

[11] WestWater Research 2017

be sold to south-of-Delta buyers at the same frequency as north-of-Delta buyers (in 3-out-of-10 years), more revenue could be generated by selling south in those years.

Working with State Water Contractors (SWCs) as buyers would have several advantages with respect to Delta conveyance. In short, SWP's Banks pumping plant has more available transfer capacity, that we could access by working with SWCs or districts. Typical south-of-Delta buyers include federal districts within the San Luis and Delta Mendota Water Authority and SWCs such as Kern County Water Agency member-districts and Metropolitan Water District (MET), shown on Figure 2.

Water assets for a SVWT portfolio

Given the ecological needs and target short-term buyers described above, as well as the potential for financial returns, the Focus Group evaluated where and what categories of water assets are available and suitable to acquire for the SVWT. Specific sources (such as property listings or water rights holders) will be identified in the Design Phase.

Our analysis considered several aspects of water assets that could be acquired, and implications for holding and transacting with that water supply. Aspects evaluated included:

- Source location
- Entitlement class or water right type
- Seniority and pricing
- Physical mechanism that would be used to demonstrate the asset consists of "real water" that is allowable for transfer, such as crop idling, groundwater substitution, or water conservation

Source location: Acquire water assets in the North

We evaluated whether to acquire assets in the Sacramento Valley, San Joaquin Valley, or both. Considerations included:

- Current value and potential for growth in the different geographies
- Feasibility of conveying water from the source to the target ecological need or buyer

To paraphrase the adage "buy low, sell high", with water we propose: "buy north, sell south".

South-of-Delta water is expensive, in that it costs more per unit volume than in other parts of the state. Water rights there are in high demand, and they are already located near its highest economic use, so the prices of water rights reflect what cities like Los Angeles and San Diego or growers of San Joaquin Valley high-value crops are willing to pay. In short, south-of-Delta water pricing already reflects its scarcity, its value, and the willingness-to-pay of the top bidders in Southern California, so it is a more expensive option for SVWT acquisition.

Lower north-of-Delta water prices, in contrast, reflect the lower demand for the water within the Sacramento Valley, and the constraints of conveying it southward. As described previously, north-of-Delta water can be conveyed through the Delta and sold in only 3 out of 10 years on average under current regulatory conditions. However, more frequent conveyance may be possible in the near future,

and demand for surface water may increase as a result of SGMA implementation and other drivers. Both of these factors are likely to increase the price of north-of-Delta water to align closer with south-of-Delta prices. For example using one estimate of the future trend of Sacramento Valley water prices, the current market price for undeveloped water rights in the Sacramento Valley is approximately only a fraction of what MET pays for water rights more locally, but this gap is expected to narrow with Sacramento Valley water rights price growing to align more closely with the MET equivalent cost within 10 years. Simply put, north-of-Delta water is currently priced low, but prices are expected to increase quickly and sharply, creating additional financial upside on north-of-Delta water purchased now.

North-of-Delta water can support shorebird habitat needs in the Sacramento Valley and can be transferred to refuges in the San Joaquin Valley through several mechanisms. This is discussed later in Section 4, *Water Trust operations*. Water acquired south-of-Delta could support refuges in the San Joaquin Valley more frequently than water acquired north-of-Delta, but the SVWT would not benefit from as much growth potential as north-of-Delta supplies. Sourcing water north-of-Delta also benefits from greater TNC on-the-ground presence and partner relationships.

We therefore recommend focusing SVWT water acquisition north-of-Delta in the Sacramento Valley, acquiring assets as soon as possible for the greatest potential financial returns due to price appreciation. The targeted region is shown in Figure 2. Consideration could be given to acquiring water south-of-Delta in the San Joaquin Valley if the asset was priced appropriately (had a high potential for growth) and had the potential to provide significant ecological benefits to San Joaquin Valley refuges. Trade-offs would be weighed on a case-by-case basis.

Entitlement classes: Acquire a variety and consider unlisted opportunities

California surface water entitlements are broadly classified by water rights and/or contract type. These classes are summarized in Table 1. Most of these assets are available to trade or buy through a variety of transaction structures. With the exception of riparian and banked water, these entitlements can be leased (transferred) on a short-term (single-year or multi-year) basis, or they can be purchased out-right, either as part of a land transaction (property with water rights associated) or separately from land (known as permanent sales/transfers). For the SVWT concept, we would purchase assets outright and hold them over a period of years to have the opportunity to manage the water in individual years during the life of the Trust—primarily to dynamically dedicate that water for nature or occasionally lease to other water users.

Table 1. Common California Surface Water Entitlements

Entitlement Class	Description
State Water Project (SWP) Contract	Contractual allocation of a portion of the SWP's annual water supply.

Entitlement Class	Description
Central Valley Project (CVP) Contract	Contractual allocation of CVP's annual water supply.
Pre-1914 Appropriative	Right to divert specific quantity, to specific location, for specific purpose(s). Right holder can provide evidence of original use prior to 1914 and continued use thereafter. More senior than rights granted after the passage of the Water Commission Act.
Post-1914 Appropriative	Right to divert specific quantity, to specific location, for specific purpose(s). Granted by what is now the State Water Resources Control Board after the passage of the Water Commission Act. Seniority determined based on year granted.
Riparian	Right of landowner adjacent to surface water to the natural flow of the watercourse to use enough water to meet needs of that land. This water cannot be stored, leased or assigned another place of use.
Banked	Surface water stored underground as a groundwater banking facility.

Source: Adapted from WestWater Research, March 2017

The following sections describe and compare the categories of water assets we'd consider acquiring for a SVWT portfolio.

Water rights acquired as part of land transactions

The conventional method of acquiring water rights for most purposes is by purchasing land with water rights associated with that property.

Acquiring land with water rights has the benefit of being a familiar asset type, with a clear process for appraisal, thus easier to establish fair market value (FMV) to comply with TNC's Standard Operating Procedures (SOPs), and easier to finance via debt capital, as with a mortgage. Land is also a more transparent market than stand-alone water rights, with more buyers and sellers, and thus has more downside protection if the water assets do not ultimately meet the needs of the buyer, since the land can be resold. It may also be possible to farm the land and earn supplemental income. However, land does entail higher overall cost than stand-alone water rights, both in the up-front price, and in the ongoing stewardship and management of the parcels.

Water rights acquired separately from land (stand-alone water rights)

Water assets separate from land may be advertised for permanent sale.[12] Compared to acquiring water rights through land transactions, stand-alone water rights may present challenges in appraisal and

[12] There is no open market or clearinghouse of stand-alone water rights for sale in California, but water brokers or those with connections and networks within the water market are aware of the opportunities.

financing due to being in an opaque market of private party transactions. However, they offer the ability to more precisely and cost-effectively achieve SVWT objectives without the additional obligation and cost of also managing land.

Stand-alone water rights may also be available from water conserved through permanent land use changes or water use efficiency measures. Many of these assets are considered "undeveloped" water rights because they have never been tested through the State Water Resources Control Board (SWRCB) as a distinct right. These assets must be developed or "proven up" as separate rights through pilot short-term transfers of the water requiring SWRCB approval. These sources are rarely conventionally listed and depend on us (or our broker) working directly with existing water rights holders. They include:

- **Conserved summer water through habitat conversion/mitigation projects:** Habitat conversion or restoration reduces the quantity of water diverted to the property during the peak irrigation months from May through September (up to 90%). This is defined as "conserved" water savings and is available for water transfer under California Water Code (CWC) §1011. Habitat conversion/mitigation projects are being funded without regard to the surplus water generated during irrigation season, but this water is available to prove up as a marketable water right. Much of this land is privately held, largely by duck clubs that are not aware of the opportunities to market the water. We could secure this water as part of a larger portfolio.

- **Conserved surface water from rice irrigation system conversion to groundwater:** Consultants deeply familiar with the Sacramento Valley rice water market[13] saw water supply changes occur in 2014-2015 during the last drought. Rather than continuing to face surface water supply uncertainty and curtailments, some growers installed groundwater-based irrigation systems. These growers are now pumping groundwater to grow rice rather than exercising their surface water rights—essentially conserving that surface water.[14] (The design of these systems doesn't allow them to easily convert back to using surface water.) This could present an opportunity for us—or other water users—to acquire those surface water rights. Passage of Senate Bill (SB) 88 requires these growers to report their diversions to the SWRCB. It is expected that soon the Board will establish a record that these growers' rights exceed the amount of water they are putting to beneficial use, and at that point the Board may rescind those surplus rights due to non-use. If "real water" can be demonstrated, per our consultants, growers may rather sell those surplus rights than simply be stripped of them through regulatory action.

- **Conserved water from municipal water use efficiency efforts (20% by 2020 state initiative, long-term behavior changes brought about by drought restrictions, etc.):** Some Sacramento Valley and Bay Area municipalities have been reducing their water diversions over the last decade as a result of water use efficiency and conservation mandates. This leaves them with a disparity between the sum total of their water rights and the volume of water they are able to beneficially use. These entities are aware that their water rights may be at risk unless they

[13] Sierra Water Development 2018

[14] It is unknown whether this conversion could have long-term implications to groundwater conditions in the Sacramento Valley. SGMA implementation should ensure that groundwater basins are brought into balance.

demonstrate beneficial use, again due to SB 88. They would likely have an interest in selling some of this conserved water to us, potentially at a discount, to green their image and help replace the revenue they've lost by delivering less water.

This "conserved water" category is driven in part by California's "use it or lose it" water provisions and by SB88 and other measures that are attempting to increase the accuracy of water use and reduce over-reporting. One consultant's estimate is that up to 20% of on-paper water rights in Sacramento Valley might be at risk of rescission once usage and reporting come closer in-line. The SVWT could offer to acquire these water rights from water rights holders. The price we would offer for these undeveloped rights would be lower than other rights that have a proven transfer record because we would need to prove up the rights through a pilot transfer, discussed later in Section 8, *Implementation phases and early work*. Once the rights are proven up, the value of the rights increases significantly, making this segment a good buy in the near term.

We must consider the implications of pursuing this segment of available water. Naturally, these questions come to mind: Where is this water now? Who or what would be using this water if we did not acquire it? In large managed rivers in the Central Valley, under most hydrological conditions and absent changes to instream flow regulations, water conserved by water rights holders does not simply stay instream to augment available habitat or improve conditions for aquatic species; it is used by the state and federal water projects to meet regulatory flow standards or it essentially defaults to more junior water rights holders (those with far less-senior appropriative rights).[15] There is also no guarantee that if the SWRCB rescinds water rights that those rights would be directed to conservation. Acquiring the water is one way we can specify how this conserved water must be used and prioritize it for nature.

We may also need to balance the opportunity with reputational risks. This approach may appear to inadvertently condone over-reporters or over-users of water by buying out their overconsumption rather than decreasing use. Also, junior water rights holders could protest our actions. On the other hand, this is an opportunity to secure more water rights for nature now, accelerated by working within the existing water rights system and market (supported by the water user community and our Sacramento Valley agricultural partners) rather than waiting for involuntary, regulatory dedications, and before other water users capitalize on the same opportunity. Targeting the water conserved through habitat conversion/mitigation projects may carry the lowest reputational risk potential of the three "conserved water" categories described above because the conserved water can be most clearly demonstrated and because of the link to habitat; however, the other categories warrant consideration.

Despite the unconventional nature of these water assets, we believe that this "conserved water" category holds strong promise as a portion of the SVWT portfolio, as a cost-effective way to acquire SVWT water that would otherwise, importantly, not simply stay instream, but rather default to junior water users in the system. Because this is a relatively unproven segment of water that carries some

[15] Through CWC §1707, one can petition the SWRCB to change a water right for the purposes of preserving or enhancing wetlands, protecting fish and wildlife, and recreation by leaving water instream. There are advantages and disadvantages to this approach beyond the scope of this document, discussed in "A practitioner's guide to instream flow transactions in California," produced by the Small Watershed Instream Flow Transfers Working Group in March 2016.

execution and reputational risks, working with experienced brokers or consultants will be necessary, and high level review by TNC would be expected, at least in the early stages. Additional due diligence during the Design Phase will also inform our consideration of these assets for the SVWT.

Seniority and water pricing: Focus on post-1914 water, priced right

Seniority of a water right is a critical criterion in determining price and usefulness. It affects the expected availability of the water – more senior rights yield water in a greater percentage of years, since they are less subject to curtailments in drier years. As a result, some early analysis suggested focusing the SVWT as much as possible on the most senior water rights.

However, additional analysis revealed several problems with focusing only on senior water rights. First, senior water rights are expensive, which would limit the amount of water we could purchase as well as the investment growth potential. Second limiting ourselves to the most senior water rights would place SVWT in an unwinnable bidding competition against high-paying agricultural and urban buyers, for whom water availability is critical. Third, pursuing only the most senior water rights shrinks what might be a "market" of available sellers to a much smaller subset. An example from one Sacramento Valley county showed just a few potential sellers within the 1914 to 1920 range of seniority.

Fair market value of a water right is difficult to determine, and there is no established standard, but one way to estimate it is by considering the revenue that could be generated by leasing that right over a 10-year period. The purchase price should be roughly equal to that expected revenue. For example, a 1960 water right may only yield water in 5 out of 10 years, and the water may be marketable to buyers in only 2 of those years. We should only consider purchasing the water right if the revenue we would expect to generate in those 2 years is equal to or less than the purchase price.[16] Therefore, when considering seniority for a diversified portfolio, "there are really no bad rights, just bad prices." However, it would be reasonable to include some relatively senior rights in a portfolio in which we want to provide water for nature in the driest years. As we move forward into the preliminary Design Phase, seniority will be one consideration alongside our objectives.

Approach to selecting water assets

Preliminary criteria development

Early in this Feasibility Assessment process, the Focus Group reviewed several potential water rights on the market. This allowed us to dig into the details of actual potential purchase opportunities and develop methods by which to evaluate the suitability of an asset for meeting SVWT objectives. It also allowed us to avoid broadcasting our specific interests to the market, which suited that phase of our feasibility analysis. One preliminary method we employed was a scorecard that rated potential assets against a set of criteria, including:

- Water quantity
- Cost

[16] Sierra Water Development 2018; Westwater Research 2017 confirms this

- Ecological benefit
- Dynamic management potential
- Risk
- Learning value
- Partnership opportunities

Although these criteria will continue to be helpful in evaluating acquisition opportunities, this opportunistic and reactive approach of evaluating only on-market opportunities generated only a small set of alternatives, and no clear understanding of the role each one could have in a structured SVWT portfolio.

An alternative approach to sourcing water

Following this preliminary survey of available water rights, consulting work with Sierra Water Development, who is deeply involved in the Central Valley water market and related investing, was useful in laying out more potential water sources available for acquisition. As a broker heavily involved in the Central Valley water market, Sierra Water Development informed us generally what assets are currently on the market as well as other potential water sources that could be proven up from interested water rights holders. They also helped us understand the roles different sources could play in a diversified, balanced portfolio, tailored to our objectives. Accordingly, to source water, we believe we should use a proactive, customized, portfolio approach to water rights evaluation and acquisition.

As illustrated in Figure 5, "Proactive rather than opportunistic" refers to our approach to the market. We can alert the market of our interests in acquiring water rights, via brokers or agents if we wished to remain initially anonymous to protect our reputation and innovative ideas while we assess the market. This allows us to canvas a broader potential market of sellers, and to generate multiple potential acquisition options in the same timeframe, to more easily compare options.

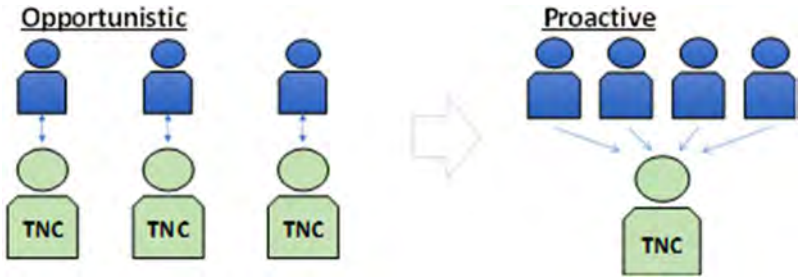


Figure 5. TNC's conceptual approach to water market opportunities
Source: TNC Internal

"Customized" refers to our setting the parameters of what we are looking for rather than taking what the market offers. For example, rather than simply accepting the offer of a $20 million property and taking on its water rights and other assets like agricultural operations, ranch buildings, etc., we can state are proactively seeking a quantity of water at a specified price we are willing to pay, specify certain land

characteristics, agricultural operations or crop types we are willing to work with, etc. This allows us to set our terms up front, rather than take terms from sellers.

A "portfolio approach" indicates that we will look to serve nature's needs across the entire portfolio of water rights, rather than within each single transaction, and that we will seek diversification across the portfolio. In effect, rather than requiring each individual transaction to blend multiple benefits (e.g. for both migratory birds and financial return), we can look to meet those goals across the entire portfolio, recognizing individual transactions will be better for one objective or another, and that a framework to evaluate trade-offs will be critical.

The other aspect of this is diversification of the portfolio to reduce risk. By blending diverse assets, including water rights of varying seniority dispersed across the Sacramento Valley, we expect better resilience of the portfolio value and water yield over time. For example, if we held a homogeneous portfolio of water rights all of the same type and seniority, curtailment in a given year of water at that level of seniority would impact the entire portfolio. For another example, if we held a homogeneous portfolio of all rice land with water rights and the price of rice fell precipitously, the land value across the portfolio could sharply decline. Instead, we recommend compiling a broad portfolio, with any given year providing some option to use water for nature and/or generate revenue.

Overall, we recommend proactively acquiring a customized, diverse portfolio that minimizes risks and balances potential conservation benefits with the potential for revenue generation to contribute toward achieving our priority conservation targets. We could acquire a mix of rights attached to land and rights not associated with land, depending on available funding, while analyzing the finance and legal implications of the two asset types. We could also diversify across other asset characteristics, including seniority, price, and the mechanism that would be used to demonstrate the asset is "real water". The proactive approach to delivering outcomes should be more efficient than an opportunistic approach and having portfolio diversity should protect the SVWT against a market change or hydrologic condition that disproportionally affects any one water asset type.

4. Water Trust operations

Operating the SVWT to achieve conservation benefits or revenue during the life of the Trust relies on transferring water from the source to other places of use. The procedures and complexity involved in transferring water in California depend on the entitlement type and whether the transfer is within the same basin (such as within the Sacramento Valley) or whether the water must move between basins (from the Sacramento Valley to the San Joaquin Valley). There are inherent trade-offs to moving water around (e.g. delivering water to birds rather than keeping water instream for fish, providing water to grow crops rather than to flood fields for birds, etc.), but also innovative opportunities for conservation.

Developing an SVWT operating plan

Early in the proposed Design Phase, a preliminary operating plan will be developed that sets clear conservation targets and a strategy outlining when (likely determined by year type) and how much

water must be provided to nature to achieve those objectives. Financial modeling (discussed later) demonstrates that we can sustainably operate the SVWT so that in the majority of years we will dedicate all SVWT water to nature. Although in some years we would lease some water to other water users, in no single year would we need to lease all SVWT water to be financially solvent. The operating plan would make our intentions clear and highlight that meeting our conservation objectives is the top priority of the SVWT.

Making water available for transfer to nature or other water users

TNC would use short-term water transfers to provide portfolio water to wetland habitat or lease the water to water buyers. Short-term transfers are regulated through the California Water Code (CWC), and several code sections are applicable.[17] Federal and state agencies have roles in approving aspects of water transfers, depending on the type of water right in question. DWR, Reclamation and the SWRCB each have contributed to a white paper that provides the details and process for water transfer approvals.[18] The approval process generally takes 30-60 days or more and may require state and federal agencies and/or the SWRCB to review and approve the transaction. Water transfers can be complex, each with unique challenges, and as such we recommend that TNC use consultants to navigate and execute each transaction.

TNC would make water available to transfer using one of several recognized mechanisms to reduce consumptive use of the water at the original source of the water right and demonstrate that "real water" is available for transfer in order for state and federal agencies to approve the transaction.[19] Typically, crop idling, groundwater substitution, habitat restoration (either to seasonal wetland or to native vegetation), or other water conservation methods will be required. For stand-alone water rights,

[17] CWC sections applicable to water transfers:

- §109 – state policy favoring voluntary water transfers.
- §475 – directs DWR to facilitate voluntary water transfers.
- §1011(b) – transfer of conserved water.
- §1020 through §1031 – water leases.
- §1435 through §1442 – temporary urgency change.
- §1700 through §1705 – permanent changes.
- §1706 – transfer of pre-1914 rights.
- §1707 – transfers for instream uses.
- §1725 through §1732 – temporary transfers.
- §1735 through §1737 – long-term transfers.
- §1810 through §1814 – use of water conveyance facilities.

[18] "Technical Information for Preparing Water Transfer Proposals". The Department of Water Resources, December 2015.
https://www.water.ca.gov/LegacyFiles/watertransfers/docs/2016_Water_Transfer_White_Paper.pdf

[19] The entire amount of the water right "on paper" is typically not available for transfer. In the Sacramento Valley, all the water that is applied may not be fully consumed at the source, leaving some available for reuse by downstream surface water or groundwater users. Due to the flow-through nature of water management in the Sacramento Valley, because downstream users are depending on that returned flow and to avoid injury to those legal users of water, the amount of transferable water is only the net additional water made available downstream of the source of the transfer that would not be available but for the transfer.

these mechanisms may have already been implemented prior to our acquisition (or prior to us entering into an option agreement with the seller). For land we acquire with associated water rights, crop idling or habitat restoration may be most viable, but we would evaluate the best option on a case-by-case basis.

- **Crop idling:** Crop idling makes water available by reducing the consumptive use of surface water and transferring the savings. For rice fields, the consumptive use factor is 3.3 acre-feet. Rolling fallowing may actually provide an environmental benefit by breaking the weed and spray cycle for rice land. However, from an environmental perspective, the rice fields and irrigation ditches provide habitat for wildlife and waterfowl that would be significantly reduced with idling, especially at scale. Prior to approval, the seller has to provide a fallowing plan that addresses environmental impacts (e.g. to endangered or threatened species like the giant garter snake).

- **Groundwater substitution:** Groundwater substitution makes water available by reducing surface water diversions and replacing the demand with groundwater pumping. The savings in surface water is transferred. To recognize the link between surface water and groundwater, DWR imposes a 13% depletion factor to the water transfer. Groundwater substitution can produce 50% to 100% more transferrable water than crop fallowing. Potential impacts to local groundwater conditions must be considered.

- **Stored water:** Stored water makes water available by releasing additional water from a reservoir. The water is released when it can be captured or diverted downstream. The seller is required to prove that the water is surplus to normal operations. In addition, there is a refill requirement in future years. Environmental impacts are negligible unless the transfer is followed by a dry/critical water year.

- **Habitat restoration/conversion to natural vegetation:** Habitat conversion or restoration reduces the quantity of water diverted to the property during the peak irrigation months from May through September (up to 90%). This is defined as “conserved water” savings and is available for water transfer. Habitat needs water at other times of the year when more surface water is typically available in the system than during the irrigation season. Habitat conversion shifts demand from peak irrigation months in the summer to off peak fall, winter and spring months.

Note that the water conserved through habitat restoration and other actions described previously do in fact make water available for transfer under CWC §1011, but these actions are not reflected in water transfer guidance documents prepared by irrigation districts, state agencies or federal agencies.

Transferring water to nature

As described previously, to provide water to benefit TNC’s conservation priorities, portfolio water would be transferred to create shorebird habitat in the Sacramento Valley or to supply migratory bird-

supporting wildlife refuges in the San Joaquin Valley.[20] Conservation benefits are central to and the top priority of the SVWT.

To create shorebird habitat, we envision that portfolio water would be transferred on a short-term basis to private agricultural landowners or public easement lands in the Sacramento Valley who agree to create the right flooded habitat conditions for shorebirds with the water. TNC's BirdReturns program has demonstrated that Sacramento Valley rice growers are able and willing to create habitat conditions for incentive payments. Tens of thousands of acres have been created through BirdReturns, and this program could help with outreach for the SVWT. There also may be opportunities to provide water to landowners for their irrigation in the summer in exchange for these landowners using another water supply to create shorebird habitat in other seasons. To facilitate these water transfers, shorebird habitat would be created on lands downstream of the original source of the water asset. The approval process would be very similar to a water transfer to agricultural or urban water users and would depend on the entitlement type of the source asset. We are executing an analogous pilot transaction this year to demonstrate this concept. See Section 6, *Pilot water transactions for nature*, below.

San Joaquin Valley refuges have a chronic shortage of water but delivering portfolio water to these refuges will require transferring water through the Delta. Through-Delta water transfers are done far less frequently for conservation uses than for other uses. Reclamation's RWSP has successfully transferred Sacramento Valley-acquired water through the Delta to San Joaquin Valley wildlife refuges on only a few occasions over the last 20 years. Program challenges have included political and institutional will and inadequate funding to compete with urban and agricultural water users, as well as the fact that this federal program has relied on the federal Jones pumping plant—with little to no capacity for transfers in most years—to transfer acquired water south. A SVWT could make cross-Delta transfers to refuges or other south-of-Delta ecological needs more common by demonstrating different ways to move water south, including partner-assisted transfers similar to the pilot project we are developing to purchase and transfer water to Kern National Wildlife Refuge (NWR), described in the Section 6, *Pilot water transactions for nature*. We could also transfer water to south-of-Delta refuges through the state's Banks pumping plant that, as discussed in the next section, has more capacity for transfers.

Another conceptual but promising way to provide water to refuges is to develop uneven exchange agreements with large groundwater banking programs such as Semitropic or Kern Water Banks. This would likely depend on a fall transfer window opening, allowing some water to be transferred through Jones and Banks pumping plants in October and November.[21] Our portfolio water could be transferred south during these low-demand months in wetter years and deposited into the bank; in exchange (potentially on an uneven ratio), the banking programs would agree to supply refuges with annual water

[20] Currently, water supplies are adequate to meet needs at Sacramento Valley refuges in most years, but SVWT water could be provided to these refuges in the future if the situation changes.

[21] This may occur due to policy changes stemming from the WIIN Act, or if the RWSP receives a special consultation with the state and federal fish and wildlife agencies to allow refuges to transfer water outside the July-September window currently permitted by the BiOps for the CVP and SWP operations.

deliveries, including in drier years when acquiring water would otherwise be cost-prohibitive for refuges. This concept would need to be proven up through a pilot project during the Design Phase.

Note that the RWSP does have funding for some water acquisitions and is willing to pay us for water, although they are typically able to afford (and are willing to pay) less per acre-foot than other water users. Through the SVWT, we may identify ways to convey water south that are less expensive than the methods the program is currently using, that may enable the program to better or more efficiently meet its obligations in the future. We could also sell permanent supplies to them at discounted rates at the end of the fund, if that factors into our conservation and financial objectives.

Transferring water through the Delta

Leasing portfolio water to southern California water users or providing water to San Joaquin Valley refuges would rely on conveying that water through the Delta through the state and federal pumping facilities, known as Harvey O. Banks and C.W. "Bill" Jones pumping plants, respectively. Despite limitations on how much and how often water can be transferred south, we estimate that we could transfer water in 3 out of 10 years on average depending on hydrology, and financial modeling demonstrates the financial viability of leasing a portion of our portfolio at that frequency.

Transfers through the Delta are complex, but possible; hundreds of thousands of acre-feet are transferred through the Delta each year. Consultants with in-depth experience and involvement with the water market would be able to assist TNC in navigating the details of cross-Delta water transfers. Regulatory restrictions, physical conveyance and capacity limitations, and procedural complexity and approvals were studied in detail. Key points are:

- To protect aquatic species including the endangered Delta smelt, transfer water can only be conveyed through the Delta pumping facilities from July 1 through September 30.
- Transfer capacity through both pumping facilities is dictated by a priority system. The SWP's Banks pumping plant has more available transfer capacity than the CVP. To have access to that capacity and priority, we would transfer SVWT water through Banks by leasing to or working with SWCs or districts, such as through the SWC's Dry Year Purchase Program. One example of this is described in Section 6, *Pilot water transactions for nature*.
- Transfer capacity is a function of water year type, and greatest when SWP allocations are between 20-35%. On average, this means that water conveyance is currently only possible through SWP facilities at a frequency of about 3 out of 10 years.
- At typical recent market prices, we estimate that selling water in 3 out of 10 years (approximate frequency of dry and critical years), $1,900/acre-foot revenue could be generated, compared to $3,700/acre-foot revenue in a 9 out of 10-year scenario.
- Although we conservatively assumed a potential transfer frequency of 3 out of 10 years in our financial analysis, indications are that the 3 out of 10 year frequency could increase over the next 10 years due to policy changes and climate change.

- Transferring SVWT water across the Delta will involve working with the California DWR to approve conveyance through Banks pumping plant and further south through the California Aqueduct, in addition to complying with the California Environmental Quality Act (CEQA) and other processes and approvals.

There is ongoing regulatory uncertainty associated with transferring water through the Delta that could affect revenue generation and habitat potential south-of-Delta, either positively or negatively. Two major regulatory processes include:

- The Reinitiation of Consultation on the Long-Term Operations (ROC on LTO) of the SWP and CVP will ultimately result in new permitted water project operations and new BiOps (discussed previously in Section 3, *Central Valley water market*) that may also affect how much and when water is pumped through the Delta.
- The SWRCB is updating the Bay-Delta Water Quality Control Plan that may affect how much water is available to divert by Sacramento Valley water rights holders or potentially for export through the Delta. These processes may conclude that more water is needed to increase the flow in the Sacramento River, to store in Shasta Reservoir to maintain cold temperatures for key fish lifecycle stages, and to increase outflow from the Delta through the San Francisco Bay at key fish migration periods.

Although it's too early to determine exactly where (or from whom) additional water would come from, if needed, water rights holders in the Sacramento Valley do feel increased pressure to protect their water rights from regulatory action, and we would take on some associated risk by acquiring Sacramento Valley water rights. At this point, it's impossible to determine exactly what the outcome will be, and these processes could take years—even decades—to settle. These complex assumptions and scenarios will be further investigated and tested with water experts and consultants during the Design Phase.

Evaluating trade-offs between water uses

In large, centralized water systems, water management decisions inherently involve trade-offs between agricultural and urban water users, between these users and the environment, between wetland habitat needed for birds and instream flows needed for fish, etc. As holders of water assets and as a conservation-focused organization, we have a unique responsibility to carefully consider the implications of how we exercise those water rights, particularly to the environment. For example, just as water becomes scarcer in dry years and demand increases, and as potential returns from selling water also increase, ecological water needs grow. Choosing where to send water in the driest years involves making critical trade-off decisions between revenue and potential conservation gain, even if only a fraction of our portfolio is leased in those years. What are acceptable thresholds and trade-offs between nature and revenue? Financial and conservation priorities must be carefully weighed and balanced as part of an SVWT operating plan to ensure that both objectives can be met but conservation is kept at the forefront. A detailed evaluation of trade-offs and guidelines for operating the SVWT will be developed during the Design Phase.

Example activities to be undertaken prior to the start of the fund to evaluate trade-offs and manage related risks include:

- Develop science-based objectives and criteria prior to the start of the fund that clearly identify ecological targets and describe when and where conservation needs will be prioritized over financial gains. Ecological objectives and minimum thresholds for revenue would be set, and metrics would be developed to evaluate success.
- To the best of our ability, identify trade-offs between different transaction elements (e.g. types, places, mechanisms of making water available for transfer, etc.) including trade-offs between wetland habitat, instream flows, and revenue generation, and develop an approach to reconciling them, such as through a Structured Decision Making process. The Design Phase of the SVWT would help to confirm this approach and how we continue to operate the Trust in light of trade-offs.
- Clarify ecological implications and the trade-offs of transferring water away from a water asset source, either within a basin or through the Delta, whether for conservation or to generate revenue.
- Design an operating plan, Informed by financial modeling and conservation science, that indicates whether water would be provided to nature or leased to other water users in different year types (or other triggers such as transfer buyer activity or anticipated wetland habitat availability) in a given year.
- Coordinate our actions with state and federal fish and wildlife agencies to avoid unintentional ecological harm through our water sales and to optimize the benefits of the water we can provide to conservation.

Piloting new opportunities for conservation through SVWT water sales

In addition to demonstrating a constructive process of navigating trade-offs that ultimately and successfully achieves conservation objectives, holding a portfolio of water rights would give us the opportunity to demonstrate water market transactions that can occur only if certain conservation conditions are met or actions taken. For example, we could agree to lease portfolio water to a potential buyer only if that buyer agrees to create wetlands or contribute a percentage of the water to instream flows. Ownership of the water therefore can provide leverage that could lead to buyers undertaking conservation actions themselves, bringing about a greater scale of conservation than could be done with the water alone. In concept, this could set a precedent for a new category of environmental water transfers in which both sellers and buyers are furthering conservation.

5. Financial viability

The Focus Group created a financial model to test the viability of using investor capital to create a financially sustainable, and scalable funding model for securing a portfolio of water rights for nature.

The objective of the model is to identify under what conditions, if any, investing in a portfolio of water rights can be financial sustainable, and to understand the trade-offs between generating revenue and achieving conservation outcomes. For this conceptual exercise, we chose to model a fund size of $50M, the results of which are reported in this section. The financial model was subsequently used to model the fund size we ultimately recommend in Section 8, *Implementation phases and early work*.

Financial model mechanics and assumptions

The model simulates acquiring a portfolio of water assets at the beginning of a 10-year period and then managing the water each year by either leasing it to agricultural water users or sending the water to nature to create habitat. It is designed for flexibility and can simulate a portfolio of any size, with a mix of asset sizes and types, including assets that are stand-alone water rights and water rights acquired with land. It is assumed that all of the portfolio assets are in the Sacramento Valley, and the user can choose if they are leased north-of-Delta or south-of-Delta, as well as input a percentage of the water portfolio that should be reserved for nature in every year. As weather patterns have a significant impact on financial returns, the model includes several options based on historical averages for water year types in the Central Valley. The model makes conservative assumptions about the SVWT's operating model. For instance, while it may be possible to generate revenue and achieve conservation outcomes in the same transaction (such as leasing water to refuges through the RWSP), these opportunities will depend on specific circumstances, and the model conservatively assumes no overlap.

Fund scenarios and returns

While the model is flexible and can be used to compare many different scenarios, we focused on the subset of scenarios described below to test the potential for generating investor returns while also providing valuable water for nature. The results are summarized in Table 2 below.

Each of these scenarios assumes a fund life of 10 years and is comprised of a $50 million portfolio of assets purchased in the Sacramento Valley and leased annually South of the Delta. It is assumed that due to conveyance constraints through the Delta, the water will be marketed in the 3 driest years out of the 10-year term. In the remaining 7-out-of-10 years the entire portfolio of water is used for conservation. Three water asset portfolios were modeled: (1) $50 million worth of standalone water rights ("Water, no Land"), (2) $50 million worth of rice farms with water rights to sufficiently farm rice ("Rice Farms"), and (3) a hybrid portfolio with $25 million of standalone water and $25 million of rice farms with water ("50/50 Mix").

Each of the three portfolios was analyzed to determine the total acre-feet of water controlled by the portfolio, and a high and low estimate of investor's internal rate of return (IRR). The high-end represents aggressive assumptions for the rate of appreciation for the water and land, and favorable weather scenarios, while the low-end assumes the opposite. Both weather scenarios use the same average expected water year types over 10 years, based on 111 years of historical water year classifications. However, the favorable weather scenario for the high-IRR puts all of the driest years up front,

maximizing early revenues and consequently resulting in a higher IRR. The low-IRR scenario puts all of the wettest years early in the fund term and dry years at the end, giving a lower IRR.

Table 2. Summary of investor returns by portfolio type for a $50 million portfolio

SUMMARY OF WATER PORTFOLIO		SUMMARY OF RETURN ON CAPITAL			
		No Excess Water for Nature		Maximum Water for Nature	
Asset Type	**Acre-feet of Water**	**Low IRR**	**High IRR**	**Low IRR**	**High IRR**
Water, No Land	**25,000**	**11.1%**	**21.2%**	**4.9%**	**10.2%**
Rice Farms	**21.429**	**11.4%**	**20.2%**	**6%**	**11%**
50/50 Max	**23,214**	**11.3%**	**20.6%**	**5.5%**	**10.6%**

Source: TNC Internal

The results in the middle columns of Table 2 above tell us that a revenue-maximizing fund could target between 11%-21% returns. The next step was to take all of the water out of the marketable portfolio and reserve it for nature, to be deployed by TNC to create/enhance wetland habitat. The right-hand columns of Table 2 show that a nature-focused fund could earn between 5%-11%.

The goal of this analysis was to find the upper and lower boundaries in the results by creating "all-or-nothing" scenarios where the strategy for deploying water is either 100% revenue seeking, or 100% conservation focused. However, in reality we would likely take a much more dynamic approach. For instance, we could market water in the first dry year and then use it for nature in subsequent dry years, or we could split the portfolio in a given year and send some to nature and some to earn revenue. Figure 6 below shows the investor returns in-between these all-or-nothing scenarios, where a portion of the water portfolio is used for nature, forgoing water leasing income with that portion of the water assets. In all cases, the non-marketed water would be available to nature in seven out of 10 years, and it's also possible that some of the marketed water could have co-benefits benefits to nature during conveyance, through payment from refuge programs, or other mechanisms.

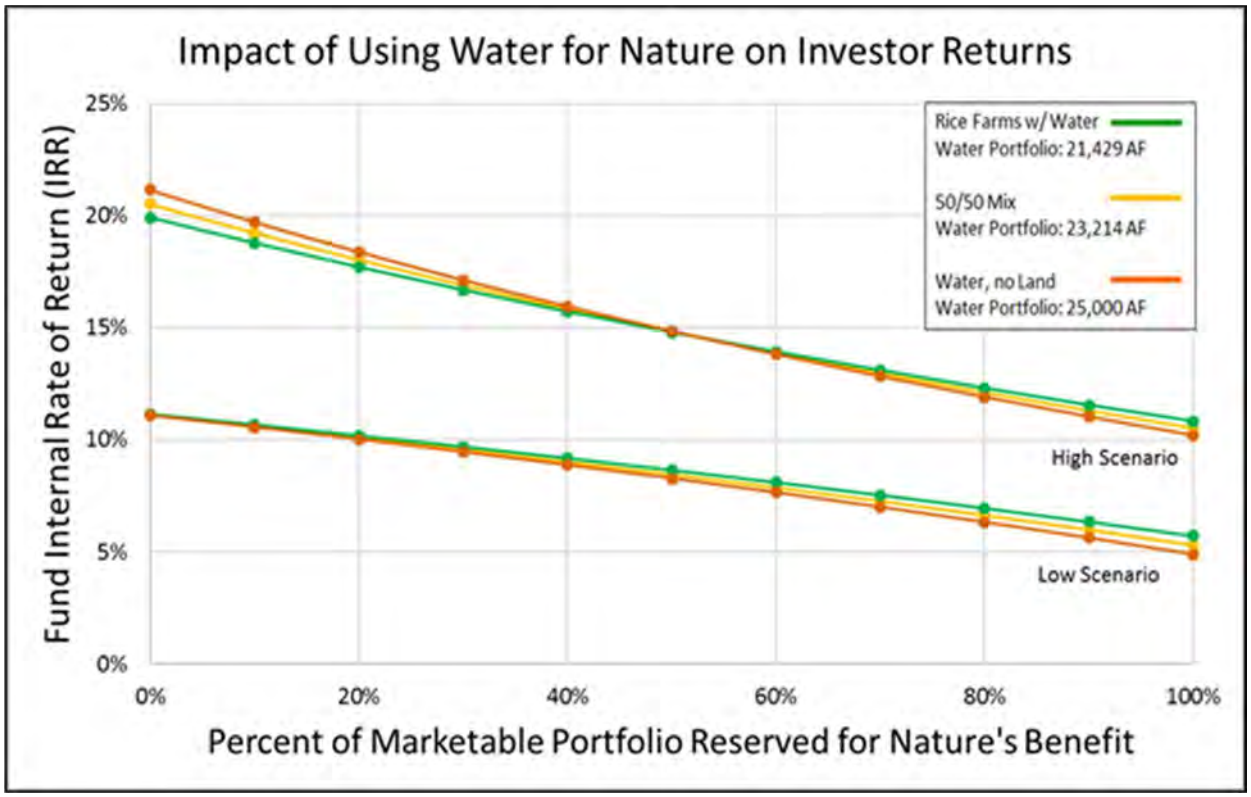


Figure 6. Water Allocation Trade-offs

Source: TNC Internal

Potential for buy-back at fund closure

TNC is interested in creating conservation benefits that are durable and last beyond the life of the fund. To that end, the scenarios modeled assume the fund would return the first 6% of returns to investors, this is the same preferred return used in similar NatureVest Funds. Once the fund earns enough income to repay investors their original investment and a 6% return, all subsequent proceeds go into a conservation fund used to buy-back or retain ownership of a portion of the water portfolio in perpetuity. Figure 7 below illustrates the portion of the portfolio that could be purchased for long-term conservation, and the trade-off between generating conservation outcomes during the fund and long-term. The key takeaway is that a fund that maximizes conservation during the 10-year investment period will earn less income with which to buy-back, or retain, ownership of the water rights at the end of the fund. Conversely, a fund that maximizes returns over the 10-year investment horizon will maximize its ability to retain ownership of the water portfolio in perpetuity but will provide reduced benefits to nature in the short-term.

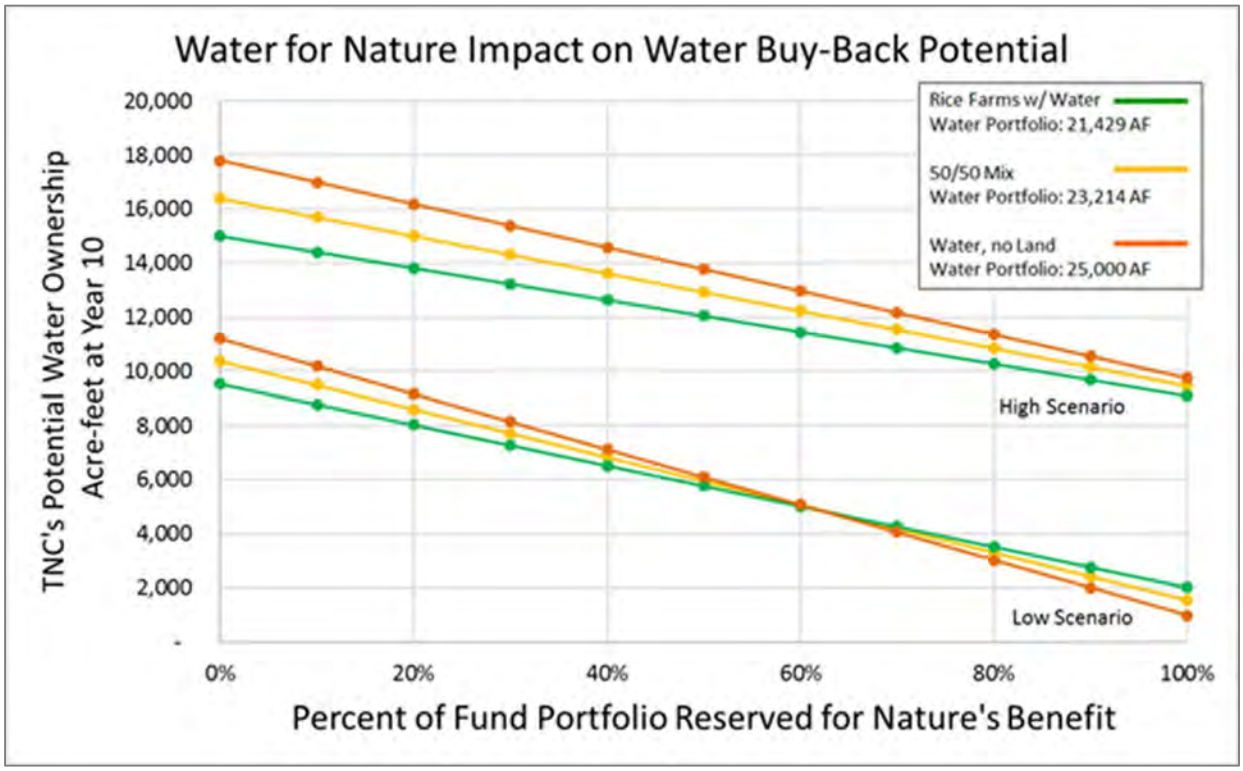


Figure 7. Water for Nature Impact of Buy-Back Potential

Source: TNC Internal

Influence of fund size on financial returns

The financial model was used to determine how financial returns are expected to change as the fund size changes. The results were similar across portfolio types, and Figure 8 shows the impact of fund size on investor returns for the "Water, no land" scenario, using conservative "low scenario" weather and water appreciation rate assumptions. The key finding is that below a $20 million fund size, returns drop off significantly. This is because the model assumes a minimum fixed cost of TNC programmatic work to support the SVWT. Less than $20 million, that fixed cost becomes material and starts to substantially impact the fund's return on investment.

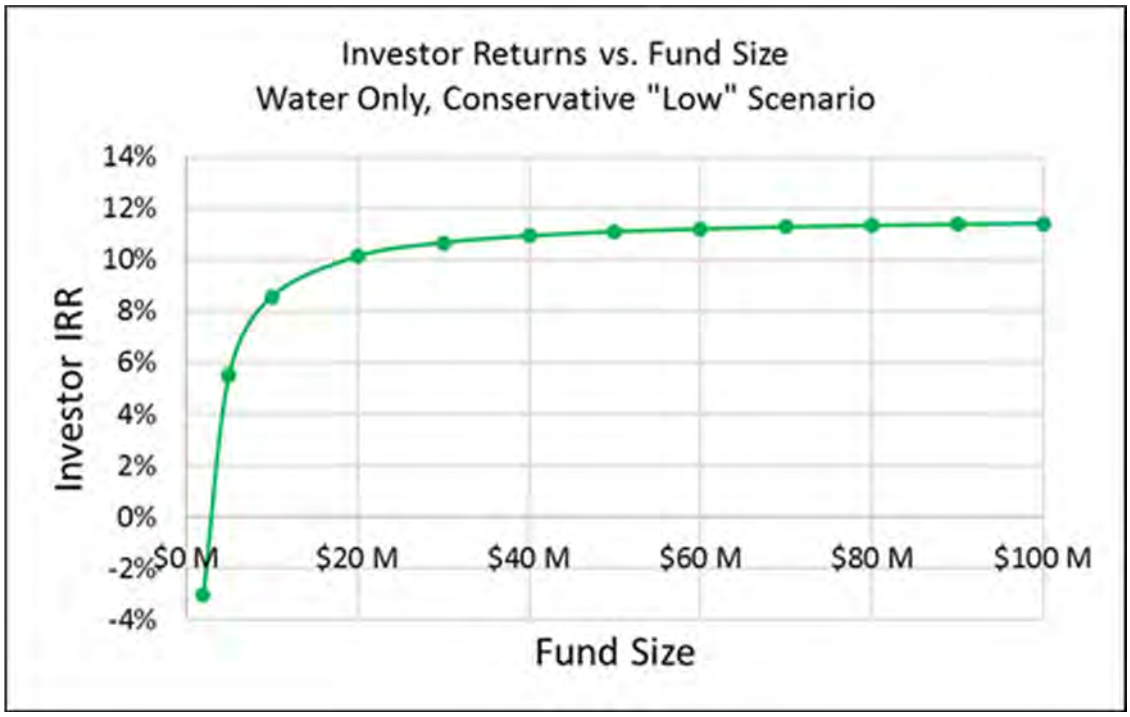


Figure 8. Impact of Fund Size on Investor Returns

Source: TNC Internal

Key financial takeaways

In summary, the financial model demonstrates that a SVWT can generate adequate returns for both investors and nature, but there are some trade-offs to analyze and consider when designing an operating plan. The key takeaways from the financial modeling exercise include:

- **Fund size:** While a $50 million fund was modeled, modeled returns are similar for a fund of $20 million or more. Below $20 million return on investment begins to drop significantly.
- **Potential return on investment:** A revenue-maximizing fund could target between 11%-21% returns, while a fund deploying most or all of the water for nature every year could target 5%-11% returns. In both cases, assets would need to be sold at the end of 10 years to realize returns.
- **Trade-offs between near-term and long-term conservation:** A fund that maximizes conservation during the 10-year investment period will earn less income with which to buy-back, or retain, ownership of the water rights at the end of the fund. Conversely, a fund that maximizes returns over the 10-year investment horizon will maximize its ability to retain ownership of the water portfolio in perpetuity but will provide reduced benefits to nature in the short-term.
- **Testing Assumptions:** A model is only as good as its assumptions. The Focus Group believes the assumptions used in the model are valid, and erred on the side of using conservative

assumptions in every case. However, each potential transaction will need to be evaluated against modeled assumptions to evaluate real-world return on investment.

6. Pilot water transactions for nature

At the outset of the SVWT feasibility assessment, we identified the need to test our ability to flexibly manage and deploy water assets as part of our evaluation of our ability to implement a SVWT. To that end, we have pursued four short-term water transactions over the past year. Three we are actively working to execute by October, and one we determined was not feasible due to a variety of circumstances, so we are not pursuing it further. We selected these projects deliberately in order to test and gain experience with different source waters and habitat uses, transferring water that we manage to a refuge, purchasing spot market water and sending to a private landowner to create wetlands, and supplying a refuge with water that has been transferred through the Delta.

We've learned valuable lessons by pursuing all four water transactions, especially related to the importance of relationships and expert support, approval processes, and internal alignment. Key learnings from our pilot transactions are described below.

Key Relationships

1. **Building relationships is necessary.** Doing a water transaction the first time with new partners takes time to develop; but once the relationships are established, transactions can move forward more quickly.
2. **Local irrigation district managers increase efficiency.** Providing water to private landowners to create shorebird habitat can be made more efficient by working in partnership with local irrigation district managers who are well-connected with landowners, local irrigation practices, and conveyance constraints.
3. **Experienced partners can aid Delta transfers.** Through-Delta transfers from the Sacramento to San Joaquin Valleys are more complex than transfers contained within a basin. Working with partners or established water transfer programs that regularly transfer water through the Delta helps to facilitate and streamline the process.

Experienced Expert and Third-Party Support

1. **Water broker support is necessary.** A water broker who is well-connected to California's opaque water market is necessary to acquire a strategic, well-balanced portfolio at the best prices, as well as to operate the portfolio to benefit nature and generate revenue by working within the criteria we set. A water broker is often paid on a commission basis and may employ the services of an engineering consultant.
2. **Engineering consultants can streamline approval.** Working with an engineering consultant who routinely executes water transfers can streamline approval and agency review processes because they are experienced with administrative processes and may be aware of how others have successfully approached similar transfers. A consultant, who is typically paid on a time-and-materials basis, may be able to perform some of the same transactional functions as a

water broker including short-term leases but may not have the same strategic portfolio-level approach or incentives as a water broker.

3. **RWSP can provide transactional support and some revenue.** Reclamation's RWSP is limited in its ability and/or willingness to pay for water but is able to bring resources to bear to complete a transaction (such as engineers and scientists to complete environmental documentation) and waive some transactional fees. Currently the RWSP will not purchase short-term lease water in the Sacramento Valley to supply Sacramento Valley refuges except in very dry years, when the program will pay approximately $100/acre-foot.[22] The RWSP will purchase short-term lease water in the San Joaquin Valley up to about $350/acre-foot, depending on year type and conveyance costs through partner districts.[23]

Agency Involvement & Approvals

1. **Each transaction is unique.** Water entitlements are complex and each water transfer is unique, although there are standard transactional requirements for each entitlement type. This supports the recommendation to employ water brokers and/or engineering consultants to navigate the issues specific to a given transaction.
2. **Contract water allocations will influence fund operations.** The ability to lease/transfer a water right in a given year depends on the water year type and CVP or SWP water allocation (typically expressed as a percentage of contract supply that the projects can deliver that year, depending on precipitation and storage levels that year). Allocation decisions are not made until February (earliest) through May (latest), creating a lot of uncertainty in the water community and compressing the leasing process each year. This variation in water allocations will shape our water asset management decisions year-over-year and will likely require support from a water broker as we will need to quickly respond once allocation decisions are finalized each year.
3. **Transactional costs are relatively small.** Transactional costs for agency or SWRCB approvals to transfer our portfolio water to nature are relatively nominal compared to the cost of acquiring water and conveying it through state or federal project facilities or water districts. The RWSP would cover these costs if it purchases the water for refuges. Typical transactional costs may include:
    a. Environmental Assessment preparation: <$1,000 (consulting), depending on transfer complexity and duration
    b. Public noticing (production, postage, online posting fees): $500-$800

[22] Currently, Sacramento Valley refuges who have functional conveyance have adequate water supplies in most years. Within the next 2-3 years, additional water supplies will be needed to supply Sutter NWR and Gray Lodge Wildlife Area for which conveyance is being constructed, so the program may then be willing to pay up to $100/acre-foot for additional Sacramento Valley water. Also, federal policy makes transferring north-of-Delta acquired spot-market water to south-of-Delta refuges problematic, primarily because the program cannot prioritize this water through the federal pumping facilities. Advocacy efforts are working to change this and allow more water acquired north-of-Delta to serve south-of-Delta refuges.

[23] The RWSP has an existing long-term water purchase agreement with the San Joaquin River Exchange Contractors which sets a price ceiling for short-term water acquired from others. In Below Normal, Dry, and Critical water years, the RWSP cannot acquire water at market rate at these prices. This contract may be renegotiated in the next couple of years.

c. SWRCB filing fee to submit a change petition involving a temporary transfer of water (for post-1914 appropriative water rights): $2,000 plus $0.30 for each acre-foot
d. Water monitoring (if needed or required by SWRCB): up to $5,000

Internal Processes & Alignment

1. **New SOPs may be necessary.** The development of new TNC SOPs or additions to existing SOPs may be necessary for selling or leasing water, and internal approval processes for water transactions need to be solidified and water program and transactional staff trained in the processes.
2. **Usefulness of existing TNC water assets is limited.** The water rights TNC currently owns or manages (e.g. Kopta Slough, McCormack Williamson Tract, Cosumnes River Preserve) are not necessarily well-suited to achieving the objectives of a SVWT, because for example, the water right type may not be transferable (i.e. riparian), or the property was purchased with public funds which limits its marketability or use, etc. A proactive, portfolio-based approach to sourcing water assets is needed, in which we start with the conservation objectives and short-term lease targets, identify the characteristics of the water assets that could best meet those objectives, and then choose the asset acquisition opportunities that align with those characteristics.

7. Legal and reputational considerations and risks

Legal feasibility

The Focus Group is working in close coordination with TNC's legal department to ensure the SVWT is developed in accordance with TNC Standard Operating Procedures (SOP) and is aligned with our non-profit 501(c)(3) status and conservation-focused mission. Initial conversations have identified Unrelated Business Income Tax (UBIT) as the most important near-term consideration during the Design Phase. Other legal considerations include the issuance of securities for fundraising, and private benefit.

Unrelated Business Income Tax

The biggest current legal consideration for the Focus Group during the Design Phase is related to Unrelated Business Income Tax (UBIT). If TNC performs income-generating activities that are not substantially related to the TNC's tax-exempt purpose and are not otherwise specifically excluded from UBIT by the Internal Revenue Code, these activities could be subject to income tax and other local taxes. Activities that trigger UBIT would require internal approval in advance.

Through discussions with TNC's legal department, the Focus Group has identified two potential pathways for mitigating UBIT concerns:

1. **Ensure that SVWT objectives are conservation-focused and clearly related to TNC's mission:** Generating income is acceptable; however, any income generated should be dedicated to

achieving our mission. For example, if we determine in a given year that providing SVWT water to nature above a certain amount wouldn't result in a measurable conservation benefit (or that benefit would be marginal), we could lease this surplus water, and the income generated by this activity would be considered incidental to our mission. As a second example, TNC could earn income through annual short-term water sales that have an environmental benefit, including to the RWSP or through a private lease with conservation restrictions on how the water is used; this income would also be considered incidental and the activities related to our mission.

Most critical is to clearly outline our conservation objectives and remove any doubt that the income is incidental. This will ensure that we're aligned with the Commerciality Doctrine, i.e. we don't want to participate in the market in the same way a for-profit entity would, where the Internal Revenue Service would have concerns that we're using our tax-exempt status for a competitive advantage. It is acceptable for TNC to conduct financial modeling and diligence for the purposes of planning, as long as our goal is conservation and not profit.

2. **Set up a separate legal entity that will own and operate water assets and pay taxes on any net income:** This option would give the SVWT flexibility in pursuing income-generating activities through a separate entity that would pay taxes on that income. NatureVest has done this for some of its investment projects. This approach would require a significant level of oversight and approvals at the TNC World Office level. The legal diligence and approval process would take several months. Taxes would need to be incorporated into the SVWT financial model.

Given that the fund will likely have non-land based assets and will focus on proving out pathways for achieving conservation through water markets, Option 1 is the suggested path for Phase 1. As we refine the operating model and objectives, we will continue to evaluate these options while working closely with TNC's legal department.

Issuance of securities and private benefit

Other legal considerations that the SVWT Focus Group will need to continue to analyze and adhere to include:

- **Private benefit:** As a non-profit TNC is prohibited from conducting activities that confer a benefit on a private interest. This applies to asset transactions that TNC pursues. The Focus Group will work closely with legal and TNC's Transactions team to ensure the final SVWT operating model does not create a private benefit concern.
- **Issuance of securities:** TNC employees are generally prohibited from discussing investment opportunities with potential equity investors targeting greater than 0% return. This will not be a concern for philanthropic funds if TNC pursues a concept that involves the issuance of securities. The team will need to work closely with legal and NatureVest's Director of Partnerships to understand any restrictions on how and with whom we discuss the concept.

Reputational considerations

Importantly, there are risks to TNC's reputation to consider with respect to participating in a developing water market that shifts water from agricultural and urban uses north-of-Delta to those south-of-Delta. Indeed, great ecological harm has been done by construction and operation of the state and federal water projects, including the Delta pumping facilities. Although today pumping is controlled by regulations and wildlife agency Biological Opinions that work to protect what is left, arguably regulations should be stronger to mitigate for or reverse the damage. Despite these sentiments, water for all water users, including the environment, is now heavily managed in the Central Valley, and ecosystems like wetlands at wildlife refuges in the San Joaquin Valley now rely on water conveyed through the Delta for their water supplies. We believe that by participating in the water market and designing transfers with the environment at the forefront, and by making well-informed trade-off decisions based on ecological needs, we have an opportunity to bring about changes in the current system that benefit conservation with far less opposition than through regulation. Our position on these issues and implications to our reputation will be carefully considered during the Design Phase of the SVWT.

Some concepts we can build upon during the Design Phase to avoid or mitigate reputational risks include:

- Make conservation outcomes central and the top priority of the operations plan.
- In cooperation with our NGO partners, use science-based approaches to establish ecological objectives and monitor progress towards those targets.
- Dedicate a portion of the portfolio of water assets for nature in every water year type.
- Require some of the water leased for revenue generation south-of-Delta to be used to create nature benefits.
- Focus messaging on the contribution we will make towards habitat water needs over the life of the Fund, and on the long-term objectives of retaining water assets for nature in perpetuity (if we choose the buy-back plan).
- Fully evaluate trade-offs across different water use scenarios by year type when designing the operations plan and continue to consider trade-offs on a case-by-case basis because ecological needs are dynamic.
- Acquire water quietly and demonstrate value to nature before broadly advertising the concept
- Build on our positive reputation and partners in the Sacramento Valley by working in-line with their objectives in choosing what water we acquire and how we use it.
- Rely on the support of a water broker who is well-acquainted with key stakeholders in the Central Valley to ensure we are following standard procedures, both legal and cultural.

Risks and preliminary mitigation measures

Launching a new fund like the SVWT inevitably involves exposing TNC to some reputational, legal and

financial risk. In order to protect TNC's reputation and resources, we are recommending a full risk assessment and mitigation plan be developed during the Design Phase. Table 3 provides an initial, preliminary assessment of the risks associated with the SVWT. We plan to build on this assessment in the coming months to fully evaluate these risks and identify approaches to avoiding or mitigating these risks. In addition, we propose pursuing a phased approach to launching the SVWT, including an initial smaller fund largely comprised of philanthropic and public capital, designed to test key assumptions and mechanisms and to ensure that risks can be adequately managed. Assuming this initial fund successfully demonstrates that these risks can be managed/mitigated, we would then move to grow the fund to a full-size of approximately $100 million that would include investment capital (assuming investor market research supports a fund of this size).

Table 3. Identified Risks and Mitigating Measures

Risk Area	Probability of Risk	Impact of Risk	Description of Risk and Mitigating Measures
Legal and Reputational Risks			
Inability to deliver water to nature on-time	Moderate	High	The feasibility study has included several pilot transactions that primarily test the plausibility of moving water around within the short timeframes as dictated by habitat needs. While several of the transactions are still ongoing, preliminary results indicate that we can successfully deploy water assets to benefit refuge water and to create wetlands on private lands.
Reputational risk including third-party impacts	Moderate	High	The greatest reputational risk is associated with TNC selling water south during dry years when it is needed by nature and by local water users in the North. We plan to mitigate this by setting aside a portion of the portfolio of water assets for nature north-of-Delta in every water year type, and by requiring some of the water leased for revenue generation south-of-Delta to be used to create nature benefits. In addition, TNC is well integrated into the Sacramento Valley community due to significant prior work in the region. A phased fund strategy would integrate TNC further, build trust in the concept, and illustrate our conservation-first approach to operating the fund. Additionally, we will rely on the support of a water broker who is well acquainted with key stakeholders in the Central Valley to ensure we are following proper norms and procedures.

Risk Area	Probability of Risk	Impact of Risk	Description of Risk and Mitigating Measures
Failure to meet conservation targets	Low	High	Water is not the only limiting factor for migratory bird conservation. For example, cultural practices on private lands also play a role. TNC's Bird Returns program has successfully created "pop-up" habitats for birds on rice fields in the Sacramento Valley; this initiative has given us confidence that our conservation targets are realistic and that we are able to create significant and measurable impacts.
Regulatory hindrances	Moderate	Moderate	The SWRCB is updating the Bay-Delta Water Quality Control Plan that may affect Delta outflow requirements and other standards that affect how much water is available to divert by Sacrament Valley water rights holders or potentially for export through the Delta. The Reinitiation of Consultation on the Long-Term Operations (ROC on LTO) of the SWP and CVP will ultimately result in new permitted water project operations and Biological Opinions that may also affect how much and when water is pumped through the Delta, that could affect revenue generation potential and habitat water south-of-Delta, either positively or negatively. These are extended, ongoing processes but each may resolve in the next 10 years.

Financial Risks

Unpredictable water prices	Moderate	Low	Water prices fluctuate significantly from year to year, and the revenue generation potential of this fund will depend on the sequencing of water year types (dry years generate more revenue than wet years). Over a 10-yr period, we expect these fluctuations to even out, so a mitigating measure is to operate the fund over a 10-yr period. We also expect the water market in the Sacramento Valley to appreciate considerably over the next 10 years due to SGMA implementation, more variable climate, hardening of water use for permanent crops and other factors (this is also supported by multiple consultants and TNC experts on the groundwater team). Together, these factors should mitigate the natural fluctuations we will see from year to year.

Risk Area	Probability of Risk	Impact of Risk	Description of Risk and Mitigating Measures
Failure to achieve projected returns	Moderate	Moderate	The financial model relies on numerous underlying assumptions; however, thorough modeling of the upside/downside potential of each assumption (including weather uncertainties, water pricing, underlying asset compositions) has resulted in a range of return expectations, all of them positive. In addition, we will mitigate for the risk of failing to meet expected returns by using a phased approach, where the initial phase is funded by public and philanthropic grants that do not require return on investment.
Inability to raise sufficient investor capital	Moderate	Low	We will mitigate for this risk by using a phased approach as described above that doesn't rely on impact capital to launch the fund. During the first phase, we will demonstrate an ability to generate returns while also providing water for nature, and we will begin cultivating investors for the second phase. Next steps include market testing with investors to determine appetite for fund participation. TNC has launched (or is preparing to launch) similar water for nature funds in Texas, Australia, and Washington which have been successful at raising capital from investors; however, fund size expectations should be reconciled with market testing.

Ecological and Climate Risks

Environmental harm`	Low	Moderate	As discussed previously, there are inherent trade-offs to moving water from one place to another, and from water user to another. Transferring water could result in unintentional ecological impacts at the water source or along conveyance routes (such as in the Delta). We will carefully design transfers with the environment at the forefront, and make well-informed, science-based decisions by fully involving our scientists and other field experts.
Unpredictable weather	High	Moderate	Weather patterns have a significant impact on financial returns; our financial model includes several extreme weather scenarios based on historical averages for water year types in the Central Valley. The team has tested financial outcomes for favorable and unfavorable weather scenarios; this risk is inherent to the fund model and is well understood. We have modeled the worst-case scenario for weather extremes and that scenario would still generate revenue for investors and significant water for nature.

Risk Area	Probability of Risk	Impact of Risk	Description of Risk and Mitigating Measures
Unpredictable weather	High	Moderate	Climate change modeling for California indicates that more severe dry years or more frequent droughts may occur. Because conveyance capacity is greater in drier years and increased incidence of dry years would correspond to more south-of-Delta sales potential over a similar period of time than without climate change. Despite these factors, we've based our analysis on the conservative assumption that existing Delta conveyance policies and climate change conditions continue.

Other Risks

Inability to acquire assets	Low	High	Significant market research has been done with three primary water consultants and brokers in the Western U.S. to better understand acquisition timing and costs, market size, and buyer/seller motivations. Based on these findings, we believe the scale of the water market in the Sacramento Valley and south-of-Delta is adequate to meet the needs of the SVWT.
Challenges with through-Delta transfers	Moderate	High	Through-Delta transfers are commonplace. Water is routinely transferred from the Sacramento Valley to the San Joaquin Valley, coastal agriculture, and urban water users. However, these transactions are complex and will likely require the support of a consultant/water broker. In general, these markets are well developed and active, but opaque. We will mitigate this risk by working with a water broker to execute through-Delta transfers (broker costs have already been built into our financial model).

Source: TNC Internal

8. Implementation phases and early work

This section describes our recommended phased approach to implementing a SVWT, preliminary work undertaken to explore elements of the first phase, and immediate next steps.

Implementation phases

We recommend proceeding with SVWT design, testing, and implementation using a phased approach that allows for testing, due diligence, and planning; gradual scaling up through creation of two different sequential funds; and a close-out period for both funds.

Design Phase

Time Frame: 6-12 months
We recommend that SVWT implementation begin with a pre-launch Design Phase to validate key assumptions and hypotheses before making significant financial commitments. Elements of the Design Phase include:

1. Finalize objectives and criteria: ecological, transactional, financial, legal, and operational.
2. Complete a thorough risk assessment and mitigation plan.
3. Develop an initial operating plan and a science-based process to evaluate trade-offs.
4. Determine roles, both internal and external, and how we may work with a water broker or other consultants.
5. Develop a preliminary portfolio by identifying, evaluating, and testing available assets for acquisition.
6. Obtain the necessary internal approvals and raise funds to acquire initial portfolio of water assets.
7. Other activities we identify as critical during this evaluation.

The Focus Group has already begun work on some elements of the Design Phase. That work is summarized later in this section under *Design Phase preliminary work*.

Following completion of the first four elements above, a transition period would begin during which we would start to raise funds for acquisitions under the next phase. Meanwhile, we and/or our water broker would identify, evaluate, and test potential assets to acquire using option agreements.

Option agreements reduce the risk of acquiring assets. An option agreement would be set up with conditions linked to our ability to successfully execute a short-term lease of that water. An option agreement can be signed with a relatively small percentage of capital at risk (option payment) and limited public knowledge. Once a short-term lease is successful (approved by the SWRCB), a record is established that the water is indeed “real water”, which significantly lowers the risk of purchasing the right and provides time to raise the capital to exercise the option agreements. After that successful transfer, we could choose (but would not be required) to exercise the option to buy the asset.

For these initial transactions, a commitment of approximately $1 million is needed to cover option agreements costs, due diligence, legal fees, engineering consultant fees, pilot transaction fees, and brokerage time from the start until the deals are done. Any water leased during the initial pilot transactions could potentially go towards paying down these costs.

Implementation Phase 1

Time Frame: 10 years, following completion of Design Phase
At the beginning of this phase we would establish an initial $25 million fund comprised primarily of philanthropic grants (with the potential for including PRI loans from foundations and zero-interest loans from Board of Trustees and California Leadership Council members), designed to evaluate whether ecological objectives can be met, test key assumptions and mechanisms, and confirm that risks can be adequately managed. The portfolio of assets acquired with these funds would include a diversity of appropriative water rights and federal or state water project contracts.

We recommend this initial fund size of $25 million for several reasons:

1. A fund of this size would enable acquisition of approximately 12,500 acre-feet of water, which is a substantial contribution toward meeting wetland habitat needs in the Central Valley (up to 15% of the unmet needs of Central Valley shorebirds outside the refuge system, or up to 10% of the unmet needs of south-of-Delta refuges).
2. Financial modeling indicates that below $20-25 million, return on investment is substantially reduced due to proportionally larger operating costs.
3. Water assets in California are expensive, and to achieve a diverse portfolio with a minimum of 4-5 unique water assets, a minimum fund size of $25 million is required.

Also of note, several other TNC funds with a similar structure and purpose have launched, or plan to launch, at or near $25 million.

Once an initial portfolio of assets is acquired, TNC would implement the operating plan developed during the Design Phase. Based on this plan and informed by the latest data on ecological needs and water supply conditions, TNC would decide annually how much water to make available for conservation purposes and how much, if any, to use for short-term leases to water buyers. The timing and frequency of exercising a short-term lease would depend on the individual water asset and buyer demand in each circumstance and would be selected strategically to maximize opportunities to achieve environmental benefits while covering programmatic costs and any external funder obligations.

Implementation Phase 2 (Optional)

Time Frame: 10 years, commencing approximately 3 years after establishment of Phase 1 fund
If the initial $25 million fund is successful (meets the preliminary Phase 1 objectives discussed later in this section) and market research indicates there is sufficient funder interest, TNC could choose to establish a second, larger fund after approximately three years, allowing us to dramatically increase our ecological impact. A substantially larger fund, such as one with a target of $100 million, would likely require a shift from a philanthropic funding model to one that relies largely on impact capital.

We recommend a Phase 2 fund size of $100 million to increase the scale of ecological impact and meet a much greater percentage of migratory bird habitat needs in the Central Valley. A $100 million fund would enable acquisition of approximately 50,000 acre-feet, which could provide up to about 60% of the unmet needs of Central Valley shorebirds outside the refuge system, or up to 40% of the unmet needs of

south-of-Delta refuges – collectively, about one-quarter of all currently unmet migratory bird habitat needs throughout the entire Central Valley.

An operating plan similar to that used for the $25 million fund would be developed and refined for Phase 2, and the $100 million fund would be operated accordingly with a similar annual decision-making approach.

Close-out(s)

Time Frame: At the end of the 10-year horizon of each fund
At the conclusion of each fund's time horizon (10 years), we would determine whether to sell or retain the water assets. Permanent sale of the assets would provide TNC with the returns necessary to meet any outstanding internal costs or external funder obligations that were not already achieved through any short-term water leasing activities during the life of the fund. Alternatively, if during the life of the fund we have secured enough revenue from short-term water leasing, or have raised sufficient funds in other ways, we could retain some or all of the water assets for nature's benefit in perpetuity.

Design Phase preliminary work

The Focus Group has already begun preliminary work on SVWT implementation. We will build on and refine this work during the Design Phase.

Preliminary SVWT objectives

Below are draft objectives – ecological, transactional, financial, legal and operational, for an initial SVWT of $25 million, and a full-size SVWT of $100 million. These draft objectives will be refined during the Design Phase.

Initial Fund ($25 million, 10-12,500 acre-feet water)
<u>ECOLOGICAL OBJECTIVES</u>

- Deploy 50% or more of the water portfolio to provide migratory bird habitat over the life of the fund and deploy no less than 25% of the portfolio to benefit nature in any given year.
- Demonstrate ability to create or enhance wetlands north-of-Delta across a range of water year types via transfers to refuges and private ag lands (likely rice). Note: this is the primary ecological target.
- Demonstrate ability to achieve ecological benefits south-of-Delta via transfers to refuges. Note: this is the secondary ecological target.
- Clarify ecological trade-offs associated with different transaction types, including trade-offs between wetland habitat and instream flows, and develop operating principles to maximize wetland habitat benefits while minimizing instream flow impacts.
- Evaluate the trade-offs of operating the fund to maximize short-term versus long-term ecological benefits (e.g. maximize profit during life of fund and use the revenue to permanently hold the water assets for nature vs. maximize nature benefits during life of fund but sell the assets at the end).

- Evaluate the need for a local implementation partner and/or technology to track ecological benefits.

TRANSACTIONAL OBJECTIVES

- Acquire 10-12,500 acre-feet in water assets and evaluate differences across water asset types in their ability to provide water for wetlands, generate revenue, operate dynamically, and manage risk (financial, legal, reputational).
- Demonstrate ability to achieve positive financial returns in dry/critically dry years via transfers south-of-Delta and evaluate potential to generate returns north-of-Delta in other year types.
- Determine viability of revenue-generating transfers to include requirements of the buyer that result in significant (simultaneous) ecological benefits.
- Prove out viability of acquiring stand-alone water rights from water conserved through unconventional permanent land use changes or water use efficiency measures.
- Determine the appropriate level of asset diversification to minimize risks while achieving short- and long-term ecological targets (e.g. how many types of each asset, including different water assets and water with land, do we need to achieve ecological and financial objectives while designing for key legal constraints?).
- Confirm our ability to acquire sufficient water assets for a full-size fund (roughly 50,000 acre-feet). Is there as much water available for acquisition as we believe there is?

FINANCIAL OBJECTIVES

- Acquire a portfolio of water assets using a variety of capital types, including philanthropic funds (individuals and foundations; gifts and loans), and possibly public funds. Identify the constraints and opportunities of each type of asset to acquiring and transacting water assets for the SVWT.
- Develop track record of deploying water assets to generate positive returns, to build case for an impact capital-focused, full-size fund of $100 million.
- Track the impact of SGMA implementation and other factors on north-of-Delta asset prices to determine whether appreciation is occurring as expected; if not, use observed trends to re-parameterize financial model and re-evaluate revenue projections for 10-yr fund.
- Determine financial impacts of different approaches to outsourcing transactional work to a water broker versus growing this function in-house.
- Evaluate financial model assumptions.

LEGAL/RISK OBJECTIVES

- Demonstrate ability to manage reputational risk associated with south-of-Delta transfers for revenue generation.
- Develop fund structure in compliance with legal limitations of a non-profit organization. Evaluate implications and trade-offs of creating a tax-paying entity to operate the fund versus housing the fund within TNC in full compliance with non-profit legal limitations.
- Evaluate whether TNC's entrance into this market (particularly re: conserved water) is serving to alert others to the opportunity, resulting in increased competition in the market, to inform operation of full-size fund.
- Determine and design around key legal constraints, including Unrelated Business Income Tax (UBIT), and real estate exemption for non-profits.

OPERATIONAL OBJECTIVES

- Determine TNC capacity/roles and water broker capacity/roles needed to implement a $25 million fund and recommend staffing approach and roles for full-size fund.
- Create a lean operating model and determine best approach to streamlining decision-making (e.g. how to deploy assets in a given year), evaluating trade-offs, and adapting over time.

Full-size Fund ($100 million, 40-50,000 acre-feet water)

ECOLOGICAL OBJECTIVES

- Provide 30,000+ acre-feet for migratory bird habitat annually, on average, through a combination of transfers north-of-Delta (refuges and private land) and potentially south-of-Delta (refuges).
- Maximize timing and location of transfers to benefit migratory birds, while ensuring no significant harm to species relying on instream flows.
- Implement a robust tracking system to quantify ecological benefits gained through water transfers.

TRANSACTIONAL OBJECTIVES

- Acquire and deploy a variety of water assets (40-50,000 acre feet, exact mix of assets TBD based on initial fund findings) to provide water for wetlands, generate revenue, operate dynamically, and manage risk (financial, legal, reputational).

FINANCIAL OBJECTIVES

- Obtain a portfolio of water assets using a variety of capital types, including philanthropic funds (individuals and foundations; gifts and loans), investor capital, and possibly public funds.
- Deploy water assets to generate sufficient returns for investors (targeting an 8% return).
- Demonstrate the potential to achieve significant gains for the environment while generating revenue for investors for a large fund size.

LEGAL/RISK OBJECTIVES

- Deploy assets in a manner that achieves fund objectives but minimizes (or mitigates) legal, financial and reputational risk.
- Continue to identify emerging risks and determine measures to minimize or mitigate those risks.

OPERATIONAL OBJECTIVES

- Efficiently deploy TNC staff and consultants to operate full-size fund, manage capacity and roles adaptively over the course of the fund.
- Operate the fund using a clear set of ecological and financial principles that guide decision-making each year.

Risk assessment and mitigation plan

As part of our next steps, we plan to complete a thorough risk assessment and mitigation plan that further examines the risks identified in Table 3. We plan to incorporate key findings from the pilot transactions and 12-month options contracts to adjust the probability and anticipated impact of the

outlined risks; at that time, we will have a better idea of mitigation strategies that can maximize our conservation impacts and financial return projections.

Role of a water broker

Early in the Design Phase, we must decide whether and how to engage a water broker in the SVWT. We strongly recommend engaging a water broker to connect us with a variety of asset options and quickly and efficiently acquire a strategic portfolio. A broker must be active in the Sacramento Valley water community and know what is already on the market as well as what could become available to acquire in the near-term. A broker could also walk us through the acquisition process and connect us to individuals who could conduct a high level of due diligence, thereby lessening our risk.

We explored the various broker- relationships we could pursue as we begin to acquire water assets, summarized in Table 4. We recommend proceeding with working with a water broker in either a "Broker" or "Fund Manager - Single Investor" framework.

Table 4. Various broker relationships and associated fee structures

Relationship Type	Description	Fee Structure	Level of Commitment by TNC
Broker	Includes identification, development, negotiation, structuring and completion of water transactions; TNC has right-of-first-refusal.	Monthly retainer and success fee	Low
Developer	TNC provides a "buy order" for broker. This generates interest of sellers to work directly with broker.	Commitment to purchase from broker	Medium-Low
Fund Manager – Single Investor	TNC is single investor (capital raised through donors); broker is also general partner and TNC is active limited partner. Broker to contribute operating capital.	Annual management fee	Medium-High
Fund Manager – Multiple Investors	Variation on #3; the water fund will seek outside investors with TNC as lead investor.	Annual management fee	High

Source: Sierra Water Development 2018

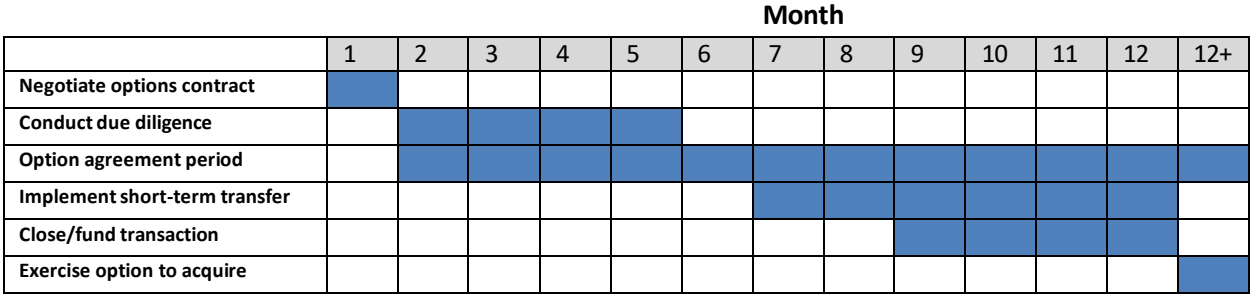
Preliminary portfolio development process

Once under contract, a broker could quickly identify water rights eligible for acquisition and provide a detailed write-up within 30 days. The broker would identify a set of water transactions totaling our target acquisition value. The transactions would include water that has been marketed and transferred

into the Dry Year Purchase Program. Once we select a water right, we would further test it through an option agreement, which can be signed in approximately 30 days. From then, we would have 12 months (or more, if desired) to decide whether to proceed with the acquisition. Most due diligence can be conducted concurrent with the option period, along with a pilot transfer of the water right that could be set up to be completed in a year. After the water transfer is approved, we or our water broker would exercise the option(s) to purchase the water rights.

Figure 9 shows the steps and time frame for acquiring a water right that includes an option agreement.

Figure 9. Timeline for acquiring a water right that includes an option agreement



Source: Sierra Water Development 2018

Preliminary sources of funding

The Focus Group analyzed several types of capital for alignment with the SVWT concept. For the proposed Phase 1 of $25 million, our focus was on identifying the lowest cost and most flexible capital. All of the capital providers in Phase 1 would be appropriate for Phase 2, with the addition of impact investors seeking a market-rate return for the larger Phase 2 at $100 million. In Table 5, we have outlined relevant preliminary sources of funding and alignment with this concept at each Phase. These preliminary sources of funding will be vetted via market testing (done in coordination with NatureVest so as to comply with marketing guidelines for impact investing) and will ultimately inform the structure of the SVWT.

Table 5. Types of Capital and Relative Alignment

Type of Capital	Suitability for Phase 1: $25m	Suitability for Phase 2: $100m	Alignment
Foundation - PRI Debt	**MEDIUM**	**HIGH**	PRI loans are attractive as we can build track record by returning capital at a below-market interest rate. Without steady cash flows from ag land in Phase 1, a PRI may be a bit more difficult to structure. TNC is familiar with structuring PRIs and has previously negotiated terms that would be well-aligned with the SVWT, and initial conversations with CFR indicate this project could be a good fit for a PRI loan.

Type of Capital	Suitability for Phase 1: $25m	Suitability for Phase 2: $100m	Alignment
Foundation - Grant	**HIGH**	**HIGH**	Grants are attractive as they do not require repayment and are among the most flexible type of capital available to the SVWT. A high percentage of grants will enable us to maximize the amount of water sent to nature and will prop up revenue for return-seeking investors. Several foundations have already provided grant capital for this effort, and initial conversations with CFR indicate this project could be a good fit for additional grant funding.
Philanthropic Gifts	**HIGH**	**HIGH**	Philanthropic gifts are attractive as they do not require repayment and are among the most flexible type of capital available to the SVWT. A high percentage of gifts will enable us to maximize the amount of water sent to nature and will prop up revenue for return-seeking investors. The Individual Giving team has identified several donors who may be interested in participating in the fund.
Public Funding	**LOW**	**LOW**	Public funding is relatively inflexible capital. It is likely that any public funding would need to be used for the acquisition of a specific asset, instead of a contribution to the larger SVWT pool of capital. Additionally, this capital will likely require long-term (20+ years) or permanent conservation benefits beyond the time horizon of the fund and could not be sold to generate revenue for other capital providers.
Board of Trustees (BOT) & California Leadership Council (CLC) - 0% loan	**HIGH**	**HIGH**	This type of capital would likely be structured as a 0% loan and would require repayment of the principal. BOT/CLC capital would allow us to develop track record for the repayment of "investors" while enabling us to maximize our benefits to nature. Several BOT & CLC members have expressed interest in funding innovative investment efforts at TNC.
Impact Investors (>0% IRR)	**LOW**	**HIGH**	Phase 1 is designed to test the SVWT concept rather than maximize revenue generation for investors; it is recommended that impact capital be considered as a highly-aligned source of capital for Phase 2. These investors would likely expect market-rate returns for their capital and will require evidence from Phase 1 that our return targets can be met.

Source: TNC Internal

9. Conclusions

This assessment indicates that a SVWT is feasible in California, and further that TNC has a unique role to play as one of only a few conservation organizations in the world that could successfully fundraise and orchestrate implementation of such a model. Launching the SVWT is also timely, due to the promising water investment opportunities and increasing demands on our water supply that will put even more pressure on our freshwater biodiversity in the next decade.

There are still many questions we must answer during the Design Phase, which we plan to complete over the next 6-12 months. In brief, if TNC chooses to proceed, the next steps for the SVWT include:

1. Launch the SVWT by entering into 4 to 5 option agreements using philanthropic support ($20-$25 million).
2. Complete initial transactions for nature and/or revenue generation with these assets.
3. Complete financial and legal due diligence (including risk assessment and mitigation plan).

Applying Spatial Data for Decision-Making and Planning in a Dynamic System

Matthew E. Reiter

Analytics Team Meeting – Fall 2021

Point Blue
Conservation science
for a healthy planet

Black-necked Stilt in Central Valley Rice

Agenda

Target: By the end of the meeting the team will be up to date on the approach currently being used to assess bids and discuss strategies for extending the effort to other crops and managed wetlands.

1. Background on current analytics
2. Review approach for upcoming auctions (managed wetlands, Delta farmlands)
3. Discuss as group

Point Blue

Overview

Background

Data input generation (data/variables/suitability)

Score Calculations and Assessment

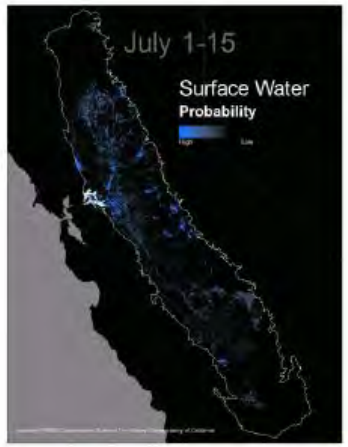
Bid Evaluation

Considerations and Next Steps

Point Blue

Where and when to put water to maximize multiple benefits in a dynamic landscape?

Data-Driven Decision Support Optimizes Water Management to Achieve Multiple-Benefits

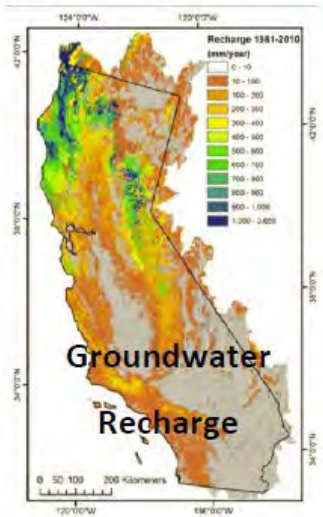


Point Blue

Biological Targets
Waterfowl
Shorebirds
Giant Garter Snake

+

Ecosystem Service Targets
Groundwater Recharge
Freshwater Biodiversity



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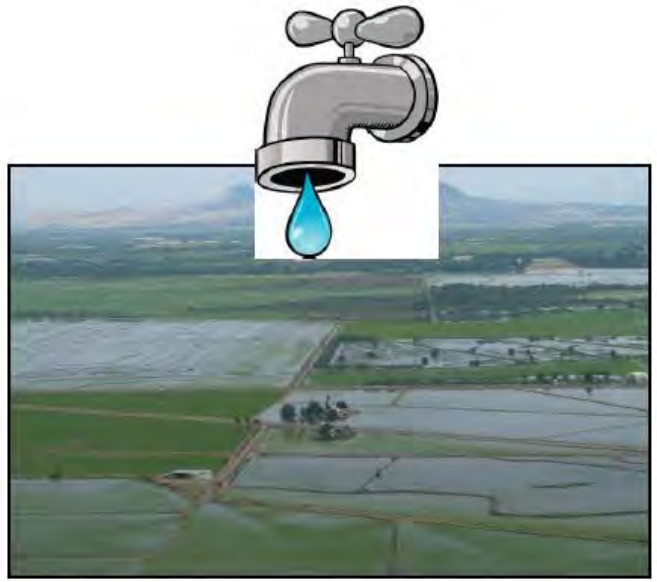
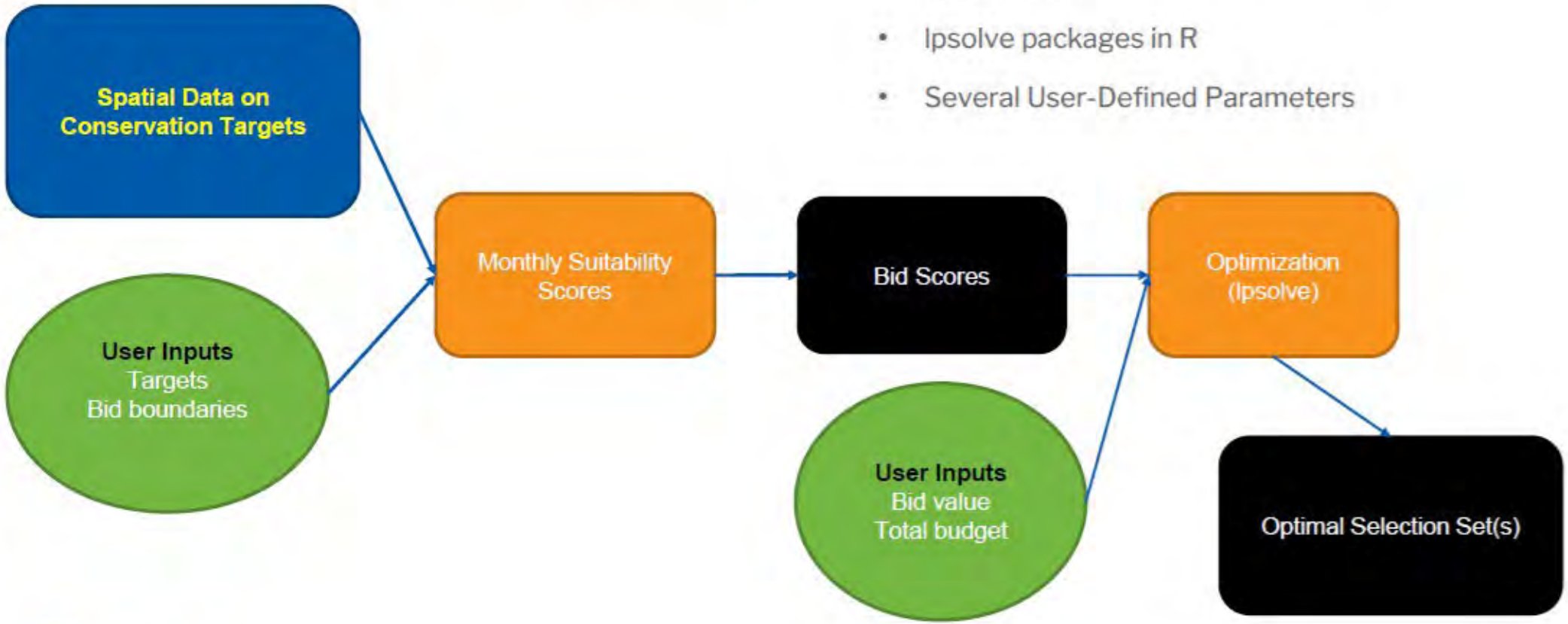


USGS science for a changing world
The Nature Conservancy
U.S. Fish & Wildlife Service
NASA

General Framework

- Leverage cloud-based systems to store all relevant data, code and to conduct optimization
- lpsolve packages in R
- Several User-Defined Parameters



Point Blue

Developing suitability scores

- Bird data (Point Blue structured surveys/filtered eBird)
- Boosted Regression Trees
- Identify key drivers for forecasting
- Assessed Real-Time versus Long-Term Average
- Drought vs. Non-Drought Years

Point Blue USGS science for a changing world The Nature Conservancy U.S. Fish & Wildlife Service NASA

Conlisk et al. models

Variables for Shorebird Models

Overall flooding (250m and 5km around observation)

Flooded wetlands (250m and 5km around observation)

Flooded rice (250m and 5km around observation)

Flooded corn (250m and 5km around observation)

Flooded row crops and grain (250m and 5km around observation)

Flooded fallow (250m around observation)

Observation Type: eBird, Point Blue, Bird Returns

Maximum temperature

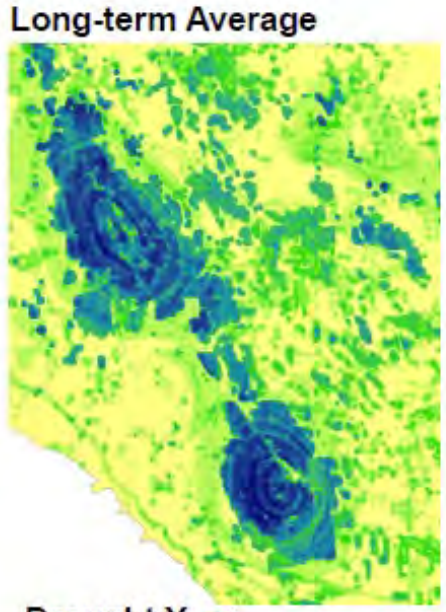
Road density (5km radius)

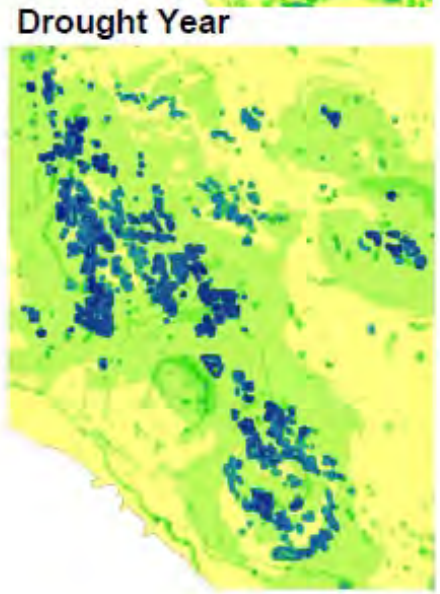
Month of year

Wetland Productivity*

Point Blue

Boosted Regression Tree





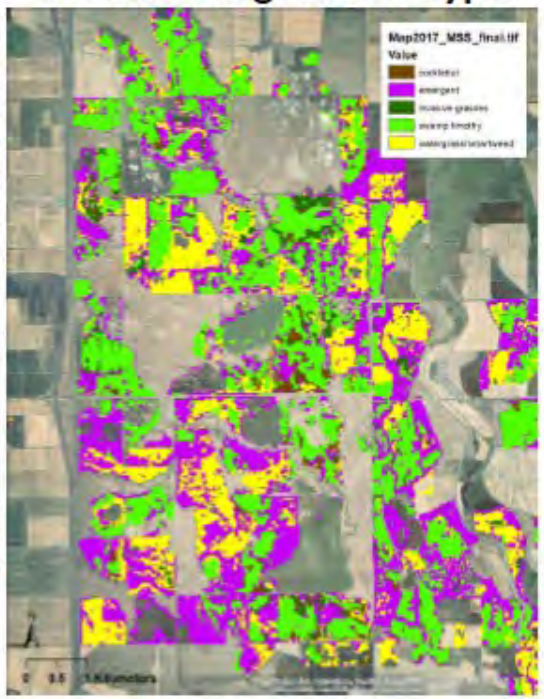
Habitat Quantity / Quality

Landsat 5 & 8
2007-2017

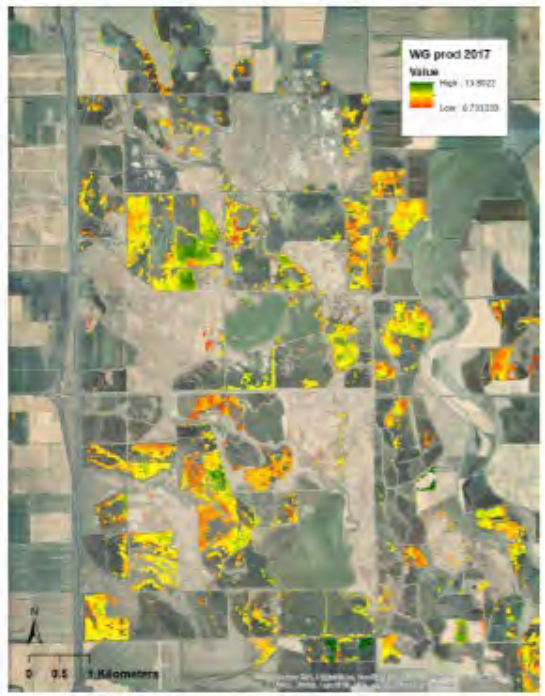
watergrass

swamp timothy

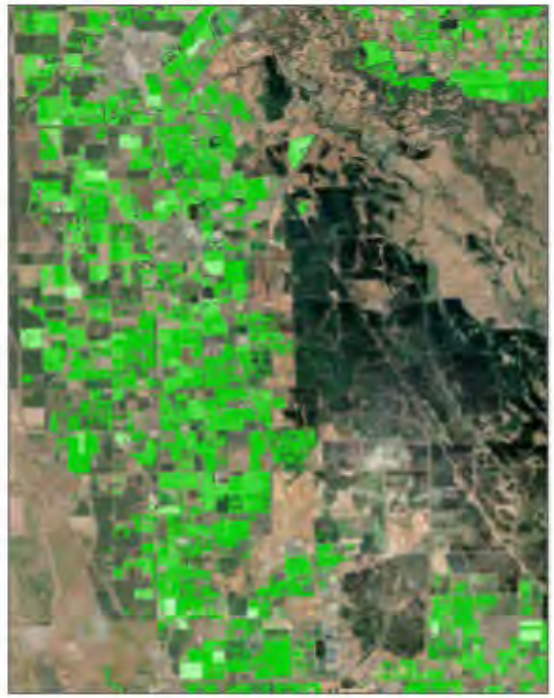
Wetland Vegetation Type



Wetland Productivity



Crop Productivity



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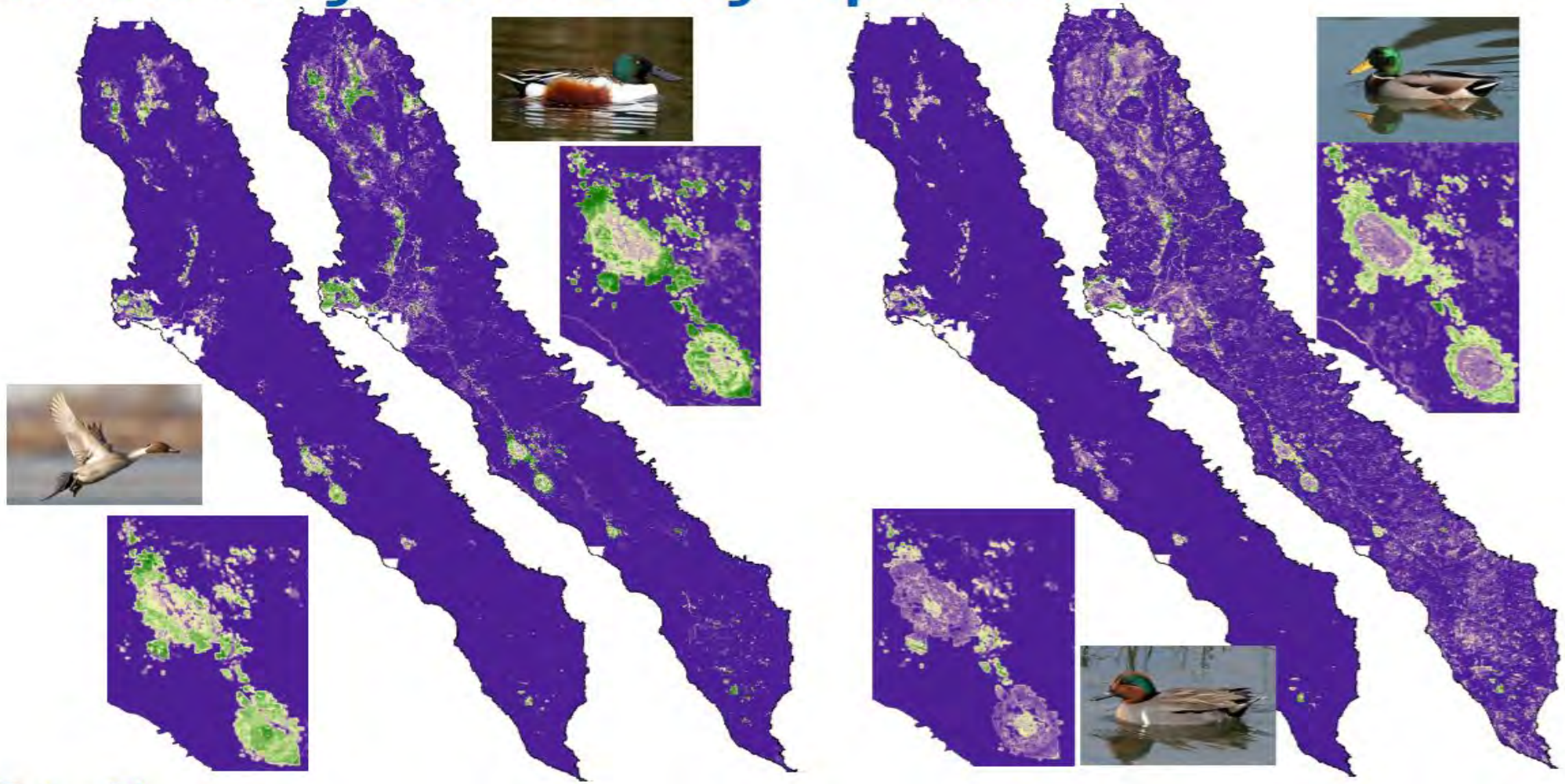
Swamp Timothy: 32,369 ha ± 2,524 ha
Watergrass/Smartweed: 13,012 ha ± 1,384 ha

Suitability varies by species



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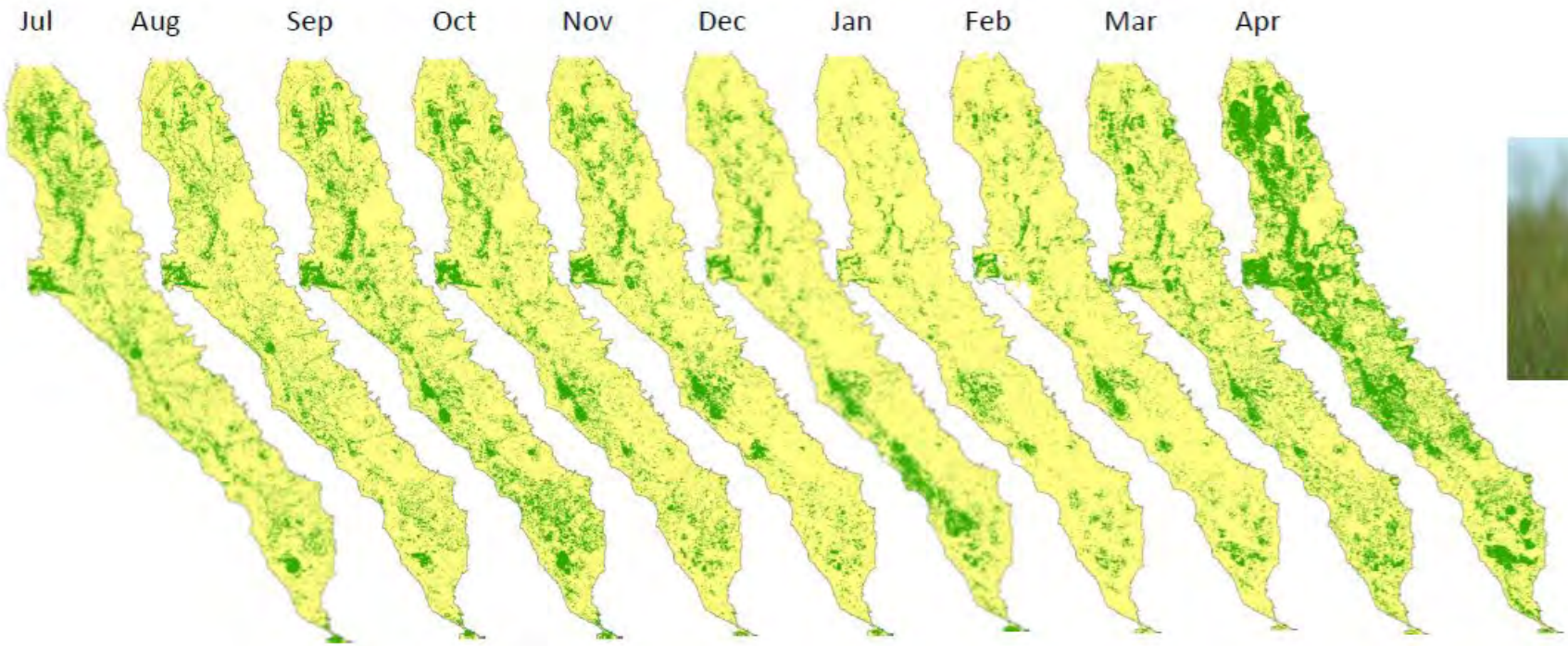
AUC: 0.89 0.92 0.93 0.89

Suitability is seasonally dynamic



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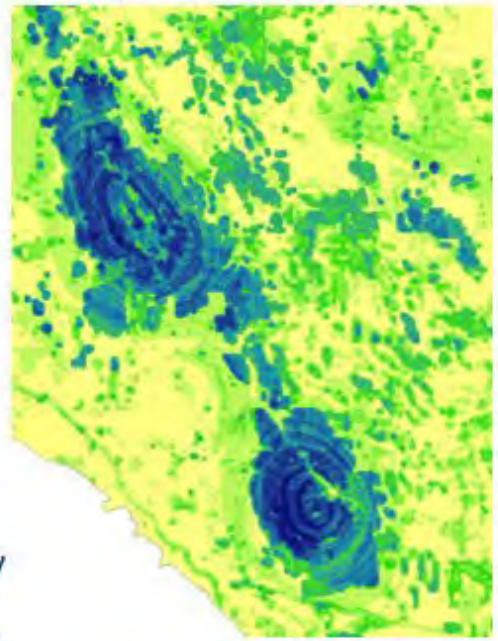
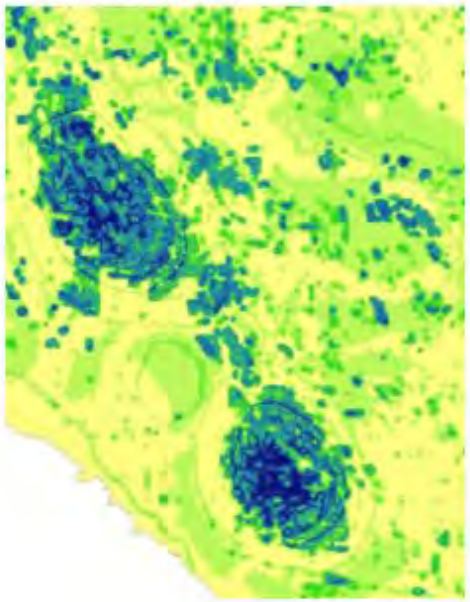
Suitability is dynamic among years

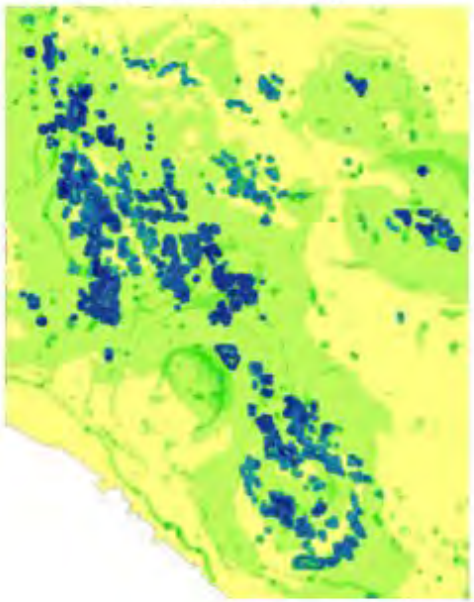
Long-term Average



Wet Year (2005)



Dry Year (2014)



Suitability

High

Low

October

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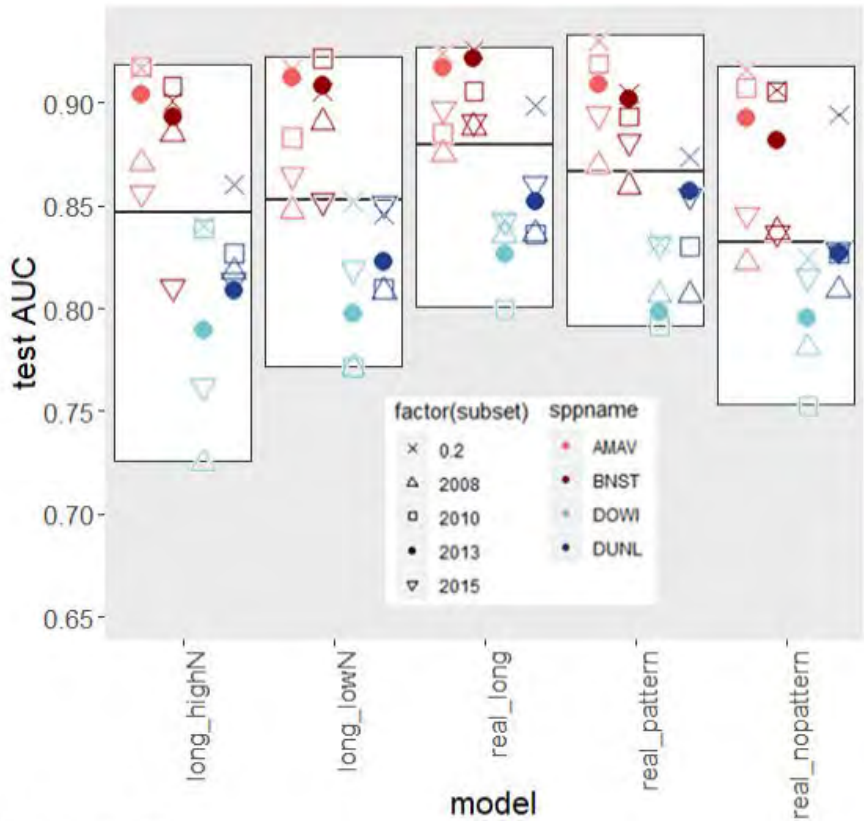
Both real-time and long-term habitat data predict habitat suitability

- Considered 5 models with combinations of real-time and long-term average water data
- All models predicted well
- Little benefit of real-time data
- Combination of real-time and long-term was best and lowest variability in AUC across species and test samples



Conlisk et al. *In Prep.*

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Generating the Water Forecast

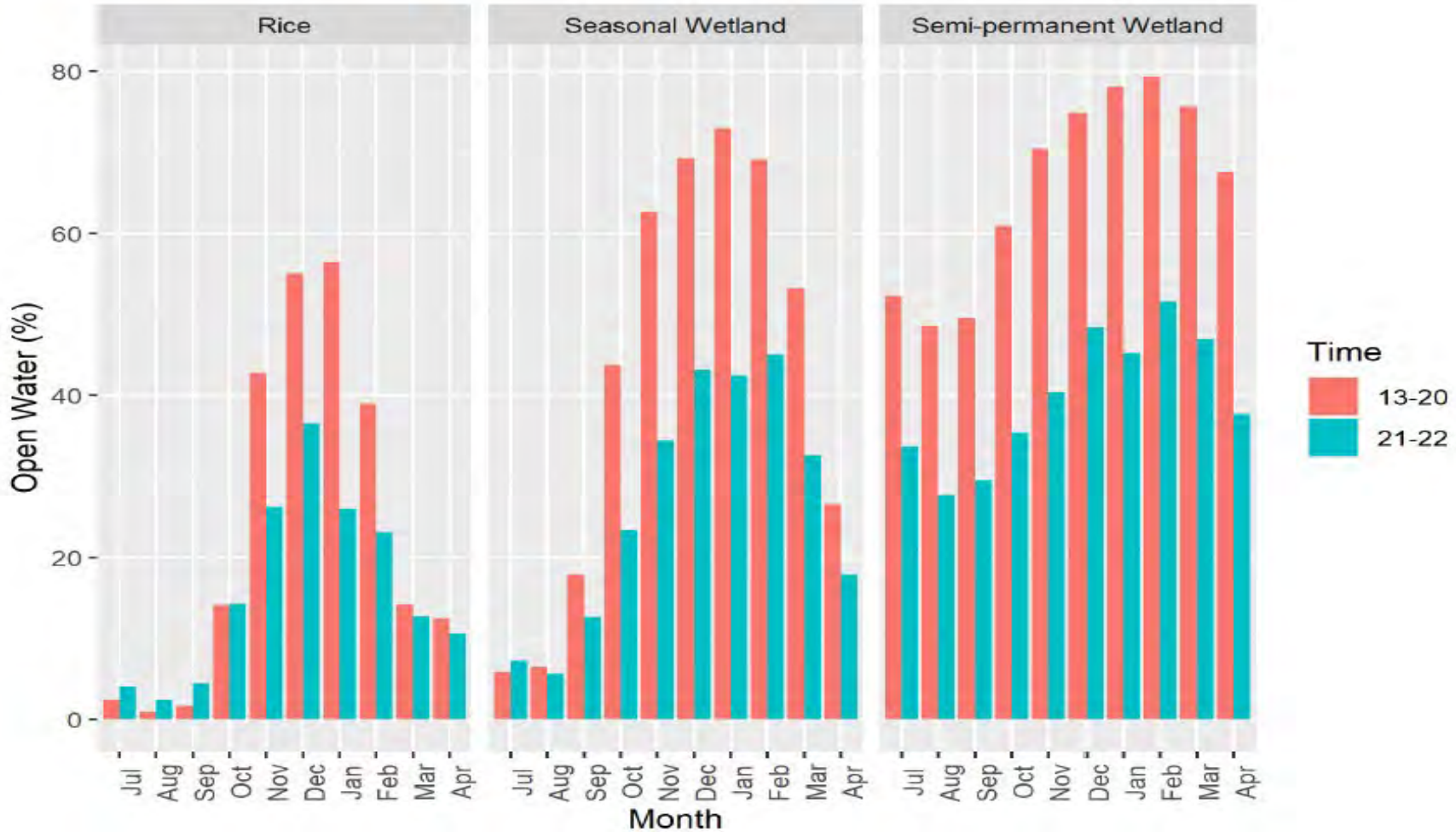
- Water Forecasts based on machine learning model
- Model uses information known as of April 1
  - 10-year average probability of flooding in a pixel
  - Water year index from previous year
  - Forecasted water year index for current year
  - Basin
  - Landsat scene

- Monthly spatial predictions shown to be 85-95% accurate

Open Water by Cover

Blue is forecasted

Red is 2013-2020 average



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Imposing flooding

- Models based on regular conditions observed at sites
- Auctions often occur in periods when fields are not typically flooded
- Need to impose flooding in the proposed fields and then calculate suitability
- Testing with previous BirdReturns data showed this is improves predictions

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Accuracy of Suitability/Selection Metrics

- Compared bird suitability forecasts using multiple approaches for 2016-2017 BirdReturns fields to observed data
- Compared mean suitability vs. sum of suitability within a survey area with total birds and total focal (those modeled) birds counted in surveys
- Sum of suitability was better predictor of total bird use ➔ makes sense as accounts for total area of habitat

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How to select bids given a budget?

- Operations Research is a branch of mathematics focused on optimization for decision making
- Linear programming (LP, also called linear optimization) is a method to achieve the best outcome (such as maximum profit or lowest cost) in a mathematical model whose requirements are represented by linear relationships.
- Linear programming provides an approach to select bids based on their habitat value, bid cost and total program budget.
- lpSolve package in R provides relatively easy approach for specifying our optimization problem

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The problem

- Maximize the overall bird value
- R and lpsolve
- Constraints
  - Budget
  - Complete bids/fields must be taken

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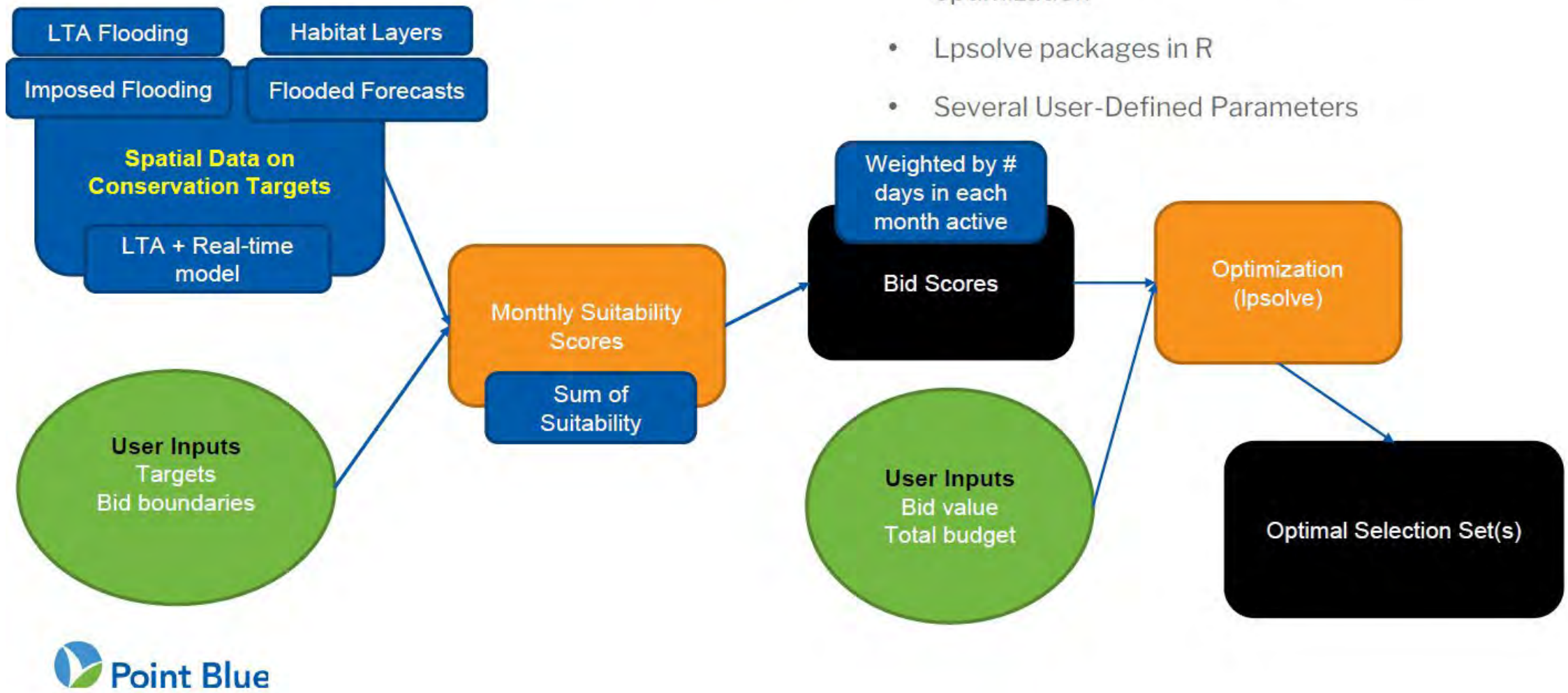
Current Framework

- Leverage cloud-based systems to store all relevant data, code and to conduct optimization
- Lpsolve packages in R
- Several User-Defined Parameters



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Extending to wetlands and the Delta

- Framework is easily extendable as wetlands, corn and field and row crops are all in the suitability models
- Need new data to test predictions as was done in rice with BirdReturns data
- Other species to include? Cranes?

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Considerations moving forward…

- The importance of start/end date and duration
- Simple approach for wetlands if oversubscribed to at least look at habitat condition
  - Shorebirds ➔ how much of wetland is open water?
  - Waterfowl ➔ % moist soil seed plants and moist soil seed productivity?
  - Need funds to update Byrd et al. (2020) maps for 2018-2021 and beyond

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Evaluating the effects of post-harvest rice field water residence time on benthic invertebrate prey resources: an experimental approach

JANUARY 2021

Prepared by: Isa Woo and Susan De La Cruz

BACKGROUND AND INTRODUCTION

The Sacramento Valley has extensive rice agricultural fields which are harvested in the fall. The practice of shallow flooding of post-harvest fields facilitates the decomposition of remaining rice stubble. Fields are typically flooded in fall and water is kept on the them until it percolates into the ground, evaporates, or is drained off in late winter. Studies have shown that these fields can be managed for the benefit of both waterbirds and fish.

The Nature Conservancy (TNC) in conjunction with partners implemented an innovative program called BirdReturns, that paid local rice farmers to flood fields and manage the water depths in areas where models projected the greatest habitat need. Results of this program documented showed significantly greater shorebird density, richness and diversity than control fields in both spring and fall (Golet et al. 2018). In addition, flooded agricultural fields have been shown to produce abundant zooplankton food resources for juvenile salmonids (Katz et al. 2017). To study the opportunities to export the high zooplankton production from flooded fields to salmonids in the river, the Fish Food on Floodplain Farm Fields (FFoFFF) program (led by Caltrout, UC Davis and others) documented extremely high zooplankton productivity where shallow water persisted for several weeks.

The FFoFFF program is partnering with TNC, Point Blue Conservation Science, and Audubon (collectively the migratory Bird Conservation Partnership [MBCP]) to determine whether water management flooding-drawdown cycle(s) on post-harvest agricultural fields in the winter can be optimized to benefit prey resources for both waterbirds and salmonids.

In 2019 – 2020 the FFoFFF program led an experiment to evaluate three water residence times manipulations (high, medium, low) at River Garden Farms (RGF) in Knight's Landing, CA, to determine the impact of the treatments on zooplankton production. The Nature Conservancy led efforts to examine waterbird response to these hydrologic manipulations and partnered with USGS Western Ecological Research Center, San Francisco Bay Estuary Field Station (hereafter USGS) to examine available benthic macroinvertebrate prey resources for waterbirds in these experimental rice fields.

Here we present preliminary updates on the benthic macroinvertebrate abundance and biomass associated with the treatments.

METHODS

Benthic invertebrate collections were closely coordinated and timed to complement FFoFFF research on zooplankton exports for fish

At RGF experimental fields were constructed with Wide, Medium, and Narrow widths corresponding to water flow rates that resulted in residence times labeled as "Low," "Medium," and "High," respectively (Figure 1). These three treatments fields were replicated three times for a total of nine fields.

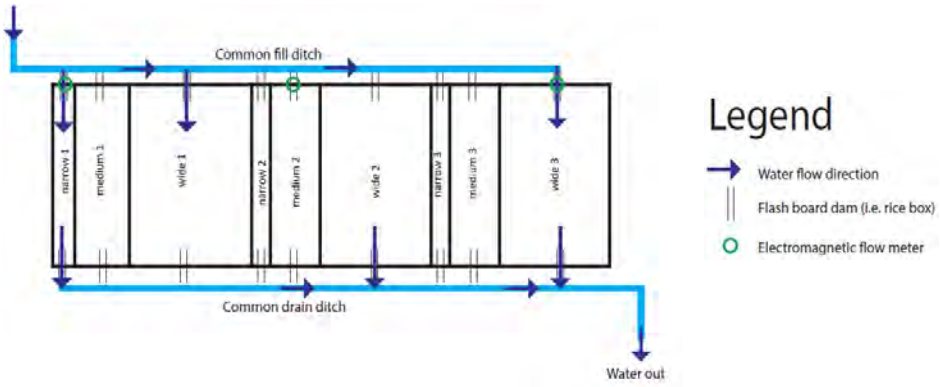

Figure 1. Schematic of constructed experiment including Narrow, Medium, and Wide fields (n = 3 per treatment) that corresponds to Low, Medium, and High water residency times for a total of nine experimental fields (from J. Montgomery).

Seven benthic cores were randomly collected from each field, for a total of 63 cores (21 cores per treatment). The experimental fields were flooded Jan 28, 2019; however, machinery used to grade the fields for water flow had resulted in highly compacted soils. The standard benthic corer used by USGS was not able to penetrate the soils, so they returned a week later with a custom plunger-top coring device. They collected benthic core samples with TNC on Feb 7 and 10, 2019. Water was drained off all fields on March 30, 2020, and 63 benthic cores were collected on April 1, 2020, from the same locations as the February collection (within 1m). All cores were stored in a cooler with ice and processed at the USGS Invertebrate Ecology Lab in Fremont, CA. Within one week of collection, all cores were sieved over a 0.5-mm mesh screen and the resulting sample matrix was stored in 95% ethanol and rose bengal dye solution for later sorting and identification. During sorting and identification, invertebrates were identified to broad taxonomic groups such as Phylum (*i.e.*, Nematoda), SubClass (*i.e.*, Oligochaeta), or Family (*i.e.*, Chironomidae), and enumerated and recorded for life stage (*i.e.*, egg, larva, pupae, nymph, or adult) using stereo dissection microscopes at a magnification range of 7–45x. For the purpose of enumeration, only whole organisms or individuals with heads were counted. Fragments and plant seeds were excluded. Samples were then dried in a drying oven until constant mass was achieved and weighed on a 0.1-mg semi microbalance. We used ANOVA to test for differences in treatment means and we used Tukey's pairwise comparisons to further test the overall treatment means of each other for major taxa.

RESULTS AND DISCUSSION

In February (Winter), four taxa were detected: Chironomidae (non-biting midges) larvae; Coleoptera (beetles) larvae; Nematoda; and Oligochaeta (earthworms; Table 1). In April (Spring), a total of 14 taxa were detected with multiple life stages for Chironomidae and Hemiptera (true bugs; Table 1).

Table 1. Macroinvertebrates detected in sediment cores from Narrow, Medium, and Wide treatments during Winter and Spring 2020.

	Winter 2020			Spring 2020		
Taxon ID	Narrow	Medium	Wide	Narrow	Medium	Wide
Cyclopoida				1	4	3
Collembola					1	
Aphididae					1	2
Brachycera larvae				1		
Chironomidae adult				1		
Chironomidae larvae	1		2	87	153	255
Chironomidae pupae				1	2	
Coleoptera larvae		1		2		
Corixidae nymph				1	8	2
Formicidae					1	
Hemiptera adult						1
Hemiptera nymph					3	1
Hymenoptera larvae						2
Nematocera pupae				2		
Staphylinidae					1	
Nematoda	12	24	16	15	27	40
Oligochaeta	7	3	4	2	1	2
Ostracoda						1
Total	*20*	*28*	*22*	*111*	*201*	*307*

Winter

A sparse number of invertebrates were detected in Winter. Out of the 63 benthic cores collected in Winter, 29 (46%) did not have any macroinvertebrates detected. A total of 70 individuals were detected, primarily Nematoda (74%), Oligochaeta (20%), Chironomidae larvae (4%), and Coleoptera larvae (1%; Table 1; Fig. 1). Total Winter invertebrate counts were similar among treatment fields (Narrow = 20 invertebrates, Medium = 28 invertebrates, Wide = 22 invertebrates) and treatment means for invertebrate abundance were not statistically different ($F_{2,20} = 0.71$, p=ns).

Although Nematodes were the most abundant taxa in winter, their dry weight was too low to be measured on the analytical balance (< 0.1 mg). Chironomidae larvae comprised the majority of total dry weight biomass, and mean biomass was higher in the Wide treatment fields (mean ± SE; 0.08 ± 0.06 mg/core) compared to the Narrow fields (0.04 ± 0.04 mg/core; Fig. 1). One Coleoptera larva was detected in the Medium treatment field (0.01 mg). And although Oligochaetes comprised 20% of overall abundance, their dry weight biomass was relatively low with the greatest biomass observed in Narrow (0.33 ± 0.20 mg/core), followed by Wide (0.19 ± 0.11 mg/core) and Medium (0.14 ± 0.08 mg/core; Fig. 1).

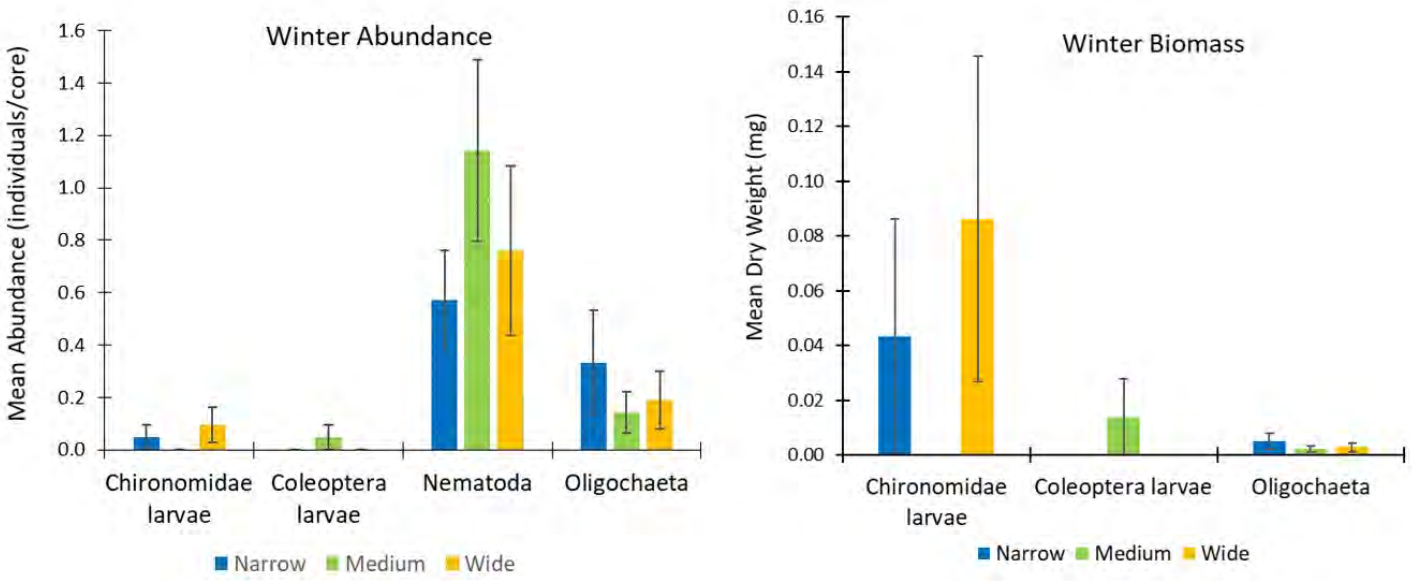

Figure 1. Mean abundance (left) and biomass (right) of invertebrate taxa in Winter by Narrow, Medium, and Wide treatment fields.

Spring

In Spring, all 63 benthic cores had benthic macroinvertebrates present and a total of 624 benthic invertebrate individuals were detected, primarily consisting of Chironomidae larvae (80%), Nematoda (13%), Corixidae (2%), and several other taxa comprising less than 2% of the total count (Table 1; Fig. 2). Treatment means for invertebrate abundance were statistically different ($F_{2,20}$ = 18.00, p<.0001). Total Spring invertebrate counts were lowest in Narrow fields (111 invertebrates), followed by Medium (201 invertebrates), and Wide fields (307 invertebrates).

Dry weight biomass was dominated by Chironomidae larva and all other taxa had negligible contributions to total biomass in Spring (Fig. 2). For Chironomidae larvae, abundance and biomass were significantly different between each treatment field (pairwise comparisons of treatment means, *all p<0.05*). The biomass of Chironomidae larvae increased as field width increased (Narrow fields = 4.1 ± 0.7 mg/core, Medium fields = 7.3 ± 1.0 mg/core, and Wide fields = 12.1 ± 1.2 mg/core; Fig. 2). Wide fields had almost three times greater biomass of Chironomidae larvae than Narrow fields.

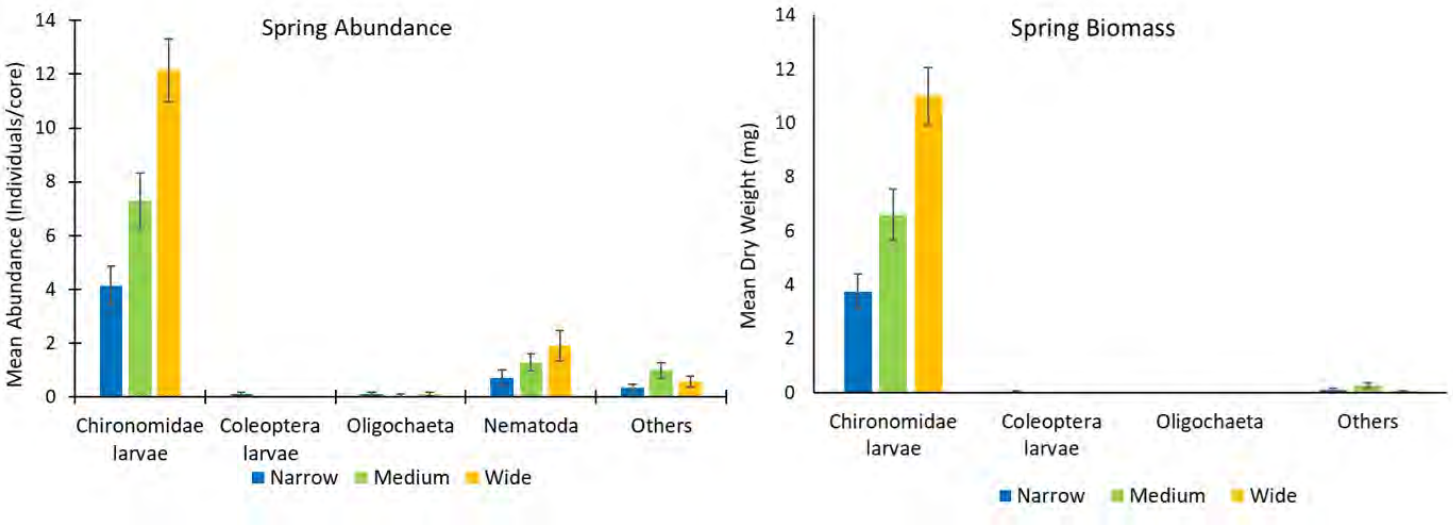

Figure 2. Mean abundance (left) and dry biomass (right) of invertebrate taxa in Spring by Narrow, Medium, and Wide treatment fields.

These results indicate that the abundance and biomass of Chironomidae larvae significantly increased as water residence times increased. Treatment effects were evident after only 62 days of shallow flooding, suggesting that management of post-harvest rice agricultural fields during winter and early spring can increase benthic prey for predators such as shorebirds and native fishes.

Chironomidae is diverse and ecologically important taxonomic family of non-biting midges (also known as nematoceran flies) that are commonly found in freshwater and brackish habitats. The Chironomid life cycle spans benthic, aquatic, and terrestrial zones: females lay eggs in aquatic habitats, larvae typically float down and settle in benthic zone, the pupa life stage is rather short-lived and swims to the surface to emerge as an adult fly (Pinder 1986). Some species of Chironomids are capable of completing multiple generations in a single year, depending on temperature or food supply (Stahl 1986). Temperature has been strongly linked to larval growth (Mackey 1977, Reynolds and Benke 2005, Tronstad et al. 2010), though food limitation may also play a role (Entrekin et al. 2007). The Chironomid larval, pupal, and adult life stages are important prey resources for a variety of ducks (Safran et al. 1997), shorebirds (Taft and Haig 2005), salmonids (Sommer et al. 2001, Benigno and Sommer 2008).

In other shallowly-flooded ecosystems, seasonal agricultural floodplains have been shown to produce substantial invertebrate prey (zooplankton) that enhanced juvenile Chinook growth rates (Jeffres et al. 2020). This study on benthic invertebrates, in coordination with zooplankton studies (led by California Trout) will shed additional light on the ability to managed flooding regimes to ultimately optimize invertebrate prey resources for both waterbirds and fish. The bioenergetic benefits of these invertebrate resources depend largely on the estimates of prey energy density and the turnover rate of invertebrate

production, which is largely unknown for this ecosystem and regions, resulting in considerable data gaps for bioenergetic models (Dybala et al. 2017). Studies aimed to address this central datagap can help improve the utility of bioenergetic models for management of these shallowly-flooded post-harvest rice fields.

ACKNOWLEDGEMENTS

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REFERENCES

Baker, M.C. 1977. Shorebird food habits in the eastern Canadian arctic. *Condor* 79:59-62.

Batzer, D.P., M. McGee, V H. Resh, and R.R. Smith. 1993. Characteristics of invertebrates consumed by mallards and prey response to wetland flooding schedules. *Wetlands* 13:41-49.

Benigno GM, Sommer TR. Just add water: sources of Chironomid drift in a large river floodplain. *Hydrobiologia*. 2008;600(1):297–305.

Dybala, K.E., Reiter, M.E., Hickey, C.M., Shuford, W.D., Strum, K.M. and Yarris, G.S., 2017. A bioenergetics approach to setting conservation objectives for non-breeding shorebirds in California's Central Valley. *San Francisco Estuary and Watershed Science*, *15*(1).

Entrekin, S.A., Wallace, J.B. and Eggert, S.L., 2007. The response of Chironomidae (Diptera) to a long-term exclusion of terrestrial organic matter. *Hydrobiologia*, 575(1), pp.401-413.

Jeffres C.A., Holmes E.J., Sommer T.R., Katz J.V.E. 2020. Detrital food web contributes to aquatic ecosystem productivity and rapid salmon growth in a managed floodplain. *PLoS ONE* 15(9): e0216019. https://doi.org/10.1371/journal.pone.0216019

Mackey, A.P. 1977. Growth and development of larval Chironomidae. Oikos, pp.270-275.

Manley, S.W., Kaminski, R.M., Reinecke, K.J. and Gerard, P.D., 2004. Waterbird foods in winter-managed ricefields in Mississippi. *The Journal of Wildlife Management*, 68(1), pp.74-83.

Pinder, L.C.V., 1986. Biology of freshwater Chironomidae. *Annual Review of Entomology*, 31(1), pp.1-23.

Reynolds, S.K. and Benke, A.C., 2005. Temperature-dependent growth rates of larval midges (Diptera: Chironomidae) from a southeastern US stream. *Hydrobiologia*, 544(1), pp.69-75.

Safran, R.J., Isola, C.R., Colwell, M.A. and Williams, O.E., 1997. Benthic invertebrates at foraging locations of nine waterbird species in managed wetlands of the northern San Joaquin Valley, California. *Wetlands*, 17(3), pp.407-415.

Sommer TR, Nobriga ML, Harrell WC, Batham W, Kimmerer WJ. Floodplain rearing of juvenile chinook salmon: evidence of enhanced growth and survival. *Canadian Journal of Fisheries and Aquatic Sciences*. 2001;58(2):325–33.

Stahl, J.B., 1986. A six-year study of abundance and voltinism of Chironomidae (Diptera) in an Illinois cooling reservoir. *Hydrobiologia*, 134(1), pp.67-79.

Taft, O.W. and Haig, S.M., 2005. The value of agricultural wetlands as invertebrate resources for wintering shorebirds. *Agriculture, ecosystems & environment*, *110*(3-4), pp.249-256.

Tronstad, L.M., Tronstad, B.P. and Benke, A.C., 2010. Growth rates of chironomids collected from an ephemeral floodplain wetland. *Wetlands*, *30*(4), pp.827-831.

Longer water residence times resulted in greater benthic prey for waterbirds and fish in experimental flooded rice fields

Isa Woo[1], Susan De La Cruz[1], Greg Golet[2], and Jacob Montgomery[3]
1 USGS, Western Ecological Research Center; 2 The Nature Conservancy; 3 California Trout

Spring-Fall. Rice is grown & harvested to generate income & feed people

Late Fall. Harvested fields are flooded to decompose rice stubble and provide hunting opportunities

Winter. Rice stubble decomposes, Invertebrates grow, waterbirds forage

Early Spring. Fields are drained transporting invertebrates to river, providing food for fish

BACKGROUND

Extensive rice agricultural fields in the Sacramento Valley have the ability to produce invertebrate prey for both waterbirds and fishes in the winter and early spring, when the fields are not in rice production. How to best manage flooding to optimize these multi-species benefits is a key management need.

METHODS

At River Garden Farms, water residence time treatments: ~0.5 hrs (Short), 1.5 hrs (Medium), and 4.3 hrs (Long; n=3) was manipulated on experimental rice agricultural floodplains. USGS examined benthic invertebrates at each pond, CalTrout examined zooplankton and juvenile Chinook

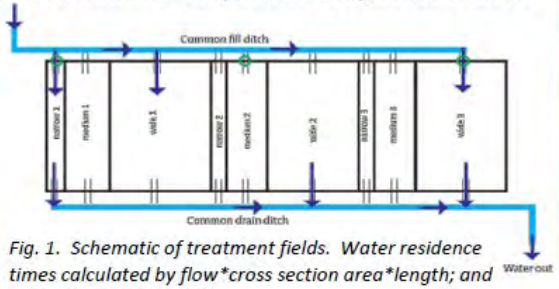


*Fig. 1. Schematic of treatment fields. Water residence times calculated by flow*cross section area*length; and controlled by field width*

For more information please contact: Isa Woo, iwoo@usgs.gov

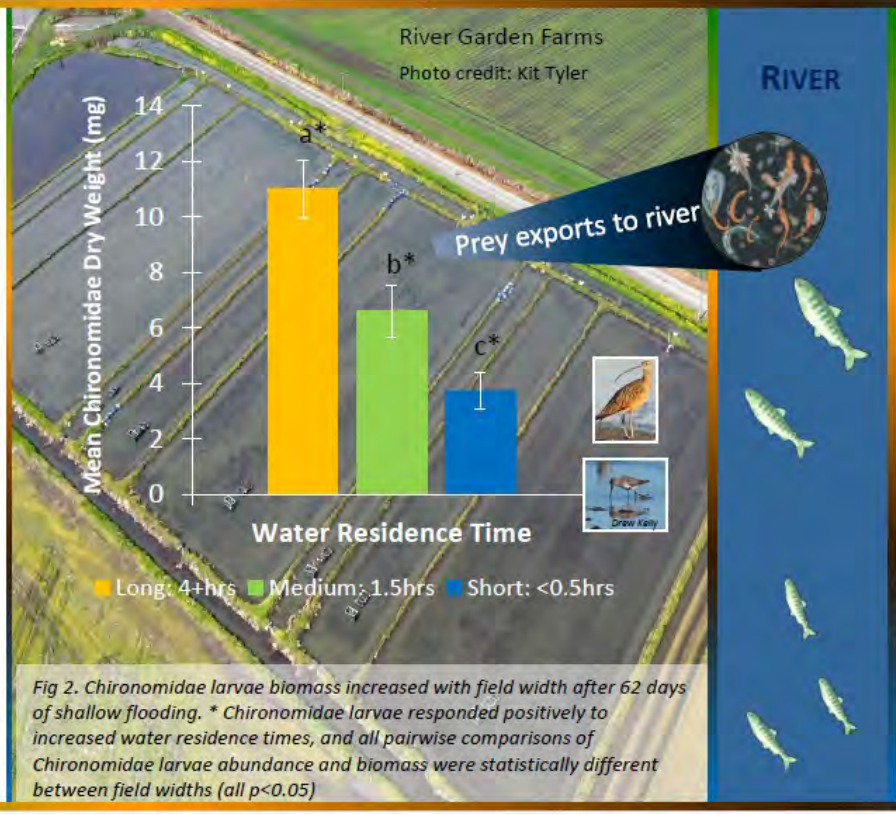
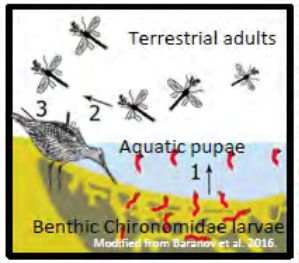


*Fig 2. Chironomidae larvae biomass increased with field width after 62 days of shallow flooding. * Chironomidae larvae responded positively to increased water residence times, and all pairwise comparisons of Chironomidae larvae abundance and biomass were statistically different between field widths (all p<0.05)*

CONCLUSIONS & IMPLICATIONS

- Chironomids (non-biting midges) are important prey resources for ducks[1], shorebirds[2], salmonids[3, 4], and comprised >80% abundance of benthic taxa
- These pilot results indicate that increased water residence time on post-harvest agricultural fields in the winter can increase prey resources for both waterbirds and salmonids.



Additional experiments are needed to determine the flood-drawdown cycle(s) that optimize invertebrate prey production and prey energy produced on shallowly flooded post-harvest rice fields.

ACKNOWLEDGEMENTS: This project was funded by The Nature Conservancy though an agreement with USGS, WERC. We thank River Garden Farms for hosting and the Water Foundation for funding development and maintenance of the site. We appreciate the help of USGS and TNC staff for invertebrate collection, and the USGS SFBE Invertebrate Ecology Lab for processing invertebrates

REFERENCES: 1) Safran et al. 1997; 2) Taft and Gaig. 2005; 3) Sommer et al. 2001; 4) Benigno and Sommer 2008

Influence of Irrigation Cut-off Dates on Forage Production in Shasta Valley Pastures

Authors: Rob Wilson, IREC Director and Siskiyou UCCE County Director, Tulelake CA, rgwilson@ucanr.edu; Giuliano Galdi, Siskiyou UCCE Agronomy Advisor, Yreka, CA, gcgaldi@ucanr.edu; Nicole Stevens, Siskiyou UCCE Research Assistant, Yreka CA, nostevens@ucanr.edu

The 2013-14 research was managed by Steve Orloff and Nicole Stevens and 2017-2019 research was managed by Carissa Koopmann Rivers and Nicole Stevens. Carissa Koopmann Rivers resigned from her position in Summer 2019 near the time of study completion and did not summarize her research. This report was produced by the Siskiyou UCCE office as a final research report for The Nature Conservancy Contract # 08082017-4716

Introduction Irrigated pasture makes up a large proportion of the irrigated acreage in the Shasta Valley. These pastures are primarily utilized for grazing cattle, but some are harvested for hay production and then grazed after an initial cutting. With drought conditions comes increased interest in potential water conservation methods. There is interest in transferring water that is traditionally used for irrigation for environmental uses to help ensure adequate flows in the Shasta River for salmonids. Salmon species utilize local rivers and streams such as the Shasta River for spawning and the initial phases of their life cycle. Many of the streams and rivers that salmonids utilize for spawning are the same ones that farmers and ranchers rely on to irrigate their crops. With the increasing demand for more water in streams, farmers are considering ways to irrigate more efficiently utilizing less water. One way to reduce irrigation demand is to cease irrigation earlier in the season than normal. However, there is likely a price associated with early-season irrigation cutoff in terms of forage yield that season and potentially stand persistence and long-term pasture productivity. This study evaluated the influence of early season irrigation cutoff on irrigated pastures in the Shasta Valley.

Study Objectives:

1. Determine the effects of different irrigation cutoff dates on soil moisture levels
2. Determine the impact of three irrigation water cutoff dates on pasture production that fall and the forage quality of the pasture
3. Evaluate the effect of early irrigation termination on pasture grass survival and forage species composition

4. Measure the carryover effect of early-season irrigation cut-off in the fall on spring pasture yield the following season

Materials and Methods Studies were conducted in privately owned flood irrigated pastures. Seven pastures were evaluated in 2013-14, six pastures were evaluated in 2017-18, and eight pastures were evaluated in 2018-19. Pasture sites were assigned a number at the beginning of the study for producer confidentiality. Each pasture was divided into three sections based on producer irrigation infrastructure so irrigation cutoff dates could be evaluated. The precise irrigation cutoff date varied depending on the grower's irrigation schedule. Target cutoff dates were mid-August (1st cutoff), early to mid- September (2nd cutoff), and early October (full season). Data from some sites was not included in data analysis due to problems related to cattle getting in enclosures or irrigation cutoff to the pasture not corresponding to predetermined cutoff times outlined in the study for various reasons such as water cutoff before October, broken pipes, etc.

Pasture sites were divided into three areas corresponding with the three irrigation cutoff treatments. Two 8' by 8' enclosures made from hog wire fencing panels and t-posts were installed in each irrigation cutoff area to exclude cattle grazing in order to measure total fall forage production. Pasture forage biomass and forage quality were measured in the enclosures in mid-October the year irrigation cutoff was imposed and the following spring in May or June shortly before producers grazed the field or cut it for hay. A sickle-bar mower was used to harvest forage biomass in two 3' by 8' quadrats to quantify forage yield in each enclosure. Forage yield was averaged across both quadrats in each treatment. Forage subsamples were collected at harvest to determine dry matter content and forage quality. Forage quality samples were sent to Ward Laboratory for analysis. After collecting fall forage data, the enclosures were removed to allow uniform grazing of the treatment area. Grass stubble height was measured at the end of the growing season in 2017 and 2018.

Soil moisture sensors were installed in each of the three irrigation cutoff treatments at all sites. Sensors were installed at 6 inches, 12 inches, and 24 inches in 2017 and 2018 and 9 inches, 18 inches, and 24 inches in 2013. Each site had a total of nine sensors. Soil moisture readings were collected weekly starting in mid- to late-August and continued until mid-October. Sensors were left in the field over the winter and soil moisture at all depths was measured the following spring in March or early April. WaterMark and GS1 sensors were used in each treatment to measure soil moisture in centibars and volumetric water content. One foot soil samples were collected at each site at the beginning of the study to determine soil fertility.

Forage composition (percent cover) was measured in each cutoff treatment area in fall and spring to document pasture species composition.

Data was analyzed using the JMP software from SAS. Data for fall forage yield, spring forage yield, forage quality, and soil moisture data were combined across sites and years for analysis of variance (ANOVA).

Results

Weather and Soil Moisture Levels Rainfall totals for 2013-14, 2016-17, and 2018-19 are shown in Table 1. Precipitation during the summer and fall growing season (May to October) were similar across years ranging from 1.6 to 2.3 inches. This amount of summer and fall precipitation is well below grass pasture evapotranspiration for May to October which exceeds 20 inches, thus supplemental irrigation is critical to summer and fall grass production. Winter precipitation (November to March) totaled 9.3 inches in 2018-19 which is adequate to refill the soil profile, whereas winter precipitation was 5.3 inches in 2013-14 and 4.6 inches in 2017-18 which may have been insufficient to refill the entire soil profile over the winter.

Table 1. Montague, CA (Siskiyou Airport) Precipitation (NOAA)

	Precipitation (inches)		
Month	13/14	17/18	18/19
August	0.5	0.02	0
September	0.74	0.07	0.01
October	0.08	0.43	0.56
November	0.47	1.58	1.27
December	0.09	0.26	2.04
January	0.19	1.29	1.34
February	2.25	0.27	3.74
March	2.31	1.18	0.98
April	0.66	1.73	1.29
May	0.42	1.24	0.96
June	0.2	0.3	0.06
July	0.14	0.22	0
Total	8.05	8.59	12.25

The influence of terminating irrigation before the end of the production system (irrigation cutoff) had a significant effect on pasture soil moisture levels averaged across sites and years (Figure 1). The 1st irrigation cutoff occurring in mid-August caused soil moisture to be significantly drier in the root zone (9 to 12 inches) from August to October compared to the 2nd irrigation cutoff in mid-September and full irrigation treatment. Soil moisture deeper in the profile at 24" inches was also drier for the 1st cutoff compared to the 2nd cutoff and full irrigation treatments (Figure 1). The level of soil moisture reduction caused by the 1st cutoff was variable across sites, but most sites had WaterMark readings over 60 centibars which is

indicative of drought stress on most soil types. There is also minimal chance of deep soil moisture moving up in the root zone since the average centibar reading at the 24" depth was also greater than 60 centibars for the mid-August cutoff.

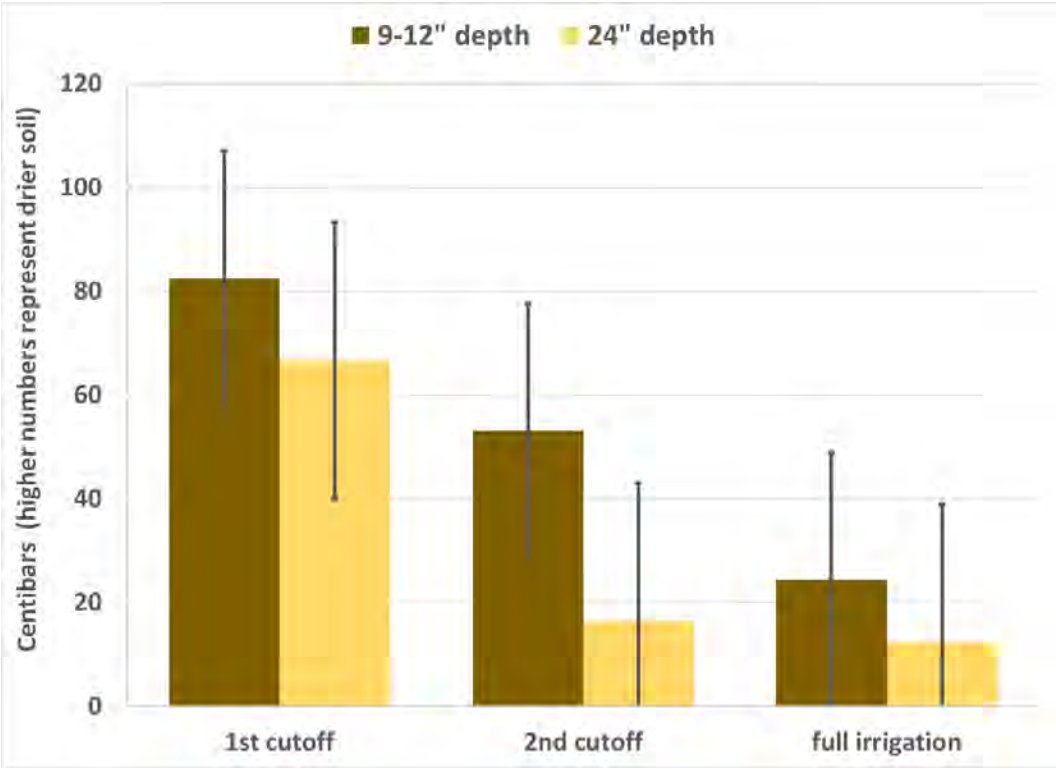


Figure 1. Influence of irrigation cutoff on the mean soil moisture reading at 9-12" and 24" averaged across weekly irrigation readings from mid-August to mid-October. Data was averaged across sites and years. Error bars represent a 95% confidence interval around the mean.

The influence of the 2nd irrigation cutoff on soil moisture levels and plant growth is less clear compared to the 1st cutoff. The average centibar reading in the root zone for the 2nd cutoff was significantly drier than the full irrigation treatment, however the centibar reading at 24 inches did not differ from the full irrigation treatment. The average centibar reading for the 2nd cutoff exceeded 50 indicating drought stress for most grass species, but some sites had an average centibar reading below 40 which is adequate for grasses during this time of the year. Average centibar readings from the full irrigation treatment were adequate to support perennial grass growth at both depths.

Pasture Forage Composition, Soil Fertility, and Forage Quality Irrigated pastures included in the data set were dominated by perennial cool-season grasses except for one that was dominated by grass-like sedges and rushes. The predominant grasses were tall fescue or perennial bluegrass. Pastures also contained 1% to 30% perennial legumes mainly clover, alfalfa, or birdsfoot trefoil. Pastures also had 1 to 32% other vegetation consisting mainly of dandelion, filaree, or foxtail barley.

Soil fertility was similar across sites and years. Soil pH ranged from 7.1 to 8.1 and soils had low soluble salts which are favorable to plant growth. Most soils had an organic matter content between 3 and 5% except the pasture dominated by sedges and rushes which had an organic matter content of 25%. Most soils were deficient in plant available nitrogen (NO3-N). Several soils were also low in phosphorus suggesting few producers apply nitrogen or phosphorus fertilizer to improve productivity. Other nutrients were found in adequate levels to support grass pasture production.

Irrigation cutoff treatments did not cause a significant change in forage quality. This was not surprising given the large variability in forage quality between sites and the fact the study design did not control for differences in plant composition between samples. Forage quality results did provide a good indication of overall forage quality in the pasture. Fall forage crude protein averaged 9.6% across sites with some sites as low as 6% and others as high as 13%. Spring forage crude protein averaged 12% across sites. Fall forage Neutral Detergent Fiber (NDF) averaged 55% across sites and spring forage NDF averaged 58% across sites. Estimated Total Digestible Nutrients (TDN) for fall forage averaged 63.5% across sites and spring forage TDN averaged 64.8% across sites. Differences in forage quality between pasture sites corresponded with pasture plant composition. For example, the pasture dominated by sedges and rushes had lower crude protein and TDN compared to pastures dominated by perennial cool season grasses.

Influence of Irrigation Cutoff Dates on Fall Forage Yields The influence of irrigation cutoff treatments on fall forage yield is presented in Figure 2. Averaged across sites and years, the 1st irrigation cutoff in mid-August caused a significant reduction in fall forage yield of 0.51 ton per acre compared to the 2nd cutoff treatment. There was a 0.70 ton per acre reduction in fall forage yield between the 1st irrigation cutoff and full irrigation treatment. There was a numeric decrease in fall forage yield between the 2nd cutoff and full irrigation treatments of 0.2 tons/acre, but this yield difference was not statistically significant. Fall forage yield varied considerably between sites similar to fall soil moisture readings.

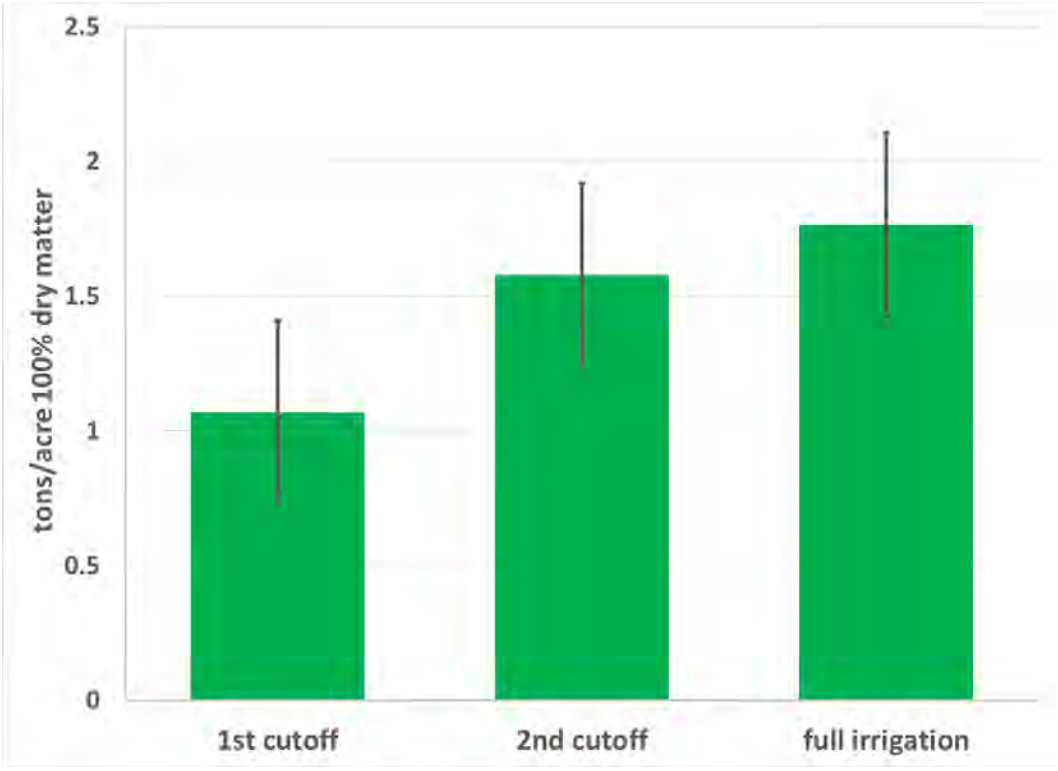


Figure 2. Mean mid-October forage yield for irrigation cutoff treatments. Data was averaged across sites and years. Error bars represent a 95% confidence interval around the mean.

Influence of Irrigation Cutoff Dates on Spring Forage Yields the Year Following the Cutoff

Average forage yield for irrigation cutoff treatments the following spring are presented in Figure 3. There was no statistical difference in spring forage yield between cutoff treatments, although spring forage yield followed the same numeric trend as fall forage yields with the 1st cutoff yield being lower than the 2nd cutoff and full irrigation treatments. Interpretation of spring forage yields across sites includes several caveats. First, spring forage yield was measured at different times at sites depending on when the producer turned cows into the pasture or if the producers decided to cut the pasture for hay. This month duration in harvest time meant sites were harvested at different grass growth stages with hay harvests being more mature than those cut before grazing. The difference in harvest time also didn't allow pastures to recover from fall cutoff treatment to the same extent since those cut for hay had more time to recover. Another factor that added variability was spring irrigation timing and frequency was not controlled in the study.

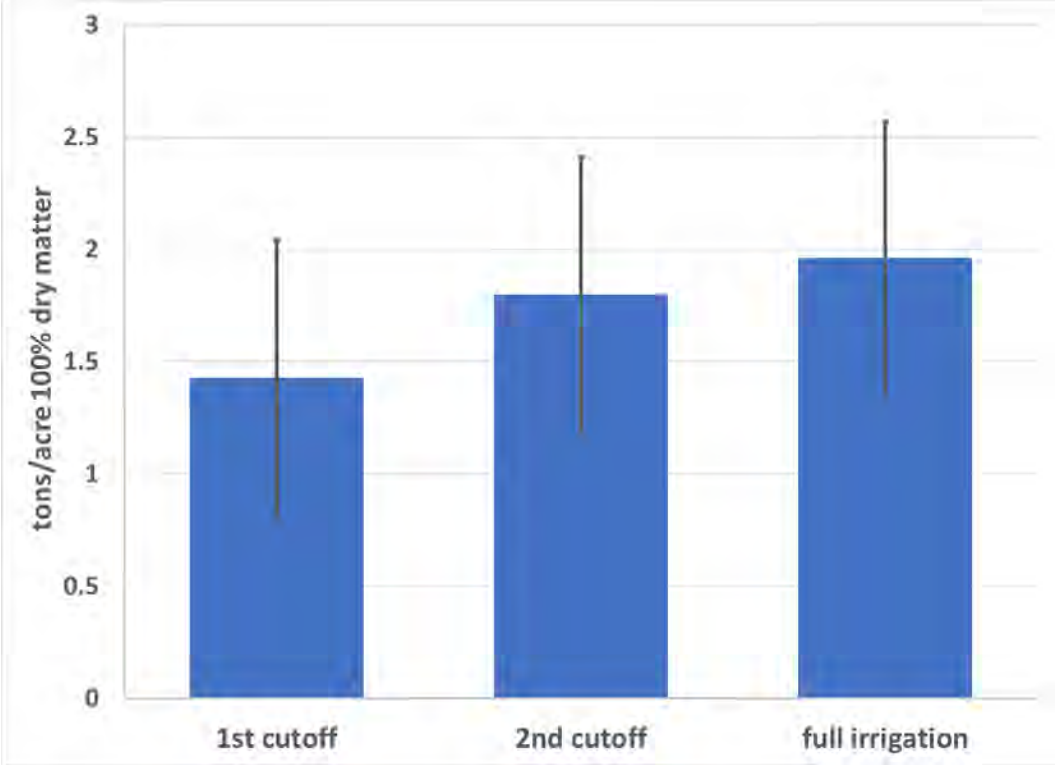


Figure 3. Mean spring forage yield collected in May or June the year following fall irrigation cutoff treatments. Data was averaged across sites and years. Error bars represent a 95% confidence interval around the mean.

Summary The mid-August cutoff caused an undesirable decrease in soil moisture and fall forage yield averaged across sites and years. The extent of fall forage yield reduction from the mid-August cutoff differed significantly between sites with fall forage yield decreasing more than 1 ton per acre at some sites while others had a minimal decrease in fall forage yield. Irrigation cut-off in mid-September had less of a negative effect on soil moisture and fall forage production compared to mid-August. The mid-September cutoff had drier soil moisture than the full irrigation treatment but fall forage yields averaged across sites and years were similar to the full irrigation treatment. When looking at forage yield for individual sites, some pasture sites did have up to a 0.6 ton per acre decrease in fall forage yield for the mid-September cutoff compared to the full irrigation treatment. Others had an increase in fall forage yield. Differences in sites' pasture species composition, soil type, and lateral and upward soil moisture movement are the likely cause for the variation between sites. Unfortunately, this study was not able to control all these factors to pinpoint the cause. Site characteristics should be examined before early cutoff is implemented as heavy soils with high organic matter have higher water holding capacity compared to sandier soils, sites closer to waterways have more potential for lateral and upward water movement, and grasses such as tall fescue are more drought tolerant than others such as bluegrass.

The carryover effect of fall irrigation cutoff treatments on pasture composition and spring pastures yield was difficult to isolate. There was a numeric trend for spring forage yield to be lower in treatments with early irrigation cutoff compared to full irrigation, but the difference was not statistically significant averaged across sites and years. Spring soil moisture differed significantly between sites with site differences being greater than differences in irrigation cutoff treatments. The study did not standardize spring irrigation timing and the date of spring forage harvest across sites. Without standardizing these factors, it is difficult to say yield differences were a result of fall irrigation cutoff or spring management practices.

Forage composition and forage quality evaluations did not show a shift in species composition or forage quality caused by the irrigation cutoff treatments. Some sites had a 10% decrease in grass cover from fall to spring while other had an increase in grass cover from fall to spring. None of sites showed a major composition shift from perennial grasses to bare ground or annual weeds.

There was a large difference in species composition and forage quality between pastures. Forage from some pastures was much higher in crude protein and total digestible nutrients across all three irrigation treatments compared to others. Most pasture soils were low in plant available nitrogen suggesting livestock manure is not providing adequate nitrogen fertilization. Producers may want to consider supplemental nitrogen fertilization or over-seeding clovers to improve pasture yields and forage quality if soil tests indicate nitrogen deficiency.

The impact of early irrigation cutoff repeated over time is beyond the scope of this study. The one-time impact of early irrigation cutoff was not detrimental to pasture composition in this study, but early irrigation cutoff on a yearly basis over the entire pasture may have more harmful effects especially in drought years.

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