## 4.2 WATER

Adequate water supplies are critical for wetland-dependent bird habitat, which includes both managed wetlands (such as refuges) and flooded agricultural lands. Water creates the well-recognized flooded ponds and moist, marshy soils that characterize wetlands everywhere. Maintaining healthy and productive wetlands requires adequate and reliable access to water. In the Central Valley ("the Valley"), wetland-dependent bird habitat is almost entirely "managed," either as semi-permanent or seasonal wetlands, or on flooded agricultural lands that provide a wetland habitat function. These wetland habitats are distributed across state and federal refuges, privately-owned conservation easement lands, other private property (such as duck clubs), and agricultural land, particularly rice.

The prevalence of each wetland habitat type is important to ensure that adequate habitat – as well as recreation, education, and other services – is provided every year by wetlands collectively, regardless of precipitation, regulatory and political environment, funding availability, commodity prices and land use decisions, and other factors. Each type of wetland habitat has different water needs, both in amount and timing of applied water.

### WHY DO WETLANDS NEED WATER?

In the spring, water provides nesting and foraging habitat for breeding waterbirds (including waterfowl, shorebirds and other water-dependent bird species), germinates seeds, and irrigates perennial plants on managed wetlands that will later provide food and shelter for birds. Summer water nurtures these plants and improves the productivity of wetland soils, provides foraging for young birds, and creates mudflat conditions important for migrating shorebirds. In the fall and winter, water is used to flood managed wetlands and some agricultural land, such as rice and corn after harvest, making waste grain and invertebrates available as food to waterfowl and shorebirds, as well as providing places to rest.

After creating these important environmental benefits, as well as numerous recreational, educational and economic benefits, most wetland water either percolates through the soil to recharge local groundwater basins or returns to rivers and streams with nutrients to enhance the aquatic food web or supplying water for other uses downstream.

Ensuring reliable and affordable water supplies for wetland habitat management may be the Central Valley Joint Venture's (CVJV) greatest challenge. Since publication of the 1990 Central Valley Habitat Joint Venture Implementation Plan (CVJV 1990), overall demand for water in the Valley has increased at an alarming rate. At the same time, complicated factors have led to reduced water supplies for many wetlands. These factors include in-stream dedication for threatened and endangered fish species, human population growth, and changing agricultural practices. The economic and political competition for water has intensified, and the cost of water in some basins has risen tenfold. In addition, climate trends are leading some wetland water supply managers to change how they plan for resiliency.

The CVJV plays several significant roles in ensuring the reliability and sustainability of wetland water supplies. These roles include communicating the extent to which bird habitat is fundamentally linked to water availability; understanding the implications of constantly changing factors related to wetland water supply; advising agencies involved in implementing significant legislation; and facilitating and encouraging advocacy, creative thinking, and on-the-ground solutions.

This subchapter first provides important historical and political context for understanding the water supply needs and challenges faced by the Valley wetlands today. Next, it explains the water needs of different wetland types and

describes the water supplies that are needed to meet those needs. Water needs are extrapolated to estimate the water necessary to meet the waterfowl and shorebird population targets and the associated habitat objectives determined for this Implementation Plan. Finally, the constraints and opportunities around acquiring, delivering, and managing water to meet wetland habitat needs are explained.

## History of Central Valley Wetland Water Supplies

The extent of habitat for wetland-dependent bird species in the Central Valley has changed extraordinarily over the last 150 years. The amount of water available to create wetlands and the way wetlands receive that water have also changed. Inundation and flooding in the Central Valley in the winter and spring, caused by confining rivers within artificial levee systems, requires flooding and irrigations to be managed through human-made structures to divert or pump water from rivers, ditches and groundwater wells. The very existence of most wetlands now relies on conveyance and delivery systems. Understanding this context and how much water wetlands need is critical to their sustainability and protection.

### Wetland water before development

Prior to the Gold Rush of the mid-1800s, the Valley contained more than four million acres of dynamic wetland complexes that included and were bordered by flooded riparian and grassland habitats (Frayer et al. 1989). Many wetlands were seasonal in nature and resulted from over-bank flooding of rivers and streams that inundated large areas of the Valley during winter and spring. The timing and duration of these waters also supported the productivity of moist soils and germination of beneficial food plants for the following year as well as supporting riparian vegetation. Slowly receding water provided habitat for a variety of bird species throughout the summer and fall months until rains returned in the late fall and winter, when the cycle began again.

### Wetland water from development through 1992

In less than a century, large-scale gold extraction techniques, flood control projects, and land reclamation projects for agriculture and urban development led to the conversion of over 90 percent of the Valley wetlands to other uses. Human settlement increased the need to control annual flooding of the major river systems to protect developing cities, homesteads and associated infrastructure. As flood control levees were built to tame the rivers, agricultural lands expanded, and dams were constructed to provide additional flood control and water storage for expanding urban, industrial and agricultural needs.

As the population of California increased, so did the demand for agricultural products and other services. The Central Valley Project (CVP), a federal water project, was initially authorized in 1935 as a long-term plan to control floods and develop and manage water for industrial, municipal and agricultural uses. The CVP and California's companion State Water Project (SWP) constructed major dams and conveyances to store water during wet years, release water when needed by agriculture during the dry summer months, and convey water to farms and cities throughout the Valley. The CVP is capable of storing over 11 million acre-ft of water and transporting it through 500 miles of canals. By the 1950s, expanding agricultural development and water projects that redirected water historically available to wetland areas had decreased Valley wetlands to an estimated 290,000 acres (CVJV 1990).

Resident and migratory bird populations were severely impacted during this time (Frayer et al. 1989). The first wildlife refuges were established in the early 1930s. As the extent of natural wetlands continued to decline into the 1970s, more public and private lands were set aside to be managed as wetlands. Water supplies for managed wetlands during this period were not secure. Most managed wetlands depended upon agricultural irrigation return flows, low-priority water contracts, or non-binding agreements with water districts. Some of those historical agreements continue to this day[1]. With few exceptions, these contracts and agreements provided water supplies on an "if and when available basis," with supplies being severely reduced, or eliminated, during drought years.

Severe drought during the latter part of the 1970s greatly reduced wetland water supplies and, in some instances, eliminated all water deliveries to remaining wetlands in the Valley. The combination of drought and poor water supply reliability resulted in significant negative impacts to wetland habitat

1. Examples include wetlands in the Butte Sink area that receive fall and winter water via a 1922 agreement with Western Canal Company and Pacific Gas & Electric Company; the Sacramento, Delevan, and Colusa National Wildlife Refuges, which receive water through agreements with Glenn-Colusa Irrigation District; and the Gray Lodge Wildlife Area, which receives a portion of its water needs from the Biggs-West Gridley Water District for lands allocated "Class 1" Feather River settlement water. Another example involves the Grassland Mutual Water Association, which filed suit against the U.S. Department of the Interior after losing San Joaquin River supplies when the Friant Dam Project began diverting flows from the San Joaquin River for agriculture and municipal and industrial uses in the Tulare Basin. A settlement provided 50,000 acre-ft of water (if and when available) for wetlands within the Grassland Water District during the fall and winter months. The California Department of Fish and Wildlife also negotiated agreements with the U.S. Bureau of Reclamation and various local water districts for many of its wildlife areas.

and to waterbird populations, and especially to non-breeding waterfowl.

By the end of the 1970s, political pressure from concerned landowners and wildlife agencies led to investigations and peer-reviewed publications that made the case for more reliable supplies of water for remaining Valley wetlands. These studies, along with passage of the National Environmental Policy Act and State and Federal Endangered Species Acts, set the stage and provided a critical basis for environmental protections for the Valley wetlands. These protections were codified in new legislation, which was under development as the U.S. Bureau of Reclamation (USBR) renewed water supply contracts with its CVP customers.

As these investigations progressed, other actions were underway that would significantly affect the Valley's wetlands. The North American Waterfowl Management Plan, an international treaty between the United States and Canada, was signed in 1986 and identified the Central Valley as one of the six priority habitat areas for North American waterfowl. The CVJV was subsequently formed in 1988. Recognizing the importance of sufficient, reliable water supplies for waterfowl health, as demonstrated by many scientific studies, one of the objectives stated in the CVJV 1990 Implementation Plan was to secure reliable water supplies for publicly-owned Central Valley wetlands, the privately managed wetlands within the Grassland Resource Conservation District (GRCD), and elsewhere in the Valley. (For more details, see text box: "The science-based need for reliable wetland water supplies.")

## CVPIA mandates wetland water

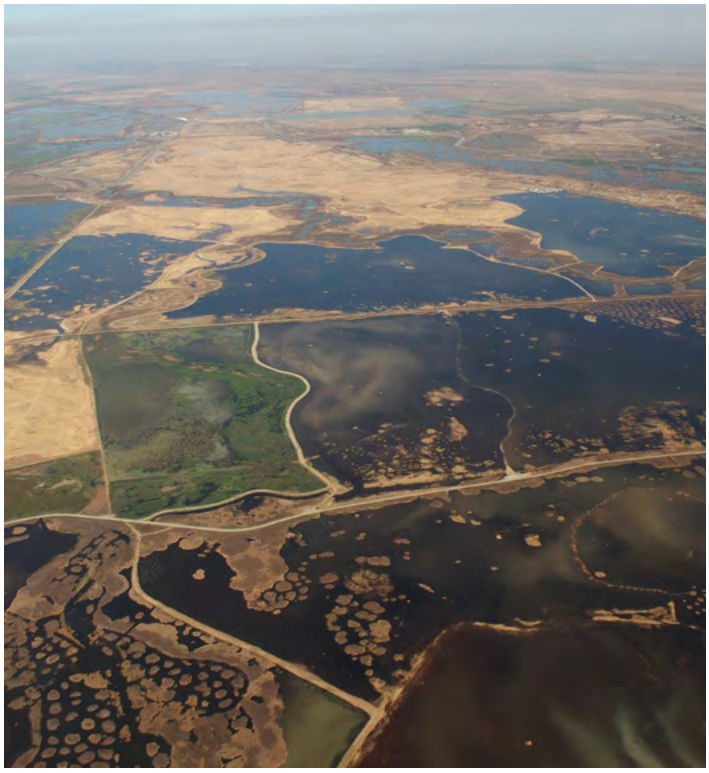
The Central Valley Project Improvement Act (CVPIA), Title 34 of Public Law 103-575, was passed in 1992. This Act amended previous authorizations of the CVP to include fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic uses, and fish and wildlife enhancement as a project purpose equal to power generation.

## WATER SUPPLY TERMS

**L2 – Level 2 refuge water supply:** The minimum amount of water necessary to maintain wetlands and wildlife habitat benefits based upon average water deliveries occurring prior to 1992. This amount totals 422,251 acre-ft per year.

**IL4 – Incremental Level 4 refuge water supply:** The additional quantity of water, above L2, that each habitat area needs to reach Full L4.

**Full L4 - Full Level 4 refuge water supply:** The total amount required by CVPIA for optimal habitat management. Some habitat areas will need investments to improve or develop infrastructure necessary to receive Full L4 supplies.



*Flooded wetlands, Grasslands Ecological Area - USFWS*

# THE SCIENCE-BASED NEED FOR RELIABLE WETLAND WATER SUPPLIES

Severely declining populations of resident and migratory birds in the 1970s and 1980s led to a number of studies on Central Valley wetland water needs. One of the first studies published during this period was the Total Water Management Study for the Central Valley Basin of California (USBR, unpublished report, 1978, see "Notes"). This study included Working Document No. 12, "Fish and Wildlife Problems, Opportunities, and Solutions" (USBR, unpublished report, 1978, see "Notes"), a survey of major fish and wildlife problems and improvement opportunities within the geographical area encompassed by the CVP. As a result of the study's findings, the USBR initiated the Central Valley Fish and Wildlife Management Study of 1979 (USBR, unpublished report, 1979, see "Notes"). The study established a comprehensive baseline of Central Valley fish and wildlife resources and recommended specific solutions to water related issues.

These studies continued into the early 1980s and resulted in a report, Refuge Water Supply, Central Valley Hydrologic Basin, California 1986 (USBR 1986) that addressed waterfowl and wetland habitat. This study served as the basis for the 1989 Report on Refuge Water Supply Investigations, Central Valley Hydrologic Basin, California (USBR 1989), estimated average historical managed wetland water supplies ("Level 2" water supplies) and developed ecologically sound estimates of wetland water needs for optimal habitat management ("Level 4" water supplies). This report provided a critical basis for codified environmental protections that were under development and required adequate water supplies to support the 19 refuges that became part of the environmental baseline requirements as USBR renewed water supply contracts with its CVP customers.

Following passage of the Central Valley Project Improvement Act (CVPIA), many CVP water users were concerned about how the refuge water supply provisions would be implemented. To address those concerns, best management practices and efficient use plans were developed for the managed wetlands covered by CVPIA. In 1996, Deputy Secretary of the Interior John Garamendi directed that an Interagency Coordinated Program Task

*Eared grebe - Tom Grey*

Force be instituted to provide a common methodology for water use planning and efficient water regimes for all wetland areas receiving water authorized by CVPIA. Their final report, An Interagency Coordinated Program for Wetland Water Use Planning: Central Valley, California (USBR et al. 1998), estimated monthly and annual water supplies needed to properly manage state, federal and GRCD seasonal and semi-permanent wetlands for each basin.

CVPIA Section 3406 (d)(6)(A,B) required the investigation of water and conveyance needs for private wetlands not covered by the other provisions of the Act. The 2000 Central Valley Wetlands Water Supply Investigations, CVPIA 3406 (d)(6)(A,B), A Report to Congress (USFWS 2000) was produced as a result. Central Valley water suppliers were interviewed and their comments incorporated into the Water Report. Most expressed concern over the long-term shortages of water supplies resulting from a statewide lack of new water development (e.g., groundwater banking, new reservoirs, and new conveyance infrastructure); a reduction of Colorado River water supplies; and increasing urban and environmental demands that reduce supplies for agricultural and other uses. Although most suppliers face no legal obstructions to providing wetland water, many believed that agriculture would have priority if water shortages develop.

Collectively, these studies provided a scientific and peer-reviewed basis for wetland water needs estimates in CVPIA and water contracts, and many of these publications are still referenced today by wetland and water managers throughout California and the West.

| REFUGE NAME | LEVEL 2 (ACRE-FT) | INCREMENTAL LEVEL 4 (ACRE-FT) | FULL LEVEL 4 (ACRE-FT) |
|---|---|---|---|
| **Colusa Basin** | | | |
| Sacramento National Wildlife Refuge[a] | 46,400 | 3,600 | 50,000 |
| Delevan National Wildlife Refuge[a] | 20,950 | 9,050 | 30,000 |
| Colusa National Wildlife Refuge[a] | 25,000 | 0 | 25,000 |
| **Subtotal** | **92,350** | **12,650** | **105,000** |
| **Sutter Basin** | | | |
| Sutter National Wildlife Refuge[a] | 23,500 | 6,500 | 30,000 |
| **Subtotal** | **23,500** | **6,500** | **30,000** |
| **Butte Basin** | | | |
| Gray Lodge Wildlife Area | 35,400 | 8,600 | 44,000 |
| **Subtotal** | **35,400** | **8,600** | **44,000** |
| **San Joaquin Basin** | | | |
| San Luis Unit[b] | 19,000 | 0 | 19,000 |
| West Bear Creek Unit[b] | 7,207 | 3,603 | 10,810 |
| East Bear Creek Unit[b] | 8,863 | 4,432 | 13,295 |
| Kesterson Unit[b] | 10,000 | 0 | 10,000 |
| Freitas Unit[b] | 5,290 | 0 | 5,290 |
| Merced National Wildlife Refuge | 13,500 | 2,500 | 16,000 |
| Los Banos Wildlife Area | 16,670 | 8,330 | 25,000 |
| China Island Unit[c] | 6,967 | 3,483 | 10,450 |
| Salt Slough Unit[c] | 6,680 | 3,340 | 10,020 |
| Volta Wildlife Area | 13,000 | 3,000 | 16,000 |
| Grassland Resource Conservation District | 125,000 | 55,000 | 180,000 |
| **Subtotal** | **232,177** | **83,688** | **315,865** |
| **Tulare Basin** | | | |
| Mendota Wildlife Area | 27,594 | 2,056 | 29,650 |
| Kern National Wildlife Refuge[d] | 9,950 | 15,050 | 25,000 |
| Pixley National Wildlife Refuge[d] | 1,280 | 4,720 | 6,000 |
| **Subtotal** | **38,824** | **21,826** | **60,650** |
| **Contract Total** | **422,251** | **133,264** | **555,515** |

*Source: CVPIA Refuge Water Supply Program*
*[a] Part of the Sacramento National Wildlife Refuge Complex*
*[b] Part of the San Luis National Wildlife Refuge Complex*
*[c] Part of the North Grasslands Wildlife Area*
*[d] Part of the Kern National Wildlife Refuge Complex*

**TABLE 4.2.1** Water deliveries to refuges required by the CVPIA.

Due in part to an investment in the legislative process by CVJV partners, provisions were made in CVPIA Section 3406 (d)(1-5) to meet wetland water needs. The law authorized water supplies for those wetland areas covered by the 1989 Report and the San Joaquin Basin Action Plan/Kesterson Mitigation Action Plan, a plan developed to mitigate the habitat losses resulting from the Kesterson National Wildlife Refuge (NWR) selenium contamination of the 1980s, and to implement the objectives of the CVJV. The CVPIA mandated delivery of historical water supplies, referred to as "Level 2" supplies, and two-thirds of the full water supply requirements for lands identified in the Action Plan from the CVP. In addition, "Incremental Level 4" water supplies were to be acquired through purchase from willing sellers and provided in increasing 10 percent increments per year until 2002, when full water supply requirements were authorized. Table 4.2.1 lists the water deliveries mandated by the CVPIA.

In addition to requiring water delivery, Section 3407(d) established the CVP Restoration Fund as a critical funding source for CVPIA activities. The Restoration Fund contributes about $50 million annually to support salmon restoration activities and water delivery to 19 critical state and federal wildlife refuges and private wetlands within GRCD in the Central Valley. Water from the CVP and hydropower users make annual payments into the Restoration Fund, and the USBR administers the program.

Several long-term water conveyance/supply contracts and agreements were negotiated during the 1990s that increased the reliability of CVPIA water supply delivery. These contracts and agreements called for the establishment of an Interagency Refuge Water Management Team (IRWMT). Comprised of USBR, USFWS, CDFW,

# CVPIA: LANDMARK LEGISLATION FOR CENTRAL VALLEY WETLAND RECOVERY

To date, the CVPIA is one of the most important legislative actions taken to protect and restore Central Valley wetland habitat, and it has laid the foundation for many significant and beneficial conservation activities in subsequent years. Since 1992, delivery of adequate, suitable quality water to certain NWRs, WAs and the private wetlands of the GRCD through CVPIA has improved wetland habitat quality and benefited many wetland-dependent wildlife populations, including waterfowl, shorebirds, colonially nesting waterbirds, and several threatened and endangered species. Annual reports to Congress and a variety of studies and reports conducted by the USFWS and CDFW have documented these benefits:

- A 600% increase in waterfowl food production within the GRCD (USBR and USFWS 2004).
- An 89% reduction in avian disease outbreaks on the Sacramento NWR Complex since 1992 (USBR and USFWS 2004).
- A 49% increase in fall shorebird use Central Valley-wide (M. Wolder, personal communication, 2012, see "Notes").
- A 50% increase in the number of heron and egret rookeries at Kern NWR (D. Hardt, personal communication, 2004, see "Notes").
- A 61% increase in visitor use on the Sacramento NWR Complex between 1992 and 2006 (USBR and USFWS 2004).
- Increases in non-waterfowl species such as the western pond turtle, as well as some threatened or endangered species (e.g., tricolored blackbird and giant garter snake) on Central Valley refuges (USBR and USFWS 2004).
- Marked increases in populations of white-faced ibis and sandhill cranes. Ibis populations increased from 100 birds in 1991 to 15,000 in 2002 at the Sutter NWR; sandhill cranes at Pixley NWR increased from 200 in 1992, to 2,000 in 1993, to 5,000 in 2001 (USBR and USFWS 2004).
- The Agricultural Waterfowl Incentive Program, CVPIA 3406 (b)(22), funded the flooding of an average of 40,000 acres of agricultural lands each winter between 1997 and 2003, providing a substantial portion of the annual waterfowl energetic need within the Pacific Flyway during that time (USBR and USFWS 2004).

These habitat improvements have led to research by universities, government agencies, and non-governmental conservation organizations such as the California Waterfowl Association; Ducks Unlimited, Inc.; Point Blue Conservation Science; University of California, Davis; United States Geological Survey's Biological Research Division, Dixon Field Station; and others that cite the benefits of refuges and the water that creates those wetlands.

*California black rail - Philip Robertson*

Despite these benefits, the CVPIA mandated water supply levels have never been fully achieved, due in large part to state and federal budget shortages, inconsistency in the timing of water deliveries, and increases in the cost of blocks of water made available annually from willing sellers on the open market, also known as the "spot market." Budgetary constraints within USBR's annual CVPIA Restoration Fund and the state's past inability to cover their 25% cost-share mandate, required by CVPIA, have restricted the amount of Level 4 water supplies that can be acquired each year. At the same time, water costs have escalated as water acquisitions to meet CVPIA, urban, and agricultural needs have influenced sharp increases in spot market prices, further stressing limited budgets.

Budget shortfalls have also inhibited the ability to complete the construction of conveyance facilities necessary to deliver water to refuge boundaries. In some cases, conveyance facilities to provide water delivery to the property boundary are still awaiting construction.

Although the future of the Restoration Fund is still uncertain, public funding through state bond measures was dedicated in November 2014 to support CVPIA refuge-related expenses. This development has expedited progress on some conveyance and water acquisition projects. The Refuge Water Supply Program will complete a Strategic Plan that identifies priority projects and opportunities to achieve Full Level 4 water supplies as quickly as possible, creates an adaptive management decision tool, and outlines likely funding needs.

and the GRCD, the IRWMT meets regularly, collaborating on the acquisition and allocation of incremental water supplies necessary for wetlands to operate at full habitat development levels (Level 4) and other wetland water related issues. The IRWMT has invited a representative from the CVJV to regularly participate in team meetings, collaborate on refuge water strategies, and convey a broader view of how refuge habitat contributes to meeting the CVJV's valley-wide objectives.

The CVPIA statutorily obligates the Secretary of Interior to consult with the CVJV in matters involving wetland water acquisition and delivery. Considering this obligation, the CVJV maintains a unique responsibility to consider water supply issues related to the implementation of this 2020 Plan by participating in forums where water issues and policies are being discussed, to assure that policy makers address wetland water needs.

### Development of water supplies for private wetlands and other wetland habitat lands

The CVPIA directed the U.S. Department of the Interior to provide firm water supplies to the 19 critical wetland complexes that include 18 federal and state refuges and the private wetlands within the GRCD, but these lands account for only one-third of the managed wetlands in the Central Valley. The CVPIA also identified additional wetlands as key components of habitat needed for birds and other species in the Central Valley, and it identified specific actions and investigations to assess water needs and water supply opportunities for these wetland areas.

Habitat provided by postharvest-flooded agricultural land, particularly postharvest rice, benefits waterfowl, shorebirds and a variety of other wildlife species and grew exponentially in the 1990s. It is the largest component of the wetland habitat mosaic today. Rice straw is high in silicate and other components that make it difficult to decompose, and straw left over from the previous harvest must be eliminated prior to the subsequent growing season. Before the 1990s, removal of rice straw was primarily achieved through burning, but air quality impacts led the legislature to mandate a phase-down of burning. The CVPIA Section (b)(22) established an incentive program for farmers to flood postharvest rice. Winter flooding provided an alternative and relatively cost-effective method of decomposing rice straw at a time when growers were unfamiliar with other methods.

By the early 2000s, postharvest flooding became the principle means of rice straw decomposition. At that time, 70 percent of the planted rice acres, or approximately 350,000 acres of harvested rice fields, were winter-flooded. A win-win for agriculture and the environment, winter flooding of rice also provides food for ducks, geese and shorebirds and provides habitat for millions of migrating waterfowl and shorebirds.

The Central Valley Wetlands Water Supply Investigations – Final Report (USFWS 2000), required by CVPIA (Section 3406(d)(6)(A,B)), reported to Congress on the adequacy of and needs for water supplies to existing private wetlands; on the water supply and delivery requirements to permit full habitat development on 120,000 acres of supplemental wetlands (public or private); and on feasible means of meeting those requirements.

Many private wetlands were developed on lands that were difficult to farm and did not have firm water supplies, water rights, or even wells. Water supplies to private wetlands were developed primarily by connecting to drains from local agricultural lands; establishing easements with farmers who agreed to flood land with water supplies available to them; pumping groundwater on-site; or more recently for many wetlands, by working with local landowners to pump or exchange groundwater to flood up wetlands. The water needs in the Water Supply Investigations report were based in part on CVJV's 1990 Implementation Plan goal for 120,000 acres of additional supplemental wetlands.

## Central Valley Wetland Water Supplies Today

Today, a variety of surface and groundwater sources supply water to Central Valley wetlands. In the Central Valley, the great majority of wetland acres are irrigated with surface water supplies. The surface water supplies available in a given year can be correlated with precipitation received in the Central Valley and Sierra Nevada, with the "water year type," a classification that accounts for precipitation over the wet season (from October through about May), and with water storage levels in reservoirs. Water rights also drive the availability of water and vary depending on the type of water right a parcel might have. Inter-annual water variability presents challenges as well as opportunities for wetland water supply management. More broadly, many Central Valley wetland water supplies are not secure and face several challenges as the demand for this highly managed but scarce resource increases, as water costs increase, and as shifts in climate and

| ENTITLEMENT OR SUPPLY SOURCE | DESCRIPTION |
|---|---|
| **Central Valley Project (CVP) Contracts** | Contractual allocation of CVP's annual water supply. Five separate CVP contracts provide Level 2 supplies for CVPIA refuges. |
| **State Water Project (SWP) Contracts** | Contractual allocation of a portion of the SWP'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 of 1913, Appropriative rights are often used by CVP and SWP contractors for winter water supplies (such as for rice decomposition) after October 1. |
| **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 (SWRCB) after the passage of the Water Commission Act. Seniority determined based on year granted. Appropriative rights are often used by CVP and SWP contractors for winter water supplies (such as for rice decomposition) after October 1. May be subject to Term 91[a] in drier years. |
| **Riparian** | Right of landowner of land located adjacent to surface water, to use the natural flow of the watercourse to meet needs of that land. This water cannot be stored, leased or assigned another place of use. May be used as a source for some wetland or riparian bird habitats when that habitat is located adjacent to a watercourse. |
| **Banked** | Contract for right to surface water stored underground as a groundwater banking facility. Not common as a wetland water source. |
| **Tailwater** | Not an established right under the SWRCB, but tailwater was a major source of wetland water prior to construction of the CVP and SWP. Chemicals in tailwater also led to ecological damage near Kesterson in the late 1980s, resulting in mitigations and water supply replacements specified in CVPIA and the San Joaquin Basin Action Plan/Kesterson Mitigation Action Plan (USBR et al. 1989). Tailwater is still a significant source of supply to many private wetlands, especially in the Sacramento Valley. Reductions can occur from water use efficiency measures implemented upstream. |
| **Surplus flows** | Wetland management may have (or could apply for) an appropriative right from the SWRCB for surplus flows, such as storm flows. Typically, these flows would only be available from December through March in above normal or wet years, and timing is not guaranteed. Access may be constrained by agricultural operations that may shut down in winter when not being used for irrigation, or by irrigation districts that close water delivery canals for annual maintenance[b]. |
| **Recycled water** | Some wetlands are supplied with recycled water through a contract with the recycled water managing entity, such as through the North Valley Regional Recycled Water Program. |
| **Groundwater** | Groundwater is an important source of water for some Central Valley wetlands. Pixley NWR, for example, currently relies on groundwater for 100% of its water supply. As SGMA is implemented, groundwater use in some areas of California, including at some wetlands, will be severely restricted. |

*[a] Term 91 is a condition of a water right that requires the user to cease diversions under the permit or license when noticed by the State Water Board.*
*[b] Surplus flows are also important for fish migration at certain times of year, which presents a challenge, but return flows from wetlands can also provide additional river flow if timed to meet fish needs.*

**TABLE 4.2.2 Water rights and other wetland water sources.**

aging infrastructure force reconsideration of water management regimes (Matchett and Flekes 2017).

The CVJV has confronted these water challenges by working collaboratively with partners on the ground; creating sophisticated spatial management tools to understand habitat availability in real time; and developing creative, science-based, multi-benefit approaches to providing reliable wetland water.

This section provides an overview of wetland water sources, the water needs of different wetland types (both by acre and the total needed to meet CVJV population targets), and the timing of those needs; and discusses the extent to which those needs are currently being met.

## Sources of wetland water

At different times of year, surface water is applied or

groundwater is pumped to meet wetland habitat needs, either directly for that purpose (e.g., a contracted water delivery to a refuge) or indirectly to meet other needs. For example, flood irrigation of pastures and other crops benefit shorebirds, and rice fields flooded in summer provide brood habitat. Also, postharvest flooding in fall and winter benefits non-breeding waterfowl. Precipitation and uncontrolled flood water may also create wetland conditions, but managed wetlands and postharvest-flooded croplands, the focus in this section, typically rely on developed and applied water supplies.

Wetland water supplies vary widely in terms of the water source and the type and seniority of water right, which in turn affect the reliability of the water delivery. For example, a portion of water delivered to CVPIA refuges by means of CVP water supply contracts has typically been reliable except during extreme droughts. Conversely, drain flows (tailwater) that supply some duck clubs may literally "dry out" when upstream agricultural districts implement a "no discharge" policy or water use efficiency measures that reduce drain flows.

Various Central Valley wetlands may rely on numerous different water supplies (Table 4.2.2).

## Wetland water needs

The timing and amount of water needed to create the necessary habitat conditions to support waterfowl, shorebird and other waterbird populations at goal levels in the Valley depend on:

- The waterfowl, shorebird or other waterbird population that must be supported at different times vary throughout the year because of such things as life stage requirements or migration chronologies.
- What kind and how much habitat (acres) is needed to support those populations.
- The amount of water needed per acre of habitat type in specific planning regions to support a given population.
- Where and when the water must be provided to create the needed habitats.

Generally, for migratory waterfowl, depths of 4 to 10 inches of water (NRCS et al. 2007) are required to create suitable habitat conditions during the peak migration and wintering period between August and March. Water is also required from April through August to maintain moist soil conditions, germinate seeds and maintain wetland plants, irrigate rice to meet waterfowl energy needs during the winter months, and provide nesting and brood rearing habitat.

Nonbreeding shorebirds require shallower water depths (mudflat to 4 inches) than waterfowl. Shorebirds typically find habitat on managed wetlands and winter-flooded rice, when flooding begins, and late in the season during drawdown, when water recedes. Breeding shorebirds nest adjacent to shallow water in managed wetlands and rice. But in general, the flooding and drawdown schedules of managed wetlands and winter-flooded rice are more consistent with the needs of waterfowl than shorebirds in the Central Valley.

| HABITAT TYPE | UNIT WATER NEED (ACRE-FT/ACRE) | TIME PERIOD |
|---|---|---|
| **Seasonal wetlands** | 5.1 | August through March, with irrigations in June |
| **Semi-permanent wetlands** | 7.4 | October through mid-July |
| **Flooded rice** | | |
| Winter flooding (for rice straw decomposition) | 2.5 | October through December |
| Growing rice (prior to winter flooding) | 5.0 | April through September |

**TABLE 4.2.3 Wetland water needs by habitat type (supply needed for full annual cycle)** (USBR et al. 1998; USFWS 2000; UC Davis 2019).

The water needs of other waterbirds, such as egrets, ibises, cranes and terns, vary widely by species, as detailed in the Breeding and Non-Breeding Waterbirds chapter.

In general, the quantity of water needed per acre of habitat depends on the wetland type – seasonal wetland, semi-permanent wetland, or flooded rice – and the depth and duration of flood most suited to waterfowl or shorebird needs. The comprehensive Central Valley Wetlands Water Supply Investigations Report to Congress (USFWS 2000) in December 2000 presented monthly water needs for seasonal and semi-permanent wetlands by drainage basin and the timing and rate at which these wetlands are flooded and maintained. Based on the information in this report and other sources, approximate annual water needs are summarized by habitat type in Table 4.2.3.

The more precise need varies depending on soil characteristics, topography, location in the Valley, and other factors. For example, due to higher evaporation rates experienced in the southern Central Valley, habitats in the Tulare Basin typically have a higher water demand than in the Sacramento Valley. Also, rice fields located on more permeable soils may require more water to maintain a flooded condition than those overlying less permeable soils.

To maintain optimal conditions for non-breeding waterbirds on seasonal wetlands, approximately 5.1 acre-ft/acre is needed per year. This water is typically applied from August through March, with one or two irrigations between April and July to ensure adequate seed production by moist soil plants.

Approximately 7.4 acre-ft/acre is needed per year to meet the needs of locally breeding ducks and other waterbirds. Water is applied for flooding from October through mid-July, including maintenance flows to offset evapotranspiration.

Flooded rice fields contribute a critical percentage of wetland habitat in the Valley. Winter-flooding requires 2.5 acre-ft/acre (M. Petrie, personal communication, 2016, see "Notes") of applied water throughout the postharvest season to promote straw decomposition and provide waterbird habitat. Applying this water between October and January corresponds to peak waterfowl habitat needs (M. Petrie, personal communication, 2016, see "Notes"). Applying the water earlier, from September (or earlier, though this is not possible unless rice is harvested atypically early) to October, provides habitat for shorebirds as they arrive in the Central Valley from more northern breeding areas (Dybala et al. 2017). Most of this water either percolates into the ground or drains as tailwater in early spring, returning to the system for other downstream uses.

Water is also needed to flood and grow the rice that eventually provides the fall and winter habitat for waterfowl and shorebirds. Growing rice requires approximately 5 acre-ft/acre (UC Davis 2019), applied between April and early September. The consumptive use of this water by the crop is about 2.8 acre-ft/acre, with the remaining evaporating, percolating into the ground or draining as tailwater spill at the end of the irrigation season, returning to the system to support other uses downstream.

Shorebirds need habitat at times that do not coincide with the time when rice fields are typically flooded postharvest. If the shorebird population reached the long-term objective, additional habitat would be particularly critical in the fall (late July to September) and spring (mid-March to April) (Dybala et al. 2017). Idled fields could be shallowly flooded in late July through August, prior to when other habitat would be flooded, and in March through April, after other habitats are drained, to make up for these shortfalls. Seasonal wetlands could also be managed, particularly on refuges, specifically to provide habitat during these time periods. Willing agricultural or refuge partners and supplemental water supplies would be needed to support these practices on the landscape.

Several CVJV partner organizations participated in a collaborative analysis to describe the water needs of Central Valley fish, waterfowl, shorebirds, and the giant garter snake, on a semimonthly basis, upstream of different control points in the Sacramento River watershed and Sacramento-San Joaquin River Delta. The annual hydrographs developed for this effort were informed by and built on the CVJV's assessment of bird habitat needs (objectives). These hydrographs (Figures 4.2.1 – 4.2.4) are presented here to illustrate the approximate pattern of Central Valley waterfowl and shorebird water needs over the course of a water year (starting in October).

Figure 4.2.1 presents the total water needs patterns of waterfowl and shorebirds, including all habitat types, from the Sacramento River watershed upstream of the American River confluence. Referred to here as the Sacramento Valley, this watershed roughly corresponds to the CVJV's Sacramento planning region. Figure 4.2.1 includes the water needed to grow the acres of rice that must later be flooded to provide adequate bird habitat.

Figure 4.2.2 breaks out the waterfowl water need in this area by habitat type. Note that the water needed for winter-flooded rice habitat has two components: water used for irrigation to grow the rice that will be winter-flooded, and water used to flood the fields postharvest. Note that more rice is grown than can be flooded. So, to estimate the water used for irrigation, only the volume of water needed to inundate lands that actually become (are later flooded for) habitat for wildlife was incorporated into the estimate of water needed for wildlife needs.

The timing of these water diversions between April and the first half of September is assumed to be proportional to a typical delivery pattern of the Sacramento Valley Settlement Contractors, who grow the majority of rice in the Sacramento Valley (pattern adapted from Sacramento Regional Water Management Plan, January 2007 and personal communication with Thad Bettner, GCID: T. Bettner, personal communication, 2016, see "Notes").

Figure 4.2.2 shows that water needed to grow rice and subsequently flood that rice in winter comprises the largest volume of water needed of all habitat types. Flooded rice fields provide over 60 percent of the food resources available to ducks and

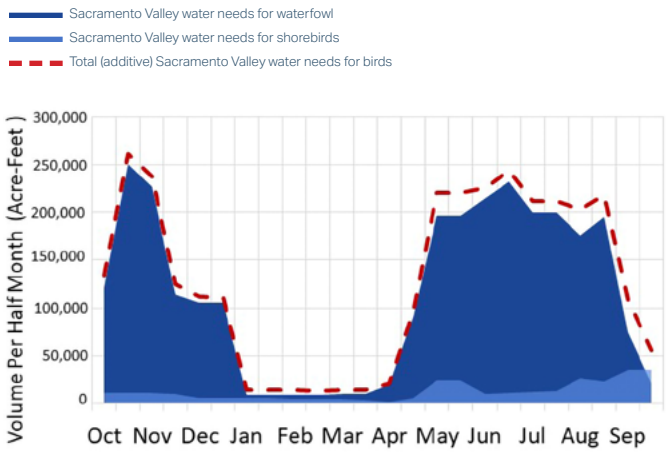



**FIGURE 4.2.1 Semimonthly waterfowl and shorebird water needs from the Sacramento River watershed upstream of the American River confluence.** The dashed line shows the sum of these needs.

geese in the Central Valley, with refuges, managed wetlands and harvested corn fields typically providing the rest. It is important to note that rice and corn must not only be grown but also winter-flooded to make food resources fully available to birds.

Figure 4.2.3 presents the total water needs pattern of both waterfowl and shorebirds including all habitat types from the Delta, San Joaquin, and Tulare Basins. Although proportionally small, water needed to grow the acres of rice that must later be flooded for birds is also included here.

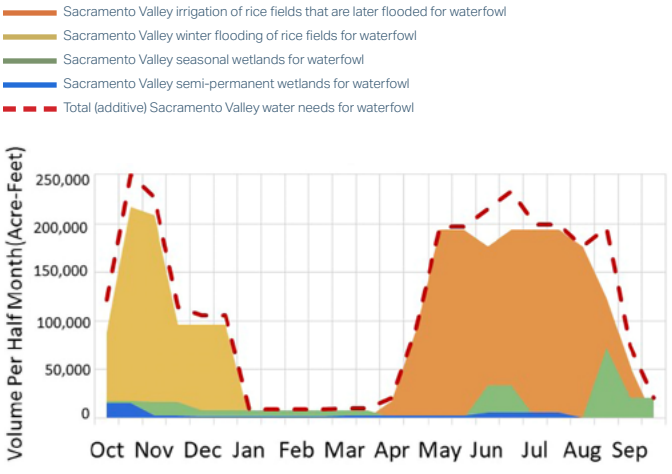



**FIGURE 4.2.2 Semimonthly waterfowl needs from the Sacramento River watershed upstream of the American River confluence: Breakout of water needed to grow rice and winter flood post-harvest for habitat.** Only the water needed to grow the rice that is later winter-flooded is included. The dashed line shows the sum of these needs.

The water needs of refuges are a component of the seasonal and semi-permanent water needs for waterfowl and shorebirds presented in the previous figures. Figure 4.2.4 presents these refuge water needs (assuming optimal water supplies required by CVPIA are available) both in the Sacramento Valley and in the San Joaquin and Tulare Basins.

These figures illustrate the general pattern of water needs at the CVJV's current acreage targets for each habitat type. The water supplies available to each of these wetland types may vary from year to year. The next section describes the availability and reliability of these water supplies by wetland type, followed by the challenges and opportunities for increasing those supplies to achieve the target water needs.

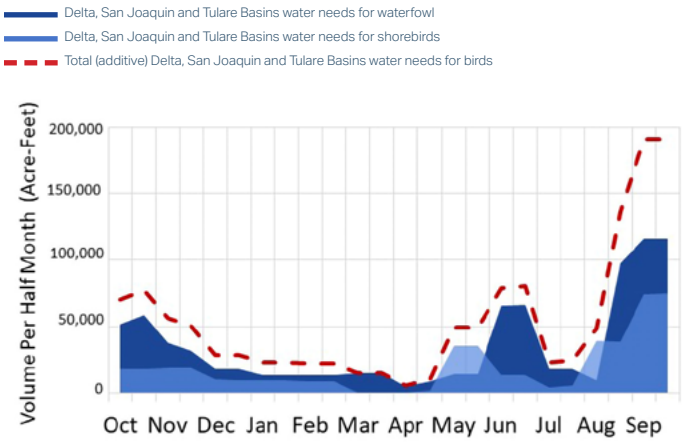



**FIGURE 4.2.3 Semimonthly waterfowl and shorebird water needs in the Delta, San Joaquin and Tulare Basins.** Dashed line shows the sum of these needs.

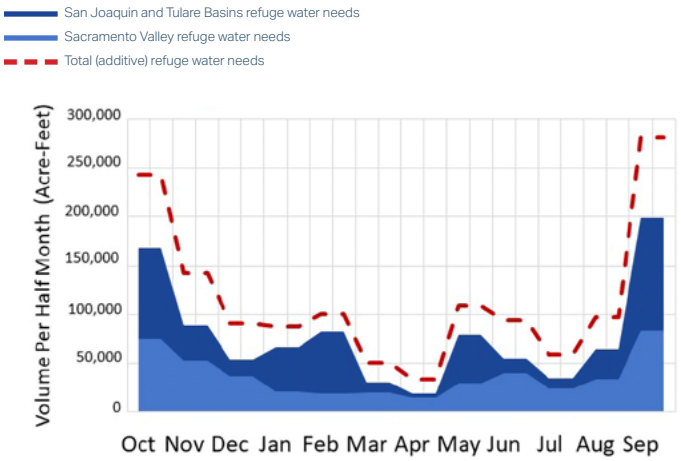



**FIGURE 4.2.4 Semimonthly refuge water needs in the Sacramento, San Joaquin and Tulare Basins.** The dashed line shows the sum of these needs.

## Meeting wetland water needs: current status

In some areas of the Central Valley, existing wetlands with reliable water supplies may receive enough water in wetter years to support best management practices. But in other areas and in drier years, water supplies are uncertain at best and not available at worst, leaving important wetland habitat dry and impacting its productivity for years to come. This section describes the extent to which CVJV partners and Central Valley land managers are providing the water necessary to meet habitat objectives on managed wetlands and winter-flooded agricultural land. The section also identifies particular gaps with respect to water supplies.

### CVPIA-covered federal refuges, state wildlife areas, and the GRCD

The CVPIA directs the U.S. Department of the Interior and the state of California to provide adequate, reliable water to 19 Valley refuges, hereafter termed "CVPIA refuges." Included are the 14 National Wildlife Refuges in the Valley; the Gray Lodge, Los Banos, Volta, and Mendota Wildlife Areas; and the GRCD. But on average, only half of the spring and summer water required to meet the needs of wildlife is delivered. Far less water is delivered to refuges in drought years, especially in the San Joaquin Valley.

Water supplies required by CVPIA have never been fully delivered to all refuges because of several physical and institutional challenges. Most CVPIA refuges receive a portion of their water supply (their "Level 2" supply) with a reliability that has, to date, matched that of senior CVP contractors. However, total water deliveries show a declining trend over the years, particularly with respect to Incremental Level 4 supplies (Figure 4.2.5).

According to delivery records through 2018 maintained by the Refuge Water Supply Program, an average of 422,000 acre-ft has been delivered to CVPIA refuges annually since 2002 (USBR, personal communication, 2017, see "Notes").

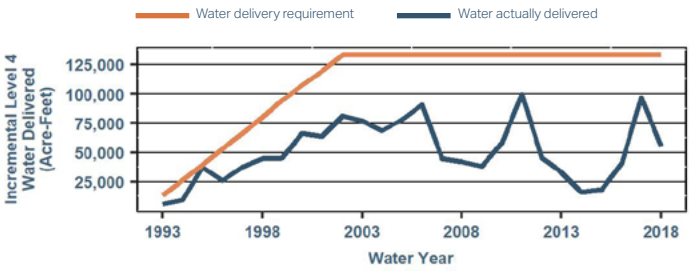



**FIGURE 4.2.5 Water supplies acquired for refuges show a declining trend.** Red line shows Incremental Level 4 water delivery requirement; blue line shows water actually delivered.

| | UNMET WATER NEED (ACRE-FT) | CONSTRAINT |
|---|---|---|
| **SACRAMENTO VALLEY** | | |
| ***Sacramento National Wildlife Refuge Complex*** | | |
| **Sacramento National Wildlife Refuge** | - | |
| **Delevan National Wildlife Refuge** | - | |
| **Colusa National Wildlife Refuge** | - | |
| **Sutter National Wildlife Refuge** | 15,900 | Infrastructure |
| **Gray Lodge Wildlife Area** | 8,600 | Infrastructure |
| **SAN JOAQUIN VALLEY** | | |
| ***San Luis National Wildlife Refuge Complex*** | | |
| **San Luis Unit** | - | |
| **West Bear Creek Unit** | 3,200 | Acquisitions |
| **East Bear Creek Unit** | 9,800 | Infrastructure, acquisitions |
| **Kesterson Unit** | - | |
| **Freitas Unit** | - | |
| **Merced National Wildlife Refuge** | - | |
| **Kern National Wildlife Refuge** | 7,200 | Acquisitions |
| **Pixley National Wildlife Refuge** | 4,700 | Infrastructure, acquisitions |
| **Volta Wildlife Area** | 2,700 | Infrastructure |
| **Los Banos Wildlife Area** | 4,600 | Acquisitions |
| ***North Grasslands Wildlife Area*** | | |
| **China Island Unit** | 1,400 | Acquisitions |
| **Salt Slough Unit** | 1,300 | Acquisitions |
| **Mendota Wildlife Area** | 1,400 | Infrastructure, acquisitions |
| **Grassland Resource Conservation District** | 19,700 | Acquisitions |
| **Subtotal** | **80,500** | |
| **Estimated average 15% carriage loss** | **12,100** | |
| **Total** | **92,600** | |

**TABLE 4.2.4 CVPIA Refuges: Average water needs and constraints (rounded to the nearest 100 acre-ft (E. Wehr et al., unpublished report, 2017, see "Notes").**

This is the Full Level 2 water supply historically delivered to refuges. The total amount required by CVPIA for optimal habitat management, known as Full Level 4, is 555,000 acre-ft. The difference between the Full Level 4 and Full Level 2 amounts is 133,264 acre-ft and is known as the Incremental Level 4 (IL4) amount. While the L2 amount is very reliable, supplied mostly via CVP yield, the Refuge Water Supply Program purchases a portion of the IL4 every year. (This is considered "applied water use" and does not account for return flows or seepage to maintain groundwater conditions in underlying aquifers.)

**Delivery shortfalls reduce the habitat contribution these refuges could make to the overall mosaic of wetland habitats needed to support resident and migrating bird populations in the Central Valley. Without these deliveries, other wetland types must provide additional acres to make up for the habitat shortfall, or bird populations could be impacted.**

The CVPIA refuges that are chronically short of water or those that face particular water supply challenges include Sutter NWR and Gray Lodge WA in the Sacramento Valley; and Kern NWR, Pixley NWR, Los Banos WA, North Grasslands WA, units within the San Luis NWR Complex, and GRCD in the San Joaquin Valley and Tulare. Table 4.2.4 lists water-short CVPIA refuges, approximate individual water needs, and whether those needs must be met through infrastructure investment or water acquisition. Note that water needs expressed are averages; needs in dry and critical years are higher.

### Other public and private non-CVPIA Refuge wetlands

Approximately two thirds of the managed wetlands in the Central Valley do not have a contract for water through the CVPIA. These seasonal wetlands are privately managed, most as "duck clubs," and they access developed water through a variety of water rights or incidental water supplies such as runoff or tailwater. Many private wetland managers rely on water supplies that are reduced in below-average water years, depend on return flows from agriculture, and/or are provided with contracts between water purveyors and federal or state agencies. Therefore, the water supplied to these wetlands and the extent of habitat may vary from year to year.

Water supplies available to these privately managed wetlands are deficient in some years and may be declining. In general, water supply deficiencies to these wetlands tend to occur during the fall flood-up period from September through November, and throughout the winter, when maintenance flows are needed to maintain flooded conditions. Wetlands could and do acquire rights to natural surplus flows from the SWRCB. However, as described previously, flows are typically only available from December through March after winter rains begin and are not available for September flood-up.

Tailwater from rice fields being drained in the fall is the source of water supply for 45,000 acres (approximately 56 percent) of the seasonal wetlands in the CVJV Sacramento planning region (Petrie and Petrik 2017). Some wetlands that rely on tailwater from agricultural operations are experiencing a reduction in supply as water use efficiency measures are implemented or as rice or row crops are converted to orchards. Refuges are experiencing similar challenges.

Wetland managers may also be reliant on operational conveyance facilities and drains to receive their water supplies. These facilities may shut down for maintenance activities when not being used for agricultural irrigation in fall and winter, which is typically when wetland water demands are highest.

### Agricultural habitats

The largest portion of non-breeding wetland dependent bird habitat in the Central Valley is now provided by agriculture, especially postharvest-flooded rice in the Sacramento Valley and, to a lesser extent, corn in the Delta Basin. Over the last few decades, migratory birds have increasingly relied on a mosaic of surrogate, temporary habitats outside of protected managed wetlands. These habitats include compatibly managed, seasonally flooded private agriculture lands.

Each year, approximately 550,000 acres of rice are planted in the Sacramento Valley and are used as breeding habitat. In a typical fall and winter, around 350,000 acres of this rice land is flooded intentionally as one way to promote decomposition of rice straw and create migratory bird habitat, as discussed previously. This acreage provides up to 50 percent of the food resources for waterfowl in the Central Valley (see the Non-Breeding Waterfowl chapter). Harvested corn crops also provide habitat and food benefits for waterfowl. In the Delta Basin, approximately 30,000 acres of corn are grown each year. This corn acreage provides roughly four percent of the food resources available for waterfowl in the Central Valley and is also especially important to sandhill cranes.

While much of the habitat provided by agriculture is used by birds in the fall and winter, creating this habitat and additional breeding habitat requires year-round water supplies. For example, starting as early as April, water is required to flood up rice fields for planting. In the spring and summer months, reliable and timely water supplies are necessary, both to cultivate the crop and to maintain breeding habitat. Once the crop is harvested, additional water supplies must be delivered to flood the fields to promote decomposition of rice straw and make waste grain accessible as food for birds. This winter flooding comes at a critical time when birds need to refuel for long migrations back to northern breeding grounds. Usually in February and March, the fields are drained and dried prior to planting, and the cycle begins again.

Most of the rice grown in the Sacramento Valley relies on surface water from the Sacramento River through CVP Settlement Contracts or Agricultural Service Contracts, or from the Feather River through State Water Project contracts. These contracts have provided relatively reliable water to grow rice in all but very dry and critically dry years. Access to water supplies in winter months for flooding fields can be limited by the lack of a right or contract to divert water, the relative priority of a winter water right, the terms of the water supply contract, reservoir operations, and other water management conditions. Therefore, although water supplies for growing rice have been relatively reliable, water supplies to flood rice fields postharvest and create habitat conditions are generally less reliable, especially in dry years and during droughts.

Trends indicate that winter flooding may decline both overall and as a percentage of rice acreage grown. Reasons for this decline include reduced water availability (whether real due to actual water curtailments or merely predicted in a given year), increased grower familiarity with dry incorporation methods, a growing market for rice straw (such as for fiberboard manufacturing), and other economic reasons. Some of these challenges are described in the Non-Breeding Waterfowl chapter.

## Wetland Water Supply Challenges

Many significant factors limit wetland water supplies now and they will continue to challenge habitat and natural resource managers into the future. Broadly, the primary water challenges facing both private and public wetland managers in the Central Valley are: (1) maintaining and increasing the reliability of water for wetland management, both quantity and quality; and (2) ensuring that funds for water supplies cover the increasing costs of water. Even CVPIA refuges that were guaranteed firm water supplies by Congressional action

*Lower Riley Slough on Faith Ranch: Water levels managed for bird habitat on private conservation-easement land - Gary Zahm, Faith Ranch*

are limited in their ability to receive adequate water supplies. (Many of these challenges were described in detail in a report entitled "Undelivered Water: Fulfilling the CVPIA Promise to Central Valley Refuges" [CVPIA IRP 2009].) The challenges described in this section currently restrict or impair wetland water supplies or funding, or they will do so if not proactively addressed. The next section will discuss potential opportunities that could address these challenges.

### Refuge water conveyance

Most CVPIA Refuge managers depend upon water being conveyed to them through local water or irrigation districts to the refuge boundary. These districts needed improvements or expansions to their infrastructure for them to meet the individual CVPIA Refuge needs in their area, while also serving the ongoing needs of their own landowners. Construction and conveyance agreements were negotiated between these districts and the USBR so that these improvements could take place.

### Refuge water funding limitations and other challenges

The CVPIA Restoration Fund is the primary source of funding for CVPIA refuge water supply acquisitions, water conveyance rights, and infrastructure projects. It is funded

by USBR's collection of environmental mitigation fees from CVP water and hydropower customers and is supplemented by contributions from the state. Approximately half of the $50 million annual fund is allocated to the CVPIA Refuge Water Supply Program each year. One challenge associated with the CVPIA Restoration Fund is the unpredictable nature of annual collections and appropriations. Various proposals to address the problem have been advanced. Any proposal to reform the Restoration Fund must be designed to preserve and enhance its ability to provide needed water supply to managed wetlands.

Another funding challenge is that federal and state budgets are unable to keep up with the increasing costs of water and the costs of maintaining reliable infrastructure on refuges. Although more permanent sources of Level 4 refuge water supply are under development, the majority of Level 4 refuge water is purchased on a year-to-year or "spot-market" basis. Increasing demands for water coupled with less water available in storage, on average, has resulted in higher water prices, reducing the amount of water that the program can acquire on an annual basis within its current budget. Costs for both permanent water rights and spot-market water are likely to continue to rise in the near future as groundwater users are increasingly forced to look to surface water supplies with the implementation of the Sustainable Groundwater Management Act. The Sustainable Groundwater Management Act of 2014 (SGMA) requires governments and water agencies of high and medium priority basins in California to halt overdraft (if it exists) and bring groundwater basins into balanced levels of pumping and recharge. This trend will further increase pressure on the Refuge Water Supply Program to provide adequate water to meet refuge needs.

## Droughts and climate trends

Droughts are a fact of life in California, but recent severe droughts have brought more attention to the potential and real impacts droughts can have on waterbird habitat in the Central Valley, a region that has lost so much available habitat over the last 150 years.

Drought impacts Central Valley wetland habitat in several ways. During a drought, water supplies are often curtailed to agricultural crops, an action that affects wetlands both directly and indirectly. Crops that may otherwise have directly provided postharvest-flooded habitat may be fallowed if water supplies are unavailable that year. Tailwater that would have otherwise flowed to supply some seasonal wetlands may be unavailable if irrigated field crops are fallowed or if "no water release" efficiency measures are implemented. Water supplies may also be curtailed to refuges, or unavailable or too expensive to purchase on the spot market, ultimately reducing wetland extent and/or food production at refuges.

Different regions of the Central Valley experience different levels of drought impact in terms of the extent of open water habitat available to birds. For example, studies found that in the Tulare and San Joaquin Basins, the amount of open water declined almost immediately in the fall/early winter following a drought water year, whereas several consecutive years of drought occurred before the Sacramento Valley experienced changes in the extent of open water. The Yolo-Delta and Suisun Planning Regions were generally unaffected by drought in terms of open water extent (Reiter, Elliott, Veloz et al. 2018). Contributing to the resiliency of the Sacramento Valley to drought is the availability of waterbird-compatible crops like postharvest-flooded rice, and senior water rights and policies such as Area of Origin that apply in the Sacramento Valley. Habitat south of the Delta, especially on refuges and private seasonal wetlands in the San Joaquin and Tulare Basins, may be more at risk during droughts.

California sustained an extreme drought between 2013 and 2015. During this lengthy drought, water supplies to wildlife-compatible agriculture and to managed wetlands and refuges were more severely curtailed than water supplies to other uses[2]. A recent study based on satellite imagery found up to 80 percent declines in postharvest-flooded agriculture and 60 percent open-water declines in managed wetlands compared to non-drought years (Reiter, Elliott, Jongsomjit et al. 2018). In 2014-2015, it was estimated that only 10 percent of wetlands were irrigated in summer. This low water supply level can result in a 44 percent decline in food production on non-irrigated wetlands (Petrie et al. 2016). During that season, avian disease outbreaks were prevented in part as a result of collaboration across refuges, coordination of water management and regulatory efforts by water agencies and the agricultural community to maximize value of limited water supplies, and incentive programs which, on average, provided 35 percent of the available habitat on the landscape and up to 100 percent of the habitat on some days during the drought (Reiter, Elliott, Jongsomjit et al. 2018). Some

2. The State Water Resources Control Board and other water managing agencies made water allocations decisions for the 2015 water year that attempted to balance available and anticipated water storage and the water needs of cities, agriculture, and the environment. Ultimately, water managers decided that Settlement Contractors (Sacramento Valley) and Exchange Contractors (San Joaquin Valley) would receive 75% and 65% of their contracted supplies, respectively, but more junior water rights holders throughout the Valley would receive 0%. On par with those contractors, CVPIA refuges were allocated 75% of Level 2 supplies (which are CVP project supplies) north of Delta and 65% of Level 2 supplies south of Delta, but this represented much less than "optimal" Level 4 water supplies to these refuges. Kern NWR, for example, received less than one-third of its Full Level 4 water supply.

research evaluating impacts of future scenario projections through year 2099 indicated that several regions in the Central Valley may require additional conservation to support summer irrigation of seasonal wetlands and winter-flooding of cropland habitats. San Joaquin and Tulare regions would become increasingly vulnerable to future impacts of water limitation, and similarly, habitats in some areas in the Sacramento Valley also would experience more frequent and severe effects of drought than historically (Matchett and Fleskes 2018).

CVJV partners responded to this drought by facilitating communication among wetland managers, studying the impact of drought on waterbird habitat availability, improving drought preparedness and response through scenario planning, recommending strategies to bolster habitat resiliency, and developing approaches to dynamically deploy habitat more efficiently and precisely when and where birds need it.

Climate trends indicate that severe droughts – as well as significant storm events and floods – may occur more frequently over the next 50 to 100 years (IPCC 2013; Diffenbaugh et al. 2015). CVJV partners can provide information on habitat impacts and needs to conservation practitioners and policymakers and develop strategies to ensure wetland habitat resiliency as these changes occur.

## Rice decomposition trends and changes in agricultural practices

As described previously, the average amount of winter-flooded rice has decreased in recent years.

In 2007 and 2008, dry incorporation of harvested rice fields – that is, plowing or disking with no intentional flooding – reached peak levels (Miller et al. 2010). Growers may have thought less water would be available those years because previous winters were dry. Although water supply curtailments were ultimately not enacted, the growers planned ahead on a more reliable method. When normal water supply conditions returned in 2009, 50,000 to 60,000 fewer acres of rice was winter flooded than it had been at its peak, with a corresponding number of fewer acres available as habitat for migratory birds. Rice growers may also have been learning how to better incorporate rice straw into soil to achieve acceptable levels of decomposition even without flooding, and thus did not wish or could not afford to return to a less reliable method (CRC 2015).

The drought from 2013-2015 resulted in water supply reductions in much of the Sacramento Valley. These curtailments and other water management decisions, including transfers to other agricultural water users, resulted in a significant decline in winter-flooded rice, especially in areas west of the Sacramento River. Reductions grew over each subsequent dry year. In 2014, although 424,350 acres of rice were harvested, it was estimated that as little as about 12 percent of those acres were postharvest-flooded, a 51 percent reduction from a typical year (Petrie et al. 2016).

Adding to these declines, and possibly in response to recent drought conditions that made winter flooding less viable, farmers have recently chosen to provide rice straw to a new state-of-the-art medium density fiberboard (MDF) manufacturing facility that is under development. This and other novel uses of rice straw offer rice growers alternatives to postharvest flooding.

Ultimately many rice growers may choose what decomposition method to use based on economics, convenience, and reliability. If the costs to winter flood increase due to rising water costs, labor, or other factors, or if water becomes less reliable and less convenient, incentive programs may be needed to encourage rice growers to reconsider the multiple benefits of winter flooding. See "New Public and Private Funding" below.

## Groundwater regulation

Local stakeholders are forming Groundwater Sustainability Agencies to manage basins and develop Groundwater Sustainability Plans. Under SGMA, these groundwater basins should reach sustainability within 20 years of implementing their sustainability plans (CDWR 2019).

Some Central Valley wetlands, particularly in the southern San Joaquin and Tulare Basins, rely on groundwater as a source – and for some the only source – of water supply. These wetlands may have no other water rights or access to surface water supplies. Implementation of SGMA in these areas is likely to reduce groundwater availability to a fraction of what is needed to manage wetlands. For example, in some parts of the Tulare Planning Region, early estimates suggest that groundwater allocations will be set at roughly only 0.5 acre-ft/acre per year of consumptive use. Some basins are developing a credit trading system enabling some land within a basin to pump more groundwater while others use less. The demand for these credits by non-wetland water users is likely to put pressure on wetland managers politically or financially, affecting continuing wetland viability.

Participation in the development of Groundwater Sustainability Plans by wetland managers or their advocates

requires investments of time and funding to be sure that wetland water supply interests are accurately reflected in the basin water budgets and allocations.

### Water management projects and regulatory processes

Ensuring that ongoing federal, state and local water management projects and regulatory processes account for wetland water needs requires significant time investment by wetland and natural resource managers and their advocates. These projects and processes often pose challenges to the wetland conservation community, but they also may present opportunities if the CVJV engages strategically.

Although the duration and ultimate resolution of these ongoing processes is difficult to predict, the following are examples of planning and regulatory processes that could affect the ability of the CVJV – for better or worse – to achieve the Implementation Plan objectives over the next 10 years.

- Bay-Delta Water Quality Control Plan Update
- Reinitiation of Consultation on the Long-Term Operations of the SWP and CVP
- WaterFix and EcoRestore
- SWRCB Wetlands Policy

## Wetland Water Opportunities

CVJV partners have achieved a great deal of success working collaboratively on the ground to secure and restore new wetland habitat and to develop new ways to provide habitat on working lands. Securing and maintaining water supplies for this habitat, and developing ways to stretch existing wetland water supplies to achieve conservation targets, is also critically important, especially to confront the challenges described above. Strategic planning, funding and market-based solutions, and harnessing state-of-the-art technology and data are just some of the opportunities that can lead to better wetland water management and more resilient wetland water supplies.

### Strategic planning

Given the challenges described in this chapter, it is important to use available resources (funding, time and water) as strategically as possible. To help with this, the Refuge Water Supply Program (RWSP) is undertaking a stakeholder strategic planning process, managed collaboratively by agency staff and some CVJV partners.

The resulting Strategic Plan will identify a path for meeting the full CVPIA refuge contractual obligations. The intent

*Manager checking a water control structure at Twin Lakes Partners for Fish and Wildlife project - Shawn Milar*

of the Strategic Plan is to set a prioritized program budget, schedule, and expectations for implementing the refuge water supply component of the CVPIA, with partner agencies and stakeholders in the shortest possible timeframe. The plan will also provide a tool for managers to assess potential projects and expenditure of resources as conditions change or new project opportunities develop.

### New public and private funding

Funding is needed to address water supply shortfalls on refuges and to encourage water-related agricultural practices, such as winter flooding, on private lands. Funding mechanisms could include bond measures, tax credits, and other creative strategies.

Some recent bond measures have allocated billions of dollars to water projects that could provide wetland benefits, and other bonds have allocated millions directly to bird habitat conservation.

Creating private wetlands or supplying wetland water could also be encouraged through tax credits or other financial incentives. As discussed previously, as winter flooding becomes more expensive or less reliable as a method for disposal, incentives may be needed to encourage growers to continue to winter flood their rice fields.

### Enhanced wetland water conservation and productivity

Implementing water conservation measures on wetlands must be done with an understanding of what the water needs are to support a particular function, or suite thereof. Discussions for achieving water efficiency should go hand in hand with discussions on desirable outcomes and the values obtained from dedicating water supplies for wetland habitat purposes. An increase in reliability and/or volume of water supplies delivered to a wetland may result in enhanced or additional beneficial uses of that wetland, measured in habitat and species diversity, caloric output, disease control, waterfowl body conditions, visitor days, recovered populations of listed species, etc. Any conservation measures implemented must not be detrimental to those outcomes, but rather be tied to achieving those same outcomes with less water.

One example of how managed wetlands can increase productivity with less water is by installing water recirculation infrastructure. Several CVPIA refuges have done so, and more projects are underway, including the Grassland Water District's North Grassland Water Conservation and Water Quality Control Project. This water recirculation project, funded through a partnership with San Luis Water District and a grant from the State of California, includes 18,000 feet of buried pipelines and three pump stations in the northern area of the GRCD, which will capture and recirculate an estimated average of 14,000 acre-ft of refuge water per year. The project will conserve water for delivery to approximately 8,000 acres of habitat.

### Improved access to and participation in the water market

As described previously, managed wetlands, both public and private, typically rely on long-held water rights or water project contracts (such as those established following the passage of CVPIA), or on incidental return flows. These are critically important supplies that must be maintained. In addition, buying, selling and exchanging water with other water users within the Valley, and even exchanging water between different wetlands, may open doors that lead to increased overall water deliveries to wetlands. A few examples of how CVJV partners are pursuing these types of opportunities are highlighted below. During the course of this Plan, new projects and water deals will continue to be identified and achieved.

#### Direct water purchases

The Refuge Water Supply Program regularly acquires water from willing sellers to provide refuges with Incremen-

## WATER TRACKER

Water Tracker is an open source, publicly accessible, near real-time assessment of open surface water in the Valley derived from remotely sensed data. Semimonthly, this automated system maps, quantifies and summarizes surface water in the entire Valley by cover type and by Joint Venture planning basin and these data are made available online (www.pointblue.org/watertracker). Development of the system involved engagement by wetland managers, conservation non-governmental organizations, and water districts throughout the Valley.

The information provided by the Water Tracker is timely and useful for deciding how best to allocate water across refuges and agricultural wetlands, providing benefits for wildlife and human communities.

The data provided by the Water Tracker has been used in combination with avian bioenergetics modeling to estimate the amount of different habitats available and needed by multiple species of waterbirds – and thus to inform the current CVJV habitat objectives. Also, it will soon be linked with other resource information (groundwater recharge potential, freshwater ecological diversity, distribution of threatened and endangered wildlife and other factors, for now and future projections) to create a spatially explicit and actionable conservation prioritization framework for the resource community.

Importantly, Water Tracker was used to assess patterns in open surface water during drought (2013 to 2015) in comparison with historical years (2000 to 2011) in habitats known to support wetland-dependent birds (Reiter, Elliott, Jongsomjit et al. 2018). The study found that the agricultural landscape had significantly less area of open water during the recent drought than during non-drought years. For example, rice growing areas showed as much as a 46% reduction in open water (particularly in February and March). The reduction in corn was as much as 80%. In rice, this effect was partially mitigated by precipitation, which had a significant positive effect on open water and was prominent in non-drought years. Seasonally managed wetlands showed about 50% declines in open water, largely observed between October and March.

In a warming climate, extreme conditions and extended droughts are forecasted to become more of the norm for California, making it increasingly difficult to meet the many demands for water in the state. Integrating current and accurate water science into state and regional decision-making processes is critical for sustaining healthy ecosystems and human communities into the future.

tal Level 4 supplies. Water is frequently acquired on the spot market as a single-year transaction, if and when water is available at prices the RWSP believes it can afford. Some multi-year agreements with entities such as the San Luis and Delta Mendota Water Authority have been negotiated, which provide the RWSP with a more predictable source of supply – at a more predictable cost – in most years. However, purchasing water in dry years, especially on the spot market, remains an expensive option. Additional permanent, reliable water supplies are needed, either through direct purchases or donations of water rights or contract reassignments. Funding for such purchases – and adequate capacity to identify, negotiate, and demonstrate the opportunities – is a critical need.

### Recycled water

As the demand grows for limited water in the Valley, recycled water is emerging as a potential source of supply for municipal and agricultural water users, as well as for wetlands. Projects like the North Valley Regional Recycled Water Program promise to provide reliable and relatively inexpensive water supply for both agriculture and wetlands in the upcoming years by recycling water. As the population grows and more water is allocated for urban use (depleting current water sources for wetlands), more recycled water potentially will be available and could become an increasingly important water supply for flooded habitats. On a case-by-case basis, more study is needed to ensure that the wide range of biological, inorganic, and organic constituents that may cause water quality concerns when wastewater is reused are adequately addressed and that recycled water projects do not further harm wetlands or riverine ecosystems.

### Water exchanges with other water users

The RWSP and GRCD have independently conceptualized and executed creative water exchanges, in which Level 2 surface supplies have been traded for a greater amount of groundwater. These exchanges take advantage of different demand timing – agricultural water users use surface water during the growing season, and in exchange they pump a greater amount of groundwater for refuges at other times of the year. While a creative potential win-win strategy to achieving additional wetland water supplies, potential water quality impacts and other issues must be considered and weighed when negotiating the deals.

### Inter-refuge exchanges and transfers

CVPIA refuge managers strive to make the most of the water supplies available to them, and to work together to ensure that each refuge has access to adequate water to the extent practicable. CVJV partners continue to look for creative and flexible water management opportunities across refuge lands that would enable habitat managers to be more responsive to the dynamic needs of migratory birds, as well as adapt to changing landscapes and climate.

| CHALLENGES | OPPORTUNITIES | REGIONAL APPLICABILITY |
|---|---|---|
| **Refuge water conveyance constraints** | Strategic planning<br>Enhanced wetland water conservation and productivity<br>New public and private funding | Sacramento Valley<br>San Joaquin Valley<br>Tulare Basin |
| **Refuge water funding limitations** | Strategic planning<br>Improved access to and participation in the water market<br>New public and private funding | Sacramento Valley<br>San Joaquin Valley<br>Tulare Basin |
| **Droughts and climate trends** | Strategic planning<br>A variety of approaches to deploying habitat<br>Water-related habitat data and tools | All |
| **Rice straw decomposition trends and agricultural practices** | New public and private funding<br>A variety of approaches to deploying habitat | Sacramento Valley |
| **Groundwater regulation** | Water-related habitat data and tools | San Joaquin Valley<br>Tulare Basin |

**TABLE 4.2.5** Summary of wetland water challenges, opportunities and applicable regions.

## Water-related habitat data and tools

New science is providing more information and tools to inform dynamic and real-time management of water supplies. This field of study, which relies on remote sensing techniques and new interfaces, can allow refuge and system managers to better understand where on the landscape water is present at any given time and pair that information with bird presence and numbers to tailor bird habitat based on current need. This type of real-time, dynamic management promises to allow managers to use water more strategically.

### Gauging habitat availability in real time

CVJV partners are developing tools to help habitat managers understand how much habitat is available in the Central Valley at a given time, and new approaches to address habitat shortfalls when and where they occur in the Valley. One example is a system called "Water Tracker", launched in 2017 by Point Blue Conservation Science to assess the extent of Central Valley open surface water, a surrogate for habitat availability, in near real-time using remote sensing technology. (See Water Tracker box for more information.)

### Robust wetland water budget estimates

Implementation of SGMA could affect wetland water availability. Some CVJV organizations are engaging in the development of groundwater policy, science, and project implementation to ensure that the needs of migratory birds are met alongside new requirements to sustainably manage groundwater. For example, some CVJV partners are working with consultants to develop more robust wetland water budget estimates, including broadly applicable methods and tools, with the objective of enabling managed wetlands to fully participate or to have water use and recharge contributions be reflected in groundwater sustainability plans. These tools, along with more robust estimates of wetland evapotranspiration or consumptive use, may also help wetland managers be more targeted and efficient in managing available water supplies and uses, both on the individual wetland scale and across multiple wetland units or refuges.

## A variety of approaches to deploying habitat

The CVJV recognizes that a variety of wetland types contribute to the mosaic of habitat that waterfowl, shorebirds, and other wetland-dependent wildlife rely on each year. Each wetland type requires different water management, both in terms of the overall volume of water that must be applied and timing of delivery. The exact composition of the habitat mosaic may change from year to year, but the overall objective is to ensure enough water is available for each wetland type when and where needed. With California's unpredictable, fluctuating hydrology and changing socioeconomic and cultural factors, flexibility may be the key to provisioning adequate wetland habitat over time.

Acquiring new, permanent easement lands and working with farmers to compatibly manage their land and water favorably for birds are two strategies that Migratory Bird Joint Ventures have used repeatedly and successfully to achieve habitat objectives. Easement managers and farmers can ensure water is available to support habitat when necessary as part of their routine management strategy. However, annual and long-term fluctuations in water supply and agricultural practices can occasionally reduce the amount of habitat that can be provided by these lands. A complimentary strategy is to dynamically and adaptively provision short-term habitat (and water) when and where migratory birds most need it. By incentivizing farmers to modify their activities or apply water for only short periods, additional habitat can be efficiently provided to address occasional critical needs.

## Summary and basin applicability

Table 4.2.5 summarizes wetland water challenges, opportunities that may help address each challenge, and the CVJV basin to which each challenge is relevant.